

SCIENTIFIC INTEGRITY AND PUBLIC TRUST: THE SCIENCE BE-  
HIND FEDERAL POLICIES AND MANDATES: CASE STUDY 1—  
STRATOSPHERIC OZONE: MYTHS AND REALITIES

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Scientific Integrity and Public Tru...

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BEFORE THE

SUBCOMMITTEE ON  
ENERGY AND ENVIRONMENT

OF THE

COMMITTEE ON SCIENCE  
U.S. HOUSE OF REPRESENTATIVES

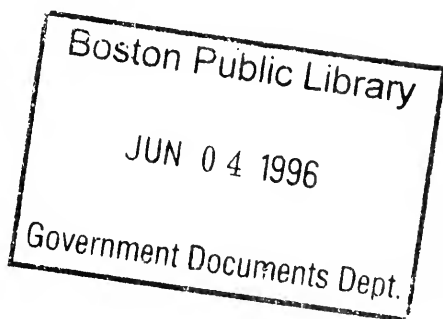
ONE HUNDRED FOURTH CONGRESS

FIRST SESSION

SEPTEMBER 20, 1995

[No. 31]

Printed for the use of the Committee on Science





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1—STRATOSPHERIC OZONE: MYTHS AND REALITIES

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# **SCIENTIFIC INTEGRITY AND PUBLIC TRUST: THE SCIENCE BEHIND FEDERAL POLICIES AND MANDATES**

## **CASE STUDY 1—STRATOSPHERIC OZONE: MYTHS AND REALITIES**

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**WEDNESDAY, SEPTEMBER 20, 1995**

HOUSE OF REPRESENTATIVES,  
COMMITTEE ON SCIENCE,  
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT,  
*Washington, DC.*

The Subcommittee met at 9:37 a.m., in room 2318 of the Rayburn House Office Building, the Honorable Dana Rohrabacher, Chairman of the Subcommittee on Energy and Environment, presiding.

Mr. ROHRABACHER. The hearing of the Energy and Environment Subcommittee will come to order.

And Mr. DeLay will be here momentarily. Mr. Doolittle is here already and they will have testimony for us in the beginning.

But first, I will begin with an opening statement.

I am Congressman Dana Rohrabacher, Chairman of the Committee.

On February 3, 1992, then-Senator Al Gore told the United States Senate that, and I quote, "If atmospheric conditions continue as they are for a few weeks, there could be an ozone hole above heavily-populated areas in the northern hemisphere. There could well be an ozone hole above Kennebunkport."

And I remember that time period very well because I remember the Senator coming to one of the hearings that we had for the science hearings with many cameras in tow and newsmen in tow, in which he made the same prediction.

But on the Senate floor, he went on to predict that there would be, and I remember, I believe he made the same predictions here with us, that there would be 300,000 additional—that's additional—skin cancer deaths in the United States. And he envisioned a future in which children would have to hide from the sun when out to play.

We now know that the hole in the sky over Kennebunkport was bunk.

I have a little headline here for you, which, a few months after Senator Gore was before our committee, predicting the hole, the newspaper headline reads: "Ozone Hole Fails to Materialize as Feared."

Well, we now know that the hole in the sky over Kennebunkport was bunk. We can see it. We can analyze it. And this hole episode—and there may be a pun intended, I don't know—turned out to be another, basically “the-sky-is-falling” cry from an environmental Chicken Little, a cry we've heard before when the American people were scared into the immediate removal of asbestos from their schools, which turned out to be exactly the wrong method and the wrong way of going about to tackle the problem, and when the American people stopped eating apples, causing millions and millions of dollars' worth of loss to apple farmers because they were afraid of Alar.

This time, the scare-mongers managed to stampede the Congress and the President of the United States. President Bush sped up what had been a deliberate timetable to phase out CFCs around the world.

But that wasn't good enough. The U.S. unilaterally imposed an onerous excise tax on CFCs which has, as it always does, led to a thriving black market, which is what we see in the United States today.

In July of this year, a senior U.S. Customs agent called bootleg CFCs, “almost as profitable as dope.”

As this funny circus goes on, we have to ask ourselves—does the science justify the actions that have been taken and the billions that have been spent? Instead of maintaining a deliberate pace, our country rushed head-long to ban the substances people rely on to cool their homes, their cars, and their refrigerators to keep fruits and vegetables and other food fresh.

Was this justified by science?

Even if we accept the premise that these chemicals are harmful to the stratospheric ozone layer, what is the actual risk of, say, extending the phase-out period of CFCs in vehicles, as compared to the impact on the American consumer faced with replacing such expensive equipment?

Are we getting objective science from our regulatory agencies, or are scientists with unconventional views being shut out of the process?

These are some of the issues that will be aired at this, the first of a series of hearings on scientific integrity and the public process. Contrary to what you might have heard, this hearing is not going to be about whether we are for or against skin cancer. The American people deserve better of their government than scare tactics that are designed to intimidate and repress rational discussion.

During the course of these hearings, this Subcommittee will air views that are politically correct and politically incorrect. We will take a close look at the science behind regulations which government officials and the media have presented largely in emotional terms, and we will hear from both sides equally—I want to repeat that—we will hear from both sides equally, and I am hoping today to promote a dialogue between the various points of view, rather than just trying to have one view prevail over the other or trying to schedule one view early on in the hearing and not letting the other view be heard until the very end of the hearing, which far too often in the past was *modus operandi* for the congressional committees.

For today's hearing, we are pleased that some of the most prominent scientific and economic experts on stratospheric ozone have agreed to testify.

With this, I will now turn and ask my esteemed colleague, who I have great respect for, who chaired the overall Science Committee for a number of years, and now is with us, gracing us with his presence and his expertise, former Chairman Brown.

Would you like to make an opening statement?

Mr. BROWN. I appreciate the Chairman's courtesy in allowing me the privilege of making an opening statement. I'm really substituting here for the Ranking Minority Member, Congressman Hayes, who couldn't be present, but will, I hope, present a statement.

Let me first say that I, as you do, welcome these hearings. What we badly need for all of science in this country is a better public understanding of the basis on which science is conducted and the basis on which regulatory decisions are made based upon that science.

And I will compliment the Chairman for the way in which he has phrased the question and on his fairness in terms of setting up a hearing in which we do have good representatives of both sides who are appearing and making their case.

And I hope that we can publicize the results of this hearing in such a way that it will contribute to the understanding of the American people on how science policy and science regulatory matters are conducted.

And they have been flawed in the past. I would be the first to agree with that.

I note with some interest the Chairman's opening statement about the Vice President and Senator Gore's statement and I will admit that that was an effort to focus attention, in a very highly visible way, on an issue which the Senator turned out to be slightly exaggerating the consequences.

Now if he were the first politician that had ever done that, I would feel that we might have a case here. But that rather typically represents the way that politicians go about getting interest focused on an issue which they are concerned with.

The process today is how we really need to hold hearings and to prepare the basis for legislation in a sounder and longer-term way.

And I say this without intending to criticize the Vice President. I watched with great admiration as he exploited every opportunity to focus public attention on science issues while he was a member of this Committee. He did it in a good way and I think that Mr. Rohrabacher is doing a very good job in trying to perhaps now bring about a broader-based view on how some of these things are done.

So, Mr. Chairman, I welcome the hearing. This is a very important issue. The global warming issue is one that we will be involved in through both policy and appropriations. We're into the level of billions of dollars per year in the area of atmospheric science and it's only appropriate that we act with great prudence with regard to that, with regard to ozone, yes.

It's my personal feeling that the scientific case for ozone depletion is by now extremely strong, if not overwhelming. Of course, this will be explored by the witnesses that we have before us.

If there ever was a way in which, an example of how good science was developed, I think the ozone issue illustrates that process.

I might say that our history of concern for ozone depletion goes back at least a full generation when it was one of the issues that came up in connection with our discussion of whether to develop a fleet of supersonic aircraft, probably 20-odd years ago. And it was thought at that time that the aircraft would destroy the ozone layer and cause the problems that we now blame on chlorofluorocarbons.

That proved to be a slight exaggeration. We never put up the fleet of supersonic transport. But it was not because of their impact on the ozone layer. It was the impact on our pocketbooks which we were worried about.

Mr. Chairman, I will ask unanimous consent that my full statement be put into the record at this point.

Mr. ROHRBACHER. Without objection.

[The full statements of Subcommittee Chairman Rohrabacher and Ranking Minority Member Brown follow:]

#### OPENING STATEMENT, HEARING ON OZONE DEPLETION, SEPTEMBER 20, 1995

On February 3, 1992, then Senator Al Gore told the U.S. Senate that "if atmospheric conditions continue as they are for a few weeks, there could be an ozone hole above heavily populated areas of the northern hemisphere. . . . There could well be an ozone hole above Kennebunkport."

Senator Gore then went on to predict 300,000 additional skin cancer deaths in the United States and envisioned a future in which children would have to hide from the sun in the when out at play.

We now know that "the hole in the sky over Kennebunkport" was bunk.

On May 1, the headlines read, "OZONE HOLE FAILS TO MATERIALIZE."

This whole episode (no pun intended) turned out to be another cry that "the sky is falling" from an environmental chicken little—a cry we've heard before when the American people were scared into immediate removal of asbestos from schools and stopped eating apples because of Alar.

This time they managed to scare the President of the United States.

President Bush sped up what had been a deliberate timetable to phase out CFCs around the world.

But that wasn't good enough. The U.S. unilaterally imposed an onerous excise tax on CFCs which has, as it always does, led to a thriving black market.

In July, a senior U.S. Customs Agent called bootlegged CFC's "almost as profitable as dope."

Does the science justify the actions that have been taken and the billions that have been spent?

Instead of maintaining a deliberate pace, our country rushed headlong to ban the substances people rely on to cool their homes, cars and refrigerators. Is this justified by the science?

Even if we accept the premise that these chemicals are harmful to the stratospheric ozone layer, what is the actual risk of, say, extending the phase out of CFC's in vehicles, compared to the impact on the American consumer faced with replacing expensive equipment?

Are we getting objective science from our regulatory agencies or are scientists with unconventional views shut out of the process?

These are some of the issues that will be aired at this first of a series of hearings on "Scientific Integrity and the Public Process."

Contrary to what you might hear today, this hearing is *not* about being for or against skin cancer. The American people deserve better from their government than scare tactics designed to intimidate and repress rational discussion.

During the course of these hearings, this subcommittee will air views politically correct and incorrect.

We will take a close look at the science behind regulations which government officials and the media have presented largely in emotional terms and hear from both sides equally.

For today's hearing, we are pleased that some of the most prominent scientific and economic experts on the stratospheric ozone issue have agreed to testify.

## OPENING STATEMENT BY THE HONORABLE GEORGE E. BROWN, JR.

## ACCELERATED PHASEOUT OF STRATOSPHERIC OZONE DEPLETION SUBSTANCES

Mr. Chairman, I welcome today's hearing as an opportunity to set the record straight on the issue of ozone depletion and the Montreal Protocol. This is perhaps one of the most important success stories that we have on how "good science" has been transformed into "good policy".

By any measure imaginable, there now exists a true consensus regarding the science of ozone depletion. Research in the U.S. and other countries supported by both the industry and Government has provided policy makers with a base of knowledge that underlies some of the most sophisticated cost-benefit analyses ever carried out. Today, the science is even stronger than when the original Montreal Protocol was signed.

The results we will hear today should provide ample proof that the Montreal Protocol has worked. The Government and industry, acting together, have averted the dire scenarios that dominated the headlines a decade ago. Moreover, we can point with pride to the international leadership role we have developed in this area.

Finally, while several issues remain, the transition to substitutes has gone smoothly with no major economic dislocations. To be certain, some individuals will feel the pinch—higher future costs for CFCs, diminishing availability of stockpiles, higher maintenance costs for old equipment and so on.

Many of us who own Beta format VCRs, 33 $\frac{1}{3}$  RPM records, and typewriters have experienced these same frustrations. While I do not mean to trivialize the cases we will hear, they should be factored into an overall cost-benefit framework and should not, by themselves, drive public policy. An analysis of costs alone provides a distorted and one-sided picture of the effects of the phase-out of CFCs.

I am mindful, of course, that some in Congress will be seeking to reverse the progress that has been made in phasing out ozone depleting chemicals and even abandon our international commitments altogether. I strongly feel that this would be a tragic and irresponsible mistake.

I want to commend the Chairman for working with us to structure a balanced hearing today and I am confident that all points of view will be aired. We have invited representative voices from the overwhelming scientific consensus that has helped us understand the atmospheric dynamics associated with CFC's. Of course, the reality is that there are skeptics regarding ozone depletion—and we have invited some of the most prominent of those skeptics here today.

I believe there is a place for such skeptics. Their challenges can provide intellectual stimulation and they can perform a valuable role in keeping the science "honest". I would hope though, that at the end of the day, our public policy is based on the predominant view, the peer reviewed science, and the international consensus. I do not believe any other rational path exists.

Congress, as an institution, lacks scientific expertise to make judgements between competing claims. The only source of internal science advice to Congress, the Office of Technology Assessment, is being exterminated as a budget saving move. Given this situation, we cannot responsibly choose to follow the guidance of the scientific fringe—no matter how intriguing and no matter how much their message may fit with our own preferences and prejudices.

I will close by reminding my colleagues that we have come a long way in developing the international consensus on ozone depletion. U.S. leadership in this area has been supported by three Administrations. U.S. negotiators will be meeting again this October to review the progress we have made. I hope that we will take a responsible view here today and provide our side with the support they will need in carrying out these important talks.

I would like to insert into the record a letter we received from the American Academy of Dermatology regarding the relationship between ozone depletion and skin cancer. I believe my colleagues will find it compelling. I look forward to the testimony of our other witnesses here today.

Mr. BROWN. Furthermore, I would like to include as a part of my statement a letter we received from the American Academy of Dermatology regarding the relationship between ozone depletion and skin cancer. (See Appendix 3 for enclosures.)

The American Academy of Dermatology, of course, includes those medical professionals who deal most with the issue of skin cancer and their statement should have considerable weight because of that.

Mr. ROHRABACHER. That will be included, without objection.

Mr. BROWN. And two additional matters. I would like that the statement of our colleague, Henry Waxman, who could not be present, be included in the record. (See Appendix 1.)

He is currently involved in the Clean Air Act and could not be here because of that.

Mr. ROHRABACHER. Without objection, it will be put in the record.

Mr. BROWN. And furthermore, a statement by the science advisor to the President on ozone depletion, Dr. Jack Gibbons. (See Appendix 3.)

Mr. ROHRABACHER. That will be put in the record, without objection, as well.

[The information follows:]





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September 18, 1995

The Honorable George E. Brown, Jr.  
Ranking Democratic Member  
Committee on Science  
U.S. House of Representatives  
2320 Rayburn House Office Building  
Washington, DC 20515-6301

Dear Congressman Brown:

On behalf of the American Academy of Dermatology, I am pleased to respond to your September 13 letter requesting the Academy's views on "the relationship between UV radiation and the various forms of malignant and non-malignant skin cancer." As you know, the Academy is dedicated to educating Americans about the dangers of skin cancer. Over the past decade, dermatologists have conducted free skin cancer screening clinics, screened over 1 million Americans, distributed thousands of skin cancer booklets and bookmarks, and conducted a concerted public information campaign to alert the American people to the dangers of the sun's rays.

I cannot understate the seriousness of the skin cancer problem. Today, skin cancer is the most common and most rapidly increasing form of cancer in the United States. In fact, there are now more cases of skin cancer in the United States than all other cancers combined. In 1989, the Academy proclaimed skin cancer to be an "undeclared epidemic," a phrase that has since been adopted by the Centers for Disease Control and Prevention (CDC). Half of all cancer diagnoses are for skin cancer, and one American in six will develop skin cancer in his or her lifetime. This year, nearly 1.2 million Americans will be diagnosed with non-melanoma skin cancer. According to a recent survey of dermatologists, an additional 80,000 Americans may be diagnosed with malignant melanoma. Although highly curable if detected and treated early, nearly 10,000 Americans will die of skin cancer this year -- about 7,500 from malignant melanoma and the rest from non-melanoma skin cancers.

Basal cell carcinoma is the most common form of non-melanoma skin cancer and is 95% curable. Basal cell usually presents as a slow-growing, raised, translucent nodule that may

*American Academy of Dermatology*

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The Honorable George E. Brown, Jr.  
 September 18, 1995  
 Page 3

a pencil eraser. If you have any of these warning signs, the Academy urges you to visit your dermatologist or personal physician, immediately.

With this background, let me try to address the specific issues cited in your letter.

**"Is there compelling laboratory or observational evidence that UV-B radiation is related to the incidence of skin cancer cases including melanoma and non-melanoma cancers?"**

The American Academy of Dermatology strongly believes that a decline in stratospheric ozone will be injurious to human health. As you know, the stratospheric ozone layer regulates the degree of ultra-violet (UV) irradiance on the earth's surface. Ozone is a selective filter, blocking all ultra-violet C (UVC) radiation, some ultra-violet B (UVB) radiation, and little ultra-violet A (UVA) radiation.

Recently, scientists at the World Meteorological Organization (WMO) reported that the seasonal hole in the earth's ozone layer over Antarctica is growing faster than ever and is already twice the size that it was at this same time last year. The ozone is also deteriorating over the northern hemisphere, but to a lesser extent. The WMO reports that ozone over Europe and North America has diminished 10%-15% since 1957, and the ultraviolet radiation has increased 13%-15%.

Even small decreases in ozone levels may result in a significant increase in the amount of UVB radiation at the earth's surface. Increased exposure to UVB radiation is deleterious to human skin. UVB radiation causes sunburn, the photoaging of the skin and, since 1894, has been definitively linked to the development of non-melanoma skin cancers. Decreases in the integrity of our stratospheric ozone will significantly increase the incidence of sunburn, accelerate the aging process, increase the incidence of non-melanoma skin cancers (as well as decrease the age of onset for these cancers), and impact other skin disease. Exposure to UV radiation can initiate or aggravate certain serious diseases such as lupus erythematosus, porphyrias, herpes simplex, and other infectious diseases. Exposure to the sun can adversely affect individuals who are taking many medications, including over-the-counter drugs like ibuprofen and diuretics, and may impede certain vaccinations.

The Honorable George E. Brown, Jr.

September 18, 1995

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crust, become ulcerated and possibly bleed without treatment. Individuals with light hair and eye color and a fair complexion are considered to be at high risk for this form of skin cancer. Basal cell carcinoma rarely metastasizes. It can, however, affect underlying structures, causing considerable damage, disfigurement, and disability. I have enclosed several explicit photographs, highlighting the significant damage caused by basal cell carcinoma. Dermatologists consider these cancers to be a very serious condition.

Squamous cell carcinoma is another form of non-melanoma skin cancer and is also 95% curable, if properly treated in its early stages. Typically, squamous cell carcinoma appears as a raised, red or pink scaly nodule or wart-like growth on the face, hands, or ears. Squamous cell carcinomas can grow in size, cluster, and spread to other parts of the body. Squamous cell carcinoma is two to three times more common in men than in women. I have also enclosed examples of squamous cell carcinomas to illustrate that these non-melanoma skin cancers are equally serious.

Malignant melanoma is the most deadly form of skin cancer, and the eighth most diagnosed cancer in our nation. The incidence rate of malignant melanoma per 100,000 Americans is increasing at the rate of 4.2% per year, faster than that of any other cancer. The mortality rate for malignant melanoma is also increasing, but fortunately at a much slower rate.

Malignant melanoma begins in the body's melanocytes, the skin cells that produce the dark protective pigment called melanin. It is melanin that is responsible for suntanned skin, acting as a partial protection against the sun's damaging rays. Melanoma may suddenly appear without warning, but it may also begin in or near a mole or other dark spot in the skin. Having dark brown or black skin is not a guarantee against melanoma. African Americans can develop melanoma, especially on the palms, soles, under finger and toenails, and in the mouth. Malignant melanoma is the leading cancer in young women in their twenties and is second only to breast cancer for women in their thirties.

For years, the Academy has recommended that every American examine his or her skin frequently to look for the dangers signs of melanoma, also known as the ABCD's of melanoma. "A" stands for asymmetry -- one half of the lesion is unlike the other. "B" is for border irregularity -- a scalloped or poorly circumscribed border. "C" stands for color variability -- does the color of the lesion vary from area to area or has the lesion changed in color. "D" is for diameter -- lesions should be no larger than 6 millimeters, the diameter of

*American Academy of Dermatology*

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*"Is there compelling evidence that a decrease in stratospheric ozone and the consequent increase in UV-B will lead to an increase in the incidence of skin cancer?"*

The Academy believes that there is sufficient evidence that a decline in stratospheric ozone will result in a higher incidence of skin cancer. For each 1% depletion of ozone, the rate of squamous cell carcinoma is expected to increase by 2%-5%, and the rate of basal cell carcinoma by 1%-3%. That same 1% decline in ozone integrity is expected to increase the incidence of melanoma mortality by .8% to 1.5%. It has been reported that a 10% reduction in stratospheric ozone could increase squamous cell carcinoma rates by 16%-18%.

*"Is there any basis for the claim that '...melanoma is mainly due to UV-A, which is not absorbed by ozone. Therefore, melanoma rates should not be affected by changes in the ozone layer.'?"*

While the action spectrum for melanoma is not complete, there is consensus among dermatologists and photobiologists that there is a linkage between malignant melanoma and UVB radiation. Excessive exposure to the sun and childhood sunburns are accepted as a cause of melanoma, especially among light-skinned people. Dermatology does not accept that UVA is solely responsible for the development of malignant melanoma.

Of course, an increase in incidence will certainly be accompanied by a commensurate increase in treatment and other costs associated with skin cancer. It is estimated that over \$1 billion are spent annually in the United States for the treatment of malignant melanoma. As malignant melanoma is highly underreported (most are treated on an outpatient basis and hence are not reported to most cancer registries), this number may be well below the true cost of treatment. Increases in incidence, especially incidence of more advanced cases of malignant melanoma, would proportionately increase treatment costs.

Until the ozone layer repairs itself, we can only hope to mediate these dire predictions by taking action to stabilize the ozone and by making important changes in our sun habits and clothing choices. The Academy is working with the CDC for new and better ways to educate the population, especially children, about the dangers of sun exposure. Of course, the most effective preventive method is sun avoidance, especially deliberate sunbathing. There is no such thing as a safe tan. If you must be in the sun between the peak hours of 10:00 am and

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4:00 pm, the following precautions are recommended: wear a wide-brimmed hat, sunglasses and protective, tightly-woven clothing as well as a broad spectrum sunscreen with a sun protection fact (SPF) of at least 15. Sunscreens should be applied twenty minutes prior to going outdoors. Water-resistant sunscreens should be reapplied often, especially after swimming or strenuous exercise. Remember, sun protection is also important during the winter and on cloudy days.

In addition, the Academy believes that the newly created UV Index will prove to be an important tool in our efforts to educate the public about the dangers of sun exposure. Similar indexes have proven valuable in Australia, New Zealand, and many other countries. The UV Index is a joint program of the National Weather Service, the Environmental Protection Agency, and the CDC. The UV Index measures the amount of solar radiation that reaches the earth on a scale of 1-10. Public health education messages have been developed to educate individuals about the importance of taking protective measures. Currently, the National Weather Service provides the UV Index in 58 cities. The Academy supports a full national roll-out of this important program to the 160 cities currently served by the National Weather Service.

I hope that this information is helpful. If I or the Academy can be of further assistance to you and the committee, please do not hesitate to call on us again.

Sincerely,



Rex A. Amonette, M.D.

President

RAA/ch

Enclosures

Mr. BROWN. And I thank the Chairman for his courtesy.

Mr. ROHRBACHER. Thank you very much. And I appreciate the distinguished former chairman of the Science Committee being with us today. He has a treasure house of experience and we appreciate him sharing that with us today.

Now we have two members with us. If they would like to give very short opening statement.

No? And Mr. Ehlers, would you like to give a short opening statement?

Mr. EHLERS. Thank you, Mr. Chairman.

First, I also commend you for calling the hearing. I think this is an issue that should be aired for a number of reasons which will emerge during the hearing.

My comments that I will offer will be short and just from my perspective as a scientist, and also in the context of Congressman Brown's statement. I will be offering them as a politician who doesn't exaggerate.

So we hope they can shed a little light on this.

I think the key point to remember is that most of the issues we'll be discussing today are what Alvin Weinberg, former director of Oak Ridge, called trans-scientific issues. They are scientific in their origin, but they're in a sense beyond science because we cannot do the experiments. We cannot go up and create an ozone hole and see what the impact is.

And so we can merely observe, model, predict. Then observe again, model again, predict again.

This results in large uncertainties in the scientific results.

And the difficulty is that, as a result of that, you will find scientists on both sides of issues and to compound the difficulty, advocates of one position or another will tend to look only at the evidence offered by the scientists who support their position and wave that triumphantly and say that science proves that such and such a policy is right or it proves it is wrong.

I think it is very important for us, those of us who are laymen and those of us who are scientists, to be very careful in this area. I think it's important to be objective. It's important to be holistic and look at the entire picture and not latch onto just one particular contaminant and say the world is going to end if we don't take care of that, without recognizing the issues that are brought forward by that action.

As Garrett Harden once observed, you can never do just one thing to the environment. You do one thing, it has repercussions in many ways.

So be objective. Be holistic. Be patient. It takes time to work out the science in some of these issues. It may take a decade or two.

In the meantime, we have to be very careful in interpreting and understanding the results.

And finally, be prudent. Act on the information you have, but don't go overboard and set up a major policy which it turns out is extremely difficult to change once the science is found to be more firm, more definite, and requires a change in policy.

So my plea to everyone on all of these issues is to understand the limitations of science, not trumpet a particular result as ending

the debate simply because it supports your position and, above all, be objective, be holistic, be patient and be prudent.

Thank you, Mr. Chairman.

Mr. ROHRBACHER. Mr. Ehlers, of course, is one of the few scientists that we have here in Congress. We have a large number of lawyers, but just a few scientists. His opinion is respected and thank you very much for those words of wisdom.

Before we seat our first panel, we have two colleagues who have drafted legislation affecting the CFC ban here with us for remarks. One is Congressman Tom DeLay, who will be arriving momentarily. He is the distinguished Majority Whip.

And my friend and colleague and fellow moderate from California, Congressman John Doolittle. Mr. DeLay will be here to speak with us about H.R. 475, which would repeal provisions of the Clean Air Act affecting the production of CFCs.

Mr. Doolittle has drafted legislation which would return the phase-out of CFCs to the original schedule. That was before Senator Gore created the stampede.

And I would ask Mr. Doolittle to step forward now and if he could be recognized for five minutes.

Mr. Doolittle?

**STATEMENT OF THE HONORABLE JOHN T. DOOLITTLE, A REPRESENTATIVE IN CONGRESS FROM THE 4TH CONGRESSIONAL DISTRICT OF THE STATE OF CALIFORNIA**

Mr. DOOLITTLE. Mr. Chairman, and Members of the Subcommittee, I appreciate your holding this hearing. I think it's vital that we air these issues.

Mr. Chairman, I'm going to leave to the capable scientists that will follow me today, and their testimony, discussion as to whether sound science justifies any ban on the production of CFCs.

My own belief is that the question is still very much open to debate.

I am convinced, however, that although further research may possibly support a future phase-out of CFC production, to date, there has not been a sufficient showing of scientific evidence to justify the current and rapidly approaching ban date of December 31, 1995.

That's why today I am introducing legislation that, if enacted, would push the ban on CFC production back to the original date set in the Clean Air Act amendments of 1990, which is January 1, 2000.

There are several reasons why I believe we should adopt this policy.

First, the so-called scientific findings that precipitated the acceleration were retracted by NASA, the agency that first announced them.

Under the Clean Air Act, in the 1987 Montreal Protocol, CFCs were to be phased out with a total ban in production taking effect on January 1, 2000.

But in February of 1992, NASA scientists held an emergency press conference to announce that an ozone hole similar to the ones over Antarctica would soon open over the Arctic and parts of North

America. The story was widely reported as a looming environmental catastrophe.

Time magazine showcased the impending disaster on the cover of its February 17 issue.

Within days, the U.S. Senate voted 96 to zero to accelerate the phase-out. President Bush agreed. According to author Ronald Bailey, less than a month after its emergency press conference, "satellite data showed that the levels of ozone-destroying chlorine had dropped significantly and provided absolutely no evidence of a developing ozone hole over the United States."

NASA waited until April to announce at another press conference that a large Arctic ozone hole had been, quote/unquote, "averted."

Did NASA's admission allay the fear and panic whipped up by the earlier prediction of apocalypse?

Clearly not. The retraction received far less attention than the initial announcement. And in what must have been a very busy news week, Time magazine buried NASA's admission in four lines of text in its May 11 issue.

Thus, despite the fact that the primary threat used to justify acceleration of the CFC ban never materialized, the accelerated phase-out remains in place.

The second reason I support returning the ban to its original date is because of the astronomical costs associated with the accelerated phase-out. There is a large amount of CFC-dependent refrigeration and air-conditioning equipment in use today. Higher CFC costs and onerous EPA regulations have already resulted in substantially higher repair costs for these systems.

Ben Lieberman of the Competitive Enterprise Institute, whom I believe you will hear from today, has estimated the cost of the accelerated CFC ban, that that cost could reach as high as \$100 billion. Some feel that this estimate is too conservative.

But, as it stands, this total represents \$1,000 per-household tax.

Such an enormous drain on the nation's economy would have to be considered, even in the face of a proven environmental catastrophe. Yet, as I have mentioned, and as others will testify, the science behind the accelerated ban remains unsubstantiated.

The third reason to delay the ban is because the cost-benefit analysis originally performed by the EPA to justify acceleration was flawed. The EPA under-estimated the costs I just referred to, and over-estimated the benefits.

Among the primary benefits, according to the EPA, was protection against melanoma skin cancer. A 1993 study, however, concluded that this cancer is caused by longer wavelength ultraviolet radiation, UVA, which is not screened by ozone, not by UVB, which is.

In other words, a rise in the incidence of melanoma cases does not depend on the level of ozone in the atmosphere.

Thus, the benefits EPA attributes to banning CFCs at the close of this year have been grossly overstated.

Mr. Chairman, in closing, I want to touch upon one more point that was raised in a Wall Street Journal article recently, entitled, "Controversy Is Brewing Over the Effects of Chemicals That Are Replacing CFCs."



An official from DuPont was asked about the possible harmful effects revealed by the study. The official dismissed the researcher's conclusions, saying they were based on worst-case scenarios.

Mr. Chairman, the extreme environmental movement uses everything based on worst-case scenarios. It's dismaying to see that DuPont apparently is using that now.

From today's testimony, Mr. Chairman, you will discover that worst-case scenarios have been driving this debate. Those of us who are skeptical about the need for an accelerated ban note that under the proponents' own worst-case scenario, the increased risk of skin cancer—imagine this—the increased risk of skin cancer that one would face without the ban is equivalent to moving 60 miles closer to the equator, for instance, from Washington, D.C. to Richmond, Virginia, or perhaps Beverly Hills down to where you surf in Laguna—if that's where you surf. Some place in your district, I'm sure—that Laguna isn't somebody else's.

Instead of responding with scientific facts, some NASA scientists, EPA officials, and extreme environmental organizations have forced this imminent CFC phase-out on the American people using fear and doomsaying.

It was the EPA that predicted in 1987 that 3 million skin cancer deaths would occur in the United States unless CFC production were curtailed. And it was NASA that predicted in 1992 that an ozone hole would open over much of the United States, Europe and Russia.

I hope this Subcommittee today will look at all of the facts involving the use of CFCs and their effect on the environment. I believe we should not allow the prohibition of CFCs to take place until Congress weighs the true costs and benefits of the accelerated ban.

Sound science must be the basis for all future decisions we make on this important issue and I commend the Chairman and this Subcommittee for using this forum to search for the truth.

[The complete prepared statement of Mr. Doolittle follows:]

JOHN T. DOOLITTLE  
4TH DISTRICT, CALIFORNIA

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**Congress of the United States**  
**House of Representatives**

Testimony of

The Honorable John T. Doolittle

before

Energy and Environment Subcommittee  
House Committee on Science

September 20, 1995

Mr. Chairman, Members of the subcommittee, thank you for allowing me this opportunity to testify here today. I'd like to begin by thanking the distinguished chairman for holding this hearing on what I believe is a very important issue.

I would also commend to the Members of the subcommittee the insights of Dr. Singer of The Science and Environmental Policy Project and Mr. Ben Lieberman of the Competitive Enterprise Institute, both of whom have been very helpful in keeping me informed of the shaky science and high costs associated with the impending ban on the production of chlorofluorocarbons. I had not had the opportunity to meet Dr. Baliunis and Dr. Setlow before today, but I am familiar with their work in this area and am glad the subcommittee will get the benefit of their testimony.

Mr. Chairman, I will leave to these capable scientists the discussion as to whether sound science justifies any ban on the production of CFCs. My belief is that the question is still very much open to debate. I am convinced, however, that although further research may possibly support a future phaseout of CFC production, to date, there has not been a sufficient showing of scientific evidence to justify the current and rapidly-approaching ban date of December 31.

That's why today I am introducing legislation that, if enacted, would push the ban on CFC production back to the original date set in the Clean Air Act Amendments of 1990. That original date was January 1, 2000. My bill requires that the EPA issue regulations allowing the production of CFCs and halons listed as class I substances in accordance with section 604(a) of the Clean Air Act. In addition, my legislation would restore prior law in determining the base tax amount for excise taxes on CFCs.

Mr. Chairman, I would like to take a few minutes to explain why I do not believe we should allow the CFC ban to take effect at the end of this year, rather than the original year 2000 date.

First, the so-called scientific findings that precipitated the acceleration were retracted by NASA, the agency that first announced them. Under the Clean Air Act and the 1987 Montreal Protocol, CFCs were to be phased out with a total ban on production taking effect on January 1, 2000. But in February 1992, NASA scientists held an "emergency" press conference to announce that an ozone hole, similar to the ones over Antarctica, would soon open over the Arctic and parts of North America. The story was widely reported as a looming environmental catastrophe. *Time* magazine showcased the impending disaster on the cover of its February 17 issue.

Within days, the Senate voted 96 to 0 to accelerate the phaseout. President Bush agreed. According to author Ronald Bailey, less than a month after its emergency press conference, "satellite data showed that the levels of ozone-destroying chlorine...had dropped significantly and provided absolutely no evidence of a developing ozone hole over the United States." NASA waited until April to announce at another press conference that a large arctic ozone hole had been "averted."

Did NASA's admission allay the fear and panic whipped up by the earlier prediction of apocalypse? Not quite. The retraction received far less attention than the initial announcement. And in what must have been a busy news week, *Time* magazine buried NASA's admission in four lines of text in its May 11 issue.

Thus, despite the fact that the primary threat used to justify acceleration of the CFC ban never materialized, the accelerated phaseout remains in place.

Another reason I support returning the ban to its original date is because of the astronomical costs associated with the accelerated phaseout. There is a large amount of CFC-dependent refrigeration and air-conditioning equipment in use today. Higher CFC costs and onerous EPA regulations have already resulted in substantially higher repair costs for these systems. One auto mechanic from Atlanta who was in Washington recently for the White House's Small Business Conference said that he was embarrassed to hand his customers the bill after recharging their cars' air-conditioners.

Although I will defer to Ben Lieberman on the specifics of the cost estimates, I know that he found the cost of the accelerated CFC ban could reach as high as \$100 billion. Some feel that this estimate is too conservative, but as it stands, this total represents a \$1,000 tax on every household in America.

Such an enormous drain on the nation's economy would have to be considered even in the face of a proven environmental catastrophe. Yet, as I have mentioned and as others will testify, the science behind the accelerated ban remains unsubstantiated.

A third reason to delay the ban is because the cost-benefit analysis originally performed by the EPA to justify acceleration was flawed. The EPA underestimated the costs I just referred to and overestimated the benefits. Among the primary benefits, according to the EPA, was protection against melanoma skin cancer. A 1993 study, however, concluded that this cancer is caused by longer wavelength ultraviolet radiation (UVA) which is not screened by ozone, not by UVB, which is. In other words, a rise in the incidence of melanoma cases does not depend on the level of ozone. If this conclusion is true, the benefits EPA attributes to banning CFCs at the close of this year have been greatly overstated.

Lastly, we have not allowed time for stable CFC replacements to develop. Again, I am guessing that Ben Lieberman will address this topic in more detail, but it is certainly worth mentioning now. Before we replace CFCs, we had better make certain that we have workable and safe replacements. It is not clear that we are there yet. Just a month ago, an article appeared in the *Wall Street Journal* entitled "Controversy Is Brewing Over the Effects Of Chemicals That Are Replacing CFCs." In explaining a study that concluded that CFC replacements may produce a toxic byproduct, Tracey Tromp of the Atmospheric and Environmental Research Inc. said, "Our concern is that we know almost nothing about the alternatives [to CFCs]."

Mr. Chairman, in closing, I want to touch upon one more point that was raised in the *Journal* article. An official from DuPont was asked about the possible harmful effects revealed by the study. The official dismissed the researchers' conclusions, saying they were based on worst-case scenarios.

From today's testimony, Mr. Chairman, you will discover that worst-case scenarios have been driving this debate. Those of us who are skeptical about the need for an accelerated ban note that, under the proponents' own worst-case scenario, the increased risk of skin cancer one would face without the ban is equal to moving 60 miles closer to the equator, for instance, from Washington to Richmond. Instead of responding with scientific facts, some NASA scientists, EPA officials, and extreme environmental organizations have forced this imminent CFC phaseout on the American people with fear and doomsaying. It was the EPA that predicted in 1987 that 3 million skin cancer deaths would occur in the United States unless CFC production were curtailed. And it was NASA that predicted in 1992 that an ozone hole would open over much of the United States, Europe, and Russia.

I hope this subcommittee will look at all of the facts involving the use of CFCs and their effect on the environment. I believe we should not allow the prohibition of CFCs to take place until Congress weighs the true costs and benefits of the accelerated ban. Sound science must be the basis for all future decisions we make on this important issue, and I commend the chairman and this subcommittee for using this forum to search for the facts.

Mr. ROHRABACHER. Mr. Doolittle, thank you very much for your legislation and your testimony today.

Ms. RIVERS, do you have some questions that you'd like to ask? Please proceed.

Ms. RIVERS. Thank you, Mr. Chair. And thank you, Representative Doolittle.

When I hear people say things like the evidence is not sufficient at this time, it perks up my ears and it almost forces me to ask the question, what would you consider to be sufficient evidence for action to be taken in this area?

Mr. DOOLITTLE. I think we need a clear scientific conclusion that there is a definite cause for the problem and that so-called problem is producing definite effects.

Theories or speculation about it are not sufficient. We need science, not pseudo-science. I think we've been in an era of pseudo-science where these dire consequences are portrayed in order to achieve a certain political objective.

Ms. RIVERS. Are you a scientist?

Mr. DOOLITTLE. I am not.

Ms. RIVERS. You are not. Have you found in peer-review articles or in the broader scientific discourse that people are saying, this really is not a problem?

Mr. DOOLITTLE. I have found that there is no established consensus as to what actually the problem is. I found extremely misleading representations by the government and government officials that are not founded on sound science.

Ms. RIVERS. That's what I was asking about, is not government scientists, necessarily, but peer-review articles, where scientists who are out in academia who are doing this on a regular basis.

Could you give me an example of some of the peer-reviewed publications that you consulted in formulating your opinion that there's no science?

Mr. DOOLITTLE. Well, you're going to hear from one of the scientists today, Dr. Singer.

Ms. RIVERS. Dr. Singer doesn't publish in peer-reviewed documents.

Mr. DOOLITTLE. You know, I'm not going to get involved in a mumbo-jumbo of peer-review documents. There's politics within the scientific community, where they're all intimidated to speak out once someone has staked out a position.

Ms. RIVERS. Right.

Mr. DOOLITTLE. And thankfully, under this Congress, we're going to get to the truth and not just the academic politics.

Ms. RIVERS. And when I went to the University of Michigan, one of the first things that I was taught about science is that you look at the methodology of anyone who is making claims.

And the general way to feel certain that you're getting good science is that you put your ideas out in a straightforward way in a peer-reviewed publication and you allow others who are doing the same work to make comments, to criticize, to replicate your findings.

And what I'm asking you, in your search for good science, is what peer-reviewed documentation did you use to come up with your decision?

What good science did you use to rely on?

Mr. DOOLITTLE. And my response to you is it is the proponents of the CFC ban that have the burden of producing the good science.

I do not have that burden.

They have failed to meet their burden and until and unless they meet that burden, we should roll back that date. I believe the extra years that we provide may give that opportunity.

Ms. RIVERS. Where I started this line of questioning was with your statement that the reason you oppose this is that there's not sufficient proof. I asked you what sufficient proof would be? You told me good science. I asked you, did you actually consult any of the sources that would be considered good science in scientific circles? And you said, no.

So I'm back to what are you—

Mr. DOOLITTLE. I didn't say, no. I consulted Dr. Singer, who is a very authoritative source, and I will stand with the doctor.

Ms. RIVERS. Okay. Thank you.

Mr. ROHRBACHER. Of course, today, there are two questions. Number one, we have to define the problem. And number two, we have to say whether the solution that has been put forward, and that is, banning CFCs and having a major speed-up of that ban, whether or not that actually works and whether or not it is worth the cost to the consumer and to the American people.

We'd now like to, with the permission of my colleagues, I'd like to call on Mr. DeLay.

Thank you very much, Mr. Doolittle. I appreciate your comments very much.

You've already been introduced, Mr. DeLay. Sometimes it's very difficult for me when I'm talking about my colleagues and introducing them, and I almost introduced Mr. DeLay as the Minority Whip.

It just feels so good to introduce you as the Majority Whip. Mr. DeLay, if you would like to proceed. You've already been introduced.

#### **STATEMENT OF THE HONORABLE TOM DeLAY, A REPRESENTATIVE IN CONGRESS FROM THE 22D DISTRICT OF TEXAS**

Mr. DeLAY. Well, thank you, Mr. Chairman, and I do apologize for being late. The meeting with the Speaker ran a little longer than we thought and it's hard to get up and leave for the Speaker.

But I do appreciate you allowing me the opportunity to participate in this very important debate on the phase-out of CFCs and the depletion of the ozone layer.

Let me start, Mr. Chairman, by saying that I recognize the importance of clean air and a healthy environment. There's been a lot said about those of us that are asking for reasonableness and good science when you make regulations and disrupt people's lives.

But dirty air and harmful ultraviolet rays affect me and my family just as much as any other American.

I'm here today because I believe that the science underlying the ban on CFCs and the connection between health and ozone depletion is debatable.

We all know, or some of us know, that recent studies have shown that as much as 95 percent of light-induced melanoma is caused by

visible spectrum of light, and not by the ultraviolet light that is filtered by the ozone layer. Evidence of this nature justifies a comprehensive review of the impact of the CFC ban on our health and on our economy, thereby on the lives of the American families.

As everyone at this hearing knows, the Clean Air Act Amendments of 1990 require that CFCs, a widespread class of refrigerants used in air conditioners and refrigerators and billions of dollars' worth of equipment, to be phased out of production out of fear that CFCs leak into the atmosphere and deplete the earth's ozone layer.

What is not so well known is that this ban is the result of a media scare some years ago from individuals who have not backed away from a number of their claims.

Most notably, on February the 3rd of 1992, just as an example of the kind of scare, the NASA scientists called an emergency press conference to announce that severe ozone depletion over the Arctic and a large part of North America was imminent, which received extensive media coverage and aroused much alarm amongst Americans.

Just a few months later, and with much less fanfare, NASA quietly admitted that its prediction was wrong. The retraction went largely unnoticed and had no effect on law.

Scientific evidence has shown that natural resources dominate the stratospheric chemicals that are suspected to cause ozone depletion. This evidence indicates that the ozone hole is controlled by climatic factors, rather than the amount of chemicals in the atmosphere.

Just this past July, the Washington Post reported that a team of scientists from MIT had shown that the concentration of ozone-depletion CFCs in the atmosphere is declining. While some scientists would have us believe that the depletion of the ozone layer is the result of decades of environmental negligence, they would also have us believe that the current phase-out of CFCs, which has been in place for less than a decade, is responsible for the remarkably swift reduction in the level of CFCs in the atmosphere.

I'm inclined to believe that we are not giving Mother Nature nearly enough credit.

It's clear that man-made CFCs do not have as much of an effect on the atmosphere as normal climatic fluctuations.

With CFC production in the United States scheduled to end by the end of this year, owners of air conditioning and refrigerating equipment are having to prematurely replace their equipment or use substitutes, many of which are distinctly inferior.

In the rush to replace CFCs, it is obvious that little or no thought has been given to the long-term effects of the new compounds on our environment.

Recent studies indicate that some of the replacement compounds significantly increase acid rain levels. In addition, the compounds being produced to replace CFCs are unpredictable and in some cases, dangerous. Some of the replacement compounds are highly flammable and others have been plagued by sudden and unexpected explosions.

CFCs affect the lives of almost every American, however. Almost no thought was given to how the CFC ban will affect the consum-

ers who bear the brunt of the costs. This phase-out may well be the single most expensive environmental measure to date with an estimated cost of \$50 to \$100 billion over the next decade—and every red cent will come out of the pockets of the American family.

According to Ben Lieberman of the Competitive Enterprise Institute, the most immediate impact on consumers is the increased cost of maintaining car and truck air conditioners. Americans own 140 million air-conditioned vehicles which use CFC-12 as their refrigerant, and the most common problem is the loss of refrigerant through leaking.

Service stations are now charging \$50 to \$200 more than they used to for this repair, since the law requires them to take additional steps to reduce the amount of refrigerant that escapes during services.

Drivers that cannot afford to have their cars retrofitted with new air conditioning equipment, at a cost of as much as \$1,000, will have to compete for dwindling supplies of CFCs at greater increased costs. At the time the ban was implemented, CFCs cost in the neighborhood of \$1 a pound. Now they cost as much as \$15 a pound.

As might be expected, these skyrocketing prices have given rise to a flourishing international CFC black market.

The phase-out will also affect the cost and quality of domestic refrigerators. Refrigerators using CFC substitutes will cost \$50 to \$100 more, and probably need replacement three to five years sooner than their CFC-12 predecessors.

The absurdity is that refrigerators only use four to six ounces of refrigerants each, so they are negligible contributors to atmospheric CFC levels.

And finally, I would like to point out that very little consideration has been given to the potential effect of this ban on energy consumption in the United States. Evidence indicates that CFCs are more energy-efficient than replacement compounds. This means we will need more gasoline to operate our cars and trucks and more electricity to support the needs of home and industrial refrigeration units.

If this is the definition of environmental progress, the need for a comprehensive review of this ban is self-evident.

Is the cost worth it? I don't think so, especially when scientific evidence linking CFCs to atmospheric damage is ambiguous.

While scientists offer the American public a dizzying array of facts and opinions on the relative importance and status of the ozone layer, billions of dollars are being spent to develop a new technology that may not even be necessary.

Mr. Chairman, I commend you for holding these timely and important hearings. Congress needs to review this issue thoroughly, and the American people need to understand the real dangers and the real costs associated with banning CFCs.

Ultimately, we must make sure that we are not jumping out of the frying pan and into the fire.

[The complete prepared statement of Mr. DeLay follows:]



STATEMENT OF THE HONORABLE TOM DeLAY  
THE COMMITTEE ON SCIENCE  
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

The Real Cost of the CFC Ban

September 20, 1995

Mr. Chairman, thank you for allowing me the opportunity to participate in this very important debate on the phaseout of CFCs and the depletion of the ozone layer.

Let me start by saying that I recognize the importance of clean air and a healthy environment. Dirty air and harmful ultraviolet rays affect me and my family just as much as every other American. I am here today because I believe that the science underlying the ban on CFCs, and the connection between health and ozone depletion is debatable.

Recent studies have shown that as much as 95% of light-induced melanoma is caused by the visible spectrum of light, and not by the ultraviolet light that is filtered by the ozone layer. Evidence of this nature justifies a comprehensive review of the impact of the CFC ban on our health and on our economy.

As everyone at this hearing knows, the Clean Air Act Amendments of 1990 require chlorofluorocarbons (CFCs), a widespread class of refrigerants used in vehicle air conditioners, refrigerators, and billions of dollars worth of equipment, to be phased out of production out of fear that CFCs leak into the atmosphere and deplete the earth's ozone layer.

What is not so well known is that this ban is the result of a media scare some years ago from individuals who have now backed away from a number of their claims.

Most notably, on February 3, 1992, NASA scientists called an "emergency" press conference to announce that severe ozone depletion over the Arctic and a large part of North America was imminent, which received extensive media coverage and aroused much alarm. A few months later, and with much less fanfare, NASA quietly admitted that its prediction was wrong. The retraction went largely unnoticed and had no effect on law.

Scientific evidence has shown that natural sources dominate the stratospheric chemicals that are suspected to cause ozone depletion. This evidence indicates that the ozone "hole" is controlled by climactic factors rather than by the amount of chemicals in the stratosphere.

Just this past July, the Washington Post reported that a team of scientists from MIT have shown that the concentration of ozone-depleting CFCs in the atmosphere is declining. While some scientists would have us believe that the depletion of the ozone layer is the result of decades of environmental negligence, they would also have us believe that the current phaseout of CFCs, which has been in place for less than a decade, is responsible for the remarkably swift reduction in the level of CFCs in the atmosphere. I am inclined to believe that we are not giving Mother Nature nearly enough credit--it is clear that man-made CFCs do not have as much of an effect on the atmosphere as normal climactic fluctuations.

With CFC production in the United States scheduled to end by the end of this year, owners of air conditioning and refrigeration equipment are having to prematurely replace their equipment or use substitutes, many of which are distinctly inferior.

In the rush to replace CFCs, it is obvious that little or no thought has been given to the long-term effects of the new compounds on our environment. Recent studies indicate that some of the replacement compounds significantly increase acid rain levels. In addition, the compounds being produced to replace CFCs are unpredictable and in many cases dangerous. Some of the replacement compounds are highly flammable and others have been plagued by sudden and unexpected explosions.

CFCs affect the lives of almost every American, however, almost no thought was given to how the CFC ban will affect the consumers who to bear the brunt of the costs. This phaseout may well be the single most expensive environmental measure to date with an estimated cost of \$50 to \$100 billion over the next decade--and every red cent will come out of the pockets of American families.

According to Ben Lieberman of the Competitive Enterprise Institute, the most immediate impact on consumers is the increased cost of maintaining car or truck air conditioners. Americans own 140 million air-conditioned vehicles which use CFC-12 as their refrigerant, and the most common problem is a loss of refrigerant through leaking. Service stations are charging \$50 to \$200 more than they used to for this repair since the law requires them to take additional steps to reduce the amount of refrigerant that escapes during servicing.

Drivers that cannot afford to have their cars retro-fitted with new air conditioning equipment, at a cost of as much as \$1000, will have to compete for dwindling supplies of CFCs at greatly increased costs. At the time the ban was implemented, CFCs cost in the neighborhood of \$1 per pound. Now they cost as much as \$15 per pound. As might be expected, these skyrocketing prices have given rise to a flourishing international CFC black-market.

The phaseout will also effect the cost and quality of domestic refrigerators. Refrigerators using CFC substitutes will each cost \$50 to \$100 more and probably need replacement 3 to 5 years sooner than their CFC-12 predecessors. The absurdity is that refrigerators only use about 4 to 6 ounces of refrigerants each, so they are negligible contributors to atmospheric CFC levels.

Finally, I would like to point out that very little consideration has been given to the potential affect of this ban on energy consumption in the United States. Evidence indicates that CFCs are more energy efficient than the replacement compounds. This means we will need more gasoline to operate our cars and trucks and more electricity to support the needs of home and industrial refrigeration units. If this is the definition of environmental progress, the need for a comprehensive review of this ban is self-evident.

Is the cost worth it? I don't think so, especially when scientific evidence linking CFCs to atmospheric damage is ambiguous. While scientist offer the American public a dizzying array of facts and opinions on the relative importance and status of the ozone layer, billions of dollars are being spent to develop a new technology that may not even be necessary.

Mr. Chairman, I commend you for holding these timely and important hearings. Congress needs to review this issue thoroughly, and the American people need to understand the real dangers and the real costs associated with banning CFCs. Ultimately, we must make sure that we are not jumping out of the frying pan, and into the fire.

Mr. ROHRABACHER. Thank you very much, Mr. DeLay. The legislation that you have offered will come to grips with many of the problems that you brought up today.

Before I ask some of our colleagues to comment, you're basically saying that this ban, the environmental impact of what we have to do because of the ban, could be worse than the problem itself.

Is that right?

When you say that the energy requirements on the alternatives are increasing, and would increase the necessity of using more fuel, what you are actually saying, then, is more carbo—they're not carbohydrates.

Carbohydrates is what you eat.

Mr. DELAY. Hydrocarbons.

Mr. ROHRABACHER. Hydrocarbons are going into the atmosphere.

Mr. DELAY. Well, certainly. I'll tell you, Mr. Chairman, and I said it during the debate of the Clean Air Act of 1990. Hardly anyone was listening, about 35 members were. And warned about some of the things that were being done with very little scientific basis to it.

In fact, in the case of the acid rain section of the Clean Air Act, the NAPAP study was totally ignored.

This is a perfect example of why we desperately need some sort of risk assessment, cost-benefit analysis in the promulgating of these regulations.

Mr. ROHRABACHER. And some of the other problems you mentioned, besides the fluorhydrocarbons, the idea that there might be some kind of acid rain.

And actually, I've read somewhere where there might be some increased cause or risk of cancer by some of the alternatives to CFCs.

Is that correct?

Mr. DELAY. Well, I think you're going to have some panels of scientists that probably speak to that better than I will. But I think it's pretty clear, or at least there is another school of thought that is not tied to Chicken Little approaches to the environment, that suggest that particularly the CFCs are not doing the damage to the ozone layer that has been claimed.

Mr. ROHRABACHER. So, just in summary, the ozone may not be threatened as we are being told, and even making the matter worse, some of the solutions for this problem that may or may not exist, actually may cause more damage to the environment. And that's what you're worried about.

Mr. DELAY. And that's what I'm worried about.

Mr. ROHRABACHER. Thank you very much. Do some of my colleagues—I guess Mr. Roemer or Ms. McCarthy?

Mr. Roemer, would you like to ask a question?

Mr. ROEMER. Mr. Chairman, certainly Mr. DeLay has advocated cost-benefit analysis, and that's something that our Committee has worked very, very hard on.

I'm a strong supporter of the cost-benefit analysis and pushed that when we were in the majority as the Democratic Party and have worked in bipartisan ways with the new majority to get that through this Committee and to get it on the floor. And I'm hopeful that we can come up with a bill.

You mentioned that you'd like to see more peer review and cost-benefit analysis in this particular area. I guess I would just ask for your comments on the "Scientific Assessment Of Ozone Depletion: 1994".

In the back of it, starting on page 29 and going through page 36, are seven pages of scientists that have contributed to this study as peer reviewers.

I know that you are a strong advocate of NASA, as I am, although we disagree on the space station. There are a host of different scientists from NASA Langley and Goddard and a host of different space centers.

Don't you think that this is something, after seven pages of peer reviewers, that that's something that you and I are trying to get in terms of scientific basis for these kinds of studies, although you might disagree with what the result is?

Mr. DELAY. I do agree. The problem is, as has been happening, frankly, in the environmental movement for years, and as was outlined in an excellent book called "Toxic Terror" by Dr. Elizabeth Wayland, who is president of the American Society of Health and Safety, I think is the name of the organization.

The problem has been, is that, and it's my experience as a scientist—my education is in biology and biochemistry—is that you look at everybody and everything and consider all approaches to developing, during the scientific method, to developing a conclusion. And you don't weight it to one way or another. You want to gain all the information you can and make a decision based upon all the information.

And I haven't seen this study, so I can't comment on this particular study. But it's been my experience that a selective group, in fact, is usually taken—well, let me put it a different way.

The conclusion is usually written before the study is even done, in many cases. And we can show you time and time again where that is the case.

In fact, politics has entered into it and you can look at the history of the NAPAP study, where the Executive Director came under criticism and indeed was fired when the study was going contrary to what some people wanted the conclusion to be.

So I think, because you're having this hearing, because people from different points of view are being heard, then Congress can make an intelligent decision.

Mr. ROEMER. I would just say that in looking through the different scientists listed over these seven pages, from NASA and Harvard and Maryland and international institutes of science and MIT, New Zealand, Germany, France, Japan, Russia, that the politics would be so different, that there probably is not some kind of consensus that they reach beforehand.

But I would be interested in your comments.

Mr. DELAY. I can give you a list of scientists, too, Mr. Roemer. I can give you scientists at the National Research Council. I can give you scientists at the Lawrence Livermore National Lab. I can give you scientists from Norway.

Mr. ROEMER. They're in here. They're in here. Livermore is in here as well, too.

Before I ask another question, let me yield to the gentlelady from Michigan.

Ms. RIVERS. Thank you, Mr. Roemer.

Mr. DeLay, one of the things that you just said struck me. You said that one of the problems out there in science today is that people don't want to look at both sides of the thing. They have a decision of what they want already. And then you proceeded to say that you never looked at the most important study on this issue, the most broadest, the one that has world-wide input.

Why did you not consult the assessment on ozone depletion when you put together your proposal and built your position?

Mr. DELAY. Well, I just haven't been presented with the study of late. I'll be glad to read it and give you my assessment of it.

Ms. RIVERS. Thank you.

Mr. ROEMER. I'd just say—is that my time, Mr. Chairman? I don't have time for any other questions?

Mr. ROHRBACHER. One more question.

Mr. ROEMER. And it's more of a statement than a question, and if you want to comment on it, Mr. Delay, I'd be happy to hear your comments.

Certainly, there are different assessments and results in this than what you've said today. The industry-led results and scientific basis that worked closely with President Bush called for the policy that has been developed over the last few years.

Your assessment today has been largely based upon a think tank and their assessment, rather than the industry-based.

Mr. DELAY. That's not true. My assessment is from reading people like Fred Singer, who I think is testifying before this Committee, reading Arnie Goldback from Norway, reading others.

We also have a problem here, too. We're creating an environmental industry that now, in fact, I've even heard from some people that have spent a lot of money complying with the CFC ban, and now they're very resistant to looking at lifting that ban because they've already spent a lot of money in compliance with government regulations.

Mr. ROEMER. I just think we're going to have many interesting opinions from the panels today and it would be helpful for you to read this study and to listen to the various opinions being offered today.

And then we'd love to have you testify again to our Committee based upon that broad-based analysis.

Thank you, Mr. Chairman.

Mr. ROHRBACHER. Thank you, Mr. Roemer. In fact, that's a perfect segue into—with no objection, the Chair will request that we move forward with the scientists, rather than making this a discussion between various elected officials on this issue.

We have distinguished scientists with us today. In fact, the Chair has gone out of the way to make sure that both sides are equally represented by prestigious individuals in the scientific community, so that we can have a dialogue on the issue with the experts, rather than between ourselves.

I'd like to thank Mr. DeLay very much.

Mr. DELAY. Thank you, Mr. Chairman.

Mr. ROHRBACHER. You have a piece of legislation that deals with this issue. Mr. Doolittle has a piece of legislation that deals with it as well.

We thank you very much for your testimony.

Mr. DELAY. Thank you, Mr. Chairman.

Mr. ROHRBACHER. And the panel will be seated. Panel No. 1 will be seated.

I'll tell you what I will do. I will make the introductions as they are seated.

Now with us, Dr. Robert T. Watson, who is the associate director of environment for the White House Office of Science and Technology Policy, and is a former director of NASA's Stratospheric Ozone Program.

We also have with us, Dr. S. Fred Singer, who is professor emeritus of environmental science at the University of Virginia, and is founder and president of the Science and Environmental Policy Project in Fairfax, Virginia.

Also with us is Dr. Daniel Albritton, and he is director of NOAA's laboratory in Boulder, Colorado, and cochairs the United Nation's Ozone Science Assessment Panel.

We have with us as well, Sallie Baliunas. She is a research astrophysicist at the nonpartisan George C. Marshall Institute and chairs their science advisory board.

We have with us, Professor Margaret Kripke, who chairs the department of immunology at the M.D. Anderson Cancer Center in Houston, Texas.

And Dr. Richard Setlow, who is associate director of life sciences at Brookhaven National Laboratory.

Before you start, let me tell you the ground rules.

Your complete testimony will be in the record. Without objection, we will make their complete testimony a part of the record.

But I will ask each of you to summarize with five minutes. And if you can summarize in five minutes, you will have much longer to speak afterwards because what I'm hoping to do is to promote a dialogue between members of the panel, as well as Members of this Committee.

So if you could summarize to five minutes, it will be very helpful to the Committee because it will help promote the dialogue. And if you can go to your central points, I think that we can get to the important issues and the areas of contention, of honest disagreement, which is why we're here today.

So, with that, I think, Dr. Watson, we will begin with you.

**STATEMENT OF DR. ROBERT T. WATSON, ASSOCIATE DIRECTOR OF ENVIRONMENT, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT, WASHINGTON, DC**

Dr. WATSON. Thank you, Mr. Chairman.

My name is Robert Watson. I'm the associate director of environment in OSTP. I co-chair the International Ozone Assessment Panel, the former director of NASA's Stratospheric Ozone Program, and have published extensively in the peer-reviewed literature on key chemical processes occurring in the atmosphere.



I greatly appreciate being given the opportunity to present the latest scientific findings of the international community to you and your Subcommittee.

It's a pleasure to be able to address what I believe to be a real success story—credible science combined with technological advances that have led to informed policy formulation at the national and international level.

The scientific community, industry, environmental organizations, and governments have all worked towards a common goal—the cost-effective protection of human health and our vital ecological systems.

The American public can be proud that the U.S. provided scientific and policy leadership, and partisan politics were put aside to protect the health of Americans.

My testimony represents the views of the very, very large majority of the international scientific community from academia, industry, government labs, and environmental organizations, not the views of single individuals with few, if any, relevant publication in the peer-reviewed journals.

Hundreds of scientists from developed and developing countries, some of whom at one time were skeptics, have been involved in the preparation and peer-review of each of these assessments.

I believe it's particularly important to note that industry scientists and industry-sponsored research played a vital role in these assessments.

The key issues are very simple. The ozone layer limits the amount of UV-B radiation reaching the earth's surface. Thus, a decrease in ozone will lead to an increase in UV-B radiation reaching the earth's surface. Increased levels of UV-B reaching the earth's surface will, not may, have adverse consequences for human health, ecological systems, and air quality.

There is absolutely no doubt that the major sources of atmospheric chlorine are from human activities, not from natural sources. Human activity is also a major source of atmospheric bromine.

Photochemically-active halogen species can catalytically destroy stratospheric ozone. Each chlorine molecule can destroy tens of thousands of ozone molecules and bromine is at least 50 times more efficient.

Since the late 1970s, ground-based, balloon and satellite data have documented significant decreases in column content of ozone over Antarctica, about 60 percent, as shown in one of my figures in my testimony, and drastic changes in the vertical distribution, close to 100 percent loss of ozone at certain altitudes.

The Antarctic ozone holes in 1990, 1992, 1993, and 1994, were the most severe on record.

As we speak today, and as expected, satellite, balloon, and ground-based data show that the Antarctic ozone hole is once again developing in the fashion similar to the last few years.

There is absolutely no doubt that the springtime Antarctic ozone hole is due to the increasing concentrations of anthropogenic chlorine and bromine. This conclusion is based on combining extensive ground, aircraft, balloon and satellite data with laboratory data and theoretical modeling.

The speculative and totally unsubstantiated hypothesis of Dr. Singer presented before Congress a few weeks ago is totally inconsistent with the observational data and theory.

With respect to global ozone, the observational data, as I've shown in figure 4 of my testimony, provides conclusive evidence that ozone depletion is occurring at all latitudes, except the tropics, and in all seasons.

Analysis of extensive ground-based Dobson and TOMS data through 1994 has shown that column ozone has decreased by 5 to 6 percent in summer in the northern hemisphere, 9 to 11 percent in winter/spring in the northern hemisphere, 8 to 9 percent in southern mid-latitudes on a year-round basis.

Figure 5 in my testimony also shows the seasonal and latitudinal trends, illustrating the very significant trends at middle and high latitudes.

In each case, the natural periodic and episodic fluctuations are taken into account—solar cycle, season and volcanic activities.

The weight of scientific evidence strongly suggests that the observed mid-latitude ozone trends are due in large part to anthropogenic chlorine and bromine.

Ozone depletion is expected to peak within the next year or so, reaching about 6 to 7 percent ozone depletion in northern mid-latitude in summer and fall over the USA, and 12 to 13 percent in winter over northern mid-latitudes, and about 11 percent in southern mid-latitudes.

The projected changes in column ozone would be accompanied by 15 percent, 8 percent, and 13 percent increases in surface erythral radiation in winter/spring in the northern mid-latitudes, summer/fall at northern mid-latitudes, and in the southern hemisphere year-round.

The link between a decrease in stratospheric ozone and an increase in surface UV has been further strengthened in recent years. Measurements in Antarctica, Australia, Canada and Europe have shown under clear-sky conditions when column ozone decreases, the amount of UV-B increases, exactly as expected by theory.

DeLuisi of NOAA has recently concluded that the signal in the Robertson Bergometer that so many people talk about is so noisy due to day-to-day changes in UV-B, and calibration of the monitors was so flawed, that no reliable data and trends can be derived.

Recent data suggests from the TOMS instrument that it is an observed increase in ultraviolet radiation in early summer, spring and late autumn at latitudes polar to 40 degrees north.

Of particular importance for human health are the increases in the incidence of non-melanoma skin cancer, melanoma skin cancer, eye cataracts, and a possible suppression of the immune-response system.

Some, such as Fred Singer and Sallie Baliunas, try irresponsibly to trivialize the issue of ozone depletion by noting that an ozone depletion of the magnitude observed is equivalent to only moving south by 100 miles or so.

The reason this risk is even this low is the success of the Montreal Protocol and its Amendments and adjustments.

Without these international agreements, we would be facing future increases in UV-B radiation of possibly 40 to 50 percent by the middle or the end of the next century, and the comparable distance to move would be more like 1,000 miles or so.

There's a large difference in skin cancer rates between cities in the northern half of the U.S. and those in the southern half. The difference for white, Anglo-Saxon males in Albuquerque and Seattle is at least a factor of five difference.

In conclusion, the Montreal Protocol and its amendments and adjustments are a success story that will in the future save thousands of American lives each year. Who amongst us would want to turn back the clock by weakening the Montreal program, leading to the deaths of innocent Americans for the sake of a few dollars?

[The complete prepared statement of Dr. Watson follows:]

Statement of  
Dr. Robert T. Watson  
Associate Director of Environment  
Office of Science and Technology Policy  
Executive Office of the President  
before the  
Subcommittee on Energy and the Environment  
Committee on Science  
United States House of Representatives  
September 20, 1995

Mr. Chairman and Members of the Subcommittee:

My name is Robert T. Watson, I am Associate Director of Environment in the Office of Science and Technology Policy, a co-chair of the International Ozone Assessment Science Panel, and the former Director of NASA's Stratospheric Ozone Program. I greatly appreciate being given the opportunity to present the latest scientific findings of the international community to you and your subcommittee. It is a pleasure to be able to address what I believe to be a real success story: credible science, combined with technological advances that lead to informed policy formulation at the national and international level. The scientific community, industry, environmental organizations and governments all worked towards a common goal: the cost-effective protection of human health and our vital ecological systems. The American public can be proud that the U.S. provided scientific and policy leadership, and partisan politics were put aside to protect the health of Americans.

My testimony represents the views of the very very large majority of the international scientific community from academia, government laboratories, environmental organizations and industry, not the views of single individuals with few, if any, relevant publications in peer-reviewed journals. Hundreds of scientists, from developed and developing countries, some of whom were at one time skeptics, have been involved in the preparation and peer-review of each of a series of international scientific assessments conducted under the auspices of the World Meteorological Organization and the United Nations Environment Programme. Assessments have been issued in 1981, 1985, 1989, 1991, and the latest in 1994. I believe it is particularly important to note that industry scientists and industry sponsored scientists (e.g., research sponsored by the Chemical Manufacturers Association Fluorocarbon Program Panel) have played a vital role in each of the assessments.

In 1994, three state-of-the-art assessments were conducted in response to the mandate of the Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer. These assessments included: (i) an assessment of our understanding of the processes controlling the present distribution and rate of change of atmospheric ozone; (ii) an assessment of the environmental impacts of ozone depletion; and (iii) an assessment of the technological feasibility and economic costs associated with the

substitution of substances controlled under the Montreal Protocol. The scientific assessment was co-chaired by Dr. Daniel Albritton of NOAA and myself; the impacts assessment was co-chaired by Dr Jan van der Leun of the Netherlands and Dr. Manfred Tevini of Germany; and the technology/economics assessment was chaired by Dr. Stephen Anderson of U.S. EPA.

The need for sound science and risk assessment as the basis for regulatory policy is absolutely critical in this and other environmental issues. I believe that the scientific basis for decision-making in the ozone issue is excellent, far better than for most other environmental issues. This is largely because of the long-term commitment to a sound scientific research program by both Congress, and by this and previous Administrations. The research programs from NASA, NOAA, NSF, EPA, DOE and others provide much of the basic foundation for these assessments.

My testimony will provide answers to what I believe are a number of the key science issues of policy relevance: (i) Why do we care about the ozone layer?; (ii) What controls the amount of ozone in the atmosphere?; (iii) Is there any evidence that human activities are changing the atmospheric concentration of ozone?; (iv) What is the effect of the Montreal Protocol?; (v) Is there any evidence of increased levels of UV-B radiation?; and (vi) What are the human health impacts of ozone depletion?

#### **Why do we care about the ozone layer?**

- The Earth's ozone layer limits the amount of harmful ultraviolet-B (UV-B) radiation (280-320 nm) reaching the Earth's surface. Thus a decrease in ozone will lead to an increase in UV-B radiation reaching the Earth's surface.
- Increased levels of ultraviolet radiation (UV-B) reaching the Earth's surface, will, not may, have adverse consequences for human health, ecological systems and air quality. Of particular importance for human health are increases in the incidence of non-melanoma skin cancer (between half and one percent of all cases are fatal), melanoma skin cancer (with a very high fatality rate), eye cataracts, and a possible suppression of the immune-response system.

#### **What controls the amount of ozone in the atmosphere?**

- The abundance of stratospheric ozone is controlled by the balance between the production of ozone and the loss of ozone. Ozone production is controlled by the rate of photolysis of molecular oxygen, where-as ozone loss is governed by a series of complex chemical reactions involving oxygen-, hydrogen-, nitrogen-, chlorine- and bromine-containing species. The large majority of these chemical reactions are well understood over the complete range of stratospheric temperature and pressure conditions.

- Ozone depletion occurs when the rate of loss of ozone increases because of human activities. This is predicted, and has been observed to occur, when human activities increase the atmospheric concentrations of chlorine and bromine species.
- There is no doubt that the major sources of atmospheric chlorine are from human activities (e.g., chlorofluorocarbons, carbon tetrachloride, and methylchloroform), not from natural sources such as methyl chloride, volcanoes or sea spray. Natural sources of chlorine account for only 0.6 ppbv: less than 20% of total chlorine loading. The atmospheric concentrations of HCl and HF have been observed to increase over the past few decades: totally consistent with the major source of atmospheric chlorine being anthropogenic halocarbons. Human activities are also a major source of atmospheric bromine (methyl bromide and halons).
- Long-lived chlorine- (e.g., chlorofluorocarbons and carbon tetrachloride) and bromine- (halons) containing chemicals have no significant removal processes in the lower atmosphere. Consequently, weather patterns distribute them uniformly over the whole globe and transport them up into the stratosphere where the bulk of the Earth's protective ozone layer resides.
- Shorter-lived chemicals such as methylchloroform (a source of chlorine) and methyl bromide (a source of bromine) do have chemical removal processes in the lower atmosphere. Hence only a fraction of these chemicals emitted into the atmosphere reach the ozone layer. Even these chemicals are relatively well mixed throughout the globe, with slightly higher concentrations in the northern hemisphere where most of the emissions occur.
- These long- and shorter-lived organic halocarbons are broken down by photochemical processes in the stratosphere into what are called "reservoir and photochemically active" inorganic species. The photochemically active species (atoms and radicals) then catalytically destroy stratospheric ozone through a series of chemical processes. These chemicals are very efficient in destroying ozone: each chlorine molecule can destroy tens of thousands of ozone molecules, and bromine is even more efficient in destroying ozone. In fact bromine is at least 50 times more efficient than chlorine in destroying ozone than chlorine per molecule.
- Antarctica is a very special situation. Chlorine and bromine are much more efficient in destroying ozone over Antarctica than over mid-latitudes because of the unique meteorological conditions in the stratosphere. These unique meteorological conditions produce very cold temperatures which causes water vapor to condense into ice crystals. These ice crystals transform most of the chlorine in the stratosphere from reservoir species into "photochemically active" forms that can destroy ozone in the presence of sunlight. Hence, almost all of the chlorine is available to destroy ozone over Antarctica.

**Is there any evidence that human activities are changing the atmospheric concentration of ozone?**

- Observational data shows that ozone is being depleted in Antarctica and at mid- and high-latitudes in both hemispheres. The magnitude of the ozone depletion over Antarctica is so large that a statistical analysis of the data is not needed: greater than 60% in column content and close to 100% loss at certain altitudes. In contrast, the magnitude of ozone depletion at middle and high latitudes is smaller, such that statistical procedures are required for an accurate determination of the trend. However, it is quite clear from the work of statisticians from universities, government laboratories and industry that global ozone depletion is occurring at a very significant rate.

**Polar Ozone:**

- Since the late-1970's ground-based, balloon and satellite data have documented significant decreases in the total column content (Figure 1) -- and even more drastic changes in the vertical distribution (Figure 2) -- of ozone over Antarctica every spring-time. The Antarctic "ozone holes" of 1992, 1993 and 1994 were the most severe on record (deepest and greatest areal extent), extending over the whole Antarctic continent: an air mass close to the size of North America. In each of these years, ozone was locally depleted by more than 99% between 14 and 19 km.
- As we speak today, satellite, balloon and ground-based data show that the Antarctic ozone hole is once again developing in a fashion similar to the last few years.
- There is no doubt that the spring-time Antarctic ozone hole is due to the increasing concentrations of anthropogenic chlorine and bromine, not caused by methane and carbon dioxide as suggested by F. Singer in his recent speculative and unsubstantiated Congressional testimony of August 1, 1995 (before the House Commerce Committee, Subcommittee on Oversight and Investigations). The consensus that chlorine and bromine are responsible for the ozone hole is a conclusion based on combining extensive ground, aircraft, balloon and satellite data, with laboratory data and theoretical modeling. Figure 3 shows the strong anti-correlation between the abundances of ozone and chlorine monoxide, the key ozone-destroying species, i.e., as the abundance of chlorine monoxide increases the concentration of ozone decreases.
- A substantial Antarctic ozone "hole" is expected to occur each spring for many more decades because stratospheric chlorine and bromine abundances will approach the pre-Antarctic-ozone-"hole" levels (late-1970s) very slowly during the next century.
- In the late-winter/early-spring periods of 1991/1992 and 1992/1993, chemical losses of ozone up to 15 - 20% at some altitudes have been deduced from a series of intense observations in the Arctic. These observations, coupled with model calculations, increase

our confidence in the role of chlorine and bromine in the observed ozone destruction. The year-year variability in the photochemical and dynamical conditions of the Arctic limits the ability to predict ozone changes in future years.

#### Global Ozone:

- o The observational data provides conclusive evidence that ozone depletion is occurring at all latitudes, except the tropics, during all seasons. Analysis of extensive ground-based Dobson data and TOMS and SBUV satellite data through 1994 has shown ozone has decreased by about 5-6% in summer and 9-11% in winter/spring in northern mid-latitudes, and by 8-9% at southern mid-latitudes on a year-round basis. At northern mid-latitudes, the downward trend in ozone between 1981 - 1991 was about 2% per decade greater compared to that of the period 1970 - 1980. Natural periodic and episodic fluctuations are taken into account (solar cycle, seasonal, volcanic, etc.). Figure 4 shows the observed global ozone trends from 1979 to 1994, after allowing for the effects of solar variability, the quasi-biennial oscillation (QBO) and seasonal cycles. Figure 5 shows the observed ozone trends by season and latitude, illustrating significant trends at middle and high latitudes.
- Periodic fluctuations in ozone caused by changes in the 11-year solar cycle can be removed from the record relatively well. The magnitude of solar cycle-induced changes in ozone have been estimated from ground-based Dobson data (30-40 year record) and the TOMS satellite data (15 year record). The best estimate probably comes from the Dobson network, where Reinsel et al. concluded that the maximum to minimum variation was  $1.18 \pm 0.66\%$ . Combining all data suggests that the peak-peak magnitude of the solar cycle effect is between 1 and 2%, significantly less than the derived human-induced trend.
- The magnitude of the seasonal cycle, depends on geographic location, and while much larger than the human-induced trend, is easy to remove quite accurately from the record because of the large number of repetitive cycles.
- Random fluctuations, e.g., daily-weekly fluctuations caused by changes in "meteorological" conditions in the troposphere and stratosphere, cannot be removed, but are taken into account in the trend analysis using autocorrelation techniques.
- Episodic fluctuations, caused by volcanic eruptions, cannot, a priori, be easily removed as the magnitude of the effect varies from one eruption to another. However, the effect of a volcanic eruption lasts for only a few years, hence cannot be the cause of any observed long-term trend.
- o The weight of scientific evidence strongly suggests that the observed mid-latitude downward trends of ozone are due in large part to anthropogenic chlorine and bromine. This conclusion is based on combining ground, aircraft, balloon and satellite data, with laboratory data and theoretical modeling. Figure 6 shows how well a theoretical model simulates the diurnal cycle of the abundances of key atmospheric constituents.



### **What is the effect of the Montreal Protocol?**

- The rate of increase of atmospheric chlorine and bromine has slowed considerably in recent years demonstrating the effectiveness of the Montreal Protocol and its amendments. Even so, the mid-latitude ozone loss and the hole over Antarctica are not expected to disappear until the middle of the next century because of the very long atmospheric residence times for the CFCs and halons, i.e., human emissions between 1960 and today will affect the health of future generations.
- Human-induced ozone layer depletion is expected to peak around the year 1998, since the peak stratospheric chlorine and bromine abundances are expected to occur then. Based on extrapolation of current trends, observations suggest that the maximum ozone loss, relative to the late 1960s, will likely be:
  - (i) about 12 - 13% at Northern mid-latitudes in winter/spring;
  - (ii) about 6 - 7% at Northern mid-latitudes in summer/fall; and
  - (iii) about 11% (with less certainty) at Southern mid-latitudes on a year-round basis.
 These projected changes in column ozone would be accompanied by 15%, 8%, and 13% increases, respectively, in surface erythral radiation, if other influences such as clouds remain constant.
- Without the Montreal protocol and its amendments and adjustments future levels of atmospheric chlorine and bromine would be far higher than today (Figure 7). Hence, future levels of ozone depletion, ground-level UV-B, and cases of skin cancer would be substantially higher than today. Figure 7 shows how the Copenhagen amendments limit peak stratospheric chlorine loading to about 3.5 ppbv, decreasing to about 2 ppbv by about 2050, at which time mid-latitude ozone depletion and the Antarctic ozone hole should have recovered. Even with the Montreal Protocol, stratospheric chlorine levels were projected to continually increase, exceeding 10 ppbv in the latter part of the century.

### **Is there any evidence of increased levels of UV-B radiation?**

- The link between a decrease in stratospheric ozone and an increase in surface ultraviolet (UV) radiation has been further strengthened in recent years. Measurements in Antarctica, Australia, Canada and Europe have shown that under clear sky conditions when column ozone decreases the amount of UV-B radiation increases by the amount expected from theory (Figure 8). Large increases of surface UV are observed in Antarctica and the southern part of South America during the period of the seasonal ozone "hole." Furthermore, elevated surface UV levels at mid-to-high latitudes were observed in the Northern Hemisphere in 1992 and 1993, corresponding to the low ozone levels of those years.

- The international assessment noted the lack of a decadal (or longer) record of accurate monitoring of surface UV levels: the UV-B network which operated between 1974 and 1985 was limited to only a few polluted sites in the USA, hence not representative of the USA, let alone other locations around the globe. The assessment also noted variations in UV-B introduced by clouds and other factors precluded the unequivocal identification of a long-term trend in surface UV radiation. It should be noted that the magnitude of ozone depletion between 1974 and 1985 over the USA was only about 2% in summer and 5% in winter, a level very difficult to detect given the limited number of sites, local pollution problems, high variability of UV-B induced by variations in ozone and cloud cover, and the low sensitivity of the instruments. J. DeLuise of NOAA has concluded that the signal from UV-B is so noisy due to day-to-day changes in UV-B, and the calibration of the monitors was so flawed, that no reliable trends can be determined from the data. The UV-B flux may have even increased (as expected) over that time period, but it would not have been detected by the network -- it would have been overwhelmed by the calibration problems. The original data sets and documentation for the network no longer exists, so it is impossible to reconstruct an accurate data base from the monitoring network.
- Recent data, since the international assessment, suggest that is highly unlikely that there is no long-term trend in UV-B. Statistically significant (2-sigma) UV-B trends during spring, early summer and late autumn at latitudes between 60 degrees North and 60 degrees South can be derived from TOMS satellite measurements. In addition, satellite estimated UV-B fluxes agree very well with ground-based measurements for all observing conditions (cloud plus aerosols and clear sky).

#### **What are the human health impacts of ozone depletion?**

- As stated earlier, ozone depletion will lead to increases in the incidence of non-melanoma skin cancer, melanoma skin cancer, eye cataracts, and a possible suppression of the immune-response system.
- Let me just discuss briefly just one issue, that of UV-B radiation and non-melanoma skin cancer. For every 1% sustained increase in UV-B radiation there will be an approximate 2% increase in the incidence of non-melanoma skin cancer in light-skinned people. The current incidence rate of non-melanoma skin cancer in the United States is approximately 750,000 new cases each year, of which between 0.5 and 1% of these cases will result in death. Even those cases that do not result in death, are a significant cost to individuals and health care services. Ozone depletion is expected to peak within the next few years at about 6-7% over Northern mid-latitudes (including the United States) in summer/fall and about 13-14% in winter/spring. Thus a sustained ozone depletion will lead to a significant increase (about 15%) in the incidence of non-melanoma skin cancer and associated deaths: clearly an important public health issue for the United States.

- Some try, irresponsibly, to trivialize the issue of ozone depletion by noting that an ozone depletion of the magnitude observed is equivalent to only moving south by a hundred miles or so. The reason the risk is even this low is the Montreal Protocol and its amendments and adjustments. Without these international agreements we would be facing future increases in UV-B radiation of possibly 40-50 percent by the middle or end of the next century, and the comparable distance to move would be more like a thousand miles or greater. If there were an increase in UV-B radiation so that people living in Boston experienced an equivalent of the radiation they expect when they visit Miami, most people would consider that change to be highly significant. There is a big difference in skin cancer rates between cities in the northern half of the U.S. and those in the Southern half. For example, the skin cancer rates for fair-skinned males in Albuquerque were approx. 700 per 100,000 versus 150 per 100,000 in Seattle, a factor of 5 increase.

### **Conclusion**

- Human-induced stratospheric ozone depletion is occurring at all latitudes except the tropics. This results in an increase in ultraviolet radiation at the Earth's surface, which is a serious human health issue for Americans.
- Those that suggest the Montreal Protocol is not needed or too expensive, clearly must put a low value on the thousands of future lives saved annually in the U.S. alone.

# Historical Springtime Total Ozone Record for Halley Bay, Antarctica (76°S)

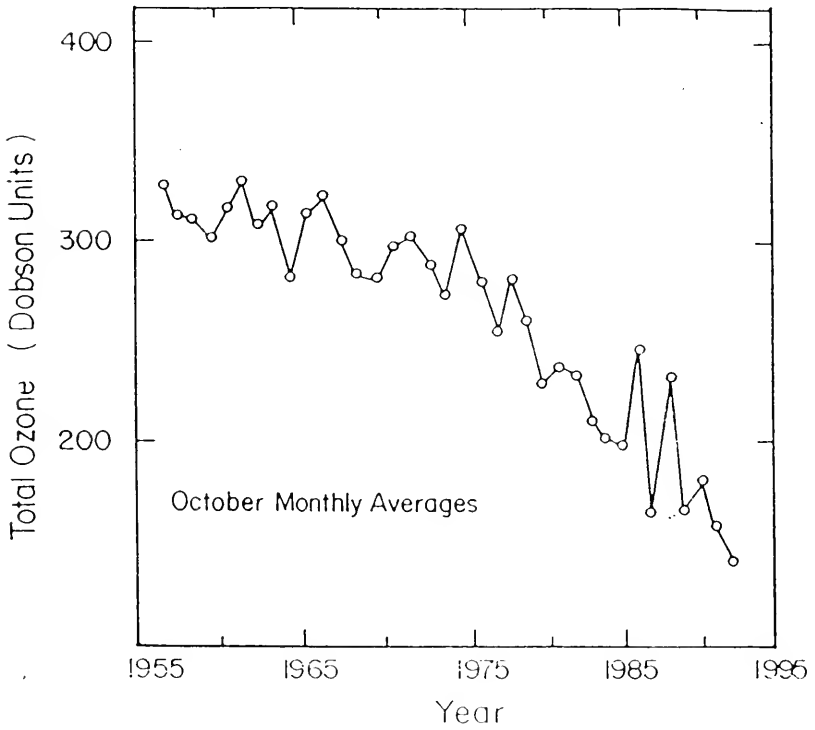


FIGURE 1

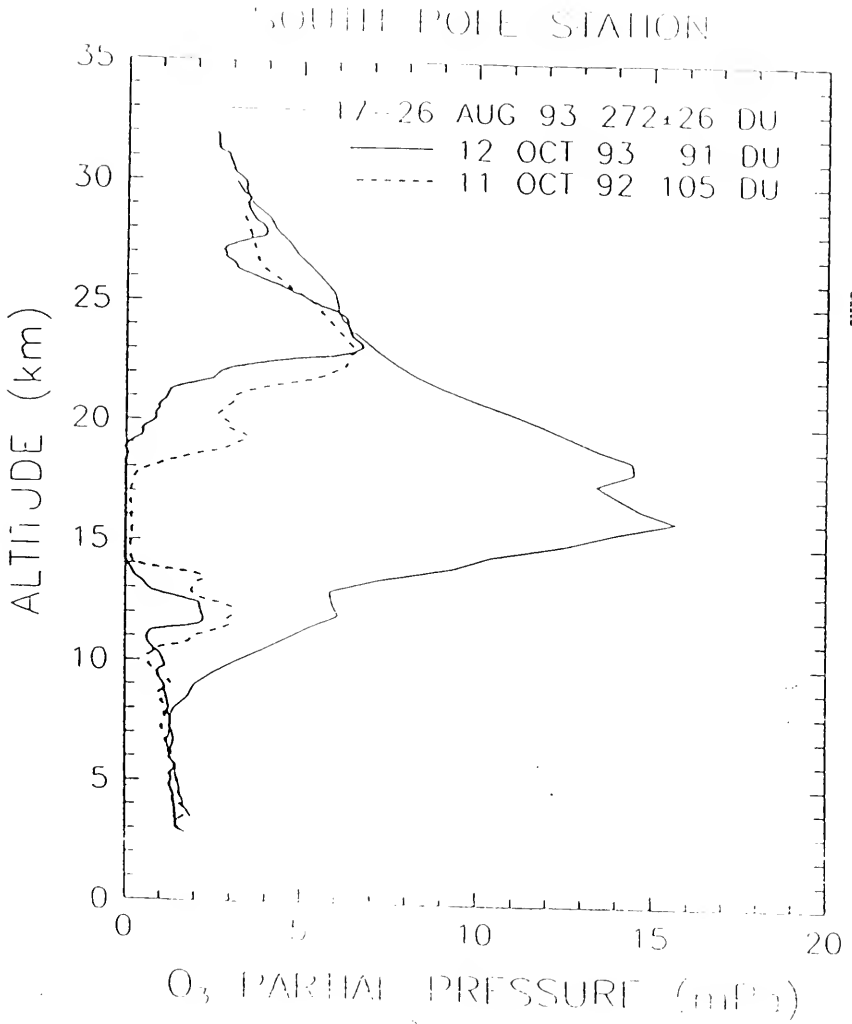


FIGURE 2

# Measurements of Ozone and Reactive Chlorine from a Flight into the Antarctic Ozone Hole

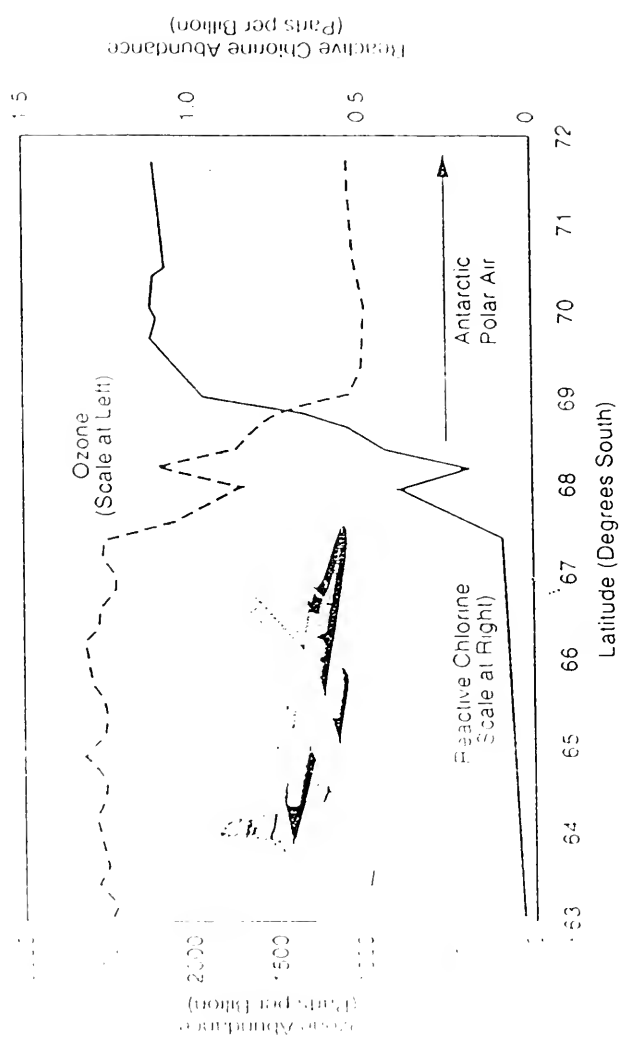


FIGURE 3

Global Ozone Trend (60°S–60°N)

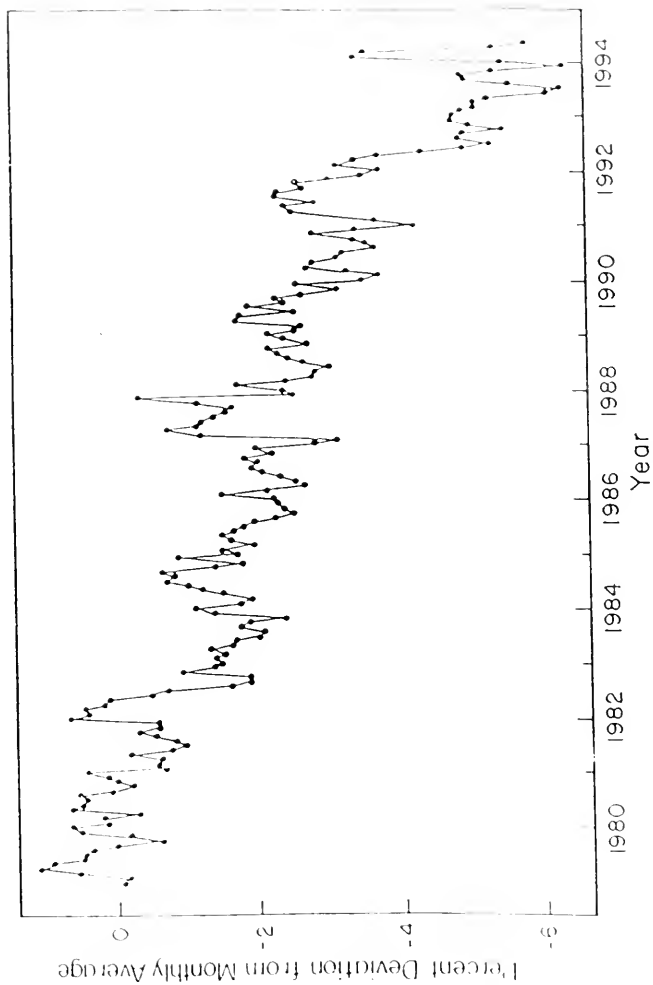


FIGURE 4

## SBUV(1/2), Dobson, and TOMS Trends 1/79 to 5/91

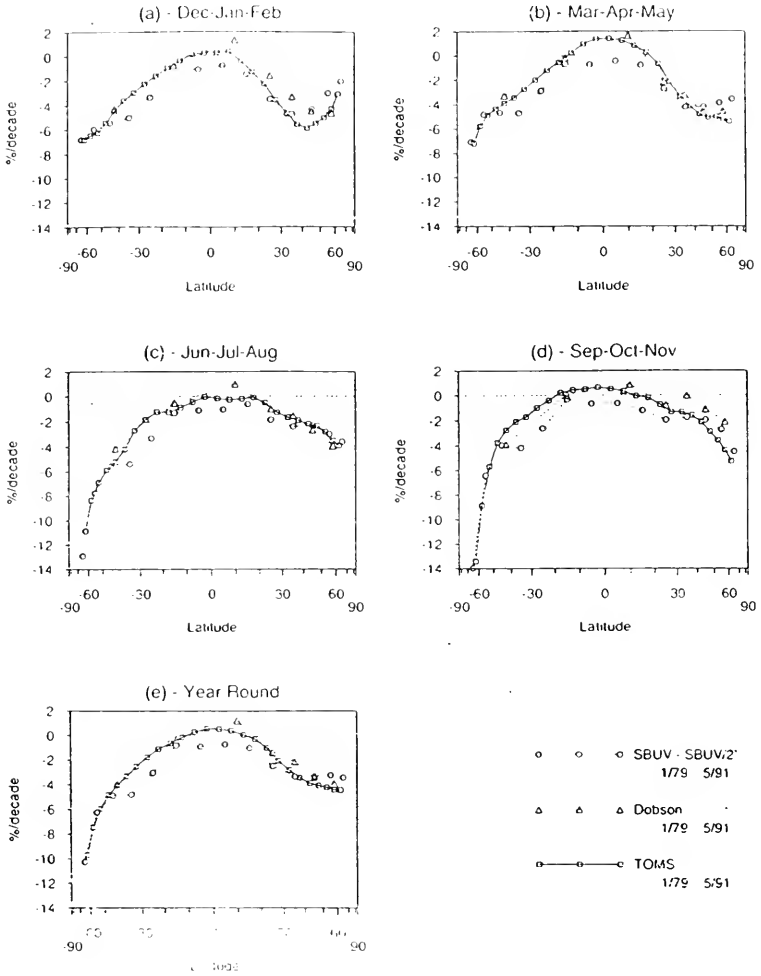


FIGURE 5



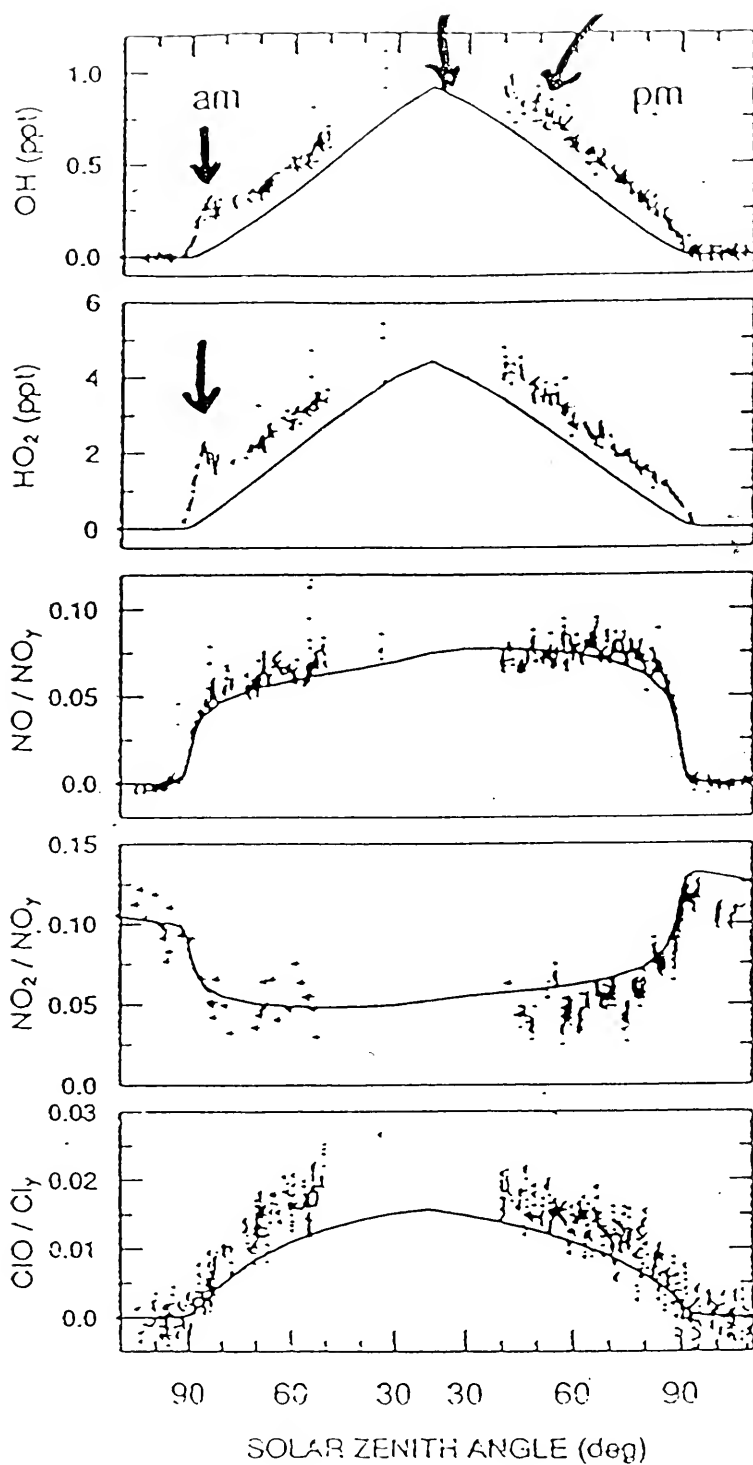


FIGURE 6

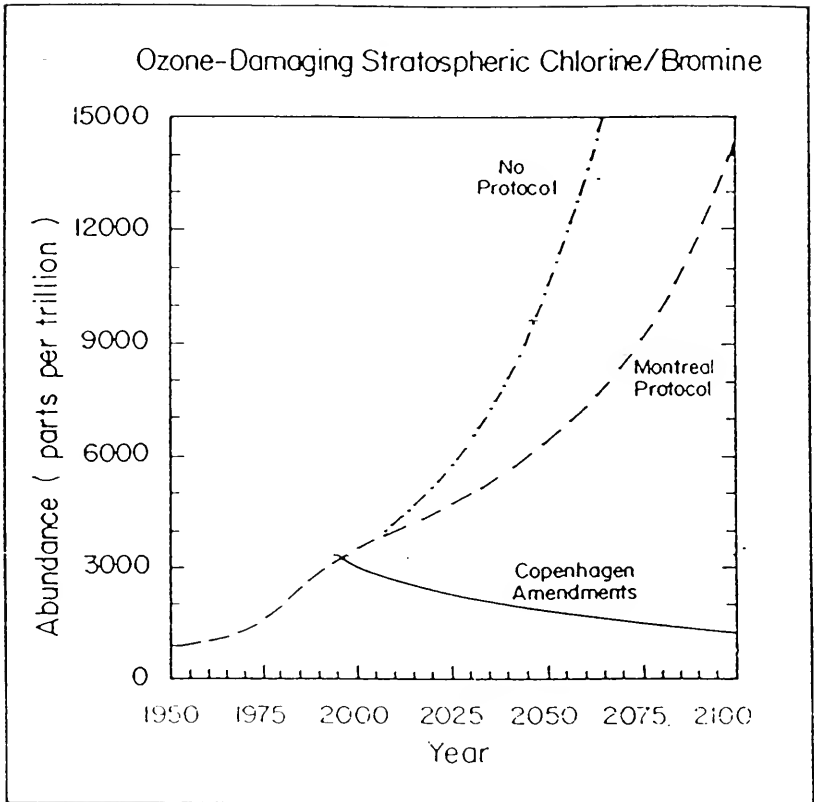


FIGURE 7

# Increases in Erythral (Sunburning) UV Radiation Due to Ozone Reductions

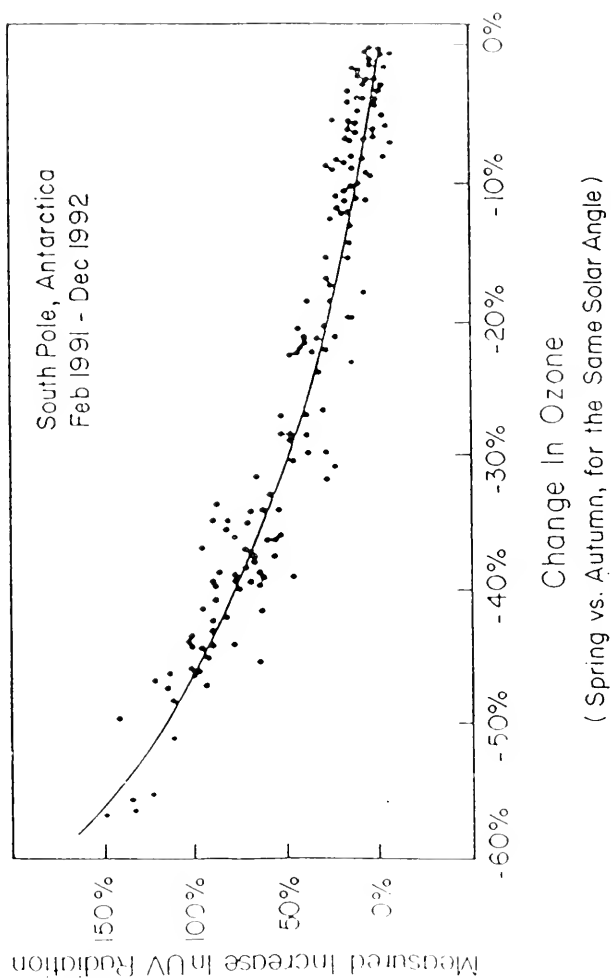


FIGURE 8

Mr. ROHRBACHER. Dr. Watson, thank you very much.

Dr. Singer, I heard your name mentioned several times. Maybe you'd like to testify next.

**STATEMENT OF DR. S. FRED SINGER, PRESIDENT, THE SCIENCE AND ENVIRONMENTAL POLICY PROJECT, FAIRFAX, VA**

Dr. SINGER. I wish I could give as emotionally charged a presentation as my colleague has just done. But I'll try to be calm and factual.

I'm a scientist who has worked for a number of years on atmospheric and ozone problems.

My relevant biography is given in the testimony. I've also attached to my testimony a recent peer-reviewed article that I've written on the ozone issue. It lists further peer-reviewed articles that I've written in the last few years.

I'm very distressed that Congresswoman Rivers was not able to find some of my peer-reviewed articles. I think there are about 200 of these in the literature and I'd be glad to supply a list.

But perhaps it's her staff that's at fault. So I should not blame her for this.

I was asked to supply some examples of lack of scientific integrity in dealing with the ozone CFC issue.

I thought I would list about half a dozen of these and you'll find them listed in my testimony and hopefully, thoroughly explained. These are cases where the science was twisted, shaped, in order to gain certain ideological objectives. There was never a case where the actual facts were, shall we say, misstated, where there was actual wrong information presented.

But it was presented in such a way as to give a misleading impression.

You, ladies and gentlemen, here are being today misled, bamboozled, and otherwise manipulated by some of the testimony that you've just heard.

My job today, I think, is to expose this to you, and I'd like to do that. I hope there will be many questions to me so that I'll have a chance to comment in some detail on the way in which the scientific information has been misrepresented to you in order to achieve certain political objectives.

I'm fortunate to have Dr. Baliunas here. She's the distinguished research astrophysicist at the Harvard Observatory. She'll be addressing the issue of ozone depletion, or so-called ozone depletion.

But let me address the issue which is an important one of the possible or claimed rise or increase in ultraviolet radiation.

You know, the people who believe that ozone has been depleted are looking very, very hard for some evidence for an increase in ultraviolet radiation to prove that ozone has been depleted.

They've not been able to find it.

If you look, for example, at Dr. Watson's testimony on page 7, you'll find some convoluted language, saying that various factors have precluded the unequivocal identification of a long-term trend in surface UV.

What this means is that he has no evidence.

Later on he says, it's highly unlikely that there is no long-term trend in UV-B.

Again, this means that he has no evidence.

But why doesn't he have any evidence for an increase in UV? I'll tell you why. Because the evidence we have shows that UV-B did not increase. It decreased. The evidence was published and covers the period of 1974 to 1985.

Now let's see how he deals with the evidence, how does he explain it away.

Well, first he says, the instrument is no good. Bad calibration. Well, when it's pointed out that the instrument is okay, then he says, well, okay. The instrument is fine, but the record is too noisy. The UV goes up and down. You can't tell if there's a trend.

When you point out that the same argument applies to ozone, he then goes to the same argument. He says, well, pollution increased in the atmosphere and that's what absorbed the UV.

But the EPA tells us that pollution has decreased in the United States as a result of the Clean Air Act, so that's a difficult problem for him.

Well, fortunately, to the rescue comes a publication in Science magazine in 1993, claiming that UV-B over Toronto has increased by up to 35 percent per year. Thirty-five percent per year—that's a very large trend if it goes on for many years.

We examined that paper. By the way, the paper was supposed to be peer-reviewed. We published a paper in Science showing that the analysis was incorrect, based on faulty statistics, and that the trend of UV-B was zero. Zilch. Nothing. Nada.

There was no trend and the paper is wrong. And it's still being quoted, not only by Dr. Watson, but also in the Scientific Assessment of 1994 that has been referred to earlier.

Well, after he shows that you cannot detect the UV trend, he then goes to a nonsequitur. If you can't get it here, you switch to something else.

The nonsequitur is, well, UV-B has increased in the Antarctic whenever ozone decreased.

Well, of course it would do that if there's a clear sky. What he doesn't tell you is that as soon as ozone increases, the UV-B decreases.

In other words, it goes up and it goes down.

But if you look at his testimony, you'll find only references to cases where the UV-B goes up. It's like telling you that it gets warmer every July and never tells you that it gets colder in December.

It leaves you with the impression that this is going to be a very hot climate some day.

Finally, there's a suggestion that the satellite instrument, the TOMS instrument, has measured a UV trend on the surface.

I know something about the instrument. I designed it many years ago. If you read his testimony carefully, you'll find out that the UV trend that he talks about is not measured. It's derived from the TOMS instrument. It is estimated.

In other words, it's calculated. It's not a direct measurement of UV reaching the surface of the Earth. There simply is no evidence for this. And this is crucial, I think, because it is UV at the surface

of the Earth that's supposed to produce all the harmful health effects that we're talking about. It's supposed to produce all the skin cancer that we're talking about, and I hope I'll have a chance later on to comment on this, but I'd better stop at this point.

Mr. ROHRABACHER. Do you have a 30-second summary that you'd like to make?

Dr. SINGER. Yes, only one point here. You often hear the statement from Dr. Watson and others that the depletion of ozone is worse than expected. Or that the ozone hole this year is worse than expected. Or that the increase in UV is worse than expected.

Expectations are based on theory, on calculation.

If you think about the statement for a minute, it sounds awful. It's very frightening. Isn't it scary—"worse than expected."

What it really means is that the expectation, the theory, is wrong. Or the observations are wrong. Or, more likely, they're both wrong.

Thank you.

[The complete prepared statement of Dr. Singer follows:]



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S. Fred Singer, Ph.D., President

### TESTIMONY OF S. FRED SINGER, PhD PRESIDENT, THE SCIENCE & ENVIRONMENTAL POLICY PROJECT

Hearing on "Stratospheric Ozone: Myths and Realities"  
House Science Committee, Subcommittee on Energy and Environment  
September 20, 1995

Mr. Chairman, Ladies and Gentlemen,

My name is S. Fred Singer. I am professor emeritus of environmental sciences at the University of Virginia and the founder and president of The Science & Environmental Policy Project in Fairfax, Virginia, a non-partisan non-profit research group. I hold a skeptical view on the adequacy of the science that supports our current stratospheric ozone policy—namely, to phase out chlorofluorocarbons (CFCs) on an accelerated schedule.

Vice President Al Gore keeps referring to scientist skeptics as a "tiny minority outside the mainstream." Others try to discredit scientist skeptics by lumping them together with fringe political groups. To counter such misrepresentations, let me present my general scientific qualifications and those relevant to the ozone issue.

#### Relevant Background:

I hold a degree in engineering from Ohio State and a Ph.D. in physics from Princeton University. For more than 40 years, I have specialized in atmospheric and space physics. I received a Special Commendation from President Eisenhower for the early design of satellites. In 1962, I established the U.S. Weather Satellite Service, served as its first director, and received a Gold Medal award from the U.S. Department of Commerce for this contribution.

Early in my career I devised the instrument used to measure stratospheric ozone from satellites. As a Deputy Assistant Administrator of the U.S. Environmental Protection Agency in 1971, I chaired an interdepartmental panel of scientists looking into the possible effects on stratospheric ozone of a proposed fleet of supersonic transports (SSTs). Ours was the first group to examine possible damage to the ozone layer from human activities and look into potential health consequences, including skin cancers. During this period I published the hypothesis that

anthropogenic methane, from cattle raising and rice growing, could deplete stratospheric ozone<sup>1</sup>. In the late 1980s I served as Chief Scientist of the U.S. Department of Transportation and also provided expert advice to the White House on the ozone issue.

### Examples of Failures of Scientific Integrity:

Today's hearing on scientific integrity as related to the stratospheric ozone layer is well timed. The United Nations Environment Programme and the secretariat for the Montreal Protocol [on Substances that Deplete the Ozone Layer] designated September 16 as the first annual International Day for the Preservation of the Ozone Layer. The White House, spurred on by the EPA, has extended the celebration into a whole week. This should remind us that ozone depletion is no longer just a scientific debate; entrenched domestic and international bureaucracies, not to mention commercial interests, now have a considerable stake in keeping alive fears of an ozone catastrophe.

This morning, I will touch on several topics that relate to the theme of scientific integrity:

- First, I want to state clearly that there is no scientific consensus on ozone depletion or its consequences. "Consensus" is a political concept, not a scientific one. It is used mainly to gain reassurance for an ideological position and to avoid having to examine the scientific arguments in detail. Consensus has been claimed also for the global warming issue. The official report from the UN-sponsored Intergovernmental Panel on Climate Change mentions the existence of "minority" views, but the editors could not, or perhaps would not, "accommodate" them<sup>2</sup>. The IPCC editors thus achieved "consensus" by ignoring contrary evidence and dissenting views. Much the same has been true in the ozone issue.

In view of the present policy to ban CFCs by the end of 1995, why spend a lot of energy fighting a *fait accompli*? I think the best answer was given by an environmental activist on an ABC News-"Nightline" television program in February 1994. Michael Oppenheimer of the Environmental Defense Fund complained that "if [skeptical scientists] can get the public to believe that ozone wasn't worth acting on, that they [the public] were led in the wrong direction..., then there is no reason for the public to believe anything about any environmental issue." Given the activist groups' miserable record of unfounded scares about the global environment, such a reaction may be warranted.

- Next, I want the record to show that the 1987 Montreal Protocol [on Substances that Deplete the Ozone Layer] was negotiated without adequate concern for scientific evidence. The chief

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<sup>1</sup> S. F. Singer, "Stratospheric Water Vapour Increase Due to Human Activities," *Nature*, Vol. 223, pp. 543-547 (1971)

<sup>2</sup> *Climate Change: The IPCC Scientific Assessment* (edited by J.T. Houghton, G.J. Jenkins, and J.J. Ephraums), Cambridge University Press, 1990, Foreword, page v.



U.S. negotiator, State Department official Richard Benedick, proudly revealed in his 1991 book, *Ozone Diplomacy*, on page 2: "Perhaps the most extraordinary aspect of the treaty was its imposition of substantial short-term economic costs...against unproved future dangers—dangers that rested on scientific theories rather than on firm data." Again, on page 18: "In July 1987, practically on the eve of the final negotiating session in Montreal, NOAA concluded that the 'scientific community is currently divided as to whether existing data on ozone trends provides sufficient evidence... that a chlorine-induced ozone destruction is occurring.'"

Benedick does not mention the fact that, as late as 1988, published evidence on stratospheric chlorine showed no upward trend, thus indicating that neither CFCs nor other manmade chemicals were contributing significantly to the total—over and above known natural sources like volcanoes and oceans. An article by MIT professor Ronald Prinn, in a book edited by Prof. Sherwood Rowland and published in 1988, makes this point quite clear<sup>3</sup>.

It is apparent from the above quotes that the negotiators and their scientific supporters were not at all inhibited by the absence of scientific evidence—or indeed by the presence of contrary information<sup>4</sup>.

• Third, the self-constituted Ozone Trends Panel first announced the existence of global ozone depletion in a March 1988 press conference, but did not present its supporting analysis for review until much later<sup>5</sup>. A study of the OTP data by two independent American scientists, which was widely distributed as a preprint, showed clearly that, even after they thought they had successfully "subtracted" the natural variations by statistical methods, the so-called "depletion trend" depended on the choice of time interval—i.e., the year the analysis starts and ends<sup>6</sup>. Curiously, this result, which shows the dominance of the large (natural) solar-cycle variation of ozone, was left out of a later published paper involving the same authors as collaborators with

<sup>3</sup> R. G. Prinn, "How Have the Atmospheric Concentrations of the Halocarbons Changed?" in *The Changing Atmosphere* (P. S. Rowland and I. S. A. Isaksen, eds.), pp. 33-48, John Wiley, New York, 1988.

<sup>4</sup> In an article of March 16, 1995, science editor Tim Radford of the Manchester Guardian conveys the general panic created at the time of the Protocol negotiations: "...fears...that the hole in the ozone would wipe out life all over the world." Such fears were encouraged by "authoritative" statements; Radford quotes an official of the U.S. National Science Foundation, warning as late as 1989: "It's terrifying. If these ozone holes keep growing like this, they'll eventually eat the world."

<sup>5</sup> R.A. Kerr, *Science* 239, pp. 1489-91 (March 25, 1988); an account of the press conference and executive summary on "depletion" by Ozone Trends Panel.

<sup>6</sup> W.J. Hill and L. Bishop, of Allied-Signal Corp.; quoted in S.F. Singer, "What Could Be Causing Global Ozone Depletion?" in *Climate Impact of Solar Variability* (K. H. Schatten and A. Arking, eds.) NASA Publication 3086, 1990

government scientists<sup>7</sup>.

There is also a still unresolved dispute about the quality of the data themselves. The OTP, and the subsequent UN-sponsored assessment groups, have never grappled with objections published by two Belgian researchers in 1992<sup>8</sup>. These scientists showed that the ozone readings were contaminated by air pollution and termed the reported ozone trend "fictitious." Because of similar absorption of ultraviolet, decreases in sulfur dioxide, brought about by reduced industrial emissions, were being falsely read as decreases in ozone.

Global ozone depletion is still a controversial subject. Starting with the OTP press conference, depletion has generally been reported to be "worse than expected." This statement should produce the logical conclusion that the CFC-ozone theory (on which "expectation" must be based) is wrong, or the observations are wrong, or they are both wrong.

- Fourth, another press conference, arranged by NASA on February 3, 1992—during crucial Congressional hearings on the NASA budget and well before the end of the series of stratospheric observations—implied the threat of an Arctic ozone hole. The resulting nationwide scare led the Bush White House to advance the phaseout of CFCs to December 31, 1995.

The Arctic ozone hole never happened—something NASA scientists could have predicted at the time of the press conference. Information leaked to a journalist indicated that NASA scientists had mid-January satellite data showing that stratospheric chlorine was already in decline. Yet the agency went ahead with the February 3 press conference and refused to reveal this information and allay public fears until a second NASA press conference three months later, on April 30<sup>9</sup>.

- Fifth, the "smoking gun" of ozone depletion activists is, of course, an increasing trend of solar ultraviolet radiation at the earth's surface. All of the published evidence before November 1993 had shown no such trend. Then, a research paper in *Science* magazine claimed upward trends

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<sup>7</sup> R.D. Bojkov, L. Bishop, W.J. Hill, G.C. Reinsel, and G.C. Tao, "A statistical trend analysis of revised total Dobson ozone data over the Northern Hemisphere," *J. Geophys. Res.* 95, 9785-9807, 1990

<sup>8</sup> D. DeMaer and H. DeBacker, "Revision of 20 years Dobson Total Ozone Data at Uccle (Belgium): Fictitious Dobson Total Ozone Trends Induced by Sulfur Dioxide Trends," *J. Geophys. Res.*, Vol. 97, pp. 5921-5937, April 20, 1992. They demonstrate that the Dobson ozone meter can misinterpret the downward trend of SO<sub>2</sub> pollution, giving rise to a "fictitious" ozone trend. Their finding was confirmed by a task group (R.T. Watson, chm.) in a Joint Workshop of the IPCC and the Int'l Ozone Assessment Panel, Hamburg, May 17-19, 1993

<sup>9</sup> R. Bailey, *Eco-Scan*, St. Martin's Press, 1993, p.120; and private communication by the author

of as much as 35 percent per year--without giving any estimate of the margin of error<sup>10</sup>. This widely touted result, featured in a press release by *Science* and still being cited by the EPA and environmental activist groups, was shown to be completely spurious<sup>11</sup>. The analysis was based on faulty statistics; the "trend" was zero.

Only later was it learned that the paper had been first submitted to the British scientific journal *Nature*, but had been rejected in the peer-review process. It's still somewhat of a mystery how this article passed the review process of *Science*.

There is still no evidence for an increased trend of surface UV to match a putative ozone depletion trend.

• Finally, there is the Setlow experiment, which demonstrates that malignant melanoma skin cancers are mainly caused by a region of the UV spectrum that is not absorbed by ozone and therefore not affected by changes in the ozone layer<sup>12</sup>. When the EPA is not ignoring this result, it is attacking it on the basis that Setlow experimented with fish and that fish are not people<sup>13</sup>. (Ironically, the EPA expresses no such qualms when using rats to determine the carcinogenicity of chemicals.) In the meantime, the EPA has resisted Congressional requests to revise its cost-benefit analysis backing the Montreal Protocol, which was based on the wholly unjustified assumption of 3 million additional skin cancer deaths.

### Conclusion:

The bottom line is this: Currently available scientific evidence does not support a ban on the production of chlorofluorocarbons (CFCs or freons), halons, and especially methyl bromide<sup>14</sup>. There certainly is no justification for the accelerated phaseout of CFCs, which was instituted in 1992 on nothing more than a highly questionable and widely criticized NASA press conference. Yet because of the absence of full scientific debate of the evidence, relying instead on unproven

<sup>10</sup> J.B. Kerr and C.T. McElroy, "Evidence for Large Upward Trends of Ultraviolet-B Radiation Linked to Ozone Depletion," *Science* 262, 1032-1034 (12 Nov. 1993)

<sup>11</sup> P.J. Michaels, S.F. Singer, P.C. Knappenberger, "Analyzing ultraviolet-B radiation: is there a trend? *Science* 264, pp. 1341-2 (27 May 1994)

<sup>12</sup> R. Setlow et al "Wavelengths effective in induction of malignant melanoma" *Proc. Natl. Acad. Sci. USA* 90, 6666-6670, July 1993

<sup>13</sup> Letter from Paul L. Stolpman, EPA, to Congressman John Doolittle, dated Nov. 9, 1994

<sup>14</sup> For backup see attached publication: S.F. Singer, "The Ozone-CFC Debate: Hasty Action, Shaky Science," *Technology: J. Franklin Institute* 332A, 61-66, 1995

theories, we now have an international treaty that will conservatively cost the U.S. economy some \$100 billion dollars<sup>13</sup>.

The history of the CFC-ozone depletion issue is rife with examples of the breakdown of scientific integrity: selective use of data, faulty application of statistics, disregard of contrary evidence, and other scientific distortions. The policy before and since the Montreal Protocol has been driven by wild and irresponsible scare stories: EPA's estimate of millions of additional skin cancer deaths, damage to immune systems, blind sheep in Chile, the worldwide disappearance of frogs, plankton death, the collapse of agriculture and ecosystems.

The latest example of "science by press release" is the scare story about a massive ozone hole, fed to the media in Sept. 1995 by the Geneva-based World Meteorological Organization. "At its present rate of growth [it] might grow to record-breaking size....," said Rumen Bojkov, a well-known WMO alarmist. But then again, it might not--according to NASA scientist Paul Newman. Australian meteorologist Paul Lehmann agrees: The hole will change its shape, volume, and size daily as it grows; he concludes that its final size is not predictable by comparing data now with those of a year ago.

These scare stories cannot pass what I call the common-sense test: A projected 10 percent UV increase from a worst-case global ozone depletion is the equivalent of moving just 60 miles closer to the equator<sup>14</sup>, say from Washington, D.C., to Richmond, Virginia. New Yorkers moving to Florida experience a more than 200 percent increase in UV because of the change in latitude. Why aren't they dropping like flies? Mail-order nurseries in the upper midwest ship field-grown plants all over the United States. Why don't these plants die?

Scientists involved in ozone research have known these facts from the beginning, but only a few have acknowledged them publicly.

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<sup>13</sup> B. Lieberman, *"The High Cost of Cool"*, Competitive Enterprise Institute, Washington DC, 1994. He estimates the ten-year cost for US automobiles alone between \$24 and \$49 billion.

<sup>14</sup> WMO Report "Scientific Assessment of Ozone Depletion" *Global Ozone Research and Monitoring Project--* Rept No. 25, World Met. Organization, Geneva CH 1211, 1991 (Fig 11-10)

## COMMENTARY

### THE OZONE-CFC DEBACLE: HASTY ACTION, SHAKY SCIENCE

S. Fred Singer

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By international agreement, the manufacture of chlorofluorocarbons (CFCs) is supposed to cease in the United States and most other developed nations by the end of 1995. Motorists will face shortages when they try to recharge their air conditioners; with the cost for repair or retrofit likely in the multi-hundred dollar range; the 10-y cost for U.S. automobiles is estimated as between \$24 and \$49 billion (1). The U.S. Environmental Protection Agency (EPA), anticipating a potential consumer revolt, had to persuade a reluctant DuPont Corporation to rescind its voluntary commitment to close down its production line by the end of 1994 (2). Hoechst AG actually closed down its CFC production in Germany on April 16, 1994.

Yet in spite of the hardships caused by the hasty phaseout of CFCs and other suspected ozone-depleting halocarbons, the EPA has never questioned the adequacy of the science that forms the basis for its phaseout policy. The facts are that the scientific underpinnings are quite shaky: the data are suspect; the statistical analyses are faulty; and the theory has not been validated (3,4). The science simply does not support this premature and abrupt removal of widely used chemicals—at great cost to the economy. This fact seems finally to have been recognized by legislators; in early 1995, Republican Congressman from Texas, Tom Delay, introduced a bill, H.R. 475, to repeal the provisions in Title VI of the 1990 Clean Air Act regulating the production and use of CFCs.

If one examines the history of governmental CFC policy, one finds that it is based mainly on panicky reactions to press releases from EPA, National

Aeronautics and Space Administration (NASA), and National Oceanographic and Atmospheric Administration (NOAA) about skin cancer and possible Arctic ozone holes—stimulated and amplified by environmental pressure groups and the media—rather than on published work that has withstood the scrutiny of scientific peers. Credence has been given to EPA "estimates" of millions of extra skin cancer deaths, to lurid stories about ozone depletion leading to blind sheep, to the travails of whales in the Antarctic, and to the worldwide disappearance of frogs and toads. It is perhaps characteristic of this topic that so many of the scary announcements have led off with some statement like: "The depletion of ozone is worse than expected"—starting with the March 1988 press conference by the Ozone Trends Panel (5). Yet since "expectation" must be based on theory, the discrepancy with observations means, logically, that either the theory is wrong or the data are wrong, or both are wrong!

For the general public, and even for the trained scientist, these scientific controversies are difficult to sort out. It is indeed a multi-faceted problem, a chain with many links connecting the release of CFCs into the atmosphere with the occurrence of skin cancer. Briefly, the steps are postulated as follows (6):

1. CFCs with lifetimes of decades and longer become well-mixed in the atmosphere, percolate into the stratosphere, and there release chlorine.
2. Chlorine, in its active form, can destroy ozone catalytically and thereby lower its total amount in the stratosphere.
3. A reduced level of ozone results in an increased level of solar ultraviolet radiation reaching the surface of the earth.

This paper was prepared for the symposium dedicated to Dixy Lee Ray. For reasons beyond the control of the editor it could not appear in the volume dedicated to that topic.

4. Exposure to increased UV leads to increases in skin cancer.

Each of these four steps is controversial, has not been sufficiently substantiated, and may even be incorrect (7,8). One can reasonably conclude that policy is rushing far ahead of the science.

#### SCIENTIFIC UNCERTAINTIES AND CONTROVERSIES

It is generally agreed that natural sources of tropospheric chlorine (volcanoes, ocean spray, etc.) are four to five orders of magnitude larger than man-made sources (9). But it is what gets into the stratosphere that counts. The debate has degenerated into arguing about how much chlorine is rained out in the lower atmosphere (10) rather than measuring whether stratospheric chlorine is actually increasing.

Contrary to the claims of some skeptics, CFCs do indeed reach the stratosphere; the secular increase of fluorine, in the form of HF, as reported by Belgian researcher R. Zander, may be sufficient proof (11,12). But as late as 1987, Zander found no long-term increase in HCl, suggesting that stratospheric chlorine comes mostly from natural sources, which are not expected to increase over time. The situation changed in 1991, however, when NASA scientist C. Rinsland published data showing HCl increasing at about half the rate of HF, suggesting both natural and man-made sources (13). Yet the Montreal Protocol to freeze CFC production and roll it back to lower levels was signed in 1987, at a time when published work still indicated little, if any, contribution from CFCs.

(Earlier aircraft-based observations of HCl increases between 1978 and 1982 by NCAR researchers Mankin and Coffey (14) were used to justify a CFC phaseout, even as late as 1993 (15,16), in spite of the fact that their data series was judged to be of poor quality and too short; according to MIT Professor Prinn, their published rate of increase of stratospheric chlorine could well be close to zero, in agreement with Zander's 1987 result (17). In any case, Mankin and Coffey themselves ascribe their observed 1982 increase to the volcano El Chichon (18) rather than to CFCs).

The question of global ozone depletion has been bedeviled by doubts about the quality of the data. Readings from Dobson ground observatories can be contaminated by long-term trends in  $\text{SO}_2$  pollution of the lower atmosphere. DeMuer and DeBacker have demonstrated that the Dobson ozone meter can misinterpret the downward trend of  $\text{SO}_2$  pollution, giving rise to a "fictitious" ozone trend (19). (Their

finding was confirmed by a task group, chaired by Robert T. Watson, in a Joint Workshop of the IPCC and the International Ozone Assessment Panel in May 1993).

Another, quite separate problem is produced by the extreme noisiness of the ozone record. To establish the existence of a small, long-term trend it is necessary to eliminate the large natural variations, especially also those correlated with the 11-y sunspot cycle. This is an impossible task given the shortness of the record and the virtual absence of data on long-term variations of the solar far-UV radiation that produces ozone in the upper atmosphere. The analysis fails a simple test: The "trend" is found to depend strongly on the choice of time interval (20). An additional problem in identifying a man-made trend arises from long-term trends in sunspot number, and therefore long-term ozone trends of natural origin (21).

Thus, the issue of whether the global ozone layer shows a steadily depleting trend is still controversial. Satellite data on global ozone content are not subject to interference from low-altitude pollution, but long-term calibration drift presents a problem; the TOMS data from satellites appear to have a calibration drift due to nonlinearities in the photomultiplier (22). In any case, the shortness of the record, 1979 to present, makes the solar-cycle correction problematic (23).

The Antarctic ozone "hole", an annual short-lived thinning of the layer first identified in 1985, is a genuine phenomenon whose intensity has increased markedly since about 1978. Its proximate cause is unquestionably stratospheric chlorine, but its fate may be controlled more by climate factors and the presence of particulates than by the concentration of chlorine itself (24); the hole may persist even if the chlorine level were to drop below the 1978 value. In any case, no theoretical predictions exist that can be tested by future observations.

Nor is the CFC-ozone theory itself in good shape. Over the years, its predictions for long-term, global ozone depletion have varied widely; during the early eighties the National Academy of Sciences published values that gradually decreased from 18% down to 3%. Since the discovery of the ozone hole, there have been no further quantitative predictions published because it was recognized that the existing theory could not cope with the heterogeneous destruction processes that depended more on particulate surface area than on the level of chlorine (25,26).

The theory could not describe ozone variations caused by the (heterogeneous) reactions on particulates (volcanic debris, aerosols, etc.) in the lower stratosphere

and therefore was not able to predict the Antarctic ozone hole. In the upper stratosphere, where only gas-phase (homogeneous) reactions take place, the theory predicts larger changes than are actually observed (27).

There is marked disagreement also among the satellite ozone data (28): In the upper stratosphere, trends seen by the SBUV instrument are negative, while SAGE I and II data show slightly positive trend values; in the lower stratosphere, SAGE shows much larger decreases than SBUV—up to 3%-6%/y in the equatorial region, a result that is difficult to explain from CFC theory.

In the lower stratosphere, recent model calculations and observations indicate that chlorine-based ozone destruction may be rate-limited by the amounts of OH and HO<sub>2</sub> radicals (29,30). If borne out, then increasing stratospheric water vapor—as a result of rising tropospheric methane from human activities, such as cattle raising and rice growing—could play a significant role in ozone chemistry (31).

## CONCERNS ABOUT SKIN CANCER

The major public concern about a possible depletion of ozone comes from the fear that solar UV-B (280-320 nm) radiation reaching the surface will increase, typically by 10%. Yet UV-B intensity increases naturally by about 5000% between pole and equator; there is less ozone traversed when the sun is closer to the zenith (32). Hence a 10% increase at mid-latitudes translates into moving 60 miles (100 km) to the south, hardly a source for health concerns.

There has been, of course, a determined search for a secular increase in UV-B to match the presumed depletion of ozone. But no such trends had been observed (33) until publication in November 1993 of a startling increasing trend, between 1989 and 1993, over Toronto, Canada (34). Close examination, however, revealed that this "smoking gun" was mostly smoke. The authors confused a short-lived increase at the end of their record with a long-term trend (35).

The driving force behind the policy to phase out CFCs has always been the fear of skin cancer, particularly malignant melanoma. The EPA has predicted 3 million additional skin cancer deaths by the year 2075 as a result of ozone depletion (36,37). But unlike basal and squamous cell skin cancers, which are easily cured growths caused by long-term exposure to UV-B, melanoma does not show the same characteristic increase towards lower latitudes (38) (Surprisingly, European data on melanoma incidence show a reverse latitude effect).

It is clear therefore that the rising incidence of melanoma over the past 50 y cannot be due to any changes in the ozone layer. Non-melanoma (basal cell and squamous cell) skin cancers are clearly linked to chronic exposures to UV-B, as judged from the increasing incidence towards lower latitudes; melanoma exhibits a different epidemiology and often occurs on areas of the body not chronically exposed to the sun. Yet the clear link to solar exposure suggests that changes in lifestyle leading to greater exposure to the sun may be the main cause of melanoma.

A breakthrough in our understanding of the mechanism of melanoma induction came with the experiments of Dr. Richard Setlow and colleagues at the Brookhaven National Laboratory. To measure the action spectrum of UV radiation for melanoma induction, they exposed hybrids of the fish genus *Xiphophorus* to specific wavelengths in the UV-A and UV-B range. The animals had been back-cross bred to have only one tumor-suppressor gene; inactivation of this gene in a melanoblast or melanocyte then permits the melanoma to develop (39). The experimenters found that the action spectrum (sensitivity per quantum) was reasonably flat across the UV-B and UV-A regions. Because of the much greater number of UV-A photons, they conclude that 90%-95% of melanomas are caused by UV-A (40).

But UV-A is not absorbed by ozone at all, and therefore melanoma rates would not be affected by changes in stratospheric ozone. This important finding undercuts one of the main reasons for the Montreal Protocol and all subsequent regulations (41).

A final point should be emphasized: If people exposed themselves to sunlight using sunscreens that merely prevent sunburns (produced by UV-B), they will increase their exposure to melanoma-inducing UV-A radiation. While long-term tanning may be somewhat protective, episodic or recreational exposures expose melanocytes to exceptionally high levels of dangerous UV-A (42). The best protection may be clothing or avoiding the sun altogether.

## POLICY ACTIONS: DUMPING THE MONTREAL PROTOCOL

The above discussion demonstrates that the scientific evidence does not support the Montreal Protocol and all subsequent efforts to phase out CFCs, halons, methyl bromide, carbon tetrachloride, and other important chemicals. Substitutes will surely be found, but much testing will be necessary to establish their safety and effectiveness (43). Then there is the huge cost, estimated at over \$200 billion worldwide, of replacing

capital equipment that cannot accept the substitutes (44), plus the as yet unquantified additional costs of regulatory uncertainty, as activists attack many CFC substitutes as "ozone-unfriendly" and demand their early phaseout. The American public may not take kindly to those who are imposing a \$1000 burden on every household with no obvious benefit. It will be interesting to see whether the new scientific results, and a scrutiny of the older ones, will force also a re-examination of existing policies.

This scrutiny has already begun. California Congressman John Doolittle, in an October 18, 1994 letter to EPA Administrator Carol Browner, suggested that EPA revise its 1987 cost-benefit analysis in light of the new scientific results on melanoma. In reply, EPA seems unwilling to accept Setlow's results until confirmed in a mammalian species, and raised various other objections. In a private communication to me, dated November 29, 1994, Setlow points out that both fish and humans have melanocytes that produce the pigment melanin, whose absorption of a UV-A photon is presumed to lead to DNA damage within the melanocyte cell. In dealing with the other EPA objections, Setlow states that "one cannot use epidemiological data that relate skin cancer to latitude to determine what wavelengths are important in skin cancer induction. If the EPA does not understand this simple point, it should not be involved in cost-benefit analysis."

Might the U.S. withdraw from the Montreal Protocol? "Scientific evidence indicates that CFCs are causing no substantive damage to our atmosphere," Congressman DeLay has stated in introducing his bill. From his frontal assault on the Clean Air Act it is but a short step to call for U.S. withdrawal from the international agreement entered into in 1987, ostensibly to "protect" the global ozone layer (though at the time there was no hard evidence that it needed protecting). Withdrawal from the Protocol and canceling the ban on CFCs may seem improbable at this late stage, however—in view of the physical, political, and emotional investments that have been made. International bureaucrats, federal regulators, environmental zealots, and especially chemical manufacturers are all counting on governments to abolish these chemicals in favor of substitutes that are often unproven or nonexistent.

Yet momentum against Montreal is building. In addition to Representatives DeLay and Doolittle, other members of Congress, on both sides of the aisle, are raising concerns about the precipitous phaseout of CFCs (freons), fire-fighting bromocarbons (halons), and the

near-irreplaceable agricultural fumigant methyl bromide. The concerns could sky-rocket when motorists find themselves without air-conditioning—short of paying extortionary prices.

Less satisfactory than dumping Montreal, but more likely as a first step, might be a delay in the phaseout date of halocarbons, perhaps returning it to the year 2000. That was the date in effect in 1992 before President Bush advanced the phaseout, stampeded by a misleading NASA press conference, which raised fears of an "ozone hole over Kennebunkport," and a panicky Senate resolution, spearheaded by then-Senator Al Gore. Michigan Democrat John Dingell initiated an inquiry into the press conference that started it all, but has failed to follow through. Perhaps the time has come to complete his investigation into the events of February 1992.

The absence of a sufficient scientific base for the ozone issue is not yet widely recognized, and a halocarbon phaseout is by now well supported by entrenched constituencies, including even some scientists who have staked their reputation and research budgets on this issue. Nevertheless, it is important for the future of scientific inquiry to permit free and open debate on the shortcomings of the CFC theory and the other scientific "facts" that have been used to shore up the Montreal policy. This will take time, however, and some attention by the Congress.

The trend in recent years has been towards stifling debate by various means: denial of research funds to younger academic researchers who hold "unconventional" views; the muzzling of senior scientists in government service; even the dismissal of federal appointees who boldly suggest that theories be validated by measurements. It is in this climate of intimidation and *ad hominem* attacks that Congress has been vainly trying to get at the facts. Yet with the federal research budget for "global change" now at the level of \$2.1 billion a year—topping even the budget of the National Cancer Institute—it should not be too difficult to find the answers.

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Mr. ROHRABACHER. Dr. Albritton.

**STATEMENT OF DR. DANIEL L. ALBRITTON, DIRECTOR, AERONOMY LABORATORY, ENVIRONMENTAL RESEARCH LABORATORIES, NOAA, BOULDER, CO**

Dr. ALBRITTON. Thank you, Mr. Chairman, Members of the Subcommittee.

My name is Dan Albritton. I'm director of NOAA's Aeronomy Laboratory in Boulder, Colorado.

For over 30 years, our laboratory has studied atmospheric chemistry, including the chemistry of the ozone layer.

In addition, in the past several years, I've served as co-chair, along with my colleague, Dr. Watson, of the Ozone Science Assessment Panel of the United Nations Environment Program.

Our job there has been to coordinate the preparation of the scientific assessments of the world-wide ozone science community.

In these two capacities, I certainly appreciate the invitation to appear before the Subcommittee and to summarize the current understanding that the world-wide ozone community has of ozone depletion.

Let me underscore right at the outset that the summary that I'm about to give you is not my own assessment. It is indeed the statement of the vast majority of the active and practicing world's ozone researchers regarding the current state of understanding of ozone depletion based upon their own results and their own laboratories, their field observations and their atmospheric monitoring and their theoretical modelling.

As part of the advice to world government's on the ozone layer, this ozone community has prepared a series of such state of understanding assessments.

In 1985, they prepared this summary, which was used as input by governments for decisions under the Montreal Protocol in 1987.

In 1989, they updated their ozone understanding for the discussions of governments in the London Amendment in 1990. And in 1991, they updated it further to describe the new findings over the last years. And that was input to the Copenhagen Amendments in 1992.

And now, as you have already cited, the world science community has summarized a current viewpoint on ozone depletion and its executive summary is the article in the short book that you have as part of your package.

These periodic assessments by the community have been deemed to have very high value. They are, first of all, scientific documents. They're based upon the published extensive scientific literature read by colleagues world-wide.

Therefore, they are a solid basis for decision-making, in contrast to anecdotal statements or privately published viewpoints.

They are pure science. The community makes no policy recommendations. That's the job of others, like yourselves, that are entrusted with the public welfare.

Secondly, these are majority statements. In fact, the very, very vast majority. This assessment was prepared by 250 scientists world-wide and peer-reviewed by 150 others.

It's therefore a touchstone of the opinion of the large community. This is in contrast to the sporadic and separate statements reflecting the opinions of either one person or a small group of individuals.

Fourthly, it's an international assessment and it draws from the world scientific community—all nations, all viewpoints, and therefore, international problems can be addressed on a common playing field.

And finally, the scientific scope is comprehensive. Both the natural changes in ozone and the human-induced changes in ozone are considered together. And that's much more comprehensive than a single statement about a single observation or a single publication.

Let me indicate to you the four key conclusions from this. And I'll do it in a graphical form to supplement the points that my colleague, Dr. Watson, mentioned.

The first point is that very large seasonal depletions of the ozone layer continue year after year to be observed in Antarctica. Forty years of Antarctic ozone data records show that this began in the 1970s and has grown larger since then.

This first chart shows the normal ozone layer as the solid line and the dashed line shows what's happened during the ozone hole. The hatched area indicates the ozone that's lost over Antarctica every year.

As Dr. Watson mentioned, the cause of this is certain. It's the anthropogenic man-made compounds of chlorine and bromine, in combination with the special conditions of Antarctica, that has accelerated the ozone depletion there, in contrast to elsewhere.

Mr. ROHRABACHER. Dr. Albritton, could I just stop you right there for one second? I want to clarify that point.

Dr. ALBRITTON. Certainly.

Mr. ROHRABACHER. You're saying that the natural—you just said it was caused by man-made.

Dr. ALBRITTON. That's right.

Mr. ROHRABACHER. You're suggesting, then, that natural causes do not contribute to this?

Dr. ALBRITTON. Natural causes are not the source of the downward trend and growing size of the ozone hole year by year.

Mr. ROHRABACHER. Okay. Thank you.

Dr. ALBRITTON. The evidence for this are direct observations that the ozone-depleting compounds are 100 times larger in Antarctica than one would expect without the special conditions of Antarctica and the chlorine there.

Secondly, in every place that these compounds are high, ozone is low.

And thirdly, that these ozone losses and high depleting compounds appear in the presence of the ice particles that accelerate the chlorine effect in Antarctica.

The second point I wanted to underscore visually with you is that ozone depletion continues to be observed by the eye over much of the globe.

The second chart shows how the ozone levels have changed over the past 30 years of observations from the ground-based network. The top box gives the raw data that these instruments take and in that you can see the very clear, reproducible, year-by-year an-

nual cycle of ozone simply because, like much of the planet, ozone depends in part on solar activity.

The lower panel shows the data after this well-known annual cycle and other variations of natural causes like solar activity and dynamics have been taken out.

My point is, regardless of which one you look at, the downward trend of the last 15 years is clear.

The third point that I wanted to underscore with you is that when ozone is depleted above, ultraviolet radiation increases at the surface.

The third chart shows data taken over long time periods that indicate that any time ozone goes down, as you move toward the left, that ultraviolet radiation goes up. And those changes are very close to what one would expect from the scattering of ultra-violet radiation and the absorption by ozone. And therefore, it is an absolute certainty that if one reduces ozone overhead, you will increase the ultra-violet radiation at the surface.

The final point I wanted to make is looking ahead to the future.

Point number four. The maximum ozone losses will likely occur in the next ten years, and thereafter our ozone layer will slowly recover. And let me explain what I mean by that.

This chart shows what has been. It also shows what might have occurred. And thirdly, it shows what is now anticipated if compliance with our international agreements is maintained.

In particular, solid curve on the left shows the observed and measured growth of the ozone depleters since 1950 up until present.

That means the burden of atmospheric chlorine has increased four times over the natural levels. If there had been no agreed-upon change in the production of those, the upper dotted curve indicates how chlorine would have grown in the atmosphere had there been no Montreal Protocol.

And finally, the dashed curve on the lower bottom scale on the right indicates what one would expect for atmospheric chlorine if there is full compliance with agreements that are to date.

Notice that that recovery is slow, and this is a very crucial point—that once placed in the atmosphere, CFCs and other compounds live a very long time. They outlive us. And therefore, even if decisions are made now, the recovery takes a very long time. And this indicates the point that if one waits, two larger effects on downward ozone trend are observed to take any actions or to have reversed actions.

It implies that the consequences of that will continue well into the next century.

In summary, Mr. Chairman, let me just note that this hearing actually began about 20 years ago, when scientists recognized the possibility that our own actions could inadvertently effect the ozone layer. And over that period, some of the world's brightest and most productive atmospheric scientists have sharpened the picture of that initial point.

Several of those scientists are in the U.S. National Academy of Sciences because of their ozone research. They have focused on understanding that problem and they have focused on telling you and others their story based on the world-wide opinion of scientists.

And so I conclude by noting that while I am speaking for them, it is the world-wide ozone research community that you just heard from.

Thank you, sir.

[The complete prepared statement of Dr. Albritton (and the Executive Summary) follow:]

TESTIMONY OF  
DR. DANIEL L. ALBRITTON  
DIRECTOR, AERONOMY LABORATORY  
ENVIRONMENTAL RESEARCH LABORATORIES  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION  
U. S. DEPARTMENT OF COMMERCE

BEFORE THE  
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT  
COMMITTEE ON SCIENCE

20 SEPTEMBER 1995

Mr. Chairman and Members of the Subcommittee:

My name is Dan Albritton. In brief, I am Director of NOAA's Aeronomy Laboratory in Boulder, Colorado, which studies the chemistry and dynamics of the Earth's atmosphere. I am also Cochair, along with Dr. Robert Watson (USA) and Dr. Piet Aucamp (South Africa), of the Ozone Science Assessment Panel of the United Nations Environment Programme, which provides scientific input to the Montreal Protocol on Substances that Deplete the Ozone Layer. In these two capacities, I appreciate this opportunity to appear before your Subcommittee to discuss the scientific understanding of stratospheric ozone depletion.

As you requested, I will focus this testimony on the scientific understanding of the ozone layer and of the impact of human activities on it. This text will summarize three aspects. (1) the series of scientific assessments that the world ozone research community has made of the state of that understanding, (2) the key points of the current scientific understanding of the ozone layer that were described in the most recent of those assessment reports, and (3) answers to common questions about ozone that were prepared as part of the "Scientific Assessment of Ozone Depletion: 1994".

## I. SCIENTIFIC ASSESSMENTS BY THE WORLD RESEARCH COMMUNITY

In 1994, the worldwide ozone-science research community prepared the seventh in their series of assessments of the scientific understanding of the Earth's ozone layer and its

relation to humankind: "Scientific Assessment of Ozone Depletion: 1994", pp. 580. (Copies are available for the Subcommittee members, if desired.) This assessment report will be part of the information upon which the Parties to the United Nations Montreal Protocol will base their future decisions regarding protection of the stratospheric ozone layer. There are two companion reports to this scientific assessment. They focus on (i) the environmental and health effects of ozone layer depletion and on (ii) the technology and economic implications of mitigation approaches.

This series of scientific reports prepared by the world's leading experts in the atmospheric sciences under the international auspices of the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) are listed below. The chronology of those scientific assessments and the relation to the international policy process are summarized as follows:

| <u>Year</u> | <u>Policy Process</u> | <u>Scientific Assessment</u>   |
|-------------|-----------------------|--|
| 1981        |                       | "The Stratosphere 1981 Theory and Measurements". WMO No. 11.   |
| 1985        | Vienna Convention     | "Atmospheric Ozone 1985". 3 vol. WMO No. 16.   |
| 1987        | Montreal Protocol     |  |
| 1988        |                       | "International Ozone Trends Panel Report 1988". 2 vol. WMO No. 18.   |
| 1989        |                       | "Scientific Assessment of Stratospheric Ozone: 1989". 2 vol. WMO No. 20.                                   |
| 1990        | London Amendment      |  |
| 1991        |                       | "Scientific Assessment of Ozone Depletion: 1991". WMO No. 25.  |
| 1992        |                       | "Methyl Bromide: Its Atmospheric Science, Technology, and Economics" (Assessment Supplement). UNEP (1992). |
| 1992        | Copenhagen Amendment  |  |
| 1994        |                       | "Scientific Assessment of Ozone Depletion: 1994". WMO No. 37.  |
| (1995)      | Vienna Amendment (?)  |  |



The genesis of "Scientific Assessment of Ozone Depletion: 1994" occurred at the Fourth meeting of the Conference of the Parties to the Montreal Protocol in Copenhagen, Denmark, in November 1992, at which the scope of the scientific needs of the Parties was defined. The formal planning of the present report was a workshop in 1993 at which an international steering group crafted the outline and suggested scientists from the world community to serve as authors. The first drafts of the chapters were examined at a meeting in early 1994 at which the authors and a small number of international experts improved the coordination of the text of the chapters.

The second draft was sent out to 123 scientists worldwide for a mail peer review. These anonymous comments were considered by the authors. At a meeting in Switzerland during the summer of 1994, the responses to these mail review comments were proposed by the authors and discussed by the 80 participants. Final changes to the chapters were decided upon, and the Executive Summary was prepared by the participants. The group also focused on a set of questions commonly asked about the ozone layer. Based upon the scientific understanding represented by the assessments, answers to these common questions were prepared.

As the report documents, the "Scientific Assessment of Ozone Depletion: 1994" is the product of 295 scientists from 36 countries, representing the developed and developing world, who contributed to its preparation and review (230 scientists prepared the report and 147 scientists participated in the peer review process). What follows in this testimony is a summary from the report of their current understanding of the stratospheric ozone layer and its relation to humankind.

While the "Scientific Assessment of Ozone Depletion: 1994" is a scientific document, its value to decision makers is considerable. The reasons for this are several fold:

- o *It is strong single concise statement from the large majority of the ozone scientific community.* In the assessment, the major representatives of the ozone research community speak at one time and one place regarding the current understanding of ozone depletion. The report, therefore, is a common reference point for decision makers, in contrast to sporadic and separate statements reflecting the opinions of one person or a few individuals.
- o *It is an international scientific assessment.* With it, all nations have a common basis of scientific input for their decision making, as opposed to several national statements. Where appropriate, scientists from developing countries are involved in preparing the assessment to the fullest extent possible.
- o *The scientific scope is comprehensive.* With the report, decision makers have available

a single, homogeneous summary of the current scientific understanding of the whole ozone-change phenomenon, ranging from the agents that cause change to the ozone-layer responses. This is more useful than separate reviews of components of the phenomenon done at different times and perhaps for different purposes.

o *Both natural and human-induced ozone-layer changes are considered* In contrast to considering only the perturbation of the ozone layer by human activities, the assessment places that human-induced change in the context of the observed and predicted changes that are a natural part of the ozone layer. The comparison of the two affords immediate and straightforward insight into the significance of the human-induced perturbations relative to the natural variations.

## II. RECENT MAJOR SCIENTIFIC FINDINGS AND OBSERVATIONS

The laboratory investigations, atmospheric observations, and theoretical and modeling studies of the past few years have provided a deeper understanding of the human-influenced and natural chemical changes in the atmosphere and their relation to the Earth's stratospheric ozone layer and radiative balance of the climate system. The "Scientific Assessment of Ozone Depletion: 1994" reported several key ozone-related findings, observations, and conclusions and are the basis for the points summarized below.

### Changes in Ozone-Depleting Gases

- o *The atmospheric growth rates of several major ozone-depleting substances have slowed, demonstrating the expected impact of the Montreal Protocol and its Amendments and Adjustments.* The abundances of the human-produced chlorofluorocarbons (CFCs), carbon tetrachloride, methyl chloroform, and halons in the atmosphere have been monitored at global ground-based sites since about 1978. Over much of that period, the annual growth rates of these gases have been positive. However, the data of recent years clearly show that the growth rates of CFC-11, CFC-12, halon-1301, and halon-1211 are slowing down. The abundance of carbon tetrachloride is actually decreasing. The observed trends in total of these chlorine-containing compounds are consistent with reported production data, suggesting less emission than the maximum allowed under the Montreal Protocol and its Amendments and Adjustments. Peak stratospheric total chlorine/ bromine loading in the troposphere, most of which is human-produced, is expected to occur in 1994, but the peak in the stratospheric will lag by about 3 - 5 years. Since the stratospheric abundances of chlorine and bromine are expected to continue to grow for a few more years, increasing global ozone losses are predicted (other things being equal) for the remainder of the decade, with gradual recovery in the 21st century.
- o *The atmospheric abundances of several of the CFC substitutes are increasing, as anticipated.* With phaseout dates for the CFCs and other ozone-depleting substances now fixed by international agreements, several hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) are being manufactured and used as substitutes. The atmospheric growth of some of these compounds (e.g., HCFC-22) has been observed now for several years.
- o *Methyl bromide continues to be viewed as a significant ozone-depleting compound.* Increased attention has been focused upon the ozone-depleting role of methyl bromide. Three potentially major anthropogenic sources of atmospheric methyl bromide have been identified (soil fumigation, biomass burning, and the exhaust of automobiles using leaded

gasoline), in addition to the natural oceanic source. While the magnitude of the atmospheric photochemical removal is well understood, there are significant uncertainties in quantifying the oceanic sink for atmospheric methyl bromide. The Ozone Depletion Potential (ODP) for methyl bromide is calculated to be about 0.6 (relative to an ODP of 1 for CFC-11).

#### Changes in Midlatitude and Equatorial Ozone Abundance

- o *Downward trends in total-column ozone continue to be observed over much of the globe, and their magnitudes are larger than those predicted by numerical ozone-loss models.* Decreases in ozone abundances of about 4 - 5% per decade at midlatitudes in the Northern and Southern Hemispheres continue to be observed by both ground-based and satellite-borne monitoring instruments. At midlatitudes, the losses continue to be much larger during winter/spring than during summer/fall in both hemispheres, and the depletion increases with latitude, particularly in the Southern Hemisphere. Little or no downward trends are observed in the tropics (20°N - 20°S). While the current two-dimensional stratospheric models simulate the observed trends quite well during some seasons and latitudes, they underestimate the trends by factors of up to three in winter/spring at mid- and high latitudes. Several known atmospheric processes that involve chlorine and bromine and that affect ozone in the lower stratosphere are difficult to model and have not been adequately incorporated into these models.

- o *Record low global ozone levels were measured over the past two years.* Anomalous ozone decreases were observed in the midlatitudes of both hemispheres in 1992 and 1993. The Northern Hemispheric decreases were larger than those in the Southern Hemisphere. Globally, ozone values were 1 - 2% lower than would be expected from an extrapolation of the trend prior to 1991, allowing for solar-cycle and periodic meteorological effects. The 1994 global ozone levels are returning to values closer to those expected from the longer-term downward trend.

- o *The stratosphere was temporarily perturbed by a major volcanic eruption.* The eruption of Mt. Pinatubo in 1991 led to a large increase in sulfate aerosol in the lower stratosphere throughout the globe. Reactions on sulfate aerosols resulted in significant, but temporary, changes in the chemical partitioning that accelerated the photochemical ozone loss associated with reactive hydrogen, chlorine, and bromine compounds in the lower stratosphere in midlatitudes and polar regions. These and other recent scientific findings strengthen the conclusion of the previous assessment that the weight of scientific evidence suggests that the observed middle- and high-latitude ozone losses are largely due to

anthropogenic chlorine and bromine compounds. The observed 1994 recovery of global ozone is qualitatively consistent with observed gradual reductions of the abundances of these volcanic particles in the stratosphere.

#### Changes in Polar Ozone

o *The Antarctic ozone "holes" of 1992 and 1993 were the most severe on record.* The Antarctic ozone "hole" has continued to occur seasonally every year since its advent in the late-1970s, with the occurrences over the last several years being particularly pronounced. Satellite, balloon-borne, and ground-based monitoring instruments revealed that the Antarctic ozone "holes" of 1992 and 1993 were the biggest (areal extent) and deepest (minimum amounts of ozone overhead), with ozone being locally depleted by more than 99% between about 14 - 19 kilometers in October, 1992 and 1993. It is likely that these larger-than-usual ozone depletions could be attributed, at least in part, to sulfate aerosols from Mt. Pinatubo increasing the effectiveness of chlorine- and bromine-catalyzed ozone destruction. A substantial Antarctic ozone "hole" is expected to occur each austral spring for many more decades because stratospheric chlorine and bromine abundances will approach the pre-Antarctic-ozone-"hole" levels (late-1970s) very slowly during the next century.

o *The conclusion that human-produced chlorine and bromine compounds, coupled with surface chemistry on natural polar stratospheric particles, are the cause of polar ozone depletion has been further strengthened.* Laboratory studies have provided a greatly improved understanding of how the chemistry on the surfaces of ice, nitrate, and sulfate particles can increase the abundance of ozone-depleting forms of chlorine in the polar stratospheres. Furthermore, satellite and in situ observations of the abundances of reactive nitrogen and chlorine compounds have improved the explanation of the different ozone-altering properties of the Antarctic and Arctic.

o *Ozone losses have been detected in the Arctic winter stratosphere, and their links to chlorine and bromine chemistry have been established.* Studies in the Arctic lower stratosphere have been expanded to include more widespread observations of ozone and key reactive species. In the late-winter/early-spring period, additional chemical losses of ozone up to 15 - 20% at some altitudes are deduced from these observations, particularly in the winters of 1991/2 and 1992/3. Model calculations constrained by the observations are also consistent with these losses, increasing the confidence in the role of chlorine and bromine in ozone destruction. The interannual variability in the photochemical and dynamical conditions of the Arctic polar vortex continues to limit the ability to predict ozone changes in future

years.

### Ozone Depletion and Radiation

o *The link between a decrease in stratospheric ozone and an increase in surface ultraviolet (UV) radiation has been further strengthened.* Measurements of UV radiation at the surface under clear-sky conditions show that low overhead ozone yields high UV radiation and in the amount predicted by radiative-transfer theory. Large increases of surface UV are observed in Antarctica and the southern part of South America during the period of the seasonal ozone "hole." Furthermore, elevated surface UV levels at mid-to-high latitudes were observed in the Northern Hemisphere in 1992 and 1993, corresponding to the low ozone levels of those years. However, the lack of a decadal (or longer) record of accurate monitoring of surface UV levels and the variation introduced by clouds and other factors have precluded the unequivocal identification of a long-term trend in surface UV radiation.

o *Stratospheric ozone losses cause a global-mean negative radiative forcing of the climate system.* In the 1991 scientific assessment, it was pointed out that the global ozone losses that were occurring in the lower stratosphere caused this region to cool and result in less radiation reaching the surface-troposphere system. Recent model studies have strengthened this picture. A long-term global-mean cooling of the lower stratosphere of between 0.25 and 0.4 degrees Celsius per decade has been observed over the last three decades. Calculations indicate that, on a global mean, the ozone losses between the 1980 and 1990 offset about 20% of the radiative forcing due to the well-mixing greenhouse-gas increases during that period (i.e., carbon dioxide, methane, nitrous oxide, and halocarbons).

### Future Ozone Changes

The research findings of the past few years that are summarized above have several major implications as scientific input to governmental, industrial, and other choices regarding human-influenced substances that lead to depletion of the stratospheric ozone layer and to changes of the radiative forcing of the climate system:

o *The Montreal Protocol and its Amendments and Adjustments are reducing the impact of anthropogenic halocarbons on the ozone layer and should eventually eliminate this ozone depletion.* Based on assumed compliance with the amended Montreal Protocol (Copenhagen, 1992) by all nations, the stratospheric chlorine abundances will continue to grow from their current levels to a peak around the turn of the century. The future total bromine loading will depend upon choices made regarding future human production and emissions of methyl bromide. After around the turn of the century, the levels of stratospheric chlorine and bromine will begin a decrease that will continue into the 21st

and 22nd centuries. The rate of decline is dictated by the long residence times of the CFCs, carbon tetrachloride, and halons. Global ozone losses and the Antarctic ozone "hole" were first discernible in the late 1970s and are predicted to recover in about the year 2045, other things being equal. The recovery of the ozone layer would have been impossible without the Amendments and Adjustments to the original Protocol (Montreal, 1987).

o *Peak global ozone losses are expected to occur during the next several years.* The ozone layer will be most affected by human-influenced perturbations and susceptible to natural variations in the period around the year 1998, since the peak stratospheric chlorine and bromine abundances are expected to occur then. Based on extrapolation of current trends, observations suggest that the maximum ozone loss, relative to the late 1960s, will likely be:

- (i) about 12 - 13% at Northern midlatitudes in winter/spring (i.e., about 2.5% above current levels);
- (ii) about 6 - 7% at Northern midlatitudes in summer/fall (i.e., about 1.5% above current levels); and
- (iii) about 11% (with less certainty) at Southern midlatitudes on a year-round basis (i.e., about 2.5% above current levels).

Such changes would be accompanied by 15%, 8%, and 13% increases, respectively, in surface erythral radiation, if other influences such as clouds remain constant. Moreover, if there were to be a major volcanic eruption like that of Mt. Pinatubo, or if an extremely cold and persistent Arctic winter were to occur, then the ozone losses and UV increases could be larger in individual years.

o *Approaches to lowering stratospheric chlorine and bromine abundances are limited.*

Further controls on ozone-depleting substances would not be expected to significantly change the timing or the magnitude of the peak stratospheric halocarbon abundances and hence peak ozone loss. However, there are four approaches that would steepen the initial fall from the peak halocarbon levels in the early decades of the next century:

(i) If emissions of methyl bromide from agricultural, structural, and industrial activities were to be eliminated in the year 2001, then the integrated effective future chlorine loading above the 1980 level (which is related to the cumulative future loss of ozone) is predicted to be 13% less over the next 50 years relative to full compliance to the Amendments and Adjustments to the Protocol.

(ii) If emissions of HCFCs were to be totally eliminated by the year 2004, then the integrated effective future chlorine loading above the 1980 level is predicted to be 5% less over the next 50 years relative to full compliance with the Amendments and Adjustments to the Protocol.

(iii) If halons presently contained in existing equipment were never released to the

atmosphere, then the integrated effective future chlorine loading above the 1980 level is predicted to be 10% less over the next 50 years relative to full compliance with the Amendments and Adjustments to the Protocol.

(iv) If CFCs presently contained in existing equipment were never released to the atmosphere, then the integrated effective future chlorine loading above the 1980 level is predicted to be 3% less over the next 50 years relative to full compliance with the Amendments and Adjustments to the Protocol.

o *Failure to adhere to the international agreements will delay recovery of the ozone layer.* If there were to be additional production of CFCs at 20% of 1992 levels for each year through 2002 and ramped to zero by 2005 (beyond that allowed for countries operating under Article 5 of the Montreal Protocol), then the integrated effective future chlorine loading above the 1980 level is predicted to be 9% more over the next 50 years relative to full compliance to the Amendments and Adjustments to the Protocol.

o *Many of the substitutes for the CFCs and halons are also notable greenhouse gases.* Several CFC and halon substitutes are not addressed under the Montreal Protocol (because they do not deplete ozone), but, because they are greenhouse gases, fall under the purview of the Framework Convention on Climate Change. There is a wide range of values for the Global Warming Potentials (GWPs) of the HFCs (150 - 10000), with about half of them having values comparable to the ozone-depleting compounds they replace. The perfluorinated compounds, some of which are being considered as substitutes, have very large GWPs (e.g., 5000 - 10000). These are examples of compounds whose current atmospheric abundances are relatively small, but are increasing or could increase in the future.

o *Consideration of the ozone change will be one necessary ingredient in understanding climate change.* The extent of our ability to attribute any climate change to specific causes will likely prove to be important scientific input to decisions regarding predicted human-induced influences on the climate system. Changes in ozone since pre-industrial times as a result of human activity are believed to have been a significant influence on radiative forcing; this human influence is expected to continue into the foreseeable future.

### III. COMMON QUESTIONS RAISED ABOUT THE OZONE LAYER

The above points summarize the current scientific understanding of the ozone layer and its depletion by human-produced chemicals. But often more-general questions arise - for example, by the public - about this environmental issue. The "Scientific Assessment of Ozone Depletions: 1994" also addressed the information needs of this audience by



including a set of common questions about ozone, with answers by the scientific community prepared for a general readership. This section of the assessment report is attached (without figures) as Annex 1 to this testimony.

Mr. Chairman, this concludes my prepared text. I would be pleased to answer any questions that you or the Subcommittee may have.

## ANNEX 1. COMMON QUESTIONS ABOUT OZONE

Ozone is exceedingly rare in our atmosphere, averaging about 3 molecules of ozone for every ten million air molecules. Nonetheless, atmospheric ozone plays vital roles that belie its small numbers. This Appendix to the World Meteorological Organization/United Nations Environment Programme (WMO/UNEP) "Scientific Assessment of Ozone Depletion: 1994" answers some of the questions that are most commonly asked about ozone and the changes that have been occurring in recent years. These common questions and their answers were discussed by the 80 scientists from 26 countries who participated in the Panel Review Meeting of the "Scientific Assessment of Ozone Depletion: 1994." Therefore, this information is presented by a large group of experts from the international scientific community.

Ozone is mainly found in two regions of the Earth's atmosphere. Most ozone (about 90%) resides in a layer between approximately 10 and 50 kilometers (about 6 to 30 miles) above the Earth's surface, in the region of the atmosphere called the stratosphere. This stratospheric ozone is commonly known as the "ozone layer." The remaining ozone is in the lower region of the atmosphere, the troposphere, which extends from the Earth's surface up to about 10 kilometers.

While the ozone in these two regions is chemically identical (both consist of three oxygen atoms and have the chemical formula " $O_3$ "), the ozone molecules have very different effects on humans and other living things depending upon their location.

Stratospheric ozone plays a beneficial role by absorbing most of the biologically damaging ultraviolet sunlight called UV-B, allowing only a small amount to reach the Earth's surface. The absorption of UV radiation by ozone creates a source of heat, which actually forms the stratosphere itself (a region in which the temperature rises as one goes to higher altitudes). Ozone thus plays a key role in the temperature structure of the Earth's atmosphere. Furthermore, without the filtering action of the ozone layer, more of the Sun's UV-B radiation would penetrate the atmosphere and would reach the Earth's surface in greater amounts. Many experimental studies of plants and animals, and clinical studies of humans, have shown the harmful effects of excessive exposure to UV-B radiation (these are discussed in the WMO/UNEP reports on impacts of ozone depletion, which are companion documents to the WMO/UNEP scientific assessments of ozone depletion).

At the planet's surface, ozone comes into direct contact with life-forms and displays its destructive side. Because ozone reacts strongly with other molecules, high levels are toxic to living systems and can severely damage the tissues of plants and animals. Many studies have documented the harmful effects of ozone on crop production, forest growth, and

human health. The substantial negative effects of surface-level tropospheric ozone from this direct toxicity contrast with the benefits of the additional filtering of UV-B radiation that it provides.

With these dual aspects of ozone come two separate environmental issues, controlled by different forces in the atmosphere. In the troposphere, there is concern about *increases* in ozone. Low-lying ozone is a key component of smog, a familiar problem in the atmosphere of many cities around the world. Higher than usual amounts of surface-level ozone are now increasingly being observed in rural areas as well. However, the ground-level ozone concentrations in the smoggiest cities are very much smaller than the concentrations routinely found in the stratosphere.

There is widespread scientific and public interest and concern about *losses* of stratospheric ozone. Ground-based and satellite instruments have measured decreases in the amount of stratospheric ozone in our atmosphere. Over some parts of Antarctica, up to 60% of the total overhead amount of ozone (known as the "column ozone") is depleted during September and October. This phenomenon has come to be known as the Antarctic "ozone hole." Smaller, but still significant, stratospheric decreases have been seen at other, more-populated regions of the Earth. Increases in surface UV-B radiation have been observed in association with decreases in stratospheric ozone.

The scientific evidence, accumulated over more than two decades of study by the international research community, has shown that human-made chemicals are responsible for the observed depletions of the ozone layer over Antarctica and likely play a major role in global ozone losses. The ozone-depleting compounds contain various combinations of the chemical elements chlorine, fluorine, bromine, carbon, and hydrogen, and are often described by the general term *halocarbons*. The compounds that contain only carbon, chlorine, and fluorine are called *chlorofluorocarbons*, usually abbreviated as *CFCs*. CFCs, carbon tetrachloride, and methyl chloroform are important human-made ozone-depleting gases that have been used in many applications including refrigeration, air conditioning, foam blowing, cleaning of electronics components, and as solvents. Another important group of human-made halocarbons is the *halons*, which contain carbon, bromine, fluorine, and (in some cases) chlorine, and have been mainly used as fire extinguishants. Governments have decided to discontinue production of CFCs, halons, carbon tetrachloride, and methyl chloroform, and industry has developed more "ozone-friendly" substitutes.

Two responses are natural when a new problem has been identified: cure and prevention. When the problem is the destruction of the stratospheric ozone layer, the corresponding questions are: Can we repair the damage already done? How can we

prevent further destruction? Remedies have been investigated that could (i) remove CFCs selectively from our atmosphere, (ii) intercept ozone-depleting chlorine before much depletion has taken place, or (iii) replace the ozone lost in the stratosphere (perhaps by shipping the ozone from cities that have too much smog or by making new ozone). Because ozone reacts strongly with other molecules, as noted above, it is too unstable to be made elsewhere (e.g., in the smog of cities) and transported to the stratosphere. When the huge volume of the Earth's atmosphere and the magnitude of global stratospheric ozone depletion are carefully considered, approaches to cures quickly become much too expensive, impractical, and potentially damaging to the global environment. Prevention involves the internationally agreed-upon Montreal Protocol and its Amendments and Adjustments, which call for elimination of the production and use of the CFCs and other ozone-damaging compounds within the next few years. As a result, the ozone layer is expected to recover over the next fifty years or so as the atmospheric concentrations of CFCs and other ozone-depleting compounds slowly decay.

The current understanding of ozone depletion and its relation to humankind is discussed in detail by the leading scientists in the world's ozone research community in the *Scientific Assessment of Ozone Depletion: 1994*. The answers to the common questions posed below are based upon that understanding and on the information given in earlier WMO/UNEP reports.

### *How Can Chlorofluorocarbons (CFCs) Get to the Stratosphere If They're Heavier than Air?*

Although the CFC molecules are indeed several times heavier than air, thousands of measurements have been made from balloons, aircraft, and satellites demonstrating that the CFCs are actually present in the stratosphere. The atmosphere is not stagnant. Winds mix the atmosphere to altitudes far above the top of the stratosphere much faster than molecules can settle according to their weight. Gases such as CFCs that are insoluble in water and relatively unreactive in the lower atmosphere (below about 10 km) are quickly mixed and therefore reach the stratosphere regardless of their weight.

Much can be learned about the atmospheric fate of compounds from the measured changes in concentration versus altitude. For example, the two gases carbon tetrafluoride ( $\text{CF}_4$ , produced mainly as a by-product of the manufacture of aluminum) and CFC-11 ( $\text{CCl}_3\text{F}$ , used in a variety of human activities) are both much heavier than air. Carbon tetrafluoride is completely unreactive in the lower 99.9% of the atmosphere, and measurements show it to be nearly uniformly distributed throughout the atmosphere as shown in the figure. There have also been measurements over the past two decades of several other completely unreactive gases, one lighter than air (neon) and some heavier than

air (argon, krypton), which show that they also mix upward uniformly through the stratosphere regardless of their weight, just as observed with carbon tetrafluoride. CFC-11 is unreactive in the lower atmosphere (below about 15 km) and is similarly uniformly mixed there, as shown. The abundance of CFC-11 decreases as the gas reaches higher altitudes, where it is broken down by high energy solar ultraviolet radiation. Chlorine released from this breakdown of CFC-11 and other CFCs remains in the stratosphere for several years, where it destroys many thousands of molecules of ozone.

*What is the Evidence that Stratospheric Ozone is Destroyed by Chlorine and Bromine?*

Laboratory studies show that chlorine (Cl) reacts very rapidly with ozone. They also show that the reactive chemical chlorine oxide (ClO) formed in that reaction can undergo further processes which regenerate the original chlorine, allowing the sequence to be repeated very many times (a "chain reaction"). Similar reactions also take place between bromine and ozone.

But do these ozone-destroying reactions occur in the real world? All of our accumulated scientific experience demonstrates that if the conditions of temperature and pressure are like those in the laboratory studies, the same chemical reactions will take place in nature. However, many other reactions including those of other chemical species are often also taking place simultaneously in the stratosphere, making the connections among the changes difficult to untangle. Nevertheless, whenever chlorine (or bromine) and ozone are found together in the stratosphere, the ozone-destroying reactions must be taking place.

Sometimes a small number of chemical reactions is so important in the natural circumstance that the connections are almost as clear as in laboratory experiments. Such a situation occurs in the Antarctic stratosphere during the springtime formation of the ozone hole. During August and September 1987 - the end of winter and beginning of spring in the Southern Hemisphere - aircraft equipped with many different instruments for measuring a large number of chemical species were flown repeatedly over Antarctica. Among the chemicals measured were ozone and chlorine oxide, the reactive chemical identified in the laboratory as one of the participants in the ozone-destroying chain reactions. On the first flights southward from the southern tip of South America, relatively high concentrations of ozone were measured everywhere over Antarctica. By mid-September, however, the instruments recorded low concentrations of ozone in regions where there were high concentrations of chlorine oxide and vice versa, as shown in the figure. Flights later in September showed even less ozone over Antarctica, as the chlorine continued to react with the stratospheric ozone.

Independent measurements made by these and other instruments on this and other airplanes, from the ground, from balloons, and from satellites have provided a detailed understanding of the chemical reactions going on in the Antarctic stratosphere. Regions with high concentrations of reactive chlorine reach temperatures so cold (less than approximately  $-80^{\circ}\text{C}$ , or  $-112^{\circ}\text{F}$ ) that stratospheric clouds form, a rare occurrence except during the polar winters. These clouds facilitate other chemical reactions that allow the release of chlorine in sunlight. The chemical reactions related to the clouds are now well understood through study under laboratory conditions mimicking those found naturally. Scientists are working to understand the role of such reactions of chlorine and bromine at other latitudes, and the involvement of particles of sulfuric acid from volcanoes or other sources.

*Does Most of the Chlorine in the Stratosphere Come from Human or Natural Sources?*

Most of the chlorine in the stratosphere is there as a result of human activities.

Many compounds containing chlorine are released at the ground, but those that dissolve in water cannot reach stratospheric altitudes. Large quantities of chlorine are released from evaporated ocean spray as sea salt (sodium chloride) aerosol. However, because sea salt dissolves in water, this chlorine quickly is taken up in clouds or in ice, snow, or rain droplets and does not reach the stratosphere. Another ground-level source of chlorine is its use in swimming pools and as household bleach. When released, this chlorine is rapidly converted to forms that dissolve in water and therefore are removed from the lower atmosphere, never reaching the stratosphere in significant amounts. Volcanoes can emit large quantities of hydrogen chloride, but this gas is rapidly converted to hydrochloric acid in rain water, ice, and snow and does not reach the stratosphere. Even in explosive volcanic plumes that rise high in the atmosphere, nearly all of the hydrogen chloride is scrubbed out in precipitation before reaching stratospheric altitudes.

In contrast, human-made halocarbons – such as CFCs, carbon tetrachloride ( $\text{CCl}_4$ ) and methyl chloroform ( $\text{CH}_3\text{CCl}_3$ ) – are not soluble in water, do not react with snow or other natural surfaces, and are not broken down chemically in the lower atmosphere. While the exhaust from the Space Shuttle and from some rockets does inject some chlorine directly into the stratosphere, this input is very small (less than one percent of the annual input from halocarbons in the present stratosphere, assuming nine Space Shuttle and six Titan IV rocket launches per year).

Several pieces of evidence combine to establish human-made halocarbons as the primary source of stratospheric chlorine. First, measurements have shown that the chlorinated species that rise to the stratosphere are primarily manufactured compounds (mainly CFCs,

carbon tetrachloride, methyl chloroform, and the HCFC substitutes for CFCs), together with small amounts of hydrochloric acid (HCl) and methyl chloride ( $\text{CH}_3\text{Cl}$ ) which are partly natural in origin. The natural contribution now is much smaller than that from human activities; as shown in the figure below. Second, in 1985 and 1992 researchers measured nearly all known gases containing chlorine in the stratosphere. They found that human emissions of halocarbons plus the much smaller contribution from natural sources could account for all of the stratospheric chlorine compounds. Third, the increase in total stratospheric chlorine measured between 1985 and 1992 corresponds with the known increases in concentrations of human-made halocarbons during that time.

### *Can Changes in the Sun's Output Be Responsible for the Observed Changes in Ozone?*

Stratospheric ozone is primarily created by ultraviolet (UV) light coming from the Sun, so the Sun's output affects the rate at which ozone is produced. The Sun's energy release (both as UV light and as charged particles such as electrons and protons) does vary, especially over the well-known 11-year sunspot cycle. Observations over several solar cycles (since the 1960s) show that total global ozone levels decrease by 1-2% from the maximum to the minimum of a typical cycle. Changes in the Sun's output cannot be responsible for the observed long-term changes in ozone, because these downward trends are much larger than 1-2%. Further, during the period since 1979, the Sun's energy output has gone from a maximum to a minimum in 1985 and back through another maximum in 1991, but the trend in ozone was downward throughout that time. The ozone trends presented in this and previous international scientific assessments have been obtained by evaluating the long-term changes in ozone concentrations after accounting for the solar influence.

### *When Did the Antarctic Ozone Hole First Appear?*

The Antarctic ozone hole is a new phenomenon. The figure shows that observed ozone over the British Antarctic Survey station at Halley Bay, Antarctica first revealed obvious decreases in the early 1980s compared to data obtained since 1957. The ozone hole is formed each year when there is a sharp decline (currently up to 60%) in the total ozone over most of Antarctica for a period of about two months during Southern Hemisphere spring (September and October). Observations from three other stations in Antarctica, also covering several decades, reveal similar progressive, recent decreases in springtime ozone. The ozone hole has been shown to result from destruction of stratospheric ozone by gases containing chlorine and bromine, whose sources are mainly human-made halocarbon gases.

Before the stratosphere was affected by human-made chlorine and bromine, the naturally occurring springtime ozone levels over Antarctica were about 30-40% lower than springtime ozone levels over the Arctic. This natural difference between Antarctic and Arctic conditions was first observed in the late 1950s by Dobson. It stems from the exceptionally cold temperatures and different winter wind patterns within the Antarctic stratosphere as compared to the Arctic. This is not at all the same phenomenon as the marked downward trend in total ozone in recent years referred to as the ozone hole.

Changes in stratospheric meteorology cannot explain the ozone hole. Measurements show that wintertime Antarctic stratospheric temperatures of past decades have not changed prior to the development of the hole each September. Ground, aircraft, and satellite measurements have provided, in contrast, clear evidence of the importance of the chemistry of chlorine and bromine originating from human-made compounds in depleting Antarctic ozone in recent years.

A single report of extremely low Antarctic winter ozone in one location in 1958 by an unproven technique has been shown to be completely inconsistent with the measurements depicted here and with all credible measurements of total ozone.

*Why is the Ozone Hole Observed over Antarctica When CFCs Are Released Mainly in the Northern Hemisphere?*

Human emissions of CFCs do occur mainly in the Northern Hemisphere, with about 90% released in the latitudes corresponding to Europe, Russia, Japan, and North America. Gases such as CFCs that are insoluble in water and relatively unreactive are mixed within a year or two throughout the lower atmosphere (below about 10 km). The CFCs in this well-mixed air rise from the lower atmosphere into the stratosphere mainly in tropical latitudes. Winds then move this air poleward – both north and south – from the tropics, so that air throughout the stratosphere contains nearly the same amount of chlorine. However, the meteorologies of the two polar regions are very different from each other because of major differences at the Earth's surface. The South Pole is part of a very large land mass (Antarctica) that is completely surrounded by ocean. These conditions produce very low stratospheric temperatures which in turn lead to formation of clouds (polar stratospheric clouds). The clouds that form at low temperatures lead to chemical changes that promote rapid ozone loss during September and October of each year, resulting in the ozone hole.

In contrast, the Earth's surface in the northern polar region lacks the land/ocean symmetry characteristic of the southern polar area. As a consequence, Arctic stratospheric



air is generally much warmer than in the Antarctic, and fewer clouds form there. Therefore, the ozone depletion in the Arctic is much less than in the Antarctic.

*Is the Depletion of the Ozone Layer Leading to an Increase in Ground-Level Ultraviolet Radiation?*

The Sun emits light over a wide range of energies, with about two percent given off in the form of high-energy, ultraviolet (UV) radiation. Some of this UV radiation (UV-B) is especially effective in causing damage to living things, including sunburn, skin cancer, and eye damage for humans. The amount of solar UV radiation received at any particular location on the Earth's surface depends upon the position of the Sun above the horizon, on the amount of ozone in the atmosphere, and upon local cloudiness and pollution. Scientists agree that in the absence of changes in clouds or pollution, decreases in atmospheric ozone will increase ground-level UV radiation.

The largest decreases in ozone during the last decade have been observed over Antarctica, especially during each September and October when the "ozone hole" forms. During the last several years, simultaneous measurements of UV radiation and total ozone have been made at several Antarctic stations. When the ozone amounts decrease, UV-B increases. Because of the ozone hole, the UV-B intensity at Palmer Station, Antarctica, in late October, 1993, was more intense than found at San Diego, California, at any time during all of 1993.

In areas where small ozone depletion has been observed, UV-B increases are more difficult to detect. Detection of UV trends associated with ozone decreases can also be complicated by changes in cloudiness or by local pollution, as well as by difficulties in keeping the detection instrument in precisely the same condition over many years. Prior to the late 1980s, instruments with the necessary accuracy and stability for measurement of small long-term trends in ground-level UV-B were not employed. Recently, however, such instruments have been used in the Antarctic because of the very large changes in ozone being observed there. When high-quality measurements have been made in other areas far from major cities and their associated air pollution, decreases in ozone have regularly been accompanied by increases in UV-B. The data from urban locations with older, less specialized instruments provide much less reliable information, especially because good simultaneous measurements are not available for any changes in cloudiness or local pollution.

*How Severe Is the Ozone Depletion Now, and Is It Expected to Get Worse?*

Scientific evidence shows that ozone depletion caused by human-made chemicals is continuing and is expected to persist until chlorine and bromine levels are reduced. Worldwide monitoring has shown that stratospheric ozone has been decreasing for the past two decades or more. Globally averaged losses have totaled about 5% since the mid-1960s, with cumulative losses of about 10% in the winter and spring and 5% in the summer and autumn over locations such as Europe, North America, and Australia. Since the late-1970s, an ozone "hole" has formed in Antarctica each Southern Hemisphere spring (September / October), in which up to 60% of the total ozone is depleted. The large increase in atmospheric concentrations of human-made chlorine and bromine compounds is responsible for the formation of the Antarctic ozone hole, and the weight of evidence indicates that it also plays a major role in midlatitude ozone depletion.

During 1992 and 1993 ozone in many locations dropped to record low values: springtime depletions exceeded 20% in some populated northern midlatitude regions, and the levels in the Antarctic ozone hole fell to the lowest values ever recorded. The unusually large ozone decreases of 1992 and 1993 are believed to be related, in part, to the volcanic eruption of Mount Pinatubo in the Philippines during 1991. This eruption produced large amounts of stratospheric sulfate aerosols that temporarily increased the ozone depletion caused by human-made chlorine and bromine compounds. Recent observations have shown that as those aerosols have been swept out of the stratosphere, ozone concentrations have returned to the depleted levels consistent with the downward trend observed before the Mount Pinatubo eruption.

In 1987 the recognition of the potential for chlorine and bromine to destroy stratospheric ozone led to an international agreement (The United Nations Montreal Protocol on Substances that Deplete the Ozone Layer) to reduce the global production of ozone-depleting substances. Since then, new global observations of significant ozone depletion have prompted amendments to strengthen the treaty. The 1992 Copenhagen Amendments call for a ban on production of the most damaging compounds by 1996. The assessment report shows past and projected future stratospheric abundances of chlorine and bromine: (a) without the Protocol; (b) under the Protocol's original provisions; and (c) under the Copenhagen Amendments now in force. Without the Montreal Protocol and its Amendments, continuing human use of CFCs and other compounds would have tripled the stratospheric abundances of chlorine and bromine by about the year 2050. Current scientific understanding indicates that such increases would have led to global ozone depletion very much larger than observed today. In contrast, under current international agreements, which are now reducing and will eventually eliminate human emissions of ozone-depleting gases, the stratospheric abundances of chlorine and bromine are expected to reach their maximum within a few years and then slowly decline. All other things being

equal, the ozone layer is expected to return to normal by the middle of the next century.

In summary, record low ozone levels have been observed in recent years, and substantially larger future global depletions in ozone would have been highly likely without reductions in human emissions of ozone-depleting gases. However, worldwide compliance with current international agreements is rapidly reducing the yearly emissions of these compounds. As these emissions cease, the ozone layer will gradually improve over the next several decades. The recovery of the ozone layer will be gradual because of the long times required for CFCs to be removed from the atmosphere.

World Meteorological Organization  
Global Ozone Research and Monitoring Project — Report No. 37

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# SCIENTIFIC ASSESSMENT OF OZONE DEPLETION: 1994

## EXECUTIVE SUMMARY

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National Oceanic and Atmospheric Administration  
National Aeronautics and Space Administration  
United Nations Environment Programme  
World Meteorological Organization

# PREFACE

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The present document contains key summaries from the *Scientific Assessment of Ozone Depletion: 1994*. The full assessment report will be part of the information upon which the Parties to the United Nations Montreal Protocol will base their future decisions regarding protection of the stratospheric ozone layer.

Specifically, the Montreal Protocol on Substances That Deplete the Ozone Layer states (Article 6): "... the Parties shall assess the control measures ... on the basis of available scientific, environmental, technical, and economic information." To provide the mechanisms whereby these assessments are conducted, the Protocol further states: "... the Parties shall convene appropriate panels of experts" and "the panels will report their conclusions ... to the Parties."

Three assessment reports have been prepared during 1994 to be available to the Parties in advance of their meeting in 1995, at which they will consider the need to amend or adjust the Protocol. The two companion reports to the scientific assessment focus on the environmental and health effects of ozone layer depletion and on the technology and economic implications of mitigation approaches.

The scientific assessment summarized in the present document is the latest in a series of seven scientific reports prepared by the world's leading experts in the atmospheric sciences and under the international auspices of the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). The chronology of those scientific assessments and the relation to the international policy process are summarized as follows:

| <u>Year</u> | <u>Policy Process</u> | <u>Scientific Assessment</u>  |
|-------------|-----------------------|---|
| 1981        |                       | <i>The Stratosphere 1981 Theory and Measurements.</i><br>WMO No. 11.  |
| 1985        | Vienna Convention     | <i>Atmospheric Ozone 1985.</i> 3 vol. WMO No. 16.   |
| 1987        | Montreal Protocol     |   |
| 1988        |                       | <i>International Ozone Trends Panel Report 1988.</i><br>2 vol. WMO No. 18.                                      |
| 1989        |                       | <i>Scientific Assessment of Stratospheric Ozone:</i><br>1989. 2 vol. WMO No. 20.                                |
| 1990        | London Amendment      |   |
| 1991        |                       | <i>Scientific Assessment of Ozone Depletion: 1991.</i><br>WMO No. 25.   |
| 1992        |                       | <i>Methyl Bromide: Its Atmospheric Science, Technology, and Economics</i> (Assessment Supplement). UNEP (1992). |
| 1992        | Copenhagen Amendment  |   |
| 1994        |                       | <i>Scientific Assessment of Ozone Depletion: 1994.</i><br>WMO No. 37.   |
| (1995)      | Vienna Amendment (?)  |   |

The genesis of *Scientific Assessment of Ozone Depletion: 1994* occurred at the 4th meeting of the Conference of the Parties to the Montreal Protocol in Copenhagen, Denmark, in November 1992, at which the scope of the scientific needs of the Parties was defined. The formal planning of the present report was a workshop that was held on 11 June 1993 in

Virginia Beach, Virginia, at which an international steering group crafted the outline and suggested scientists from the world community to serve as authors. The first drafts of the chapters were examined at a meeting that occurred on 2 - 4 March 1994 in Washington, D.C., at which the authors and a small number of international experts improved the coordination of the text of the chapters.

The second draft was sent out to 123 scientists worldwide for a mail peer review. These anonymous comments were considered by the authors. At a Panel Review Meeting in Les Diablerets, Switzerland, held on 18 - 21 July 1994, the responses to these mail review comments were proposed by the authors and discussed by the 80 participants. Final changes to the chapters were decided upon, and the Executive Summary contained herein was prepared by the participants.

The group also focused on a set of questions commonly asked about the ozone layer. Based upon the scientific understanding represented by the assessments, answers to these common questions were prepared and are also included here.

As the accompanying list indicates, the *Scientific Assessment of Ozone Depletion: 1994* is the product of 295 scientists from the developed and developing world<sup>1</sup> who contributed to its preparation and review (230 scientists prepared the report and 147 scientists participated in the peer review process).

What follows is a summary of their current understanding of the stratospheric ozone layer and its relation to humankind.

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<sup>1</sup> Participating were Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, Cuba, Czech Republic, Denmark, Egypt, France, Germany, Greece, Hungary, India, Iran, Ireland, Israel, Italy, Japan, Kenya, Malaysia, New Zealand, Norway, Poland, Russia, South Africa, Sweden, Switzerland, Taiwan, The Netherlands, The People's Republic of China, United Kingdom, United States of America, and Venezuela.

# EXECUTIVE SUMMARY

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## Recent Major Scientific Findings and Observations

The laboratory investigations, atmospheric observations, and theoretical and modeling studies of the past few years have provided a deeper understanding of the human-influenced and natural chemical changes in the atmosphere and their relation to the Earth's stratospheric ozone layer and radiative balance of the climate system. Since the last international scientific assessment of the state of understanding, there have been several key ozone-related findings, observations, and conclusions:

**The atmospheric growth rates of several major ozone-depleting substances have slowed, demonstrating the expected impact of the Montreal Protocol and its Amendments and Adjustments.** The abundances of the chlorofluorocarbons (CFCs), carbon tetrachloride, methyl chloroform, and halons in the atmosphere have been monitored at global ground-based sites since about 1978. Over much of that period, the annual growth rates of these gases have been positive. However, the data of recent years clearly show that the growth rates of CFC-11, CFC-12, halon-1301, and halon-1211 are slowing down. In particular, total tropospheric organic chlorine increased by only about 60 ppt/year (1.6%) in 1992, compared to 110 ppt/year (2.9%) in 1989. Furthermore, tropospheric bromine in halons increased by only about 0.25 ppt/year in 1992, compared to about 0.85 ppt/year in 1989. The abundance of carbon tetrachloride is actually decreasing. The observed trends in total tropospheric organic chlorine are consistent with reported production data, suggesting less emission than the maximum allowed under the Montreal Protocol and its Amendments and Adjustments. Peak total chlorine/bromine loading in the troposphere is expected to occur in 1994, but the stratospheric peak will lag by about 3-5 years. Since the stratospheric abundances of chlorine and bromine are expected to continue to grow for a few more years, increasing global ozone losses are predicted (other things being equal) for the remainder of the decade, with gradual recovery in the 21st century.

- **The atmospheric abundances of several of the CFC substitutes are increasing, as anticipated.** With phase-out dates for the CFCs and other ozone-depleting substances now fixed by international agreements, several hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) are being manufactured and used as substitutes. The atmospheric growth of some of these compounds (*e.g.*, HCFC-22) has been observed for several years, and the growth rates of others (*e.g.*, HCFC-142b and HCFC-141b) are now being monitored. Tropospheric chlorine in HCFCs increased by 5 ppt/year in 1989 and about 10 ppt/year in 1992.
- **Record low global ozone levels were measured over the past two years.** Anomalous ozone decreases were observed in the midlatitudes of both hemispheres in 1992 and 1993. The Northern Hemispheric decreases were larger than those in the Southern Hemisphere. Globally, ozone values were 1-2% lower than would be expected from an extrapolation of the trend prior to 1991, allowing for solar-cycle and quasi-biennial-oscillation (QBO) effects. The 1994 global ozone levels are returning to values closer to those expected from the longer-term downward trend.

- **The stratosphere was perturbed by a major volcanic eruption.** The eruption of Mt. Pinatubo in 1991 led to a large increase in sulfate aerosol in the lower stratosphere throughout the globe. Reactions on sulfate aerosols resulted in significant, but temporary, changes in the chemical partitioning that accelerated the photochemical ozone loss associated with reactive hydrogen ( $\text{HO}_x$ ), chlorine, and bromine compounds in the lower stratosphere in midlatitudes and polar regions. Absorption of terrestrial and solar radiation by the Mt. Pinatubo aerosol resulted in a transitory rise of  $1^\circ\text{C}$  (globally averaged) in the lower-stratospheric temperature and also affected the distribution of ozone through circulation changes. The observed 1994 recovery of global ozone is qualitatively consistent with observed gradual reductions of the abundances of these volcanic particles in the stratosphere.
- **Downward trends in total-column ozone continue to be observed over much of the globe, but their magnitudes are underestimated by numerical models.** Decreases in ozone abundances of about 4 - 5% per decade at midlatitudes in the Northern and Southern Hemispheres continue to be observed by both ground-based and satellite-borne monitoring instruments. At midlatitudes, the losses continue to be much larger during winter/spring than during summer/fall in both hemispheres, and the depletion increases with latitude, particularly in the Southern Hemisphere. Little or no downward trends are observed in the tropics ( $20^\circ\text{N}$  -  $20^\circ\text{S}$ ). While the current two-dimensional stratospheric models simulate the observed trends quite well during some seasons and latitudes, they underestimate the trends by factors of up to three in winter/spring at mid- and high latitudes. Several known atmospheric processes that involve chlorine and bromine and that affect ozone in the lower stratosphere are difficult to model and have not been adequately incorporated into these models.
- **Observations have demonstrated that halogen chemistry plays a larger role in the chemical destruction of ozone in the midlatitude lower stratosphere than expected from gas phase chemistry.** Direct *in situ* measurements of radical species in the lower stratosphere, coupled with model calculations, have quantitatively shown that the *in situ* photochemical loss of ozone due to (largely natural) reactive nitrogen ( $\text{NO}_x$ ) compounds is smaller than that predicted from gas phase chemistry, while that due to (largely natural)  $\text{HO}_x$  compounds and (largely anthropogenic) chlorine and bromine compounds is larger than that predicted from gas phase chemistry. This confirms the key role of chemical reactions on sulfate aerosols in controlling the chemical balance of the lower stratosphere. These and other recent scientific findings strengthen the conclusion of the previous assessment that the weight of scientific evidence suggests that the observed middle- and high-latitude ozone losses are largely due to anthropogenic chlorine and bromine compounds.
- **The conclusion that anthropogenic chlorine and bromine compounds, coupled with surface chemistry on natural polar stratospheric particles, are the cause of polar ozone depletion has been further strengthened.** Laboratory studies have provided a greatly improved understanding of how the chemistry on the surfaces of ice, nitrate, and sulfate particles can increase the abundance of ozone-depleting forms of chlorine in the polar stratospheres. Furthermore, satellite and *in situ* observations of the abundances of reactive nitrogen and chlorine compounds have improved the explanation of the different ozone-altering properties of the Antarctic and Arctic.
- **The Antarctic ozone "holes" of 1992 and 1993 were the most severe on record.** The Antarctic ozone "hole" has continued to occur seasonally every year since its advent in the late-1970s, with the occurrences over the last several years being particularly pronounced. Satellite, balloon-borne, and ground-based monitoring instruments revealed that the Antarctic ozone "holes" of 1992 and 1993 were the biggest (areal extent) and deepest (minimum amounts of ozone overhead), with ozone being locally depleted by more than 99% between about 14 - 19 km in October, 1992 and 1993. It is likely that these larger-than-usual ozone depletions could be attributed, at least in part, to sulfate aerosols from Mt. Pinatubo increasing the effectiveness of chlorine- and bromine-catalyzed ozone destruction. A substantial Antarctic ozone "hole" is expected to occur each austral spring for many more decades because stratospheric chlorine and bromine abundances will approach the pre-Antarctic-ozone-"hole" levels (late-1970s) very slowly during the next century.



- **Ozone losses have been detected in the Arctic winter stratosphere, and their links to halogen chemistry have been established.** Studies in the Arctic lower stratosphere have been expanded to include more widespread observations of ozone and key reactive species. In the late-winter/early-spring period, additional chemical losses of ozone up to 15 - 20% at some altitudes are deduced from these observations, particularly in the winters of 1991/2 and 1992/3. Model calculations constrained by the observations are also consistent with these losses, increasing the confidence in the role of chlorine and bromine in ozone destruction. The interannual variability in the photochemical and dynamical conditions of the Arctic polar vortex continues to limit the ability to predict ozone changes in future years.
- **The link between a decrease in stratospheric ozone and an increase in surface ultraviolet (UV) radiation has been further strengthened.** Measurements of UV radiation at the surface under clear-sky conditions show that low overhead ozone yields high UV radiation and in the amount predicted by radiative-transfer theory. Large increases of surface UV are observed in Antarctica and the southern part of South America during the period of the seasonal ozone "hole." Furthermore, elevated surface UV levels at mid-to-high latitudes were observed in the Northern Hemisphere in 1992 and 1993, corresponding to the low ozone levels of those years. However, the lack of a decadal (or longer) record of accurate monitoring of surface UV levels and the variation introduced by clouds and other factors have precluded the unequivocal identification of a long-term trend in surface UV radiation.
- **Methyl bromide continues to be viewed as a significant ozone-depleting compound.** Increased attention has been focused upon the ozone-depleting role of methyl bromide. Three potentially major anthropogenic sources of atmospheric methyl bromide have been identified (soil fumigation, biomass burning, and the exhaust of automobiles using leaded gasoline), in addition to the natural oceanic source. Recent laboratory studies have confirmed the fast rate for the  $\text{BrO} + \text{HO}_2$  reaction and established a negligible reaction pathway producing HBr, both of which imply greater ozone losses due to emissions of compounds containing bromine. While the magnitude of the atmospheric photochemical removal is well understood, there are significant uncertainties in quantifying the oceanic sink for atmospheric methyl bromide. The best estimate for the overall lifetime of atmospheric methyl bromide is 1.3 years, with a range of 0.8 - 1.7 years. The Ozone Depletion Potential (ODP) for methyl bromide is calculated to be about 0.6 (relative to an ODP of 1 for CFC-11).
- **Stratospheric ozone losses cause a global-mean negative radiative forcing.** In the 1991 scientific assessment, it was pointed out that the global ozone losses that were occurring in the lower stratosphere caused this region to cool and result in less radiation reaching the surface-troposphere system. Recent model studies have strengthened this picture. A long-term global-mean cooling of the lower stratosphere of between 0.25 and 0.4°C/decade has been observed over the last three decades. Calculations indicate that, on a global mean, the ozone losses between 1980 and 1990 offset about 20% of the radiative forcing due to the well-mixed greenhouse-gas increases during that period (i.e., carbon dioxide, methane, nitrous oxide, and halocarbons).
- **Tropospheric ozone, which is a greenhouse gas, appears to have increased in many regions of the Northern Hemisphere.** Observations show that tropospheric ozone, which is formed by chemical reactions involving pollutants, has increased above many locations in the Northern Hemisphere over the last 30 years. However, in the 1980s, the trends were variable, being small or nonexistent. In the Southern Hemisphere, there are insufficient data to draw strong inferences. At the South Pole, a decrease has been observed since the mid-1980s. Model simulations and limited observations suggest that tropospheric ozone has increased in the Northern Hemisphere since pre-industrial times. Such changes would augment the radiative forcing from all other greenhouse gases by about 20% over the same time period.

- The atmospheric residence times of the important ozone-depleting gases, CFC-11 and methyl chloroform, and the greenhouse gas, methane, are now better known. A reconciliation of observed concentrations with known emissions using an atmospheric model has led to a best-estimate lifetime of 50 years for CFC-11 and 5.4 years for methyl chloroform, with uncertainties of about 10%. These lifetimes provide an accurate standard for gases destroyed only in the stratosphere (such as CFCs and nitrous oxide) and for those also reacting with tropospheric hydroxyl radical, OH (such as HCFCs and HFCs), respectively. Recent model simulations of methane perturbations and a theoretical analysis of the tropospheric chemical system that couples methane, carbon monoxide, and OH have demonstrated that methane perturbations decay with a lengthened time scale in a range of about 12 - 17 years, as compared with the 10-year lifetime derived from the total abundance and losses. This longer response time and other indirect effects increase the estimate of the effectiveness of emissions of methane as a greenhouse gas by a factor of about two compared to the direct-effect-only values given in the 1991 assessment.

## Supporting Scientific Evidence and Related Issues

### OZONE CHANGES IN THE TROPICS AND MIDLATITUDES AND THEIR INTERPRETATION

- Analysis of global total-column ozone data through early 1994 shows substantial decreases of ozone in all seasons at midlatitudes (30° - 60°) of both hemispheres. For example, in the middle latitudes of the Northern Hemisphere, downward trends of about 6% per decade over 1979 - 1994 were observed in winter and spring and about 3% per decade were observed in summer and fall. In the Southern Hemisphere, the seasonal difference was somewhat less, but the midlatitude trends averaged a similar 4% to 5% per decade. There are no statistically significant trends in the tropics (20°S - 20°N). Trends through 1994 are about 1% per decade more negative in the Northern Hemisphere (2% per decade in the midlatitude winter/spring in the Northern Hemisphere) compared to those calculated without using data after May 1991. At Northern midlatitudes, the downward trend in ozone between 1981 - 1991 was about 2% per decade greater compared to that of the period 1970 - 1980.
- Satellite and ozonesonde data show that much of the downward trend in ozone occurs below 25 km (i.e., in the lower stratosphere). For the region 20 - 25 km, there is good agreement between the trends from the Stratospheric Aerosol and Gas Experiment (SAGE I/II) satellite instrument data and those from ozonesondes, with an observed annual-average decrease of  $7 \pm 4\%$  per decade from 1979 to 1991 at 30° - 50°N latitude. Below 20 km, SAGE yields negative trends as large as  $20 \pm 8\%$  per decade at 16 - 17 km, while the average of available midlatitude ozonesonde data shows smaller negative trends of  $7 \pm 3\%$  per decade. Integration of the ozonesonde data yields total-ozone trends consistent with total-ozone measurements. In the 1980s, upper-stratospheric (35 - 45 km) ozone trends determined by the data from SAGE I/II, Solar Backscatter Ultraviolet satellite spectrometer (SBUV), and the Umkehr method agree well at midlatitudes, but less so in the tropics. Ozone declined 5 - 10% per decade at 35 - 45 km between 30° - 50°N and slightly more at southern midlatitudes. In the tropics at 45 km, SAGE I/II and SBUV yield downward trends of 10 and 5% per decade, respectively.
- Simultaneous *in situ* measurements of a suite of reactive chemical species have directly confirmed modeling studies implying that the chemical destruction of ozone in the midlatitude lower stratosphere is more strongly influenced by HO<sub>x</sub> and halogen chemistry than NO<sub>x</sub> chemistry. The seasonal cycle of ClO in the lower stratosphere at midlatitudes in both hemispheres supports a role for *in situ* heterogeneous perturbations (i.e., on sulfate aerosols), but does not appear consistent with the timing of vortex processing or dilution. These studies provide key support for the view that sulfate aerosol chemistry plays an important role in determining midlatitude chemical ozone destruction rates.



- The model-calculated ozone depletions in the upper stratosphere for 1980 - 1990 are in broad agreement with the measurements. Although these model-calculated ozone depletions did not consider radiative feedbacks and temperature trends, including these effects is not likely to reduce the predicted ozone changes by more than 20%.
- Models including the chemistry involving sulfate aerosols and polar stratospheric clouds (PSCs) better simulate the observed total ozone depletions of the past decade than models that include only gas phase reactions. However, they still underestimate the ozone loss by factors ranging from 1.3 to 3.0.
- Some unresolved discrepancies between observations and models exist for the partitioning of inorganic chlorine species, which could impact model predictions of ozone trends. These occur for the ClO/HCl ratio in the upper stratosphere and the fraction of HCl to total inorganic chlorine in the lower stratosphere.
- The transport of ozone-depleted air from polar regions has the potential to influence ozone concentrations at middle latitudes. While there are uncertainties about the importance of this process relative to *in situ* chemistry for midlatitude ozone loss, both directly involve ozone destruction by chlorine- and bromine-catalyzed reactions.
- Radiosonde and satellite data continue to show a long-term cooling trend in globally annual-average lower-stratospheric temperatures of about 0.3 - 0.4°C per decade over the last three decades. Models suggest that ozone depletion is the major contributor to this trend.
- Anomalous large downward ozone trends have been observed in midlatitudes of both hemispheres in 1992 and 1993 (*i.e.*, the first two years after the eruption of Mt. Pinatubo), with Northern-Hemispheric decreases larger than those of the Southern Hemisphere. Global-average total-ozone levels in early 1993 were about 1% to 2% below that expected from the long-term trend and the particular phase of the solar and QBO cycles, while peak decreases of about 6 - 8% from expected ozone levels were seen over 45 - 60°N. In the first half of 1994, ozone levels returned to values closer to those expected from the long-term trend.
- The sulfur gases injected by Mt. Pinatubo led to large enhancements in stratospheric sulfate aerosol surface areas (by a maximum factor of about 30 - 40 at northern midlatitudes within a year after the eruption), which have subsequently declined.
- Anomalous low ozone was measured at altitudes below 25 km at a Northern-Hemispheric midlatitude station in 1992 and 1993 and was correlated with observed enhancements in sulfate-aerosol surface areas, pointing towards a causal link.
- Observations indicate that the eruption of Mt. Pinatubo did not significantly increase the HCl content of the stratosphere.
- The recent large ozone changes at midlatitudes are highly likely to have been due, at least in part, to the greatly increased sulfate aerosol in the lower stratosphere following Mt. Pinatubo. Observations and laboratory studies have demonstrated the importance of heterogeneous hydrolysis of  $\text{N}_2\text{O}_5$  on sulfate aerosols in the atmosphere. Evidence suggests that  $\text{ClONO}_2$  hydrolysis also occurs on sulfate aerosols under cold conditions. Both processes perturb the chemistry in such a way as to increase ozone loss through coupling with the anthropogenic chlorine and bromine loading of the stratosphere.

- Global mean lower stratospheric temperatures showed a marked transitory rise of about 1°C following the eruption of Mt. Pinatubo in 1991, consistent with model calculations. The warming is likely due to absorption of radiation by the aerosols.

#### **POLAR OZONE DEPLETION**

- In 1992 and 1993, the biggest-ever (areal extent) and deepest-ever (minimum ozone below 100 Dobson units) ozone "holes" were observed in the Antarctic. These extreme ozone depletions may have been due to the chemical perturbations caused by sulfate aerosols from Mt. Pinatubo, acting in addition to the well-recognized chlorine and bromine reactions on polar stratospheric clouds.
- Recent results of observational and modeling studies reaffirm the role of anthropogenic halocarbon species in Antarctic ozone depletion. Satellite observations show a strong spatial and temporal correlation of ClO abundances with ozone depletion in the Antarctic vortex. In the Arctic winter, a much smaller ozone loss has been observed. These losses are both consistent with photochemical model calculations constrained with observations from *in situ* and satellite instruments.
- Extensive new measurements of HCl, ClO, and ClONO<sub>2</sub> from satellites and *in situ* techniques have confirmed the picture of the chemical processes responsible for chlorine activation in polar regions and the recovery from those processes, strengthening current understanding of the seasonal cycle of ozone depletion in both polar regions.
- New laboratory and field studies strengthen the confidence that reactions on sulfate aerosols can activate chlorine under cold conditions, particularly those in the polar regions. Under volcanically perturbed conditions when aerosols are enhanced, these processes also likely contribute to ozone losses at the edges of PSC formation regions (both vertical and horizontal) just outside of the southern vortex and in the Arctic.
- Satellite measurements have confirmed that the Arctic vortex is much less denitrified than the Antarctic, which is likely to be an important factor in determining the interhemispheric differences in polar ozone loss.
- Interannual variability in the photochemical and dynamical conditions of the vortices limits reliable predictions of future ozone changes in the polar regions, particularly in the Arctic.

#### **COUPLING BETWEEN POLAR REGIONS AND MIDLATITUDES**

- Recent satellite observations of long-lived tracers and modeling studies confirm that, above 16 km, air near the center of the polar vortex is substantially isolated from lower latitudes, especially in the Antarctic.
- Erosion of the vortex by planetary-wave activity transports air from the vortex-edge region to lower latitudes. Nearly all observational and modeling studies are consistent with a time scale of 3 - 4 months to replace a substantial fraction of Antarctic vortex air. The importance of this transport to *in situ* chemical effects for midlatitude ozone loss remains poorly known.
- Air is readily transported between polar regions and midlatitudes below 16 km. The influence of this transport on midlatitude ozone loss has not been quantified.

## TROPOSPHERIC OZONE

- There is observational evidence that tropospheric ozone (about 10% of the total-column ozone) has increased in the Northern Hemisphere (north of 20°N) over the past three decades. The upward trends are highly regional. They are smaller in the 1980s than in the 1970s and may be slightly negative at some locations. European measurements at surface sites also indicate a doubling in the lower-tropospheric ozone concentrations since earlier this century. At the South Pole, a decrease has been observed since the mid-1980s. Elsewhere in the Southern Hemisphere, there are insufficient data to draw strong inferences.
- There is strong evidence that ozone levels in the boundary layer over the populated regions of the Northern Hemisphere are enhanced by more than 50% due to photochemical production from anthropogenic precursors, and that export of ozone from North America is a significant source for the North Atlantic region during summer. It has also been shown that biomass burning is a significant source of ozone (and carbon monoxide) in the tropics during the dry season.
- An increase in UV-B radiation (*e.g.*, from stratospheric ozone loss) is expected to decrease tropospheric ozone in the background atmosphere, but, in some cases, it will increase production of ozone in the more polluted regions.
- Model calculations predict that a 20% increase in methane concentrations would result in tropospheric ozone increases ranging from 0.5 to 2.5 ppb in the tropics and the northern midlatitude summer, and an increase in the methane residence time to about 14 years (a range of 12 - 17 years). Although there is a high degree of consistency in the global transport of short-lived tracers within three-dimensional chemical-transport models, and a general agreement in the computation of photochemical rates affecting tropospheric ozone, many processes controlling tropospheric ozone are not adequately represented or tested in the models, hence limiting the accuracy of these results.

## TRENDS IN SOURCE GASES RELATING TO OZONE CHANGES

- CFCs, carbon tetrachloride, methyl chloroform, and the halons are major anthropogenic source gases for stratospheric chlorine and bromine, and hence stratospheric ozone destruction. Observations from several monitoring networks worldwide have demonstrated slowdowns in growth rates of these species that are consistent (except for carbon tetrachloride) with expectations based upon recent decreases in emissions. In addition, observations from several sites have revealed accelerating growth rates of the CFC substitutes, HCFC-22, HCFC-141b, and HCFC-142b, as expected from their increasing use.
- Methane levels in the atmosphere affect tropospheric and stratospheric ozone levels. Global methane increased by 7% over about the past decade. However, the 1980s were characterized by slower growth rates, dropping from approximately 20 ppb per year in 1980 to about 10 ppb per year by the end of the decade. Methane growth rates slowed dramatically in 1991 and 1992, but the very recent data suggest that they have started to increase in late 1993. The cause(s) of this behavior are not known, but it is probably due to changes in methane sources rather than sinks.
- Despite the increased methane levels, the total amount of carbon monoxide in today's atmosphere is less than it was a decade ago. Recent analyses of global carbon monoxide data show that tropospheric levels grew from the early 1980s to about 1987 and have declined from the late 1980s to the present. The cause(s) of this behavior have not been identified.

## CONSEQUENCES OF OZONE CHANGES

- The only general circulation model (GCM) simulation to investigate the climatic impacts of observed ozone depletions between 1970 and 1990 supports earlier suggestions that these depletions reduced the model-predicted warming due to well-mixed greenhouse gases by about 20%. This is consistent with radiative forcing calculations.
- Model simulations suggest that increases in tropospheric ozone since pre-industrial times may have made significant contributions to the greenhouse forcing of the Earth's climate system, enhancing the current total forcing by about 20% compared to that arising from the changes in the well-mixed greenhouse gases over that period.
- Large increases in ultraviolet (UV) radiation have been observed in association with the ozone hole at high southern latitudes. The measured UV enhancements agree well with model calculations.
- Clear-sky UV measurements at midlatitude locations in the Southern Hemisphere are significantly larger than at a corresponding site in the Northern Hemisphere, in agreement with expected differences due to ozone column and Sun-Earth separation.
- Local increases in UV-B were measured in 1992/93 at mid- and high latitudes in the Northern Hemisphere. The spectral signatures of the enhancements clearly implicate the anomalously low ozone observed in those years, rather than variability of cloud cover or tropospheric pollution. Such correlations add confidence to the ability to link ozone changes to UV-B changes over relatively long time scales.
- Increases in clear-sky UV over the period 1979 to 1993 due to observed ozone changes are calculated to be greatest at short wavelengths and at high latitudes. Poleward of 45°, the increases are greatest in the Southern Hemisphere.
- Uncertainties in calibration, influence of tropospheric pollution, and difficulties of interpreting data from broadband instruments continue to preclude the unequivocal identification of long-term UV trends. However, data from two relatively unpolluted sites do appear to show UV increases consistent with observed ozone trends. Given the uncertainties of these studies, it now appears that quantification of the natural (i.e., pre-ozone-reduction) UV baseline has been irrevocably lost at mid- and high latitudes.
- Scattering of UV radiation by stratospheric aerosols from the Mt. Pinatubo eruption did not alter total surface-UV levels appreciably.

## RELATED PHENOMENA AND ISSUES

*Methyl Bromide*

- Three potentially major anthropogenic sources of methyl bromide have been identified: (i) soil fumigation: 20 to 60 ktons per year, where new measurements reaffirm that about 50% (ranging from 20 - 90%) of the methyl bromide used as a soil fumigant is released into the atmosphere; (ii) biomass burning: 10 to 50 ktons per year; and (iii) the exhaust of automobiles using leaded gasoline: 0.5 to 1.5 ktons per year or 9 to 22 ktons per year (the two studies report emission factors that differ by a factor of more than 10). In addition, the one known major natural source of methyl bromide is oceanic, with emissions of 60 to 160 ktons per year.

- Recent measurements have confirmed that there is more methyl bromide in the Northern Hemisphere than in the Southern Hemisphere, with an interhemispheric ratio of 1.3.
- There are two known sinks for atmospheric methyl bromide: (i) atmospheric, with a lifetime of 2.0 years (1.5 to 2.5 years); and (ii) oceanic, with an estimated lifetime of 3.7 years (1.5 to 10 years). The overall best estimate for the lifetime of atmospheric methyl bromide is 1.3 years, with a range of 0.8 to 1.7 years. An overall lifetime of less than 0.6 years is thought to be highly unlikely because of constraints imposed by the observed interhemispheric ratio and total known emissions.
- The chemistry of bromine-induced stratospheric ozone destruction is now better understood. Laboratory measurements have confirmed the fast rate for the  $\text{BrO} + \text{HO}_2$  reaction and have established a negligible reaction pathway producing  $\text{HBr}$ , both of which imply greater ozone losses due to emissions of compounds containing bromine. Stratospheric measurements show that the abundance of  $\text{HBr}$  is less than 1 ppt.
- Bromine is estimated to be about 50 times more efficient than chlorine in destroying stratospheric ozone on a per-atom basis. The ODP for methyl bromide is calculated to be about 0.6, based on an overall lifetime of 1.3 years. An uncertainty analysis suggests that the ODP is unlikely to be less than 0.3.

#### *Aircraft*

- Subsonics:** Estimates indicate that present subsonic aircraft operations may be significantly increasing trace species (primarily  $\text{NO}_x$ , sulfur dioxide, and soot) at upper-tropospheric altitudes in the North-Atlantic flight corridor. Models indicate that the  $\text{NO}_x$  emissions from the current subsonic fleet produce upper-tropospheric ozone increases as much as several percent, maximizing at northern midlatitudes. Since the results of these rather complex models depend critically on  $\text{NO}_x$  chemistry and since the tropospheric  $\text{NO}_x$  budget is uncertain, little confidence should be put in these quantitative model results at the present time.
- Supersonics:** Atmospheric effects of supersonic aircraft depend on the number of aircraft, the altitude of operation, the exhaust emissions, and the background chlorine and aerosol loadings. Projected fleets of supersonic transports would lead to significant changes in trace-species concentrations, especially in the North-Atlantic flight corridor. Two-dimensional model calculations of the impact of a projected fleet (500 aircraft, each emitting 15 grams of  $\text{NO}_x$  per kilogram of fuel burned at Mach 2.4) in a stratosphere with a chlorine loading of 3.7 ppb, imply additional (*i.e.*, beyond those from halocarbon losses) annual-average ozone column decreases of 0.3 - 1.8% for the Northern Hemisphere. There are, however, important uncertainties in these model results, especially in the stratosphere below 25 km. The same models fail to reproduce the observed ozone trends in the stratosphere below 25 km between 1980 and 1990. Thus, these models may not be properly including mechanisms that are important in this crucial altitude range.
- Climate Effects:** Reliable quantitative estimates of the effects of aviation emissions on climate are not yet available. Some initial estimates indicate that the climate effects of ozone changes resulting from subsonic aircraft emissions may be comparable to those resulting from their  $\text{CO}_2$  emissions.

### ***Ozone Depletion Potentials (ODPs)***

- If a substance containing chlorine or bromine decomposes in the stratosphere, it will destroy some ozone. HCFCs have short tropospheric lifetimes, which tends to reduce their impact on stratospheric ozone as compared to CFCs and halons. However, there are substantial differences in ODPs among various substitutes. The steady-state ODPs of substitute compounds considered in the present assessment range from about 0.01 - 0.1.
- Tropospheric degradation products of CFC substitutes will not lead to significant ozone loss in the stratosphere. Those products will not accumulate in the atmosphere and will not significantly influence the ODPs and Global Warming Potentials (GWPs) of the substitutes.
- Trifluoroacetic acid, formed in the atmospheric degradation of HFC-134a, HCFC-123, and HCFC-124, will enter into the aqueous environment, where biological, rather than physico-chemical, removal processes may be effective.
- It is known that atomic fluorine (F) itself is not an efficient catalyst for ozone loss, and it is concluded that the F-containing fragments from the substitutes (such as  $\text{CF}_3\text{O}_x$ ) also have negligible impact on ozone. Therefore, ODPs of HFCs containing the  $\text{CF}_3$  group (such as HFC-134a, HFC-23, and HFC-125) are likely to be much less than 0.001.
- New laboratory measurements and associated modeling studies have confirmed that perfluorocarbons and sulfur hexafluoride are long-lived in the atmosphere and act as greenhouse gases.
- The ODPs for several new compounds, such as HCFC-225ca, HCFC-225cb, and  $\text{CF}_3\text{I}$ , have been evaluated using both semi-empirical and modeling approaches, and are found to be 0.03 or less.

### ***Global Warming Potentials (GWPs)***

- Both the direct and indirect components of the GWP of methane have been estimated using model calculations. Methane's influence on the hydroxyl radical and the resulting effect on the methane response time lead to substantially longer response times for decay of emissions than OH removal alone, thereby increasing the GWP. In addition, indirect effects including production of tropospheric ozone and stratospheric water vapor were considered and are estimated to range from about 15 to 45% of the total GWP (direct plus indirect) for methane.
- GWPs, including indirect effects of ozone depletion, have been estimated for a variety of halocarbons, clarifying the relative radiative roles of ozone-depleting compounds (*i.e.*, CFCs and halons). The net GWPs of halocarbons depend strongly upon the effectiveness of each compound for ozone destruction; the halons are highly likely to have negative net GWPs, while those of the CFCs are likely to be positive over both 20- and 100-year time horizons.

## **Implications for Policy Formulation**

The research findings of the past few years that are summarized above have several major implications as scientific input to governmental, industrial, and other policy decisions regarding human-influenced substances that lead to depletion of the stratospheric ozone layer and to changes of the radiative forcing of the climate system:



- **The Montreal Protocol and its Amendments and Adjustments are reducing the impact of anthropogenic halocarbons on the ozone layer and should eventually eliminate this ozone depletion.** Based on assumed compliance with the amended Montreal Protocol (*Copenhagen, 1992*) by all nations, the stratospheric chlorine abundances will continue to grow from their current levels (3.6 ppb) to a peak of about 3.8 ppb around the turn of the century. The future total bromine loading will depend upon choices made regarding future human production and emissions of methyl bromide. After around the turn of the century, the levels of stratospheric chlorine and bromine will begin a decrease that will continue into the 21st and 22nd centuries. The rate of decline is dictated by the long residence times of the CFCs, carbon tetrachloride, and halons. Global ozone losses and the Antarctic ozone "hole" were first discernible in the late 1970s and are predicted to recover in about the year 2045, other things being equal. The recovery of the ozone layer would have been impossible without the Amendments and Adjustments to the original Protocol (*Montreal, 1987*).
- **Peak global ozone losses are expected to occur during the next several years.** The ozone layer will be most affected by human-influenced perturbations and susceptible to natural variations in the period around the year 1998, since the peak stratospheric chlorine and bromine abundances are expected to occur then. Based on extrapolation of current trends, observations suggest that the maximum ozone loss, relative to the late 1960s, will likely be:
  - (i) about 12 - 13% at Northern midlatitudes in winter/spring (i.e., about 2.5% above current levels);
  - (ii) about 6 - 7% at Northern midlatitudes in summer/fall (i.e., about 1.5% above current levels); and
  - (iii) about 11% (with less certainty) at Southern midlatitudes on a year-round basis (i.e., about 2.5% above current levels).

Such changes would be accompanied by 15%, 8%, and 13% increases, respectively, in surface erythema radiation, if other influences such as clouds remain constant. Moreover, if there were to be a major volcanic eruption like that of Mt. Pinatubo, or if an extremely cold and persistent Arctic winter were to occur, then the ozone losses and UV increases could be larger in individual years.
- **Approaches to lowering stratospheric chlorine and bromine abundances are limited.** Further controls on ozone-depleting substances would not be expected to significantly change the timing or the magnitude of the peak stratospheric halocarbon abundances and hence peak ozone loss. However, there are four approaches that would steepen the initial fall from the peak halocarbon levels in the early decades of the next century:
  - (i) If emissions of methyl bromide from agricultural, structural, and industrial activities were to be eliminated in the year 2001, then the integrated effective future chlorine loading above the 1980 level (which is related to the cumulative future loss of ozone) is predicted to be 13% less over the next 50 years relative to full compliance to the Amendments and Adjustments to the Protocol.
  - (ii) If emissions of HCFCs were to be totally eliminated by the year 2004, then the integrated effective future chlorine loading above the 1980 level is predicted to be 5% less over the next 50 years relative to full compliance with the Amendments and Adjustments to the Protocol.
  - (iii) If halons presently contained in existing equipment were never released to the atmosphere, then the integrated effective future chlorine loading above the 1980 level is predicted to be 10% less over the next 50 years relative to full compliance with the Amendments and Adjustments to the Protocol.
  - (iv) If CFCs presently contained in existing equipment were never released to the atmosphere, then the integrated effective future chlorine loading above the 1980 level is predicted to be 3% less over the next 50 years relative to full compliance with the Amendments and Adjustments to the Protocol.

- **Failure to adhere to the international agreements will delay recovery of the ozone layer.** If there were to be additional production of CFCs at 20% of 1992 levels for each year through 2002 and ramped to zero by 2005 (beyond that allowed for countries operating under Article 5 of the Montreal Protocol), then the integrated effective future chlorine loading above the 1980 level is predicted to be 9% more over the next 50 years relative to full compliance to the Amendments and Adjustments to the Protocol.
- **Many of the substitutes for the CFCs and halons are also notable greenhouse gases.** Several CFC and halon substitutes are not addressed under the Montreal Protocol (because they do not deplete ozone), but, because they are greenhouse gases, fall under the purview of the Framework Convention on Climate Change. There is a wide range of values for the Global Warming Potentials (GWPs) of the HFCs (150 - 10000), with about half of them having values comparable to the ozone-depleting compounds they replace. The perfluorinated compounds, some of which are being considered as substitutes, have very large GWPs (e.g. 5000 - 10000). These are examples of compounds whose current atmospheric abundances are relatively small, but are increasing or could increase in the future.
- **Consideration of the ozone change will be one necessary ingredient in understanding climate change.** The extent of our ability to attribute any climate change to specific causes will likely prove to be important scientific input to decisions regarding predicted human-induced influences on the climate system. Changes in ozone since pre-industrial times as a result of human activity are believed to have been a significant influence on radiative forcing, this human influence is expected to continue into the foreseeable future.

## COMMON QUESTIONS ABOUT OZONE

Ozone is exceedingly rare in our atmosphere, averaging about 3 molecules of ozone for every ten million air molecules. Nonetheless, atmospheric ozone plays vital roles that belie its small numbers. This Appendix to the *World Meteorological Organization/United Nations Environment Programme (WMO/UNEP) Scientific Assessment of Ozone Depletion: 1994* answers some of the questions that are most commonly asked about ozone and the changes that have been occurring in recent years. These common questions and their answers were discussed by the 80 scientists from 26 countries who participated in the Panel Review Meeting of the *Scientific Assessment of Ozone Depletion: 1994*. Therefore, this information is presented by a large group of experts from the international scientific community.

Ozone is mainly found in two regions of the Earth's atmosphere. Most ozone (about 90%) resides in a layer between approximately 10 and 50 kilometers (about 6 to 30 miles) above the Earth's surface, in the region of the atmosphere called the stratosphere. This stratospheric ozone is commonly known as the "ozone layer." The remaining ozone is in the lower region of the atmosphere, the troposphere, which extends from the Earth's surface up to about 10 kilometers. The figure below shows this distribution of ozone in the atmosphere.

While the ozone in these two regions is chemically identical (both consist of three oxygen atoms and have the chemical formula "O<sub>3</sub>"), the ozone molecules have very different effects on humans and other living things depending upon their location.

Stratospheric ozone plays a beneficial role by absorbing most of the biologically damaging ultraviolet sunlight called UV-B, allowing only a small amount to reach the Earth's surface. The absorption of UV radiation by ozone creates a source of heat, which actually forms the stratosphere itself (a region in which the temperature rises as one goes to higher altitudes). Ozone thus plays a key role in the temperature structure of the Earth's atmosphere. Furthermore, without the filtering action of the ozone layer, more of the Sun's UV-B radiation would penetrate the atmosphere and would reach the Earth's surface in greater amounts. Many experimental studies of plants and animals, and clinical studies of humans, have shown the harmful effects of excessive exposure to UV-B radiation (these are discussed in the WMO/UNEP reports on impacts of ozone depletion, which are com-

panion documents to the WMO/UNEP scientific assessments of ozone depletion).

At the planet's surface, ozone comes into direct contact with life-forms and displays its destructive side. Because ozone reacts strongly with other molecules, high levels are toxic to living systems and can severely damage the tissues of plants and animals. Many studies have documented the harmful effects of ozone on crop production, forest growth, and human health. The substantial negative effects of surface-level tropospheric ozone from this direct toxicity contrast with the benefits of the additional filtering of UV-B radiation that it provides.

With these dual aspects of ozone come two separate environmental issues, controlled by different forces in the atmosphere. In the troposphere, there is concern about increases in ozone. Low-lying ozone is a key component of smog, a familiar problem in the atmosphere of many cities around the world. Higher than usual amounts of surface-level ozone are now increasingly being observed in rural areas as well. However, the ground-level ozone concentrations in the smoggiest cities are very much smaller than the concentrations routinely found in the stratosphere.

There is widespread scientific and public interest and concern about losses of stratospheric ozone. Ground-based and satellite instruments have measured decreases in the amount of stratospheric ozone in our atmosphere. Over some parts of Antarctica, up to 60% of the total overhead amount of ozone (known as the "column ozone") is depleted during September and October. This phenomenon has come to be known as the Antarctic "ozone hole." Smaller, but still significant, stratospheric decreases have been seen at other, more-populated regions of the Earth. Increases in surface UV-B radiation have been observed in association with decreases in stratospheric ozone.

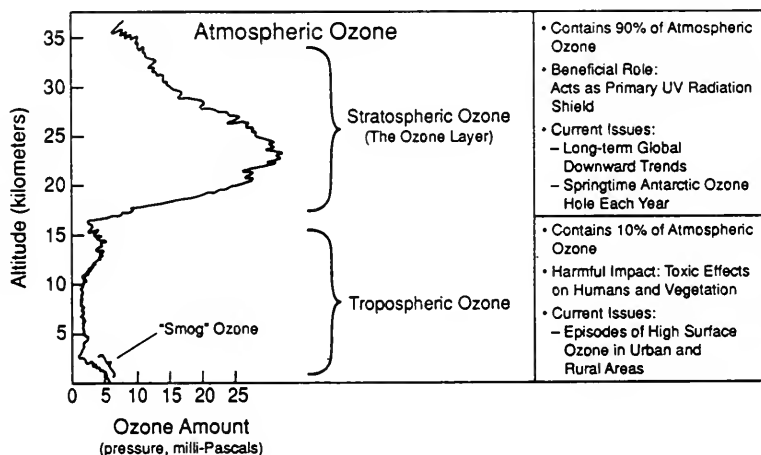
The scientific evidence, accumulated over more than two decades of study by the international research community, has shown that human-made chemicals are responsible for the observed depletions of the ozone layer over Antarctica and likely play a major role in global ozone losses. The ozone-depleting compounds contain various combinations of the chemical elements chlorine, fluorine, bromine, carbon, and hydrogen, and are often described by the general term *halocarbons*. The com-

pounds that contain only carbon, chlorine, and fluorine are called *chlorofluorocarbons*, usually abbreviated as *CFCs*. CFCs, carbon tetrachloride, and methyl chloroform are important human-made ozone-depleting gases that have been used in many applications including refrigeration, air conditioning, foam blowing, cleaning of electronics components, and as solvents. Another important group of human-made halocarbons is the *halons*, which contain carbon, bromine, fluorine, and (in some cases) chlorine, and have been mainly used as fire extinguishants. Governments have decided to discontinue production of CFCs, halons, carbon tetrachloride, and methyl chloroform, and industry has developed more "ozone-friendly" substitutes.

Two responses are natural when a new problem has been identified: cure and prevention. When the problem is the destruction of the stratospheric ozone layer, the corresponding questions are: Can we repair the damage already done? How can we prevent further destruction? Remedies have been investigated that could (i) remove CFCs selectively from our atmosphere, (ii) intercept ozone-depleting chlorine before much depletion has taken place, or (iii) replace the ozone lost in the stratosphere (perhaps by shipping the ozone from cities that have too

much smog or by making new ozone). Because ozone reacts strongly with other molecules, as noted above, it is too unstable to be made elsewhere (e.g., in the smog of cities) and transported to the stratosphere. When the huge volume of the Earth's atmosphere and the magnitude of global stratospheric ozone depletion are carefully considered, approaches to cures quickly become much too expensive, impractical, and potentially damaging to the global environment. Prevention involves the internationally agreed-upon Montreal Protocol and its Amendments and Adjustments, which call for elimination of the production and use of the CFCs and other ozone-damaging compounds within the next few years. As a result, the ozone layer is expected to recover over the next fifty years or so as the atmospheric concentrations of CFCs and other ozone-depleting compounds slowly decay.

The current understanding of ozone depletion and its relation to humankind is discussed in detail by the leading scientists in the world's ozone research community in the *Scientific Assessment of Ozone Depletion: 1994*. The answers to the common questions posed below are based upon that understanding and on the information given in earlier WMO/UNEP reports.



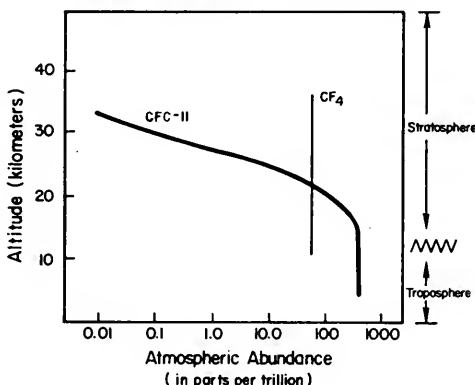
## How Can Chlorofluorocarbons (CFCs) Get to the Stratosphere If They're Heavier than Air?

Although the CFC molecules are indeed several times heavier than air, thousands of measurements have been made from balloons, aircraft, and satellites demonstrating that the CFCs are actually present in the stratosphere. The atmosphere is not stagnant. Winds mix the atmosphere to altitudes far above the top of the stratosphere much faster than molecules can settle according to their weight. Gases such as CFCs that are insoluble in water and relatively unreactive in the lower atmosphere (below about 10 km) are quickly mixed and therefore reach the stratosphere regardless of their weight.

Much can be learned about the atmospheric fate of compounds from the measured changes in concentration versus altitude. For example, the two gases carbon tetrachloride ( $\text{CF}_4$ , produced mainly as a by-product of the manufacture of aluminum) and CFC-11 ( $\text{CCl}_3\text{F}$ , used in a variety of human activities) are both much heavier than

air. Carbon tetrachloride is completely unreactive in the lower 99.9% of the atmosphere, and measurements show it to be nearly uniformly distributed throughout the atmosphere as shown in the figure. There have also been measurements over the past two decades of several other completely unreactive gases, one lighter than air (neon) and some heavier than air (argon, krypton), which show that they also mix upward uniformly through the stratosphere regardless of their weight, just as observed with carbon tetrachloride. CFC-11 is unreactive in the lower atmosphere (below about 15 km) and is similarly uniformly mixed there, as shown. The abundance of CFC-11 decreases as the gas reaches higher altitudes, where it is broken down by high energy solar ultraviolet radiation. Chlorine released from this breakdown of CFC-11 and other CFCs remains in the stratosphere for several years, where it destroys many thousands of molecules of ozone.

Measurements of CFC-11 and  $\text{CF}_4$



## What is the Evidence that Stratospheric Ozone is Destroyed by Chlorine and Bromine?

Laboratory studies show that chlorine (Cl) reacts very rapidly with ozone. They also show that the reactive chemical chlorine oxide (ClO) formed in that reaction can undergo further processes which regenerate the original chlorine, allowing the sequence to be repeated very many times (a "chain reaction"). Similar reactions also take place between bromine and ozone.

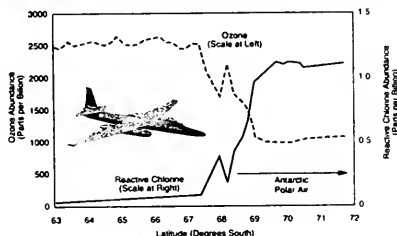
But do these ozone-destroying reactions occur in the real world? All of our accumulated scientific experience demonstrates that if the conditions of temperature and pressure are like those in the laboratory studies, the same chemical reactions will take place in nature. However, many other reactions including those of other chemical species are often also taking place simultaneously in the stratosphere, making the connections among the changes difficult to untangle. Nevertheless, whenever chlorine (or bromine) and ozone are found together in the stratosphere, the ozone-destroying reactions must be taking place.

Sometimes a small number of chemical reactions is so important in the natural circumstance that the connections are almost as clear as in laboratory experiments. Such a situation occurs in the Antarctic stratosphere during the springtime formation of the ozone hole. During August and September 1987 — the end of winter and beginning of spring in the Southern Hemisphere — aircraft equipped with many different instruments for measuring a large number of chemical species were flown repeated-

ly over Antarctica. Among the chemicals measured were ozone and chlorine oxide, the reactive chemical identified in the laboratory as one of the participants in the ozone-destroying chain reactions. On the first flights southward from the southern tip of South America, relatively high concentrations of ozone were measured everywhere over Antarctica. By mid-September, however, the instruments recorded low concentrations of ozone in regions where there were high concentrations of chlorine oxide and vice versa, as shown in the figure. Flights later in September showed even less ozone over Antarctica, as the chlorine continued to react with the stratospheric ozone.

Independent measurements made by these and other instruments on this and other airplanes, from the ground, from balloons, and from satellites have provided a detailed understanding of the chemical reactions going on in the Antarctic stratosphere. Regions with high concentrations of reactive chlorine reach temperatures so cold (less than approximately  $-80^{\circ}\text{C}$ , or  $-112^{\circ}\text{F}$ ) that stratospheric clouds form, a rare occurrence except during the polar winters. These clouds facilitate other chemical reactions that allow the release of chlorine in sunlight. The chemical reactions related to the clouds are now well understood through study under laboratory conditions mimicking those found naturally. Scientists are working to understand the role of such reactions of chlorine and bromine at other latitudes, and the involvement of particles of sulfuric acid from volcanoes or other sources.

**Measurements of Ozone and Reactive Chlorine from a Flight into the Antarctic Ozone Hole**



## Does Most of the Chlorine in the Stratosphere Come from Human or Natural Sources?

Most of the chlorine in the stratosphere is there as a result of human activities.

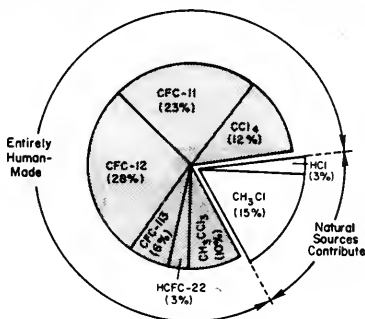
Many compounds containing chlorine are released at the ground, but those that dissolve in water cannot reach stratospheric altitudes. Large quantities of chlorine are released from evaporated ocean spray as sea salt (sodium chloride) aerosol. However, because sea salt dissolves in water, this chlorine quickly is taken up in clouds or in ice, snow, or rain droplets and does not reach the stratosphere. Another ground-level source of chlorine is its use in swimming pools and as household bleach. When released, this chlorine is rapidly converted to forms that dissolve in water and therefore are removed from the lower atmosphere, never reaching the stratosphere in significant amounts. Volcanoes can emit large quantities of hydrogen chloride, but this gas is rapidly converted to hydrochloric acid in rain water, ice, and snow and does not reach the stratosphere. Even in explosive volcanic plumes that rise high in the atmosphere, nearly all of the hydrogen chloride is scrubbed out in precipitation before reaching stratospheric altitudes.

In contrast, human-made halocarbons — such as CFCs, carbon tetrachloride ( $\text{CCl}_4$ ) and methyl chloroform ( $\text{CH}_3\text{CCl}_3$ ) — are not soluble in water, do not react with snow or other natural surfaces, and are not broken down chemically in the lower atmosphere. While the exhaust

from the Space Shuttle and from some rockets does inject some chlorine directly into the stratosphere, this input is very small (less than one percent of the annual input from halocarbons in the present stratosphere, assuming nine Space Shuttle and six Titan IV rocket launches per year).

Several pieces of evidence combine to establish human-made halocarbons as the primary source of stratospheric chlorine. First, measurements (see the figure below) have shown that the chlorinated species that rise to the stratosphere are primarily manufactured compounds (mainly CFCs, carbon tetrachloride, methyl chloroform, and the HCFC substitutes for CFCs), together with small amounts of hydrochloric acid ( $\text{HCl}$ ) and methyl chloride ( $\text{CH}_3\text{Cl}$ ) which are partly natural in origin. The natural contribution now is much smaller than that from human activities, as shown in the figure below. Second, in 1985 and 1992 researchers measured nearly all known gases containing chlorine in the stratosphere. They found that human emissions of halocarbons plus the much smaller contribution from natural sources could account for all of the stratospheric chlorine compounds. Third, the *increase* in total stratospheric chlorine measured between 1985 and 1992 corresponds with the known increases in concentrations of human-made halocarbons during that time.

**Primary Sources of Chlorine Entering the Stratosphere**

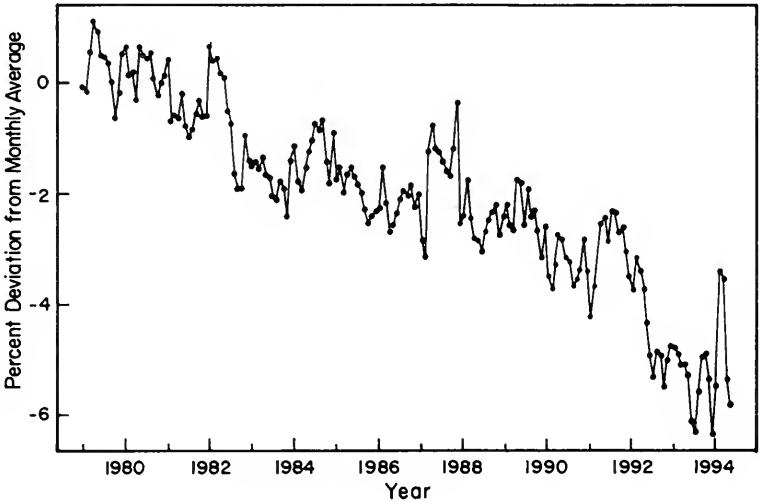


## Can Changes in the Sun's Output Be Responsible for the Observed Changes in Ozone?

Stratospheric ozone is primarily created by ultraviolet (UV) light coming from the Sun, so the Sun's output affects the rate at which ozone is produced. The Sun's energy release (both as UV light and as charged particles such as electrons and protons) does vary, especially over the well-known 11-year sunspot cycle. Observations over several solar cycles (since the 1960s) show that total global ozone levels decrease by 1-2% from the maximum to the minimum of a typical cycle. Changes in the Sun's output cannot be responsible for the observed long-term changes in ozone, because these downward

trends are much larger than 1-2%. Further, during the period since 1979, the Sun's energy output has gone from a maximum to a minimum in 1985 and back through another maximum in 1991, but the trend in ozone was downward throughout that time. The ozone trends presented in this and previous international scientific assessments have been obtained by evaluating the long-term changes in ozone concentrations after accounting for the solar influence (as has been done in the figure below).

**Global Ozone Trend (60°S–60°N)**





## When Did the Antarctic Ozone Hole First Appear?

The Antarctic ozone hole is a new phenomenon. The figure shows that observed ozone over the British Antarctic Survey station at Halley Bay, Antarctica first revealed obvious decreases in the early 1980s compared to data obtained since 1957. The ozone hole is formed each year when there is a sharp decline (currently up to 60%) in the total ozone over most of Antarctica for a period of about two months during Southern Hemisphere spring (September and October). Observations from three other stations in Antarctica, also covering several decades, reveal similar progressive, recent decreases in springtime ozone. The ozone hole has been shown to result from destruction of stratospheric ozone by gases containing chlorine and bromine, whose sources are mainly human-made halocarbon gases.

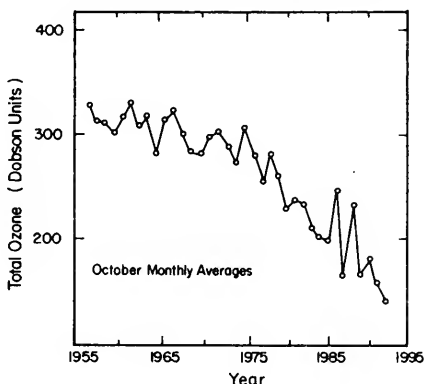
Before the stratosphere was affected by human-made chlorine and bromine, the naturally occurring springtime ozone levels over Antarctica were about 30-40% lower than springtime ozone levels over the Arctic. This natural difference between Antarctic and Arctic conditions was first observed in the late 1950s by Dobson. It stems

from the exceptionally cold temperatures and different winter wind patterns within the Antarctic stratosphere as compared to the Arctic. This is not at all the same phenomenon as the marked downward trend in total ozone in recent years referred to as the ozone hole and shown in the figure below.

Changes in stratospheric meteorology cannot explain the ozone hole. Measurements show that wintertime Antarctic stratospheric temperatures of past decades have not changed prior to the development of the hole each September. Ground, aircraft, and satellite measurements have provided, in contrast, clear evidence of the importance of the chemistry of chlorine and bromine originating from human-made compounds in depleting Antarctic ozone in recent years.

A single report of extremely low Antarctic winter ozone in one location in 1958 by an unproven technique has been shown to be completely inconsistent with the measurements depicted here and with all credible measurements of total ozone.

**Historical Springtime Total Ozone Record  
for Halley Bay, Antarctica (76°S)**



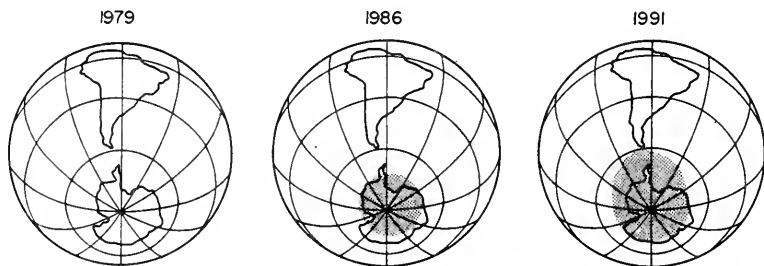
## Why is the Ozone Hole Observed over Antarctica When CFCs Are Released Mainly in the Northern Hemisphere?

Human emissions of CFCs do occur mainly in the Northern Hemisphere, with about 90% released in the latitudes corresponding to Europe, Russia, Japan, and North America. Gases such as CFCs that are insoluble in water and relatively unreactive are mixed within a year or two throughout the lower atmosphere (below about 10 km). The CFCs in this well-mixed air rise from the lower atmosphere into the stratosphere mainly in tropical latitudes. Winds then move this air poleward — both north and south — from the tropics, so that air throughout the stratosphere contains nearly the same amount of chlorine. However, the meteorologies of the two polar regions are very different from each other because of major differences at the Earth's surface. The South Pole is part of a very large land mass (Antarctica) that is com-

pletely surrounded by ocean. These conditions produce very low stratospheric temperatures which in turn lead to formation of clouds (polar stratospheric clouds). The clouds that form at low temperatures lead to chemical changes that promote rapid ozone loss during September and October of each year, resulting in the ozone hole.

In contrast, the Earth's surface in the northern polar region lacks the land/ocean symmetry characteristic of the southern polar area. As a consequence, Arctic stratospheric air is generally much warmer than in the Antarctic, and fewer clouds form there. Therefore, the ozone depletion in the Arctic is much less than in the Antarctic.

**Schematic of Antarctic Ozone Hole**



## Is the Depletion of the Ozone Layer Leading to an Increase in Ground-Level Ultraviolet Radiation?

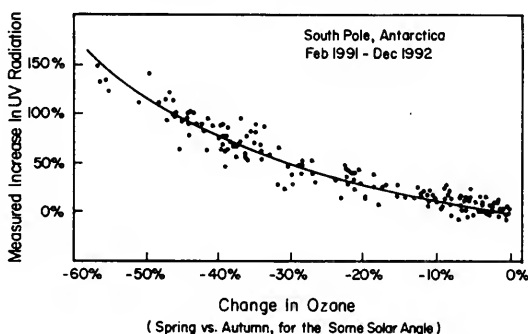
The Sun emits light over a wide range of energies, with about two percent given off in the form of high-energy, ultraviolet (UV) radiation. Some of this UV radiation (UV-B) is especially effective in causing damage to living things, including sunburn, skin cancer, and eye damage for humans. The amount of solar UV radiation received at any particular location on the Earth's surface depends upon the position of the Sun above the horizon, on the amount of ozone in the atmosphere, and upon local cloudiness and pollution. Scientists agree that in the absence of changes in clouds or pollution, decreases in atmospheric ozone will increase ground-level UV radiation.

The largest decreases in ozone during the last decade have been observed over Antarctica, especially during each September and October when the "ozone hole" forms. During the last several years, simultaneous measurements of UV radiation and total ozone have been made at several Antarctic stations. As shown in the figure below, when the ozone amounts decrease, UV-B increases. Because of the ozone hole, the UV-B intensity at Palmer Station, Antarctica, in late October, 1993, was

more intense than found at San Diego, California, at any time during all of 1993.

In areas where small ozone depletion has been observed, UV-B increases are more difficult to detect. Detection of UV trends associated with ozone decreases can also be complicated by changes in cloudiness or by local pollution, as well as by difficulties in keeping the detection instrument in precisely the same condition over many years. Prior to the late 1980s, instruments with the necessary accuracy and stability for measurement of small long-term trends in ground-level UV-B were not employed. Recently, however, such instruments have been used in the Antarctic because of the very large changes in ozone being observed there. When high-quality measurements have been made in other areas far from major cities and their associated air pollution, decreases in ozone have regularly been accompanied by increases in UV-B. The data from urban locations with older, less specialized instruments provide much less reliable information, especially because good simultaneous measurements are not available for any changes in cloudiness or local pollution.

**Increases in Erythmal (Sunburning) UV Radiation  
Due to Ozone Reductions**



## How Severe Is the Ozone Depletion Now, and Is It Expected to Get Worse?

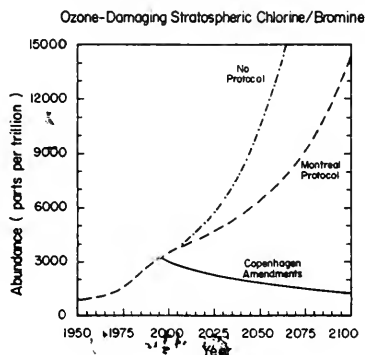
Scientific evidence shows that ozone depletion caused by human-made chemicals is continuing and is expected to persist until chlorine and bromine levels are reduced. Worldwide monitoring has shown that stratospheric ozone has been decreasing for the past two decades or more. Globally averaged losses have totaled about 5% since the mid-1960s, with cumulative losses of about 10% in the winter and spring and 5% in the summer and autumn over locations such as Europe, North America, and Australia. Since the late-1970s, an ozone "hole" has formed in Antarctica each Southern Hemisphere spring (September / October), in which up to 60% of the total ozone is depleted. The large increase in atmospheric concentrations of human-made chlorine and bromine compounds is responsible for the formation of the Antarctic ozone hole, and the weight of evidence indicates that it also plays a major role in midlatitude ozone depletion.

During 1992 and 1993 ozone in many locations dropped to record low values: springtime depletions exceeded 20% in some populated northern midlatitude regions, and the levels in the Antarctic ozone hole fell to the lowest values ever recorded. The unusually large ozone decreases of 1992 and 1993 are believed to be related, in part, to the volcanic eruption of Mount Pinatubo in the Philippines during 1991. This eruption produced large

amounts of stratospheric sulfate aerosols that temporarily increased the ozone depletion caused by human-made chlorine and bromine compounds. Recent observations have shown that as those aerosols have been swept out of the stratosphere, ozone concentrations have returned to the depleted levels consistent with the downward trend observed before the Mount Pinatubo eruption.

In 1987 the recognition of the potential for chlorine and bromine to destroy stratospheric ozone led to an international agreement (The United Nations Montreal Protocol on Substances that Deplete the Ozone Layer) to reduce the global production of ozone-depleting substances. Since then, new global observations of significant ozone depletion have prompted amendments to strengthen the treaty. The 1992 Copenhagen Amendments call for a ban on production of the most damaging compounds by 1996. The figure shows past and projected future stratospheric abundances of chlorine and bromine: (a) without the Protocol; (b) under the Protocol's original provisions; and (c) under the Copenhagen Amendments now in force. Without the Montreal Protocol and its Amendments, continuing human use of CFCs and other compounds would have tripled the stratospheric abundances of chlorine and bromine by about the year 2050. Current scientific understanding indicates that such increases would have led to global ozone depletion very much larger than observed today. In contrast, under current international agreements, which are now reducing and will eventually eliminate human emissions of ozone-depleting gases, the stratospheric abundances of chlorine and bromine are expected to reach their maximum within a few years and then slowly decline. All other things being equal, the ozone layer is expected to return to normal by the middle of the next century.

In summary, record low ozone levels have been observed in recent years, and substantially larger future global depletions in ozone would have been highly likely without reductions in human emissions of ozone-depleting gases. However, worldwide compliance with current international agreements is rapidly reducing the yearly emissions of these compounds. As these emissions cease, the ozone layer will gradually improve over the next several decades. The recovery of the ozone layer will be gradual because of the long times required for CFCs to be removed from the atmosphere.



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Mr. ROHRABACHER. Dr. Albritton, I appreciate your fine testimony today and the testimony we've heard.

I would suggest to our members that we go and vote and we come immediately back after the vote and then we will hear the next testimony and finish up the panel and then go into the question period.

So we are in recess for ten minutes.

[Recess.]

Mr. ROHRABACHER. Ladies and gentlemen, we will move along. We will proceed.

Dr. Watson, I want you to know that I am never concerned with people with beards who aggressively make their case. [Laughter.]

Dr. Baliunas.

**STATEMENT OF DR. SALLIE BALIUNAS, SENIOR SCIENTIST,  
THE GEORGE C. MARSHALL INSTITUTE, WASHINGTON, DC**

Dr. BALIUNAS. Thank you. Mr. Chairman and Members of the Committee, I am a research astrophysicist. The following statement is my personal view of the technical issues and does not represent any institutional position.

The following is drawn from the peer-reviewed literature and from the WMO reports.

Chart 1 on the easel—thank you—shows ozone fluctuations between 1957 and 1991 and these data are the northern hemisphere ozone measurements from ground-base stations.

The ozone decrease over most of the world that is everywhere but the Arctic and Antarctic has been stated as roughly three-tenths percent per year between 1978–79 and 1994.

However, note three aspects of the ozone record.

First, accurately subtracting the large natural effects is difficult.

And, two, selecting starting points for the analysis over relatively short records affects the outcome.

And three, plotting the chart on this kind of scale magnifies very small changes.

Now because they cover a longer interval of time than the satellite data, these data more clearly reveal the extent of natural variability. The record also indicates the level of natural variability before the 1970s, before any substantial anthropogenic impact on ozone.

Now ozone levels change by a large amount every year between spring and fall. Over Washington, D.C., ozone varies annually by 25 percent, some 80 times greater than the stated anthropogenic decline. An average season has been subtracted from the data in Chart 1, leaving other natural factors—for example, changes in the sun's ultra-violet output or changes in the upper atmosphere wind patterns of the earth, and any other trends.

Additional factors which are not currently corrected in records may also exist. For example, decades-long shifts in meteorological patterns.

Now the trends of ozone decline are usually established for two starting points—1970 and 1978 or 1979.

In the records shown in Chart 1, 1970 is the year of maximum ozone level for the entire 34-year record, and 1978–79 is a minor peak in the record.

Mr. ROHRABACHER. Excuse me for interrupting your testimony here.

So you are saying that the year that is being used to judge all the rest of the years on the amount of ozone was one of the highest levels of ozone.

Is that correct?

Dr. BALIUNAS. Look on the chart. The very highest peak there—maybe Debbie could point to the year 1970, and follow it up to the top, the very highest peak in this 34-year record. A minor peak of 1978–79, fortuitously, when the satellites happened to be launched, or coincidentally.

Mr. ROHRABACHER. Okay. And you're suggesting that that skews the analysis?

Dr. BALIUNAS. That choosing those end-points in a very short record, if one does not understand all the physical causes of ozone change, does tend to skew the records, indeed.

Mr. ROHRABACHER. Thank you.

Dr. BALIUNAS. And the fact that the observed trends depends on the selection of end points means that the trend has some uncertainty and is not reliably determined.

Finally, Chart 1 shows the ozone fluctuations of a few percent on a greatly magnified scale. However, the zero point on the scale is missing. The total amount of ozone and its variations are shown in Chart 2.

These are the exact same data as in Chart 1 and show the ozone fluctuations in perspective, and again, the seasonal data, the large seasonal data, are missing.

Now as for the accelerated phase-outs, the observational evidence casts doubt on a substantial rapid thinning of ozone over most—

Mr. ROHRABACHER. Excuse me, again. Can you tell us what you think the significance of that chart is?

Dr. BALIUNAS. The first chart shows that the small changes have been magnified on the scale. This chart shows the entire column of ozone above our heads.

Mr. ROHRABACHER. And your conclusion from that is? I'm not going to put words in your mouth. I just want to know what you conclude because I think I know what you conclude.

Dr. BALIUNAS. This is what the total amount of ozone looks like. One can draw one's own conclusion about the level of variability of several tenths percent per year, and determining that.

Mr. ROHRABACHER. It doesn't look like there's much variation.

Dr. BALIUNAS. It is difficult to see on this scale.

Mr. ROHRABACHER. Thank you.

Mr. EHLERS. Mr. Chairman, may I also ask a clarification on the chart?

Mr. ROHRABACHER. Yes. Certainly.

Mr. EHLERS. You said that this chart was the same as the previous one, except you're including the whole scale. But wasn't the first one percent change rather than—

Dr. BALIUNAS. That's right, rather than the entire column.

Mr. EHLERS. Now you don't have units on the first one. Are those percentage points? They're not Dobson units.

Correct?

Dr. BALIUNAS. That's right. The average Dobson level on the other one is slightly over 300. You can tell by looking at this chart, by looking at the mean level there, zero.

Mr. EHLERS. Right. But I'm just clarifying.

Dr. BALIUNAS. Yes. The other chart is percent change from the average.

Mr. EHLERS. And where it says minus two, it means minus two percent?

Dr. BALIUNAS. Minus two percent.

Mr. EHLERS. From the average.

Dr. BALIUNAS. Right.

Mr. EHLERS. Thank you.

Mr. OLVER. Mr. Chairman?

Mr. ROHRABACHER. Yes.

Mr. OLVER. As long as we're butting in here to clarify charts, may I do a little bit of that, too?

Mr. ROHRABACHER. That's absolutely fine, yes, sir.

Mr. OLVER. Dr. Baliunas, you just said—I think I heard you said a couple of times, the total amount of ozone.

When you say the total amount of ozone, is that meant to mean the total amount of ozone in the atmosphere integrated over all degrees?

Dr. BALIUNAS. The Dobson unit is a column, one centimeter square, to be specific, above the ground. This is averaged over the northern hemisphere of ground station.

Mr. OLVER. The northern hemisphere.

Dr. BALIUNAS. Northern hemisphere. It excludes the Arctic only from 30 degrees to 60 degrees north.

Mr. OLVER. So the data that you're talking about in this is an integrated set of columns from over the northern hemisphere—

Dr. BALIUNAS. From ground stations. From 30 to 60 degrees north, yes.

Mr. OLVER. Thirty to 60 degrees.

Dr. BALIUNAS. That's right.

Mr. OLVER. Only in the northern temperate zone.

Dr. BALIUNAS. That's right.

Mr. OLVER. Okay.

Dr. BALIUNAS. This would cover—this is land-based stations in North America.

Mr. OLVER. Are these data in your—

Dr. BALIUNAS. These are mentioned in the WMO report. They are included in my testimony.

Mr. OLVER. It's included in your testimony.

Dr. BALIUNAS. They are not my research. It's peer-reviewed literature, again.

Mr. OLVER. But just to make sure I understand. This is just the northern hemisphere.

Dr. BALIUNAS. Right. Ground-base data, no ocean coverage.

Mr. OLVER. Could your aide show the previous chart again? It was on very briefly as I was coming back in, so that I might see.

Dr. BALIUNAS. That's the percent change from that mean.

Mr. OLVER. In that northern temperate zone.

Dr. BALIUNAS. In that same, right, northern hemisphere.

Mr. OLVER. Thirty to 60 degrees.

Dr. BALIUNAS. Right. And these two charts are included in the testimony.

Well, indeed, based on these small trends, the 1994 world meteorological executive summary estimates the cumulative ozone impact loss in the next 50 years if all the CFCs currently contained in refrigerators, air conditioners, et cetera, were released.

Since most of the CFCs are already in the atmosphere, preventing the release of CFCs in existing equipment would have little effect.

In fact, it would avoid an additional maximum ultra-violet-B exposure equivalent to a move 1,000 yards closer to the equator.

Now the penalty for a four-year delay in the phase-out, what would the delay of setting back the manufacturing date for CFCs to the original year 2000 from 1996, cost in added UV-B exposure?

Similarly, assume the maximum future loss of 1.5 percent as given in the WMO 1994 report for the northern mid-latitudes in summer and fall, and assume that loss, that maximum loss, is sustained for four more years.

The effect of that four-year delay would be equivalent to moving 20 miles closer to the equator for four years. Such small increases in UV-B are hardly significant when compared to the natural fluctuations in UV-B. For example, 50 percent seasonal changes.

Given the background of large natural fluctuations, such small increases in UV-B also cannot be reliably extrapolated to yield a small risk.

Mr. ROHRABACHER. Excuse me, again. I'm sorry for interrupting.

You say the seasonal changes. When is the season that is the maximum UV-Bs?

Dr. BALIUNAS. Spring, summer, fall.

Mr. ROHRABACHER. That's the maximum time of exposure, when we have exposure for human beings?

Dr. BALIUNAS. The maximum—let me get this exactly right.

Over Washington, D.C., ozone varies 25 percent.

Mr. ROHRABACHER. Right.

Dr. BALIUNAS. And it drops from the spring to the fall and then recovers the following spring.

Mr. ROHRABACHER. Okay. Now, let me put it this way, in another way.

The ozone layer is thickest in the winter or in summer months?

Dr. BALIUNAS. It is thickest in the—ozone levels drop in the spring. So it's thickest towards the spring in the northern hemisphere and drops in the fall.

Mr. ROHRABACHER. Okay. You can continue.

Dr. BALIUNAS. And, of course, the sun is changing at a slightly different angle. So the amount of UV-B exposure is maximum usually in the late spring, early summer.

Mr. ROHRABACHER. Okay. Go right ahead.



Dr. BALIUNAS. I'm finished. My last sentence, just to reiterate—the effect of the four-year delay would be equivalent to moving 20 miles closer to the equator for four years. Such small increases in UV-B are not significant compared to the natural variations of 50 percent at the latitude of Washington, D.C., and given this large backdrop, can't be extrapolated to meaningful levels of risk.

Thus, the delay of four years would entail no significant risk to public health.

[The complete prepared statement of Dr. Baliunas follows:]

Ozone Variations and Accelerated Phaseout of CFCs  
 U.S. House of Representatives Subcommittee on Energy and Environment

September 20, 1995

Sallie Baliunas

I am a research astrophysicist and Chair of the Science Advisory Board of the George C. Marshall Institute, a nonpartisan science and public policy research group. The following statement is my personal view of the technical issues and does not represent any institutional position.

The accelerated phaseout of some stratospheric-ozone-depleting substances (SODS), moved from 2000 to 1996, arose partly from a 1992 prediction of severe ozone loss over North America. That prediction of severe loss is now known to be incorrect. Two topics will be reviewed to show why the accelerated phaseout might be reconsidered:

1. Global Ozone Changes

The ozone decrease over the rest of the world – that is, everywhere but in the Arctic and Antarctic – has been stated as roughly three-tenths of a percent per year between 1978-1979 (when satellites were launched to make the first global ozone measurements) and 1991 (before the eruption of Mt. Pinatubo, which complicates the interpretation of the ozone record). There are two major difficulties in the analysis of the ozone record which affect the determination of a trend of a few tenths per cent per year: (1) accurately subtracting the natural effects; and (2) selecting starting points for the analysis in relatively short records.

Chart 1, showing the ozone fluctuations between 1957 and 1991 (prior to the eruption of Mt. Pinatubo), underscores the difficulties involved in determining a trend of a few tenths percent per year: These data are the Northern Hemisphere (latitudes 30 to 60 degrees N) ozone measurements from ground-based stations (Krzyscin 1994). Because they cover a longer interval of time than the satellite data, they more clearly reveal the extent of natural variability, and thus the difficulty of determining the SODS-caused trends. The record is also of interest because it indicates the level of natural variability before the 1970s, and before the significant buildup of SODS in the atmosphere and thus any substantial anthropogenic impact on ozone.

The first difficulty in determining a trend as small as 0.3% per year is the fact that ozone levels vary naturally by large amounts. For example, ozone levels drop by a large amount every year between spring and fall (in the Northern Hemisphere) and then recover. Over Washington, DC, ozone varies annually by 25%, some 80 times greater than the stated anthropogenic decline.

Ozone also varies because of other natural factors, including changes in the upper atmosphere wind patterns of the earth (the quasi-biennial oscillation, or QBO, which introduces ozone fluctuations over periods of 2-3 years), and the sun's ultraviolet output, which varies every 11 years. Additional factors which are not corrected in the records may exist, for example, decades-long shift in meteorological patterns (Komhyr et al. 1991).

Because the magnitudes of these natural effects are so large, they must be accurately known before the anthropogenic trend can be deduced from the data. One of the important factors contributing to this natural variability is changes in the sun's ultraviolet flux, which cause the creation and dissociation of ozone. But large variations in the sun's ultraviolet output are known to occur and are *unpredictable*. Furthermore, they have not been measured accurately even for one solar cycle. Instead, proxies are used to estimate the ultraviolet flux changes, for example, the 10.7 cm radio flux. NASA-Goddard researchers (Herman et al. 1991) found that ozone *increased* from 1978 - 1991 after they subtracted from the satellite ozone data

the known influences as well as the proxy of the solar effect. That increase is an error that means that the estimate of the solar contribution by proxy is uncertain.

Further evidence of the difficulty in subtracting the effects of solar variability by proxy can be seen in the earlier ozone measurements (Chart 1). In 1957 the most intense peak in the entire four-century span of sunspot observations was recorded. That highest of sunspot peaks should have produced the highest ultraviolet output from the sun, and therefore, a very high ozone peak. Yet the ozone from the Northern Hemisphere shown in Chart 1 was very low in the late 1950s — roughly as low as at present. If the proxy method were used to estimate the effect of the sun on ozone in 1957-58, the very high ultraviolet flux expected for the sun would lead to a substantial *reduction* in the corrected ozone levels. The corrected 1957-58 levels would appear *even lower* than they are in the chart. This result reveals both the uncertainty of the proxy method and the large range of natural variability.

Two additional features to note in this record are:

(i) The trends in ozone decline in the 1994 WMO report are estimated for two starting points: 1970 and 1978-79 (the latter is the start of the global ozone records measured by satellites). But trend analyses based on relatively short time intervals can be skewed by the endpoints chosen. In fact, in the case of the Northern Hemisphere data shown, 1970 is a year of *maximum* ozone abundance for the entire 34-year record, and 1979 is a minor peak of ozone in the record. So choosing 1970 or 1978-79 as the starting point creates the maximum possible downward trends in ozone since then. The selection of other starting points, for example, 1976 or 1957, would indicate no significant downward trend since then. The fact that the inferred trend depends entirely on the selection of the endpoints means that the trend has not been reliably determined.

(ii) Plotting the data in this way emphasizes very small changes in ozone. Chart 1 shows the ozone fluctuation of a few percent on a greatly magnified scale, after the average seasonal fluctuation has been subtracted. However, the zero-point of the scale is missing. The total amount of ozone and its variations are shown in Chart 2. *These are the same data as in Chart 1.* On this scale, the fluctuations in ozone are seen to be insignificant.

A longer ozone record comes from Tromsø, Norway (Henriksen et al. 1994). It covers a very limited geographical region, but spans some 50 years, from 1935 to 1989. Although these measurements are less precise than the satellite measurements, they give a better indication of natural variability because of the greater length of the record. This 50-year record shows large, natural fluctuations over Tromsø. For example, ozone dropped 15% over three years in the early 1940s. In the early 1960s, the ozone was roughly 10% lower than today. All these fluctuations occurred prior to widespread use of SODS, and must be natural.

## 2. Ultraviolet-B

Instead of increasing, UV-B measured at eight stations either decreased or did not change at ground level between 1974 and 1985 (Scotto et al. 1988). A recent recalibration of those data by NOAA researchers (DeLuise et al., 1995, private communication) yields a tentative, small positive trend, but only for clear sky conditions, with no significant, increasing trend for all-sky data. A sustained effort of UV-B monitoring from 1975-1990 at a Smithsonian laboratory in Maryland (Correll et al. 1992) shows that UV-B dosage dropped 20% there (latitude 40N) between 1979 and 1990, when ozone declined about 3-4%.

Toronto researchers (Kerr and McElroy 1993) began a high-quality UV-B measuring program in 1989. Those data, properly reanalyzed by Michaels et al. (1994), and recent, unpublished updates included in the 1994 WMO report, also show no significant increasing trend in UV-B.

The *Executive Summary* of the 1994 WMO report concludes: "Uncertainties in calibration, influence of tropospheric pollution, and difficulties in interpreting data from broadband instruments continue to preclude the unequivocal identification of long-term trends. (p. xv)"

As for media reports of eye and skin diseases increasing in Chile during times of ozone declines and UV-B increases related to the Antarctic polar vortex, a team of Johns Hopkins physicians and researchers (Schein 1995) found "no increase in ... conditions attributable to UV-B exposure ... for periods of known ozone depletion compared with control periods." Those researchers note that the extra UV-B exposure on a few days resulted only in a 1% increase in annual UV-B exposure.

#### Conclusions

The observational evidence casts doubt on (a) a substantial thinning of ozone over most of the world, and (b) increasing trends in UV-B radiation. The accelerated phaseouts, such as the 1992 decision to end U.S. production of some SODS at the end of this year instead of 1999, occurred partly in response to theoretical predictions made in 1992 of severe ozone depletion for the high latitudes of North America. The magnitude and impact of that prediction are now seen to have been greatly exaggerated. In fact, the 1994 WMO report (p. 3.29) says, "In the Arctic, ozone increases are found in both 1992 and 1993..."

Some replacement coolants are posited as strong agents of global warming, and have entered the international negotiations on limits to greenhouse gases. Current policy discussions to eliminate from use those replacement chemicals threaten to create another series of phaseouts to some yet as undefined substitutes.

According to the WMO 1994 *Executive Summary*, eliminating all emissions of methyl bromide from agricultural, structural and industrial use in 2001 would alleviate some of the cumulative ozone loss over the next 50 years. Assuming the maximum theoretical UV-B increase from the cumulative loss of ozone, how much additional UV-B exposure will be averted by this proposed elimination of methyl bromide? Since UV-B strengthens toward the equator, the maximum projected UV-B dosage avoided is equivalent to a move less than three miles closer to the equator.

The 1994 WMO *Executive Summary* also estimates the cumulative ozone loss in the next 50 years if all CFCs currently contained in refrigerators, air conditioners, etc., were released. Since most of the CFCs are already in the atmosphere, preventing the release of CFCs in existing equipment would have little effect. In fact, it would avoid an additional maximum UV-B exposure equivalent to a move 1000 yards closer to the equator for 50 years.

#### Penalty for a 4-year delay in SODS phaseout

What would a delay of 4 years – setting the date of the manufacturing ban for CFCs like CFC-11 and CFC-12 back to the original year 2000 from 1996 – cost in added UV-B exposure? Assume that the maximum future loss of 1.5%, as given in the WMO 1994 *Executive Summary* for Northern midlatitudes in summer and fall, is sustained for 4 more years. The effect of the 4-year delay would be equivalent to moving less than 20 miles closer to the equator for 4 years. Such small increases in UV-B are hardly significant compared to the natural fluctuations in UV-B, for example, 50% seasonal changes at the latitude of Washington, DC. Thus, the delay would entail no significant risk to public health.

# Northern Hemisphere Ozone

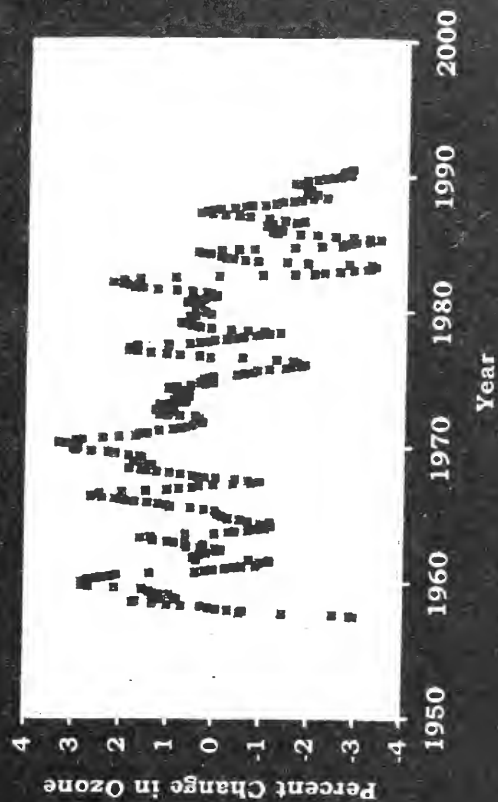
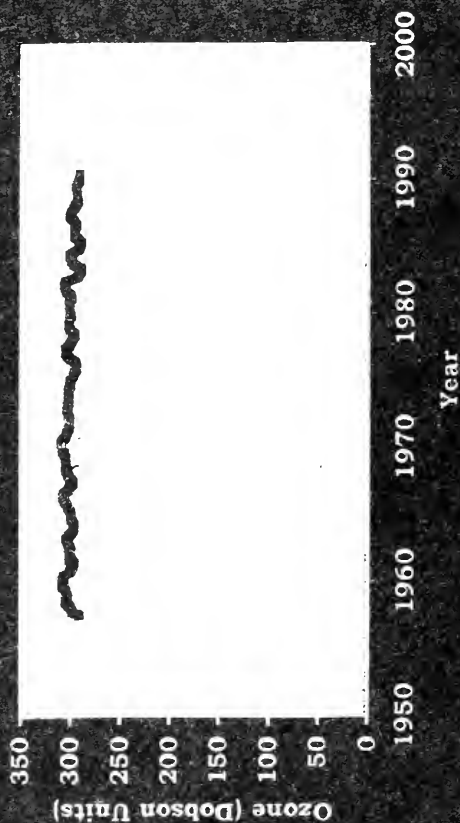


Chart 2

# Northern Hemisphere Ozone



Mr. ROHRABACHER. Dr. Setlow, we'd ask you to testify now. And then right after your testimony, we will then break for the vote and come back for the final witness, and then for questions for the whole panel.

I think that's probably the best way we should go about it.

Dr. Setlow.

**STATEMENT OF DR. RICHARD SETLOW, ASSOCIATE DIRECTOR,  
LIFE SCIENCES, BROOKHAVEN NATIONAL LABORATORY,  
UPTON, NY**

Dr. SETLOW. Thank you, Mr. Chairman.

I'm going to speak about biology in two aspects. One is to tell you a fish story, and I'm sure in Congress, you're very familiar with such things.

The second is to tell you something about the uncertainties in our knowledge. You've just been hearing about the uncertainties in our physical knowledge. I assure you that the uncertainties in our biological knowledge are much, much greater, probably ten- to a hundred-fold greater.

We don't know how to extrapolate or predict what the biological effects might be of ozone depletion and ultra-violet increases at the surface of the earth among humans, plants, animals, eco-systems and so on.

I just want to call your attention to the fact that in a rational world, the funding should be proportional to the uncertainty. If we're uncertain about something, we should put more money into finding that out than if we're not.

In the case of the ozone depletion story, the funding has been inversely proportional to the uncertainty. The greater the uncertainty, the less the funding.

That is to say, biology has never received adequate funding to solve the questions, the answers to which you need. And I will exemplify this with a fish story and tell you a little bit about skin cancer and melanoma.

You have to remember that cancer is a very complicated disease. It involves many steps—initiation, progression, immune-surveillance, and so on.

We don't know which is the rate-limiting step in environmental carcinogenesis. Remember that.

I'm going to describe to you an experiment that tells you about the initiation, the start of the process, by producing damage to DNA, and we know that damage to DNA is important because individuals who are defective in the ability to repair DNA have skin cancer prevalences 1000 or more fold greater than the normal.

But we don't know about the normal population. We know about the repair-deficient population.

So what we really need is some knowledge about animal models. Since we don't easily do experiments on people, we're not permitted to do that, and we have to count on epidemiological data, and the epidemiological data really are built upon a pre-conceived notion of animal models, we must rely on animal models.

There is no good animal model at the moment that will tell us what wavebands of ultra-violet give rise to melanoma.

I assume you all know that most skin cancer comes from sunlight exposure. But which portions of sunlight is the question.

The only convenient model at the moment is a model using fish, small tropical fish that have been bred to be very sensitive to melanoma induction, deliberately. So that a short exposure in the laboratory of these little fish gives rise to the start of a melanoma that is perceptible by a few months and can be scored. And in this way, we measure the sensitivity as a function of wavelength, inducing melanomas.

We find that the most sensitive wavelength is in the UV-B region of the spectrum. But that is not the whole story because we have to worry about how much UV-B and UV-A is actually in natural sunlight. There's much more UV-A in sunlight than UV-B. So what we're really interested in is the product of the two.

I have a table in my text which shows for nonmelanoma skin cancer and for melanoma skin cancer, the values for UV-A and UV-B, the sensitivities per unit energy, and how much of skin cancer on a mouse model for humans would give rise to nonmelanoma skin cancer—about 95 percent, roughly speaking, of UV-B is the important one.

In the case of melanomas, 90 percent of the effect would come from UV-A.

Now when I say melanomas, you must remember, these are experiments done with fish. Are you willing to extrapolate from fish to humans? Well, I'm willing to extrapolate from fish to humans because, after all, fish have DNA. They have melanocytes. They have melanin. And they get melanomas.

Many people are not very happy about extrapolating this fish story to humans, and so that's an uncertainty. The big uncertainty lies not in the data on fish, but on whether it's valid to extrapolate. This is a big biological problem.

Moreover, our experiments deal with the initiation, the first step in cancer induction in these fish because they've been bred to be sensitive to that.

What about all the other steps in humans—progression, immunosurveillance? How do they depend upon wavelength?

So the point I'm trying to make is that the cancer depends on lots of steps about which we have limited knowledge. We know one step very carefully for fish. We know some of these steps for mice for nonmelanoma skin cancer.

My conclusion is that the large increase in skin cancer over the years, especially melanoma, I should say, over the years, four to five percent per year, well documented, good scientific, peer-reviewed data, arises obviously not from anything to do with ozone depletion because melanoma has been increasing for 50 years.

It has to do with our lifestyles, how we go out in the sun, how we apply sunscreens. Sunscreens screen out the UV-B. And those of us that like to go out in the sun put them on and stay out for a longer time and we get UV-A.



And so, hypothetically, this is the reason for the increase in melanoma. It is our lifestyle. It is not ozone depletion.

Whether you make the extrapolation, as I say, requires other models and a lot more knowledge.

Thank you.

[The complete prepared statement of Dr. Setlow follows:]

Testimony of Richard Setlow  
before the  
United States House of Representatives  
Committee on Science  
Subcommittee on Energy and Environment

September 20, 1995

Sunlight and Malignant Melanoma:  
Prediction of the Effects of Ozone  
Depletion and Sunscreen Use

## Sunlight and Malignant Melanoma: Predictions of the Effects of Ozone Depletion and Sunscreen Use

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Before discussing sunlight exposure and human skin cancer, I make a few general philosophical remarks on the concerns of ozone depletion and UV increases. The concerns are mostly biological--the effects on humans, animals, plants, and terrestrial and aquatic ecosystems. The quantification of these concerns involves the product of two different estimations: 1) the increase in UVB for a given decrease in stratospheric ozone and 2) the increase in biological effects for a given increase in UVB. The first is estimated from physical and chemical measurements and theory and has uncertainties of ~ 10-20%. The second depends on biological measurements and theory and is uncertain, I am sorry to say, by a factor of 2-10, i.e. 100-1,000%. There is an impedance mismatch between the physicochemical and the biological uncertainties. Even if we knew the physicochemical values with great precision, we cannot now predict the biological effects with certainty. It should be obvious to you that the funding--the determiner of scientific effort--should be proportional to the uncertainty. I regret that since the 1970s through the present the funding has been inversely proportional to the uncertainties, the greater the uncertainty, the less the funding. Thus, for example, it is not clear which of the several steps in carcinogenesis--initiation, promotion/progression, immunological surveillance, metastasis--is the rate limiting step for skin cancer induction in normal humans. This is especially the case for melanoma.

A recent article (Journal of the American Medical Association, August 9, 1995, page 445) indicates that there are "now an estimated 1 million new cases of skin cancer each year in the United States." Skin cancer deaths number ~ 9,000 per year of which 7,200 are due to malignant melanoma. Malignant melanoma of the skin has been increasing 4-5% per year for approximately 50 years--obviously not the result of changing ozone. It is associated in a complex way, compared to non-melanoma skin cancer, with exposure to sunlight (Armstrong & Kricker, *Melanoma Res.* 3, 395-401 [1993]). It is more common

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\*I am a Sr. Biophysicist and the Associate Director for Life Sciences. I have a Ph.D. in Physics from Yale University and have been working in the field of biophysics and on the effects of ultraviolet radiations on molecules, viruses, cells, and animals since the early 1950s. I was elected to the National Academy of Sciences in 1973 and have served on numerous committees dealing with the effects of radiations. I was a member of the National Research Council Climatic Impact Committee from 1972 until it issued its Report in 1975. I have been recognized nationally and internationally for my work. My most recent research deals with an experimental model--fish--that may be used to determine the wavelengths effective in melanoma induction.

in fair skinned individuals and its prevalence is higher at low latitudes. The fact that individuals deficient in repair of DNA damage have a melanoma prevalence over 1,000-fold greater than normal individuals is evidence that sunlight-induced DNA damage is an initiating stimulus for melanoma. The effects of DNA damage are ameliorated, in part, by human DNA repair systems, systems that may be quantitatively more effective than in mouse or in fish.

Epidemiological evidence and data from experiments with mice indicate that chronic exposure to UVB--the shorter UV in sunlight that is absorbed by DNA and is mostly screened out by stratospheric ozone--is the most effective spectral range for inducing non-melanoma skin cancer. Similar data for malignant melanoma are not as clear, but they indicate that the spectral regions not affected by ozone depletion--presumably the longer UVA wavelengths--are important ones. At present, the only useful animal model to measure the wavelengths effective in light-induced melanoma induction is small backcross hybrid tropical fish, bred to be very sensitive to induction. (Several mammalian models are now being developed.) The biological effect of UV depends upon the biological sensitivity in different spectral regions, such as UVB and UVA, the amount of sunlight in these spectral regions and how the biological response varies with the dose--the dose-response relation. The latter is not really known for human melanoma induction. However, the wavelength sensitivity for the initiation of melanoma is known from experiments on fish. There is appreciable sensitivity for melanoma induction in the UVA region. Because of the large amounts of UVA in sunlight, the UVA in sunlight is the most effective spectral range for melanoma induction in fish. Is it appropriate to extrapolate from fish to humans? I think so, but there is no consensus yet. The wavelength sensitivities of the other steps in carcinogenesis are not known although human epidemiological data seem to indicate that UVB exposure is not of major importance (Magnus, Int. J. Cancer 47, 12-19 [1991]). A simple summary of our results is given in the following table.

APPROXIMATE RELATIVE VALUES FOR SKIN CANCER  
INDUCTION BY UVB AND BY UVA

Non-melanoma (mouse)

|     | <u>energy in<br/>sunlight</u> | x | <u>sensitivity per<br/>unit energy</u> | = | <u>sensitivity<br/>to sunlight</u> |                   |
|-----|-------------------------------|---|--|---|------------------------------------|-------------------|
| UVB | 1                             |   | 1                                      |   | 1                                  | } 95% from<br>UVB |
| UVA | 50                            |   | 0.001                                  |   | 0.05                               |                   |

Melanoma (fish)

|     |    |  |     |  |    |                   |
|-----|----|--|-----|--|----|-------------------|
| UVB | 1  |  | 1   |  | 1  | } 90% from<br>UVA |
| UVA | 50 |  | 0.2 |  | 10 |                   |

The results on fish--a fish story--if extrapolated to humans indicate: 1) any ozone depletion and attendant UVB increase will have only a small effect on melanoma induction, and 2) the use of sunscreens that principally absorb UVB, so as to minimize sunburn, encourage individuals to spend more time in the sun and so increase their UVA exposure and increase the risk of melanoma initiation. A recent case-control epidemiological study indicates that melanoma prevalence is higher among individuals using sunscreens than those who do not (Int. J. Cancer 61, 749-755 [1995]).

A brief summary of our experimental results is given in a chapter in a book entitled, Ozone - Sun - Cancer: Molecular and Cellular Mechanisms Prevention Conference, published in 1995. A copy of the chapter is attached. I would appreciate it if it were included in the record of my testimony.



# Ozone Sun Cancer

Molecular and cellular  
mechanisms  
Prevention

L. Dubertret, R. Santus, P. Morlière  
editors

1995



## Cancer of the melanocytic system

R.B. SETLOW\*

Most skin cancer among caucasians is associated with exposure to sunlight [1], and damages to cellular DNA are implicated as initiating events because repair-deficient individuals (xeroderma pigmentosum) are orders of magnitude more susceptible than normal individuals. Within reasonably homogenous populations, skin cancer increases toward low latitudes, but this association does not indicate the wavelength regions involved in cancer induction. At present, the only animal model suitable for determining the wavelengths effective in melanoma induction are certain inter- and intra-species hybrids of the small fish, *Xiphophorus*. Genetic evidence indicates that the hybrids contain only one tumor suppressor gene and, therefore, are very sensitive to cancer induction by single exposures to light [4]. I and my colleagues [3] exposed 5-day old fish, in spectrophotometer cuvettes, to different monochromatic wavelengths and fluences. The fish were kept for two months in tanks shielded with yellow plastic, so as to minimize the possibility of photoreactivation, and were scored at four months. The melanoma prevalence increased with exposure to a maximum of  $\sim 0.5$  (Fig. 4-1). The fluence-response curves were fitted to surviving fraction =  $a + b(1 - e^{-kE})$ , where  $a$  is the background prevalence with no exposure,  $b$  is the maximum induced prevalence,  $k$  is the sensitivity parameter (the cross section for melanoma induction), and  $E$  is the incident fluence. The value of  $k$  at 302 nm was  $0.05 \text{ m}^2/\text{J}$  giving a mean melanoma inducing exposure, for swimming fish, of  $200 \text{ J/m}^2$ , corresponding to 3.5 cyclobutane pyrimidine dimers per Mbp of DNA in irradiated fish skin. At this wavelength the mean erythema dose for a stationary human is  $400 \text{ J/m}^2$  [2].

The sensitivities at the other wavelengths tested, relative to the value of 1.00 at 302 nm, are given in Fig. 4-2a, along with the action spectrum for human erythema and the mid-summer sun's spectrum at 41°N latitude. The melanoma sensitivity in the UV A region is orders of magnitude greater

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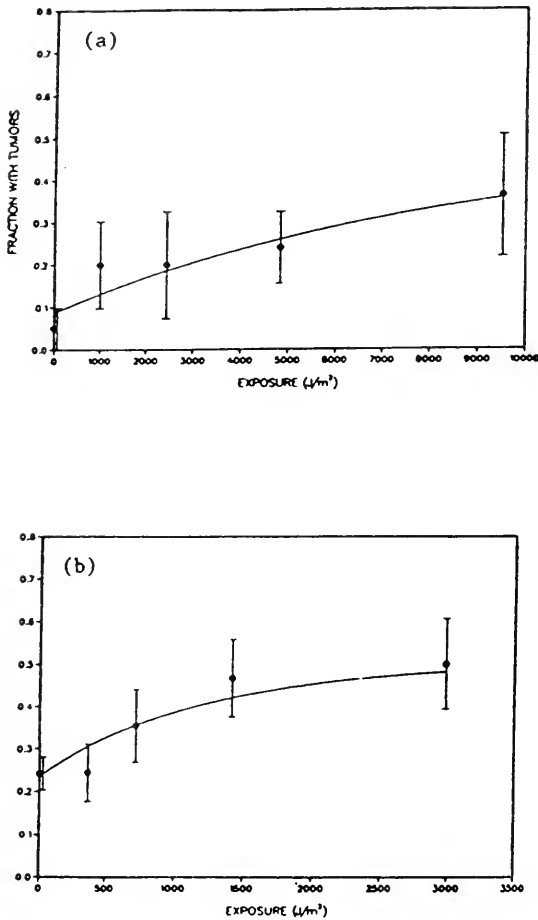


Fig. 4-1 Fluence response curves for melanoma induction in hybrid fish by a) 405 nm, and b) 313 nm. The errors are standard deviations. The background level at 405 nm is less than at 313 nm. The latter experiment used fish maintained in the ambient light of a shaded greenhouse. The former used fish maintained in tanks screened, for two months, by yellow plastic. We interpret the difference as indicating that visible light is effective in melanoma induction.



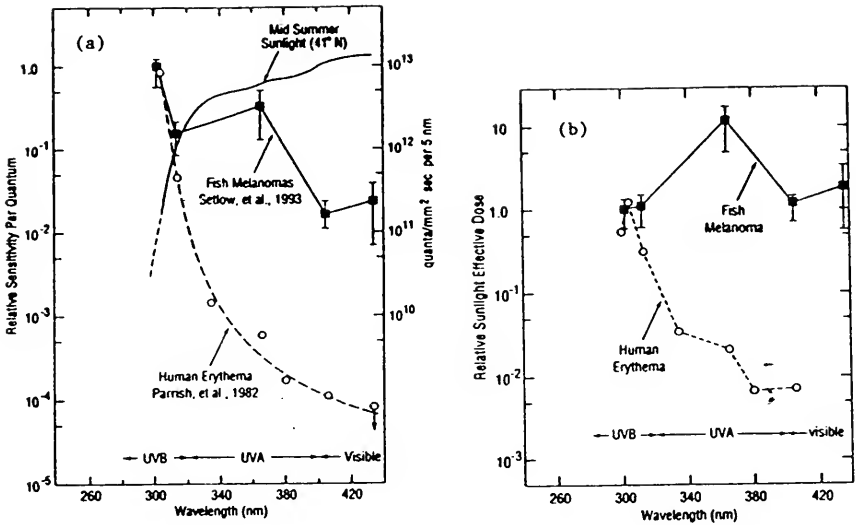


Fig. 4-2 a: Action spectra for melanoma induction and human erythema normalized to 1.00 at 302 nm. Note the exponential sensitivity scale. b: The relative sunlight effective dose versus wavelength.

than for erythema, and sunlight contains much more UV A than UV B. The product of the sun's spectrum multiplied by the action spectrum is the relative sunlight dose as a function of wavelength (Fig. 4-2b). If the human action spectrum were similar to the fish spectrum, UV B would contribute only 5 to 10% of the melanoma inducing effect and 90 to 95% could be ascribed to UV A and visible. Hence,  $\text{O}_3$  depletion would have a negligible effect on melanoma incidence. The high sensitivity to UV A may be explained by free radicals or other activated products formed in melanin which then may affect cellular DNA. Since most sunscreens absorb much more UV B than UV A [1]. Individuals who use UV B sunscreens and increase their exposure time to the sun, would increase their UV A carcinogenesis dose. An 8-fold increase in exposure time by an individual using an SPF 8 UV B sunscreen would result in a 5 to 6-fold increase in melanoma inducing dose. Hence, the habits of sun exposure, especially the use of sunscreens, would greatly increase the melanoma inducing dose and could be responsible for the melanoma epidemic and exponential increase, 5% a year for 40 or more years.

This work was supported by the Office of Health and Environmental Research of the U.S. Department of Energy.

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2. PARRISH JA, JAENICKE KF, ANDERSON RR: Erythema and melanogenesis action spectra of normal human skin. *Photochem Photobiol* 1982 **36**: 187-191.

Data from 250 nm to 405 nm (see Fig. 4-2a). Note that the values of the ordinate in Fig. 4-1a of this reference are too large by a factor of 10.

3. SETLOW RB, GRIST E, THOMPSON K, WOODHEAD AD: Wavelengths effective in induction of malignant melanoma. *Proc Natl Acad Sci USA* 1993 **90**: 6666-6670.

The fish model, described in ref. 2, was used to determine the melanoma susceptibility to single exposures to 302, 313, 365, 405, and 436 nm (see Fig. 4-2a).

4. SETLOW RB, WOODHEAD AD, GRIST E: Animal model for ultraviolet radiation-induced melanoma: Platyfish-swordtail model. *Proc Natl Acad Sci USA* 1989 **86**: 8926-8926.

A description of useful animal models, *Xiphophorus maculatus* x *Xiphophorus helleri* backcross hybrids that develop malignant melanomas within 4 months of exposure to sunlamp radiation > 290 nm or > 304 nm delivered as one or 20 treatments. Exposure of the fish to visible fluorescent light after UV reduces the tumor prevalence to background levels.

5. URBACH F: Ultraviolet radiation and skin cancer. In SMITH KC (Ed.), *Topics in Photomedicine*, Plenum, New York, 1984, pp. 39-142.

A comprehensive review of the photobiology, epidemiology and clinical aspects of non-melanoma and melanoma skin cancer throughout the world.

Mr. ROHRABACHER. Doctor, thank you very much. We're going to break now and just go vote and come right back and proceed with the testimony and then the questioning with the entire panel.

So this hearing is now in recess.

[Recess.]

Mr. ROHRABACHER. The hearing will come back to order and move forward. As Members come in, we will permit them to participate. I'd like to thank all the witnesses so far. We're going to have questions and answers of the entire panel after Dr. Kripke presents her testimony. And then, we will break for lunch after the questioning of this panel and before we call the next panel.

So, Dr. Kripke.

**STATEMENT OF DR. MARGARET L. KRIPKE, PROFESSOR AND CHAIRMAN, DEPARTMENT OF IMMUNOLOGY, UNIVERSITY OF TEXAS, M.D. ANDERSON CANCER CENTER, HOUSTON, TX**

Dr. KRIPKE. Thank you, Mr. Chairman.

My name is Margaret Kripke and I am here as a scientist who works in the area of health effects of UV-B radiation.

My research over the past 20 years or so has focused on the role of UV-B radiation in both melanoma and non-melanoma skin cancer and on the effects on the immune system.

In addition, I currently serve on the United Nations Environment Programme Panel that reviews the health effects of ozone depletion according to the Montreal Protocol. And much of my testimony today is based on the panel's 1994 assessment, which represents the collective wisdom of scientists all over the world who carry out research in this field.

And it is, if I may paraphrase, the conclusion of this document that even a small increase in UV-B radiation present in sunlight is likely to have important consequences for plant and animal life on earth and will almost certainly jeopardize human health.

The best studied harmful effect of UV-B radiation on human health is the induction of non-melanoma skin cancers, basal and squamous cell carcinomas.

Now, as has been mentioned earlier, the incidence of these skin cancers in the United States is already enormous. It's approaching a million new cases per year. This number has been increasing steadily over the past several decades.

And additional increases, beyond those already observed, will certainly result from ozone depletion.

You also heard this morning that currently CFC phase-out scenarios predict that stratospheric ozone levels will reach a minimum in the next few years and then will gradually return to baseline levels by about the year 2050.

Well, what will that do to skin cancer incidence?

Because of the long latent period, the lag period from ultra-violet exposure to skin cancer incidence, this means that the increase in skin cancer incidence will be with us much longer than 2050.

In fact, it will probably only begin to peak in around the year 2050.

So the skin cancer increases due to increased ultra-violet radiation are likely to be with us well into the next century and clear to the end of the next century.

Chronic exposure to ultra-violet radiation also is associated with several harmful effects on the eyes. The most important of these is cataract, which causes blindness in about 17 million people world-wide. And it is clear that the incidence of cataract will increase if UV-B levels rise.

Now, what about melanoma skin cancers?

As you heard from Dr. Setlow, there is great uncertainty in the wavelengths of ultra-violet light that contribute to melanoma. These uncertainties preclude our ability to estimate the impact of ozone depletion on this type of skin cancer at the present time.

It is very important to know what are the wavelengths of ultra-violet light involved in melanoma skin cancer. If UV-B is the predominant wavelength, then the impact of ozone depletion can be considerable.

If UV-A is the principal cause of melanoma, then the impact of ozone depletion is much less.

But I will point out, based on Dr. Setlow's testimony, that the effect is not zero.

There is some circumstantial evidence in humans for a causal role of UV-B radiation in melanomas from past studies, but I think there is newer data from molecular approaches to this problem that promise to provide us with a more direct answer to this question.

Very recent molecular studies on human melanomas point to a role for UV-B radiation in melanoma induction, but so far, they do not point to a role for UV-A radiation.

Now although these findings are still preliminary and incomplete, they point very strongly toward a causal role of UV-B radiation in the development of some melanomas in humans.

UV-B radiation also perturbs the body's immune system. Now our immune system is what protects us against infectious diseases and certain kinds of cancer. And so, anything that could have an impact on immune function has the potential to jeopardize human health by increasing the incidence or the severity or the duration of infectious diseases and certain kinds of cancers as well.

The ability of UV-B radiation to alter and to decrease the body's immune function is well demonstrated in laboratory animal models. It has also been demonstrated in animal models that ultra-violet radiation decreases immunity to infectious agents, such as herpes virus, leishmania, mycobacterial infections, which cause leprosy and tuberculosis, candida, trichinosis, Lyme disease, the list goes on.

In most of these disease models, immune responses to the infectious organisms are diminished and the severity or duration of disease is increased.

There is now also substantial evidence that UV-B radiation can alter and decrease immune function in humans, including one study showing that the immune response to leprosy is decreased in human skin exposed to UV radiation.

This study is one of the only ones available in humans that investigates the effect of ultra-violet radiation on the immune response to an infectious organism.

But I think the message is very clear. Both the animal studies and the limited data available in humans give us reason to believe

that increased UV-B radiation could increase the severity of some infections in human populations.

Furthermore, skin pigmentation, which is protective against skin cancer, does not provide much protection against the immunosuppressive effects of ultra-violet light in humans, suggesting that the population at risk is very large and not limited to the light-skinned individuals who are at risk for skin cancer.

Now because infectious diseases constitute an enormous public health problem world-wide, any factor that has the potential to reduce immune defenses and increase the severity of infectious diseases is likely to have a devastating impact on human health.

At the present time, however, not a single prediction about the impact of ozone depletion on a single infectious disease in a single geographic location in human beings is available.

And this is not because the problem is not important, but it is because there is no information on which to base this type of an assessment.

My last point is that, finally, UV-B radiation may also adversely affect human health indirectly, by interfering with the food chain, by means of its effects on crops, plants and marine organisms.

I think it is very ironic and very unfortunate that the two potential health consequences of ozone depletion that could have the greatest impact on human health by affecting the food supply, by affecting infectious diseases, which are in fact the two greatest health problems in the world, are the two areas in which we have the least amount of available relevant information.

Thank you, Mr. Chairman.

[The complete prepared statement of Dr. Kripke follows:]

**HUMAN HEALTH EFFECTS OF ULTRAVIOLET-B RADIATION**

Margaret L. Kripke, Ph.D.

Vivian L. Smith Chair in Immunology  
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**United States House of Representatives  
Committee on Science  
Subcommittee on Energy and Environment**

Hearing on Accelerated Phaseout of  
Stratospheric Ozone Depletion Substances

September 20, 1995

## INTRODUCTION

My name is Margaret Kripke, and I am here today as a scientist and expert in the area of health effects of UV-B radiation. My research over the past 20 years has focused on the role of UV-B radiation in both melanoma and nonmelanoma skin cancer and on the effects of UV-B radiation on the immune system. In addition to my personal research expertise in this field, in 1987, I chaired a subcommittee of the U.S. EPA Science Advisory Board that reviewed the EPA's document on the science behind the causes and effects of stratospheric ozone depletion, and I currently serve on the United Nations Environment Programme Panel that reviews the environmental effects of ozone depletion every 4 years, in accordance with Article 6 of the Montreal Protocol. Much of my testimony today is based on the panel's 1994 assessment of the available scientific information on ozone depletion (1), which represents the collective wisdom and consensus of scientists all over the world who carry out research in this field.

## OVERVIEW

The amount of UV-B radiation in natural sunlight is dependent on the concentration of ozone molecules in the atmosphere. Reducing the ozone concentration would increase the amount of UV-B radiation reaching the surface of the earth. Even a small increase in the amount of UV-B radiation present in sunlight is likely to have important consequences for plant and animal life on earth and will almost certainly jeopardize human health. The best understood harmful effects of UV-B radiation on human health are its ability to cause basal and squamous cell cancers of the skin and eye damage, including cataract, which can lead to blindness. Sufficient information is now available to permit quantitative estimates of the impact of ozone depletion on nonmelanoma skin cancer and cataract.

UV-B radiation also contributes to the development of melanoma skin cancer and perturbs the body's immune system in ways that can reduce immunity to infectious agents. These effects are poorly understood, and therefore, the magnitude of the impact of increased UV-B on these health problems cannot be estimated at the present time. UV-B radiation may also adversely affect human health indirectly by interfering with the food chain. On a global scale, the potential of UV-B radiation to increase the infectious disease burden, cause blindness, and reduce the world's food supply constitute the most important possible consequences of increased UV-B radiation for the world's populations.

### **EFFECT OF UV-B RADIATION ON BASAL AND SQUAMOUS CELL CANCERS OF THE SKIN**

Most basal and squamous cell carcinomas of the skin occur on the most heavily sun-exposed body sites of light-skinned individuals, and the incidence rates of these cancers increase with age. These observations, coupled with years of laboratory studies of animal and cell culture models, demonstrate that cumulative lifetime exposure to solar UV-B radiation is the most important cause of these non-melanoma skin cancers. The incidence of these skin cancers in the U.S. is already enormous and is approaching 1 million new cases per year. The number has been increasing steadily over the past few decades, and additional increases in the rate of non-melanoma skin cancer development, above and beyond those already observed, will result from ozone depletion. Current CFC phaseout scenarios predict that stratospheric ozone levels will reach a minimum around the year 2000 and will gradually return to 1950 levels by the year 2050. Because of the long latent period for the development of non-melanoma skin cancers, however, this pattern of ozone depletion will cause the incidence of skin cancer to continue to rise at least until the year 2050 and probably beyond. The latest estimates indicate that for a 1% reduction in ozone, the incidence of non-melanoma skin cancer will increase by  $2.0 \pm 0.5\%$ . With approximately 1.25 million new cases of skin cancer each year worldwide today, this means that



a sustained 10% decrease in average ozone concentration would lead to 250,000 additional non-melanoma skin cancers each year.

## EFFECTS OF UV-B RADIATION ON THE EYES

Chronic exposure of the eyes to UV-B radiation is associated with several deleterious effects on vision. These effects are independent of eye and skin color; thus, the population at risk is very large. UV-B radiation contributes to the formation of cataract, which causes blindness in 17 million people worldwide. It is estimated that a 1% decrease in ozone concentration will increase the incidence of cataract by around 0.5%; however, the exact number is uncertain because the wavelengths of UV-B radiation involved are not precisely defined. It is certain, however, that the incidence of cataract will increase if ambient UV-B levels rise unless mitigating behaviors are adopted. In countries where sunglasses and cataract surgery are not readily available, the problem of blindness caused by cataract will undoubtedly increase.

## EFFECT OF UV-B RADIATION ON MELANOMA SKIN CANCER

Melanoma, a cancer of pigment producing cells, accounts for only about 4% of skin cancer cases in the U.S., but it is responsible for more than 60% of the deaths. Based on many epidemiological and laboratory studies, it is now clear that exposure to solar UV radiation is a major risk factor for human melanoma in light-skinned populations. However, major uncertainties preclude our ability to estimate the impact of ozone depletion on this type of skin cancer at the present time. First, the role played by UV in melanoma development is not well understood and is probably quite complex; second, the dose-response (how melanoma incidence is related to the amount and frequency of UV exposure) is not understood; third, the exact waveband of UV involved in melanoma development (action spectrum) has not been established.

The question of waveband is particularly important because wavelengths in the UV-A region of the spectrum (320-400 nm) will

be minimally affected by ozone depletion, whereas those in the UV-B region (280-320 nm) will be strongly affected. There is some circumstantial evidence for a causal role of UV-B, which has been reviewed extensively in the past (1). However, molecular approaches to this problem promise to provide a more direct answer to this question. Recent molecular studies of human melanomas point to a role for UV-B in melanoma induction, but do not provide evidence of a role for UV-A (2). In one of these studies, a melanoma susceptibility gene called MTS-1 was analyzed in 30 human melanoma cell lines for the presence of UV-specific mutations; 37% of the melanomas had mutations in this gene, and 67% of the mutations were of the types caused by UV-B. The most common type of mutation caused by UV-A radiation (3) was not found among 31 mutations in MTS-1 analyzed in various studies to date. These studies suggest that a minimum of 25% of melanomas may involve UV-B exposure. The actual percentage may be much higher because more than this one gene is likely to be involved in melanoma development, and a direct alteration in DNA is only one of several ways in which UV-B can contribute to cancer induction. Although these findings are still preliminary and incomplete, they point toward a causal role of UV-B radiation in melanoma development in humans.

## EFFECTS OF UV-B RADIATION ON THE IMMUNE SYSTEM

The immune system is the body's main defense mechanism against infectious diseases. In addition to providing protection against bacterial, viral, fungal, and parasitic infections, the immune system also protects against the development of certain types of cancer, particularly those associated with cancer viruses and UV radiation. Any impairment of immune function could jeopardize health by increasing susceptibility to infectious diseases, increasing the severity or duration of infections, or increasing the incidence of certain cancers.

The immunosuppressive effects of UV-B radiation in laboratory animals are well documented. Immune responses initiated or

elicited within UV-B-irradiated skin are diminished, and immunization through UV-B-irradiated skin can lead to a long-lasting state of unresponsiveness to the immunizing agent. With higher doses of UV-B, immune responses initiated at unexposed sites may also be suppressed. These findings led to concerns that immunity to infectious diseases might also be compromised by UV irradiation, resulting in an increase in the severity or incidence of certain diseases. This possibility was borne out in a number of rodent models of infectious diseases, including cutaneous herpesvirus infection, leishmaniasis, mycobacterial infections similar to tuberculosis and leprosy, candidiasis, trichinosis, AIDS, and Lyme disease (borreliosis). In all of these disease models, immune responses to the infectious organism was diminished, and the severity of the disease was increased. Only with one disease, schistosomiasis, was no effect of UV irradiation found. Why resistance to this particular disease is unaffected by UV-B irradiation is unknown, which makes it impossible to predict which diseases will be affected and which will not.

There is also substantial evidence that UV-B alters immune function in humans by mechanisms similar to those described in the rodent models, although much less information is available for humans. The immune response to chemicals applied to UV-B-irradiated human skin is reduced, and long-lasting unresponsiveness has been observed in some individuals. One recent study demonstrated that the immune response to the leprosy bacillus elicited in UV-irradiated skin of healthy, immune subjects was significantly reduced, compared to that in unirradiated skin of the same individuals (4). This study is one of the few to date in human subjects that investigates the effect of UV radiation on the immune response to an infectious organism.

Taken together, information from the animal models and the limited data available in humans give reason to believe that increased UV-B radiation could increase the severity of some infections in human populations. Furthermore, skin pigmentation

does not seem to provide much protection against the immunosuppressive effects of UV irradiation in humans, suggesting that the population at risk of such effects is very large. Because infectious diseases constitute an enormous public health problem worldwide, any factor that reduces immune defenses and increases the severity of infectious diseases is likely to have a devastating impact on human health. At the present time, however, not a single prediction about the impact of ozone depletion on a single infectious disease in a single geographic location can be made. Unless additional information is obtained, this situation will not change.

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Mr. ROHRABACHER. Thank you very much, Doctor. I would note that your testimony does have a lot of "may"s and "could"s in it, and that you actually are highlighting that, to the sense that you're saying that further study must take place and that not enough study has been done to make the conclusions of what may or could happen.

I think that's really an important consideration when looking at this issue.

Before we go on to questions, and I'll go directly to the Members of the Committee, but let me just say one thing for the record from the Chairman's point of view.

And that is that quite often in history, we see cases where all of the experts are on one side and within a few years, all the experts are on the other side.

So, I am not swayed by arguments that here's a big list of scientists that are on my side and you only have a smaller group of scientists on your side.

I'm just not swayed by that at all.

I note that five years ago, the idea of a single-staged orbit rocket system for the United States was derided. Today, everybody in the industry looks at that. That is our great hope, for a single-staged orbit.

But five years ago, it was being laughed off as just something that eccentrics argued in favor of. And this can be shown time and time again.

I understand that, for example, in the case of when someone has certain diseases, for example, and—I'm thinking about heartburn. What's the disease I'm talking about here?

Ulcers. Where the medical profession has a totally different view of ulcers today than it had five years ago, and that the vast majority of doctors swore that it had something to do with acid and tension and now they claim it's bacteria. And in fact, they used to say, drink a glass of milk. And now they say that's the very worst thing you can possibly do.

So when we're looking at things like the ozone hole, or we're looking at things that deal with scientific judgments, let us be honest enough to look at the arguments, rather than trying to belittle the other person's position by saying that these are erratic arguments, rather than going to the heart of the argument.

That's what we have a panel of people before us today for, who have different points of view. And what we're interested in is which one of those views is correct, not who has more people on their side.

With that——

Mr. BOEHLERT. Mr. Chairman, may I just make an observation there?

Mr. ROHRABACHER. Certainly.

Mr. BOEHLERT. First of all, I want to compliment you on the composition of the panel because, obviously, we have diverse points of view represented on the same panel.

And I know you and I have discussed this many times, the frustration we had when we were in the minority, that the alternative side was called at 4:00 in the afternoon, after everybody had departed.

This is refreshing to see this balance on this panel.

But I would make this other observation. I think we have to go with the best available science at the time. We're never going to have absolute certainty.

And the example you use, the single-staged orbit rocket, that was an engineering problem, a little bit different than hard science, as we're discussing it.

But I want to compliment you very much for the composition of this panel and the manner in which you're conducting the hearing.

Mr. ROHRABACHER. Okay. Thank you very much. And Mr. Ehlers will be the first Member of the Committee to have questions. And we will, as I say, hopefully, try to have questions that are aimed at promoting dialogue among the panelists.

Thank you.

Mr. EHLERS. Thank you, Mr. Chairman. The very first is a specific question to the last member of the panel. This issue of immunology relating to this, or immune response, is new to me.

It wasn't quite clear to me from your testimony how this works. Are you talking only about those infections or diseases which enter through the skin, and that irradiated skin has a reduced immune response? Or is it a more general, systemic problem?

Dr. KRIPKE. In the animal models at least, there are two ways in which ultra-violet light can change the body's immune system. One is exactly as you've stated, where an organism, a foreign substance, comes through UV-irradiated skin and then the immune response to that organism is decreased.

But it is also true in the animal models that ultra-violet irradiation causes systemic immune suppression, so that some organisms can be introduced at non-irradiated sites and still have an increased disease-causing pathway.

Mr. EHLERS. Okay. As a fair-skinned individual, this makes plain why I get sick all the time. [Laughter.]

I would like to go back to my opening statement and relate to that and then ask all of you to respond to a specific question.

I made my comments at the beginning about the uncertainty of a good deal of scientific evidence when it's difficult to do the experiments, which it is in this case, certainly.

It seems to me the disagreement we have on the panel reflects this difficulty. But it seems to me it's at different stages.

If you look at the issue of the presence of CFCs or their kin in the atmosphere, that can be determined with a fair degree of certainty. We now have satellite measurements of that and other approaches. It's working quite well.

So we have a good deal of certainty there.

The impact of the presence of CFCs on ozone, the total amount of ozone there is less well understood, I believe, and certainly not as accurately measured. Partly, I believe, because the mechanism may not be totally understood, largely because of the natural fluctuations in ozone.

So it seems to me that there, you're introducing a fair amount of uncertainty.

But the real issue that we get concerned about and the basis upon which we form public policy is the health effects of the ozone depletion.

I appreciated Dr. Setlow's comment about the funding is inversely related to the uncertainty, and I think that's a very valid point.

But I would be interested in the response of each of you to the following question—what should we do as a Federal Government to try to reduce the uncertainty involved here? Where are the most fruitful areas of research in determining what we really have to know in terms of public policy?

And that is, what is the correlation between CFC use and health effects?

That's, I think, the crux of what we're examining here as a panel today. And which areas of science need the most research? Where are the greatest uncertainties in that? Is it perhaps the fact that there are other ozone-depleting chemicals around that we haven't observed as carefully and don't know the effects on?

What can we do in terms of control of the natural chemicals up there? Can we have anything to do with that, such as methane and others?

Just a whole host of questions here and the time is limited, so I'd like to have you each try to zero in on what you as an individual panel member think we should be doing in terms of trying to pin down this uncertainty, get the kind of results that will convince not only me, but Chairman Rohrabacher and others of the proper avenue to take in public policy.

Dr. Watson.

Dr. WATSON. Thank you. I start with a premise which is slightly different.

I believe we do know enough to firmly establish the relationship between human activities and loss of ozone. I don't think there's any question whatsoever based on incredible amounts of laboratory data, of both homogenous—that's gas-phase—and heterogenous chemistry or observations of aircraft, balloon and satellites.

There is no doubt in my mind and the large majority of scientists that we have established cause and effect over Antarctica. None whatsoever. And that when you have ozone depletion over Antarctica, you get more UV-B.

The two big areas where I do believe we do not have what some people would like to see as sufficient evidence is well-determined trends of ultra-violet radiation at the earth's surface, at mid-latitudes, where we all live. And also whether or not there is a direct relationship, or what that relationship is, between ultra-violet B radiation and melanoma.

So I believe we have established beyond doubt the ozone is depleting because of human activities. Unfortunately, we do not have the right ground-based system at mid-latitudes to observe that predicted increase in ozone. But we also do know that some of the health effects are well established, that is, UV-B and nonmelanoma. And as Dr. Kripke said, even in those cases, half to one percent of the cases are fatal.

So we have got a link. The two weaknesses, therefore, ground-based observed at mid-latitudes of UV-B, and a better understanding of some of the non-melanoma health effects, the other things other than non-melanoma.

Mr. EHLERS. Thank you.

Dr. SINGER. I'd like to comment on your question. Your question relates to the health effects.

I'm not a health scientist and therefore, I have to use what I would call a common-sense approach to this problem.

We've heard from Dr. Kripke about what she regards as the devastating health effects of a small increase in UV-B. By small increase, I suppose she means five or ten percent, the type of increase that's being envisioned as a result of the putative ozone depletion.

I just want to point out that if you move from New England to Florida, you get an over 200 percent increase in UV-B because of the steeper sun angle. It has nothing to do with ozone, really. It's the steeper sun angle, same amount of ozone.

And therefore, if the effects were really devastating, looking at it now as a physicist, not as a health scientist, I would expect to see all kinds of epidemics in Florida, people whose immune systems were collapsing.

I would see epidemics of cataracts and all sorts of things because of the much, much higher levels of UV-B in Florida, which exist naturally.

Mr. ROHRABACHER. Well, Dr. Singer. Let's ask the two, then.

Are there such epidemics taking place in Florida of cataracts and melanomas?

Dr. KRIPKE. I can't answer the question about cataracts. That's not my area of expertise. Perhaps someone else can.

Mr. ROHRABACHER. Is there any information on cataracts because cataracts was something that was brought up earlier. It was in your testimony, I believe, that it would have an impact on cataracts.

Do we have any evidence for it?

Dr. SINGER. Well, I've read a paper by Professor Schlein. Oliver Schlein is a professor of ophthalmology at Johns Hopkins University. He published a paper this year, in April of 1995. The work was supported by EPA and NASA.

He went down to the Antarctic to study the effects on eyes of increased UV-B. He reported no effect.

Mr. ROHRABACHER. What about between the northern part of the United States and the southern part of the United States?

Dr. KRIPKE. I think that the part of the world that is more likely to be affected are parts of the world where sunglasses are not available and cataract surgery is not available.

There are ways to decrease the impact of ultra-violet radiation on the eyes, such as wearing sunglasses. We can prevent blindness from cataracts by cataract surgery.

So I think the place that you would expect to see the biggest impact of those kinds of effects of ultra-violet light are in underdeveloped countries where those mitigating factors are not available.

Mr. ROHRABACHER. Do we have any evidence of that happening?

Dr. KRIPKE. I can't answer that question.

Ms. RIVERS. The nonmelanoma cancer.

Mr. ROHRABACHER. Nonmelanoma cancer.

Ms. RIVERS. Is it not true that there are higher incidences in climates closer to the equator?



Dr. KRIPKE. That is clearly true. There is a latitude gradient for skin cancers.

I don't think there's any question that nonmelanoma skin cancer is related to ultra-violet B radiation. I can't imagine that there is still anyone in the world who doesn't believe that UV-B radiation is not the major cause of nonmelanoma skin cancer.

So one thing we can say for absolute certainty is that if UV-B radiation at the earth's surface increases, there will be more cases of nonmelanoma skin cancer.

I don't think anyone will argue with that.

Dr. SINGER. Just to complete my answer to you, I agree that increased UV-B will produce more nonmelanoma skin cancers.

The question really is how many more?

Mr. ROHRABACHER. Dr. Setlow, you're the other health specialist with us on the panel today.

Dr. SETLOW. You have to understand that my background originally was in physics, and that makes me an expert in health. [Laughter.]

Mr. ROHRABACHER. Thank you.

Dr. SETLOW. The important point about diseases is that they have to be enumerated. And in the case of certain cancers, there's a good registry. They're reported. Melanoma is reported. Nonmelanoma is not reported really in any rational way, and cataracts certainly are not reported to a central registry.

So it's very difficult to get those data over the U.S. It's very easy to get melanoma data and, with special surveys, nonmelanoma.

And it's very clear, as Margaret Kripke said, there's a lot more nonmelanoma in sunny climates. The best and biggest comparison comes between Australia and Norway, similar kinds of fair-skinned populations.

Nonmelanoma in Australia is about 20-fold greater than in Norway, a tremendous difference. Melanoma in Australia is only about two-fold greater than in Norway.

So there's either a very different dose response relation or a very different wavelength relation, which you can't tell from the epidemiology.

Mr. ROHRABACHER. I think the central question is whether or not this relates to the depletion of the ozone and how does that fit in with this?

Dr. Albritton.

Dr. ALBRITTON. Thank you, Mr. Chairman.

I am an atmospheric chemist and by no means an expert in health. The only area of health that I am an expert in is that of airline food on human beings. [Laughter.]

But I do know who to check with on advice. I pointed out earlier that there is an assessment panel on effects and Dr. Kripke participated in that and described it on hers. And I did recall, and as I'm asked questions on areas that I don't know anything about, having looked up issues in the health effects assessment.

You had asked about cataracts. Let me just read to you the ophthalmologist's reports in the health effects assessment.

It's noted that a 1 percent increase in stratospheric ozone depletion has been predicted to be associated with a 0.6 to 0.8 percent

increase in cataracts. This estimate, although crude, has not been improved upon since the last assessment.

So that's their current statement on the role of ozone depletion and cataracts.

Thank you.

Mr. EHLERS. Dr. Baliunas next?

Dr. BALIUNAS. The question was where to put areas of research funding.

I would guess accurate UV-B ground-level measurements are really needed because the current measurements are fraught with uncertainty.

There also should be, and I believe there is, research on the environmental and health impacts of the replacement chemicals that are being phased out.

So we thoroughly understand their impact on the environment as well, whether or not the replacements are causing, will cause acid rain problems.

Mr. EHLERS. Thank you. Dr. Setlow.

Dr. SETLOW. I come back more or less to my original statement. And that is we're concerned, not because of the ultra-violet, but because of the effects on life on Earth. And therefore, there has to be more money put into the area of greatest uncertainty.

What are the effects on biological systems?

I'm sorry to say that, in most cases, you're only going to get this by putting more money into that field. And I'm not sure exactly how to do it. I can give you my prejudices, but they're only prejudices.

I happen to be prejudiced in favor of fundamental research. Tell people you have to know something about these effects. And if there's money, lo and behold, the answer, might/may appear.

Without that, the answer will not appear.

Mr. EHLERS. Dr. Kripke.

Dr. KRIPKE. I also—I guess we all have our own biases based on our background and interest in this area.

But I think the most important thing from my perspective is understanding what are the consequences of UV-B radiation. And again, we have very little information on some of those potentially important effects.

I think the two most important ones, really, are the immunological, potential immunological effects of UV-B radiation because the order of magnitude of that problem may be large. Lots of people are susceptible. It doesn't take much ultra-violet light to alter the immune system.

The other area of uncertainty I think it's very important to have information on is melanoma. I think we are currently in a stage of scientific development where a little bit of money put into that question for human melanomas will probably go a long way.

I think we can get some useful answers by doing some critical experiments in humans of that kind.

I agree with Dr. Baliunas that I am concerned about replacement CFC compounds, and I think that we do need to know what are the potential health consequences of those compounds as well.

So those would be my three areas where I think we need more information and/or more research.

Mr. EHLERS. Thank you. And Mr. Chairman, it appears that the consensus is that we need better data on UV reaching the earth, both UV-A and UV-B, but especially UV-B.

Secondly, identify the effects of that on human health.

And thirdly, take a look at some of the replacement chemicals. Thank you very much.

Mr. ROHRBACHER. Mr. Ehlers, thank you very much.

Now Mr. Oliver.

Mr. OLIVER. Thank you, Mr. Chairman.

I'm glad somebody summarized the last five or six statements because I'm not sure that I would have been able to have picked out exactly what that summary was from the comments made.

Let me just ask a quick question of Dr. Singer and Dr. Baliunas.

Do you think there should be any controls on the CFCs that are being produced at the present time, given the data that we have?

Dr. SINGER. This is really not a scientific question, I take it. You want my personal feelings on it?

Mr. OLIVER. Yes.

Dr. SINGER. I really have no strong personal feelings about CFCs. My real concern in this whole matter, the reason I'm in this, I don't have a vested interest in this matter at all. It's just to make sure that the science that backs our policies is properly conceived, the science is properly done.

Mr. OLIVER. Well, does the science, as it is now, suggest that we should or should not be controlling CFCs?

Dr. SINGER. I'm more concerned about the fact that I see the science being misused, mishandled, distorted. That's been my theme.

Mr. OLIVER. Okay.

Dr. SINGER. And I'd like to make sure that all sides of the scientific issue are aired and properly discussed.

Mr. OLIVER. Would you like to answer that, comment on it?

Dr. BALIUNAS. Well, I also have no preference. Some of the narrow question addressed here of the accelerated phase-out or delay over the next four years, as the advancement of the phase-out from the year 2000 to 1997.

Mr. OLIVER. You're against the phase-out, the advancement of the phase-out?

Dr. BALIUNAS. Not personally. It's just that it involves a broader issue than the science. It involves the risk/benefits. And I can't comment on those, and the second panel shall.

It involves an economic question as well.

Dr. SINGER. Can I come back to your question? Perhaps I can shed some more light on this.

Specifically, I am in favor of delaying the phase-out to the original date of 2000. I'm not against the phase-out of CFCs, as such.

But I think that we're proceeding in a very hasty way, on the basis, for example, of a theory which has never been proven.

Let me just remind you of the fact that this theory that underlies all of this, the so-called CFC ozone theory, was not able to predict the Antarctic ozone hole, the biggest thing we have, a genuine event, genuine phenomenon.

Never predicted by the theory. It came as a complete surprise.

Well, this theory has been changing every year. Every year. You look at the National Academy of Sciences and study their reports. Every two years, they've come up with a prediction of ozone depletion which was different by a large amount.

Therefore, I think it pays for us to kind of take stock and do a good job on the theory, on the observations, on the UV-B measurements, before we take hasty and, I think, economically very destructive actions.

Mr. OLVER. I guess I'm fearful that if one waited until the certainty of the chemistry and the immunology in a process like this, that we may have been left with something which is either irreversible or exceedingly difficult to reverse, the timeframes on that.

I recognize and I'm sensitive to what the Chairman had said earlier about theories. It was only earlier in this century that the first people who suggested plate tectonics were essentially driven from their field in disgrace. But now everybody in those fields certainly believes it.

I was kind of curious. Let me—it's terrible. I would like to follow a number of different points of questioning here. But I'm sort of curious from Doctors Watson and Albritton.

If you took the spectrum of scientists over a range of from zero concern about this issue to—zero to 100 scale, where the 100 is intense alarm over the issue—where are the number of scientists? Where is the scientists?

You have your data with large numbers of scientists who sign on to what is an average kind of position. But where is that averaged positioned?

Some of them do not view the same alarm as some others within those who have signed on to the data. And where are those who have not signed on? How many of them—what's the distribution of atmospheric scientists or people who work over this whole issue, if I may ask?

Would anyone be able to give me what the distribution looks like, where they are on that scale?

Dr. WATSON. Obviously, I'm biased. I've been associated with international ozone assessment since 1981 and I've either chaired or cochaired with Dr. Albritton all of the assessments involving hundreds of scientists from around the world, and they do come from all walks of life.

As I said in my testimony—

Mr. OLVER. Where is the center of the distribution?

Dr. WATSON. I believe that 95 to 100 percent of the scientists—I can't say 100, because, obviously, there's two at this table who do not believe it—95 to at least 99 percent of the scientists believe those documents on the table in full.

Mr. OLVER. All right. I'm not going to get an answer in the terms that I was looking for it, in any case there. But that's okay. I can understand why that might be.

Let me follow a question here between the two biologists, one physicist, actually, who's admitted to being a physicist rather than a biologist, on this question.

In the data, Dr. Setlow, in your data, you have mentioned that in fish melanoma, 90 percent is UV-A, 90 percent comes from

UVA. And in mouse melanoma, nonmelanoma, 95 percent is UV-B.

In fish, is nonmelanoma also very heavily UV-B? Is this something that I should be able to take away, that nonmelanoma is heavily UV-B?

I'm not sure that one can have melanoma in mice.

Dr. SETLOW. One can have melanoma in mice.

Mr. OLVER. And is that heavily UV-A? Do I see that across all of the animal kingdom?

Dr. SETLOW. The experiments on mice have not been completed for melanoma.

Mr. OLVER. Some of you physicists, give me a relatively narrow range of what UV-A and UV-B is.

Dr. SETLOW. Okay. UV-B, depending on to whom you speak, is, roughly speaking, 290 to 320 nanometers.

Mr. OLVER. Yes.

Dr. SETLOW. And that is what is absorbed by ozone, primarily.

Mr. OLVER. That's B.

Dr. SETLOW. That's B. UV-A goes from 320 to 400. That's the visible.

Mr. OLVER. Okay. Now, if we're talking about that, you have indicated that the rate-limiting step in the biological process on melanoma is not known. I think I've got that correct, that you think the rate-limiting step is not known.

It seems to me that, while we may be looking at broad spectra here, that what is likely to be happening, likely to be happening—I'm perhaps way out on a limb on this—but where there would be specific site processes within the DNA molecules or non-DNA molecules since only a portion—is all of this affected?

You spoke of DNA molecules. Is all the melanoma believed to come from reactions in the DNA molecules?

Dr. SETLOW. The simple answer is yes. The more complicated answer is that DNA absorbs strongly in the UV-B region. And everyone believes that UV-B definitely affects DNA directly.

Mr. OLVER. Is the belief that this is really kind of a general, across the spectrum of UV-B, or is in site-specific locations where—

Dr. SETLOW. No, no.

Mr. OLVER [continuing]. On the DNA molecule?

Dr. SETLOW. All the UV-B, from, roughly speaking—

Mr. OLVER. That take in specific energy.

Dr. SETLOW. In specific places in the DNA.

Mr. OLVER. Specific places, this is going to be rather specific energy.

Mr. ROHRBACHER. Mr. Olver, I'll let you finish this line of questioning, but we should move on.

So if you could wrap it up.

Dr. SETLOW. I don't think this is the question to get into an elaborate discussion of absorption.

Mr. OLVER. Well, that may well be. I think what I was surprised at was your comment after—and I'll finish with this—that while we don't know what the rate-limiting step is, which is specific chemical reaction steps, that's the very implication of the rate-limiting step that goes on in this process, that then you followed that

by saying that you—I think I've got this correct—that you believe that melanoma is not ozone-related, but life-style-related.

You, as a physicist and a biologist working in this field, have moved from what research gets very specific, to an extremely generalized kind of a comment.

Mr. ROHRABACHER. As a surfer, as the only surfer in the room, I'm going to say this is the last question.

So go right ahead.

Mr. OLVER. Fine.

Dr. SETLOW. Okay. I said, if you assume that humans are like fish, that conclusion held. The complication is that melanoma arises in pigment cells, melanocytes. And melanin absorbs at all wavelengths and it is possible that energy, light energy absorbed in melanin, may ultimately affect DNA by indirect mechanisms.

Mr. OLVER. And the melanin itself is part of that DNA molecule.

Dr. SETLOW. No, it is not. It's another thing. Let's call it a sensitizer, if you like.

There are a whole bunch of pigments.

Mr. OLVER. What does it mean, then, that you tell that it comes from DNA, from alterations of the DNA.

Dr. SETLOW. Oh, yes.

Mr. OLVER. But the melanin, which is specifically absorbing the UV-B, is not part of the DNA molecule.

Dr. SETLOW. The melanin is sitting on the side. The melanin absorbs energy and goes—whap, to the DNA.

Mr. OLVER. Oh, I see.

Dr. SETLOW. That's the way it would happen.

But what I meant by rate-limiting steps is the initiation, the start of an altered cell comes from a change in the DNA, whether directly by light energy absorbed in the DNA or absorbed melanin, perhaps.

Mr. OLVER. So the melanin, in this instance, is acting somewhat like a free radical.

Dr. SETLOW. Correct.

Mr. OLVER. Once it has absorbed the energy and then that is the thing in its free-radical state that attacks the DNA molecule and it is the alteration of the DNA molecule that produces the melanoma.

Dr. SETLOW. That's a possibility, yes. That's an explanation.

Mr. OLVER. And the melanin is back in a position to—

Dr. SETLOW. What I was thinking—

Mr. ROHRABACHER. Thank you.

Dr. SETLOW [continuing]. On the rate-limiting step.

Mr. ROHRABACHER. Thank you, Mr. Olver. And maybe you'd like to finish.

Dr. SETLOW. You start with an aberrant cell that can give rise to a melanoma. But there may be immuno-suppressive effects that prevent that cell from growing and becoming malignant. And so, the immune system may be important also in melanoma development. If you have a good immune system, you may have less melanoma.

We don't know which is the most important.

Mr. ROHRABACHER. Thank you very much, Doctor.

Mr. OLVER. Mr. Chairman, no question. But I still am quite surprised that after this discussion, and even as we've just gone through this, that Dr. Setlow is so specific about how one does this and then says that it's life-style, as opposed to not knowing what the rate-limiting steps are.

Mr. ROHRABACHER. The good doctor may well mean that we surfers who spend our time out in the sun voluntarily for a large number of hours have more of a chance of getting melanoma than a nun who's totally covered by her cloak.

Those are choices that people make.

Mr. BOEHLERT. Are you saying that nuns don't surf? [Laughter.]

Mr. ROHRABACHER. Well, we'll get back to that one later.

Now we'll have Ms. Rivers, who may want to ask Mr. Singer about his peer review, the number of peer-reviewed articles that he's written.

Ms. RIVERS. Before I do that, I would like to ask Dr. Watson, Dr. Albritton, Dr. Setlow, and Dr. Kripke, if they are familiar with a publication called the Journal of the Franklin Institute, with what regard that journal is held in the scientific community, and if they know whether or not it is maintained in the library of the institution at which they work?

Dr. WATSON. This is a journal<sup>1</sup> that came to my attention this morning for the first time. It is not in the library of the White House. It began in 1994, with a circulation of 400 people.

It is obviously in a number of libraries and businesses and a number of institutions. We understand its circulation is 400.

Ms. RIVERS. Okay. Dr. Albritton, are you familiar with it, or is it in your institution?

Dr. ALBRITTON. That journal is not in our institution. I'm not aware of it, nor have I heard it discussed at ozone-related scientific meetings.

Ms. RIVERS. Okay. Dr. Setlow.

Dr. SETLOW. I'm familiar with it from my early, early days as a physicist, but I have not seen it for many years and, to the best of my knowledge, it is not in our institution at the present time.

Ms. RIVERS. Dr. Kripke.

Dr. KRIPKE. I've never heard of it.

Ms. RIVERS. Okay. Thank you. Dr. Singer, I have a list of documents that, having talked to a lot of people, seem to have general agreement that these are the fora in which this issue is discussed on a regular basis.

I'd be curious to know if you believe there are others that should be on this list, and we'll see if others agree—Science, Nature, Geophysics Research Letter, the Journal of Geophysical Research, Atmosphere and Environment, Physics Today, the Journal of Physical Chemistry, and the Journal of Chemical Physics.

Are you aware of others that you think have that sort of broad readership and broad contribution that should also be on this list, such as—in the area of ozone depletion, the discussion of ozone depletion.

Dr. SINGER. Well, I would probably list another half-dozen journals.

<sup>1</sup>See letter from Dr. Watson to the Chairman pertaining to this section of the dialogue.

Ms. RIVERS. Such as?

Dr. SINGER. EOS, which is the house journal of the American Geophysical Union.

Ms. RIVERS. Okay. I'll let you stop with that.

I went back through because I wanted to be careful about what I said. I went back through our information. And from at least 1980, in the document list that I gave you here, which are the main journals of discussion in ozone depletion, we found only one article by you—and that was not an article. That was a comment, a technical comment, over the last 15 years.

Am I incorrect? Have you actually published in peer-reviewed documents of these calibers in the last 15 years, articles on ozone depletion, original research on ozone depletion?

Dr. SINGER. Well, you have a list attached to my testimony and you're very free to peruse any of the references therein.

Ms. RIVERS. Well, I'm asking you, the question that I'm asking you.

Dr. SINGER. Including references in Science and Nature, which are listed there, and EOS.

Ms. RIVERS. I have Science, a technical comment in Science.

Dr. SINGER. How many would you be satisfied with?

Ms. RIVERS. Well, EOS which you just gave me, I understand is a newsletter and not a peer-reviewed document.

Dr. SINGER. That's not true.

Ms. RIVERS. Okay.

Dr. SINGER. Not true.

Ms. RIVERS. We have a difference of opinion. But my statement earlier, which came around the comments about published research—

Dr. SINGER. And actually, Technology is also peer-reviewed. The Journal of the Franklin Institute is peer-reviewed, and I wish the editor were here to reassure you.

Ms. RIVERS. But it has not the caliber or the distribution of the list that I read a few moments ago.

Dr. SINGER. I have no idea what the distribution is.

Ms. RIVERS. Okay.

Dr. SINGER. I was asked by the editor to write an article, which I did.

Ms. RIVERS. But my question is, in these documents, these well-recognized scientific, peer-reviewed documents, have you published anything other than the technical comment, which is a response to someone else's article, on ozone depletion in the last 15 years?

Dr. SINGER. Ozone depletion hasn't been around as a subject for that long.

Ms. RIVERS. Or for however long they've been around. Well, then you said earlier you published 200 articles.

Dr. SINGER. How far back do you want to go?

Ms. RIVERS. Well, if ozone depletion hasn't been around for many years, or for that many years, but you claim that you've published before on ozone depletion, I'm finding stuff only from the early '70s by you on ozone depletion and earlier.

Dr. SINGER. 1971, there's a fundamental paper on ozone depletion.

Ms. RIVERS. Okay. So it existed at least then, ozone depletion.



Dr. SINGER. You can start there if you like, certainly.

Ms. RIVERS. All right. I'm curious to know, and I have to say, the reason I didn't ask—

Dr. SINGER. I don't see the relevance to your question, but please go ahead.

Ms. RIVERS. Dr. Baliunas, the question about whether you had the document, I notice that both of your institutes, the George Marshall Institute and the Science and Environmental Policy Project, have the same chairman of the board of directors and have three board of science advisors in common, which is pretty interesting.

What other collaboration do the two organizations have?

Dr. SINGER. Let me answer that question, if I can.

I don't think that we have any formal collaboration that I can point to.

Am I wrong on this?

Dr. BALIUNAS. No collaboration underway and none that we've ever done.

Ms. RIVERS. Okay. Just a coincidence that the same people are on the board.

Dr. BALIUNAS. Just a coincidence.

Mr. ROHRABACHER. Ms. Rivers, your time is just about up.

Ms. RIVERS. Thank you.

Mr. ROHRABACHER. If you have one last question to ask.

Ms. RIVERS. I do. Given that the overwhelming number of scientists who are working on this topic fall on the other side of both Dr. Baliunas and Dr. Singer, I wonder what your explanation for that is.

Is there some sort of conspiracy to keep them—

Dr. SINGER. Yes, I have an explanation.

Ms. RIVERS. Okay. Great.

Dr. SINGER. Would you like to hear it?

Ms. RIVERS. Yes, I would.

Dr. SINGER. In the case of the ozone depletion work, my work has been ignored. My papers have been ignored and you will not find a reference to anything that I've published in here, no matter when it was published.

In the case of global warming, we have actual evidence which I can cite to you, because in the case of global warming, we have a published book called Global Climate Change. And in the book, the editors of the book, who happen to include Dr. Watson, say that there was a minority of scientists who did not agree with the conclusions.

They failed to state whether the minority was one percent or 49 percent, so we don't know. But they do say that they couldn't accommodate the views of the minority. And they didn't.

Ms. RIVERS. Okay. Dr. Albritton, would you like to respond to that, given that you've worked on these issues?

Dr. ALBRITTON. Yes. I am confused by Dr. Singer's statement that his paper was ignored. His one paper that has been referred to, the comment, is referenced on page 9.21 of the current assessment.

It also references the reply of the original authors about whom he was commenting.

And so we not only had included the original paper. We included comments and discussion related to both sets of comments on that paper.

Ms. RIVERS. Thank you. Thank you, Mr. Chair.

Mr. ROHRABACHER. Just a note before we go on to Mr. Boehlert, that there have been times in history, and I think the panel will agree, and probably everyone in this room will agree, when the large majority of scientists changed their views on something that they were very adamant about.

Just to follow up on your question, has there been any situation where—and quite often, when the vast majority of scientists believed in something, they actually were somewhat aggressive and somewhat repressive towards other people who brought up another point of view.

Has anyone on this panel experienced that? In other words, maybe some scientists are keeping their head low because the fact is that the common knowledge of the day happens to be that ozone is a major problem and anybody questioning that might feel some pressure.

Does anyone want to comment on that possibility?

Dr. SINGER. My comment on that is that my impression is that a large majority of scientists do support the present ozone story.

Mr. ROHRABACHER. Yes.

Dr. SINGER. Dr. Watson, at the last hearing last month, referred to me as a minority of one. I think he might want to change his mind after today. At least we have two or maybe more here.

The problem is that there are many, many scientists who do not speak up. And the reason they do not speak up is because they do not want to lose their research funding.

I have personal experience with this and I think Dr. Baliunas can probably enlighten you on this matter further.

Mr. ROHRABACHER. Dr. Baliunas—well, Dr. Watson first, and then Dr. Baliunas.

Dr. WATSON. Thank you, Mr. Chairman.

You're absolutely correct. The majority of scientists have in some cases been proven wrong, as history tells us.

I think after the international ozone trends panel came out in 1988, where we first noted the ozone trends, not only in Antarctica, but in high northern latitudes, there was a real question of whether they were correct or not.

Allied Chemical vehemently believed they were wrong. So did DuPont and so did many of the chemical industry.

A country, the Soviet Union, at that time also believed they were completely wrong.

Allied Chemical put some of their very best statisticians on the job to try and disprove the ozone assessment. The Soviet Union also put some of their best statisticians.

That's what I mean when, many times, minority views, the majority views have been challenged by the minority. They now are key players in the international assessment.

So I believe that not all funding comes from the U.S. Government. It comes from some very conservative governments around the world, and it also comes from industry.

Mr. ROHRABACHER. And Dr. Watson, now that it is the commonly accepted position that the ozone hole is a major threat, do you believe that some people might be a little, let's say, heavy-handed in their dealings with people who disagree with them on this issue?

Dr. WATSON. Obviously, as you say, I speak aggressively and I would not deny that.

However, I do believe that through the international peer-review process, and journals, I believe the minority of scientists have many, many avenues through which they can get their minority views to the public.

Mr. ROHRABACHER. Dr. Baliunas, would you like to comment?

Dr. BALIUNAS. Most chilling is that I've been directly told by officers of federal funding agencies not to apply for funding to work on, quote, certain questions, in this area.

They give two reasons.

One is that answering these questions would undermine the possibility of getting new funds. And this suggests a complete breakdown of the peer-review process.

In addition, answering these questions, or even investigating them, might deter policymakers from, quote, doing the right thing.

Mr. ROHRABACHER. I think that that is—this is what happened to you?

Dr. BALIUNAS. This is what happened to me, personally. There are many other stories, but they are hearsay, and so, I don't want to repeat them.

Ms. RIVERS. Mr. Chair, we should get names and dates and places and investigate this, because if there are agents, scientific agencies in this country who are giving that kind of information, we should know it.

So I would ask that Ms. Baliunas give times and names.

Dr. BALIUNAS. I would be glad to submit that. In fact, I've been badgered. My staff has been badgered in the last several days, my superiors, by an advocacy group, once the witness list came out.

The employer that employs me is unrelated to this testimony. Nevertheless, they've been calling and calling and calling and badgering them, and this has had great effect. It's disrupted my work environment. It's an attempt to intimidate me and to censor my—

Ms. RIVERS. This was a federal employee that was doing this?

Dr. BALIUNAS. No. This is an advocacy group, going to one of my employers completely unrelated.

Ms. RIVERS. You started out when you said applying for grants for the Federal Government.

Dr. BALIUNAS. Those were federal employees.

Ms. RIVERS. And you can give us names and times?

Dr. BALIUNAS. Yes. And what I did early this morning, but did not send, was, due to these institutional pressures, I almost withdrew from this hearing. I just did not fax this to you at the last moment.

Mr. ROHRABACHER. I do think that that is a rather significant element that's been introduced into the testimony today. And it also reflects that some people who are naturally not inclined to buck the common knowledge, that perhaps there's been even something that's been added to that in the sense that, today, when we

have so many people involved in science that actually receive their funds from federal grants, that this is a very serious charge.

We'll go back to that.

Mr. Boehlert, we have time for five minutes' worth of questioning from you, and then we will break for the vote.

Mr. BOEHLERT. Mr. Chairman, I'd like to observe, we've had a depletion problem of our own.

When Dr. Ehlers, who has a Ph.D in physics, left, the scientific expertise of this group up here declined by 100 percent. [Laughter.]

We have difficulty because we're generalists at best, for the most part. So we have to look to the experts for advice to guide our policymaking.

And when the preponderance of scientific testimony supports one direction, that usually is a direction I am comfortable with.

So, Dr. Albritton, I'd like to ask—I'm sure there was some dispute in all the studies you cite there. But how broad and how deep was the consensus?

Dr. ALBRITTON. A few points on that, sir.

First of all, the summary of the document was prepared by the peer review panel and authors, all simultaneously. And that is, the wording and the consensus statements in here were agreed upon by over 80 international scientists that included not only the authors of the chapters, but those who had written, peer-reviewed them, and also participated in a verbal peer review.

I would indicate, in terms of this booklet and the words in there, that the agreement of that group that prepared the larger book was 100 percent.

Mr. BOEHLERT. Let me be very specific. Dr. Singer made a number of assertions disputing whether UV-B is increasing.

What do you believe is wrong with his assertions?

Dr. ALBRITTON. Would you repeat that, sir?

Mr. BOEHLERT. Well, Dr. Singer made a number of assertions disputing whether UV-B is increasing. He made those assertions. And I'd like to know what you think is wrong.

Dr. ALBRITTON. Yes. I'd reply to that in two ways.

What is absolutely sure, numerous data sets indicate and demonstrate with direct measurements of overhead ozone and surface UV, that when overhead ozone decreases, that surface UV increases.

That's been shown, as indicated earlier, in several studies, direct measurements.

What we lack because of the shortness of the measuring record is any long-term trend in the change of UV. Several reasons for that.

It's a difficult measurement. Some of the earlier studies were placed in areas where pollution could interfere with that, and that the modern instruments started only a few years ago.

So I fully support the research statements made earlier that we need to foster and support that start that we've made.

But the fact that we have not yet observed over that time scale a trend, does not imply that a loss of ozone would—that there's anything incorrect about the loss of ozone and the increase of UV.

That is extremely well understood.

Mr. BOEHLERT. Just a quick two-parter.

Should we be concerned with ozone depletion, even if we don't know its full impact?

And do any of you dispute the assertion that man-made chemicals contribute to ozone depletion? Anyone dispute the second part of it?

Dr. ALBRITTON. As far as I can tell from the involvement in scientific conferences, following the literature that was cited earlier, participating in these assessments, the practicing ozone research community believes that if CFCs were to continue to increase in the atmosphere, that stratospheric ozone layer would continue to deplete.

Mr. BOEHLERT. I was talking about our side when Dr. Ehlers left. Dr. Olver over there is a scientist, too.

What about the first part of the question? Should we be concerned with ozone depletion, even if we don't know its precise impact?

Dr. WATSON. I think the answer is, yes, sir. And that's the way I think most of these documents are written, and that is, we do not know all of the implications of ozone depletion, but we know some.

As the two medical experts on this panel have said, and the international scientific community has said, if there's an increase in ultra-violet radiation, we will certainly see an increase in non-melanoma skin cancer.

While only a half to one percent of those cases are fatal, it is still a very serious human health issue. There are costs associated with that nonmelanoma skin cancer and, indeed, unfortunately, a number of such people do die.

So that we know quite well.

So even with that information alone, we can say it's a human health issue.

With respect to other issues, such as the effects on food, natural terrestrial eco-systems, suppression of immune system, there are indications that there would be adverse effects.

My personal belief would be, even if we only knew ozone led to an increase in nonmelanoma skin cancer, with some level of fatalities, that in itself is enough to be concerned about, and all of these other factors, such as suppression immune response system, melanoma, impacts on the ecological system, would make it further an issue to be concerned about.

Mr. BOEHLERT. Dr. Singer.

Dr. SINGER. I'd like to explain why I disagree.

You cannot tell from any evidence we have how much nonmelanoma skin cancer is produced by a change in ozone.

I know that Dr. Watson claims that if UV increases by one percent, then skin cancer will increase by two percent.

That number cannot be maintained, in my view. It is not correct. I'll explain why that is so.

The clue comes from the fact that skin cancers of all sorts have been increasing for the last 60 years. It has nothing to do with changes in UV, nothing to do with changes in ozone. It has, as Dr. Setlow correctly pointed out, it has a lot to do with change in life-style.

People expose themselves more to the sun than they did many decades ago. That's the clue.

And now, specifically, when Dr. Watson mentions that the skin cancer rate, the nonmelanoma skin cancer rate, is five times greater in Albuquerque than in Seattle, and uses this as a way of getting at the numerical value, I can show you that he's wrong on two counts.

In the first place, this bill has a built-in assumption which assumes that you have as many clear days in Seattle as you do in Albuquerque.

That's not a valid assumption.

The second assumption is that people in Albuquerque or New Mexico and Arizona wear raincoats all the time, like they do in Seattle, and cover themselves.

That's not true, either.

There's more exposure to the sun in warmer climates. And that fact alone can explain a great deal of the increase in skin cancer. We don't know how much of it. But, certainly, from the historical evidence, I would say a great deal of it.

Mr. ROHRABACHER. Dr. Singer, with that, we will have to break. We will recess for just about 10 minutes. We'll come back for about 10 more minutes of questioning for the panel, and then we will break for lunch before the next panel.

So thank you very much. We are in recess for 10 minutes.

[Recess.]

Mr. ROHRABACHER. I call this hearing into order again.

Seeing that none of my fellow members are here at this point, I will just move forward some questions. As I say, as we finish this round of questioning, we will break for half an hour for lunch and then have the second panel.

First of all, I have a series of questions that I'd like to ask.

One thing, some of the questions early on, and some of the testimony earlier brought up some questions.

First of all, I guess I should ask Dr. Albritton this. When Dr. Baliunas suggested that when we were talking about measuring and trying to determine depletion of ozone, that you were using as your benchmarks the highest year of ozone—a year where you had the highest level of ozone.

Now, perhaps you could—and by the way, I understand how you can use charts to prove things. And if you do that, doesn't that skew the whole chart? And is that the case? And does that skew your findings?

Dr. ALBRITTON. Mr. Chairman, we actually did a different approach than what was described here.

We had no single one starting point on the downward trend. We actually included the previous years as the baseline to determine that starting point. And that way you don't unduly weight it with any one starting point.

In the report back on this, we examined the sensitivity of choosing the year in which the downward trend may have started. And it is a relatively small sensitivity because of the point that I mentioned; namely, we're fitting with a curve that looks very much like a hockey stick where there is a level period and then a linear trend.

That decreases any weight on a starting point.

Thank you.

Mr. ROHRABACHER. Well, is it possible that—let me ask you this.

Is it possible that we could have had ozone holes in the Antarctic or elsewhere in the world in the many, many hundreds or millions of years that the earth has been around, before?

Dr. ALBRITTON. All the evidence obtained from direct measurements over Antarctica is that it requires elevated levels of chlorine and bromine to cause the ozone hole that we observe now.

Indeed, the early part of the monitoring record in Antarctica, one saw variations that were limited to the natural variations that one sees in ozone in that area. And it was roughly in the 1980s that the observational records showed the overall downward trend.

So I would take from that that without elevated chlorine in the past, that would not have occurred, what we see now.

Mr. ROHRABACHER. So there weren't ozone holes in the past.

Dr. ALBRITTON. No, sir.

Mr. ROHRABACHER. Is that accepted by the panel? I'm not sure. Yes, sir, Dr. Singer?

Dr. SINGER. I don't accept this statement. I published on it in EOS, as a matter of fact, in 1988.

My view is as follows. It's very different from the one just presented and differs from the view presented by Watson.

The hypothesis I have is that chlorine is in fact the agent that affects ozone, but only in the presence of the ice particles. And I think this is supported by the present evidence.

Now what does it take to make ice particles? It takes water vapor and a low temperature.

Therefore, if we had had in the past, and we have a long past on this earth, several billion years, if we'd had in the past a climatic situation that gave you very low temperatures and water vapor in the stratosphere, I think you would have had ozone holes.

And by the same token, if the stratosphere should not warm up, or if the water vapor content of the stratosphere would go down, the ozone hole would disappear, even if we have chlorine in the stratosphere.

That is the view that I have. It's a hypothesis. It should be tested.

Mr. ROHRABACHER. Dr. Watson, would you like to comment on that?

Dr. WATSON. Thank you. Dr. Singer is obviously absolutely correct. You must have ice crystals.

There was enough water vapor and ice crystals back in the last 20 or 30 years. But there's something much more important. You have to have chlorine. You need a specific amount of chlorine.

What we've done is we've not only looked in the laboratory. We've measured in the field exactly the concentrations of the chlorine.

The amounts of chlorine pre-Antarctic ozone hole, pre-human activities, was only about six-tenths of a part per billion, not enough to cause the observed change.

So you need cold temperatures and you need the elevated levels of chlorine that have been put in there by human activities.

It can very, very easily be demonstrated. In fact, I would absolutely welcome a paper by Dr. Singer to be peer-reviewed by the scientific audience.

Mr. ROHRABACHER. Earlier on, when we were talking about—I guess what I'm trying to get at is whether or not the ozone is possibly a naturally occurring phenomenon that could have been—we do know that it's cyclical within the year because we've seen that some times of the year it's bigger, and other times of the year, it almost disappears, if not disappears altogether.

There's something natural going on here as well. Don't the natural occurrences have something to do with this, as well as simply what mankind is involved with?

And I'll open that up to the panel. Maybe first, Dr. Albritton, or Dr. Singer, either one.

Dr. ALBRITTON. Yes, thank you. Ozone is a naturally-occurring compound. It's made by the sun's rays and it was removed over its million original years by natural chemical processes.

And so the balance of the ozone layer that has existed ever since we've had an atmosphere is a balance between the solar input like the water coming into the bathtub, and natural chemical processes that drain it away.

That level does fluctuate. It fluctuates because the natural processes fluctuate.

For example, it fluctuates with the intensity of the sun. It fluctuates with the intensity of the removing chemicals.

We've observed the level of that fluctuation. That level of fluctuation is much smaller than the general downward trend that we've seen in ozone over the 1980s.

What we've done is we've taken a natural chemical cycle like chlorine and we've augmented the amount of chlorine in the atmosphere, so it's like enlarging the hole at the bottom of the bathtub.

With the same input, the water level tends to gradually go down, superimposed on that natural fluctuation as it goes down.

Mr. ROHRABACHER. The CFCs that are produced here, I take it what you're saying is that the CFCs that are produced here have the impact on the Arctic ozone hole.

Why is it that we don't have them creating the ozone hole over the northern hemisphere?

Dr. ALBRITTON. That's a very good question.

Mr. ROHRABACHER. Do the CFCs do that here?

Dr. ALBRITTON. Why does the ozone hole appear over the southern hemisphere and not exactly in the same manner over the northern hemisphere?

Mr. ROHRABACHER. Right. And do our CFCs contribute to the ozone hole there?

Dr. ALBRITTON. Yes, sir. CFCs having a very long lifetime are distributed all over the globe.

Mr. ROHRABACHER. Okay.

Dr. ALBRITTON. It's the special nature of our planet being asymmetric in the way the land masses are distributed.

Over Antarctica, you have a continent. You have a high-elevation continent. You have it surrounded entirely by oceans, which isolates this area and lets it be the coldest of the two poles.

So, in brief, the reason that the large number of ice particles form in the stratosphere over Antarctica is that that is a colder end of the planet than the north.



The reason the north is warmer is all of our land masses, with their mountains, are in the northern hemisphere. And so the dynamics of the air bouncing off those mountains make the Arctic a lot warmer place.

Mr. ROHRABACHER. So that global warming, if it's true, is going to solve this problem for us.

Is that what we can conclude?

Dr. WATSON. Mr. Chairman, unfortunately, it's exactly the opposite of that. [Laughter.]

The carbon dioxide that we put into the atmosphere is predicted to warm the lower part of the atmosphere. It's actually part of Fred's thesis that it is that CO<sub>2</sub> that's cooling the lower stratosphere.

So, actually, more carbon dioxide would make this problem worse.

Mr. ROHRABACHER. All right. I was being a little facetious there, I'll have to admit.

Dr. Singer.

Dr. SINGER. Mr. Chairman, you asked the other question, which is why do people count ozone depletion from the year 1970, when it was the maximum?

Obviously, if you did that, you'd always get a decrease.

What we have to do in order to—let me say, I don't accept the idea of ozone depletion, as yet. I'm not convinced that the present data conclusively demonstrate it, and I'll explain why.

The natural variations are very large and you have to remove the natural variations, stick to the 11-year solar cycle in the record, before you can decide whether or not there is really a trend, a long-term trend.

It's a very simple problem. It's a very difficult problem to do.

In my view, you cannot do this if the record is very short. You cannot do this if the record is only two or three solar cycles. You have to have a longer record.

Unfortunately, to get a longer record takes time. You can't hurry the situation. Even if you throw money at it, you can't speed it up.

I know that this is something that we'll do.

But now let me tell you what happened. The ozone trends panel came up, as Dr. Watson reports, and Albritton reports, with their story in 1988. At the same time, an independent team of scientists working at Allied Signal, if that's correct, did an independent analysis. Their names are Hill and Bishop.

They published their analysis in a preprint, which I have. This preprint showed, and I believe I quote them correctly because I had long discussions with them. But even if you try to take out the natural variations, the so-called trend still depends on when you start and when you stop. It depends on your selection of time interval.

And then something very curious happened. They published their work finally in a peer-reviewed, refereed journal, together with some other scientists, some of whom were government scientists. And suddenly, that part of their work disappeared. It was never mentioned again.

Mr. ROHRABACHER. It was lost in the ozone hole. [Laughter.]

Dr. SINGER. Something like that.

Mr. ROHRABACHER. Dr. Watson, go right ahead.

Dr. WATSON. If Dr. Albritton could actually hold—in the silver document there, the Bishop data is actually in there with Bill Hill. He actually does a sensitivity analysis of taking out the solar cycle, the seasonal cycle.

It also shows the sensitivity to changing the starting point.

It did not disappear. It's actually in the international assessments. And as Dr. Albritton said earlier, it's a relatively small effect.

In other words, you broadly get the same effect, whether you start in 1965 or 1975.

Allied was extremely concerned about that. At that time they were the second largest producer of CFCs in the world. They did not want to phase them out.

Their own analysis showed that there's some sensitivity, but it's small.

Mr. ROHRABACHER. I would hope after the hearing today, you folks could maybe go into that document and apparently Dr. Singer thinks there's something that's not there and you believe something is there, and you can determine that for yourself.

Dr. SINGER. This is not a peer-reviewed document. This is not a publication that has been mentioned by Congressman Rivers as a peer-reviewed journal.

In the peer-reviewed journal, the Journal for Geophysical Research, Hill and Bishop don't mention this, the fact that the trend depends very strongly, I think—it's a matter of judgment—very strongly on when you start and when you stop, on the selection of time interval.

Let me also mention——

Mr. ROHRABACHER. Before we get stuck on this one issue.

Dr. SINGER [continuing]. Allied Signal is now the largest manufacturer of CFC substitutes.

Mr. ROHRABACHER. And before we get stuck in this one area, we'll let Dr. Albritton have one last thing, and I have a couple more questions. And we'll move on to Members of the Committee who have not had a chance to ask, and then some other Members who have some other questions.

Dr. ALBRITTON. Just a tiny footnote to end that discussion.

Mr. ROHRABACHER. Yes.

Dr. ALBRITTON. Dr. Lane Bishop is a lead author on the current chapter of the ozone trends panel here.

Mr. ROHRABACHER. All right. And we'll talk about that later.

Now, Dr. Albritton and Dr. Watson, you both refer to the Montreal Protocol as effective. And in fact, during your testimony, Dr. Watson, you actually said—well, this can only be calculated as to what if we didn't have it? This is going to be the results that would have been detrimental.

What are Russia, China, and India, the three countries that represent a majority of the world's population, doing to carry out the Montreal Protocol?

Dr. WATSON. India and China also have to follow the same phase-out schedule as the developed world, but with a ten-year lag. They have agreed at the international forum that they will also phaseout.

They also, however, need technical and financial help to phase out. That's why there's something called the Montreal Protocol Trust Fund, of which the United States contributes about 25 percent, which unfortunately this Congress decided to eliminate in the President's budget.

My view is India, China, and Russia will all follow the international obligations and phase out the CFCs, assuming there is indeed financial and technical support to help them.

Mr. ROHRABACHER. But they're not now, and they're having no impact at all in those countries, right?

Those countries are still operating—their activities have not been altered because of the protocol. Isn't that correct?

Dr. WATSON. The activities in Russia have been altered and the activities in India and China, they are following what they signed up for. That is, a complete phaseout, like us, ten years after us.

Mr. ROHRABACHER. Well, what about reports that these countries are becoming the source of actually manufacturing more CFCs and involvement in a huge black market that's been developing all over the free world right now?

Dr. WATSON. I honestly cannot address that. But, hopefully, you could maybe address that to the next panel, which may have got more expertise on that subject.

It's just outside my expertise.

Mr. ROHRABACHER. All right. That's a fine suggestion.

Let me just ask this. If people were allowed to keep freon in their air conditioners, as was planned until the year 2000, and we didn't speed up this situation, as we did because of—and I might add, the stampede created by a political leader and group of political people who, I think, created a false alarm, what would be the difference today in the world's ozone layer?

Dr. ALBRITTON. We made an estimate of that using the same techniques that were done for the international assessment. And let me rephrase your question slightly.

It would be impossible to go backward to the early 1987 levels because measures have already been done to reduce those.

But we calculate that if one were to continue at the 1995 present emission levels up to the year 2000, and that is, delay that phase-out, that in terms of the total amount of ozone that will be lost between now and, say, the middle of the next century, it would add five percent more loss total to that ozone.

That would be a 20-year period where the ozone depletion would be approximately one percent higher, and others can translate that into the health effects.

Mr. ROHRABACHER. So it would be one percent higher if we wouldn't have moved forward.

Dr. ALBRITTON. The total effect of delaying it that 5 years is to add 5 percent more ozone depletion over the next 50 years.

Mr. ROHRABACHER. But where was the 1 percent, again?

Dr. ALBRITTON. The actual year-by-year ozone decrease in the next 20 years would be one percent more than we had anticipated.

Mr. ROHRABACHER. And do we see any major health impacts from that?

Dr. KRIPKE. Well, according to the 1994 assessment, there were some calculations made about what happens to skin cancer inci-

dence, nonmelanoma skin cancer incidence, under several different scenarios of phase-out.

It shows that, with the Copenhagen Amendment to the Montreal Protocol, which is the current scenario that we are operating under, that even under the best conditions, which these represent, there will still be a 25-percent increase in nonmelanoma skin cancer in the year 2050, in comparison to what it was in 1980.

And this is at approximately 50 degrees north latitude.

So even under the very best scenario of phaseout, there will be more cases of skin cancer than there were before.

So I think there's no question that decreasing the rate of phase-out will have an impact, a significant impact on nonmelanoma skin cancer.

Mr. ROHRABACHER. We'll let the next panel decide whether or not, and we'll talk about the costs that were related to speeding this up, and whether or not the number of skin cancer cases and the cost related to skin cancer cases would sometimes, if treated early on, are negligible costs. And sometimes if they're not treated early on, are somewhat expensive.

Dr. KRIPKE. May I respond to that, please, Mr. Chairman?

Mr. ROHRABACHER. Not until I finish the statement. Then you're very welcome to respond.

And that is, compared to the billions of dollars that are taken out of our economy by the decision to speed this up—there is an impact.

For example, earlier, you were complaining that we didn't have money for the research of certain diseases. Well, that money is coming out of the same pot that's disappearing because we sped up the process.

This is all coming out of the same economy.

And if money is not absolutely necessary to spend the money, and it costs us, let's say, \$20 billion out of our system, or some people would estimate it at much higher levels, the cost of speeding this up, that money is now not available for education, for health care, for the research that you support.

And please do comment on that.

Dr. KRIPKE. I think one misconception, one popular misconception needs to be set straight for the record. Which is that it's not true that a delay in seeking treatment for nonmelanoma skin cancer is responsible for increased economic costs.

There are many cases of nonmelanoma skin cancer which are lethal, which are aggressive, which are invasive.

We happen to have a particularly high incidence of such cancers in the State of Texas. And it is not true that these skin cancers are aggressive, disfiguring and life-threatening because there is a delay in seeking treatment.

That is a misconception.

Mr. ROHRABACHER. You mean, in other words, some people who don't seek treatment earlier would go through the same problem, anyway. It's just something out of control.

Dr. KRIPKE. That is correct. Clearly, early diagnosis is very important for skin cancer and for getting treatment. But it is not true that early diagnosis will prevent all serious cases of nonmelanoma skin cancer.

Mr. ROHRABACHER. I don't think I used the word, prevent. I don't think that ever came up until this moment.

Dr. KRIPKE. The other point I'd like to make is that nonmelanoma skin cancer has a significant economic and psychological burden as well.

It is not as life-threatening as melanoma skin cancers, as we all know. But nonmelanoma skin cancer is a serious disease. If any of you have had it, you will know that it can be cosmetically disfiguring. It occurs—

Mr. ROHRABACHER. Would you, then, and as my staff member recommends, which is a good question, would you then recommend that people not move from the northern part of the United States to more central United States or southern United States, in order to—because the risk is just too high?

Dr. KRIPKE. I wouldn't recommend anything. I don't recommend people where they should live.

Mr. ROHRABACHER. You've been recommending something all day. I mean, the fact is you're here to testify about risks. But you're not willing to tell someone because of the increased—it sounds like to me you're saying the increased risk is dramatic. But yet, that increased risk, as we've heard in earlier testimony, is increased as much as moving from one part of the country to the other.

You don't think that we can then recommend people not to move from Maine to Florida?

Ms. RIVERS. Mr. Chairman, would you yield for a moment?

Mr. ROHRABACHER. Not until the question is answered. Thank you.

Dr. KRIPKE. I think we can recommend that if people do move from Maine to Florida, that they need to try to protect themselves from the increased ultra-violet radiation that they will undoubtedly experience. Just as we will have to try to tell people to protect themselves from increases in UV-B radiation that are caused by ozone depletion.

Mr. ROHRABACHER. Did you see this report that I have here, and it's from the American Journal of Public Health? It was reported in 1995, it says.

It's a study in Chile, in fact, of southern Chile, that says that the study does not support existing lay reports that, basically, the ozone hole is causing any more cancer.

Have you seen this report?

Dr. KRIPKE. Yes, I'm aware of that study. And that study refers specifically to the ozone hole over the Antarctic.

You will be aware that there were originally some reports in the news media of cataracts in rabbits and all kinds of bizarre health effects that were possibly attributed to the ozone hole over the Antarctic.

There has been no scientific substantiation of those claims based on the study that you're quoting.

That does not mean that UV-B radiation does not cause skin cancer.

Mr. ROHRABACHER. I believe that—maybe you could draw that a little bit closer to me, the relationship there.

I thought that the depletion of the ozone, like the ozone hole, was what was going to cause us to have more of that.

Dr. SETLOW. But skin cancer results from a chronic exposure over many years to sunlight. The ozone hole has not been with us for a terribly long time. And it isn't there for most of the year.

So the fact that there's an ozone hole does say that there's going to be more ultra-violet than usual. But, of course, the amount of ultra-violet isn't very great in those few months.

And so it's a question of the integrated exposure, not the instantaneous exposure, that gives rise to skin cancer.

Mr. ROHRABACHER. So, in the long run, it will happen.

Ms. RIVERS. Mr. Chair? That's what I was seeking recognition on earlier because I've heard this argument get put forward a couple of times about, it's the same as moving 60 miles south.

But my understanding of it is that the ozone layer would be depleted at a rate of 3 to 4 percent. And so, when you look at compounded effects over time, that the risk gets larger and larger and larger.

Is that a correct assessment, Dr. Watson?

Dr. WATSON. Because of the international regulations, the Montreal Protocol—and we do need all countries to obey the Montreal Protocol—we believe ozone depletion will finally peak, maximize about 7 percent less over mid-latitudes in summer than what it was, say, in 1970.

The effect that 7-percent ozone depletion will not be an instantaneous rise in the number of skin cancer cases. It's the chronic exposure, as both Margaret Kripke and Dr. Setlow have said.

We will see the effect of ozone depletion today in 20, 30, 40 years ahead. And so, we will expect to see those increases in the future, not today.

Mr. ROHRABACHER. However, you did say earlier in your testimony, had we not gone forward with the Montreal Protocol, that things would have been a lot worse. And that sort of doesn't coincide with what you just said.

Dr. WATSON. I think it does, sir. What I mean is, because of the Montreal Protocol, we've managed to limit ozone depletion to only seven or eight percent.

Without the Montreal Protocol, we would probably in the future be looking at ozone depletions of 10, 20, even 30 percent.

Mr. ROHRABACHER. But in the earlier testimony, you did mention some health impact. I don't have it right on the top of my head now, but I remember you mentioning that.

Dr. WATSON. I think after you read it carefully, sir, you'll find it is consistent.

Mr. ROHRABACHER. All right. Thank you very much.

I'd now like to call on the distinguished former Chairman of the Science Committee, Congressman Brown.

If you have any questions for the panel, please feel free.

Mr. BROWN. I apologize first to the panel because I haven't been able to be present this morning. We're having a mark-up in another committee and I will be required to leave again shortly for a vote in that committee.

But as I said this morning, I wanted to compliment the Chairman on arranging for this hearing. I think it will do a great deal

to enlighten the public on some of the factors involved and action on these long-term potential environmental threats. And also on the scientific processes involved.

And I want to commend the witnesses for the job that they have done.

Let me suggest just a couple of questions. One, I gathered the impression here earlier that the Chairman perhaps was suggesting that the speed-up in action taken in 1992 to phase out CFCs might have been due to some hysteria created by careless politicians raising the threat of tragedy striking or something of that sort.

Was there any such relationship between the 1992 action and any political propaganda that may have been issued around that time that may have been favorable to an earlier phase-out?

Dr. Watson.

Dr. WATSON. If I could answer that, sir. Several people have mentioned the NASA press statement that was made in February of 1992.

The statement that was made was absolutely correct, and indeed, as it was followed on by then- Senator Al Gore was correct. If the conditions, meteorological conditions, had continued, there would have been a significant loss of ozone over Kennebunkport.

It was a prediction with all the right caveats.

I personally believe that had no effect on the international negotiations, for a very simple reason. As was also stated by April of that year, there had been not a retraction, but a clarification of the situation. The clarification was that there was no ozone hole over Kennebunkport because the meteorological conditions changed.

Now the Copenhagen Amendments were signed in November of 1992, a full eight months after even the so-called retraction by NASA. The Senate in this country, in a very bipartisan manner, didn't ratify that until a full year after that situation.

So, in my view, Mr. Chairman, the reasons that the Copenhagen Amendments were so forcefully pushed through internationally—who don't care about NASA press statements—and within the Senate, was they observed that we by now had seen global ozone depletion at all seasons, except for the tropics. And it was that information that pushed the amendments to the Montreal Protocol.

Mr. BROWN. Do any of the other witnesses wish to contradict or add to that?

I pointed out this morning that the habit of politicians of making what might be fairly outrageous statements is not confined to the vice president or to any other single politician.

I do it myself, on occasion. [Laughter.]

Dr. SINGER. I think I would like to make a short statement to balance or put into perspective what Dr. Watson just said.

What brings me into this whole question that we're discussing today is this deplorable way in which policy is being made by press release.

Mr. BROWN. Yes.

Dr. SINGER. And I think this is very, very bad. Very bad. It prevents and precludes the careful examination of the evidence and it will lead us, I think, into situations that are extremely costly, into hasty actions that are unjustified by scientific evidence.

In my testimony, I give a large number of examples.

Right now, for example, this week, we're faced with a press release from the World Meteorological Organization by a well-known ozone activist who tells us that the ozone hole this year is going to be worse than it's ever been.

How does he know that? Well, he's only seen it for the first few days.

But we have, fortunately, some balance in this. A NASA scientist has said, this is not true—Paul Newman.

It's in my testimony.

Another scientist in Australia has said, it's impossible at this stage to predict what the eventual ozone hole would be like. It may well be worse than it was last year, or it may be less.

But it illustrates how press releases are being used—or misused, I should say—to force all kinds of political action that may be harmful to our economy.

Mr. BROWN. Well, Dr. Singer, let me say that I agree thoroughly with the principle that you've espoused. I don't believe in policy being made by press release, either.

Did you want to respond to that, Dr. Watson?

Dr. WATSON. Yes, because I would also like to concur that we should not make policy by press release. I want to add just one more thing.

President Bush obviously was the President that for the United States made the decision to negotiate the Copenhagen Amendments.

He did not, I'm quite convinced, look at the NASA press release. Alan Bromley was his science advisor at the time and Alan Bromley took advice from a large number of people and discounted that press release.

So I do not believe we or President Bush made policy by looking at a press release.

Mr. BROWN. Well, the general principle is sound, that we shouldn't. And we've seen that in many, many situations.

I was very disturbed, serving on the agriculture committee, when I saw the first press releases about the bad effect of Alar on apples.

There is some underlying basis for being worried about Alar. But there was no basis for assuming that there would be an epidemic of cancer in children because of what we were doing. And yet, the press releases would seem to indicate that.

This bears out your point.

Now let me say in defense of politicians, that it's sometimes very difficult to convey to the public a true sense of a very complex situation. And that happens to be true in the case of ozone.

It is illustrated by a couple of charts which I'd like to raise a question about now.

Dr. Watson, you have in your testimony a chart labelled Figure 4, which says, global ozone trend—60 degrees south of 60 degrees north. And it seems to indicate a substantial decreasing trend in ozone.

Dr. Baliunas, you have a chart labelled Chart 2, northern hemisphere ozone, which seems to show no trend in terms of any decrease in ozone.

And at the first blush, the two charts would seem to be contradictory. And yet, I note, Dr. Baliunas, that your chart says only



northern hemisphere ozone and it's measured in some abstruse unit which I've never heard of, Dobson units. And it extends from 1955 to 1990.

Dr. Watson, your chart only extends from 1975 to 1994. It is not measured in the same abstruse unit. Apparently the chart shows percent deviation from monthly average.

Now, I ask you, is the apparent contradiction in what these two charts seem to say real or not?

Dr. BALIUNAS. There's several factors to note in this Chart 1 and Chart 2, which were the same data.

Mr. BROWN. And I'm using this to illustrate the point that some of these things are difficult to convey to the public.

Dr. BALIUNAS. Yes. These are ground-based data from the northern hemisphere ozone, slightly different from the data in Dr. Watson's testimony.

Mr. BROWN. Which also includes southern hemisphere.

Dr. BALIUNAS. Which also includes southern hemisphere. The northern hemisphere data that I show from the ground-based stations agrees where the satellite data overlap with it in those regions.

And the data I show here in Chart 1 and Chart 2 have been corrected for the spring to fall seasonal change, but no other effect. It hasn't been corrected for the solar effect. It hasn't been corrected for the QBO, and it has not been corrected for any other volcano impact.

Dr. Watson's chart I believe does correct for those. So there's not real contradiction. It's just that he's charting it to show the trend. I was showing some of the natural variability.

So two different aspects.

Mr. BROWN. But your chart does not show as much, what looks like variability, as his chart does.

Dr. BALIUNAS. Well, if you look at the percent change, my Chart 1, which is the same as Chart 2, I still have a lot of natural variability, but there is a trend in the latter part of the data that would be reflected in his.

Mr. BROWN. I see, yes.

Dr. BALIUNAS. If I were to correct everything out, Chart 2 is the same data, but on an absolute scale in terms of these Dobson units, which is the amount of ozone in the column.

Mr. BROWN. Did you wish to comment, Dr. Watson, about that?

Dr. WATSON. Yes.

Mr. BROWN. And I'm looking for guidance as to how we can convey this kind of information to a public who doesn't understand these things.

Dr. WATSON. Exactly. What the scientists wanted to portray in my Figure 4, which is this from the International Ozone Assessment—it's not my work, personally—was to try and show what were the effects of human interactions on the ozone there.

They took the ozone record from both satellite and from ground-based stations and they then took out seasonal fluctuations. They took out the effect of what we call the quasi-biannual oscillation. That's changes in the weather patterns every two years. And they took out the seasonal cycle.

So you could take out the natural effects on the ozone there.

What you have left is that trend and what one can clearly see, there was approximately a 5-percent ozone depletion between 1979 and 1994.

If you actually just flip over the page to my Figure 5, you can actually see how it is very sensitive to latitude. There is no change in the tropics independent of season, and you have a large change, larger change, as you move to the mid- and higher latitudes of both the northern and southern hemisphere.

So in the ozone assessment, we try to get the information most relevant to policymakers. We try to separate out the long-term trend.

That has nothing to do with natural variability.

Mr. BROWN. All right. I thank you for that explanation.

Incidentally, do either of the charts, or do any of you, find variation here that coincides with the 11- or 12- or 13-year sunspot cycle?

Does that have any bearing on this?

Dr. BALIUNAS. Well, all charts of this sort respond to the 11-year cycle. It's the solar ultra-violet flux that has to do with this.

Mr. BROWN. Yes.

Dr. BALIUNAS. The ultra-violet flux is not directly measured, unfortunately, over this entire interval and has to be determined by proxy.

Mr. BROWN. Well, I appreciate this explanation. I think it's helpful to me.

I apologize again for not being able to spend more time with you. I would enjoy it very much. And I thank you, Mr. Chairman.

Mr. ROHRABACHER. I'll have to say that we've had a long panel here. I'm hungry, myself. I haven't had anything to eat today.

Mr. OLVER. I'm quite willing to go without lunch for about 5 more minutes.

Mr. ROHRABACHER. Out of courtesy to my colleague, I will go forward with another 5 minutes. But let me note just one thing before we go into the last round of questioning, then.

And that is, caveats—I believe that caveats sometimes are not properly used. And I know that you've got to say that this is what I believe, except, or could be or may be, and all this.

When I was a journalist, every time I hear people using caveats, usually, and I'm not claiming this of this panel at all, but usually, caveats are used to create misimpressions.

I would just warn the panel and warn the Members of the Committee, et cetera, that caveats, we should be very skeptical when caveats are used.

Admittedly, when you're trying to be honest about it, it might prove just the opposite, meaning that some caveats are used because someone realizes that someone on the other side might be correct and there might be some avenue there that you're leaving yourself open to an honest discussion.

That's one thought.

And the other thing. In terms of whether or not the political misuse of certain information created policy in terms of what the ozone hole was going to do over the northern hemisphere, one need only to say, look at the vote that took place after Mr. Gore's presentation before this Committee and for his speeches.

It was a vote of 96 to zero. And I'm sure that there were many Republicans that were rather skeptical before. But Mr. Gore up there saying, absolutely, there was going to be this ozone hole, I bet there was a caveat in there somewhere that probably made it clear that it wasn't absolute, but it just sounded like he was saying it was absolutely going to happen.

There were a lot of Republicans that were skeptical who went right along with it. And what happened was that the ozone hole failed to materialize.

That's really what we're talking about here. If we're going to make policy, let's make it based on things that are real.

And one last thing before we let Mr. Olver have his 5 minutes of questioning. And that is, one of the other things that we have to have in order to determine policy is a free and open discussion.

And perhaps the most disturbing thing that's come out of this hearing is not whether or not caveats are being used and whether people disagree on this. But instead, what Dr. Baliunas has stated very clearly for the record is that there was an attempt to stifle her discussion of this issue.

Now all over the United States, we've heard talk about what's politically correct and politically incorrect and heard about there are certain forces in our society that are intolerant of disagreement.

When we start hearing reports that distinguished scientists and the people who are looking into an issue like this have had threats that they shouldn't come and testify, or that they shouldn't participate in the discussion of an issue, this is very serious. And perhaps that's the most serious thing that came out of this hearing today.

I plan to follow through with Dr. Baliunas on this, and I will be contacting directly those groups within government, and outside of government as well, that think that they can try to stifle discussion on issues like this.

Ms. RIVERS. Mr. Chair, can we make sure that the findings—first, the accusations and the findings are a part of the official record so that since this was raised in the course of this discussion, it will be on the record for Congress and the American people?

Mr. ROHRABACHER. Would you submit for the record a letter detailing efforts that have been made, that you believe were made on this issue, not just for this hearing, but over your discussion of this issue, that you've seen where groups inside government and outside government have tried to stifle discussion of this issue?

Dr. BALIUNAS. I will.

Mr. ROHRABACHER. So we can expect that.

Ms. RIVERS. And please, specificity is important in these kinds of accusations.

Mr. ROHRABACHER. That's correct.

Ms. RIVERS. Dr. Watson.

Dr. WATSON. Yes, Mr. Chairman. I view that as one of the most serious things I've heard today. I know this Administration would certainly like to know of any wrong-doing by any federal employee who has tried in any way to threaten or coerce Dr. Baliunas.

So we would like, through you, Mr. Chairman, that when information, written information, is documented, is sent to you, I cer-

tainly will take this to the President's science advisors and other relevant people in the Administration.

Mr. ROHRABACHER. We will do a preliminary investigation of this, and I can tell you that if we find there to be validity to this charge, that there will be another hearing and we will have people called before this Committee and put under oath to see what they're doing.

I can guarantee you that right now.

Mr. Olver, you've got 5 minutes while my stomach is growling.

Mr. OLVER. Thank you very much, Mr. Chairman.

I was very grateful for the former Chairman's and Ranking Member's discussion here. But I have been working in the same kind of direction, trying to figure out—I've been looking, having had a little bit more time to think about these graphs and so forth.

I'm still a bit puzzled. Let me ask a few quickies here.

Do we all agree on the scientific side of this panel, the atmospheric side of the panel, at least, without the biological side, because I really want to talk about the ozone layer itself here, that there is little seasonal variation in the tropics of ozone?

Is that relatively agreed? Okay. And may I use the tropics as 30 north to 30 south, or is that not a fair usage? Roughly. Roughly? Okay.

All right. So if we agree that that is relatively nonseasonal, and we also agree—let me see if this is true, that there is an agreement on the part of the scientists that the ozone problem depletion occurs more in the southern hemisphere around Antarctica because that's where the ice crystals are. It's colder. Ice is necessary, along with the chlorine or fluorine or bromine or something or other, in there.

Is that also agreed on? Okay.

Now, if that's the case, then there is something really puzzling about these two pieces of data. Even after one corrects, as the Ranking Member had gone through, and recognizing that Dr. Baliunas's data is only for—well, cover 50 years, 40 years, whatever. And the data on the part of Dr. Watson is really only 15 years.

So you're only looking at the eastern end of this data on the part of Dr. Baliunas. And that's falling, where it looks only at the northern hemisphere, which the 30 to 60 on the northern side, which is less subject to the closeness to the great hole that appears seasonally each year in the southern hemisphere. And yet, the percentages that are being shown there are plus or minus only a few percent. Even at its peaks it's zero and goes to minus four. Whereas, the data that covers and averages across everything, all four of these sectors, from plus 60 to minus 60, is data that shows a trend here going at the 6 percent level.

Which suggests, at least, that the corrections that Dr. Baliunas has agreed have been made in the data, must be pretty dramatic for that set of data to also be true.

If you follow that—I see some people sort of nodding roughly. So the general thing.

If we've corrected for everything and haven't over-corrected and so forth, then there's some pretty dramatic differences between these two data, sets of data, as they have been put forward.

Now let me just follow with Dr. Singer for a minute.

I think I understand from what you said that you feel that one should be considering several cycles, several sun cycles, solar cycles, 11-year solar cycles. And we really only have data going back maybe three cycles, while we've had CFCs.

I think the argument is that you can't yet tell whether CFCs, CVCs, whatever, has had much effect on this because we haven't been able to go back more than a couple of cycles while we were producing these things.

Is that what I'm hearing?

Dr. SINGER. You're partly correct, sir.

The reason we need a number of solar cycles has nothing to do with CFCs, as such. It has to do with the fact that each solar cycle is different from each other. The sunspot number in each cycle is different.

Mr. OLVER. Okay.

Dr. SINGER. They're sort of *sui generis*. In other words, you cannot—

Mr. OLVER. But you have said that the maximum ozone occurred a couple of cycles ago and so everything obviously is going to go downhill from that because that was maximum.

Dr. SINGER. Yes, sir.

Mr. OLVER. What is the nature of our data? You've said, yes, you agree to that.

Dr. SINGER. We have ground-based ozone data only since 1957.

Mr. OLVER. So we've got three cycles' worth of ground-based ozone data.

Dr. SINGER. On a global scale, yes.

Mr. OLVER. And before that, we don't know.

Dr. SINGER. Before that, we have ozones—

Mr. OLVER. So how can you say that that was at a maximum at the time that CFCs and so forth began to come in, if we don't have that ground-based data in the first place?

Dr. SINGER. Ground-based data on a global scale only started in 1957.

Mr. OLVER. But then, how can you say that that was at a maximum at that time? Clearly, it's gone down since that time.

Dr. SINGER. Actually, we have a record of global ozone, actually, observation, since 1957. And according to the information published, ozone showed a maximum in 1970 and then started to go down.

Mr. OLVER. Basically, three cycles.

Dr. SINGER. The question is, is this due to solar effects or natural changes, or is it due to CFCs?

Mr. OLVER. But your comment, if I remember correctly, was that you're not convinced that the ozone layer depletion has anything to do with CFCs and it may be just natural phenomena that would have been there is we looked back farther.

Dr. SINGER. Yes.

Mr. OLVER. If we looked back six or more cycles farther back, that we would see a series of cycles along these lines.

Dr. SINGER. Yes. And the reason I think so—

Mr. OLVER. Do you agree that the ozone layer, that the ozone hole is expanding, is larger than it was some years ago?

Dr. SINGER. That's an interesting question. Let me answer all of these interesting questions, if I can.

Mr. ROHRBACHER. This will have to be the last question.

Dr. SINGER. Starting with the ozone hole. The ozone hole, as I mentioned before, was not predicted by the theory. This is why I'm skeptical of the present theory.

The present theory cannot even predict what the hole will be like next year, or 10 years from now, or 20 years from now. The reason for this is that the hole is pretty much controlled by climate changes and not by ozone concentration—sorry—by chlorine concentration at this stage.

The hole, as I mentioned before, is genuine. It's a transient phenomenon.

Now the question of global ozone is quite different from the question of the Antarctic hole. The question is what was the global ozone like before 1957?

My answer is I wish we knew. But we do have some idea because we have sunspot number observations and we know that ozone depends on the sunspot number in some way. The more sunspots you have, the more ozone you have in the atmosphere.

And that's why, since sunspots have an 11-year cycle, you see an 11-year cycle also in the ozone in the last 35 years.

Now, you may know that sunspots have varied tremendously over the last two hundred years. There was a period of time around 1700 when there were no sunspots for many years, for some reason. We don't know why.

Actually, Sallie Baliunas is probably a greater expert on this than I am and will tell you that this is so.

And my supposition is that ozone should have varied by tremendous amounts naturally because of these large natural variations in sunspot number.

Mr. OLVER. I have a feeling that I could understand this.

Mr. ROHRBACHER. That's the opposite feeling that I have. [Laughter.]

As the Chairman, I'm going to use the Chairman's prerogative to give Dr. Watson 30 seconds to summarize his reaction to that last statement, out of fairness, and then to call a halt to this panel.

Dr. WATSON. Two quick questions. Dr. Singer is right. We only have about 30 years or three solar cycles of global ozone. We have some individual stations like at Rosa that go back to 1930, six solar cycles.

So when we've analyzed over six solar cycles—

Mr. OLVER. Where?

Dr. WATSON. At Rosa in Switzerland. When we take that data and all the satellite data and all the global ground-based data, we tend to believe, based on a lot of analysis, that the maximum solar variability is only 1 to 2 percent.

And yet, what we're observing in many latitudes is ozone depletions of 5 to 10 percent.

So the solar variability is small compared to the observed trends.

Mr. OLVER. It's a correction that you make.

Dr. WATSON. It's a correction and it's taken into account in all statistical analysis.

Mr. ROHRABACHER. With that, I'm sure that the transcript of this hearing will be perused by people who have much greater depth of understanding of these issues than the Chairman.

I want to thank each and every one of you. I appreciate your testimony. I think this has been very thought-provoking. It's also thought-provoking to people who are decision-makers and have some scientific background.

I think we've accomplished something here today.

So thank you all for participating. I'm going to have lunch. We will be back in one-half hour, which makes it 2:15, we'll reconvene.

We're in recess.

[Whereupon, at 1:45 p.m., the Subcommittee recessed, to reconvene at 2:15 p.m., of the same day.]

#### AFTERNOON SESSION

Mr. ROHRABACHER. I'd like to welcome all of you back and welcome the second panel for today.

I think that the last panel provided some very thought-provoking intellectual confrontations. I was very pleased that we had the issue for what I consider to be a high level of debate on a very important issue.

Our second panel consists of:

Mary D. Nichols, who serves as Assistant Administrator for Air and Radiation at the Environmental Protection Agency;

Ben Lieberman, an environmental researcher, an environmental researcher with the Competitive Enterprise Institute;

Kevin Fay is with the Alliance for Responsible Atmospheric Policy, an industry-sponsored organization;

Richard Stroup is an economics professor at Montana State University and a senior associate with the Policy Economy Research Center in Montana, as well; and finally,

Dale Pollet. He is a project leader at the Louisiana Cooperative Extension Service.

Jimmy Hayes is not here to introduce you, but he was scheduled to. So I am sure he is at a hearing, making his vote count.

So, Mr. Pollet, and the rest of you, I'd like to welcome you to the hearing today.

I think we will then start off with Ms. Nichols.

#### **STATEMENT OF THE HONORABLE MARY D. NICHOLS, ASSISTANT ADMINISTRATOR FOR AIR AND RADIATION, UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, WASHINGTON, DC**

Ms. NICHOLS. Thank you, Mr. Chairman.

Mr. ROHRABACHER. And again, if we could do, as we did with the first panel, try to look at 5 minutes and then we'll have some discussion between us afterwards.

Thank you.

Ms. NICHOLS. I'll do my best to summarize my summary of my testimony.

I'd like to start off by saying, Mr. Chairman, that I believe that the global phase-out of CFCs and other ozone-depleting chemicals is a model of the proper relationship between science, economics, and international diplomacy.

It rest on an overwhelming consensus within the community of qualified scientists, economists, and business analysts.

The phase-out policy was developed under Presidents Reagan and Bush, with strong bipartisan support, and the Clinton Administration is proud to carry it forward to its completion.

In addition, it enjoys overwhelming international support with 150 nations having become parties to the Montreal Protocol.

And indeed, to the best of my knowledge, Mr. Chairman, this is the only country in the world which is even considering the possibility of altering the phase-out schedule.

Mr. Chairman, protecting the ozone layer should be a matter of common ground. And I am puzzled and dismayed that, apparently, it is not.

I am particularly concerned by Congressman DeLay's legislation that would entirely repeal the ozone layer protection provisions of the Clean Air Act, as well as by Congressman Doolittle's proposal which is only a little less drastic, to roll back the CFC phase-out deadline to 2000.

I believe that these proposals would be disastrous, not only to the ozone layer, but also to the health of the American people, because they would exalt what I think have to be considered fringe views on science and economics over the international scientific consensus, as well as wreaking havoc in industries that have invested very large sums of money, talent and effort to make a smooth transition away from CFCs.

They would also, of course, put the United States in violation of the Montreal Protocol and break faith with the other nations of the world that have been and are doing their part to protect the ozone layer.

I've been asked to focus primarily on the decision that was made in 1992, before my arrival here in Washington, to accelerate the CFC phase-out deadline from 2000 to 1996.

And I'd just like to point out that the decision, I believe, having looked at it again, was right at the time that it was made and is even more clearly justified in retrospect today.

I'm not going to go through all of the arguments on the climate issue. I think you heard a lot from the scientists this morning.

Rather simply to say, I'm not a scientist. I'm not here in that capacity. I'm a policy-maker and have been for many years in areas that deal with science and environmental policy.

In making the decisions about implementing this program, I need to rely on the work of scientists.

And I have to say that when you look at the list, such as the one that's on that chart that's in front of you, of the international atmospheric chemists who have completed the review of the chemistry on ozone depletion for the United Nations's evaluation that was most recently completed, and who signed on to the assessment that supports the phase-out, on the one side, compared with the list on the other side, I think it is compelling to a person in my position.

I have been charged to act in defense of the environment, using the best sound science at our disposal. I believe that, in that context, numbers, or at least numbers of reports by people with the appropriate credentials, do have to count.



Now, on the issue of the costs and the benefits of the phase-out, and whether the health effects are justified, I'm sure you're going to be hearing a lot more about that from others.

I'd simply like to use the chart here again—I did ask to have a couple of things blown up, simply because I think it's a good illustration—that even if you ignore the difficulties about melanoma in terms of the lack of an exact cost-benefit, or cost risk to dose response ratio, and simply focus on the non-melanoma skin cancers about which there is essentially 95 percent agreement among the health scientists on this issue, the costs of the program, of the phase-out program, are exceeded by the benefits by as much as 700 to one.

Now that's a cumulative number, admittedly, over the whole period of the program.

So I would simply say that with respect to the accelerated phase-out—that is, moving it from the year 2000 to the year 1996—the incremental cost of doing that was about \$9.9 billion. That's mostly in retrofitting things that would otherwise have been replaced. And the benefits range there, again, just for the nonmelanoma cancers, is approximately \$220 to \$860 billion.

I think, in the work that we do, that's an extremely attractive investment.

I'd also like to just briefly focus on the major controversy, and that is on the report by the CEI. And I know Mr. Lieberman is here and he will adequately defend his own report. But I'd like to just simply highlight why it is that we differ in our assessment of the costs and benefits from the data that's put forward in that report.

CEI claims that the phase-out will cost \$45 to \$100 billion. We conclude that those numbers are way off. And they're way off because of a couple of key errors in the way that the assessment was done.

Primarily, these have to do with some incorrect assumptions about replacement schedules, an assumption that refrigerators using HFC will cost \$50 to \$100 more, which is not true, an assumption that the new technology is more prone to breakdowns, which has not proven out to be true, failure to consider the improved energy efficiency of the new refrigerators, which nets a benefit of more than \$5 billion over a ten-year period to the consumers. As well as errors in the cost of retrofits and mistakes about the viability of alternatives.

I think that I'll leave that up here and we'll, I'm sure, want to refer to it later in questions and answers.

But I'd just like to conclude by saying that we at EPA are proud of the work that we have been doing in implementing the Montreal Protocol. We feel that it's a success story not only for the environment, but for the business community as well.

Thank you for your interest.

[The complete prepared statement of Ms. Nichols follows:]

**TESTIMONY OF MARY D. NICHOLS  
ASSISTANT ADMINISTRATOR FOR  
AIR AND RADIATION  
U.S. ENVIRONMENTAL PROTECTION AGENCY  
BEFORE THE  
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT  
OF THE  
COMMITTEE ON SCIENCE  
U.S. HOUSE OF REPRESENTATIVES**

**September 20, 1995**

Mr. Chairman, Members of the Subcommittee, thank you for the opportunity to testify before you on protection of the stratospheric ozone layer. The global phaseout of CFCs and other ozone-depleting chemicals is an unparalleled triumph of the soundest possible science, economics, and diplomacy. It rests on an overwhelming consensus within the community of qualified scientists. The same consensus exists among qualified economists and business analysts on the costs and consequences of the phaseout. The phaseout policy was developed under Presidents Reagan and Bush with strong bipartisan support, and the Clinton Administration is proud to carry it forward to completion. This policy rightly enjoys overwhelming public support in this country and around the world. One hundred and fifty nations have become parties to the Montreal Protocol, the treaty through which the phaseout is being accomplished world-wide.

Mr. Chairman, protecting the ozone layer should be a matter of common ground between us. I am both puzzled and dismayed that, apparently, it is not.

I am especially dismayed by Congressman Delay's proposal to entirely repeal the ozone layer protection provisions of the Clean Air Act, and by Congressman Doolittle's

proposal – only one step less drastic – to rollback the CFC phaseout deadline to 2000. These proposals would be disastrous to the ozone layer and to the health of the American people. They would exalt fringe views on science and economics over the international scientific consensus. They would wreak havoc in industries that have invested very large sums of money, talent, and effort in carrying out the smooth transition away from CFCs. Finally, they would put the United States in violation of the Montreal Protocol and break faith with other nations that, under that treaty, have done their part in the global effort to protect the ozone layer.

I have been asked to focus primarily on the scientific basis for accelerating the CFC phaseout from 2000 to the beginning of 1996, and on the economic costs of doing so. This decision was right when it was made under the Bush Administration in 1992, and it is even more clearly justified in retrospect today. Some of the witnesses here today, who stand far outside the consensus of qualified experts, claim that the benefits of this step were exaggerated and the costs underestimated. Building on the testimony of Drs. Watson, Albritton, and Kripke, I will address why the critics are wrong on both the science and the economics.

You will recall that the original Montreal Protocol was negotiated and signed in 1987 under President Reagan. President Bush was twice responsible for accelerating the phaseout of ozone-depleting substances, first in 1990 and again in 1992, to the current end-of-year deadline for ending CFC production. The decision to speed up the CFC phaseout to 1996 was taken domestically under the Clean Air Act and internationally under the Montreal Protocol. As you are aware, Section 606(a) of the

1990 Clean Air Act Amendments directed the Administrator to accelerate the phaseout if any one of three conditions existed: .

- if at any time an assessment of current scientific information pointed to the need for a more stringent schedule to protect the environment;
- if the availability of substitutes for listed substances made a more stringent schedule practicable, taking into account technological achievability, safety, and other relevant factors; or
- if the Montreal Protocol was modified to phase chemicals out more rapidly than the then-existing Clean Air Act schedule.

All three of these conditions were met in 1992, and remain valid today.

Addressing the first criterion, it is important to realize that the scientific basis for accelerating the phaseout did not represent simply EPA's view of the science. From the very beginning, EPA has relied on international scientific ozone assessments conducted by several hundred of the world's leading atmospheric and health scientists, who reviewed all available data. These assessments represent the definitive statement on the state of the science and provide the soundest possible basis for EPA and international action. The 1992 scientific assessment further strengthened the link between CFCs and ozone depletion and showed that ozone depletion was taking place at a substantially greater rate than had been thought just two years before, when the deadline of 2000 was adopted. The most recent scientific assessment, issued earlier this year (Scientific Assessment of Ozone Depletion: 1994; WMO Report 37), confirms the conclusions of the 1992 assessment concerning the effects of CFCs.

You have heard various complaints about these assessments from witnesses this morning. The substantive issues they raised were fully examined and thoroughly rejected through the science assessment process. Basing policy on these scientific assessments clearly represents the use of sound science. To reject those assessments based on the complaints you have heard today would mock sound science.

For example, the claim has been made that (1) UV-B radiation plays no role in the development of melanoma skin cancer and (2) therefore we need not be concerned about ozone depletion. The first proposition is extreme: the preponderance of evidence suggests that UV-B does in fact play a significant role in causing melanoma, although the exact dose-response relationship appears complex.

The second proposition is also misguided. The accelerated CFC phaseout would still be easily justified even if there were no link between UV-B and melanoma skin cancers, because over 85% of the quantified health benefits of the phaseout come from avoiding non-melanoma skin cancers and cataracts.

We have also heard it said that ozone depletion would increase UV-B radiation by no more than if you moved a few hundred miles south -- which people do all the time. The reality is more serious. Cities near the equator receive about 20% more UV radiation than cities further from the equator, and skin cancer rates in cities closer to the equator are higher. For example, in a recent study, skin cancer rates for white males in Albuquerque, New Mexico were approximately 700 per 100,000 versus 150 per 100,000 for a similar population in Seattle. Given current depletion rates of about 5% at midlatitudes, people living in Washington, D.C. experience the equivalent of the radiation they would have received if they visited Jacksonville, Florida. While it may not

matter if one person moves south, the reality of ozone depletion is a move south for the entire U.S. population. The change in lifetime risk for the susceptible population for developing skin cancer is significant.

We are currently experiencing depletion of approximately 5% at midlatitudes. Moreover, if no action had been taken to limit CFCs, depletion would eventually have reached as high as 20% or more, and UV-B increases and resulting increases in skin cancers would have been drastic indeed.

Let me turn now to the second criterion set forth in the Clean Air Act: whether the increased availability of substitutes for CFCs made it practical to speed up the phaseout to 1996. Due to the market signals created by the phaseout, and to the remarkable efforts of hundreds of firms in dozens of industries, the rate of technological changes have exceeded all expectations. Once consensus existed on the need to replace these substances, producers and manufacturers responded quickly and shifted to alternatives. Because of these advances, no industry challenged moving the deadline up to 1996.

As to the third statutory criterion, the Parties to the Montreal Protocol decided in 1992 to move the CFC phaseout up to 1996. Methyl chloroform and carbon tetrachloride were also scheduled for phaseout by 1996, and halons were given a deadline of 1994. The United States is one of 150 countries that is a Party to the Protocol. We supported the 1996 deadline then, as did all our economic competitors. I am not aware of any country in the world that is considering any rollback on its CFC phaseout commitment. In fact, much of Europe completed the phaseout last year. I

should also note that any move to postpone the domestic phaseout deadline would put this country in violation of the Montreal Protocol and international law.

I would now like to turn to the costs and benefits of our phaseout program.

Thorough cost and benefit analyses were undertaken both in 1990 for the decision to phase out by 2000, and in 1992 to support the acceleration to 1996. These studies reflect years of research on cause, effect, costs, and benefits. On the cost side, we have extensively involved all aspects of industry – producers and users, big and small companies, original equipment makers and service and repair industries.

Our studies and all inputs and comments from others were made public for comment. We are confident that the numbers accurately reflect the costs and benefits of this program.

Based on these extensive regulatory impact analyses, EPA's 1992 analysis indicates that the benefits of the phaseout exceed its costs by a factor of up to 700 to 1. If we were to update this analysis based on the information available in the 1994 international assessments, this ratio of benefits to costs would continue to be overwhelming. We estimated that the total cumulative cost of the current 1996 phaseout requirements would be approximately \$10 billion for the period 1989-2000, and approximately \$46 billion over the period 1989-2075, based on a 2% discount rate. The total public health benefits from reduced cases of skin cancer, cataracts, and other health effects are estimated to be between \$8 and \$32 trillion over the same period (the range depends on the assumed value of a life). As noted above, 85% of the program's benefits come from avoided non-melanoma skin cancers. The bottom line is that we are getting an incredibly large bang for the buck!

Despite these extensive analyses, some recent reports have outlandishly inflated the costs of the phaseout. For example, the Competitiveness Enterprise Institute (CEI) in its report, "The High Cost of Cool," begins with demonstrably wrong factual assumptions, makes numerous methodological errors, and thus reaches unsupported conclusions.

For example, the report erroneously implies that for many applications, existing air-conditioning and refrigeration equipment will have to be discarded and replaced immediately. This is just plain wrong. Existing equipment can remain in use indefinitely, and substantial amounts of recycled CFCs will be available to repair that equipment for years to come.

Further, industry has been extremely successful in developing low-cost retrofits for existing equipment and highly energy-efficient new equipment that works without CFCs. Overall costs will be relatively low because these energy efficiency gains significantly reduce lifetime operating expenses. In fact, in some sectors, such as household refrigeration and building chillers, it will often pay for homeowners or building owners to replace current equipment well before it has broken down.

Another error: the CEI report assumes that HFC-134a refrigerators will cost \$50 to \$100 higher than similar CFC-12 refrigerators. The leading refrigerator makers disagree, however. According to them, the prices of these appliances will not increase as a result of the alternative refrigerant. CEI's report also assumes that new technology is more prone to failure. But manufacturer warranties have not changed for the new HFC-134a appliances. Again, CEI has failed to consider that these new appliances are



up to 30% more energy efficient, and will net consumers energy savings of \$5.1 billion over the next 10 years.

The CEI report also claims that the average cost of a mobile air-conditioner retrofit is \$433. In fact, the extra cost of a retrofit (over prior repair costs) was estimated in 1991 to be \$217. Because substantial progress continues to be made, the most recent estimate is that a minimum cost retrofit (one that is made when other major repairs are needed) will cost under \$100. The marketplace has also responded to the production phaseout by building significant reserves of CFC-12 for sale and use after the production ban, which will permit millions of car owners to avoid retrofit entirely. Additionally, a number of firms are developing and testing innovative refrigerants that could even further reduce car owners' repair costs.

In sum, EPA estimates the cost of the phaseout to be \$4 billion to the refrigeration and air-conditioning sector over a 12-year period. While this is not an inconsiderable sum, it is less than 1/10th to 1/25th of the inflated \$45-100 billion figure from CEI.

Let me turn briefly to another ozone-depleting substance, methyl bromide, which is scheduled to be phased out domestically under the Clean Air Act in 2001. Methyl bromide is a pesticide used in a substantial variety of agricultural applications. The 1992 and 1994 international scientific assessments have concluded that it is a powerful ozone-depleting chemical and an important contributor to ozone depletion, especially in the near term. The 1994 UNEP Scientific Assessment of Ozone Depletion, peer-reviewed by over 250 scientists, found that the ozone-depleting potential for methyl bromide is 0.6. The range of uncertainty would bring it to no lower than 0.3 and no

higher than 0.9. Even the lowest end of this range exceeds the 0.2 threshold that makes a chemical a class I ozone depleting substance that must be phased out under the Clean Air Act. The 1994 Science Assessment states that "Methyl bromide continues to be viewed as a significant ozone-depleting compound." Additional research is ongoing to address outstanding uncertainties, and to define the precise ODP, which may turn out to be slightly higher or lower than 0.6. The Assessment also stated that the elimination of anthropogenic methyl bromide emissions is the single most effective policy to further reduce ozone destruction over the next several years.

Farm users of methyl bromide are understandably concerned that they do not currently have satisfactory substitutes for all uses of this chemical. I understand and am sympathetic to their concern. In the long run, the critical issue, though, is not whether technically and economically adequate alternatives for all methyl bromide uses are available now, but whether they will be available by the time the phaseout deadline arrives. There will not be a single chemical that replaces all of the many uses of methyl bromide. Alternatives to methyl bromide are often pest-specific, and can reduce pest levels when used as part of an overall integrated pest management program. Numerous chemical and non-chemical methods may effectively control many of the pests on which methyl bromide is used. Research on additional alternatives is under way and will likely result in a wide range of options. Viable alternative materials need not be identical to methyl bromide, but must effectively and economically manage pests now being controlled by methyl bromide.

We fully recognize, however, that there is no guarantee that acceptable alternatives will be available for all uses of methyl bromide prior to 2001. We believe

that having a safety valve – allowing continued production for specified essential uses where no alternatives exist – is an important part of this process. To this end, we are willing to work with stakeholders to craft an appropriate safety valve that would permit applications for essential use exemptions if they are needed as the phaseout deadline approaches.

The recent bill introduced by Congressman Miller is not an acceptable solution to the problem. It would return to the regulatory structure of the 1950's and 1960's by overriding both the Clean Air Act and the Federal Insecticide, Fungicide and Rodenticide Act and returning effective control over this pesticide to USDA. The bill would place the U.S. out of compliance with the Montreal Protocol through which this country has achieved unprecedented international cooperation to protect the ozone layer under presidents of both parties. The bill would also replace the innovative, market-driven phaseout process which has worked flexibly and successfully for other ozone-depleting chemicals with a complicated "command and control" regime requiring specific rulings for thousands of current methyl bromide uses. By effectively blocking the phaseout of methyl bromide in the U.S., the bill would ensure higher levels of dangerous ozone depletion. We are willing to work with stakeholders on an essential use provision, as I have said. A broad rollback of the methyl bromide phaseout is simply not warranted.

In closing, we must stay the course if we are to be successful in restoring the ozone layer. We must continue our leadership role by meeting our phaseout commitments as a Party to the Montreal Protocol, and ensuring that we take the responsible road of decreasing skin cancer and cataract risks for our children and future

generations. This is where sound science and sound policy lead. I urge you to join and support us in this effort.

Thank you, Mr. Chairman, Members of the Subcommittee for your attention. I would be happy to answer any questions you may have.

Mr. ROHRABACHER. Mr. Fay, we've got a vote that's coming up in about 13 minutes. So you've got 5 minutes.

Then we'll break and we'll vote and we'll come right back.

# **STATEMENT OF KEVIN FAY, ALLIANCE FOR RESPONSIBLE ATMOSPHERIC POLICY, ARLINGTON, VA**

Mr. FAY. Thank you, Mr. Chairman.

You have my formal written testimony before you. I'll try to quickly summarize our written statement.

At the outset, let me tell you that I represent the businesses and industries, large and small, who have had to live with this issue for the last 20 years. We're very interested in a good environment.

But we're also very interested in a good economic climate in which to do business. We're interested in balanced budgets, regulatory reform, low taxes, and other such desirable things.

But there are so many myths and misrepresentations on this issue, it's difficult for policy-makers and for businessmen oftentimes to know which way to turn.

Let me make one thing real clear.

No one, no one, not us, not the environmentalists, not EPA, not the scientific community, not the media, and not political policy-makers, can claim the mantle of complete virtue on this issue.

First of all, I can state without any doubt, as one who has lived throughout this entire 20-year process on this, the acceleration of the phase-out of CFCs in 1992, had nothing to do with the February, 1992 press conference by NASA.

The decades-long examination of ozone science is well understood and supported by expert industry scientists.

From our perspective, while we may disagree on the rates of change or estimates of environmental effects, we long ago reached an agreement on the appropriate course of action.

There's no question that political opportunists have taken their shots at us and at the American consumers through the adoption of multi-billion-dollar excise taxes or through the adoption of certain unnecessary regulations mandated by the Clean Air Act.

Political opportunists continue to try to take advantage of this issue. Recent efforts to try to portray the so-called analysis as fact, such as CEI has done, or to somehow link the deaths, as he tried to do recently in his op-ed piece, the deaths in the Chicago heatwave, is shocking in its irresponsibility.

Even Fred Singer this morning agreed that CFCs should be phased out.

What we are debating is the rate of change both in the environment, in the industry, and among the public.

The crux of the policy debate appears here to be over about four to five years of CFC production.

The realities are the fundamental scientific basis for the CFC phase-out is credible and has remained basically unchanged since the original policy decision to phase out production of the compounds.

The producer and user industries acted responsibly in moving quickly to develop and implement safe and effective substitute technologies that allowed that phase-out to be accelerated.

Because of that quick action, further harsh measures regarding other compounds such as HCFCs, are unnecessary today.

Much work remains to be done, however, in order to ensure full compliance with the protocol both here and at the international level, including completion of the phase-out in developing countries.

Much still can be done to reduce the costs and regulatory burdens imposed as a result of the congressionally mandated excise taxes and certain provisions of the Clean Air Act.

While we think the examination of the scientific activities is certainly useful, we believe that the proper congressional focus at this time should be the streamlining of policies in effect in this country and at the international bargaining table.

This should be done in order to ensure the completion of the transition out of ozone-depleting CFCs while maintaining our economic competitiveness.

We have several suggestions.

At the international level, the U.S. should take a strong position that there's no need to alter the protocol's control schedule on HCFCs. The protocol's technology and assessment panel experts, of which we have participated, have agreed that HCFCs are critical in order to achieve the CFC phase-out.

The protocol parties must continue progress to have the developing countries eliminate their reliance on CFCs. The treaty does provide for a delay of phase-out in these countries.

Many major developing countries, including Brazil, China, Mexico and Malaysia, have announced phase-outs well in advance of the treaty requirements.

The U.S. should be fostering these actions by fulfilling its existing financial commitment to the protocol multilateral fund, rather than eliminating funding, as has been proposed in the current appropriations process.

According to one estimate, the government has collected more than \$6 billion in ozone depletion excise taxes from U.S. consumers of CFCs. It is difficult to understand the justification for not funding the protocol efforts since the American taxpayer has paid for it.

The more quickly developing countries phase out of CFCs, the more likely that U.S. technologies, with their accompanying jobs, could be adopted in order to accomplish this objective.

Because of the quick action to address the issue internationally, the parties to the protocol should also be encouraged not to revisit the treaty every two years in anticipation of major amendments.

This is what they've been doing.

The basic framework is working well and should not now be revisited unless there is significant new scientific information.

At home, several steps could be taken in order to streamline the regulatory provisions.

The Congress could eliminate several provisions of Title 6 of the Clean Air Act amendments that have the potential to impose great costs, but which provide no significant environmental benefit.

The labelling provisions, particularly with regard to HCFCs, should be deleted altogether.

The safe alternatives program could be sunset once there is no nexus to substitution of ozone-depleting compounds. In fact, the al-

liance has filed a legal challenge to the EPA snap program in order to prevent unnecessary overreaching. And provisions eliminating the use of substitutes in so-called non-essential products could be deleted.

Continued increases in the ozone depletion excise tax, which is scheduled to continue going up every year, should be ended. In fact, if the Congress is truly concerned about the cost to the consumer of the ozone protection program, it could adopt a tax credit for equipment retrofits.

The alliance believes that such a program could be revenue-neutral in the near-term.

Finally, the government must continue to enforce the laws concerning the illegal import of CFCs. The illegal imports and the avoidance of excise tax in these compounds make CFCs more available, reduce the incentive for users to shift, and penalize legitimate companies who are complying with the laws.

The illegal imports create the impression in the marketplace that CFCs are plentiful and that retrofits can be deferred.

They're also frustrating the attempts of legitimate businesses to plan for the post-production period.

Finally, the effects science should be continued. We do not have a good scientific understanding of ozone depletion effects. There is no question about that. We've known that all along. It's shocking that it has not been done.

I will stop there and let you go vote.

Thank you.

[The complete prepared statement of Mr. Fay follows:]



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### **TESTIMONY OF KEVIN FAY ALLIANCE FOR RESPONSIBLE ATMOSPHERIC POLICY**

#### **HOUSE COMMITTEE ON SCIENCE SUBCOMMITTEE ON ENERGY AND ENVIRONMENT SEPTEMBER 20, 1995**

Thank you Mr. Chairman, and members of the Committee. My name is Kevin Fay; and I am counsel to the Alliance for Responsible Atmospheric Policy. I am pleased to appear before you on behalf of the approximately 250 industry members of the Alliance. The Alliance is a U.S. industry coalition that was organized in 1980 to address the issue of stratospheric ozone depletion and efforts at that time by the United States government to unilaterally further regulate the production and use of chlorofluorocarbons, or CFCs. Today, the Alliance coordinates industry participation in the development of reasonable international and U.S. government policies regarding ozone protection.

We are particularly pleased to have the opportunity to address the topic before the committee today: "Stratospheric Ozone: Myths and Realities". Over the last two decades, it appears that the ozone protection issue has generated enough myths and discussion to fill several books. It has become difficult to separate these myths from reality.

Depending on the "politically correct" vantage point, the ozone depletion story is either about industry and technology bringing about global destruction in pursuit of financial gain; or in the alternative, environmentalism and social engineering out of control. From our perspective, the ozone depletion issue is about complex scientific information concerning the impacts of technology on the environment, and efforts to lessen these impacts in as cost-effective manner as possible.

The realities are:

--that the fundamental scientific basis for the CFC phaseout is credible, and has remained basically unchanged since the original policy decision to phase out production of the compounds;



--that the producer and user industries acted responsibly in moving quickly to develop and implement safe and effective substitute technologies that allowed the phaseout to be accelerated;

--that because of quick action by industry, further harsh measures regarding other compounds such as HCFCs are unnecessary;

--that much work remains to be done in order to ensure full compliance with the Protocol at the international level, including completion of the phaseout in developing countries and better enforcement of trade in illegally imported material; and

--that much can be done to reduce costs and regulatory burdens imposed as a result of Congressional mandated excise taxes and certain provisions of the Clean Air Act.

A brief review of ozone protection history would be helpful at this point.

When the Alliance was organized in 1980, the ozone depletion theory was six years old. However, a panel of industry scientific experts, the Fluorocarbon Program Panel of the Chemical Manufacturers Association, had been meeting since 1972 to consider the question of what happens to CFCs in the atmosphere.

CFCs and CFC-reliant technologies developed over the last several decades contributed substantially to the quality of life for our society. In 1980 we believed that rigorous scientific analysis would eventually disprove what was then considered to be an unproved scientific theory.

When it was organized, the Alliance's goals were to ensure that any regulatory decisions be based on the best scientific information available; that any proposals for action be pursued at the international level, particularly in light of the global nature of the issue and the tremendous competitiveness concerns for the industries that could be affected; and that any proposals not single out specific industries for regulatory scrutiny (as had been done in the late 1970's with the U.S. aerosol ban.) We have achieved these goals because sound science has resulted in internationally agreed upon controls which are responsible and cognizant of societal needs in specific sectors.

In 1986, the comprehensive assessment of ozone science was released by NASA and the World Meteorological Organization (WMO). It was on the basis of the information contained in that assessment, information that industry experts had assisted in developing, that industry representatives came to the conclusion that the potential existed for serious and unacceptable future environmental risks, if CFC growth continued well into the next century. It was an appropriate and responsible result.

On September 16, 1986, the Alliance publicly released a statement which acknowledged this information, and issued the first call by industry for the negotiation of an agreement at the international level to limit the production of these compounds. (Attachment 1). The Montreal Protocol was completed and signed exactly one year later. The original treaty then called for only a 50% reduction in the production of CFCs and a freeze in halons by 1998.

The treaty was the first signal to the marketplace to accelerate development of CFC substitutes. The view at the time by many in industry was that CFCs could still be used, but that stopping growth in their use would be difficult. The "race was on", however, to develop and implement safe and effective alternatives if companies were going to compete with technologies that were to be economically viable.

The scientific developments after completion of the Protocol focused both on the 1986 discovery of the Antarctic ozone hole and continued refinements of the atmospheric models based on better observational data from the atmosphere and the laboratory. Again, industry scientists were familiar with this work and integral to its completion. Scientific consensus developed around several key elements:

- atmospheric chlorine concentrations appeared consistent with emissions of CFC compounds since their production began in the 1930's;

- the Antarctic ozone hole appeared to develop when stratospheric chlorine concentrations reached 2 parts per billion;

- the ozone hole appeared to result from a complex series of chemical reactions and the unique Antarctic meteorology which triggered the availability of free chlorine radicals in the atmosphere when the first sunlight of springtime appeared. The primary source of the chlorine came from chlorine- and bromine-containing compounds; and

--continued use and emissions of chlorinated and brominated compounds, including CFCs were projected to result in a substantial increase in atmospheric chlorine and bromine over the next several decades, even with the Montreal Protocol reductions.

The NASA/WMO Ozone Trends Panel Executive Summary of March 15, 1988 led policymakers to conclude that production of CFC compounds needed to be eliminated altogether. The scientific information led to the 1990 amendments to the Protocol to phase out these compounds by the year 2000. Efforts to identify CFC substitutes were accelerated even further.

Domestic events had also focused additional attention on the issue, with the adoption by Congress over industry objection, of the excise tax on ozone depleting compounds in 1989; and with the completion of the 1990 Clean Air Act Amendments. The tax, which rose from \$1.25 per pound of CFCs to \$5.35 this year is a severe penalty on consumers. The message to the industry was clear - these compounds were going to be taxed, reduced and ultimately phased out. It was clearly in industry's interest to do everything possible to introduce substitute technologies as rapidly as possible. The industry's goal was to manage the transition away from ozone depleting chemicals, while preserving the benefits their technologies provided along with the desirable health and safety characteristics that these technologies provide.

A multi-billion dollar investment in new technologies was needed to shift manufacturing techniques and introduce new products relying on new compounds such as hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), and other chemical or not-in-kind technologies.

At the same time, the Alliance continued to call to policymakers' attention the problem of dealing with the existing base of CFC-reliant installed equipment, particularly air conditioning and refrigeration equipment, which has been estimated to be worth more than \$135 billion. This issue was paramount when the Alliance was founded in 1980, as well as in 1986 when we called for international action. Our grounds for opposition to the excise tax was that it is unfair to tax consumers who had no other recourse but to pay the tax in order to have their motor vehicles and equipment serviced. It was primary in our request during the Clean Air Act Amendment debate for an exemption from the production phaseout for the service of this equipment.

In 1991-92, in the face of the continuing drumbeat of additional scientific reports of the worsening atmospheric conditions, policymakers were moving once again to accelerate the reduction schedule. Technology assessments completed internationally and here in the United States concluded that technologies would soon be available to eliminate the need for CFC compounds in most manufacturing applications.

The transition from CFCs was slowed due to the uncertainty over policies which might have been adopted concerning the HCFC substitutes. The HCFCs were deemed essential by the Protocol experts in order to achieve a CFC phaseout. Some European countries had already proposed eliminating HCFCs by the year 2000. The transition was also slowed by delays in implementing certain provisions of Title VI of the Clean Air Act Amendments, particularly Section 612 dealing with the approval of "safe alternatives" (known as the SNAP Program). Also of great concern was the implementation of other Title VI provisions, particularly labeling, which had the potential to impose substantial costs on products that ultimately would have been borne by consumers, and the continued problem that no policymaker seemed willing to address: the problem of the existing equipment base.

The existing equipment issue was particularly vexing because neither the Clean Air Act Amendments nor the Montreal Protocol contained any provision or procedure for assuring the continued viability of this equipment. To our knowledge, no environmental program has ever before or since required the kind of massive scale retrofit of millions of commercial and consumer products. Industry needed a strategy to deal with this concern.

As a result, the Alliance filed a petition with the Environmental Protection Agency (EPA) on February 11, 1992 to accelerate the phaseout of CFCs consistent with anticipated availability of technology implementing CFC substitutes. (Alliance press releases and a summary of the petition are enclosed as Attachment 2). In return, the Alliance requested the government to provide a reasonable period of assured usage for the HCFC technologies; defer the majority of the labeling requirements; provide a policy framework for assuring production of CFCs for the existing equipment base; and accelerate the determinations of safe alternatives under section 612 of the Clean Air Act Amendments.

As a result of this petition and other efforts, the CFC phaseout was accelerated to January 1, 1996 as part of the 1992 Copenhagen amendments to the Montreal Protocol. More importantly, the industry received approvals of its alternatives under the SNAP program; the domestic labeling provisions were essentially delayed; the parties to the Protocol

adopted a schedule allowing use of the HCFCs until 2030; and the Protocol was amended to put in place a process for seeking an essential use exemption for continued CFC production.

An important lesson was learned during this period and the HCFC use strategy that was adopted actually incorporates a "service tail" as part of the production schedule so that the existing equipment problem being experienced on CFCs would be much reduced with respect to HCFCs.

The United States is currently in its last year of CFC production for domestic use under the Protocol and Clean Air Act requirements. Use of these compounds during the last five years has consistently been less than that allowed by the treaty. The reductions are due to several factors, including:

- more rapid replacement of CFCs with substitute compounds or not-in-kind technologies than was previously anticipated;

- greater efforts to reduce servicing losses as a result of the high cost of the CFC refrigerant and the implementation of now mandatory rules prohibiting the venting of refrigerants;

- more careful management of the use of the compounds in all sectors, including electronic solvent cleaning, medical uses, high efficiency insulating foams, etc.; and

- a black market for CFCs.

Despite these lower than projected use levels, concern remained high for the existing equipment base. As a result, manufacturers, distributors, wholesalers, building owners, and refrigeration service networks, have adopted their own strategies for assuring the needed supply of the compounds in the post-1995 CFC-phaseout period. These strategies have required the investment of millions of dollars in CFC banks, assistance programs for customers concerning retrofit decisions, as well as efforts with large customers to bank their own multi-year supply of refrigerants for this equipment.

There is no easy or uniform solution to this issue. The charges made by some, however, that the "impact on consumers was scarcely considered," is not accurate. The fact is that

industry actions have been guided by unprecedented concern by the affected industries for the costs on their customers, and on the health, safety and welfare of the users of the existing and substitute technologies. It is possible that problems in performance or other parameters will arise with the substitutes. That is the inevitable risk of an accelerated phaseout. Industry has done its best to avoid such problems.

Management of the ozone depletion issue continues to be an unprecedented effort on the part of industry, government, and yes, responsible environmental group representatives to address a unique global concern. We have expended more than \$6 billion to implement these new technologies on a world wide basis.

As we stated at the outset, the myths of ozone depletion do not stand up to credible scrutiny. The reality is that the Montreal Protocol process has worked much better than anyone has anticipated. The focus is not on whether the science justified the actions that were taken. There was enough scientific consensus on which to make credible policy decisions. Industry has participated in that process and, to the best of our ability, provided guidance on the means to accomplish the environmental protection agenda in as cost-effective a manner as possible.

The Alliance believes that the proper Congressional focus should be the streamlining of policies in effect in this country and at the international bargaining table. This should be done in order to ensure the successful completion of the transition out of ozone-depleting CFCs, while maintaining our economic competitiveness. We have several suggestions.

At the international level, the United States should take a strong position that there is no need to alter the Protocol's control schedule on HCFCs. The Protocol's technology and assessment panel experts have agreed that HCFCs remain critical to the elimination of CFCs, and further tightening of controls on these compounds provide little or no benefit, particularly if such actions were to encourage continued developing country usage of CFCs. Concern for growth and continued production of CFCs in developing countries should be a priority since such activity could severely slow recovery of the ozone layer.

The Protocol parties must continue progress to have developing countries eliminate their reliance on CFCs. The treaty provides for a delayed phaseout of CFCs in these countries. Many major developing countries, including Brazil, China, Mexico, and Malaysia, have announced phaseouts well in advance of the treaty requirements. The U.S. should be fostering these actions by fulfilling its existing financial commitment to the Montreal

Protocol Multilateral Fund, rather than eliminating funding as has been proposed in the current appropriations process. (According to one estimate, the government has collected more than \$6 billion in ozone depletion excise taxes from U.S. consumers of CFCs. It is difficult to understand the justification for not funding the Protocol efforts since the American people are paying for it through this tax.)

The more quickly developing countries phase out of CFCs, the more likely that U.S. technologies, with their accompanying jobs, could be adopted in order to accomplish this objective.

Because of the quick action to address the issue internationally, the Parties to the Protocol should also be encouraged not to revisit the treaty every two years in anticipation of major amendments. The basic framework is working well and should now be revisited only upon significant new scientific information.

At home, several steps could be taken in order to streamline regulatory provisions. The Congress could eliminate several provisions of Title VI of the Clean Air Act Amendments that have the potential to impose great costs, or subject specific industries, small businesses, and consumers to potential liability for no significant environmental gain. The labeling provisions, particularly with regard to HCFCs should be deleted altogether; the SNAP program should be sunset once there is no nexus to substitution of ozone depleting compounds (the Alliance has filed a legal challenge to the SNAP program in order to prevent unnecessary overreaching on the part of EPA); and provisions eliminating the use of substitutes in so-called "non-essential products" could be deleted. Decisions by government are not as efficient as the marketplace.

Continued increases in the ozone depletion excise tax should be ended. In fact, if the Congress is truly concerned about the costs to the consumer of the ozone protection program it could adopt a tax credit for equipment retrofits. The Alliance believes that such a program would be revenue neutral in the near-term.

Finally, the government must continue to enforce the laws concerning the illegal import of CFCs. Illegal imports and the avoidance of excise tax on these compounds make CFCs more available, reduce the incentive for users to shift to alternatives, and penalize legitimate companies who are complying with U.S. laws. The illegal imports create the impression in the marketplace that CFCs are plentiful, and that retrofits can be deferred.

The illegal imports are frustrating the attempts of legitimate businesses to plan for the post-production period through stockpiling.

Just because the Montreal Protocol has worked well does not mean, as some would have it, that all future global environmental initiatives would be patterned after the Protocol's ban on specific chemicals, or that it means the creation of some supranational regulatory body. The Protocol was designed to address a unique set of scientific, economic, and environmental circumstances that was not well understood by the public, the media, or for that matter, many policymakers. It is difficult to envision a similar set of circumstances on other more typical environmental issues. It is encouraging to note that when the circumstances warranted such action, that governments and industries alike were able to put aside more parochial concerns and act in the interest of the general public good.

Because of industry's active role in understanding the science, and assessing the economic and policy issues, we believe that the process has gone better than it could have. The costs involved are real. While the benefits are still being assessed, we stand by our record of rapid response and participation in this process. We encourage the Congress to further enhance this process by using hearings such as these to better understand the issues, and to streamline the regulatory procedures and the burdens they entail, but to also remain mindful of the historical perspective involved with the establishment of the original policy objectives within which we have had to operate.



STATEMENT  
OF  
RICHARD BARNETT  
CHAIRMAN  
ALLIANCE FOR RESPONSIBLE CFC POLICY

September 16, 1986  
National Press Club  
Washington, D.C.

Good Morning Ladies and Gentlemen:

I have a brief statement that I will read after which I will be happy to answer your questions.

The Alliance for Responsible CFC Policy was organized six years ago to represent the interests of users and producers of chlorofluorocarbons (CFCs). This was in response to what we considered to be an unwarranted proposal by the U.S. Environmental Protection Agency (EPA) to cap and eventually reduce production of this unique family of chemicals which have contributed so significantly to the quality of life of all Americans and to people around the world. The proposed EPA action was based on the theory that CFCs are emitted into the atmosphere and, because of their unique stability, eventually reach the earth's protective ozone layer, where they may deplete the ozone through a complex series of reactions.

In the belief that government ought not regulate based on an unproven or unverified theory, Alliance members established some basic goals with regard to the ozone depletion theory, CFC usage, and potential government policies.

First, it was our desire to encourage the pursuit of adequate credible scientific research on this important environmental issue, and then to ensure that any government policy be based on the best and most current scientific information;

Second, it was our goal to encourage efforts to resolve this issue in the international arena because of its global scope and to prevent any unproductive, harmful, unwarranted unilateral domestic regulatory program that would injure U.S. industry to the benefit of our international competition;

Third, it was our goal to amend the Clean Air Act to provide greater international emphasis on this issue and to give better guidance to the EPA Administrator regarding stratospheric ozone protection activities and the need for regulation.

In the six years that have gone by, we feel that much has been accomplished to obtain our goals, but we believe that much remains to be done.

We have seen wide swings of findings from conflicting scientific reports regarding CFCs and ozone depletion. With as much as we have learned from the intensive scientific scrutiny, we have also learned that there is a lot we still do not know. We believe the scientific research must continue.

In the intervening years, the Alliance has informed our political leaders, administrative officials, and the public-at-large, as to the many benefits that CFCs offer to our society, in comfort control, food preservation and preparation, energy efficiency, cleaning and sterilization processes, and many other uses, as well as the tremendous contribution to worker and consumer health and safety.

Additionally, we have been an active participant in efforts to promote greater international cooperation, as exemplified by our support for the Vienna Convention for Protection of the Ozone Layer, and our participation in domestic and international efforts to address ozone protection issues such as the recently concluded series of workshops sponsored by EPA and the United Nations Environment Programme.

As you can imagine, the Alliance's activities as a coalition require the active physical as well as financial participation of our member companies. We have worked to live up to our name and be an Alliance for *Responsible* CFC Policy. To do so requires a constant evaluation of the complex scientific, economic, and environmental policy issues confronting us and maintaining and, if necessary, adjusting our position in accordance with the most current information available to us.

In 1980, the Alliance urged that at least 3 to 5 years was necessary to allow the scientific research to continue and to gather critical monitoring information regarding the projections being made by computer models. Therefore, the 1986 release of the NASA/WMO science assessment on stratospheric ozone was an important event with regard to our own continuing evaluation process.

In general, I want to stress that the Alliance does not believe that the scientific information demonstrates any actual risk from current CFC use or emissions. We recognize, however, the growing concern for potential ozone depletion and climate change as a result of large future growth of CFC emissions and the buildup of many other trace gases in the atmosphere, and the concern with the discovery of unexplained phenomena such as the large reductions in ozone levels during the Antarctic spring.

The science is not sufficiently developed to tell us that there is no risk in the future. In fact, all of the computer models calculate that large future growth in CFC emissions may contribute to significant ozone depletion in the latter half of the next century.

We support further scientific research and believe that regulatory policies should be periodically reexamined in the light of additional research findings.

On the basis of current information, we believe that large future increases in fully halogenated CFCs (the most durable ones, thought to contribute most to ozone depletion) would be unacceptable to future generations and, in our view, it would be inconsistent with the goals of this Alliance to ignore the potential for risk to those future generations.

The Alliance, therefore, believes that a responsible policy is necessary that meets four criteria. The policy must

- provide some assurance that we never reach the "doomsday" scenarios that have been put forth;
- foster the spirit of international cooperation needed to reach scientific consensus on this issue and the need for an appropriate global response;
- fulfill our responsibilities as businessmen and women to our shareholders, employees, and customers; and
- recognize the substantial contributions that CFCs make to the quality of our lives, and to the health, safety, and economic benefit of workers and consumers alike.

I am pleased to announce to you today, that the Alliance Board of Directors approved the following policy statement on September 4th. We believe this policy statement meets the criteria I have just stated.

Further, we believe that this policy is a significant step in the direction of developing a positive approach to the issue of global ozone protection and the responsible use of CFCs. We recognize that the process of developing these prudent precautionary measures and establishing specifics will not be easy. As a coalition of many companies and industries, we may expect more specific policy suggestions from our members. We look forward to contributing to the development of the broader consensus on this issue, and hope that others will join us in a spirit of international cooperation as we pursue the difficult tasks necessary to achieve a global policy consensus in the months and years ahead.

Thank you.

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**ALLIANCE PETITION SEEKS MORE THAN 50% REDUCTION IN  
OZONE DEPLETION COMPOUND ALLOWANCES**

Washington D.C., February 11, 1992 - The Alliance for Responsible CFC Policy, an industry coalition composed of CFC and HCFC producers and users, today petitioned U.S. Environmental Protection Agency (EPA) Administrator William Reilly to accelerate the phaseout schedule for CFCs and certain atmospheric long-lived HCFCs.

Alliance Executive Director Kevin Fay stated, "The accelerated schedule we have requested EPA to implement domestically and internationally for phasing out these ozone-depleting compounds is more than a 50% reduction from that which is currently allowed by the Montreal Protocol. It is consistent with technological and economic feasibility, the health and safety concerns of workers and consumers, and environmental protection needs. It represents a difficult but realistic schedule for the phaseout of these compounds."

The Alliance petition was filed in acknowledgment of substantial technological advances as well as in response to announcements over the last year concerning additional measurements of potential ozone depletion around the globe. The significant proposed reduction schedule is possible, according to the Alliance, because of progress made by industry in developing ozone protective CFC replacement technologies. These technologies are identified in the December 1991 United Nations Environment Programme (UNEP) Technology and Economic Assessment Report.

The Alliance petition requests that the ban on the production and use of CFCs for new equipment take place on January 1, 1996. Presently, both the Montreal Protocol and the Clean Air Act require that production of CFCs be ended by January 1, 2000, although it is likely that the Protocol will be revised later this year.

The Alliance also believes that the present CFC phasedown schedule can be accelerated at a rate which is achievable in light of industry's technological capabilities. Therefore, the following production schedule has been requested in today's petition:

**Percentage Production of 1986 Baseline Levels**

| <u>Year</u> | <u>Montreal Protocol</u> | <u>Clean Air Act</u> | <u>Alliance Petition</u> |
|-------------|--------------------------|----------------------|--------------------------|
| 1993        | 100                      | 75                   | 50                       |
| 1994        | 100                      | 65                   | 40                       |
| 1995        | 50                       | 50                   | 25                       |
| 1996        | 50                       | 40                   | 0*                       |
| 1997-1999   | 15                       | 15                   | 0*                       |
| 2000        | 0                        | 0                    | 0*                       |

\*exemption for service of equipment, to be determined in future technical assessments.

"While industry has made substantial progress in reducing CFC production and usage, encouraging recovery and recycling of the compounds, and making a safe transition to alternative compounds significant hurdles still remain. The petition takes into consideration the time it will take for EPA to determine whether the alternatives are acceptable for a period of time to justify their production. It also represents a very demanding schedule upon which industry can complete its implementation of the alternatives in the products and processes that use them," Fay said.

The petition also recognizes the needs of consumers and businesses who own over \$135 billion of existing equipment such as automobile air conditioners, refrigerators, and large air conditioning systems which operate on CFCs. While some have advocated that the total CFC production phaseout occur between 1995 and 1997, the Alliance requests that from January 1, 1996 until January 1, 2000, a limited amount of production be allowed annually to service and maintain existing refrigeration and air conditioning equipment. This amount is to be determined by future technology assessments on the availability of cost-effective retrofit technology and the success of CFC recycling and reclamation efforts.

Any attempt to eliminate CFC production without consideration of the existing equipment would create a potential shortfall of necessary refrigerant to service this equipment. Such a shortfall would result in the early obsolescence of this equipment, and reduced operating efficiencies which could cause increased energy consumption by this equipment. While CFC recovery and recycling will make up for some of the shortfall, no study has indicated that a shortage can be eliminated through even the most aggressive recycling and conservation efforts.

The petition also requests acceleration of the phaseout schedule for HCFC-22, HCFC-141b, and HCFC-142b beyond the current Clean Air Act requirements. Under the Alliance petition, production of these compounds for use in new products or equipment would be ended by January 1, 2010. Total production of these HCFCs would be ended by January 1, 2020.

The Alliance For Responsible CFC Policy, organized in 1980, is a coalition of U.S. companies that produce CFCs, HCFCs, and HFCs, as well as products and processes that rely on these compounds. CFCs and HCFCs are used extensively as refrigerants in air conditioning and refrigeration equipment, including motor vehicles; as solvents in the electronics industry; as blowing agents for the manufacture of high efficiency foam insulation and foam packaging; and as sterilants and medical aerosols in the health industry.

Table 1

ACTIONS REQUESTED BY ALLIANCE PETITION

## - Accelerated Phaseout of CFCs:

| <u>Year</u> | <u>Allowable Annual Production<br/>of 1986 Quantities</u>   |
|-------------|---|
| 1993        | 50%   |
| 1994        | 40%   |
| 1995        | 25%   |
| 1996        | 0% for new equipment  |
| 1996-1999   | Allocation for service of<br>equipment manufactured<br>before Jan. 1, 1996<br>(amount to be determined) |
| 2000        | 0%  |

- No production of CFCs after January 1, 1996 for use in equipment manufactured after that date.

- A production allowance from 1996-1999 (amount to be determined based on 1986 levels) for service of refrigeration and air-conditioning equipment manufactured before Jan. 1, 1996.

- Accelerated phaseout of HCFC-22, HCFC-141b and HCFC-142b:

|                    |   |
|--------------------|---|
| After Jan. 1, 2010 | No such HCFCs allowed to be produced for use, or used, in new products and equipment. |
|--------------------|---|

|                    |                        |
|--------------------|------------------------|
| After Jan. 1, 2020 | No production allowed. |
|--------------------|------------------------|

- Limited one-year waiver from accelerated CFC phaseout for applications where no substitutes are viable
- Minimum period of 15 years for safe alternatives
- Deferral of labeling except for containers or products containing CFCs until Jan. 1, 1995
- Exemptions for products demonstrated as essential under Section 610(d)(2)
- Coordination of U.S. actions with Montreal Protocol negotiations

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Kevin Fay 703-243-0344**ALLIANCE PLEDGES SUPPORT FOR PRESIDENT'S PROGRAM ON  
OZONE LAYER, PETITIONS EPA FOR PROMPT ACTION**

WASHINGTON, D.C., February 11, 1992 - The Alliance for Responsible CFC Policy, an industry coalition composed of CFC and HCFC users and producers, endorsed the call today by President Bush to accelerate the domestic and international efforts to protect the earth's ozone layer, and filed a petition with EPA requesting acceleration of the phaseout schedule for certain ozone depleting compounds. "The United States, both government and industry, will maintain its leadership position in the global ozone protection effort," said Kevin Fay, the Alliance Executive Director. "The President's action today is responsive to the environmental concerns announced last week by NASA, and consistent with the technological advances achieved by industry in developing substitute chemicals and technologies."

The CFC Alliance has urged that the critical steps necessary to accelerate the phaseout of CFC compounds are:

- the rapid approval by EPA of industry developed substitutes as required by the Clean Air act;
- development of an action plan to deal with the huge base of existing installed equipment, primarily refrigeration and air conditioning equipment;
- invigorated diplomatic efforts to ensure the participation of all nations, particularly the developing nations, in the Montreal Protocol process; and
- swift action by the Federal government to implement procurement policies for ozone protecting technologies, as well as recycling, reclamation, and retrofit programs for government owned existing equipment.

"The President's proposal addresses several of these key elements. U.S. industry will actively assist the Bush Administration in the prompt implementation of these steps," said Fay. "The Montreal Protocol has achieved an unprecedented level of cooperation in addressing this serious global environmental concern. Without the technical, financial, and political support of the U.S. government, as well as industry, the world would be unable to deal with this environmental crisis. U.S. industry pledged its support in 1986 to address this issue in a responsible manner. Our support for the President's action today is consistent with that commitment."

"The use of market mechanisms to implement the Montreal Protocol have been largely responsible for the industry's ability to reduce its reliance on CFCs well-ahead of current regulatory mandates," said Fay. According to EPA figures, the U.S. has already reduced its reliance on CFCs 40% greater than that required by the Protocol.

In response to the President's call to U.S. CFC producers to immediately reduce CFC production to 50% of 1986 baseline levels, Fay indicated that he believed that the U.S. producers, Allied-Signal, DuPont, Elf Atochem, and LaRoche, would respond affirmatively.

At the same time, the Alliance pointed out that the President's plan achieves the environmental objective while recognizing the needs of American consumers and small business. In 1996, the United States will have 130 million automobiles, 160 million refrigerators and freezers, 5 million commercial refrigeration and air conditioning systems, and 80,000 large building chillers that run on CFCs. This equipment, valued at more than \$135 billion, will require a mix of recycled CFCs, a limited amount of new CFC production, and the application of cost-effective retrofit technologies in order to avoid huge capital obsolescence costs to the economy.

The Alliance reported that it filed a petition with EPA today to accelerate the CFC reduction schedule, achieving a phaseout of production by December 31, 1995. The petition also seeks a limited exemption from the phaseout in order to service the existing equipment base. The exception would only be utilized if subsequent technical developments do not produce cost-effective solutions for retrofitting this equipment and reclaimed and recycled refrigerant is unable to provide for its needs. The petition is consistent with the President's action.

The petition also seeks an accelerated phaseout of the atmospheric long-lived HCFCs, bridging compounds needed in order to complete the CFC phaseout. The Alliance requests that long-lived HCFC production be phased-out in 2020. The petition also addresses other issues pertaining to the implementation of Title VI of the Clean Air Act Amendments of 1990, including labeling deferrals, and identification of safe alternatives.

The Alliance For Responsible CFC Policy, organized in 1980, is a coalition of U.S. companies that produce CFCs, HCFCs, and HFCs, as well as products and processes that rely on these compounds. CFCs and HCFCs are used extensively as refrigerants in air conditioning and refrigeration equipment, including motor vehicles; as solvents in the electronics industry; as blowing agents for the manufacture of high efficiency foam insulation and foam packaging; and as sterilants and medical aerosols in the health industry.

**1994/1995 Membership List  
Alliance for Responsible Atmospheric Policy**

3M Company  
 A. Cook Associates, Inc.  
 Abbott Laboratories  
 Abco Refrigeration Supply Corp.  
 Acme - Miami  
 American Electronics Association (AEA)  
 Air Comfort Corporation  
 Air Conditioning Contractors of America  
 Air Conditioning & Refrigeration Institute  
 Air Conditioning Suppliers, Inc.  
 Air Products  
 Alliance Pharmaceutical Corporation  
 AlliedSignal  
 - American Auto. Manufacturers Assoc.  
 American Frozen Food Institute  
 American Pacific Corporation  
 American Refrigerant Reclaim Corporation  
 American Thermaflo Corp.  
 American Trucking Associations  
 Amtrol, Inc.  
 Anderson Bros. Refrigeration Service, Inc.  
 Apex Ventilations  
 ARCA/MCA  
 Arizona Public Service Co.  
 Arjay Equipment Corporation  
 Arrow Air Conditioning Service Company  
 Arthur D. Little, Inc.  
 Ashland Inc.  
 Astro-Valcour Inc  
 Association of Home Appliance Manufacturers  
 AT&T  
 Ausimont USA  
 Automotive Consulting Group, Inc  
 Bard Manufacturing Co.  
 Beltway Heating & Air Conditioning Co. Inc.  
 Beverage-Air  
 Big Bear Stores Co.  
 Blue M Electric  
 Building Owners and Managers Association (BOMA)  
 Booth Refrigeration Services Conditioning  
 Bristol Compressors  
 c/o Moog Training Center  
 Carner Corporation



Calotex  
 Center for Applied Engineering  
 Central Coating Company, Inc.  
 Cetylite Industries, Inc.  
 Chemical Packaging Corp.  
 Chemtronics, Inc.  
 Clayton Auto Air, Inc.  
 Commercial Refrigerator Manufacturers Association  
 Copeland Corporation  
 Day Supply Company  
 Dow Chemical U.S.A.  
 E.I. Dupont De Nemours and Company  
 E.V. Dunbar CO.  
 Eastman Kodak  
 Ebco Manufacturing  
 Electrolux/White Consolidated  
 Elf Atochem North America, Inc.  
 Elliott-Williams Company, Inc.  
 Engineering & Refrigeration, Inc.  
 Falcon Safety Products, Inc.  
 FES Inc.  
 Flex-O-Lators, Inc.  
 Foam Enterprises, Inc.  
 Foamseal, Inc.  
 Food Marketing Institute  
 Foodservice & Packaging Institute  
 Ford Motor Company  
 Forma Scientific  
 Fox Appliance Parts of Augusta  
 Franke Filling, Inc.  
 Fras-Air Contracting  
 Free-Flow Packaging Corp.  
 Freightliner Corporation  
 Gardner, Carton & Douglas  
 Gebauer Company  
 General Electric Company  
 General Motors  
 Graineer  
 Gulfcoast Auto Air  
 H. C. Duke & Son, Inc.  
 Hale and Dorr  
 Halocarbon Products Corporation  
 Halsey Supply Co., Inc.  
 Harold Electric Co.  
 Henry Valve Company  
 Highside Chemicals  
 Hill Refrigeration Corp.  
 Howard/McCray Refrigerator Co., Inc.

Hughes Aircraft Company  
 Hussmann Corporation  
 ICI Americas Inc.  
 IG-LO, Inc.  
 Illinois Supply Company  
 IMI Cornelius Company  
 Institute of Heating & Air Conditioning Industries  
 Institute of International Container Lessors  
 Integrated Device Technology Inc.  
 International Assoc. of Refrigerated Warehouses  
 International Cold Storage Co., Inc.  
 International Mobile Air Conditioning Assoc.  
 International Pharmaceutical Aerosol Coalition  
 Interstate Truckload Carriers Conference  
 Johnson Controls  
 Joseph Simons Co.  
 Keyes Refrigeration, Inc.  
 King-Weyler Equipment Co., Inc.  
 Kline & Company Inc.  
 Kraft General Foods  
 KYSOR WARREN  
 LaRoche Chemicals  
 Lennox Industries  
 Liggett Group Inc.  
 Lintern Corporation  
 Lorillard  
 Lowe Temperature Solutions  
 Luce, Schwab & Kase, Inc.  
 Malone and Hyde Inc.  
 Manitowoc Equipment Works  
 Marine Air Systems  
 MARVCO Inc.  
 Maytag Corporation  
 McGee Industries, Inc.  
 Mechanical Service Contractors of America  
 Merck & Co., Inc.  
 Metl-Span Corporation  
 Miles Inc.  
 Mobile Air Conditioning Society  
 Monsen Engineering Co.  
 Montgomery County Public Schools  
 Moog Automotive Inc.  
 Moran, Inc.

Nat. Assoc. Of Plumbing-Heating-Cooling Contractors  
 National Assn. of Food Equipment Manufacturers  
 National Automobile Dealers Association  
 National Refrigerants, Inc.  
 National Training Centers, Inc.  
 NC State Board of Refrigeration  
 Neaton Auto Products Mfg., Inc.  
 New Mexico Engineering Res. Instit.-U of NM  
 North Colorado Medical Center  
 Northern Illinois Gas  
 Northern Research & Engineering Corporation  
 Northland Corporation  
 Norton Company-Sealants Division  
 O'Brien Associates  
 Omar A. Muhtadi, Inc.  
 Omega Refrigerant Reclamation  
 Orb Industries, Inc.  
 Patterson Frozen Foods, Inc.  
 Peirce-Phelps, Inc.  
 Pennzoil Company  
 Perlick Corporation  
 Polyisocyanurate Insulation Manufacturers Association (PIMA)  
 Polycold Systems International  
 Premier Brands Ltd.  
 Ralph Wright Refrigeration  
 Rawn Company, Inc.  
 Reeves Refrigeration & Heating Supply, Inc.  
 Refrigeration Engineering, Inc.  
 Refrigerant Management Services  
 Refrigeration Service Engineers Society  
 Refron  
 Revco Scientific  
 Rhode Island Refrigeration Supply Comp, Inc.  
 Ritchie Engineering Co., Inc.  
 Rite Off  
 RJR Nabisco  
 Robinair Division, SPX Corp  
 RSI Co.  
 Rule Industries, Inc.  
 SCM Glidco Organics  
 Scott Polar Corporation  
 Service Supply of Victoria, Inc.  
 Servidyne Inc.  
 Sexton Can Company  
 Sheetmetal, Air-Conditioning Contractors National Association (SMACNA)  
 South Central Co., Inc.

Mr. ROHRABACHER. Thank you, Mr. Fay. We have about 8 minutes left before this vote—7 minutes. Which means that I'll have to run over and vote.

I'll be very interested in hearing your analysis of how the Senate was able to vote 96 to zero and it had nothing to do with President Gore's presentation to the Senate and to this House committee several years ago.

Mr. FAY. I'll be happy to discuss it.

Mr. ROHRABACHER. So we'll be looking forward to that and we're in recess, then, for, say, 15 minutes.

[Recess.]

Mr. ROHRABACHER. Someone was just telling me about the ozone-eating radiator that he had seen and all these exciting things.

Now, Mr. Lieberman, you're the next witness. You seem to have been the focus of several comments during the prior testimony. So I'm looking forward to hearing your testimony.

Mr. LIEBERMAN. I have a lot of friends. [Laughter.]

Mr. ROHRABACHER. Go right ahead, Mr. Lieberman.

**STATEMENT OF BEN LIEBERMAN, ENVIRONMENTAL RESEARCH ASSOCIATE, COMPETITIVENESS ENTERPRISE INSTITUTE, WASHINGTON, DC**

Mr. LIEBERMAN. Mr. Chairman, I'd like to thank you and the other Members of the Subcommittee for the opportunity to speak to you about ozone deletion and the CFC phaseout.

This is an issue that I have followed for two years as an environmental research associate with the Competitive Enterprise Institute.

My comments will focus on the consumer impact of the accelerated CFC phase-out. Unfortunately, this is a side of the issue that has been largely ignored. For many years, the proponents of the phase-out have dominated the debate with exaggerated claims of environmental gloom and doom.

But now that the environmental threat is proving to have been overstated, more people are starting to ask questions about how much this will cost them.

In addition, millions of Americans have gotten a wake-up call in the form of substantially higher air-conditioner repair bills, a trend that will greatly increase in the years to come.

The air conditioning and refrigeration industry has become an ally of the EPA in supporting the CFC phase-out. For the most part, the refrigerant and equipment makers have already stopped producing CFCs and CFC-using equipment and have switched to production of substitutes.

At this point, they want CFCs out of the picture as soon as possible so they can start selling the substitute systems.

This is one environmental issue where big government and big industry are now on the same side. Both are lined up against the consumer.

I would like to present some basic facts about what is occurring and will continue to occur to air conditioning and refrigeration costs.

The most costly category is motor vehicle air conditioners. There are approximately 140 million car and truck air conditioners that

use CFC-12. I estimate that the cost of a car air conditioner repair has increased about \$100, on average.

Thus, the approximately 20 million that need repairs each year cost \$2 billion more annual. The cost will be even higher in future years.

Another category of affected equipment is the refrigeration systems in approximately three-quarters of a million restaurants, food stores, and other small businesses.

The added cost could reach several thousand dollars per facility, one more onerous regulatory burden on small businesses.

Also affected are the chillers that air condition large office buildings, and residential refrigerators. In all, the total cost could reach \$100 billion, although there is some controversy over that, over the next decade, or about \$1000 per household.

I would also like to add that the cost burden of the CFC phase-out is being disproportionately shouldered by American consumers. There is a misconception that the costs of the CFC phase-out are equally shared among the peoples of the world.

Although there is an international phase-out of CFCs, most of the costs are being incurred here in the U.S. For one thing, the U.S. has more affected equipment than any other nation and there are several costly provisions that only affect Americans.

Also, developing nations such as China, India, and Mexico, have a ten-year delay in phasing out CFCs.

Further, unlike the U.S., many other nations are not strongly enforcing the phase-out. For example, the evidence, the anecdotal evidence I've heard is that black market CFCs are readily available throughout much of western Europe and at prices lower than in the U.S.

Thus, the argument that this is a globally-shared burden is spurious and unilateral relief for American consumers would not be unfair.

The costs have been exacerbated by the acceleration of the CFC phase-out from the January 1, 2000 deadline in the Clean Air Act, to the end of this year.

This is true for several reasons.

First, for the large volume of CFC equipment currently in existence, the accelerated phase-out will interfere with its continued use. Many perfectly good systems will have to be prematurely replaced or retrofitted when CFCs become scarce, probably in 1997, maybe 1998.

On the other hand, a slower phase-out would have allowed most existing systems to live out their useful lives and then be replaced in due course by non-CFC systems.

In addition, the abrupt phase-out of CFCs is resulting in the introduction of substitute refrigerants and equipment being rushed into service with minimal field testing and many technical bugs yet to be worked out.

Consumers would be better off if they could continue using their CFC systems until the new systems have been improved upon. But the accelerated phase-out denies them this option.

Further, many have raised environmental concerns about several leading CFC substitutes. For example, HCFCs, which are now used as replacements for CFCs in several applications, are themselves

being considered for an accelerated phase-out by the parties to the Montreal Protocol, based on the belief that they also contribute to ozone depletion.

HFC-134a, the most common substitute, has been called a contributor to global warming. And recently, a scientific study reported that the breakdown products of several CFC-substitutes may damage wetlands.

There are also safety and toxicity concerns that have not been adequately addressed. And whenever asked for firm assurances that these substitutes won't also be later restricted, EPA has always balked.

Thus, it may well be that after consumers are forced to endure the abrupt and costly phase-out of CFCs, they will be subject to a second phase-out for the CFC substitutes that were rushed into use and then later found to be environmentally unacceptable as well.

These problems could be substantially reduced by allowing a few more years of limited CFC production.

The Doolittle Bill would return the phase-out deadlines to those in the 1990 Clean Air Act, allowing limited CFC production until the year 2000.

We have heard testimony from some scientists that this small amount of additional CFC production, really about one percent compared to what's already out there, will make very little difference from an environmental standpoint. But it would be enough to save American consumers billions of dollars. It will enable those with CFC equipment to continue using their systems with CFCs for at least a few more years, by which time we will better know which substitute refrigerants are technically and environmentally acceptable.

This will avoid the problem of expensive false starts. It will also spare equipment owners from having to rely on black market and recycled refrigerants which are lacking in quantity and quality, by providing a supply of new and pure refrigerants.

Thank you.

[The complete prepared statement of Mr. Lieberman follows:]

Testimony of Ben Lieberman  
Environmental Research Associate, Competitive Enterprise Institute  
before the  
Subcommittee on Energy and Environment of the Committee on Science  
U.S. House of Representatives  
September 20, 1995

Mr. Chairman, I would like to thank you and the other members of the subcommittee for the opportunity to speak to you about ozone depletion and the CFC phaseout. This is an issue that I have followed for two years as an environmental research associate with the Competitive Enterprise Institute.

My comments will focus on the consumer impact of the accelerated CFC phaseout. Unfortunately, this is a side of the issue that has been largely ignored. For many years, the proponents of the phaseout have dominated the debate with exaggerated claims of environmental gloom and doom. The widely publicized predictions of skin cancer and cataract epidemics, crop failures, destruction of the ocean food chain, animals going blind, and so forth, have tended to overshadow concerns about the costs of eliminating CFC production. But now that the environmental threat is proving to have been overstated, more people are starting to ask questions about how much this will cost them. In addition, millions of Americans have gotten a wake up call in the form of substantially higher air-conditioner repair bills, a trend that will greatly increase in the years to

come. For the first time, the cost side of the CFC phaseout is getting the attention it deserves.

To the limited extent the EPA has addressed the costs, they have not been honest with the American people. Their extremely low cost estimates have no basis in reality, and cannot stand up to scrutiny. Also, the air-conditioning and refrigeration industry has become an ally of the EPA in supporting the accelerated CFC phaseout. For the most part, the refrigerant and equipment makers have already stopped producing CFCs and CFC-using equipment and have switched to production of substitutes. In effect, the impending phaseout has forced them to market products that cannot compete with the proven reliability of CFCs. At this point, they want CFCs out of the picture as soon as possible so they won't have to deal with the problem of convincing consumers to abandon existing CFC systems that are serving them so well for expensive substitutes that have no track record. A return to CFC production, even a temporary one, will cost the industry money, because it will enable millions of owners of existing CFC-equipment to continue using their systems for several more years. And every piece of CFC equipment that stays in use is one less piece of new equipment that gets sold. It is not surprising that industry groups oppose any additional CFC production and tend to downplay the problems for consumers caused by the accelerated CFC phaseout. This is one environmental issue where big government and big industry are now on the same side. Both are lined up against the consumer.



Since both the EPA and industry have not been forthcoming regarding the real costs of the phaseout, I would like to present some basic facts about what is occurring and will continue to occur to air-conditioning and refrigeration costs. Although the bulk of the consumer impact will take place in the next few years, consumers have already been affected to the tune of several billion dollars, and a number of troubling problems have begun to emerge. I believe that the accelerated CFC phaseout may become the single most expensive environmental measure ever.

There are several categories of air-conditioning and refrigeration equipment impacted by the phaseout. The most costly category is motor vehicle air-conditioners. There are approximately 140 million car and truck air-conditioners that use CFC-12. Most owners of pre-1994 cars or trucks are affected. Model year 1994 and newer vehicles use a substitute refrigerant, HFC-134a. I estimate that the cost of a car air-conditioner repair has increased about \$100 on average, thus the approximately 20 million that need repairs each year cost \$2 billion more annually. The cost will be even higher in future years, particularly if CFCs become prohibitively expensive or unavailable, which many predict to occur by 1997 or 1998. If this happens, owners will have to retrofit their vehicles to use a CFC-substitute. Retrofit costs vary from model to model, but a typical cost is \$200 to \$500. And there are serious questions as to how long a retrofit will last.

Another category of affected equipment is the refrigeration systems in approximately three quarters of a million restaurants, food stores, and other small businesses. The equipment used in these establishments already costs more to repair, due to higher refrigerant and labor costs. And if CFCs become scarce by 1997 or 1998, much of it will have to be prematurely replaced or retrofit, which can cost thousands of dollars - one more onerous regulatory burden on small businesses.

Another affected category of equipment is the chillers that air-condition large buildings. These systems are very expensive to purchase and install, and the phaseout will necessitate a number of premature replacements and costly retrofits of existing CFC systems over the next decade.

Residential refrigerators are also affected. Because of their importance in our lives and widespread use, even a small increase in the costs of non-CFC refrigerators, or decline in their quality and reliability, can have a substantial effect.

The phaseout will also affect states and municipalities, as well as the federal government. Millions of pieces of air-conditioning and refrigeration equipment are publicly owned. From the refrigeration systems in school cafeterias to public hospitals to air-conditioned federal buildings, governments are also going to pay more and taxpayers will foot the bill.

In all, the total costs could reach \$100 billion over the next decade, or about \$1,000 per household. Beyond the dollar costs is the impact on human health. Air-conditioning, far from

being a luxury item, is a life saving technology, particularly during heat waves. Refrigeration is also important in providing a safe and inexpensive food supply and plays a vital role in medical care. Regulations that raise the cost and lower the availability and quality of air-conditioning and refrigeration could impact the health of our nation.

I would also like to add that the cost burden of the CFC phaseout is being disproportionately shouldered by American consumers. There is a misconception that the costs of the CFC phaseout are equally shared among the peoples of the world. Although there is an international phaseout of CFCs, most of the costs are being incurred here in the U.S. For one thing, the U.S. has more affected equipment than any other nation. In contrast, the Scandanavian countries, which have taken the lead in demanding stringent phaseout deadlines, have much less to lose because they have far less air-conditioning equipment. Also, developing nations such as China, India, and Mexico have a ten year delay in phasing out CFCs, and several nations, including Russia, have indicated that they will not comply with the current deadlines. In addition, there are provisions that only affect Americans, like the onerous EPA regulations requiring expensive and time consuming procedures during repairs of air-conditioning and refrigeration equipment, as well as the heavy excise taxes on CFCs. Further, while our government is trying hard to crack down on the burgeoning black market in CFCs, other nations are making scant enforcement efforts. For example, the anecdotal evidence

I've accumulated suggests that black market CFCs are readily available throughout much of Western Europe, and at lower prices than in the U.S. Thus, the argument that this is a globally shared burden is spurious, and unilateral relief for American consumers would not be unfair.

The costs have been exacerbated by the acceleration of the CFC phaseout from the January 1, 2000 deadline in the original 1990 amendments to the Clean Air Act, to the January 1, 1996 deadline we have right now. This is true for several reasons.

First, for the large volume of CFC equipment currently in existence, the accelerated phaseout will interfere with its continued use. Many perfectly good systems will have to be prematurely replaced or retrofit when CFCs become scarce. On the other hand, a slower phaseout would have allowed most existing CFC systems to live out their useful lives, and then be replaced in due course by non-CFC systems. With automotive air-conditioners, for example, normal fleet turnover results in 10% of older cars going off the road each year. And since new cars no longer use CFCs, we would have seen a steady decline in the number of CFC-using motor vehicle air-conditioners without a draconian phaseout and its accompanying costs.

In addition, the abrupt phaseout of CFCs is resulting in the introduction of substitute refrigerants and equipment being rushed into service with minimal field testing and many technical bugs yet to be worked out. Few knowledgeable engineers believe these new systems will be as reliable and last as long as their

CFC-using counterparts. Consumers would be better off if they could continue using their CFC systems until the new systems have been improved upon. But the accelerated phaseout denies them this option.

Further, scientists and environmentalists have raised concerns about several leading CFC substitutes. For example, HCFCs, which are now used as replacements for CFCs in several applications, are themselves being considered for an accelerated phaseout by the parties to the Montreal Protocol, based on the belief that they also contribute to ozone depletion. HFC-134a, the most common substitute, has been called a contributor to global warming. And recently, a scientific study reported that the breakdown products of several CFC-substitutes can accumulate in wetlands, and concluded that the ecological consequences could be serious. There are also safety and toxicity concerns that have not been adequately addressed. And, whenever asked for firm assurances that these substitutes won't also be restricted, EPA has always balked. Thus, it may well be that after consumers are forced to endure the abrupt and costly phaseout of CFCs, they will be subject to a second phaseout for the CFC substitutes that were rushed into use and then later found to be environmentally unacceptable as well. The costs of such false starts could add billions to the phaseout's ultimate price tag.

Also, the accelerated phaseout is going to become far more costly than expected because refrigerant recovery and recycling, which is mandated by the law and the EPA regulations, is turning

out to be a disappointment. Despite optimistic statements by the EPA that recovery and recycling of existing CFCs will provide an ample supply to meet future demand, it is clear that it will fail to do so. Thus far, the quantity and quality of recycled refrigerant is far below expectations. In some cases, recycled CFCs are so contaminated that they can actually damage a system. The trade press is replete with articles such as "Recovered Refrigerant: Where is It?" (Air Conditioning, Heating, and Refrigeration News, May 16, 1994). And the fact that there is a growing black market is also evidence that recycled refrigerants are not sufficient to meet demand.

These problems could be substantially reduced by allowing a few more years of CFC production. The Doolittle Bill would return the phaseout deadlines to those in the 1990 Clean Air Act, allowing limited CFC production until the year 2000. We have heard testimony from scientists that this small amount of additional CFC production will make very little difference from an environmental standpoint. But it would be enough to save American consumers billions of dollars. It will enable those with CFC equipment to continue using their existing systems with CFCs for at least a few more years, by which time we will better know which substitute refrigerants are technically and environmentally acceptable. This will avoid the problem of expensive false starts. It will also spare equipment owners from having to rely on black market and recycled refrigerants which

are lacking in quantity and quality, by providing a supply of new and pure refrigerant.

In conclusion, the accelerated phaseout of CFCs will be very costly to consumers, particularly over the next few years. Allowing an additional amount of limited CFC production until 2000 would be environmentally inconsequential, but would greatly reduce the costs to consumers. Not doing so may well lead to a consumer backlash.

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**THE HIGH COST OF COOL**

**THE ECONOMIC IMPACT OF THE CFC  
PHASEOUT IN THE UNITED STATES**

Ben Lieberman

June 1994

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# THE HIGH COST OF COOL

## THE ECONOMIC IMPACT OF THE CFC PHASEOUT

Ben Lieberman

### EXECUTIVE SUMMARY

Chlorofluorocarbons (CFCs) are an important class of compounds. They have an impact on the life of nearly every American. Yet, as a result of environmental fears, their production will soon be eliminated - by the year 1996. In making this decision, little consideration was given to the costs of eliminating such a widely used class of compounds over a relatively short period of time.

This study examines the probable economic cost of the CFC phaseout on the refrigeration and air conditioning sector in the United States. The estimated cost of the CFC phaseout is \$44.5 to \$99.4 billion over the next decade. This estimate breaks down as follows (figures in billions):

|                            |                   |
|----------------------------|-------------------|
| ● Vehicle air conditioners | — \$28.0 - \$42.0 |
| ● Energy consumption       | — \$ 0 - \$32.1   |
| ● Domestic refrigeration   | — \$ 4.0 - \$ 8.0 |
| ● Commercial refrigeration | — \$ 3.0 - \$ 5.4 |
| ● Chillers                 | — \$ 4.4 - \$ 5.0 |
| ● HCFCs & HCFC Equipment   | — \$ 5.1 - \$ 6.9 |

Compliance with the law will impose large up-front costs on businesses and individuals. Much equipment will need to be replaced or modified (retrofitted).

After decades of fine-tuning and extensive field experience, air conditioning and refrigeration equipment using CFCs has become very reliable. In contrast, most CFC replacements are new, and manufacturers are still near the bottom of the learning curve in making the massive technological changes necessary.

Because of the accelerated phase-out, which provides a limited time frame in which to end dependence on CFCs, non-CFC systems are being rushed into use, despite many unsolved problems. In effect, a multi-billion dollar field test of experimental equipment is being conducted at consumer expense. The frequency of break downs, and the costs of repairs can be expected to increase for many applications.

The CFC phaseout may well be the single most expensive environmental measure taken to date. During the policy debate, the costs were underemphasized to the point that they never became an important factor. The impact on consumers was scarcely considered. It may be too late to reverse course on the CFC phaseout, but it can serve as a lesson for the future.

# THE HIGH COST OF COOL

## THE ECONOMIC IMPACT OF THE CFC PHASEOUT

### IN THE UNITED STATES

by Ben Lieberman

#### INTRODUCTION

Chlorofluorocarbons (CFCs) are an important class of compounds. They are the refrigerants used in over \$100 billion worth of air-conditioning and refrigeration equipment in the U.S. They have an impact on the life of nearly every American, as many people own CFC-using equipment and purchase goods and services that rely on CFCs.

As a result of environmental fears, their production will soon be eliminated. A number of scientists have argued that CFCs and other compounds deplete the earth's ozone layer.<sup>1</sup> According to the theory, CFC molecules that escape into the atmosphere at ground level eventually rise to the upper atmosphere (stratosphere), where they are broken down by sunlight and release their chlorine atoms. The chlorine atoms then destroy ozone molecules, leading to depletion of the stratospheric ozone layer. Since the ozone layer partially shields the earth from incoming ultraviolet radiation, its depletion is predicted to lead to an increase in ultraviolet radiation reaching ground level.<sup>2</sup> Because increased ultraviolet radiation levels could adversely affect human health and the environment, the Congress and the international community have outlawed the production of CFCs by the end of 1995.

In making this decision, there was little consideration given to the costs of eliminating such a widely used class of compounds over a relatively short period of time. In the U.S., these costs will be between \$44.5 to \$99.4 billion over the next decade for refrigeration and air-conditioning alone. This amounts to approximately \$445 to \$994 per household. These costs should have been taken into account during the CFC phaseout decisionmaking process.

The federal government, once it chose to embark on the accelerated CFC phaseout, has tried to minimize the issue of the costs to the public. While overstating the dangers of ozone depletion in numerous reports, hearings, and press conferences, agency officials and legislators have often underemphasized the economic consequences and human impact of eliminating CFC production by 1995.<sup>3</sup> The few studies that estimate the costs tend to understate them, while overstating the environmental benefits of eliminating CFCs.<sup>4</sup> As a result,

*CFCs have an impact on the life of nearly every American.*

the public has accepted the CFC phaseout in near total ignorance of the impact it will have on them.

This paper will attempt to provide a realistic assessment of the costs in the U.S. of eliminating CFC production by 1995. It will be limited to the impact on refrigeration and air-conditioning<sup>2</sup>, and will emphasize the costs that, directly or indirectly, will be imposed on American consumers over the course of the next ten years.

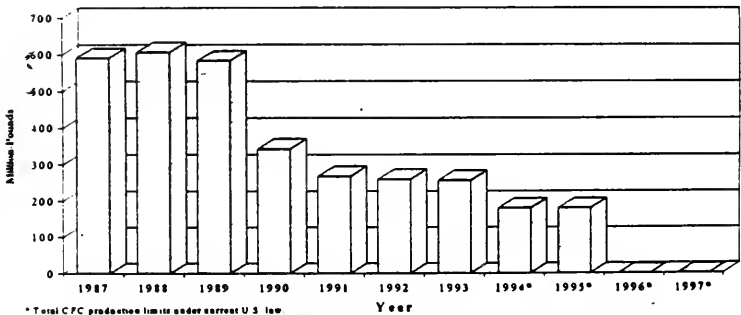
*There was little consideration given to the costs of eliminating such a widely used class of compounds over a relatively short period of time.*

#### THE CURRENT STATE OF THE LAW

Both international and U.S. law restrict the production of CFCs.<sup>6</sup> In 1987, the international community responded to fears of global ozone depletion by ratifying the Montreal Protocol on Substances That Deplete the Ozone Layer (Montreal Protocol). It was signed initially by 24 nations, including the U.S. and most major CFC producers. Today the Montreal Protocol has 123 signatories. It originally called for an eventual 50 percent reduction in global CFC production, but has since been amended to require a total phaseout, except for "essential" uses, by the end of 1995 for developed nations and 2005 for developing nations.<sup>7</sup>

Domestically, the Congress included provisions to the Clean Air Act Amendments of 1990, which set production limits on CFCs, culminating in a total phaseout by the year 2000. In February 1992, the phaseout was accelerated in response to a NASA press conference, where several scientists predicted a severe depletion of the ozone layer over North America during the winter.<sup>8</sup> The Senate unanimously passed an amendment urging president Bush to

#### U.S. PRODUCTION OF CFC-11 AND CFC-12 1987 - 1997



move up the phaseout date to 1995, to which the president agreed.<sup>9</sup> A few months later, NASA admitted that their prediction was incorrect, but the accelerated phaseout was unaffected.<sup>10</sup>

In response to Congress, the EPA recently promulgated the regulation that outlines the phaseout.<sup>11</sup> Generally, CFC production is limited to 25 percent of 1986 production levels for 1994 and 1995, with a complete end to production on January 1, 1996.<sup>12</sup> Estimates of past and projected CFC production in the U. S. are displayed in the chart above. In addition, a related class of compounds called HCFCs is being phased out under a slower timetable.<sup>13</sup> The EPA has also imposed regulations regarding the manner in which air-conditioning and refrigeration equipment is serviced and disposed of, in an attempt to reduce the atmospheric release of existing CFCs.<sup>14</sup>

*CFCs are rapidly becoming scarce.*

### AN OVERVIEW OF THE COSTS

Before analyzing the effect of the phaseout on specific end uses, it is worthwhile to take an overall view of its impact. Compliance with the law will impose large up-front costs on businesses and individuals, as much equipment will need to be replaced or modified (retrofitted). In addition, there will be increases in ongoing operational expenditures as a result of higher maintenance costs, refrigerant costs and energy consumption. This will add as much as \$9.94 billion annually over the next decade to the cost of meeting America's refrigeration and air-conditioning needs. The breakdown of the costs over the next decade assessed in this paper is displayed in the table at right and the chart below.

#### ESTIMATED CFC PHASEOUT COSTS REFRIGERATION AND AIR-CONDITIONING 1994 through 2003 (figures in \$billions)

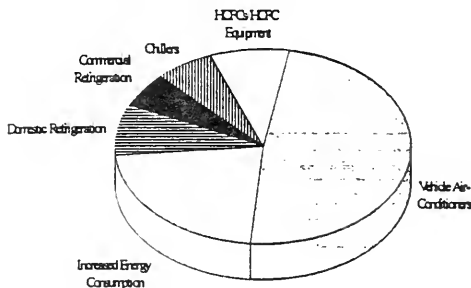
| Cost                     | Range              |
|--------------------------|--------------------|
| Vehicle Air-Conditioners | 28.0 - 42.0        |
| Energy Consumption       | 0 - 32.1           |
| Domestic Refrigeration   | 4.0 - 8.0          |
| Commercial Refrigeration | 3.0 - 5.4          |
| Chillers                 | 4.4 - 5.0          |
| HCFCs and HCFC Equipment | 5.1 - 6.9          |
| <b>TOTAL</b>             | <b>44.5 - 99.4</b> |

Note: The following are not included in the above analysis: refrigerated transportation, industrial refrigeration, medical and laboratory equipment, dehumidifiers, vending machines, water coolers, drinking fountains.

#### Equipment Costs

In the U.S., there is approximately \$135 billion worth of air-conditioning and refrigeration equipment in commercial and domestic use.<sup>15</sup> Much of this equipment has a useful life of 10 to 25 years, needs additional refrigerant to make up for leakage over time, and is not designed to work with non-CFC refrigerants.<sup>16</sup> Because CFCs are rapidly becoming scarce, much equipment will have to be prematurely replaced or

### CFC PHASEOUT COSTS ESTIMATED DISTRIBUTION



retrofitted to use CFC alternatives. Billions of dollars in additional equipment and installation outlays will be required to maintain the status quo.

Even after the current base of equipment is replaced, there may be ongoing increases in equipment costs. There are some indications that the alternative systems will have a shorter useful life than their CFC-using counterparts, but it is difficult to know for certain as non-CFC equipment has only recently come into use. Although the potential costs of more frequent replacements could be high, they cannot be accurately estimated at this time and will not be included in the total accounting.

## OPERATIONAL COSTS

### Maintenance

After decades of fine-tuning and extensive field experience, air-conditioning and refrigeration equipment using CFCs had become very reliable. In contrast, most CFC replacements are new, and manufacturers are still near the bottom of the learning curve in making the massive technological changes necessary. Properly matching equipment with these new refrigerants will take several more years. This task is further complicated by the fact that many non-CFC refrigerants have inherent chemical and thermodynamic properties that make them difficult to manage.

Under ordinary circumstances, extensive research and development would be completed by industry prior to new equipment being introduced in the market. However, because of the accelerated phaseout, which provides a limited time frame in which to end dependence on CFCs, non-CFC systems are being rushed into widespread use, despite many unsolved problems. In effect, a multi-billion dollar field test of experimental equipment is being conducted at consumer expense. The frequency of breakdowns, and the costs of repairs can be expected to increase for many applications.

Further, the rapid introduction of numerous new refrigerants has thrown the refrigeration and air-conditioning service industry into a state of confusion. In the last few years, no less than 10 new refrigerants have come into use, and more are on the way.<sup>17</sup> Some have unique equipment requirements and servicing needs, which are currently being discovered through trial and error.<sup>18</sup>

*In effect, a multi-billion dollar field test of experimental equipment is being conducted at consumer expense.*

Further, because some of the new refrigerants are chemically incompatible with others, service equipment that comes in contact with one refrigerant (for example recovery devices or gauges) may cause contamination if later used on a system with a different refrigerant. Unless servicemen own and maintain several sets of dedicated equipment, refrigerant cross-contamination will become a serious problem.

The situation is so complex that even skilled servicemen admit that they are often not certain as to the proper procedure. Costly mistakes made during installation, routine maintenance, and repairs will be common for many years, imposing significant costs on equipment owners.

Also, refrigerant recovery rules, requiring servicemen to take measures to prevent refrigerant leakage during servicing, and rules requiring leak detection and repair, are time consuming and require expensive equipment, adding to the costs of repairs and maintenance.<sup>19</sup>

Air-conditioning and refrigeration servicing has become more costly.<sup>20</sup> Some servicemen estimate that they will be charging clients about 25 percent more than they had previously. However, the total increase in maintenance costs cannot be determined at this time, as most of these costs are incurred after equipment has been in use for a few years, and non-CFC equipment has only recently made inroads into the American market. Because of the uncertainties, these costs will not be included in the total accounting, except in those cases where it is specifically noted.

### Refrigerant Use

Before the phaseout took effect, the market price of the most common types of CFC refrigerants, CFC-11 and CFC-12, was less than \$1.00 per pound wholesale. Today, as a result of production limits and excise taxes, they cost approximately \$8.00 to \$10.00 per pound at the wholesale level, and up to twice that for some retail users.<sup>21</sup> This amount is expected to rise considerably in the months and years ahead. In 1994 and 1995, the quantity of CFCs allowed to be produced is about 180 million pounds annually, but based on recent years, considerably more than that will be needed.<sup>22</sup> After January 1, 1996, when all production ends, cost increases will further accelerate due to limited supplies.<sup>23</sup> Predictably, a black market in CFCs is developing.<sup>24</sup>

Refrigerant recovery and subsequent recycling or reclamation, though required by law, is not likely to make up for the shortfall. There are limitations on how much refrigerant can be recovered and reused.<sup>25</sup> Also, compliance has not been widespread, particularly among those servicing equipment with a small refrigerant charge.<sup>26</sup>

The leading replacement refrigerants are also expensive. Unlike CFCs, the patents on which have long since expired, many of these new compounds are still under proprietary protection.<sup>27</sup> Others are more expensive to produce. The

*Costly mistakes made during installation, routine maintenance, and repairs will be common for many years.*

*A black market in CFCs is developing.*

most common replacement, hydrofluorocarbon-134a (HFC-134a), costs at least \$7.00 per pound.<sup>28</sup> In addition, some replacement refrigerants require expensive lubricants and additives in order to function properly. Cheaper alternatives, such as ammonia and hydrocarbons, have limitations—flammability, toxicity, regulatory barriers—that will take several years to overcome, and are not likely to be widely used in the U.S. in the near future.

Before the stringent production restrictions were in effect, the U.S. produced and consumed approximately 650 to 700 million pounds of CFCs annually, at least 300 million of which were used as refrigerants.<sup>29</sup> Conservatively estimating a \$5.00 per pound increase in the current cost of CFCs and alternatives over the pre-phaseout cost of CFCs, an additional \$1.5 billion per year will be spent on refrigerants. Most of these costs are included in the costs of new equipment and retrofits, and are not separately discussed.

### Energy Use

Air-conditioning and refrigeration are energy intensive, consuming about 28 percent of the nation's electricity.<sup>30</sup> CFCs are currently used in many of these applications. Their replacement has raised concerns about the impact on energy consumption.

As refrigerants, CFCs are relatively energy efficient. Their thermodynamic properties—thermal conductivity, latent heat of vaporization, boiling point—are nearly ideal, for a variety of applications. In contrast, many of the leading replacements, such as HFC-134a, are not as well suited, and a loss in energy efficiency (relative to comparable CFC-using equipment) is unavoidable.<sup>31</sup> In addition to thermodynamic efficiencies, there may be other problems with non-CFC systems that will lead to greater energy use.<sup>32</sup>

One hypothetical estimate of the annual increase in overall electricity use resulting from a CFC phaseout gives the range of 13 to 94 billion kWh/yr, or (assuming \$ 0.06 per kWh) \$0.78 to \$5.64 billion dollars.<sup>33</sup> The middle of this range amounts to an additional energy cost of \$3.21 billion per year.

Other recent studies by the EPA, DOE and the alternatives industry found little or no energy penalty.<sup>34</sup> They compared the efficiencies of new alternative systems utilizing optimized engineering design with the old and inferiorly equipped CFC systems they are replacing. Relative efficiencies of comparable CFC and non-CFC systems were not considered.<sup>35</sup> The energy efficiency gains in new equipment are due to technological advances largely unrelated to the refrigerant chosen, although the CFC phaseout may have provided the impetus for immediate implementation of these costly improvements. In effect, the efficiency gap between new non-CFC and old CFC systems is being narrowed, and in some cases eliminated, but at the expense of higher equipment costs.

Nonetheless, the gap between comparable CFC and non-CFC systems persists. However, the extent of this gap is difficult to determine, as the energy efficiency of new non-CFC equipment is currently being improved, and the

*In nearly every case, the phaseout of CFCs will result in higher costs and decreased performance.*



efficiency of comparable CFC systems can only be speculated, as CFCs are no longer being used in state-of-the-art equipment. In addition, the CFC phaseout has accelerated the retirement rates for old, inefficient systems. For these reasons, it is hard to estimate what energy consumption would have been without the CFC phaseout, and what it will be with the phaseout.

For the purposes of this study, the assumed range of increased annual energy expenditures is \$0 to \$3.21 billion, or \$0 to \$32.1 billion over the next decade. The low end of this range assumes that energy use for air-conditioning and refrigeration will be no different than if there had been no CFC phaseout. The high end, which represents the middle of the range discussed previously, estimates a penalty of about 2 percent of total energy consumption.

### THE IMPACT ON SPECIFIC END USES

The higher initial and ongoing costs discussed above will affect most kinds of refrigeration and air-conditioning applications. In nearly every case, the phaseout of CFCs will result in higher costs and decreased performance. The most heavily affected applications will each be discussed separately.

#### Vehicle Air-Conditioners

Americans own approximately 140 million automobiles and trucks that use CFCs in their air-conditioners.<sup>36</sup> Unless willing to do without air-conditioning, these owners are faced with two choices—continue using CFCs, or retrofit their system to use an alternative refrigerant. Either choice entails increased costs.

##### Continue Using CFCs:

Generally, vehicle air-conditioners run without problems for the first few years, and then need servicing once every two or three years thereafter. The most common problem is refrigerant leakage. Approximately 20 million cars and trucks are brought in for air-conditioner servicing each year.<sup>37</sup>

The accelerated phaseout already has increased the cost of servicing. Servicemen are required to comply with refrigerant recovery rules in order to reduce the amount of refrigerant that escapes during servicing.<sup>38</sup> This takes as much as a half hour and requires equipment costing about \$1,000. As a result, labor costs for air-conditioner servicing have gone up.

The cost of the refrigerant, CFC-12, has also increased from under \$1.00 per pound to as much as \$10.00 wholesale and about twice that retail. A vehicle may need up to three pounds to be fully operational. The cost is expected to rise further, particularly in 1996 when all production ends.

It is now illegal to sell small cans of CFC-12 to the public, which were used to recharge vehicle air-conditioners.<sup>39</sup> Considering that 60 to 80 million pounds of refrigerant were sold in these cans, it is reasonable to assume that millions of people recharged their own vehicle air-conditioners, at minimal cost.<sup>40</sup> They are no longer able to do so. Now they are forced to take their vehicles to an EPA-

*Approximately 20 million cars and trucks are brought in for air-conditioner servicing each year.*

certified mechanic or dealer whenever their air-conditioner needs servicing, and pay the market price for refrigerant and labor.

As a result, recharging an air-conditioner low on refrigerant, which cost between \$20 and \$40 as recently as 1991 (and just a few dollars for do-it-yourselfers), currently averages approximately \$100.<sup>41</sup> This figure will increase, possibly doubling by 1996, if CFC-12 costs continue their present trends. Performing repairs on a system, such as fixing a leak, averages \$265, a 20 percent increase over the 1991 average.<sup>42</sup> This amount is also likely to increase with time. Also, the number of vehicle owners being persuaded by servicemen to spend considerably more to repair leaks rather than "top off" (adding lost refrigerant without repairing the leak) will increase, in order to avoid the possibility of further CFC-12 losses in the future.<sup>43</sup> In Florida and parts of California, leak repair is required by state law.

#### Retrofit:

CFC-using air-conditioners can be modified to use an alternative refrigerant, HFC-134a. However, this is an expensive changeover, requiring the replacement of several components, including the hoses, safety valve, O-ring seals, drier, and possibly the condenser, as well as a thorough flushing of the system to remove all traces of CFC-12 and mineral oil, which act as contaminants in the presence of HFC-134a. The estimated average cost of a retrofit is \$433.<sup>44</sup> Also, there are unanswered questions as to the performance and reliability of retrofits.<sup>45</sup> It is unlikely that many consumers will choose the retrofit option, unless CFC-12 becomes prohibitively expensive or totally unavailable.

#### Total Costs For Existing Vehicles:

Assuming the 140 million CFC-using vehicles need an average of two more air-conditioner repairs or recharges before they are retired over the course of the next ten years, and each servicing averages \$100 to \$150 more than a comparable pre-phaseout servicing, the increased cost will be \$28 to \$42 billion over the next decade.<sup>46</sup> The total will be even higher if difficulties in obtaining CFC-12 force a large number of people to retrofit their vehicles. The option of simply not repairing an inoperative CFC-12 air-conditioner is also costly, as it will reduce the resale value of a vehicle by several hundred dollars.<sup>47</sup>

#### New Vehicles:

New car and truck air-conditioners are now designed to use HFC-134a. Introduced in a few models in 1992 and 1993, HFC-134a air-conditioners will predominate in 1994 models. The auto industry has spent several hundred million dollars to redesign vehicle air-conditioning systems and retool assembly lines to accommodate the changes. Eventually, these costs will be passed on to consumers in one form or another.

*The auto industry has spent several hundred million dollars to redesign vehicle air-conditioning systems.*

It is unlikely that HFC-134a systems will be as reliable as CFC-12 systems.<sup>48</sup> High failure rates after several years in use may be common. Unlike CFC-using systems, which (excepting minor repairs and occasional recharges) often lasted as long as the vehicle, a number of HFC-134a air-conditioners will probably need a major repair during the vehicle's useful life. If so, owning and maintaining a new HFC-134a air-conditioner for the life of the vehicle will cost several hundred dollars more than a comparable pre-phaseout CFC system. Any additional costs will become apparent only after the new HFC-134a air-conditioners have been subjected to a few years of use.<sup>49</sup> Because these costs are speculative, they are not included in the total accounting for this paper.

### Domestic Refrigerators

There are about 140 million refrigerators in domestic use in the U.S.<sup>50</sup> Nearly every household has at least one. They are reasonably priced and extremely reliable, often providing 15 or more years of trouble-free service. Until recently, nearly all used CFC-12 as their refrigerant. The phaseout will have relatively little effect on these refrigerators, as less than 5 percent ever require servicing due to refrigerant leakage.

However, refrigerator manufacturers are already preparing for the phaseout. As a result of CFC-12 shortages and price increases, several refrigerator manufacturers have begun to make the transition to non-CFC refrigerators, well ahead of the January 1, 1996 phaseout date. By that time, all newly manufactured refrigerators will be CFC-free.

As with vehicle air-conditioners, the alternative refrigerant of choice for new domestic refrigerators is HFC-134a.<sup>51</sup> Although it is too early to determine the price of these new refrigerators, at least one introductory model is priced \$100 higher than a comparable CFC refrigerator, most of which range from \$500 to \$1,500, depending on the brand name and features.<sup>52</sup> Assuming a \$50 to \$100 increase per refrigerator, the nearly 10 million domestic refrigerators (and stand-alone freezers) sold each year will cost an additional \$0.5 to \$1.0 billion.<sup>53</sup>

Assuming HFC-134a refrigerators predominate beginning in 1996, the cost over the next decade will be \$4.0 to \$8.0 billion.

HFC-134a refrigerators may use more energy than an equivalent CFC system.<sup>54</sup> Like vehicle air-conditioners, HFC-134a refrigerators are unlikely to be as reliable and long-lasting as their CFC-using counterparts.<sup>55</sup> Expensive repairs may be common, some necessitating replacement, particularly after about 8 years of use. Because the first HFC-134a refrigerators are only a few years old, there is no direct evidence regarding their long-term reliability.<sup>56</sup> If they prove less durable than CFC refrigerators, the cost of additional repairs and premature replacements could be significant. This potential cost is not included in the total accounting.

*There are about 150 million refrigerators in domestic use in the U.S.*

*HFC-134a refrigerators are unlikely to be as reliable and long-lasting as their CFC-using counterparts.*

## Chillers

There are at least 80,000 chillers operating in the United States.<sup>57</sup> Chillers, so called because they chill water which is used to cool air, are the most efficient means to air-condition large buildings. They also provide the cooling in certain industrial applications. About 65,000 are low-pressure chillers that use CFC-11, and most of the rest are high-pressure chillers that operate with CFC-12, HCFC-22, or R-500 (a mixture that includes CFC-12).<sup>58</sup> These systems are expensive to purchase and install and are expected to last more than 20 years. Most contain a thousand or more pounds of refrigerant, and often have high leak rates.<sup>59</sup> Thus, the future of this equipment has been significantly affected by the phaseout.

Thus far, less than 10 percent of chillers have been replaced or retrofitted to use non-CFC refrigerants.<sup>60</sup> Most will still be reliant on CFCs when production comes to an end in 1996.<sup>61</sup>

Chiller owners are faced with several choices, and must make them in a short period of time and with limited information. Basically, they can continue to use CFCs, retrofit existing equipment to use an alternative refrigerant, or replace their system with a totally new non-CFC chiller. Each choice entails significant additional costs. Which option is appropriate in each case depends on the type and condition of the chiller, and the characteristics of the building it is located in. It also depends on the future availability of CFCs and the rate of non-CFC technological breakthroughs. At this point, the number of chiller owners that will choose each option and the total cost can only be estimated. The three options will be discussed in turn.

### Continue Using CFCs:

There is no legal requirement that CFC equipment be retired, only that CFC production cease. Existing CFC chillers can be used beyond the phaseout date, provided that sufficient refrigerant is available. However, with CFC production to end in 1995, the only way of assuring the long-term operation of CFC chillers is to minimize the amount of additional refrigerant needed. This requires refrigerant containment, i.e. taking steps to reduce refrigerant leakage, and recovering (rather than venting) refrigerant during maintenance and servicing (both of which are also regulatory requirements). It also necessitates storing extra CFCs for future use.<sup>62</sup> This option is particularly attractive for CFC-11 chillers in good working order, where leakage can be reduced to a minimum.<sup>63</sup> Assuming that about half (30,000 to 35,000) of the CFC-11 chiller owners choose this option over the next decade, and the average cost is approximately \$20,000 to \$30,000 parts and labor,<sup>64</sup> the total cost over the next decade will be \$0.6 to \$1.05 billion dollars.

### Retrofit:

For about 15,000 to 20,000 existing chillers, retrofitting to use alternative refrigerants is an economically sound decision. Perhaps 10,000 to 15,000 CFC-11 chiller owners, anxious to end their reliance on CFCs, will choose to retrofit to

*There is no legal requirement that CFC equipment be retired, only that CFC production cease.*

HCFC-123. Retrofitting will also be chosen by the owners of many relatively new CFC-12 and R-500 chillers, because difficulties in reducing leakage makes continued reliance on CFCs risky, and total replacement would be wasteful. They can be retrofitted to use HFC-134a. In either case, a retrofit entails extensive modifications to a chiller.<sup>65</sup> Retrofit costs range from \$10,000 to well over \$100,000.<sup>66</sup> Assuming an average retrofit cost of \$50,000, the total cost of retrofitting chillers will be \$0.75 to \$1.00 billion over the next ten years.

#### Premature Replacement:

Since continued reliance on CFCs or retrofitting involves significant costs and risks, some building owners may choose to purchase and install a new chiller.<sup>67</sup> Assuming 30,000 existing chillers will have been replaced in the next 10 years,<sup>68</sup> and half of these replacements are attributable to old chillers in need of replacement anyway, 15,000 replacements can be attributed to the phaseout. New chillers vary in cost depending on size, and the cost of installation depends on the features of each building. Assuming an average cost of \$120,000, these chillers will add \$1.8 billion to the phaseout cost.<sup>69</sup>

#### Safety Costs:

Primarily because of safety concerns surrounding some of the replacement refrigerants, new building code requirements for buildings with chillers are likely to become law.<sup>70</sup> The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) sets the model standards which nearly all local building codes follow.<sup>71</sup> Standard 34 categorizes refrigerants based on their toxicity and flammability. The most commonly used CFCs and HFC-134a are listed as A1, because they have low toxicity and low flammability. HCFC-123 is classified B1, because of higher toxicity and low flammability.<sup>72</sup> Standard 15 now requires that equipment rooms with a class A1-using chiller have ventilation systems, oxygen monitors, and a self-contained breathing apparatus. B1-using chillers require a refrigerant vapor detector and alarm system in addition to these requirements. The typical cost of bringing a building into compliance will be from \$10,000 to \$20,000.<sup>73</sup> Assuming an average of \$15,000, the cost for all 80,000 chillers will be \$1.2 billion.

*There are safety concerns surrounding some of the replacement refrigerants.*

#### Total Costs:

Within the next two years, chiller owners will have to make the transition to a market where CFCs, if available, will be very expensive. The total cost of continuing the use of CFCs, retrofitting, or replacing chillers, as well as the cost of compliance with new safety standards will be \$4.4 to \$5.0 billion over the next decade.

#### **Commercial and Institutional Refrigeration**

There are at least five million (and probably closer to ten million) pieces of CFC-using commercial and institutional refrigeration and freezing equipment in the U.S.<sup>74</sup> They are used in the 24,000 supermarkets and 228,000 smaller food

stores,<sup>75</sup> 729,000 restaurants, bars, hotels, schools, and other places that serve food and drink,<sup>76</sup> and approximately 200,000 other businesses (pharmacies liquor stores, florists etc.) that require such equipment.<sup>77</sup> Complying with the law will be a complex and expensive task.

These applications require equipment that provides a large volume of storage space for refrigerated or frozen items. Like chillers, these systems are expected to last a long time and occasionally leak, requiring additional CFC supplies to stay operational. Therefore, over the next decade, most of them will be retrofit to run with alternative refrigerants.<sup>78</sup> As with chiller owners, the majority of affected establishments have not yet done anything, thus the total costs can only be estimated at this time. It is assumed that these costs will eventually be passed on to consumers.

#### Supermarkets and Food Stores:

Retail refrigeration equipment falls into two general categories, medium and low temperature. Medium temperature equipment includes meat, fish, dairy, delicatessen, and produce cases, and walk-in coolers for storage. Most medium temperature systems use CFC-12. Low temperature applications include multi-deck frozen food cases, closed door freezer cases, and open chest type freezers and walk-in freezers. Most of this equipment uses a mixture called R-502, which contains CFCs. Supermarkets typically have about 30 medium and low temperature systems, while convenience stores and other small food retailers have fewer than 10, and the systems tend to be smaller than their supermarket counterparts.

The cost of retrofitting a single system in a supermarket is approximately \$1,500.<sup>79</sup> Thus, a typical 30-system supermarket will cost approximately \$45,000 to retrofit. This amounts to \$1.1 billion nationwide. Smaller food stores will probably range from \$3,000 to \$5,000 each, or \$0.7 to \$1.1 billion nationwide.

#### Food Service:

The 729,000 restaurants and other places that serve food or drinks typically have 10 or fewer pieces of equipment. In addition to having the same types of equipment used in food stores, they will also have ice machines and small, self-contained equipment for storing and serving food and drinks.<sup>80</sup> Typical retrofit costs are estimated to be in the \$1,000 to \$3,000 range, for a total of \$0.7 to \$2.2 billion.

#### Other Commercial Uses:

At least 200,000 other businesses use refrigeration, usually fewer than five pieces of self-contained equipment. The retrofit cost to these businesses will probably average of \$250 to \$500 each, or \$0.5 to \$1.0 billion in total.

*A typical supermarket will cost approximately \$45,000 to retrofit.*

### Total Costs:

Well over one million establishments will have to make changes in their refrigeration equipment in order to cope with the lack CFCs. The total cost for these businesses and institutions will likely be \$3.0-\$5.4 billion.

### **HCFC Equipment**

In addition to CFCs, a related class of refrigerants called hydrochlorofluorocarbons (HCFCs) are also being phased out of production, but under a slower timetable. In the U.S., HCFC-22, the most commonly used HCFC, will be phased out beginning in 2010.<sup>41</sup> However, it is possible that the deadline will be accelerated.

HCFC-22 is used in 43 million central air-conditioners in America's homes, and in about 2 million air-conditioners in other buildings.<sup>42</sup> The refrigerant recovery rules also apply to HCFC-22 equipment. On average, central air-conditioners require the type of servicing necessitating recovery once every five years. Thus, in a given year, approximately 20 percent of the nation's central air systems will require refrigerant recovery. Assuming nine million of these procedures are performed on residential and other central air-conditioners annually at a typical charge of \$40 to \$60,<sup>43</sup> the total cost will be \$360 to \$540 million annually, or \$3.6 to \$5.4 billion over the next decade. Further, air-conditioners use about half of the 300 million pounds of HCFC-22 produced each year.<sup>44</sup> The price of HCFC-22 has doubled from about \$1 per pound to \$2.<sup>45</sup> Assuming the price remains at \$2 per pound, an additional \$150 million will be spent annually on HCFC-22 for air-conditioning, or \$1.5 billion over the next decade. Added to the refrigerant recovery costs, the increased costs associated with HCFCs will total \$5.1 to \$6.9 billion for the next ten years.

*Hydrochlorofluorocarbons (HCFCs) are also being phased out of production.*

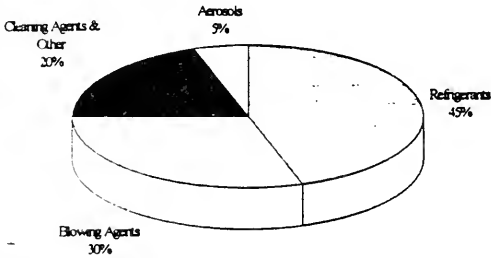
In addition to central air-conditioners, HCFCs are used in some chillers, commercial refrigeration units, and other equipment. Also, a number of CFC systems are being retrofit to use HCFCs. A future supply of HCFCs will be needed to maintain these systems. If the HCFC phaseout is accelerated, as some predict, the additional cost of compliance would be great.

### **Other Equipment and Uses**

In addition, other types of CFC-using air-conditioning and refrigeration equipment will also be affected, but are not separately discussed. Refrigerated transports (trucks, rail cars, ships, sea-land containers), refrigeration used in industrial processes, medical and laboratory equipment, dehumidifiers, water coolers and drinking fountains, and vending machines are not included. In aggregate, the cost of replacing or retrofitting these systems will be significant, but are left out of the total accounting for this paper.

Finally, it must also be remembered that CFCs are also used for other applications besides refrigeration and air-conditioning. CFCs have been used as cleaning agents, solvents, and as blowing agents for foam insulation. The accompanying chart displays the distribution of CFC uses in the United States

### DISTRIBUTION OF CFC USES PRIOR TO MONTREAL PROTOCOL



SOURCE: Alliance for a Responsible CFC Policy

prior to the signing of the Montreal Protocol. Note that before the phaseout, refrigeration accounted for less than half of total CFC use in the United States.

### CONCLUSION

The total costs of the CFC phaseout on refrigeration and air-conditioning will be an estimated \$44.5 to \$99.4 billion over the next decade (see table on page three).<sup>26</sup> These costs will ultimately be borne by consumers, and will average \$445 to \$994 per household. This includes direct cost increases of owning and maintaining a vehicle air-

conditioner, an air-conditioned residence, and a refrigerator, as well as indirect cost increases affecting such things as food and rents in commercial buildings. However, this estimate does not include a wide-range of other costs that will be felt by consumers, including decreased convenience and efficiency.

Moreover, the phaseout has forced the reallocation of corporate research and development monies. The demand to meet the phaseout's requirements in time has meant that other, potentially more lucrative, investments have been deferred. These foregone opportunities are difficult, if not impossible, to measure, but represent additional costs imposed by the phaseout.

The CFC phaseout will likely become the single most expensive environmental measure taken to date. During the policy debate, the costs were underemphasized to the point that they never became an important factor. The impact on consumers was scarcely considered. However, as consumers begin to pay for this policy they will recognize that environmental measures can be expensive undertakings. It may be too late to reverse course on the CFC phaseout, but it can serve as a lesson for the future.



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## ENDNOTES

<sup>1</sup> See M. J. Molina and F. S. Rowland, "Stratospheric sink for chlorofluoromethanes: chlorine atom-catalysed destruction of ozone," *Nature* 249 (1974): 810-812; Executive Summary of the Ozone Trends Panel, March 15, 1988, Synthesis of the Reports of the Ozone Scientific Assessment Panel, Environmental Effects Assessment Panel, Technology and Economic Assessment Panel, Prepared by the Assessment Chairs for the Parties to the Montreal Protocol, (November 1991).

<sup>2</sup> Ibid.

<sup>3</sup> For example, during the Senate debate on the acceleration of the phaseout date from 2000 to 1995, many Senators repeated claims of increases in skin cancer, cataracts, immune system suppression, as well as crop failures and destruction of the ocean food chain that are said to be occurring as a result of an increase in ground level ultraviolet radiation caused by ozone depletion. However, direct measurements of ultraviolet radiation show no such increase. In effect, the feared consequence of ozone depletion, a significant global increase in ultraviolet radiation, is not known to be occurring. Thus, the claims of human health and environmental consequences are purely speculative. At the same time, none of the Senators seriously discussed the costs of eliminating CFCs. See *Congressional Record*, (February 6, 1992), S1128 - S1138.

<sup>4</sup> See ICF Incorporated, *Regulatory Impact Analysis: Compliance With Section 604 of the Clean Air Act for the Phaseout of Ozone Depleting Chemicals*, (July 1, 1992), and addendum. (The costs of eliminating CFCs are calculated at \$9 billion through the year 2000, and the benefits, largely the millions of additional cases of skin cancer assumed to be averted by the phaseout, are calculated to exceed costs by as much as \$31 trillion).

<sup>5</sup> In addition to their role as refrigerants, CFCs, HCFCs and related compounds slated for phaseout have literally hundreds of uses in agriculture, manufacturing, medicine, insulation, and fire suppression. In a number of these applications, alternative compounds are either more expensive or less effective than the compounds they are replacing. A detailed discussion of these costs is beyond the scope of this study.

<sup>6</sup> With limited exceptions, the law restricts CFC production and consumption (production plus imports minus exports) regardless of the end use. Specific restrictions on each end use could have afforded the opportunity to tailor the law to quickly proscribe CFC use in applications where CFC replacements are effective and economical (such as solvents and cleaning agents), while allowing more time in applications where rapid CFC elimination poses a substantial hardship (as in several refrigeration and air-conditioning uses). However, an across the board phaseout was chosen, partly for political reasons. See Dan McInnis, "Ozone Layers and Oligopoly Profits," in Greve and Smith, eds., *Environmental Politics: Public Costs, Private Rewards*, (New York: Praeger, 1992), p. 145.

<sup>7</sup> Essential uses are narrowly defined to include uses that are necessary for health and safety reasons or are critical to the functioning of society. In addition, it must be shown that there are no available substitutes that are acceptable.

<sup>8</sup> NASA News, Scientists Say Arctic "Ozone Hole" Increasingly Likely (February 3, 1992).

<sup>9</sup> *Congressional Record*, (February 6, 1992), S1128-S1138.

<sup>10</sup> NASA News, NASA Spacecraft Finds Large Arctic Ozone Depletion Averted (April 30, 1992).

<sup>11</sup> 58 *Federal Register* 65018 - 65082.

<sup>12</sup> DuPont, the largest CFC producer, had voluntarily agreed to cease production one year earlier than required. However, the EPA, fearing shortages, persuaded them to continue production until the phaseout deadline.

<sup>13</sup> 58 *Federal Register* 65025 - 65028.

<sup>14</sup> Clean Air Act Amendments of 1990, Sections 608 and 609; 58 *Federal Register* 28660 - 28734.

<sup>15</sup> Congressional Research Service, "CFC Phaseout: Future Problem for Air Conditioning Equipment?" (April 1, 1993), p. 4.

<sup>16</sup> *Ibid.*

<sup>17</sup> Had the phaseout been slower, industry could have settled on the best replacement refrigerant for each application. Such standardization would have reduced the costs and complexities of moving away from CFCs. But with so little time to act, and the replacement technologies still in the early stages, a large number of competing refrigerants have been introduced into the market, many of which will become obsolete in the next few years, as the best refrigerants emerge from the pack. The same is true for the many oils, filter driers and other components now on the market.

<sup>18</sup> For example, choosing the correct filter drier for an air-conditioning or refrigeration system used to be an easy task. Now, with numerous combinations of refrigerants, oils, and additives, it is difficult to know which type of filter drier will perform satisfactorily. The incorrect choice can cause damage to a system by failing to properly remove enough moisture, or by filtering out oil additives.

<sup>19</sup> Clean Air Act Amendments of 1990, Sections 608 and 609; 58 *Federal Register* 28660 - 28734.

<sup>20</sup> See "The Alternative Solution," *Refrigeration Service Contracting*, (November 1993), pp. 20-26.

<sup>21</sup> Informal survey of three wholesalers in the Washington, D.C. area, March, 1994; Omnibus Budget Reconciliation Act of 1989, and subsequent revisions. (The tax is \$4.35 per pound in 1994, rising to \$5.35 in 1995.)

<sup>22</sup> "Refrigerant Shortfall Challenges Chiller Owners," *Air Conditioning, Heating and Refrigeration News* (March 22, 1993), pp. 2-3.

<sup>23</sup> Congressional Research Service, "CFC Phaseout: Future Problem for Air Conditioning Equipment?" (April 1, 1993), pp. 9-11.

<sup>24</sup> "Imported CFC-12 Bypasses Tax, Sells For Less, Say Producers," *Air-Conditioning, Heating and Refrigeration News* (May 16, 1994), pp. 1-2.

<sup>25</sup> For example, in automobile air-conditioners, some or all of the refrigerant has already leaked out before a vehicle is brought in for servicing, and little or none is left to be recovered. In cases of repairs of hermetic compressor motor burnouts, the refrigerant may be too contaminated to be reused. Also, if two or more recovered refrigerants are commingled, the entire mixture may be unusable.

<sup>26</sup> See "Recovery-Recycling Unit Sales Still Soft", *Air Conditioning, Heating and Refrigeration News* (July 19, 1993), pp. 20-22; "ACCA Members Cite Poor Quality, Lack of Good 'Used' Refrigerant", *Air Conditioning, Heating and Refrigeration News* (September 6, 1993); "Recovered Refrigerant: Where is it?" *Air Conditioning, Heating and Refrigeration News* (May 16, 1994), pp. 3-4.

<sup>27</sup> McInnis, p. 148.

<sup>28</sup> Informal survey of three wholesalers in the Washington, D.C. area, March 1994.

<sup>29</sup>Chemical Manufacturers Association, *Production, Sales, and Calculated Release of CFC-11 and CFC-12 Through 1988*; McInnis, p. 138; 1993 Statistical Panorama, *Air Conditioning, Heating and Refrigeration News*, (March 29, 1993), at 24.

<sup>30</sup>"CFCs: The Challenge of Doing Without", *Electric Power Research Institute Journal*, vol. 14, no. 6 (1989), p. 6

<sup>31</sup>James M. Calm, *Characteristic Efficiencies and Costs For Air-Conditioning Equipment With Selected Refrigerant Alternatives* (Virginia: Air-Conditioning and Refrigeration Institute, 1991).

<sup>32</sup>For example, air-cooled condensers on some retrofitted CFC-12 and R-502 condensing units are slightly undersized, and during periods of hot weather will lead to higher discharge pressures and greater energy use. Also, systems using non-CFC refrigerant blends require a fairly critical charge of refrigerant to maintain peak efficiency. Thus, even a small leak will significantly increase energy consumption, as compared to CFC systems where leakage had a smaller impact on efficiency. Further, refrigerant cross-contamination may reduce energy efficiency, particularly in commercial refrigeration systems.

<sup>33</sup>"CFCs: The Challenge of Doing Without," *Electric Power Research Institute Journal*, vol. 14, no. 6 (1989), p. 10.

<sup>34</sup>EPA, *Moving to Alternative Refrigerants*, November 1993; *Alternative Fluorocarbons Environmental Acceptability Study* and the U.S. Department of Energy, *Energy and Global Warming Impacts of CFC Alternative Technologies* (December 1991).

<sup>35</sup>*Ibid.*

<sup>36</sup>American Automobile Manufacturers Association of the United States, *Motor Vehicle Facts and Figures*, annual; Montreal Protocol, Report of the Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee, (December 1991), Figure 10.1; 1993 Statistical Panorama, *Air Conditioning, Heating and Refrigeration News* (March 29, 1993), p. 7.

<sup>37</sup>Ward Atkinson, Sun Test Engineering.

<sup>38</sup>Clean Air Act Amendments of 1990, Section 609

<sup>39</sup>*Ibid.*

<sup>40</sup>Atkinson

<sup>41</sup>1993 Mobile Air-Conditioning Society, *Field Service Data Book*.

<sup>42</sup>*Ibid.*

<sup>43</sup>Many vehicle air-conditioning systems develop slow leaks, which cause the gradual loss of refrigerant. Leakage frequently occurs through high and low side Schrader valves, by diffusion through aging and hardened hoses, and through the compressor shaft seal. These minor leaks rarely damage the system, provided the pressure in the system remains above atmospheric, and merely necessitate the addition of a pound or two of refrigerant. However, now that a CFC recharge costs more, and future supplies are uncertain, some people may choose to have the leak repaired, although such a job will probably cost \$250 or more. Many servicemen, for obvious reasons, are encouraging customers to repair leaks rather than top off a system. Others, as a matter of policy, refuse to top off

systems unless leaks are repaired. Some are telling customers that federal law requires leak repairs, which is not the case.

<sup>44</sup> Montreal Protocol, Report of the Refrigeration, Air-Conditioning and Heat Pumps Technical Options Committee, (December 1991), p. 173. (Some 1992 and 1993 CFC air-conditioners were designed to be easily retrofitted to HFC-134a, and the cost will be lower. For older cars, depending on the model and year, the retrofit costs range from \$250 to \$800.)

<sup>45</sup> HFC-134a and the polyalkylene glycol (PAG) oil used with it cannot operate properly in a system which previously used CFC-12 and mineral oil unless virtually all of the original refrigerant and lubricant is removed from the system. Mineral oil is not miscible with HFC-134a and any left behind will reduce heat transfer and interfere with fluid flow. Residual CFC-12 will combine with HFC-134a to form an azeotrope, generating higher internal pressures. It can be expected that some retrofits will fail because the system was not thoroughly flushed. Further, HFC-134a operates at a much higher discharge pressure, which will place a life-shortening strain on the system, particularly when stalled in traffic on hot days.

<sup>46</sup> The low end of this range assumes that future servicing costs will be only slightly higher than current costs, while the high end assumes significant cost increases, particularly after 1995.

<sup>47</sup> Putnam, Hayes & Bartlett, Inc., *Report for the U.S. Department of Energy, Assessment of the Impacts Associated with a Total CFC Phaseout* (July 10, 1989), p. 11.

<sup>48</sup> The higher discharge pressures of HFC-134a will likely cause an increase in compressor failures. See "Race Against Time", *Design News* (October 1, 1990), pp. 132-136. Further, the polyalkylene glycol (PAG) oil used as a lubricant is extremely hygroscopic (water attracting). See Tecumseh Products Company, *Guidelines For Utilization of R134a*. Thus, ambient moisture may be drawn into a system during servicing or after a collision or other major leak, which can lead to system failure. Also, HFC-134a, unlike CFC-12, does not form wear-reducing metal chlorides. See ARI Tech Update, *Lubrication is The Key Issue in CFC Phaseout* (August 1993). And, as with all new technologies that have not been thoroughly tested, there will likely be unforeseen problems that develop after a few years of actual use.

<sup>49</sup> Several automotive engineers with major auto makers privately admit that they expect an increase in the number of vehicle air-conditioners needing a major repair to stay in operation, particularly after about five years of use.

<sup>50</sup> Congressional Research Service, *CFC Phaseout: Future Problem for Air Conditioning Equipment?* (April 1, 1993), p. 5.

<sup>51</sup> The fact that HFC-134a is the most widely used replacement refrigerant, despite its many drawbacks, is a consequence of the acceleration of the phaseout date from the year 2000 to the end of 1995. Given the lead times needed by manufacturers, many industries had to make hasty decisions as to which replacement to use. A number of other refrigerants are more promising than HFC-134a but need a few more years of research and development before being ready for use. On the other hand, HFC-134a was one of the first replacements developed and mass produced and was chosen largely because it was the best refrigerant available on such short notice. And, once an industry commits to a particular refrigerant, it is very expensive to switch to another. As a result, HFC-134a will likely see widespread use for many years, even in applications for which it is not ideally suited.

<sup>52</sup> "A Greener Way to Keep Food Cool," *Washington Post*, Home Section (April 14, 1994), p. 5; "Refrigerators For A Wiser World", *Consumer Reports* (February 1994), pp. 80-86.

<sup>53</sup> "1994 Statistical Panorama," *Air Conditioning, Heating and Refrigeration News* (April 11, 1994), p. 32.

<sup>54</sup> Montreal Protocol, *Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee* (December 1991), p. 80. HFC-134a is primarily a medium temperature refrigerant, and is not well suited for American refrigerators with a large freezer section, which operate at a coil temperature of about -10°F. At this low temperature, HFC-134a may exhibit reduced capacity versus CFC-12. See Dupont, *Retrofit Guidelines for SUVA 134a in Stationary Equipment*. Some comparisons obfuscate the relative efficiencies by comparing an advanced design HFC-134a model with a basic CFC-12 model, or by using theoretical rather than actual efficiencies. See EPA, *Multiple Pathways to Super-Efficient Refrigerators*. Note that there may also be a slight decline in efficiency resulting from CFC-blown foam insulation used in refrigerator walls and doors being replaced by substitute foams.

<sup>55</sup> The polyol ester (POE) oil chosen to be used in HFC-134a refrigerators is 100 times more hygroscopic than the mineral oil used with CFC-12. If, for example, the system experiences a leak during moving or is left open for more than 15 minutes during servicing, enough moisture can enter to cause chemical reactions that may damage the compressor or block the capillary tubes, the latter requiring replacement of the entire hermetic system. In addition to moisture problems, HFC-134a and POE oils have a low tolerance for other contaminants, (such as residual chlorine in servicing equipment that was also used to repair a CFC system). As a result, HFC-134a refrigerators will suffer more frequent breakdowns, some of which cannot be repaired. See Whirlpool Corp., *HFC-134a Refrigerant Service Procedures*.

<sup>56</sup> The experience with CFC-12 refrigerators when they were new may be repeated with the new HFC-134a units. The first models worked well initially, but suffered unexpected problems after several years of use. For example, the oil originally chosen broke down, causing capillary tube blockage, and a new oil with additives had to be developed. Also, the insulation protecting the motor windings was weakened by unexpected reactions between the refrigerant, oil, and trace impurities, and had to be replaced with a new type of insulating material. These and other technical problems were totally unanticipated when the systems were initially designed and tested. They revealed themselves only after years of field experience. The same is likely to occur with the new HFC-134a systems.

<sup>57</sup> 1993 Survey, Air-Conditioning and Refrigeration Institute.

<sup>58</sup> "1993 Statistical Panorama," *Air Conditioning, Heating and Refrigeration News*, March 29, 1993, pp. 6-7.

<sup>59</sup> Alternative Fluorocarbons Environmental Acceptability Study and the U.S. Department of Energy, *Energy and Global Warming Impacts of CFC Alternative Technologies* (December, 1991) ch.6 and App. E.

<sup>60</sup> "Slow Conversion to Non-CFCs Worries Chiller Manufacturers," *Air Conditioning, Heating and Refrigeration News* (April 12, 1993), p. 3.

<sup>61</sup> Ibid

<sup>62</sup> Specifically, refrigerant containment first requires a thorough inspection of the system for leaks, and replacement of any gaskets or connections that show signs of deterioration. Then, a high efficiency purge unit is installed, which allows the system to be periodically purged of air without refrigerant also escaping. Isolation valves are installed at the oil sump to reduce refrigerant leakage during oil changes. Pressurizing devices, which reduce leakage when the chiller is not in use, and safety relief valves which prevent total loss of charge in an emergency may also be necessary. Older chillers may require eddy current testing of the condenser tubes in order to detect any weaknesses in them. CFC monitoring devices may be installed to aid in early leak detection. Since some leakage will still occur, an extra supply of refrigerant needs to be obtained, and placed in a tank or drum suitable for long term storage. Refrigerant recovery devices will also be necessary for use during servicing.

<sup>60</sup> CFC-11 chillers operate at sub-atmospheric pressures, thus not much refrigerant leaks out. On the other hand, CFC-12, CFC-22 and R-500 operate at pressures above atmospheric, and a line break, for example, could cause the entire refrigerant charge to escape.

<sup>61</sup> Informal survey of three chiller contractors, March 1994. (Actual cost is dependent on the size, age, and condition of the chiller and building.)

<sup>62</sup> A retrofit of a high-pressure chiller involves modifications of the gear drive and impeller (in order to reduce the loss in capacity), and careful system flushing of the old refrigerant and oil. Finally, a charge of HFC-134a and compatible ester-based lubricant is added. Low-pressure chiller retrofits to HCFC-123 require modifications of the motor and impeller, as well as replacement of motor windings, O-rings, gaskets, and seals. In both cases, refrigerant recovery equipment will have to be procured.

<sup>63</sup> Retrofit costs average \$50 - \$70 per ton, and chillers that are candidates for retrofit are in the 200 - 3000 ton range. The term ton refers to the amount of cooling required to freeze one ton of water in a day, or 12,000 Btu/hour, and is the common unit for measuring cooling capacity. See EPA, *Moving to Alternative Refrigerants, Ten Case Histories*, (November 1993); "One Company's Strategy," *Engineered Systems*, (September 1993).

<sup>64</sup> Chiller owners who continue to use CFCs run the risk of needing additional CFCs at some future date and not being able to obtain it. Also, retrofits to HCFC-123 and HFC-134, considering the initial cost, expected useful life, and operating costs, may not be as attractive as a total replacement in some cases. In addition to new systems using HCFC-123 or HFC-134a, HCFC-22 chillers using screw compressors are gaining market share because of their efficiency and versatility.

<sup>65</sup> An Air-Conditioning and Refrigeration Institute survey of chiller manufacturers estimates that 22,000 CFC chillers will have been replaced by non-CFC chillers by the year 1996.

<sup>66</sup> "One Company's Strategy," *Engineered Systems* (September 1993). (Estimated cost of chiller replacement is \$275 - \$375 per ton.)

<sup>67</sup> Strictly speaking, these new requirements are not a direct consequence of the CFC phaseout, and in fact are applicable to chillers that use CFCs. However, their promulgation occurred as a result of concerns over the toxicity of replacement refrigerants, particularly HCFC-123.

<sup>68</sup> See "Taking The Fear Factor Out of Refrigerants," *Engineered Systems* (January 1994), pp. 42-47. (Most local building codes have not yet made these revisions, but are expected to make them within the next two years.)

<sup>69</sup> Ibid.

<sup>70</sup> Informal survey of three chiller contractors, March, 1994.

<sup>71</sup> Statement of the Air-Conditioning and Refrigeration Institute on Depletion of the Stratospheric Ozone Layer, January 25, 1990. (This is a very rough estimate, and is likely too low, given the number of establishments using such equipment. Other estimates are lower, but exclude many categories of equipment.)

<sup>72</sup> *Statistical Abstract of the United States 1993*, "Retail Foodstores-Number and Sales, by Type: 1980 to 1991," p. 777.

<sup>73</sup> *Statistical Abstract of the United States*, "Commercial and Institutional Groups-Food and Drink Sales: 1980 to 1993," p. 779.

<sup>77</sup> *Statistical Abstract of the United States*, "Retail Trade Establishments-Number, Sales, Payroll, and Employees, by Kind of Business: 1987," p. 775.

<sup>78</sup> Some of this equipment, particularly the smaller systems, will practice containment and continue using CFCs for as long as supplies are available. Nonetheless, it is assumed that most existing systems will be retrofit within the next ten years.

<sup>79</sup> "Allied Signal's AZ-50 Alternate Refrigerant Well-Received By Texas Supermarket Chain", *Air Conditioning, Heating and Refrigeration News* (January 24, 1994), p. 76. A retrofit of a commercial refrigeration system involves removing the original CFC charge, replacing the filter drier, recharging the system with a new refrigerant and compatible oil (medium temperature refrigerant replacements include MP-33, MP-39, MP-66, and HFC-134a, while low temperature replacements include AZ-50, HP-62, HP-80, HP-81, HFC-125, and HCFC-22), and a check of the system for proper performance. A supermarket will require about 300 hours of labor, while a convenience store may require 30 hours or less.

<sup>80</sup> Thus far, very few self-contained systems have been retrofit. It is expected that their owners will continue to use CFCs until they are no longer available, and then retrofit or replace the equipment. Retrofit costs will probably be in the \$200-\$300 range.

<sup>81</sup> 58 *Federal Register* 60158. (Another HCFC, HCFC-123, is being used in many new and retrofit chillers, and is discussed in that section. Its production will be frozen in 2015 and eliminated in 2030.)

<sup>82</sup> U.S. Bureau of the Census, *Current Housing Reports*; Energy Information Administration, *Commercial Building Characteristics*: 1989, Table 86. (There are also about 50 million window air-conditioners, which are not significantly impacted by the phaseout. Large buildings are cooled by chillers, and are discussed separately.)

<sup>83</sup> Informal survey of 5 residential air-conditioning servicemen in the Washington, D.C. area, March 1994.

<sup>84</sup> "1994 Statistical Panorama," *Air-Conditioning, Heating and Refrigeration News* (April 11, 1994), pp. 25-26.

<sup>85</sup> Informal survey of three wholesalers in the Washington, D.C. area, March 1994. (The other half of HCFC-22 production is used chillers and commercial equipment and is discussed separately.)

<sup>86</sup> Had the phaseout not been accelerated from 2000 to 1995, the cost would have been about one quarter of this amount.



**STATEMENT OF PROFESSOR RICHARD L. STROUP, SENIOR ASSOCIATE, POLICY ECONOMY RESEARCH CENTER, BOZEMAN, MT**

Dr. STROUP. Thank you. I am an economist. My experience as director of the Office of Policy Analysis of the Department of the Interior for a few years in the early 1980s gives me some background here to make some observations.

My job there, the job of the office I directed, was to give managers, decision-makers—the secretary, the assistant secretaries—the other side of the story.

The Secretary and the Assistant Secretaries recognize that every agency, whether it's a pro-development agency like the Bureau of Mines or a preservationist agency like the U.S. Fish and Wildlife Service, or a scientific agency, like the U.S. Geological Survey, all agencies tend to cite facts, to cite data and to interpret data so as to enhance their budgets and so as to support the policy stands that they've already taken.

I believe that the question before Congress is the following—is the evidence on CFC impacts on the ground sufficient to force some serious risks and some large costs onto the American public?

To promote public health and to promote other environmental goals, we do want to avoid risks. And I believe that all policy choices available here, every one of them, involves risks.

But also, we want to promote the development of citizen wealth and incomes because wealthier is healthier.

I believe the accelerated ban harms this particular goal.

The key question then is: Will the known costs and the added risks that we force onto Americans by banning CFCs rapidly, will those problems be counter-balanced, offset by the benefits of reduced stratospheric ozone depletion?

Ben Lieberman has detailed some, or he details in his written testimony some of the dollar costs. I might add that, as an economist, it's pretty clearly obvious that you cannot lower the dollar cost to consumers by restricting their options.

You cannot make it better for the dollar costs of consumers by taking away options from them.

I want to show the basis for expecting risks, serious health risks, from the ban of CFCs, or the ban of any other widely-used chemical or material.

I'll use the bans on asbestos use and the de facto bans on asbestos resulting from some very pessimistic interpretation of asbestos health risks relative to the assumed gains from using substitutes.

And I want to cite a few sentences here from a case that was before the 5th Circuit Court of Appeals. I want to cite a few sentences from the three-judge panel's opinion.

The case is Corrosion-Proof Fittings v. EPA, 1991.

The three judges in their opinion said the following:

"We are concerned with the EPA's evaluation of substitutes, even in those instances in which the record shows that they are available. The EPA explicitly rejects considering the harm that may flow from the increased use of products designed to substitute for asbestos, even when the probable substitutes are known carcinogens."

And then they go.

"Many of the substitutes that EPA itself concedes will be used in place of asbestos have known carcinogenic effects."

And they go on.

"Eager to douse the dangers of asbestos, the agency inadvertently actually may increase the risk of injuries Americans face."

The court then references, "EPA's explicit failure to consider the toxicity of likely substitutes."

One final sentence from the court here.

"In short, a death is a death, whether occasioned by asbestos or by a toxic substitute product."

I want to move now to another result, not a toxic result, but another result of the overemphasis of one risk relative to others. And that is, as some in this room know, the extremely pessimistic interpretation of asbestos science by advocates also led to the horribly tragic results of the Challenger tragedy.

The maker of the asbestos-containing putty used to seal the O-rings of the Challenger stopped producing the putty because of the public asbestos scare and the fear of asbestos lawsuits, which were burgeoning at that time. They stopped producing the stuff.

So a new putty had to be used.

The new arrangement failed. The seven astronauts died a fiery death, traumatizing millions of us who saw the tragedy.

There are arguments about whether NASA should have seen the problem and acted differently. But no one to my knowledge argues that the old O-ring system with the original putty would have failed.

I don't know of anyone that makes that argument, that it would have failed anyway.

That O-ring system, that old O-ring system that was no longer available, like CFCs today, had a proven track record of safety and effectiveness.

I believe that Ben Lieberman is right, that the monetary costs of quickly phasing out CFCs are large. Many alternatives have to be tested to discover which is the best for every application.

When that has to be done quickly, it won't be done as thoroughly.

Like asbestos, CFCs can certainly be replaced. But not without sacrificing many benefits, such as safe, cheap refrigeration, which increases food safety and has other advantages as well.

As Dr. Robert Watson of NASA, who we heard from earlier this morning, has put it, and I quote here. He was quoted in 1988: "If we banned all CFCs tomorrow, probably more people would die from food poisoning than would die from ozone depletion."

Fortunately, we did not ban it tomorrow. There have been technological improvements since Dr. Watson said that. But a key trade-off remains—more costly equipment will be used more sparingly. Refrigerators will be smaller and fewer than they otherwise would have been had the CFCs and the technological change over time, too, been made available.

By contrast, refrigerators that are less costly and require less energy when they're used with equally advanced equipment using CFC substitutes, would allow more and larger refrigerators, providing safer foods, causing less food poisoning, and in fact, less cancer as well.

Time is an important element in advancing technology. Reducing the time available before the substitutes have to be found and perfected and made available to ordinary people is surely increasing the cost of the substitutes.

Mr. ROHRABACHER. Time is also important in the hearing, Mr. Stroup. [Laughter.]

Dr. STROUP. Okay.

Mr. ROHRABACHER. If you would like to give a 30-second summary, go right ahead.

Dr. STROUP. All right. How much do we risk by reversing the acceleration of the CFC ban in the U.S.?

I don't expect any agency or the head of any lab which is better financed when the public and the Congress strongly have a concern about this because that leads to better funding.

I don't expect any scientist in that position to say, it is not a problem.

I, and virtually every scientist, will say, it is a problem. It's only a question of how big a problem. I think the evidence is that, overall, our children will thank us if we reverse the acceleration of this phase-out.

[The complete prepared statement of Professor Stroup follows:]

Prepared Testimony of Richard L. Stroup  
 Before the Subcommittee on Energy and The Environment  
 of the House Committee on Science  
 September 22, 1995

Mr. Chairman and Committee members: I want to thank you for the opportunity to provide my views on the economics of policies regarding the accelerated U.S. phaseout of CFCs. I am an economist and have been applying economic analysis to environmental and natural resource questions since my participation in the 1960s, as an economics doctoral candidate, in the Air Resources Program at the University of Washington. My dissertation, on the economics of controlling sulfur dioxide emissions, was written under the sponsorship of that program. Since that time I have been researching, writing and teaching about environmental and natural resource issues as an economics professor at Montana State University and as a senior associate of the Political Economy Research Center. Under the Intergovernmental Personnel Act, I also served for two and a half years as Director, Office of Policy Analysis, at the U.S. Department of the Interior.

#### **Cost of the Accelerated Phaseout of CFCs**

A number of costs will be imposed by the accelerated phaseout of CFCs. Some of them have been estimated. The phaseout is intended to provide benefits, of course, in the form of decreased depletion of stratospheric ozone. The existence of some benefit, in the form of reduced destruction of stratospheric ozone seems clear, although the size and importance of that benefit is very much in question by scientists and others, due to the uncertainty of the impact of CFCs on the complicated chemistry of the ozone, and on the UVB reaching the earth's surface. Large costs due to the phaseout seem unavoidable, although here again there are serious questions about just how large they will be. Cost estimates of certain cost components are available. The most comprehensive cost estimates are, I believe, those of Mr. Ben Lieberman, who is with us today. However, these and other estimates must, of necessity, be based on assumptions about technological innovations that are still being tested, and in some cases innovations that are still being researched. These dollar figures cannot and do not claim to give the full picture. In my remarks, I would like to share with you some considerations that should be included in the analysis of how science is used in policies that phaseout the manufacture and use of CFCs.

Proper decisionmaking requires fully and impartially examining both the gains claimed for any policy option, and the sacrifices imposed by that policy. It is important to recognize that those sacrifices will be real. Even when they are expressed as expenditures of dollars, the dollar figures represent real sacrifices and real harms to people. Among these are health risks imposed by the accelerated phaseout of CFCs.

#### **Costs Are Not Just Monetary Costs**

The monetary costs of quickly phasing out CFCs are large. Many alternatives must be tested to discover which is best for each application. Currently, due to the accelerated phaseout, different refrigerants are being used to replace CFCs in various uses. To avoid mixing these substitutes, separate facilities must be built and maintained, and it is important

that refrigerants must not, for technical reasons, be accidentally mixed. Yet mistakes are made despite the expense of the separate facilities. If there were more time for detailed testing in laboratories, these compounds would be more extensively tested before being used in the field, so that fewer of them would be "field tested" to the extent that they are. As a result, fewer problems would probably occur. This and other problems increase the likelihood that mistakes will affect efficiency, cost and even the safety of those working with and near the refrigerants.

But there are other harms likely to be done as well. CFCs can be replaced, but we will sacrifice their many benefits, such as safe, cheap refrigeration, which increases food safety and has other advantages. The accelerated phaseout of CFCs is increasing cost and thus, for many people, reducing availability. Dr. Robert T. Watson, of NASA, has put it, "If we banned all CFCs tomorrow, probably more people would die from food poisoning than would die from depleting ozone."<sup>1</sup> Of course some technological improvements have been made since Dr. Watson said this, but the key tradeoff remains: more costly equipment will be used more sparingly.

By contrast refrigerators that are less costly and require less energy than those with equally advanced equipment using CFC substitutes, would allow more and larger refrigerators, providing safer foods and causing less food poisoning and less cancer.<sup>2</sup> While technological advances in refrigeration equipment are continuing, as they would if CFC use were not being phased out, we should not attribute most of the advances we see in refrigeration technology to the CFC ban. Many would occur without the ban. To allow CFC use for a longer period would almost surely make refrigeration cheaper than it will be with the accelerated phaseout. Time is an important element in advancing technology; reducing the time available before substitutes must be found and perfected is surely increasing the cost of those substitutes.

In contrast, allowing more time would reduce the costs of the changeover. Making more time available would also decrease the likelihood of costly mistakes, safety hazards and failures. The artificial speedup means that replacements and the equipment needed for them are less fully researched before decisions must be made; and they are less fully tested before they come into use. Our knowledge of their safety is unnecessarily limited under this policy.

### **The Presumed Benefits of Technology Forcing**

It is often claimed that benefits from policies such as the rapid phaseout of CFCs will bring important advantages by forcing industry into technological improvements. New technologies to reduce the problems of chemically less stable replacements for the forbidden CFCs will surely appear, and they may even provide spinoff benefits. But that is likely to be true of any R&D expenditures; and if R&D projects could be chosen to address a wider array of goals rather than being forced by law into mitigating the problems from replacing CFCs very rapidly (and thus in a more costly fashion), we should expect greater total benefits. Only if there were severe costs brought on by the failure to accelerate the replacement, and thus avoided by rapid replacement, would the shift of resources to the accelerated replacement be likely to provide superior returns to the forced investment.

### **Potential Environmental Problems from Accelerated Phaseout of CFCs**

New chemical products that will escape into the atmosphere, especially when they are adopted rapidly, pose a potential threat to the environment. Replacements for CFCs are no

exception. T. K. Tromp and his colleagues, writing recently in *Nature*, the prestigious British journal of science, pointed out the potential problem of three of the proposed replacement compounds, theorizing that the breakdown products from those substitutes might become concentrated in certain wetlands. The breakdown products, if concentrated, can harm certain sensitive species. The concentration problem is theoretical rather than actual and measured at this point, but then so is the problem of increased UVB reaching the surface of the earth due to CFCs. Neither danger may in fact be serious, but the costs of replacing CFCs are much more likely than the simply theoretical costs of not doing so. In addition, the danger from reversing the acceleration, and phasing out the use of CFCs over, say, 4 additional years, should be quite small.

### **Business Support for the Accelerated Phaseout of CFCs**

Despite the meager health benefits that may be gained by accelerating the CFC phaseout, and the apparent high cost of the phaseout, which may include some theoretical problems such as the concentration in nature of chemical breakdown products from replacements, the acceleration policy will receive some prominent support. That support will in part come from businesses that provide (or will try to provide) substitutes for CFCs. Such businesses can be expected to support the rapid phaseout of CFCs for the same reason that suppliers to the military support larger budgets to procure the products they make, and highway construction firms support larger highway construction budgets. Suppliers of CFC substitutes, like suppliers to the military and to the highway program, want to increase the demand for their products, and to increase it as soon as possible. They are investing in providing the new products, and they will gain more profits if demand for their products is stimulated more, and earlier, by the accelerated phaseout.

### **Mistaking Costs for Benefits**

Costs of programs such as the accelerated CFC phaseout are sometimes viewed, falsely, as benefits to society. The argument made is that demand for new equipment due to the policy will spur the economy, and that jobs are created by the need to scrap functioning refrigeration or air conditioning units, for example. But this is very much like viewing a terrible hurricane as a generator of benefits because it creates a huge demand for rebuilding what the hurricane has destroyed. Similarly, considering this production and these jobs as a benefit of the program requiring that economical, working equipment be replaced, is simply wrong. Any net benefits accruing to society from replacing CFCs more quickly will come from reducing the harmful effects of CFCs, not from the increased demand. Forcing users to replace economical, functioning equipment with new equipment to meet the law is, in itself, a cost to be borne, not a benefit.

### **Wealthier Is Healthier and More Environmentally Sound**

Here, as in all of environmental policy, it is important to recognize the importance of income and wealth, in providing our society with both the willingness and the ability to make sacrifices for a better environment. Poorer people are usually willing to settle for lower environmental quality, just as they must settle for lower quality food, housing and clothing. To reduce ozone depletion from CFCs on an accelerated basis will impose sacrifices of income

and wealth, as these are usually measured.

Richer nations--those having experienced significant economic growth--are environmentally cleaner and more healthful than are poor nations.<sup>3</sup> There are at least two reasons for this: First, to become richer, societies develop technological tools that use resources more efficiently and thus place less stress on the natural environment, per unit of output. Second, people who have met their most basic needs and do not need to worry about where the next meal will come from will demand a better environment and can afford it, just as they demand better food, shelter and medical care. Results from one study suggest that when community income rises by one percent, community demand for environmental quality rises by three times that amount. In other words, the demand for environmental quality rises with income at about the same rate as does the demand for BMWs!<sup>4</sup>

The correlation between income and environmental quality will not surprise anyone who knows that the members of environmental groups such as the Sierra Club have incomes that, on average, are double those of the average American.<sup>5</sup> Any policy that reduces a nation's income will reduce its willingness and ability to pay (in economists' lingo, its demand) for environmental quality. Policies that promote economic growth will lead to better environmental quality.

Reasonable estimates of costs for the accelerated phaseout of CFCs run into the tens of billions of dollars. The impact of this goes beyond the creature comforts and market goods that we normally consider, and even beyond environmental goods and services: wealth and efficiency are among the most important risk-reducing and health-enhancing factors in all societies. Such a policy is good on balance for the environment only if it brings substantial benefits to offset the resulting reduction in demand for other environmental programs.

It is important to recognize that economic growth does not favor only those whose personal incomes rise. That is, it isn't just individually affluent people who benefit from a society's wealth and economic efficiency. Any person, whether rich or poor, is much better off to be caught in a disaster such as a flood or an earthquake in a rich country than in a poor one. A rich nation can protect itself better against foreseen dangers and unforeseen developments as well.<sup>6</sup> To the extent that nations (and humans generally) have the advantages that come from societal wealth, they have by far the best hope to avert or survive crises from threats of almost any imaginable risk, from a large meteor on a collision course with Earth to a new and more virulent form of AIDS. Richer societies are more resilient. If "insurance" against a particular risk, such as some increase in the threat of increased UVB reaching the earth, is bought at the cost of reduced economic growth, then a decline in the automatic insurance represented by wealth, and the societal resilience it provides, is one of the costs borne by future generations. It is a cost that might be worth bearing, but surely not without careful consideration.

Inquiries like this hearing, into the application of science as applied to regulatory policy, are conducted for good reason. The pressures and incentives facing political and bureaucratic decisionmakers help to explain regulatory inefficiency. Efficiency, after all, has no political constituency. Each important political group naturally seeks advantage for itself and for its point of view from the political system. The political system cannot operate efficiently when doing so gets in the way of powerful interest groups or populist passions. Unfortunately, an agency estimating the costs and benefits of its proposed regulations tend to

bias the results to support the policy of the agency. That is, any agency has what Justice Stephen Breyer calls "tunnel vision." It readily sees the benefits of what it has set out to do, but seldom sees the full costs of that chosen course of actions when others can be made to bear those costs.

The accelerated phaseout of CFCs is, in my view, a very costly policy. The tendency to ignore or understate costs causes inappropriate optimism about the ease of replacing CFCs on an accelerated basis. I am confident that our children will, in all likelihood, thank us if this policy is reversed.

## ENDNOTES

1. Watson was quoted by Alston Chase, in Chase's column in *Outside* magazine March, 1988.
2. In addition to reduced food poisoning, for example, cancer of the stomach was reduced by the availability of home refrigeration, according to Howson, et al., in "The Decline in Gastric Cancer: Epidemiology of an Unplanned Triumph," in *Epidemiologic Reviews*, Vol. 8, (1986), p. 2.
3. See World Bank economist Marian Radetzke's, "Economic Growth and Environment," presented at a World Bank Symposium November 21-22, 1991, for a review of the evidence and reasons why the relationship between economic growth and environmental quality tends to be positive.
4. These results were reported by Donald Coursey, economist at the University of Chicago, in "The Demand for Environmental Quality," a paper presented January 1993 at the annual meeting of the American Economic Association in Anaheim, CA and in private conversations since that time.
5. A 1986 survey of readers of the Sierra Club magazine indicated that the median household income was \$46,100, compared with median household income in the U.S. of \$23,618. A full 83% had graduated from college, while among Americans as a whole, 19.4% had completed four or more years of college in 1985. (Sierra Club magazine data provided by the Sierra Club, 530 Bush St., San Francisco, CA 94108.)
6. Perhaps the best comprehensive treatment of this general topic was presented by the late Aaron Wildavsky in *Searching for Safety* (New Brunswick: Transaction Press, 1988), especially in Ch. 3.



Mr. ROHRABACHER. Thank you, Mr. Stroup.

I know it's very difficult for an economist.

Dr. STROUP. And a professor, too.

Mr. ROHRABACHER. And a professor, too. But I will refrain from a joke about laying economists head to head, and I'll just refrain.

Dr. STROUP. Thank you, sir. [Laughter.]

Mr. ROHRABACHER. Dr. Pollet.

**STATEMENT OF DR. DALE K. POLLET, PROJECT LEADER, ENTOMOLOGY, LOUISIANA COOPERATIVE EXTENSION SERVICE, BATON ROUGE, LA**

Dr. POLLET. Mr. Chairman, Members of the Subcommittee, my name is Dale Pollet and I am entomology project leader for the Louisiana Cooperative Extension Service.

My full credentials are part of the written record submitted to the Committee.

You have asked that I address the economic impacts of the phase-out of methyl bromide. Attached to my written statement are various references, well-accepted economic analyses. They consistently show the loss of methyl bromide will severely impact American farming and food production.

American farmers depend on methyl bromide to grow, store, transport, and process more than 100 vegetables, fruits, grains and fiber.

Mr. Chairman, in your State of California, the phase-out will severely harm the production of grapes, strawberries, carrots, walnuts, pecans, cherries and other berries, rice, citrus, tomatoes, peppers, plums and melons.

If the ban takes effect, California's fast-growing agricultural export business will come to a stop since Japan and other major markets require that imported produce must be fumigated with methyl bromide.

The ports of Los Angeles, San Diego and Oakland will lose substantial revenues. Methyl bromide is also used in the ports of New Orleans and Baton Rouge to fumigate cut flowers, grains, vegetables, propagative plant material, lumber, and lumber products.

Oakland's American Presidents Line reports that it alone would lose \$50 million in revenues annually. Introduction of a new destructive pest into California would cost farmers in that state \$1.2 billion and would affect 14,000 jobs.

Methyl bromide currently prevents that from happening.

Louisiana would not do much better. Our rice mills depend on methyl bromide to meet Food and Drug Administration cleanliness standards. Louisiana strawberry growers—a \$10.7 million industry—will suffer immeasurably, as will the tree nurseries and our reforestation efforts.

Members of the Subcommittee, the phase-out of methyl bromide will hurt agriculture in the northwest and the southeast, the grain-producing states—California, Florida, Michigan, New York and Texas.

Narrowly stated, in terms of jobs and income, the economic impact of the U.S. phase-out will be significant.

For example, the U.S. Department of Agriculture studied just 21 crops in five states and projected \$1.5 billion in direct economic

losses. But dollars do not begin to describe the impact of America's pending loss of methyl bromide.

The loss of methyl bromide will contribute to the slow but clear loss of American food production independence. For more than a decade, American growers have been moving their operations to Chile, Mexico and other nations which respect and encourage farming. Many American farmers simply will not be able to compete in the U.S. market or any other without methyl bromide—and not one other agricultural exporting nation plans to ban methyl bromide.

Our problem is no one here has ever been hungry and we take agriculture for granted.

Food is as close as the nearest store.

Mr. ROHRABACHER. Dr. Pollet, do you have any overall estimate as to the cost to agriculture if this was banned?

Dr. POLLET. To the family?

Mr. ROHRABACHER. No, no. Just the cost, overall, in the billions of dollars.

Dr. POLLET. Well, just using the information that we had, the cost from just those five states on those 21 commodities was a billion and a half dollars.

Mr. ROHRABACHER. Billion and a half dollars.

Dr. POLLET. To supplement that, you'd probably have to multiply that number several times over to get anywhere close to what it would be.

Mr. ROHRABACHER. Okay. Well, that's substantial. Proceed.

Dr. POLLET. The loss of methyl bromide will affect American nutrition at a time when our own government urges us to eat five fresh fruits and vegetables daily as a means of preventing cancer and heart and circulatory disease.

Most farmers are lucky to make a profit a few times a decade. The loss of methyl bromide does not simply mean lower yields. It means fewer farmers with lower yields, higher prices, reduced quality, and a decreasing likelihood that Americans will eat right.

The loss of methyl bromide will affect America's ability to fight world hunger. The government of India—at a recent meeting of the nations participating in the Montreal Protocol—said that the loss of methyl bromide will seriously affect food storage.

The government of Kenya warns of food riots if methyl bromide is banned.

Ironically, Mr. Chairman, the loss of methyl bromide will have some negative impacts on the environment. I already have mentioned that reforestation may be harmed by this phase-out. But potentially more damaging would be agriculture's return to several liquid and solid chemical pesticides which could upset existing IPM programs which have reduced pesticide usage.

Removal of methyl bromide would therefore be in opposition to the President's program to reduce pesticide usage and would increase pressure on environmental and water quality controls and worker safety.

I say potentially more damaging because EPA already has banned or severely limited the use of all of these chemicals and will not guarantee that any will be available after the January 1, 2001, phase-out of methyl bromide.

Farmers simply do not have true alternatives to methyl bromide at present and if something new is developed now, it would require ten-plus years and \$50 to \$100 million to get it through the required process before it would be available to the agricultural community if it passes all the tests.

There is no such alternative on the horizon.

Therefore, let us assume that there are no uncertainties about methyl bromide's impact on the ozone layer. Will the most optimistic environmental benefits be greater than the damage we will cause with this phase-out?

Then let us assume, as so many others have concluded, that we don't know if a phase-out of methyl bromide will have any impact on the ozone layer. Are we recklessly destroying American agriculture with this phase-out?

I end my statement with that question, but would be pleased to answer the Subcommittee's questions.

[The complete prepared statement of Dr. Pollet follows:]



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THE LOUISIANA COOPERATIVE EXTENSION SERVICE PROVIDES EQUAL OPPORTUNITIES IN PROGRAMS AND EMPLOYMENT. LOUISIANA STATE UNIVERSITY AND  
A & M COLLEGE LOUISIANA PARISH GOVERNING BODIES SOUTHERN UNIVERSITY, AND UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING



A State Partner in the Cooperative Extension System

Hearing before the Subcommittee on Energy and Environment  
Committee on Science  
United States House of Representatives  
Wednesday, September 20, 1995

Statement of Dale Pollet, Ph.D.  
Project Leader, Entomology  
Louisiana Cooperative Extension Service

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- Ironically, Mr. Chairman, the loss of methyl bromide will have some negative impacts on the environment. I already have mentioned that reforestation will be harmed by this phaseout. But, potentially more damaging would be agriculture's return to several liquid and solid chemical pesticides which could upset existing IPM programs which have reduced pesticide usage. Removal of methyl bromide would therefore be in opposition to the president's program to reduced pesticide usage and would increase pressure on environmental and water quality controls and worker safety.

I say "potentially" more damaging, because EPA already has banned or severely limited the use of all of these chemicals, and will not guarantee that any will be available after the January 1, 2001 phaseout of methyl bromide. Farmers simply do not have true alternatives to methyl bromide at present and if something is developed now, it would require 10 plus years and \$50 to \$100 million to get through the required process before it would be available to the agricultural community if it passes all tests. There is no such alternative on the horizon.

Therefore, let us assume that there are no uncertainties about methyl bromide's impact on the ozone layer. Will the most optimistic environmental benefits be greater than the damage we will cause with this phaseout?

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  3. Jerry Bartlett - Degesch, Reserve, LA
  4. Doug Curtis - Hendrix and Dail, Greenville, NC
  5. John Pyzner - LA Cooperative Extension Service, Calhoun, LA
  6. James Boudreaux - LA Cooperative Extension Service, Baton Rouge, LA
  7. Tad Hardy - LA Department of Agriculture & Forestry, Baton Rouge, LA
  9. Dalton Monceau - The Industrial Fumigant Company, Jennings LA
  10. Lynn Mayes - The Industrial Fumigant Company, Olathe, KS
  11. Allen Fugler - LA Pest Control Association, Baton Rouge, LA



Mr. ROHRABACHER. Thank you very much. Interestingly enough, my district has very few farmers. But one was visiting my office just the other day, a young man who runs a strawberry farm.

He brought his issue up, independent, not knowing that I was involved in this hearing whatsoever, and just told me how devastating this was going to be to his personal and his family income and to his business in general.

We have a vote on, as you can tell. I think what we will do is I will call a recess and I will come back, and when we come back, that will be the last recess we take and we will go into some questions and get this hearing done with.

And let me just say, I think that this has been a fantastic panel. I think already you've really raised some important questions and I want to see some discussion between you and hopefully, I'll go vote and we can come back and have that discussion.

So I thank each and every one of you. I'm sorry for making you wait another 10 minutes.

We are recessed for 10 minutes.

[Recess.]

Mr. ROHRABACHER. The Subcommittee will reconvene.

First of all, let me say for everyone to hear, I remember, and I'm not going to go through some of the things that I've remembered in other hearings and everybody is sick and tired of hearing these memories that I've got of horror stories that didn't turn out to be true, whether we're talking about the ozone hole or these other things.

I do remember one, however, when I was in my younger years, when they banned cyclamates.

Do you all remember cyclamates?

Now I will hope that the panel will correct me if I am wrong, if my memory has some sort of ozone holes in it. [Laughter.]

But that about a year or two ago, they decided that they were wrong about cyclamates and that cyclamates actually weren't the health threat.

And what had happened was the American industry put hundreds of millions of dollars into developing this, basically a means of having a diet drink and helping people's health, by the fact that they could drink a cola and have less calories and thus, build up less fat or whatever, from drinking cola.

And then, all of a sudden, the FDA decided—and there was some evidence that would indicate that there was going to be a health threat. Cyclamates were banned, but cyclamates were never banned in Canada.

And so, when they came back, what we saw out of this was not something that made us any better, but instead, we saw about a billion dollars' worth of wealth evaporate from our society. And our economist friend there understands that when you do things like that, that actually means that people are not as well off.

People's lives, people don't eat as well because of things like this. They don't live at a higher standard of living. There's an anxiety level among poor people who might be a notch or two higher in the economic order if we didn't waste that kind of money.

And when you waste money like this in a society, there are health implications to wasting the money in the first place.

And what we are looking at now, and one of the things that we want to focus in on with this panel, is whether or not the benefits in terms of, number one, we've talked about the risks in the first panel, but what are the costs and the benefits of what has been, of the solution that we've heard in terms of banning CFCs?

Let me first say that I—and I repeat this for the third time in the hearing—I am not impressed with lists of people, these are all the guys that agree with me, and look how little the list is for the people who disagree with me, and thus, my arguments hold more water.

That doesn't go with me at all because I have, in my life, been a single voice on several issues and after a few years, finding that everybody agreed with me after a few years, when in the beginning, nobody agreed with me.

What counts are the arguments on your side, do they withstand scrutiny and do they withstand the challenge of someone else's position?

I'd like to ask Ambassador Nichols, basically today—Administrator, not Ambassador. Excuse me.

Ms. NICHOLS. I appreciate the promotion.

Mr. ROHRABACHER. That's all right. [Laughter.]

You had stated in your testimony on August 1st, before the Commerce Committee, that your cost/benefit analysis was 1000 to 1 ratio and today you seem to testify that it was 700 to 1 cost/benefit ratio.

And some of my staff who read your former testimony as well as your current testimony sort of picked that up. We were kind of wondering what happened in between there?

Ms. NICHOLS. I went back, actually, and asked the staff—I think I may have mentioned this in my earlier summary of the testimony—to give a more conservative estimate based on not including the information about the melanoma cancers versus the nonmelanoma cancers because, as you heard from the medical witnesses earlier, although there's a pretty strong correlation between the radiation and the melanoma cancers, there's a question mark about exactly what level of exposure causes what amount of cancer risk.

And so, I simply decided to exclude that data and come up with a lower number.

Mr. ROHRABACHER. That's a very good answer.

Now we've talked a little bit in the hearing about the growing black market production of CFCs, especially in China and India, and possibly Russia. But also, I might add, I come from California and people are talking about that now in terms of being a major Mexican export to the United States, just like some other products that are illegal.

So what is the actual benefit? If we end up with a black market in these things, what's the actual benefit? Isn't the damage that's being done to our economy and the fact that we're paying so much more, the fact that it's going into a black market rather than a market where people are paying taxes and it's being done above the board?

What is the offset on this?

Ms. NICHOLS. Let me just make one comment. I think Mr. Fay would also like to say something, if that's all right.

Mr. ROHRABACHER. That's fine.

Ms. NICHOLS. I just wanted to say that I had an opportunity to actually visit China for the Administration as part of the signing of a research agreement.

And while I was there, I visited the ministry in China that has control over their CFC production and actually was shown the CFC factory that they used to have that has now been shut down in compliance with the Montreal Protocol.

It's true that the rest of the world is lagging behind the U.S. in the phase-down. The developing countries were given an extra ten years before they had to completely get out of the business of production.

But if you look at the growing market in China for refrigerators, which is the appliance that everybody buys—the minute they get a TV set and get a little extra money, they get a home refrigerator so that they don't have to go to the market every day.

The refrigerators that they are now buying because of the Montreal Protocol are CFC-free refrigerators and they're more energy-efficient.

So that, in the long run, this is helping the global situation.

Mr. ROHRABACHER. Does anyone on the panel have anything that is contrary to that one thing about China?

Mr. LIEBERMAN. I do know that there was one Chinese official who was threatening to build 100 more CFC facilities recently unless they get more money.

Mr. FAY. Let me add to that.

There's been a lot of misinformation about the developing countries.

China just announced last week that they are accelerating their phase-out. They're not legally required to phase out. They're allowed to grow under the treaty. That's designed because of their tremendous needs for the population.

But they have announced their goal just last week of accelerating the phase-out to the year 2005.

Russia is not in compliance with the protocol. I can tell you that very frankly. Russia has announced they are closing down all of their factories, with the exception of one, which will continue to manufacture, and we think that the Russian production is the largest source of black market material in the United States right now.

Mr. ROHRABACHER. But they've announced they're closing.

Right?

Mr. FAY. They have announced they're closing.

Mr. ROHRABACHER. Announcements in tours are very impressive.

Mr. FAY. Well, it's very difficult to get anybody's attention in Russia on anything right now. And closing CFC plants, surprisingly, is pretty high on their priority list, but it's not right up there.

Mr. ROHRABACHER. Mr. Fay, do you believe that the black market problem in CFCs is going to decrease, then?

Mr. FAY. As soon as the Congress eliminates the excise tax, yes, sir, I do, because that is what's creating the black market, is the \$5.35 tax on the compounds.

It's equivalent of a \$10-per-gallon gasoline.

Mr. ROHRABACHER. Well, let's move to the Administration. Will you be supporting this?

Ms. NICHOLS. I don't think I'm authorized to have a position on that issue.

Mr. ROHRABACHER. Is the Administration considering supporting the elimination of CFC taxes?

Ms. NICHOLS. I'm not aware of any such request that's been forthcoming that I've seen.

I would note, however, for the record, that the proceeds of that tax do not come to the EPA budget.

Mr. FAY. Mr. Chairman, I would, note as you well recognize, the tax bills originate in the House. This tax proposal originated with the Reagan Administration.

Whatever we want to do with it, we'll be happy to work with you and anyone else who would consider restructuring the tax, either so that it is to be used for the issue from which you're taking the money, or at least capping it so that it doesn't continue to grow.

Mr. ROHRABACHER. Did the Reagan Administration really originate this, or was this something originated in Congress that just happened to be signed during then?

Mr. FAY. No. The Reagan Administration originated this.

Mr. ROHRABACHER. Is that right? I thought we were against taxes.

Mr. FAY. It was. They were. The theory here was it was a windfall profits tax, since we were going to be reducing supply, that, somehow or other, that the private sector would gain windfall profits.

Therefore, we had to protect them from themselves.

Mr. ROHRABACHER. That shows you the danger of those windfall profits tax ideas. [Laughter.]

Professor, did you have something to add to this?

Dr. STROUP. Yes. The question, I guess, if the CFCs are being smuggled in only because of the tax, my question is to EPA or Mr. Fay, why are the other countries growing larger in their production of CFCs, given that EPA at least claims that the new refrigerator technologies and the things actually being produced are cheaper than CFCs?

So the consumers are benefited by this, not harmed by this. If that's true, why aren't American companies underselling the CFC machines and the CFCs abroad?

Mr. FAY. The fact is that the developing country plans, frankly, have them growing in both technologies right now. We just assume they only grow in the new technology.

But if they have the production capacity in existing plants, they have been looking to expand that capacity by debottlenecking plants.

Mr. ROHRABACHER. Okay. Let me note that I am known in China as a China-basher.

It's not really accurate. If the Chinese do things, if the Chinese regime does things, if it as a regime has the policies that are pro-democratic and are amicable to the rest of the world, that's fine. I would applaud them.

But, usually, this monstrous regime does many things that are just opposite to that and sometimes they actually take people around to gulag camps that are nothing more than playgrounds until the person leaves.

And I'm not sure whether or not—I mean, I know that they've been stealing from California. Not only do they steal our CDs and our records and the creations of our artistic community, but to rub it in, the army has built these factories and they actually reproduce this and all the profit from reproducing it and selling it overseas in competition with our own people goes to help strengthen the Red Chinese army.

Now they've made an announcement that that practice is stopping, too. I'm anxious to see that stop and I hope that they are telling the truth.

I wouldn't bet my refrigerator on it.

Mr. FAY. Our attitude on that is, just as arms control with the Russians and the Chinese, trust but verify.

Mr. ROHRBACHER. Right. Right. One issue that we'd like to discuss, and Ms. Rivers, you have some time now as well to ask as many questions as she'd like. Or Mr. Ehlers.

What about the issue that the alternative is really just as potentially damaging as what you're getting rid of?

What about this issue that, like with asbestos, where they said, oh, you've got to get rid of all the asbestos. And later on, we found out, by trying to get rid of it, we actually put more people at risk.

What about all of these substitutes actually being worse than the original problem in terms of the risks to people's health?

Ms. NICHOLS. Mr. Chairman, I think Congress learned some lessons from the cyclamate issue, perhaps, or others, in terms of alternatives and wrote in a provision in the Clean Air Act that required testing of alternatives to CFCs to make sure that they, number one, were better from the ozone-depleting point of view, and two, didn't create other unintended consequences for health or the environment.

Mr. ROHRBACHER. Well, what about this one that creates acid rain? And the other one that creates a cancer problem for the wetlands.

Ms. NICHOLS. To the best of my knowledge, the acid rain issue is a phony issue. It was alleged at one time that there would be more energy used because the substitutes wouldn't be as efficient as the CFCs, and therefore, you'd have more power plants churning out more sulphur oxides and causing acid rain.

Mr. ROHRBACHER. All right.

Ms. NICHOLS. Not true.

Mr. ROHRBACHER. That's not true.

Ms. NICHOLS. As it has happened—

Mr. ROHRBACHER. There was just a scientist—I think it was Mr. Singer, in fact, testified pretty early—

Ms. NICHOLS. Well, the facts have simply turned out to the contrary, that the substitutes have been part of the redesign of equipment to make it more efficient. And we're seeing actual savings in energy used by these refrigerants.

So we were right, for once.

Mr. ROHRABACHER. Unfortunately, I didn't bring that up to the panel of scientists earlier because I do remember the point specifically that CFCs are a rather efficient way.

But now what you're saying is actually the new alternatives are more efficient.

Ms. NICHOLS. The alternatives, per se, aren't what's causing the improvement in efficiency. It's that in designing the products in order to use the new refrigerants, the manufacturers have also re-designed other aspects of the equipment.

So that the total product, which is what you buy, is more energy-efficient.

Mr. ROHRABACHER. Mr. Lieberman is about ready to jump out of his chair. So please move forward.

Mr. LIEBERMAN. This energy-efficiency argument is extremely misleading.

Actually, CFCs are, in almost every application, more efficient, not less efficient, than comparable non-CFC systems.

It is true if you replace a 25-year-old dinosaur of a CFC system with a brand new, state-of-the-art, non-CFC system, you'll see an improvement in energy efficiency.

That improvement has nothing to do with the refrigerant being used. It has to do with technological improvements independent of the refrigerant used.

And as a matter of fact, if CFCs could still be used in state-of-the-art equipment, we would see a gain in efficiency.

So EPA actually has energy-efficiency on the wrong side of the ledger. Compared to a no-phase-out scenario, none of us are talking about that, but compared to a no-phase-out scenario, we would see equipment far more efficient than anything available today.

Mr. FAY. I'm going to flat out disagree with Mr. Lieberman.

Mr. ROHRABACHER. All right.

Mr. FAY. You've got two lawyers up here talking about stuff that we ought to have engineers discussing, Mr. Chairman.

But, frankly—

Mr. ROHRABACHER. That's all right. We've got lawyers making lawyers making laws here, too. [Laughter.]

Mr. FAY. There seems to be a suggestion that the industry gleefully spent \$6 billion retooling and investing to convert out of these compounds so they could do it again because they know they're not quite as good.

Well, that's just not true.

The industry—these compounds that we've converted to have been around a long time. These compounds, we have spent nearly \$100 million. They are the most thoroughly studied chemicals in the history of chemical development.

There are thousands of chemicals out there that we use on a daily basis that we have no clue what their impacts may be on health, environment, whatever.

The user industry, the producer industry studied these from a toxicity standpoint, from an environmental standpoint in terms of breakdown products, from an energy-efficiency standpoint.

And for these people to sit here and somehow make light of the investment that these industries made in good faith, and these

products, is absolutely ridiculous. And to make them and be wrong is even worse.

Mr. ROHRBACHER. Well—

Mr. FAY. Now wait a minute. You talked earlier, in the earlier panel about policy-making by press release. And it's the same kind of—excuse my language—the same kind of crap we get from either the environmental side—excuse me—the environmental side or these advocacy groups who want to come in and use us as their fodder.

It's got to stop. That's what the American people are sick of.

The industry came in and said we can solve this problem. Here's how we think we'll do it, we can do it. Here's how long we think it will take.

And now they want it to stop.

Mr. ROHRBACHER. Mr. Fay, we should hesitate to use that language.

Mr. FAY. I'm sorry.

Mr. ROHRBACHER. Okay. Thank you.

Mr. FAY. I apologized in advance.

Mr. ROHRBACHER. I slip at times myself, but I try not to.

Let me shift the argument, then, away from refrigeration to what Mr. Pollet was talking about in terms of the effect that this will have on agriculture, because this is totally different than what we're talking about in CFCs in refrigeration.

Mr. Pollet has made some arguments that ethyl—methyl bromide—earlier on, I was talking about carbohydrates in the air. I don't want to make a mistake again.

But Mr. Pollet was talking about the billions of dollars that this will cost and we're talking about not only direct cost of billions of dollars, but also a loss of competitiveness for American agriculture overseas, which this is a major impact on our economy, a major impact on the well-being of many families which this is the way they earn their living.

Could you folks address that?

Mr. FAY. Let me just say, look, I heard every argument this morning in the earlier panel by Mr. Doolittle, Mr. DeLay that we made in 1983, okay?

We used to say the same thing. It was only a 60-mile move south, that you couldn't replace the chemicals.

We found out we could. Does methyl bromide have some serious problems in terms of being able to limit their use?

Absolutely.

Do we have a problem because when Congress adopted the Clean Air Act, they didn't put a provision in there for essential use exemptions, which we said you had to do, which they didn't do on the existing equipment base for refrigerants, which we said you had to do?

Absolutely.

So we're sitting here saying that the issue is fake, that we've got all these scientists debating whether it's a real issue or not a real issue.

Industry and farmers and consumers, they don't have time for that. We've got to make a policy decision. We're going to move on and correct the problems with the law, not that debate.

Mr. ROHRABACHER. The policy suggestion that you're making then is that we make an exception for agriculture on this?

Is that what you're saying?

Mr. FAY. If in fact there is a need for an essential-use exemption for agriculture, yes. But does that mean that they can't do anything? No, it doesn't. We've seen that time and again.

But do they need an essential-use exemption for the existing equipment base of automobiles? None of that existed. We managed to get that in 1992 in the treaty by which we're operating. That did not exist and we managed to get that in there because we finally got somebody to pay attention.

Mr. ROHRABACHER. Administrator Nichols, is there any support within the Administration about this type of exemption?

Ms. NICHOLS. Yes, Mr. Chairman. I have met personally with representatives of grower organizations here in town, along with the Deputy Secretary of Agriculture, Rominger. Both of us are Californians and maybe that has something to do with it.

But we've also had support from the White House for working on some specific language that would create the ability to give an essential-use exemption for agricultural uses that cannot be substituted.

Mr. ROHRABACHER. Let me recommend that the Administration move forward very quickly on this so that the agricultural interests and the people who we're talking about here will understand, be able to take a look at what their alternative is and the alternative that you're offering.

Ms. NICHOLS. I think the basic principle, as has been suggested in other areas, should be that they would be granted in enough time in advance so that the users would know what was available to them, but that there would be a careful set of criteria to make sure that we continue to maintain the incentive for research on alternatives.

Mr. ROHRABACHER. Mr. Pollet, would you like to comment on that?

Dr. POLLET. Yes. There really are no other materials. You talk about Telon-2. Telon has been banned in California and it's strictly for pneumatocides. Whereas, methyl bromide will take out insects, diseases, and I'm talking about bacteria and viruses as well, nematodes, also weed seeds.

And there's no other material on the market, either now or conceivably in the future, that will work that effectively.

If you take that material off the market—

Mr. ROHRABACHER. We're talking about an exemption now that would permit you to use it.

Is that what you're advocating, Mr. Fay?

Ms. NICHOLS. Excuse me. To be careful about that, it depends on the use.

There is no single compound that does everything that methyl bromide does. There's no question about that. Methyl bromide is an extremely effective biocide. It kills everything in its path.

For certain purposes, there are substitutes.

Mr. ROHRABACHER. But, Mr. Fay, were you advocating that there be an exemption for this?



Mr. FAY. I'm not advocating a blanket exemption for agricultural uses, no. I'm saying if there's a need for an exemption in these areas, then that's something that the Congress should look at.

If there's a need for an exemption in other areas, that's something that the Congress should look at. The Congress should leave itself some outs in case, just as you say, if the data changes or information proves to be wrong.

Mr. ROHRABACHER. But you're not willing to advocate that now.

Mr. FAY. An agricultural exemption, just a flat-out blanket exemption?

Mr. ROHRABACHER. For the methyl bromide here.

Mr. FAY. No. No. It's not my issue. We have not worked on the methyl bromide products. They are late coming into the issue. I understand that. And in terms of—I can't speak to the availability of substitutes on that basis.

Mr. ROHRABACHER. Well, let me just say that this gentleman represents not just himself here. If you listen to what he had to say, this is really important to the well-being of our country.

Mr. FAY. No, no. I understand that. And as I pointed out, we made all of the same arguments about 15 years ago.

Mr. ROHRABACHER. Okay. Well, we take him very—

Dr. POLLET. Let me just say this. It's not just agriculture. There are a lot of PCOs and whatnot, use this in the fumigation of homes for pesticide control, and things like the Formosan termite, which is extremely difficult to control.

It's probably one of the most economical ways of doing it.

If you have to do something with the Formosan termite, it usually takes you three or four applications of other materials.

Mr. ROHRABACHER. Mr. Pollet, thank you very much.

I'm going to turn now to Mr. Ehlers first, and then Ms. Rivers.

Mr. EHLERS. Ms. Rivers.

Mr. ROHRABACHER. Is that right? Pardon me.

Ms. Rivers.

Ms. RIVERS. Thank you, Mr. Chair.

I want to ask a sort of bottom-line question. But before I do that, I want to go back to the issue that Mr. Fay raised because I was heading in the same direction, which is this whole idea that we have been condemning public policy being developed in the press or through anecdote.

And frankly, we've had some problems here on this Committee sometimes.

And as I was going through the testimony and listening to folks, two things really jumped out at me that I think I want to ask about.

One is directed to Professor Stroup. And that was your suggestion that the imposition of the accelerated phase-out of CFCs has increased the price and lowered the energy-efficiency of refrigeration units and that the effect of this is that fewer people will be able to purchase home refrigeration, which in turn will cause deleterious health effects, such as food poisoning and stomach cancer.

Before I ask my question, it's interesting. We were having a discussion around a similar topic here around energy efficiency and the cost of refrigeration. I was amazed when I was able to get data

from the Livermore labs that in fact the cost of refrigerators has gone down significantly over the last 25 years.

I'm very interested in knowing specifically how large the price increases for home refrigeration you project. And where you determine that these significant health risks come from.

I'm asking, I guess, for your underlying data for both of those assumptions.

Dr. STROUP. Well, first of all, I don't disagree that the price of refrigeration is coming down. That's not the point.

As Mr. Ben Lieberman said earlier, that relates to two things. One is the technological trend. We have constant improvement in automobiles. We have constant improvement in refrigerators. We have constant improvement in almost everything—computers, you name it.

Some of that technological trend has, I believe, been soaked up, so to speak. It's been a smaller decline in the cost of refrigeration than it would have been, I believe.

What I have read is that CFCs are thermodynamically more efficient than their substitutes. That's the basis for my statement. Plus what I said earlier, which is that you cannot, I think, make consumers better off dollar-wise by taking away options from them.

I just don't think that that is likely to happen.

Ms. RIVERS. The other thing that was interesting in the Livermore data is that there are more kinds, more and different kinds of refrigerators available than there was 25 years ago.

Dr. STROUP. Sure.

Ms. RIVERS. So in fact there's a greater efficiency.

But your answer begs the question, which is, if in fact the actual cost of refrigeration is not going up and is not likely to go up under these changes, where do you get the argument that the elimination of CFC is going to produce greater incidences of food poisoning and stomach cancer?

Dr. STROUP. If there would have been a 20-percent reduction—suppose there has been a 10-percent reduction. I don't know what that number really is. But suppose there could have been a larger reduction.

Then refrigerators would be more available. Then they would be larger. Then the food poisoning would fall because the potato salad brought in from the picnic is more likely to be refrigerated and so on.

Ms. RIVERS. So you're saying that it's purely hypothetical. You have no data to suggest that this would actually happen.

Dr. STROUP. I don't know what the partial is. All I know is I read that the thermodynamic efficiency of CFCs is greater than any of its substitutes.

And how can you conclude anything else?

Ms. RIVERS. And you say that since there is an efficiency difference, that your projection is that refrigeration will cost more.

So that it's pure speculation on your part, is what you're saying.

Dr. STROUP. It's pure logic. And I have no data beyond that logic. That's correct.

Ms. RIVERS. Thank you. The other similar issue that I would like to raise, and this I would like to address to Mr. Lieberman.

And that is relative to statements that you presented in—I believe it's The Washington Times. Yes, The Washington Times. Arguing that the death of hundreds of people in Chicago was a direct result of these changes around CFCs.

And I would like to know, particularly given that Mr. Ted Rees from the Air Conditioning Institute immediately contradicted you and the Cooke County coroner's office also immediately contradicted you.

What were the underlying data that you relied on to make your comments in the paper?

Mr. LIEBERMAN. I think if you read my article and if you submit it to the record—

Ms. RIVERS. I have.

Mr. LIEBERMAN [continuing]. You'll see that I was actually very careful. I was speaking in hypothetical terms.

Mainly, this was an article that the Chicago heatwave should be a warning for the future, that if further reductions in the availability of refrigerants and further increases in costs are going to be implemented, is being discussed by the parties of the Montreal Protocol, namely, a more drastic reduction in the phase-out, or drastic acceleration of the phase-out of HCFC-22, if that was to occur, then future heatwaves would definitely be affected.

I was very, very careful to say that—I don't remember my exact language, but I said that there's no evidence that anyone was actually hurt. But the possibility cannot be discounted.

I'm just theoretically saying that, in broad terms, if you make air-conditioning more expensive, you will make it less available.

Ms. RIVERS. So what you're saying then is you just used the death of 500 people as a platform on which to make your point.

Thank you.

Mr. LIEBERMAN. Yes.

Mr. ROHRABACHER. I think the witness also was suggesting that there were enough caveats to cover him. We've heard a lot about caveats.

Ms. RIVERS. You mentioned that earlier, that caveats are often used as an opportunity to not tell the truth.

Mr. ROHRABACHER. No, no. That's right. Caveats are—however—

Ms. RIVERS. I have one more question. I'm sorry. And this is the bottom-line question that I made reference to.

Mr. ROHRABACHER. Maybe we can let Mr. Liebermann just have one chance to answer.

Ms. RIVERS. Okay.

Mr. ROHRABACHER. Go right ahead, Mr. Liebermann.

Mr. LIEBERMAN. I suppose I shouldn't have written an article that gave them some fodder to discredit me.

I'm a newcomer. I haven't written much, so there wasn't much to pick on me for, and this was the best they could do.

Read it yourself. You'll see.

Ms. RIVERS. It's pretty good, you have to admit.

Mr. ROHRABACHER. Mr. Liebermann, I wouldn't apologize.

Mr. LIEBERMAN. Read it for yourself.

Mr. ROHRABACHER. I wouldn't apologize. All I would say is, when I saw your article, I remember that I had been driving around all

summer in a car without air-conditioning and I was sweating and I felt really bad this summer.

I had a tendency to think that maybe this had something to do with the increase in the price of freon, that it had something to do with this CFC ban.

I don't think it was a jump of logic to suggest that maybe some other people up in Chicago were sweating and maybe it had a deleterious effect on their health.

I don't know any information about it, but I was sure sweating and I was angry about it. So apparently you were, too.

Mr. LIEBERMAN. I would also add that the hypotheticals that were necessary to come up with cost/benefits of \$32 trillion in EPA's regulatory impact assessment I think also deserve a closer look as well.

Mr. ROHRABACHER. Okay.

Mr. LIEBERMAN. I don't know if there are \$32 trillion around.

Mr. ROHRABACHER. Ms. Rivers, do you have one more question, please?

Ms. RIVERS. I do.

Mr. ROHRABACHER. And then we'll go to Mr. Ehlers.

Ms. RIVERS. Okay. I'd like to address this to Ms. Nichols.

And that is, I've heard a lot of arguments about the economic consequences of continuing with the elimination of these chemicals.

But in talking to a variety of people, I have also heard people talk about the economic effect of rolling back and not going forward.

Could you speak at all to the costs to industry or the country in general if we choose now to abort in the middle of this process?

Ms. NICHOLS. We have not done an analysis of the effects, let's say, of the proposal that is in Mr. Doolittle's "Dear Colleague" letter to rollback, partly because the effects are somewhat unknowable, since it's a violation of the Montreal Protocol Treaty. We don't know what the effects on the rest of the world would be in terms of the overall effect on the ozone hole.

So you'd have to just look at the cost to industry and the investments that have been made on that side in reliance on the current date.

We know, obviously, some companies are actually moving ahead of the deadline to get ahead and we'd have to go back and do a more careful look at that.

So I can't really give you any numbers right now. But, clearly, directionally, it would be a disadvantage to those firms that have made the investment.

Ms. RIVERS. Mr. Fay, can you speak to that?

Mr. FAY. It would be hard to say what the costs are because the phase-out is complete. There are—but for a few exceptions, there are no major equipment manufacturers in this country any longer using CFC compounds.

And the chemical companies, what they make from now on will only be what they're allowed to make as a result of the exemption for developing countries and to ship overseas.

I can tell you that if it's going to come from somewhere, if you roll back the phase-out, if the material could somehow find its way legally into the country, it would come in from China, India or Rus-

sia, because there are no companies in this country that I'm aware of who have any intention or interest in—I don't know how many people got back into cyclamates, Mr. Chairman, but they're not looking into restaring their CFC plants.

Mr. ROHRABACHER. I would agree with the witness that that's maybe true of companies.

I can tell you that there are a lot of people out there who are looking for freon for their air conditioner.

Mr. FAY. There is plenty of refrigerant available. The production has not ended from that standpoint this year.

Mr. ROHRABACHER. Yes.

Mr. FAY. It's expensive, yes.

Mr. ROHRABACHER. That's right, yes. If you earn as much as a Washington lawyer, it's not so bad. But if you're some regular human being, it's a pretty expensive proposition.

Mr. FAY. When the Congress puts a tax on it, the equivalent of \$10 a gallon on gasoline, it's going to be expensive.

We were opposed to the tax. We didn't support it. I mean, it's expensive.

Mr. ROHRABACHER. Boy, I'll tell you. I don't remember Ronald Reagan doing that, but I guess he did. [Laughter.]

Mr. FAY. The other side of the aisle very gleefully adopted it, I can assure you. [Laughter.]

Mr. ROHRABACHER. They never met a tax they didn't like.

Mr. Lieberman, did you want to say something. You got kind of beat up there.

Mr. LIEBERMAN. Well, I do want to add that the Doolittle bill actually does roll back the tax. It doesn't eliminate it. It rolls it back, Congressman Doolittle being a moderate, obviously.

Mr. ROHRABACHER. Right. Okay. Well, thank you very much.

Mr. Ehlers.

Mr. EHLERS. Thank you, Mr. Chairman. It's been a long day, so I'll be brief.

I would just like to pin down this efficiency issue a little bit better.

Mr. Lieberman, Professor Stroup, you both made the comment that the thermodynamic efficiency of HFCs is lower than the CFCs.

Can you give me the data on that? Why is that? How much lower is it?

Mr. LIEBERMAN. I don't have the exact data, but I can certainly give that to you and submit it for the record.

Mr. EHLERS. Mr. Fay, perhaps you know.

Mr. FAY. I don't have the precise figures. Technically, from a chemical-for-chemical basis, that is true.

Mr. EHLERS. By what percentage?

Mr. FAY. I couldn't tell you. But they've been able to engineer around that.

A couple percent, I'm told.

Mr. EHLERS. That's extremely small because the variation of efficiency of compressors is greater than that, depending on how carefully you build them, what the tolerances are, and so forth.

So it's basically a non-effect, then.

Mr. FAY. Well, on a global scale, a couple percent actually ends up being a lot. But the chemicals themselves—

Mr. EHLERS. No. I'm saying, if we're worried about a couple percent, then we ought to worry about the engineering of the compressors, too.

Mr. FAY. Exactly. That's exactly it.

Mr. EHLERS. Because that exceeds a couple percent variation.

Thank you, Mr. Chairman. I think I made the point.

Mr. ROHRABACHER. Thank you very much. And I would like to note for everyone gathered that we do have several new pictures on the wall.

There's a new painting over here. I imagine that has something to do with the ozone hole. [Laughter.]

And there's another one over here [indicating]. I think that is less abstract. I think that has something to do with the aerospace industry.

I have thoroughly enjoyed your testimony today.

Mr. EHLERS. Mr. Chairman, I believe that's a pollution vacuum.

Mr. ROHRABACHER. A pollution vacuum.

Mr. EHLERS. That's sucking all the pollution away from the earth and right out to the sun. [Laughter.]

Mr. ROHRABACHER. This is why we have a scientist here, to open and broaden our horizons of the possibilities and potentials of the human mind.

I want to thank you all. I appreciated your testimony. This has been—I think it's been a very fine hearing, where we had a contrast of opinions, which is what the purpose of this was.

I appreciate all of you coming. Thank you very much.

The hearing is adjourned.

[Whereupon, at 4:16 p.m., the hearing of the Subcommittee on Energy and Environment was adjourned.]

# APPENDIX

JIMMY HAYES  
7th District, Louisiana

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**Congress of the United States**  
**House of Representatives**  
**Washington, DC 20515-1807**

September 20, 1995

  
Jimmy Hayes  
Member of Congress

Opening Statement by Congressman Jimmy Hayes (D-LA),  
Ranking Democrat on the House Subcommittee on  
Energy and Environment, regarding  
the Ozone Depletion hearing

Mr. Chairman, the issue of stratospheric ozone depletion that is before our Subcommittee today may be somewhat unclear in its public policy and economic implications, but not in its scientific foundations.

Theories regarding the adverse impact that both natural and man-made Chlorofluorocarbons (CFC's) have had on ozone depletion enjoy some of the most broad-based support of any matter of environmental interest. Principles of chemistry confirm that CFC's, which are inert and stable substances on earth, react with ozone in the upper atmosphere to draw away oxygen molecules, thus destroying the ozone.

The agreement of over forty nations under the Montreal Protocol and subsequent amendments represented the acknowledgement of the policy makers, industries, and scientists throughout the developed and developing world that a problem existed and that a collective solution was the only workable strategy to address the situation. At the time of the Protocol, U.S. manufacturers sold about \$750 million in compounds annually to about 5,000 customers in refrigeration, air-conditioning, automotive, plasticfoam, and electronic industries. Those industries then produced \$27 billion in goods and services per year directly dependent on CFC's.

The Subcommittee is well aware of my position on how government, more specifically the federal government, should perform its oversight function over the environment. We must utilize the best available and most credible science -- peer reviewed science -- and we must ensure that relevant risks, costs, and benefits to society are appropriately weighed. I firmly believe that, with only limited fiscal, natural, and human resources, it is indeed government's responsibility to allocate its resources in a way that maximizes their effectiveness. We can

protect our environment without writing thousands of pages of regulations and prohibitions. We must focus on the most pressing problems -- those that pose the most risk to our society, not those that yield minimal benefit for too high a price.

It is for these reasons that I believe that postponing the phase-out of CFC's would be a waste of our limited resources. When factoring the investments that have already been directed toward the phase-out in terms of time, money, human capital, etc..., the costs involved in the delay would surely outweigh the benefits. Economic principles tell us that choices boil down to utility. Billions of dollars have already been spent to develop viable substitutes and it is my understanding that those products and technologies are on-line to take over the market. Businesses which produce and are dependent on CFC's would not have changed their production and utilization processes unless some benefit -- utility -- was gained that justified these important investments.

This is not to say that there are not issues which remain in doubt. After all, someone once said that "everyone knows in research there are no final answers, only insights that allow one to formulate new questions."

For example, I fully recognize and agree with the legitimate concerns of some of my constituents that the cost associated with replacing or repairing refrigerators, car air conditioners, or commercial chillers will continue to be exorbitant. Mr. Lieberman makes this point in his testimony. The industry has made the capital equipment problem among its top priorities. It is my hope that stockpiles of CFC's and grandfathering some of this equipment may acceptably resolve some of this dilemma. I will work with the Chairman, my constituents, and other interested stakeholders to move our policy in a suitable direction.

Finally, I wanted to touch on the much more complex issue of the phase-out of methyl bromide. Methyl bromide's primary uses center around pre-planting treatment of soils to control insects, pests, fungus, and certain other diseases. It can also be employed for post harvesting fumigation of agricultural commodities for prevention and removal purposes as well as structural fumigation where grain is stored.

Whereas research into CFC's effect on ozone depletion has been conducted for decades, scientists have only tied methyl bromide to ozone depletion since 1991. Unlike CFC's, data does not as explicitly and unequivocally assert that man-made occurrences of bromine in the atmosphere outnumber natural sources.



Under Title VI of the Clean Air Act Amendments, methyl bromide has been classified as exhibiting ozone depletion potential (ODP) and is targeted for phase-out by the year 2001. It is worth noting that methyl bromide is not part of the phase-out schedule under the Montreal Protocol dealing with the elimination of CFC's worldwide. U.S. phase-out is unilateral. While the upcoming Protocol conference in Vienna is expected to discuss methyl bromide, the disagreement in the scientific community over its precise ODP and its impact on meeting the ozone stabilization deadlines, no decisions regarding its international disposition are likely to be made. No other major agricultural exporting nation plans to ban methyl bromide.

With this in mind, I welcome Dr. Dale Pollet of the Louisiana Cooperative Extension Service to the Subcommittee to testify on the threat to the agricultural community of a unilateral phase-out of methyl bromide. Dr. Pollet received his Ph.D. in Entomology from Virginia Tech and his B.S. from Louisiana State University. He has been a leader in our state of addressing the impacts of a number of pest control methods and been involved in the development of the Integrated Pest Management efforts with the Louisiana Cooperative Extension Service.

In his statement, Dr. Pollet points out the \$1.5 billion in direct economic losses due to a premature phase-out schedule of methyl bromide prior to the development of viable substitute products. He also alludes to the consequences of a ban on the rice mills of Louisiana, many of which, I might mention, are located in the Seventh District.

According to USDA's own data, of the estimated 135 commodities that require fumigation as condition of import or export, only 17 have an alternative treatment currently approved and 93 are under review. The three chemicals which perform these substitute functions are being examined by EPA for potential carcinogenic effects. Remember also that these are all post harvest function which only account for approximately 5% of methyl bromide uses. No acceptable substitutes have been approved for pre-treatment.

I would conclude by saying that even if substitute technologies were available today, it could still take up to ten years to ensure approval under the FIFRA process. Methyl bromide is the **alternative** to many chemicals long banned by federal regulators, and herein lies the predicament. Assuming that scientific consensus is reached on the ozone depletion effects of methyl bromide, a process must be formulated to ensure that the options to methyl bromide produce an overall environmental benefit.

I applaud the Chairman for the timeliness of this proceeding and am looking forward to hearing the testimony.

Statement of Rep. Henry A. Waxman  
Before the Subcommittee on Energy and Environment  
Committee on Science

September 20, 1995

The ozone depletion program in the Clean Air Act is one of the strongest, best-justified environmental programs in the world.

There are three fundamental reasons why the ozone depletion program has been a success.

First, the science of ozone depletion is well established. Virtually the entire international scientific community agrees that ozone depletion is a severe environmental threat. There is overwhelming evidence that there is an ozone hole; that man-made chemicals are causing this hole; and that if this hole is not repaired, widespread ecological damage and harm to human health will result.

Second, the ozone controls established in the Montreal Protocol and the Clean Air Act Amendments of 1990 are succeeding. We have already phased-out completely one class of ozone-depleting chemicals, the halons. At the end of this year, we will complete the phase-out of CFCs. These controls have been achieved with none of the economic hardship or dislocation feared when we passed the 1990 Clean Air Act.

Third, responsible U.S. industry supports the ozone depletion program. The major CFC makers like DuPont and the major CFC users like the auto companies have already found effective substitutes for ozone-depleting chemicals. Often these substitutes save more in energy-efficiency than they cost. These U.S. industries want to see the ozone depletion program successfully completed — they do not want it rolled back.

I realize that there are some in Congress, including the Majority Whip Tom DeLay, who want to repeal the ozone depletion provisions of the Clean Air Act. This is simply an irresponsible and extreme position. Those who want to get rid of controls on ozone-depleting chemicals are far out of the mainstream. They are pushing an agenda that lacks scientific support, would jeopardize health and environment worldwide, and is opposed by responsible U.S. industry.

The ozone depletion program has always had bipartisan support in

the past. In 1987, President Reagan signed the Montreal Protocol, the international agreement protecting the ozone layer. In 1990, Congress adopted title VI of the Clean Air Act, which further accelerated the phase-out of ozone-depleting chemicals, with overwhelming bipartisan support. In 1992, President Bush again accelerated the phase-out of ozone-depleting chemicals in 1992.

In light of this history and the proven success of the ozone depletion program, this bipartisan support should continue today.

STATEMENT SUBMITTED BY  
DEPUTY ASSISTANT SECRETARY RAFE POMERANCE  
DEPARTMENT OF STATE  
HOUSE SCIENCE COMMITTEE  
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT  
SEPTEMBER 20, 1995

Mr. Chairman, I would like to thank you for affording me the opportunity to submit for the record the following statement on the current state of international stratospheric ozone agreements.

Ozone depletion, a problem common to all mankind, transcends national frontiers. Man-made compounds have in recent years posed a threat to the gaseous layer of the stratosphere which serves to screen out Ultraviolet-B radiation. Increasing amounts of such radiation only raise the risk of added cases of skin cancer, reduced agricultural production and damage to aquatic ecosystems, etc. The international response to such depletion -- viz., the 1985 Vienna Convention for the Protection of the Ozone Layer and the follow-on 1987 Montreal Protocol on Substances that Deplete the Ozone Layer -- have been paradigms of international cooperation.

The Protocol, to which nearly 150 countries have now acceded, has gained virtually universal acceptance. This

has been due principally to three reasons: (1) the excellent scientific analyses which have served as the underpinning for the adopted control measures; (2) support among business circles, especially in the United States; and (3) the creation of the Montreal Protocol Multilateral Fund in London in 1990. The Fund was established to assist Article 5 nations (i.e., developing countries whose per capita consumption of chlorofluorocarbons (CFCs) was relatively low) to meet their Protocol phaseout obligations with respect to ozone-depleting substances (ODS).

The Article 2 Parties (i.e., developed countries) agreed to support the Fund because (1) assistance was limited to the incremental or "extra" phaseout costs; (2) aid was to be given only to those developing countries whose consumption of ODS was historically very low; and (3) the amount of the Fund was a small price to pay to protect the large domestic investments that developed countries had made to phase out ozone-depleting compounds. To date, some \$350 million has been disbursed for more than 800 activities in over 85 developing countries. When completed, these projects are expected to result in a one-quarter to one-third reduction of developing countries' use of controlled ODS. It is

important to highlight the fact that a number of Article 5 countries, which are currently required to freeze their consumption and production of CFCs in 1999 and phase out by 2010, are moving to phase out even more rapidly than scheduled.

The current situation we now face with regard to the Multilateral Fund poses major difficulties. The United States was the major force behind the Fund's \$510 million replenishment (the U.S. share is about \$114 million) for the three year-period beginning in 1994. We are, however, now confronted with the situation of being unable to pay our annual voluntary contributions to the Fund. As a result of Congressional cuts in State Department and EPA requested appropriations in previous years, we are presently some \$28 million behind in our voluntary contributions. Absent appropriations along the lines of the \$51 million requested by the Administration for FY 1996, it is inevitable that we will fall further behind. This situation resonates with a certain degree of irony given our leadership position in developing technologies that reduce the effects of ODS. U.S. industry could stand to gain substantially more from Fund-related activities. For example, a New Jersey manufacturer has won a \$10 million contract for supplying technologies to help an agricultural concern in the Philippines phase out its use of ODS.

The efficacy of and need for the Protocol and its London and Copenhagen Amendments of 1990 and 1992, respectively, are beyond question. I would also like to add that the Protocol and its subsequent amendments were negotiated by the Reagan and Bush Administrations, both of which recognized the absolute importance of acting to assert U.S. leadership in addressing this environmental threat. In a report entitled "Scientific Assessment of Ozone Depletion: 1994", the world's leading atmospheric scientists reported a diminution in the rate of growth of major ozone-depleting substances in the stratosphere (i.e., CFCs and halons). In fact, the scientific community has observed an actual reduction in levels of methyl chloroform, another ozone-depleting compound.

In November, approximately 150 nations will meet in Vienna to commemorate the tenth anniversary of the Convention, as well as to hold the Seventh Conference of the Parties of the Montreal Protocol. At this Conference, the Parties will consider additional phaseout measures for developing countries with respect to their production and consumption of CFCs, halons, carbon tetrachloride and methyl chloroform (i.e., Annex A and B substances). In addition, the Protocol Parties will review developed country obligations with respect to hydrochlorofluorocarbons (HCFCs) and methyl bromide and threshold control measures for developing countries for

the latter two ozone-depleting substances.

At the recently concluded Twelfth Open-Ended Working Group Meeting of the Parties to the Montreal Protocol in Geneva, a session designed to lay the foundation for November's Conference of the Parties, a subgroup of developing and developed countries presented their report on additional developing country phaseout measures with respect to CFCs, halons, etc. The group recommended a series of scenarios for consideration by the Conference of the Parties which entail different environmental and financial costs.

In considering the matter of CFCs, it is also important to reiterate the fact that no delegation in Geneva, not even those which are experiencing difficulties meeting their phase out commitments, questioned the scientific basis for the phaseout of the production and consumption of these compounds.

At the Open-Ended Working Group meeting, the United States continued to advocate the belief that a universal phaseout for methyl bromide on the part of both developed and developing countries is perhaps the single most important measure that can now be adopted to protect the



ozone layer. I note that no final agreement was reached on the definitions of the methyl bromide quarantine and pre-shipment exemptions in Geneva. This is a matter of great importance to American agriculture. We also broached in a plenary session in Geneva the idea of establishing a "critical agricultural use" exemption for methyl bromide. The proposal, which evoked a great deal of developed and developing country interest, would permit the post-phaseout use of methyl bromide where, inter alia, substitutes are neither commercially available, effective, nor economically feasible.

While the United States stands alone in articulating the need for an across-the-board universal 2001 phaseout for methyl bromide, a number of countries such as Austria, Canada, Denmark, Germany, The Netherlands, Sweden, Switzerland, etc. have embraced the concept of an Article 2 country phaseout by 2001. Australia and Malawi continued in Geneva to support the notion of a developing country freeze on methyl bromide consumption.

Concerning HCFCs and developed countries, we argued strongly for the maintenance of the status quo with respect to both the ultimate 2030 phaseout date and the 3.1 percent cap. While the Nordic nations and the EU

continued to stress the need to advance the phaseout date, Australia, Canada, Italy, Japan, South Africa etc. have gone on the record as endorsing our position. As to developing countries, we made an equally strong pitch for an HCFC freeze in 2000 at 2000 levels.

We also succeeded in Geneva in getting the Working Group to recommend to the Conference of the Parties the approval of all of our "essential use" nominations for controlled substances (e.g., CFCs for metered dose inhalers).

In considering the foregoing, it is important to note that in Geneva the G-77 countries and China made it very apparent that Article 5 countries needed, among other things, information from the Protocol's Technology and Economic Assessment Panel (TEAP) on the economic and financial implications associated with various methyl bromide and HCFC control scenarios, as well as data on the economic implications attendant to the remaining Annex A and B phaseout scenarios. In addition, the developing countries requested the Multilateral Fund's Executive Committee to give them a notional indication of future contributions to the Fund based on currently agreed control measures. The reports of the TEAP and the

way to framing the debates and ultimate outcomes in Geneva.

In assessing the state of the Protocol, it is also important to cite the fact that Russia and several other countries with economies in transition (CEITs) lack the means to meet their CFC phaseout commitments by January 1, 1996. While the Central European nations, according to a TEAP study, will only have short periods of non-compliance (i.e., 1-2 years with support from the Global Environment Facility), the case is very much different with respect to the Russian Federation and other nations formerly part of the Soviet Union. In addition, most of the CEITs have, of late, failed to meet their voluntary contributions to the Multilateral Fund. Such contributions are supposed to constitute some 15% (about \$77 million) of the Fund.

In conclusion, the ozone layer continues to deteriorate. It is imperative, therefore, to meet this threat. Complacency will only negate the gains made to date and will only put off further, if ever, the time when the ozone layer will be restored. A recently released World Meteorological Organization (WMO) report cited last week by the Washington Post observes that the seasonal ozone hole over Antarctica continues to expand.

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The report indicates that the hole is now the size of Europe.

The United States will only be able to maintain its leadership position in the Montreal Protocol negotiations, as well as in other international environmental fora, if we are in a position to make good on our voluntary contributions. Given the global nature of the problem, such contributions, relatively small in size, will redound to the benefit of not only the developing world, but also to the American people.

Thank you Mr. Chairman.

## APPENDIX 2

ANSWERS TO QUESTIONS DERIVED FROM THE SEPTEMBER 20, 1995 HEARING  
SUBMITTED TO CHAIRMAN DANA ROHRABACHER BY DR. S. FRED SINGER.

## 1. Please list peer-reviewed scientific journals in which you have published.

(Answer) *Journal of the Franklin Institute, Physical Review, Physical Review Letters, Reviews of Geophysics, Journal of Geophysical Research, Transactions of the American Geophysical Union, Astrophysical Journal, Physics of Fluids, Icarus, Environmental Geology, Environmental Conservation, Environmental Science and Technology, Meteorology and Atmospheric Physics, Science, Nature.* This is not a complete list; there may also be others. I have published well over 150 scientific papers.

## 2. Your name is not listed as a contributor or reviewer in the 1994 WMO Ozone Assessment. Why is that?

(Answer) It has been the sad experience of many of my colleagues that their critical comments and objections are ignored by the editors, but that their names are then cited as if they approved of the Assessment. For example, in the 1990 IPCC Report, the editors explicitly acknowledged the existence of dissenting views, but then stated that they "could not accommodate them." The editors did not identify the dissenters, did not reveal how many dissented, nor state the substance of the dissenting views.

The 7-page list of scientists (exhibited also by witness Mary Nichols as evidence of a "consensus") certainly looks impressive; but, I would note, there is no way of determining how many actually agree with the overall conclusions of the Assessment.

3. You appended to your testimony your recent publication in the *Journal of the Franklin Institute*. Does it contain new scientific information?

(Answer) It is primarily an up-to-date review of the evidence, but it also contains some new information. It points out for the first time that a theoretical paper (by Ravishankara et al.) and an experimental paper (by Wennberg et al.), both published in *Science* in 1994, lead to the interpretation that the major destroyer of ozone in the lower stratosphere derives from water vapor, rather than from CFCs. But water vapor is now increasing, likely because of human activities.\* If this hypothesis is correct, then a ban on CFC production would not achieve the desired result.

## 4. In his testimony Dr. Watson doubts your hypothesis that increasing levels of atmospheric methane and carbon dioxide are causing the Antarctic ozone hole. Please comment.

(Answer) Dr. Watson misquotes me and is wrong as well. It is generally accepted that chlorine cannot remove ozone without the presence of ice crystals. Ice crystals require water vapor and low temperatures. In 1988, I published the hypothesis that ice crystals are rate-limiting for ozone

removal, rather than just the concentration of chlorine; increasing methane increases stratospheric water vapor and carbon dioxide lowers the temperature.\* Dr. Watson may not be aware that the same idea was published more recently by Blake and Rowland, without attribution to my earlier paper.

**5. The WMO released a report this month (September 1995) claiming a more rapid increase in the Antarctic ozone hole. What is your comment?**

(Answer) It is generally agreed that the AOH is controlled more by climatic factors than by the concentration of atmospheric CFCs, more or less as I hypothesized in 1988.\* I note, for example, that the 1994 hole was smaller than the 1992 and 1993 events, but of course there was no press release. With respect to 1995, I will let other scientists speak to the issue:

The latest example of "science by press release" is the scare story about a massive ozone hole, fed to the media in Sept. 1995 by the Geneva-based World Meteorological Organization. "At its present rate of growth [it] might grow to record-breaking size....," said Rumen Bojkov, a well-known WMO alarmist. But then again, it might not--according to NASA scientist Paul Newman. Australian meteorologist Paul Lehmann agrees: The hole will change its shape, volume, and size daily as it grows; he concludes that its final size is not predictable by comparing data now with those of a year ago.

**6. Please comment on EPA's cost-benefit analysis for a CFC ban, and comment particularly on the costs and benefits for poorer nations.**

(Answer) I am completely puzzled by the unrealistic benefit numbers, up to \$32 trillion, put forth by EPA. The numbers seem to be growing, in spite of the reduced skin cancer threat from a putative ozone depletion. Their methodology should be presented in detail and then carefully examined. I suspect that they've not dealt realistically with the number of deaths from melanoma and non-melanoma skin cancers. I also suspect that they have used an unrealistic discount rate in arriving at a benefit-to-cost ratio of 700 to 1000.

As far as tropical nations are concerned, their benefits would be close to zero, since ozone is not predicted to be depleted in the equatorial region. On the other hand, their costs in terms of morbidity and mortality will be very much higher than in developed countries, since they will find it more difficult to purchase new air conditioners and refrigerators.

**7. The American Academy of Dermatology has linked melanoma and the Antarctic ozone hole. Please comment.**

(Answer) It is true that Dr. Darrell Rigel has testified that skin cancer incidence has more than doubled since the AOH developed in the late 1970s. But of course, his statement is misleading, or perhaps even designed to mislead:

- An Antarctic ozone depletion cannot possibly affect skin cancer rates in the United States, some 10,000 miles away.

- Cancers develop only after a latency period of decades.

- Melanoma skin cancers have been increasing, by some 800 percent since 1935, clearly related to lifestyle changes and not to any change in ozone.

8. In his testimony, Dr. Watson claimed that a 1% increase in UV-B radiation would lead to a 2% increase in the incidence of non-melanoma skin cancers (NMSC). Do you support this estimate?

(Answer) I believe his result is incorrect. It is derived by noting that the incidence of NMSC is five times greater in Albuquerque than in Seattle; (clear-sky) UV intensity increases by a factor of 2.5 as one moves towards the equator. But one cannot simply relate the ratio of skin cancers to the ratio of UV-B. Watson's high ratio of 2:1 hides two unjustified assumptions: (i) that the fraction of clear days in Seattle is equal to the number of clear days in Albuquerque, and (ii) that people in Albuquerque walk around in raincoats rather than short-sleeved shirts and typically get no more body exposure per day than people in Seattle. When these two assumptions are allowed for, the skin cancer-to-UV ratio may well drop by a large factor.

9. Please comment on the need and urgency for a production ban on methyl bromide.

(Answer) I have addressed this issue on August 1, 1995, in testimony to the House Commerce Committee, Subcommittee on Oversight and Investigations. Briefly:

- Methyl bromide (MeBr) comes mainly from natural sources, like the ocean.

- MeBr has a lifetime in the atmosphere of only about 1 year, unlike CFCs. This means that if a problem arises and production is stopped, the enhanced level will quickly decay down to the natural level.

- I note that Dr. Watson's testimony constantly refers to "stratospheric chlorine and bromine." But there is no published evidence I know of that stratospheric bromine is increasing. The amounts present there are minute and extremely difficult to detect.

10. What would you do about CFCs at this stage of our present knowledge?

(Answer) As I stated in my testimony, I do not have a vested interest either for or against CFCs or other chemicals. Since CFCs are increasing in the atmosphere, a tax rather than production controls might be the most appropriate policy measure. A higher price would encourage both conservation and recycling, and thereby reduce the amounts released into the atmosphere.

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\* "Does the Antarctic ozone hole have a future?" *Eos* 69, 1588 (1988)

11. You have expressed doubts about the reality of ozone depletion. Please explain.

(Answer) It is difficult if not impossible to remove the natural variations from the ozone record in order to detect the existence of a small downward trend--presumably due to manmade chemicals. The attached graph, taken from a research paper by NOAA scientist Jim Angell, tells the story. It shows the strong, *but not perfect* correlation between total ozone and sunspot number, since global ozone measurements were started in 1957. It also shows that each sunspot cycle is different. Unfortunately, it would require ozone data over many cycles to permit the statistical removal of the sunspot variation from the ozone record and allow reliable extraction of a small, long-term trend.

The lower graph displays another phenomenon: the great variability of the sunspot maximum over the last 300 years, showing the existence of natural trends lasting for decades. This means that an observed ozone trend, even if real, may not necessarily be anthropogenic; it could be natural.

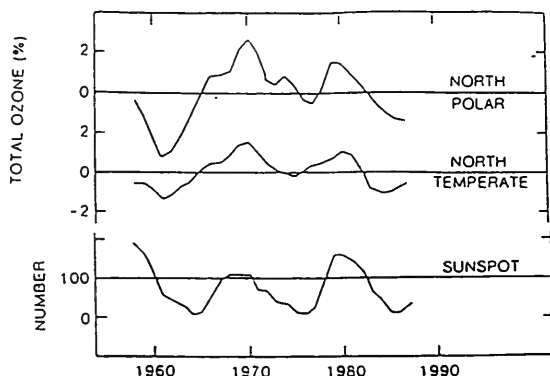


Figure 1. Total ozone change (in %) and sunspot number (Angell, 1989).

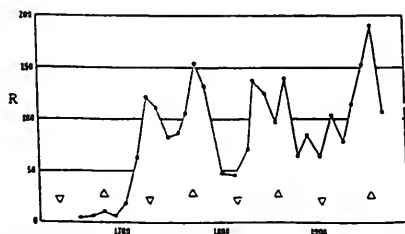


Figure 2. Annual mean sunspot number  $R$  at maxima of the 11-y cycle, A.D. 1645 to present, to demonstrate long-term trends in solar activity. Evident is the 80-year "Gleissberg cycle" (extrema shown as triangles) imposed on a persistent rise since the Maunder Minimum.



### APPENDIX 3

Remarks by  
Dr. John H. Gibbons  
Assistant to the President for Science and Technology  
Sound Science, Sound Policy: The Ozone Story  
University of Maryland at College Park  
September 19, 1995

Good morning. I'm delighted to be here to talk to a group that includes the next generation of environmental scientists and engineers. It's appropriate to be talking today to those who will be conducting research and developing policy in the future because what is happening now in Washington will shape your opportunities. This is Ozone Awareness Week and the ozone story is one of the best examples I know of sound science leading to sound policy. However, at the same time that we celebrate this success, investments in environmental science and technology are under attack in Congress under the guise of balancing the budget.

Achieving a balanced budget is also a priority for the Clinton Administration. We're in our third year in a new era of deficit reduction, and that hasn't happen since Truman was President. But this Administration is committed to balancing the budget while maintaining investments in the future, in education and science and technology. We believe that deficit reduction and wise public investment are totally consistent goals. It's no accident that industries that grew out of federal investment in science and technology -- industries as diverse as agriculture, aeronautics, computers, biotechnology and medical equipment -- today dominate the world's markets. In fact, economists estimate that over the past fifty years, innovation has been responsible for as much as half of our Nation's economic growth. Science and technology are key for a strong economy, for public health and safety, and improving environmental quality. We must continue a strong commitment to environmental R&D so we can better understand how the global environment -- our life support system -- actually works, and how to be wise stewards of that support system. Over the long-term this kind of investment pays enormous dividends to the people.

Let's look at an example of one such payoff - the stratospheric

ozone story. I'm sure most of you know what ozone is -- a fascinating, highly reactive, unstable molecule consisting of three atoms of oxygen. Ozone occurs both near the Earth's surface -- where it is a major constituent of smog, and in the region of the upper atmosphere six to thirty miles above the surface. Paradoxically, while surface ozone is harmful to human health and the environment, the "other" ozone - that in the stratosphere - is absolutely necessary for life.

Research has been key to understanding stratospheric ozone which blankets the Earth and helps make it a liveable planet. Stratospheric ozone forms an invisible shield protecting us from the hazardous ultraviolet - or UV - radiation that streams towards the Earth continuously from the Sun. UVB radiation can directly harm people. For every 1% increase in UV-B radiation, there will be an about a 2% increase in non-melanoma skin cancer in light-skinned people. We currently have about 750,000 new cases each year in the U.S., of which between 1/2 to 1% will result in death. Increased exposure to UVB can also cause cataracts--already the 3rd highest cause of blindness in the US. Increased UV-B is also associated with decreased immune system response in all populations.

Without the Montreal Protocol and its amendments (international agreements to phase out ozone-depleting chemicals), we would be facing future increases of 40-50% of UV-B in the next century as opposed to expected peaks of 6-7% in the summer/fall and 13-14% in the winter/spring.

The story of how we reached these international agreements began twenty years ago when two research scientists, Mario Molina and Sherwood Rowland, hypothesized that chlorofluorocarbon molecules (CFCs) are stable enough to diffuse to the stratosphere where the sun's ultraviolet radiation would split off the chlorine atom, whereupon each chlorine atom would act as a catalyst, destroying thousands of molecules of ozone.

Back then there was little but laboratory data to support the theory. No one had looked for an ozone hole in the sky- - we didn't even have the tools to try. There was no long-term record demonstrating that ozone levels were declining on a global basis. There

were no satellite, aircraft or balloon-based measurements of trace gas species showing the intermediate steps in the process leading to chlorine-driven destruction of ozone. In fact, all we really knew was that CFC concentrations in the atmosphere had been rising and that a seemingly plausible, but unproven, hypothesis existed that chlorine from CFCs could destroy ozone.

CFCs were invented in the early 1930s as a replacement for hazardous compounds like ammonia then widely used as refrigerants. CFCs are odorless, extremely stable, relatively non-toxic and nonflammable. Not surprisingly their use quickly spread to a wide range of industrial and consumer applications, from refrigeration to aerosols propellants to foam products and eventually as solvents in the electronics industry.

Given the scientific consensus that now exists, it is hard to imagine the controversy that surrounded this theory two short decades ago. In part, this controversy was driven by the lack of clear and convincing evidence in support of the theory, but also largely because of concern that CFCs were critical to our quality of life and no substitutes existed to replace them.

How then did we quickly evolve from a politically charged situation in the late 1970s to today where 150 nations of the world have agreed to phase-out CFCs by the end of this year in all developed countries and soon thereafter in developing countries?

First and foremost, this issue has been driven by major and definitive advances in our scientific understanding. We have gone well beyond our rudimentary knowledge in 1974 of the impact of CFCs on ozone chemistry. While uncertainties remain, we are confident about the atmospheric processes that control stratospheric ozone and the role that CFCs and other chlorinated and brominated compounds have on those processes.

The most striking example of this concerns the so called Antarctic Ozone Hole. When ground-based and satellite data were first published showing the existence of this ozone hole, which opens in the Antarctic spring, the scientific community, not to mention the public at large, were taken completely by surprise. No models or theories had

predicted any such phenomenon. At first, the scientific community was at a loss as to explain its cause. Was it due to CFCs, the result of some meteorological conditions, or was some other unknown factor at work here? Was the condition unique to Antarctica, to polar conditions in general, or likely to affect global ozone levels?

These were more than interesting questions for the scientific community to debate. Just about the same time news about the ozone hole surfaced in the scientific literature, nations were coming together to discuss what actions they should take to protect the ozone layer. But a definitive policy decision was dependent on a sound scientific understanding of the issue.

In what must be considered record time and with broad international and public and private sector cooperation, two major scientific campaigns were organized in 1987 and again in 1988 to collect data concerning the Antarctic ozone hole. Based on extensive field measurements, lab experiments and modeling, the consensus view emerged that CFCs cause the depletion of ozone over Antarctica.

This finding brought a sense of urgency to policy makers. As we all know, ozone is a global issue and requires a global response. Reductions in the use of CFCs in the United States -- even though the United States was the major source of CFCs -- were not going to solve the problem if other nations continued to expand their own use. Subsequently, a series of international scientific studies were conducted. These reviews began in the 1970s and were formally brought into the Montreal Protocol when it was signed in 1987. They have become the bedrock against which policy decisions are taken.

The original Protocol called for a 50% reduction in CFCs by 1998, but also called for periodic review of scientific and technology issues. The first such review was issued in 1989 and led to the Parties agreeing that on the basis of new scientific information that even greater reductions were needed to protect the ozone layer, and that chemical substitutes had advanced enough to make practical the full phase-out of CFCs by the end of the century. I'd like to emphasize that extraordinary technological progress in developing CFC alternatives by the industrial sector permitted a faster phase-down. A similar process in 1992 led to agreement that CFCs would be phased out in the developed

world by the end of this year. The recent 1994 international assessment of the situation confirms the soundness of the science and phase-out policy.

Let me summarize the evidence that is now very clear and broadly accepted by experts around the planet:

1. There is no doubt that the major source of atmospheric chlorine and bromine is from human activities (e.g., CFCs and Halons), not from natural sources such as volcanoes or sea spray.
2. There is no doubt that downward trends of stratospheric ozone are occurring at all latitudes, except the tropics, during all seasons. Extensive ground-based data and satellite data have shown that since 1970 ozone has decreased by about 5-6% in summer and 9-11% in winter/spring in northern mid-latitudes, and by 8-9% at southern mid-latitudes on a year-round basis. The weight of scientific evidence suggests that the observed mid-latitude downward trends of ozone are due primarily to anthropogenic chlorine and bromine.
3. There is no doubt that the spring-time Antarctic ozone hole is due to anthropogenic chlorine and bromine---based on combining ground, aircraft, balloon and satellite data, with laboratory data and theoretical modeling.
4. During periods of declining ozone, stations in Antarctica, Australia and mountainous regions in Europe, have shown that ground-level UV-B increases, as expect
5. The rate of increase of atmospheric chlorine and bromine in the atmosphere has slowed considerably in the last few years, demonstrating the effectiveness of actions taken under the Montreal Protocol and its amendments. Even so, and if everything goes forward smoothly, the mid-latitude ozone loss and the hole over Antarctica are not expected to disappear until the middle of the next century

While the story I have told so far shows science, technology, and policy moving forward in harmony, I must also report that recently

a discordant note has been struck. Amazingly, there are those today on Capitol Hill who don't want to believe that the ozone hole exists, who won't trust the evidence of startling observations year after year showing a hole over Antarctica the size of the United States. Just last week, the World Meteorological Organization announced that the hole is beginning to open again, as predictable as Old Faithful. Within a few weeks, some 60% of the total overhead ozone will be depleted.

Even as the hole opens, Congress is holding hearings tomorrow to question the science of ozone depletion and the soundness of the phaseout. Incredible. The scientific community has spoken time and time again, with a virtually unanimous voice, that the phenomenon is real, and the problem is immediate and that fortunately, due to early action, effective chemical substitutes for CFCs are available. Industry agrees.

Yet, tomorrow, Congress will give a few vocal skeptics equal standing with the hundreds of scientists represented by the international assessments. Such ideologically driven attempts to paint a distorted picture of the scientific consensus on climate change and ozone depletion are highly regrettable. You can not wish ozone holes away. Refusing to face the facts won't change the facts. Healthy skepticism is an essential and treasured feature of scientific analysis. But willful distortion of evidence has no place at the table of scientific inquiry.

I firmly believe that the American people expect the federal government to support science and technology so that we can continue to discover, learn about, and deal with phenomena like ozone depletion. The American people do not want this country to put its head into the sand and hope that problems simply go away. They understand that ignorance is assuredly not the route to our salvation!

Congressional leaders have said they want to fully support basic scientific research. But their proposals to cut the funds for global climate change research - including funds for stratospheric ozone research - suggest their deeds do not match their words. For example, though over a trillion dollars of insured property along the U.S. Atlantic coast is vulnerable to sea level rise caused by global warming, Congress is proposing major cuts in the research needed to help protect

this investment. Despite one of the worst hurricanes seasons in decades, scientific research at NOAA aimed at understanding climate is targeted for cuts of between 30 and 40%. NASA's Mission to Planet Earth, which combines satellite measurements with ground-based research and analysis in the first comprehensive study of the planet we live on, was slated for a \$300 million (25%) cut next year by the House of Representatives. Fortunately, and due in no small part to the leadership of your Senator, Barbara Mikulski, the Senate has not gone along with this extreme action, limiting their cuts to \$60 million.

Proposals to eliminate the National Biological Service and the Environmental Technology Initiative, eviscerate the Superfund research budget, and slash more than 40% of the funding for energy efficiency and renewable energy research rest on the same know-nothing stance as do proposals to gut the effective enforcement of the Clean Water Act and the Clean Air Act. Unbelievably, just last week Congress attached riders on to the budget reconciliation bill that would disband all Department of the Interior surveying and mapping activities by October 1996. If enacted, it would end research on water quality, natural hazards, land use, and ecosystems. Does Congress really think we don't need maps to chart our way forward?

Although Congress continues to profess support for regulatory decision making based on sound science and credible economic analysis, their actions belie their rhetoric. They say they favor more risk assessment and cost/benefit analysis, yet they are cutting the very research programs that provide the scientific information required to do such analysis.

Not only does Congress not want to know some of the answers, they also don't want you to know. For example Congress has proposed to severely limit the public's right to know by limiting expanded information on chemical releases into communities. We think citizens have the right to know. The House Appropriations bill for the Department of Transportation even includes a rider prohibiting the labeling of tires for rolling resistance so that consumers won't know which will help them save gas -- and money.

But we know that lack of information is always more expensive in the long run. A successful market economy fundamentally depends

on the availability of accurate information. We in the Clinton Administration believe that rather than putting our heads in the sand and blindly groping for short-term budget savings, we recognize and protect key investments for the future - investments that are just as important as debt reduction and will lead to real, long-term improvements in the economy, environment, health, and security.

Some crises in the global environment, like ozone depletion, climate change and loss of biodiversity have long time constants--on the order to decades to centuries to develop and, if they can be reversed, the time needed for recovery is much longer--on a time scale somewhere between human and geological time. Political time scales are more often on the scale of hours to days.

Rene Dubos recognized our focus on fast-changing or short-term phenomena as one of the great tragedies of humankind. Adlai Stevenson spoke about Americans in particular as "those people who never really see the handwriting on the wall until their backs are up against it." The crises I see developing cannot be solved by ignoring them. In fact, they will continue to grow worse as long as we refuse to address them.

Those of you sitting in this room will be part of the group that must address, and I hope, help us solve these problems. But we today must assure that you have the tools for that task tomorrow. If our nation is to be a leader in the 21st century, it must excel in education, science, and technology. The nations that are able to take advantage of new opportunities and that can respond to environmental and economic challenges will be our future leaders. They will be nations geared toward the future, not the past.

Many members of Congress are acting upon the general impression that government is inevitably intrusive and wasteful. This Administration disagrees. We believe that the government can be a force for good in the life of the nation -- that government can help create, for the future, a more perfect union -- and we will stand by that conviction no less fervently than the Founding Fathers. The lessons of stratospheric ozone: scientific discovery and analysis, innovative technology, invention of substitutes, and diplomatic agreements of cooperation between governments can combine to avert major



planetary problems. Let us see this episode through successfully and apply its lesson to the other challenges that beset us. To do less would be to betray ourselves and our children.

EXECUTIVE OFFICE OF THE PRESIDENT  
OFFICE OF SCIENCE AND TECHNOLOGY POLICY  
WASHINGTON, D.C. 20500

October 11, 1995

The Honorable Dana Rohrabacher  
U.S. House of Representatives  
Chairman  
Subcommittee on Energy and Environment  
B-374 Rayburn House Office Building  
Washington, DC 20515

**RE: Hearing on "Stratospheric Ozone: Myths and Realities," Wednesday,  
September 2, 1995, 9:30 a.m., Room 2318 of the Rayburn House Office Building**

Dear Mr. Chairman:

The purpose of this letter is to clarify my answer to a question asked by Congresswoman Rivers before the Subcommittee on Energy and Environment, "Hearing on Scientific Integrity and Public Trust: The Science Behind Federal Policies and Mandates Case Study 1 -- Stratospheric Ozone: Myths and Realities" on September 20, 1995.

The following paragraphs reflect the text I wish to clarify (currently page 105 of the printed testimony attached, line 2468):

"... Ms. RIVERS. Before I do that, I would like to ask Dr. Watson, Dr. Albritton, Dr. Setlow, and Dr. Kripke, if they are familiar with a publication called the Journal of the Franklin Institute, with what regard that journal is held in the scientific community, and if they know whether or not it is maintained in the library of the institution at which they work?

Dr. WATSON. This is a journal that came to my attention this morning for the first time. It is not in the library of the White House. It began in 1994, with a circulation of 400 people.

It is obviously in a number of libraries and businesses and a number of institutions. We understand the circulation is 400.

Ms. RIVERS. Okay. Dr. Albritton, are you familiar with it, or is it in your institution?

Dr. ALBRITTON. That journal is not in our institution. I'm not aware of it, nor have I heard it discussed at ozone-related scientific meetings.

Ms. RIVERS. Okay. Dr. Setlow?

Dr. SETLOW. I'm familiar with it from my early, early days as a physicist, but I have not seen it for many years and, to the best of my knowledge, it is not in our institution at the present time.

Ms. RIVERS. Dr. Kripke?

Dr. KRIPKE. I've never heard of it."

I wish to clarify for the record that the journal Congresswoman Rivers was referring to in her initial question cited above was, TECHNOLOGY: *Journal of the Franklin Institute* not *Journal of the Franklin Institute*. These are two distinct journals, published by two separate publishers.

S. Fred Singer's four page commentary titled, "Commentary: the ozone-CFC debacle: hasty action, shaky science," appeared in TECHNOLOGY: *Journal of the Franklin Institute*, Vol. 332A, No. 1, 1995.

I have confirmed with Bob Miranda (914) 592-7720 an employee of the TECHNOLOGY Journal's publisher, Cognizant Communications Corporation, Elmsford, New York and the Library of The Franklin Institute (215) 448-1200 that TECHNOLOGY: *Journal of the Franklin Institute* was first published in the latter half of 1994 and has a distribution of 400.

The *Journal of the Franklin Institute* -- first published in 1826 -- has been in existence for approximately 170 years, and is as old The Franklin Institute itself -- established in 1824 in Philadelphia, PA -- the same cannot be said for TECHNOLOGY.

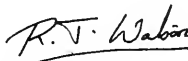
Dr. Setlow's response that he was familiar with the Journal was undoubtedly in reference to the *Journal of the Franklin Institute* not TECHNOLOGY.

For your convenience, I have included the cover page and publisher information for TECHNOLOGY.

I would like a footnote added to the text of my response directing readers to an appendix which corrects any misunderstanding about the publication in question.

If you have any questions pertaining to this letter or any other matter, please call me at (202) 456-6202.

Sincerely,



Robert T. Watson  
Associate Director for Environment



# TECHNOLOGY

JOURNAL OF THE FRANKLIN INSTITUTE

VOLUME 332A • NUMBER 1 • 1995



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## TECHNOLOGY: *Journal of The Franklin Institute* The 170th year of Publication

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October 19, 1995

Chairman Dana Rohrabacher  
Subcommittee on Energy and Environment  
United States House of Representatives  
Washington, D.C. 20515

Dear Mr. Rohrabacher:

During testimony before the House Subcommittee on Energy and Environment on September 20, 1995, I was asked to provide certain information to the Subcommittee, in writing. The information requested concerns evidence for a lack of free and open inquiry in scientific matters related to global change research.

First, it may be helpful to provide some information on my background. I received my PhD degree in astrophysics from Harvard University in 1980 and have been a research physicist at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, since then. I am a contract employee of the Smithsonian Institution; that is, my salary, benefits, overhead, rent, supplies, support for my scientific experiments, equipment, etc., including the costs of student researchers, employees and scientists working on my programs are funded by contracts.

Enclosed is my *curriculum vitae*; as noted, I am also Deputy Director of Mount Wilson Institute — which has managerial responsibility for Mount Wilson Observatory — whose physical plant is worth roughly \$70 million. The Observatory is where the bulk of my research has been conducted since 1980. In addition, I serve as Senior Scientist at the George C. Marshall Institute, a nonprofit science and public policy research group. I also donate considerable time to science education, especially for programs helping minority and female students.

I have authored and co-authored more than 125 papers in the peer-reviewed literature; a list can be provided upon request.

This brief introduction is intended to demonstrate that I have been successfully competing for scientific funding through-

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Compuserve.COM

out my professional life. It was thus a great disappointment to learn that scientific competence is not always the dominate factor in climate change research.

At scientific conferences, conversations on the deterioration of scientific ethics in global change research are common. I suspect this deterioration reflects the effect of increased competition for increasingly scarce scientific funding. Three personal experiences follow:

1. In April, 1990, I attended a climate change symposium at Goddard Space Flight Center, in Maryland. At that meeting I had a coffee-break conversation with an official in the atmospheric science program of the National Science Foundation (NSF). I asked for information on the possibility of applying for funds to study the impact of long-term variations in the Sun on both the earth's climate and the ozone layer. The research rationale is that the Sun's variations are one of several natural influences that must be accurately known so the best estimate of the human-made effects can be determined.

I was told such research would not be considered for funding because it might raise doubts regarding the importance of anthropogenic influences on the environment. I was further informed those doubts could have two undesirable consequences: first, they would give policymakers an excuse to forego mitigation efforts; second, *they would jeopardize the possibility of getting more funds for climate change research*. The next day at the meeting, I asked the official to clarify his position. I was told never to mention the conversation had occurred.

I do not know if the views of one official would actually affect the proposal process. However, my status as a researcher, who needs successful proposals to survive, meant I never pursued the matter; and indeed, I never submitted a proposal to NSF in the area of climate change.

2. Prior to my September 20, 1995 testimony before your subcommittee, pressure was exerted on me by the advocacy group, Ozone Action. In a July 28, 1995 issue of *Ozone Action News*, this organization described me as one who "... gather[s] bad out-of-date studies..." on stratospheric ozone variation. There was no evidence offered to substantiate of this claim. On September 18, Ozone Action called the Public Relations Office of the Smithsonian Observatory to ask if my pending testimony were an official position of the Smithsonian Institution. The Public Relations Office responded that my testimony was not official.

The next morning, September 19, Ozone Action sent someone to inspect the 990 tax forms of the George C. Marshall Institute, in order to determine the source of funding for my work at that organization. Later that day, the Public Relations Office of the Smithsonian sent me a message that Ozone Action had faxed to that office the cover of one of my Marshall essays on ozone. Ozone Action included the brief biography that the Marshall Institute provides for the authors of its reports. My biography included the fact that I am a scientist at the Harvard-Smithsonian. The voice-mail message from the Public Relations Office

of the Smithsonian said Ozone Action was "desperate to link my testimony to the Smithsonian."

Such conduct by Ozone Action was, I believe, meant to engage institutional pressures on me not to appear at the hearing. The result of this intimidation was that late on the eve of the hearing, I drafted a letter to you withdrawing from testifying. The letter was never sent because I decided not to succumb to these tactics and to appear anyway.

3. My confidence in the peer-review process has been shaken by an episode involving the editors of the journal *Nature*. In October, 1992, my colleagues and I submitted a manuscript to *Nature* on work relating to changes in the Sun, which might have impact on terrestrial climate change. The manuscript received treatment unprecedented in my 15 years of experience. Briefly: The paper was held in the review process for 14 months and apparently went through five different referees and three different editors. After two referees accepted the paper, the editors kept trying until they found a referee who would recommend rejection. This violates *Nature's* stated policy of accepting manuscripts approved by two reviewers.

Even more indefensible, one reviewer suggested our results were a direct consequence of my funding from a foundation supported by an oil company.<sup>1</sup> The clear implication was that I had doctored my findings to please a corporate interest. This was a mere assertion, however, since the reviewer offered no evidence to support this attack on my integrity. Yet the attack was implicitly accepted by *Nature's* editors since it was forwarded by them to us without comment or disavowal.

After this shameful episode, we submitted the manuscript to the most prestigious journal in astrophysics, *The Astrophysical Journal*. *The Astrophysical Journal* accepted it for publication immediately.

The lack of editorial objectivity in some scientific journals, as I have described briefly, raises questions about the peer review process. Enclosed is a perceptive comment on this matter by Dr. David Goodstein, Vice Provost and Professor of Physics and Applied Physics at Cal Tech, which recently appeared in *The American Scientist*. He describes the breakdown of the peer review process as a result of increased competition for decreasing research funds.

The situation has deteriorated in the last year. In September, 1994, a press statement released by Intergovernmental Panel on Climate Change (IPCC) officials stated that "The world's climate is at serious risk." This press statement was drafted before the meeting of the panel of scientists advising the IPCC at which

---

1. "The particular choice [of analysis] made in this paper, and its implications for the global warming debate, may be considered desirable by some of the sponsors listed in the acknowledgements, but it is not science." Anonymous reviewer for *Nature*, December 31, 1993.



the findings referred to in the press statement were supposed to be discussed. In violation of IPCC rules, the scientific drafts had not been distributed to participants prior to the meeting. The scientists on the IPCC panel were not even informed of the existence of this IPCC release beforehand, although it nominally represented their opinion. An editorial in *Nature*<sup>2</sup> called this "communication by press release" and "a rotten way to conduct international business."

In December 1994, a commentary in *Nature*<sup>3</sup> referred to the "rapid politicization of the climate debate" and concluded, "Under pressure, even scientists will deliver what their paymasters prefer to hear."

As you see, my experiences are a part of a much larger problem. I hope this information, requested by the Subcommittee, is helpful.

Sincerely,



Sallie Baliunas

Enclosures: Curriculum Vitae

*American Scientist* commentary on deterioration of peer review

*Nature* editorial on IPCC press release

*Nature* commentary on politicization of climate change research

---

2. "IPCC's ritual on global warming," *Nature* 371, 269 (1994).

3. *Nature* 372, 402 (1994).

**SALLIE BALIUNAS, Astrophysicist****ACADEMIC APPOINTMENTS:**

|              |   |
|--------------|---|
| 1980-present | Astrophysicist, Smithsonian Astrophysical Observatory   |
| 1989-present | Adjunct Professor, Center of Excellence in Information Systems<br>at Tennessee State University |
| 1990         | Visiting Scholar, Dept. of Physics and Astronomy, Dartmouth College                             |
| 1980         | Research Associate of Harvard College Observatory   |

**EDUCATION:**

|      |                           |
|------|---------------------------|
| 1980 | Ph.D. Harvard University  |
| 1975 | A.M. Harvard University   |
| 1974 | B.S. Villanova University |

**HONORS AND PRIZES:**

|           |   |
|-----------|---|
| 1993-1994 | Weason Fellow, Stanford University                              |
| 1988      | Bok Prize, Harvard University                                   |
| 1988      | Newton Lacy Pierce Prize, American Astronomical Society         |
| 1987      | Villanova University Alumni Medallion Award                     |
| 1980-1985 | Langley Abbot Fellowship, Smithsonian Institution               |
| 1979      | Donald E. Billings Award in Astro-Geophysics, Univ. of Colorado |
| 1977-1979 | Amelia Earheart Fellowship, Zonta International Corp.           |

**OTHER APPOINTMENTS:**

|              |  |
|--------------|--|
| 1991-present | Deputy Director, Mount Wilson Institute                                      |
| 1989-present | Member, Board of Trustees, Mount Wilson Institute                            |
| 1993-present | Board of Directors, Astronomical Society of the Pacific                      |
| 1993         | Committee of Visitors, Astronomical Sciences, NSF                            |
| 1992-present | NSF Advisory Committee for Astronomical Sciences (ACAST)                     |
| 1992-1993    | Peer Review Panel on Carbon Dioxide Limits for Tennessee<br>Valley Authority |
| 1992-present | NSF-RISE (Radiative Inputs from Sun to Earth) Steering Ctte                  |
| 1990-1993    | NASA Science Operations Management Operations Working<br>Group (SOMOWG)      |
| 1987-91      | Chairman, Science Advisory Board, Mount Wilson Institute                     |
| 1984-1987    | AURA Observatories' Visiting Committee                                       |

*International Ultraviolet Explorer (IUE) Satellite*

|                  |   |
|------------------|---|
| 1985-87; 1989-92 | Users' Committee  |
| 1978-present     | Guest Investigator  |
| 1989-1990        | Scientific Organizing Committee, NASA/ESA/SERC<br>IUE Symposium, Toulouse, France |

*Automatic Photoelectric Telescopes (APT)*

|              |  |
|--------------|--|
| 1988-present | Organizer, 3rd and 4th Summer Workshop                     |
| 1986-present | Science Advisory Panel, Smithsonian-Fairborn Observatories |
| 1988-1991    | Co-organizer of 9th, 10th, 11th I.A.P.P.P. Symposia        |

*Editorial, Educational and Other Advisory Appointments*

|              |  |
|--------------|--|
| 1993-present | Chair, Editorial Board, <i>Publications of the Astronomical Society of the Pacific</i>   |
| 1991-1994    | Editorial Board, <i>Solar Physics</i>  |
| 1993-present | Organizer, Smithsonian Institution Associates Annual Expedition to Mount Wilson Observatory  |
| 1991-present | Chair, Science Advisory Board, George C. Marshall Institute  |
| 1992-1993    | Scientific Organizing Committee, IAU Colloq. 143, <i>Solar Irradiance Changes</i>  |
| 1992-1993    | Organizer, American Association of the Advancement of Science session, <i>What Astrophysics Can Tell Us about Climate Change</i> , Boston, MA, 1993          |
| 1992         | Guest Editor, <i>Annual Review of Astronomy and Astrophysics</i>   |
| 1993         | Scientific Organizing Committee, <i>Optical Astronomy from the Earth and Moon</i> , 105th Meeting of the Astronomical Society of the Pacific, San Diego, CA. |
| 1989-1990    | Science Advisory Board, George C. Marshall Institute   |
| 1992         | Editor, <i>Proceedings of Robotic Observatories Symposium</i>  |
| 1989-1990    | Science Panel, Astronomy and Astrophysics Survey Committee (J. Bahcall, Chairman)  |
| 1989-1990    | Co-Chair, Scientific Organizing Committee, 101st Meeting Astronomical Society of the Pacific, Boston, MA   |
| 1989         | Chair, ROSAT X-ray Satellite Peer Review Panel, Hot Stars  |
| 1987-1992    | Astronomy Committee, Maria Mitchell Observatory  |
| 1987-present | SYNOPSIS Steering Committee, NOAO  |
| 1985-present | Lecturer, Smithsonian National Associate Program   |
| 1991-present | Advisory Board, Learning Technology Center, Vanderbilt University  |
| 1984         | Editor, <i>Proceedings of the Third Cambridge Workshop on Cool Stars, Stellar Systems and the Sun</i>  |
| 1981, 1983   | Organizing Committee, Cambridge Cool Stars Workshop II, III  |

**PROFESSIONAL SOCIETIES:**

American Astronomical Society  
 American Geophysical Union  
 American Physical Society  
 Astronomical Society of the Pacific  
 International Astronomical Union  
 Sigma Xi  
 Solar Physics Division, American Astronomical Society

## PEER REVIEW AFTER THE BIG CRUNCH

David Goodstein

According to modern cosmology, the universe began about 10 billion years ago in an event known as the Big Bang. It has been expanding ever since. We do not know whether it will go on expanding forever. If the density of matter in the universe is sufficiently large, gravitational forces will eventually cause it to stop expanding, and then to start falling back in upon itself. If that happens, the universe will end in a second cataclysmic event that cosmologists call the Big Crunch.

I have a rather analogous theory of the history of science. According to this theory, modern science appeared on the scene in Europe almost 300 years ago, and in this country a little more than a century ago. In each case it proceeded to expand at a frightening exponential rate. The phenomenon is shown on Figure 1, a semi-logarithmic plot of number versus year. The upper curve, first published around 1960 by Derek de Solla Price, shows the cumulative number of scientific journals founded worldwide. For 200 years, from 1750 to 1950 (when the plot was made) the number increased by a factor of 10 every 50 years, extrapolating to one million today (there are actu-

ally about 40,000). To check Price's assertion that any measure of the size of science would have the same behavior, I have plotted on the same scale the number of Ph.D.'s granted in physics in the United States. That started around 1870, and grew even faster for 100 years.

Exponential expansion cannot go on forever, and so the expansion of science, unlike the expansion of the universe, was guaranteed to come to an end. I believe that in American science, the Big Crunch took place about 25 years ago—after two decades that saw the enormous postwar ex-

David L. Goodstein is vice provost and professor of physics and applied physics at the California Institute of Technology, where he has been on the faculty for more than 25 years. In 1995 he was named the Frank J. Gilloon Distinguished Teaching and Service Professor. He is the author of more than 100 research articles and the book *States of Matter*, published in 1975 by Prentice Hall and reissued by Dover Press in 1985. He has served on numerous science and academic panels, including the Standing Review Board of the Keck Telescope and the Committee on Equal Opportunities in Science and Engineering, a National Science Foundation oversight committee. He is the host and project director of "The Mechanical Universe," an award-winning and widely used 52-part college physics telecourse based on his popular lectures at Caltech. Address: Office of the Provost, Caltech, Pasadena, CA 91125.

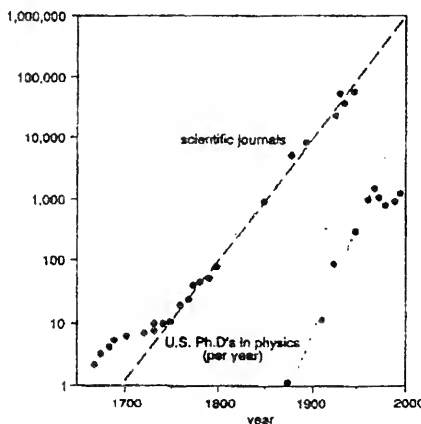


Figure 1. The end of science's Big Bang.

pansion of academia and the creation of corporate and government research laboratories all around the U.S. in response to economic growth and the Cold War. The good times ended forever around 1970, as one can see from the graph. By importing students and employing Ph.D.'s as temporary postdocs, we have stretched time out, pretending that nothing has changed, waiting for the good times to return. For a quarter-century we have been trying to ignore the end of the great expansion of American science. What we have to do now is solve a problem that has never even occurred to the cosmologists: What do you do after the Big Crunch?...

The crises most talked about are the shortage of jobs and research funds. But they are just the beginning. Under stress from those problems, other parts of the scientific enterprise have started showing signs of distress. One of the most essential is the matter of honesty and ethical behavior among scientists. What had always previously been a purely intellectual competition has now become an intense competition for scarce resources. The public and the scientific community have both been shocked in recent years by an increase in the number of cases of fraud committed by scientists. There is little doubt that the perpetrators in these cases felt themselves under intense pressure to compete for scarce resources, even by cheating if necessary. As the pressure increases, this kind of dishonesty is almost sure to become more common.

The pressure for resources has become severe enough that I believe one of the crucial pillars of the whole edifice, peer review, is in grave danger.

Peer review is used by scientific journals to decide what to publish. It is also used by granting agencies to decide what research to support. Obviously, sound decisions on what to publish and what research to support are crucially important to the proper functioning of science. Journal editors usually send manuscripts submitted to them to referees who remain anonymous to the authors of the manuscript. Funding agencies sometimes do the same, especially for small projects, and sometimes assemble panels of referees to judge proposals for large projects.

Peer review is quite a good way to identify valid science. It was wonderfully well suited to an earlier era when progress in science was limited only by the number of good ideas available. Peer review is not at all suited, however, to adjudicate an intense competition for scarce resources such as research funds or pages in prestigious journals. The reason is obvious enough. The referee, who is always among the few genuine experts in the field, has an obvious conflict of interest. It would take impossibly high ethical standards for referees to fail to use their privi-

leged anonymity to their own advantage. Most scientists do hold themselves to high standards of integrity, but as time goes on, more and more referees have their ethical standards eroded by the unfair reviews they receive when they are authors. Thus the whole system is in peril. Peer review is one among many examples of practices that were well suited to the time of exponential expansion, but that will become increasingly dysfunctional in the difficult future we face.

Editors of scientific journals and program officers at funding agencies have the most to gain from peer review. They steadfastly refuse to believe that anything might be wrong with the system. Their jobs are made easier because they have never had to take responsibility for decisions. They are also never called to account for their choice of referees, who in any case always have the proper credentials. Since the referees perform a professional service, almost always without pay, the primary responsibility of the editor or program officer is to protect the referee. Thus referees are never called to account for what they write in their reviews. As a result they are able, with relative impunity, to delay or deny funding or publication to their rivals. When misconduct of this kind happens, it is the referee who is guilty, but it is the editors and program officers who are responsible for propagating a system that makes misconduct almost inevitable. This kind of misconduct is, I fear, rampant in all fields of science.

Recently, as part of a talk to a large audience of mostly young researchers at an extremely prestigious university, I outlined this analysis of the crisis of peer review. The moderator, a famous senior scientist, was incredulous. He asked the audience how many disagreed with my heresy. No one responded. Then he asked how many agreed. Every hand in the house went up. Many in my generation wish to believe that nothing important has changed in the way we conduct the business of doing science. We are wrong. Business as usual is no longer a real option for how we conduct the enterprise of science.

We must find a radically different social structure to organize research and education in science after the Big Crunch. The institutions of the scientific enterprise evolved to suit an environment very different from the one we live in now, and from the one we face in the future. Unless we can figure out how to guide it, the transition is likely to be messy and painful for the participants. So far, we have not even admitted that the problem exists.

I think we have our work cut out for us.

(Note: A similar discussion appeared in the June issue of *Biotechnology* [13:618].)

# IPCC's ritual on global warming

If the threat of global warming is serious (which cannot be denied), it deserves more seemly ways of making authoritative opinion public than that followed at last week's meeting at Maastricht.

So the greenhouse effect is real, then? That will be the first reaction of those who read of last week's meeting at Maastricht of the Intergovernmental Panel on Climate Change (IPCC), which is preparing its second assessment of the extent to which greenhouse gases in the atmosphere will affect the Earth's radiation balance. By all accounts (but see page 274), carbon dioxide has continued to accumulate, but only half as quickly as carbon dioxide is generated by the combustion of fuel. (The remainder is probably locked up in the biosphere, or dissolved in the oceans, temporarily or otherwise.) And while the concentration of methane in the atmosphere is increasing at a decelerating rate, IPCC says that, molecule for molecule, its effect on climate is greater than previously allowed. But interested readers (of whom there are in principle about 5 billion) will have to wait until the secretariat has taken account of last week's discussion, and until Cambridge University Press has turned the outcome into type, before they will be able to weight the quality of the discussion.

This is a rotten way to conduct international business, the more so because literally everyone in the world will eventually be affected by it. Last week's reports from Maastricht suggest that the goal of restraining emissions of carbon dioxide below those of 1990 (the European Union's collective goal) will be insufficient even to prevent a further doubling of carbon dioxide concentration in the atmosphere. That has been on the cards from the outset, but the apportionment of allowable emissions among the potential claimants on them will be a much more difficult task than the negotiation of the Convention on Climate Change at Rio de Janeiro two years ago, where it must have seemed to many that a mere signature could prevent climatic deterioration. If IPCC is serious (and there is no reason to believe otherwise), it should now be doing everything it can to make the further agreements that will be necessary winnable.

Communication by press release and "Executive Summary" (a euphemism for sound-bites directed at those who do not read) is no way in which to do that. What the world needs is a measured critical review of the literature on greenhouse gases and their effects on climate, perhaps covering the period since the last assessment in 1990. That is exactly how the UN Scientific Committee on Energetic Atomic Radiation (UNSCEAR) has conducted its business since its creation at the instance of the government of India in the 1950s. Such a framework is an entirely suitable vehicle for considered opinions on the significance of emerging

trends, and indeed is particularly well-suited to the consideration of the global warming problem, where uncertainties now extant are likely to be removed as the years pass. A useful format for IPCC's reports would be a listing of the continuing uncertainties and a periodic discussion of the extent to which they had been removed.

On this occasion, the press release put out from Maastricht declares that "the scientific consensus established in 1990 by the IPCC on climate science still holds". What does that mean? Certainly not that IPCC or its sponsoring agencies, the UN Environmental Programme and the World Meteorological Organization, were the first to define the global warming issue (which was almost the single-handed creation of Dr Roger Revelle at Harvard University). Unanimity? Nobody denies that carbon dioxide is a greenhouse gas, but argument persists in the research community about the effects on climate. To be persuasive, IPCC must show that it has given these issues the respectful considerations their origins command. Sadly, we shall not know for some time whether that essential obligation has been discharged. □

## Discoveries for Africa

Africa deserves a big share of the pride in early hominid discoveries.

THE interest of the accounts on pages 306-312 and 330-333 of the latest australopithecine species to be recovered from Ethiopia is unlikely to be overlooked. With an age estimated at 4.4 million years, *Australopithecus ramidus* is almost a million years older than *A. afarensis* and that much closer to the probable divergence of the hominid line from that of the Great Apes, estimated by molecular cladists at about 4-6 million years ago. That means that the most conspicuous gap in the pre-human fossil record has been filled even though, as always, the need for further specimens to yield more detail will remain.

Interest and importance apart, it is important that a few temptations should be avoided. The similarity of *A. ramidus* with the chimpanzee, rather than the gorilla, is remarked on by the authors of the new discovery as well as by Dr Bernard Wood (see page 280). That will lead many to conclude that *Pan*, the chimpanzee, was the closest living relative to the early hominids. But that is inference only, absent a better understanding than at present of the course of evolution of

**Sonja A. Boehmer-Christiansen**

CONTROVERSY continues to surround the Framework Convention on Climate Change, signed at the Earth Summit in Rio in 1992. While preparations are under way for the first meeting of the signatories to the convention, due to be held in Berlin next year, the scientific community, represented by the Intergovernmental Panel on Climate Change (IPCC), is already under fire for its delay in coming up with satisfactory advice.

Greater scientific certainty over climate change is unlikely until early in the next century. Indeed, there are doubts over whether we shall ever know enough about climate change in advance of the policy decisions needed to head off potential dangers. But policymakers continue to hope that, with sufficient funding, the appropriate scientific knowledge can be produced according to a timetable.

The climate treaty requires industrial countries to try to stabilize their national greenhouse gas emissions at 1990 levels by the year 2000. No binding targets beyond 2000 have been agreed; indeed, hopes are fading that this can be achieved globally. At Rio, the treaty was left deliberately imprecise to ensure both that the United States signed, and that the entire issue remain open to future research results.

Reductions in emissions have already been achieved, though primarily as a result of the recession and (for example in the former East Germany) deindustrialization. In some countries, the rapid replacement of coal and oil by less carbon-intensive fuels may be sufficient to achieve stabilization of emissions. But energy systems are difficult to turn around, and both development goals and sociopolitical expectations are slow to change.

The problem lies not with nature but with society. Given this fact, why have governments, despite their alleged concern over climate change, concentrated on funding research in the physical sciences to investigate the subject? Are these sciences driving policy — or vice versa?

Taking global warming seriously requires giving attention to issues such as the choice of fuels and technologies, energy pricing and investments'. High economic stakes are involved. As a result, both the climate treaty and its underlying scientific debate have become swept up in global energy politics. The responsibility given to science is great — perhaps too much so for institutions increasingly

dependent on 'soft' contract research income.

Scientists naturally prefer to experiment with mathematical models of the Earth's various systems free of responsibility for policy<sup>2</sup>. Uncertainty is their security. Indeed, some can already be seen withdrawing from policy involvement. For



Demonstration against the UK tax on heating bills—changing social attitudes make more difference than defining energy problems.

others, including the chairman of the IPCC, global warming has become the justification for a crusade against materialism and for a 'new organizing principle' — the preservation of the Earth. Yet global warming could not have entered international politics without the support of influential voices from the scientific community.

How and why did scientists create public concern in the first place? And why was this taken up — far too rapidly for many scientists — not only by environmentalists, but also by governments? The political energy needed to turn a research topic into a treaty with major implications was generated surprisingly quickly, even though it can still be argued that the treaty does little more than codify the research, the data collection and monitoring needed to

underpin future national policies.

Much of the answer lies in shifts in the energy market in the 1980s. During this decade, both the Chernobyl accident and cheap fossil energy challenged forecasts of energy demand, and invited the involvement of energy interests in global politics. Energy prices generally collapsed in the middle of the decade and have remained low. This reversed the situation of the 1970s, when both the expansion of nuclear power and major research and development efforts on renewable energy technologies created major institutional interests. By the 1980s, these institutions found themselves under threat, and therefore began lobbying via well-established channels inside governments, leaving green rhetoric to the media, environmental groups and UN agencies.

Global warming can therefore be said to have gained its political relevance less from scientific evidence and speculation than from the unexpected collapse of fuel prices, which recreated an earlier world of cheap energy. A 60 per cent drop in oil prices occurred only months after scientists had made a sweeping statement on the possible dangers arising from growing fossil fuel consumption. The 'green' energy lovers consequently tried to 'capture' the expected regulatory process, while coal (and to a lesser extent oil, for which substitution was harder) became the main villains.

So far, the oil industry, rather than nuclear power, has been the major winner. With expensive European coal likely to disappear altogether, and the former Soviet Union opening up its resources to the West, natural gas is replacing both coal and nuclear power in unregulated markets. Gas has become the 'rational' choice for generating electricity, with lower fuel and labour costs, reduced emissions, and the added bonus of avoiding further investments in costly acid rain abatement technologies, such as flue gas desulphurization.

Where this strategy aroused protests, the greenhouse effect was cited in justification. When the collapse of oil prices reduced tax revenue, the privatization of electricity became even more desirable. Individuals and firms were urged to invest in energy-saving measures, if only to reduce cost increases. 'No regret policies', rather than precaution, became the response to scientific uncertainty. As a result, policies could be rationalized as

ironmental, even though adopted for other reasons. The nuclear lobby had seemed to reap a greater reward from its investment in research: it now joined a chorus calling for energy prices to 'internalize' the external costs of fossil fuels, inviting subsidies for itself, or taxation for competitors — preferably both.

The British government, for one, discovered that, by changing the fuel mix, pollution control was feasible with the support of industry, leading to lower generating costs. Environmentalists could be accommodated, as well as vocal lobbies supporting energy efficiency and renewables. Still other groups again wanted to clean technologies to industrializing countries — and then promote privatization in order to make profitable investments — or demanded constraints on private mobility. Supporters of the idea of technological modernization saw climate-change policies as steps towards sustainable development. Vast amounts of data on 'global change' would not only serve research, but also make the Earth's surface more visible for all who could afford to use the new Earth observation maps.

Global warming was also attractive to politicians because of its value to both critics and supporters of deregulation policies. In Britain, for example, separate groups pursuing commercial interests, foreign policy goals and domestic politics each discovered their own uses for the warming hypothesis. For some, the opportunities included the pursuit of global scientific research agendas, for others, the enhancement of bureaucratic power at home. Some saw the possibility of thwarting the ambitions of the European Commission (EC) in Brussels by making sure that decision-making powers remain outside EC forums in the hands of less efficient — and poorly financed — UN bodies.

Calls for environmental regulation were generally attractive to environmental bureaucracies. Having been created in the early 1970s, these had remained relatively weak, and often closely tied to research in the natural sciences. Global warming allowed national bodies to expand their influence — both domestically and internationally — while organizations such as the UN Environment Programme (UNEP) and the World Meteorological Organization (WMO) have been able to attract considerably more attention and funding. Furthermore, beleaguered national politicians gained a world stage on which to indulge in global green rhetoric without, as yet, having to face issues of domestic implementation. A climate treaty became desirable to many groups — but not major measures to reduce emissions.

We can now ask how, and why, scientific institutions initiated the debate, and how they subsequently responded to its



Wind energy — beneficiary of the energy crisis and of the global warming debate. These are Mitsubishi turbines under construction at Llandinam in mid-Wales.

politicization. In 1985, a group of research scientists, ecologists, climate and energy demand modellers mainly from Sweden, Canada, the United States and the United Kingdom met in Villach, Austria. UNEP, WMO and the International Council of Scientific Union (ICSU) sponsored the conference, which also attracted support from major environment/energy research bodies such as the International Institute for Applied Systems Analysis, Harvard University and the Stockholm Environment Institute.

Only two government scientists attended this 1985 symposium, one from the UK Meteorological Office, the other from the US Department of Energy. The gauntlet thrown to the world was therefore largely European, the main challengers being contract research institutions with interests in the carbon cycle and climatic variability.

The Villach conference drew the attention of policymakers to the dangers of global warming, and the need for more climate related research. ICSU had just finalized its International Geosphere-Biosphere Programme (IGBP). Developed in the United States during the early 1980s, and adopted by the ICSU in 1986, it would address the problem jointly with the World Climate Research Programme (WCRP), which had been set up in 1979, and was also seeking new tasks.

Warming was a high but uncertain risk. It was also expected to happen soon if — as energy demand forecasters predicted — CO<sub>2</sub> concentrations were to double within decades. This assumption has been incorporated into all existing models and adopted by IPCC, with the United States and the Netherlands providing emission scenarios for the first report in which the dates for such doubling were fixed.

In this context, stringent regulations would be needed to prevent warming, opening up energy markets to 'green' technologies (including fast breeders). Past CO<sub>2</sub> increases made warming intuitively more credible, although cynics pointed out that model predictions can always be manipulated. Several policy measures were recommended, including a

global legal instrument requiring countries to reduce the emission of greenhouse gases, particularly CO<sub>2</sub>.

The Villach conference had been organized by individuals who formed the core of the Advisory Group on Greenhouse Gases (AGGG), a small panel agreed at the conference and meant to advise sponsors, as well as governments. Consisting only of independent (non-government) scientists, it remained a major influence on UN-related activity until 1990.

The message of the Villach meeting spread rapidly, backed up by the Brundtland Report and its message of sustainable development. Diplomatic circles had already been alerted by individuals such as the former British diplomat Sir Crispin Tickell, who studied climate change at Harvard while on secondment in the late 1970s, and has since maintained close links with scientists in Europe and the United States. In the mid-1980s, Tickell helped to persuade the British Prime Minister Margaret Thatcher that global warming was an issue that deserved both her attention and generous funding. He appears to have been equally persuasive with the EC, the United Nations, the British Foreign Office, and ICSU.

With the support of environmentalist networks pursuing their own goals, the new global threat soon flourished. The public became alarmed. Many governments, especially those (such as the United States) who depend on fossil fuel, did not like AGGG, but preferred the WMO, which they are able to influence directly through national representatives.

The WMO decided to 'capture' the AGGG. In 1987, its executive proposed to set up a small body of experts from countries strong in climate-change research, including a small number of people representing other nations and international scientific bodies such as ICSU. The IPCC evolved from this idea during the subsequent politicization of the issue. Formally set up in autumn 1988 by the WMO and UNEP, its activities are controlled by government appointees who, in practice, tend to be influential government scientists with connections to the WMO and other international bodies.



## COMMENTARY

Effective IPCC leadership fell to a small group of committee members, most of whom had strong links to NASA, as well as large national laboratories and meteorological offices. The research networks supporting two of the three working groups which were set up in 1988 already existed as parts of World Climate Research Programme. The first of these, for example, the science assessment group, is managed through the UK Meteorological Office, and funded by the Department of the Environment. The second working group, which is looking at the impact of climate change, was in the hands of the Russians, strongly supported by Australia, but has recently found a home within NASA, with a chairman who advises the US president.

Initially, government officials and representatives of various pressure groups formed the third, less permanent group. This was asked to produce realistic 'response strategies' on the basis of the 'scientific' inputs from the other two groups — even though these were not yet available. Impacts and responses were combined in 1993, with a new group was set up to look at 'cross-cutting' aspects, with contributions from a wider range of social sciences.

In 1990, the WMO informed policymakers that they should consider the consensus views of the scientific community as 'timely assessments' of the climate threat. The IPCC was made available to them as a 'single established source' for information on this subject, and while the committee's task would not be to define or set up research programmes, its recommendations would be of value to the agencies responsible for research — ICSU, WMO and UNEP.

The IPCC 1990 science assessment was produced by Britain, with major assistance from a small group researching ozone science inside NASA. It provided political legitimacy to a national research agenda coordinated globally by ICSU, WMO and UNEP, and already defined — in the context of the warming threat by the ICSU's Committee on Problems of the Environment, SCOPE — for the 1985 Villach meeting.

IPCC reports summarize the findings of its research networks, with drafting and editing carried out by small groups of lead authors. These tend to be selected by the science managers, who also draft IPCC 'policymakers' summaries' — themselves important political documents and skilful exercises in scientific ambiguity. A widely praised 'scientific consensus' of 1990, for example, which assessed the prospects of climate change, used language which simultaneously allowed Greenpeace to call for a target of reducing emissions by 60 per cent, and the UK Treasury to conclude that no action was needed until more scientific certainty was available —

each citing the same source.

A second assessment exercise is in preparation. But the credible regional predictions and emission models so urgently desired by policymakers are not yet available. Global experimentation continues.

So far, there has been little redirection of global energy policy to take account of the potential threat of global warming. This failure could be blamed on the scientific community, on falling energy prices or on politicians. Only if it could be shown that scientists intentionally created a more powerful threat than the evidence suggested, could this lack of response be considered wise. There is some evidence for this, although a responsiveness of 'science' to both internal need and external pressure is surely not surprising.

But, given both the energy politics of the mid-1980s, and the large number of non-scientific actors involved, the rapid politicization of the climate debate occurred in a context of scientific ambivalence, influenced by forces beyond the control of science. Global policy on global warming is emerging from untidy political processes — not through technocratic design. Given the scientific uncertainties that still exist, this may well be for the best.

IPCC has undoubtedly boosted research activities in countries with strong atmospheric, oceanographic and space research capacities. It has also stimulated mathematical modelling of some global macro-economic factors, as well as of carbon emissions related to fuels, demand and technologies. Most of the OECD countries, as well as those in the EU, now possess major global environmental change research programmes which also consider institutions and broader social questions.

There have been rewards to those institutions in advanced countries who, with the help of environmentalists, have been able to link science policy to at least symbolic commitments to the global environment. Furthermore, uncertainties in scientific advice have served the interests of research by reinforcing calls for extra research funds.

But political battles over the knowledge base gave also grown. This may explain the withdrawal of science into adopting a more neutral position on appropriate policy responses than appears to be the case between 1985 and 1992, incidentally the preparatory phase for the Rio conference and for beginning the implementation of the IGBP. Now that the authority of science has been weakened, claims to both policy relevance and truth — as well as the capacity of the natural sciences to deliver policy advice that can be quickly implemented — can legitimately be questioned. The creation of knowledge at increasing rates by a few individuals

engaged in a political game, one of whose primary goals is to obtain funding for their own work, must influence the way that environmental problems are defined and prioritized.

Resistance to universalist and political 'neutral' claims made by Western policymakers in the name of science appears to be growing, while appeals to ethics and issues such as fairness, equity and 'social exclusion' are growing stronger.

In 1971 the American climatologist R. A. Bryson voiced 'a sneaking suspicion' that calls for more data and monitoring prior to the Stockholm Conference were "mostly for the care and feeding of big computers"<sup>10</sup>. He speculated that it would be more appropriate to monitor parameters with a more direct impact on human welfare. In Rio in 1992 it was agreed that the world should be concerned that over 12 million children a year die from preventable diseases. But the types of science and technology that promise commercial competitiveness and political power do not address such issues.

Under pressure, even scientists will deliver what their paymasters prefer: to hear. Honest science may be less useful, in the short term, than relevant science, a lesson that has to be continuously relearned. Policy-related advisory networks need to become more sophisticated and less self-serving — and policymakers to develop broader decision-making structures — to prevent this from happening. This cannot mean listening to green or energy lobbies to the exclusion of all others. Advisers and decision-makers need each other, but knowledge funded by soft money and created under conditions of dictated relevance and competitive bidding is surely unlikely to inspire the degree of trust upon which wise policy must be based. □

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**John Maddox, Editor**  
Nature  
1234 National Press Building  
529 14th Street NW  
Washington, D.C. 20045-2200

Dear Mr. Maddox:

On September 20, the Committee convened a hearing to examine various questions regarding the scientific integrity of the ozone depletion theory. During the course of that hearing, one witness, Dr. Sallie Baliunas, stated that she had encountered a breakdown in the traditions of free and open scientific inquiry related to this issue. She was requested at that point to supply the Committee with specific instances in which her research was inappropriately inhibited. On October 19, she responded to the Committee.

I am writing you to ascertain the facts surrounding one portion of her response relating to the editorial policies of Nature magazine. In part, she asserts the following:

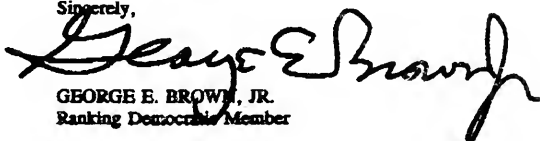
- o In October 1992, she submitted a manuscript relating to changes in the Sun which had implications for global change.
- o The manuscript was held for review for 14 months and went through five different referees and three different editors.
- o Two referees accepted the paper but the editors kept trying to find a referee who would recommend rejection.
- o One reviewer suggested her results were a direct consequence of her funding from a foundation supported by an oil company.
- o This attack was accepted by the editors and the paper was rejected.

Mr. John Maddox  
Page Two  
11/15/95

Although these assertions do not suggest any violation of law, they do imply a lack of objectivity on the part of Nature magazine. If true, this would be an especially troubling aspect of the peer review process that policy makers must depend on.

I would deeply appreciate your review of this matter.

Sincerely,

A handwritten signature in black ink, appearing to read "George E. Brown, Jr.", written in a cursive style.

GEORGE E. BROWN, JR.  
Ranking Democratic Member

## nature

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17 November 1995

Representative George E. Brown Jr  
Ranking Democratic Member  
US House of Representatives  
Committee on Science  
Suite 2320 Rayburn House Office Building  
Washington, DC 20515-6301

Dear Mr Brown:

Thank you for your letter of 15 November, enquiring about the facts surrounding Dr Sallie Baliunas's interaction with *Nature* in 1992-3. In several particulars, the information that Dr Baliunas gave you is incorrect. Although we follow a policy of not disclosing the steps taken in dealing with individual manuscripts, on this occasion Dr Baliunas has in my judgement forfeited the right to privacy, for which reason I am sending you a copy of an internal note to me by Dr Laura Garwin, Physical Sciences Editor of *Nature* for the past eight years.

You will see from Dr Garwin's note that Dr Baliunas has failed to disclose that she submitted four versions of her article at various intervals. The paper was seen by four referees, not five; this number of referees is by no means unprecedented, and the reasons are given in Dr Garwin's note. Two referees did not "accept the paper"; of the four referees consulted, only one (referred to as referee 2 in Dr Garwin's note) finished the review process by recommending publication. Dr Baliunas also misrepresents *Nature* when she refers to a "stated policy" that we accept any paper recommended by two referees; there is no such policy, explicit or otherwise. More damaging is her assertion that we "kept trying until they found a referee who would recommend rejection"; we simply followed the sensible course of going to a person who would be able to judge the technical issues that had by that time become apparent.

Regarding referee 3's mention of the authors' sources of funding, this was not "accepted by the editors"; it was completely irrelevant to our decision. (Nor was it a direct attack on the authors' integrity, as Dr Baliunas suggests. The phrase "it is not science" referred to the fact that the authors had not given any justification for their choice of statistical averaging method, when other choices would have yielded different outcomes.) The decision to reject the paper was made on purely technical grounds, which the authors have never chosen to rebut.

[more]

Representative George E. Brown Jr  
17 November 1995  
page 2

I shall send a copy of this letter and its enclosure to Dr Baliunas. We understand that Dr Baliunas's letter does not form part of her testimony, but if a reference to it is made in the record, we would naturally be grateful if this response could be similarly referred to. Naturally, one of my colleagues or I would be glad to provide you with a formal rebuttal if you wished for that.

You may think this a trivial matter, but we pride ourselves on the care with which we deal with authors' manuscripts and are naturally angered when what we do is misrepresented.

Yours sincerely,



Sir John Maddox  
Editor

John Maddox from Laura Garwin

10 November 1995

**History of Zhang Z10772B**

Paper arrived 26 Oct 1992 -- assigned to David Lindley. At that point a related paper (Lockwood L04771A) by some of the same authors (Skiff, Radick, Baliunas and Lockwood were on both papers) was still under consideration; it was accepted on 29 October (published 17 December). The Lockwood paper looked at brightness variability in 33 Sun-like stars and concluded that the Sun is in an unusually steady phase (as regards brightness, although not as regards chromospheric magnetic activity), compared to these others. They speculated that there might be times when the Sun exhibits much larger brightness changes.

In Zhang Z10772B, the authors refined their comparisons of the Sun and Sun-like stars and found a correlation between chromospheric activity, luminosity (brightness), and sunspot number, allowing them to reconstruct the Sun's brightness back to the time of the Maunder minimum. They concluded that solar brightness changes have been substantial (as much as 0.7%), and that climate changes such as the Little Ice Age and the recently observed warming trend can be accounted for entirely by solar variability. (So no need for an enhanced greenhouse effect.)

The paper was rejected on 9 December (just over five weeks from submission) with a letter saying that "neither reviewer finds the reasoning...persuasive". Both referees said that the arguments depended on assumptions that were not clearly stated or explored; both also found the conclusions speculative. We concluded that "a more sophisticated and comprehensive treatment [would be] needed, both to justify the selection of a subset of stars from the overall sample and to give a proper accounting of all the uncertainties and variables involved."

On 30 December, the authors submitted a revised version, with responses to the referees. By this time David Lindley had left *Nature*, so Karl took the paper over. One of the original referees (let's call him referee 0) was unavailable, so we went back to the other one (referee 1), plus a replacement for referee 0 (referee 2). Referee 1 still had reservations about the statistics, but felt that they could be dealt with by further revision. Referee 2 recommended against publication, but largely on the grounds of clarity -- although he may also have had worries about the statistics (referee 2's report wasn't very clear). Karl felt that there "could well be something for us here", and gave the authors an open-ended decision (P+Q) on 20 April 1993.

...p.2

On 5 May we received a further revised version, with an explanation of how this paper related to the Lockwood paper (this had been a source of confusion for us and our referees, as the relationship between the two papers was not very clear and seemed to be contradictory). We went back to referees 1 and 2. Referee 1 felt that his reservations about the statistics had not been adequately addressed, and recommended against publication. Referee 2 recommended publication but of a version that we did not see! (He sent us a fax saying he recommended publication of a version dated 28 June, whereas the version we had been sent arrived in our office on 5 May. He had also been in direct discussion with the authors, and we were not told the substance of their conversation.) Karl must have been away when it became time to make a decision, so Phil gave the authors another open-ended decision (P+Q) on 22 September, saying that "we cannot offer to publish the paper unless [the relationship between it and the Lockwood paper] can be clearly resolved in a further revised manuscript".

On 11 October the authors submitted a final revised version. Finally, the methodology was sufficiently clear for Karl to understand what they had done, and how it related to the Lockwood paper. He decided that we needed a real statistician (referee 1 is a climate expert who uses statistics in his work, but not a professional statistician) to evaluate the methodology. The statistician (referee 3) found the paper to be seriously flawed (and, incidentally, an insufficient advance on previous work), and we rejected it on 31 December.

So, contrary to Dr Baliunas's assertions, only one (not two) of our three referees recommended publication. The time between original submission and final rejection was indeed fourteen months, but in that time the paper was revised three times and underwent four rounds of review. The first decision was made in five weeks. The paper was seen by four referees (not five). It was handled by three editors because David Lindley left *Nature* at the end of 1992. (It is quite common for a file to be handled by more than one editor during its life, as we routinely handle the files of colleagues who are away from the office.)

Far from "trying [to find] a referee who would recommend rejection", there are two identifiable junctures in the file's history where the editor concerned could justifiably have rejected the paper but chose to give it another chance. The first was in April 1993, when Karl decided that there "could well be something for us here"; the second was in September of that year, when Phil decided to give the authors another chance, though referee 1 was inclined not to do so.

...p.3

Finally, the quote from referee 3 regarding Dr Baliunas's sources of funding was most certainly not a factor in our decision regarding the paper. We regret the fact that Dr Baliunas felt insulted by it, and in retrospect perhaps we should have dissociated ourselves from the comment, but it is completely irrelevant to the rejection of Dr Baliunas's paper.



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1730 M STREET, N.W., SUITE 502  
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December 18, 1995

The Honorable George Brown  
U.S. House of Representatives  
Washington, D.C. 20515

Dear Congressman Brown:

Sir John Maddox sent me copies of his letter and the memo by his colleague, Laura Garwin, regarding *Nature*'s review of our paper on solar brightness changes.

Sir John indicates that the handling of our manuscript, which extended over a 14-month period, was not unprecedented. This is not so in my experience. As I stated in my letter to Congressman Rohrabacher, I have published more than 125 papers in peer-reviewed scientific journals, including *Nature*, and the treatment of this manuscript by *Nature* is unique in my professional experience.

To clarify an issue raised by Dr. Garwin: There were five reviewers of the paper, not four. Dr. Garwin noted reviews by four referees: Referees 0, 1, 2 and 3. However, Referee 2, who chose to reveal his identity to us (he was Dr. O.R. White of the High Altitude Observatory), sent both to us and to *Nature* an E-mail on 3/23/93 saying, "In reviewing your paper for *Nature*, I had several discussions with Dr. Andy Skumanich about your results and the analysis. He had originally been asked to be the third referee, but declined because of time constraints. His counsel has been invaluable ..."

Thus the comments by Referee 2 (White) actually were the product of two reviewers — White and Skumanich. *Nature* knew of this development from White's E-mail of 3/23/93 and apparently accepted it. Skumanich is a competent referee for our paper and we have no complaint about this. However, the bottom line is that a total of five reviewers actually generated the reviews sent to us.

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The more serious issues relate to the handling of our manuscript by *Nature*. A review of Sir John's materials and a re-examination of our file on this matter leads me again to the conclusion that the handling of the peer review process for this manuscript was highly unusual on the part of *Nature's* editors and at least one reviewer. The record also suggests that this unusual treatment was related to implications read into our results (although not contained in our manuscript) to the effect that global warming could be explained as the product of natural factors of climate change — in this case, the sun — instead of manmade greenhouse gases.

These conclusions are based on the following irregularities in the review process.

1. Dr. Garwin's memo indicates that *Nature* selected a climate expert — designated as Referee 1 by Dr. Garwin — as one of two reviewers of our paper. Why did *Nature* choose a climate expert? *Only one sentence of the original manuscript referred to terrestrial climate.* The paper is concerned entirely with stellar astrophysics and solar variability. A climate expert can know little or nothing about the basic facts, current literature, and observational and theoretical methodology in those fields, and cannot serve as a competent referee for this paper.

2. Referee 3 referred explicitly in his review to the paper's "implications for the global warming debate." By this time we had already dropped the single sentence that mentioned climate, so that the paper contained no hint whatsoever of a climate connection. Referee 3 had no reason to view the paper in the context of the politically sensitive global warming issue, or any climate question; or, in fact, as anything but a contribution to stellar and solar physics. Yet Referee 3 did so. The fact that he did indicates that Referee 3 was giving the paper a political rather than a technical reading.

This impression is confirmed by the further statement in Referee 3's review in which he suggested that we had fraudulently doctored our main result because one of our funding sources (the Mobil Foundation) was connected to the oil industry. This remark by Referee 3 indicated a biased reading of the paper, which taints his technical comments. *Nature's* editors should have replaced this referee as soon as they read that statement suggesting that our results had been doctored to suit an oil industry sponsor. Dr. Garwin writes, "Perhaps in retrospect we should have dissociated ourselves from the comment," but dissociation would not have been enough. The taint of that political reading should have been removed from the review process by the replacement of Referee 3 with another referee.

In sum, these circumstances indicate that *Nature's* editors and at least one referee were reading into the paper's results a politically sensitive implication — the importance, or lack thereof, of manmade global warming. They were not handling it as an analysis in stellar astrophysics and solar physics, although 100% of the paper's content was in those fields and 0% dealt with climate.

One other feature of the *Nature* review was also highly irregular, and surely a departure from normal procedures of peer-review. As of 4/20/93, Referee 1 had agreed with our response to his principal criticism of the original manuscript, and had conditionally accepted the revised version. He wrote, "I recommend publication subject to the author's dealing with the following issues, which," he wrote, "should be relatively easy to deal with."

Five months later, he reversed himself and recommended rejection. Why did he change his mind? In the interim, someone — either *Nature*'s editors or Referee 2 — had given him Referee 2's comments. The materials forwarded to us by *Nature* indicate that these materials had affected his thinking. How do we know this? Because Referee 1 wrote in his review received by us from *Nature* on 9/22/93, that his reservations "*have been echoed and amplified by the other referee* (emphasis added)."

The point to having two or more referees is to secure *independent* reviews. When Referee 1 was given access to Referee 2's review, Referee 1's review was no longer independent — as Referee 1 explicitly acknowledges in the passage quoted above.

3. Sir John states that the rejection of the paper was on "purely technical grounds," connected with our "choice of statistical averaging method." The latter comment was taken from the review by Referee 3, who is described by Dr. Garwin as a professional statistician. This comment by Referee 3, is without merit. We would have been delighted to rebut Referee 3's comments on our statistical procedures and demonstrate that, but we were not given the opportunity to do so.

Finally, as a confirmation of the high technical quality of our manuscript and the correctness of its statistical analyses, I note that after rejection by *Nature* the paper was submitted for publication in the *Astrophysical Journal* and accepted seven weeks later. Furthermore, there were no critical comments by the reviewer on our statistical analysis. The *Astrophysical Journal* covers a narrower field than *Nature*, but it is the leading publication in the world in the field of astrophysics — as prestigious as *Nature* within its larger field — and its editors pride themselves as much as *Nature*'s editors on the care with which they deal with authors' manuscripts.

Sincerely,



Sallie Baliunas  
Senior Scientist

cc: Sir John Maddox  
Congressman Robert Walker  
Congressman Dana Rohrabacher

Followup Questions Submitted to The Honorable Joseph F. Vivona—Enclosure 2: Page 6 of

15. On page 469 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Up to 35 million metric tons of potential carbon equivalent emissions will be reduced, helping the country meet its energy needs without harming the global environment."

Please document the claim of reductions of "[u]p to 35 metric tons", including accompanying assumptions.

16. On page 469 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request*, it is stated: "Over this period [to 2010], the export market potential for renewable energy technologies is greater than \$1 trillion."

Please document this statement, and clarify whether or not the export market potential referred to above encompasses only renewable technologies or all electrical generating capacity.

17. Page 470 of Volume 2 (of 5) of the *FY 1997 Congressional Budget Request* contains the following performance measures for renewable energy technologies for the year 2000:

| <u>Technology</u>        | <u>Performance Objective</u>  | <u>Cost Reduction Goal</u>   |
|--------------------------|---|--|
| Photovoltaics            | 500 megawatts installed domestically and 200 megawatts overseas.  | 10 to 15 cents per kilowatt-hour from the current level of over 20 cents.  |
| Solar Thermal Electric   | 400 megawatts domestic and 200 megawatts overseas.  | Less than ten cents per kilowatt-hour from approximately 17 cents (solar only mode) today.                         |
| Wind                     | 3,700 megawatts domestic and 4,000 megawatts overseas.  | 2.5 cents per kilowatt-hour for good wind areas from the current four to five cents.                               |
| Geothermal               | 500 megawatts domestic and 2,500 megawatts overseas, installed or under development. Reduce electric peak loads by 2,000 megawatts from domestic Geothermal Heat Pumps. | 3.5 cents per kilowatt-hour for average grade resources compared to current 5 to 8 cents per kilowatt-hour.        |
| Biofuels                 | 1,200 megawatts of new electric power domestic, and 800 megawatts overseas; 600 million gallons of biomass-derived transportation fuels produced per year.              | Reduce the cost of ethanol from biomass by 50 percent by the year 2010 from the current cost of \$1.22 per gallon. |
| Solar Domestic Hot Water | Increase market penetration by 40 to 60 percent.  | 25-40 percent reduction in installed cost.   |

# 'Ozone hole' fails to materialize as feared, NASA says

A. P.

5/1/92

THE ASSOCIATED PRESS

The dread "ozone hole" never materialized over the Northern Hemisphere last winter despite early findings of huge amounts of ozone-destroying chemicals in the air, NASA scientists reported yesterday.

Not only that, but other government scientists announced that bacteria found in Potomac River mud can eat up the very chemicals that have alarmed environmentalists in recent years by attacking the Earth's ozone layer.

The NASA scientists, reviewing results of seven months' observations, said that after a record buildup of ozone-damaging chemicals last January, the amounts rapidly dissipated because of sudden warming in February and March.

While the tests continued to show a thinning of the ozone layer that protects the earth from ultraviolet rays, the sudden warming prevented any severe ozone depletion over the Arctic region, the scientists said.

Nevertheless, they said, the potential for severe ozone destruction over parts of the United States, Canada and Europe remains a matter of serious concern because of the high concentrations of destructive chlorine that were detected.

"With so much chlorine in the stratosphere, a slight temperature difference can make an enormous difference in the potential for ozone depletion," said Joe Walters, one of the NASA scientists involved in the ozone observation program.

Chlorine monoxide, a man-made chemical byproduct, reacts chemically to destroy ozone. Scientists have found that its destructive potential is greatest in cold weather when there are ice crystals.

The scientists, part of a team assembled by the National Aeronautics and Space Administration, said that while the ozone hole that had been feared never materialized, there was still a 10 to 20 percent ozone loss over the Northern Hemisphere last winter.

"It [was] not an ozone hole," added James G. Anderson, a Harvard University professor of chemistry and a NASA project scientist, but "the amount of ozone destroyed this year is still significant."

Meanwhile, the U.S. Geological Survey reported yesterday that sci-

entists probing river muck have discovered bacteria that can eat chlorofluorocarbons, the main chemicals threatening the ozone layer.

The bacteria that break down chlorofluorocarbons, known as CFCs, were found along the Potomac River in Virginia and in pond, marsh and swamp sediments in Maryland, South Carolina and Virginia, officials said.

In recent years scientists have blamed CFCs for much of the reported damage to the ozone layer.

The CFC-eating bacteria are harmless to humans, but can operate only in the absence of oxygen, according to Derek Lovley, a microbiologist working at the Geological Survey in Reston.

Oxygen-free environments exist worldwide in swamps, marshes, rice paddies and other wetlands, he noted. In addition, CFC-containing products are often disposed of in landfills, which are also oxygen-free.

Mr. Lovley said he grew a mix of bacteria from the sediments in the presence of levels of CFCs found in the atmosphere, and some of the chemicals were destroyed by the bacteria. The test was part of a series of experiments involving the ability of bacteria to eliminate contaminants, he said.

Previously, it had been thought that bacteria could not degrade CFCs, he said. "But we knew that similar chemicals are degraded by bacteria, so we thought that maybe it just hadn't been tested in an [oxygen-free] environment," he said.

Mr. Lovley and hydrologist Joan C. Woodward reported their discovery in the May issue of *Environmental Science and Technology* magazine.

As the CFCs circulate in the lower atmosphere they penetrate slightly into wetlands and soils, giving the bacteria a chance to destroy at least some of the chemicals. And since the chemicals can remain in the air for many years, "mechanisms that remove even a minor fraction of the CFC-11 and CFC-12 in the lower atmosphere will have a significant long-term impact on the amounts that reach the stratosphere," Mr. Lovley said.

American Academy of Dermatology



NATIONAL CONFERENCE ON  
ENVIRONMENTAL HAZARDS TO THE SKIN  
OCTOBER 15-16, 1992

COMPREHENSIVE POSITION STATEMENT



## Introduction and Purpose of the Conference

The American Academy of Dermatology's National Conference on Environmental Hazards to the Skin, October 15-16, 1992, in Washington, D.C. was the first comprehensive meeting to discuss effects of the world's deteriorating environment on the skin.

Wilma F. Bergfeld, M.D., president of AAD, was chairman of the Conference. Presenters included 30 experts in the fields of medicine, environmental issues, government regulation and research. These experts also participated in developing a consensus statement leading to an action plan.

The Conference explored three different environmental areas including the issue of ozone depletion and other atmospheric hazards; occupational/man-made hazards; and naturally occurring hazards to the skin.

Generous corporate support for this program was provided by the following sponsors: Roche Dermatologics, Ortho Pharmaceuticals Corporation, Dermik Laboratories, Inc., Unilever Research U.S., Chesebrough-Ponds U.S.A., Warner Lambert Company, United States Environmental Protection Agency, The Procter & Gamble Company, Neutrogena Dermatologics, The Andrew Jergens Company, Schering-Plough Healthcare Products, Cosmair, Inc.

## Executive Summary

This report summarizes the deliberations of the two-day meeting. The objectives of the conference were:

- To define a set of wide-ranging issues related to skin and the environment;
- To begin to define the magnitude of the problem; and
- To have a set of consensus panels address the needs and opportunities for increased research, education, prevention and legislative action.

The first half-day was devoted to the status of ozone depletion in the atmosphere which leads to increased ultraviolet B (UVB) at the earth's surface with consequent increases in skin neoplasms, including melanoma. The next half-day speakers discussed some of the natural plant, marine animal and terrestrial animal effects on human skin. On the final half-day experts discussed the man-made, especially the industrial hazards which affect the skin.

A supplemental meeting report summarizes scientific deliberations and has more detailed versions of the recommendations. The needs summarized are in research, public and professional education which relate to educational programs, preventive programs, and research applicable to more than one set of these environmental hazards. These needs offer the AAD new opportunities to educate the public-at-large.

This summary highlights the major recommendations of the supplemental report and includes recommendations for the atmospheric hazards, other natural hazards and the man-made hazard sections of the report. The detailed body of the report should be reviewed to obtain supporting data and for more detailed versions of the initiatives which should be addressed.

### A. Research Needs:

1. Better definition of environmental changes and the extent of dermatology-related problems due to environmental factors.
  - Improved quantification of the changes in UVB at the earth's surface related to alterations in the ozone layer.
  - Improved surveillance reporting and investigation of environmentally and occupationally caused skin diseases. Identification of the pertinent risk factors for disorders such as irritant and allergic contact dermatitis and skin tumors including melanoma. Use of cohort studies to find the real prevalence of pesticide-induced skin disease.
2. Definition of the basic mechanism of environmentally-caused disease.
  - Definition of the action spectra for the production of melanoma.
  - Further evaluation of action spectra for nonmelanoma skin cancer.
  - More precise definition of the effects of acute and chronic exposure to UVB and ultraviolet A (UVA) on skin, the immune system and adaptive and repair functions of skin after UV injury.
  - Determination of the genetic factors predisposing to skin cancers and melanoma, contact dermatitis and irritant dermatitis and definition their molecular basis.
  - Characterization of the plant allergens causing contact and photocontact dermatitis and urticaria and definition of the molecular basis of their action. Development of new patch tests for plant agents including sesquiterpenes.
  - Delineation of the mechanism by which marine venoms and toxins (e.g., brown recluse spiders) injure the skin.
  - Development of better information about the cutaneous and systemic toxicity of agents before they are introduced into the environment. Development of systems for reporting on the toxicity of

new agents to the appropriate governmental agencies.

- Encouragement of motivational research to get optimum acceptance of prevention programs.

#### B. Development of New Protective, Preventive and Therapeutic Agents:

- Development of better sunscreens and other photoprotective agents including establishing optimum guidelines for their use.
- Development of new barrier preparations for contact and irritant dermatitis.
- Development of new plant varieties which lack highly allergenic compounds.
- Development of new antisera vaccines and diagnostic agents for toxic arthropod reptile toxins.
- Development of new broad-spectrum antimicrobial agents for topical use including the development of new preservatives for skin preparations.
- Increased research on physical and chemical engineering to improve the handling of toxic substances by workers.
- Further studies to optimize protective clothing.

#### C. Prevention by Education and Early Disease Detection:

- Development of better measures to assess the effectiveness of mass skin cancer screening programs.
- Encouragement of sun avoidance and avoidance of sunburn. Determination of the effectiveness of programs to have daily "sun intensity" measures broadcast by local media to decrease sun exposure.
- Continuation and increased emphasis on skin cancer screening programs including more active participation of senior citizen groups. Encouragement of programs which will allow treatment of skin cancers in patients who are underinsured or economically disadvantaged.

#### D. Public Education

- Development of a major program in public education on the "ABCD" rules for detecting melanoma with media, milk carton panels and mass media.
- Development and coordination of enhanced programs in sun education, plant hazards and marine hazards for the pediatric age group. This should include support of education by pediatricians and school nurses with pamphlets, videotapes, game kits, etc.
- Establishment of goals that by graduation from the eighth grade students should know principles of sun

protection, be able to identify the most allergenic plants and know how to identify and avoid the major poisonous and venomous creatures in the United States.

- Incorporation of health and safety concerns about the workplace environment in school and college health programs.
- Education pamphlets and videos for waiting rooms on the environment and effects of changes in the ozone layer.
- Special education programs for older Americans (especially for men who in the past, in contrast to women, have neglected to examine their skin). Determination of medical specialties, (internal medicine, urology, etc.) and community sites having potential for such education.
- Alerting the public to the danger of tanning salons.
- Development, support and encouragement of programs for workers and management on proper techniques of personal hygiene to minimize occupational risks in the workplace.

#### E. Physician Education

- Increased education on the effect of the environment, including the work environment on the skin, at all phases of undergraduate and postgraduate medical education.
- Development of computer-linked databases for occupational and environmental hazards with listing of resource individuals for usual and serious conditions.
- Emphasis of all environmental education in dermatology residency training programs and strong encouragement of active programs in patch testing in the residencies.

#### F. Public Action:

##### 1. Coalitions

- Leadership in coalitions to increase funding for health research related to the environment. Association with all national and international medical organizations actively working to improve the environment.
- Involvement with senior citizen groups with respect to setting standards for environmental health. Active support of skin cancer screening efforts. Inclusion of preventive care as a guaranteed part of the Medicare program.
- Participation with groups such as the American



Cancer Society, Centers for Disease Control, Skin Cancer Foundation and senior citizen groups to expand and enhance educational efforts. Institution of a formal clearing house or a formal coalition of these groups and organizations for this purpose.

- Establishment of "Industry-AAD" roundtable with the sunscreen and sun protective manufacturers and the AAD (FDA could also be included) so that the needs and specifications for new products can be discussed.

## 2. Legislative and Regulative Action

- Tighter regulation of the tanning booth industry including prohibiting the use of tanning facilities by minors, informing the public of the risks, limiting total dose people can be exposed to.
- Testimony at all the appropriate congressional committees to get increased funding for those governmental/regulatory agencies which support research on the environment.
- Support of all national and international measures to decrease the production and spreading of ozone depleting chemicals in to the environment.
- Modification of FDA rules to encourage the development of new topical agents and vaccines for poison ivy and poison oak.
- Setting of threshold limits for allergen release for consumer and environmental products known to have significant skin hazards. Development of maximum allowable levels of exposure to irritants.
- Support of the 1988 National Institute on Occupational Safety and Health (NIOSH) strategy document.
- Detailed labelling of all products which come in contact with human skin including beauty salon products and over-the-counter products.
- Increased supply of allergens available for diagnostic contact dermatology testing.
- Assurance of a full-time occupational dermatologist on the staff of NIOSH.

## Other Actions at the Environmental Conference:

- Passed resolution supporting the acceleration of the ban on ozone depleting chemicals and sent to AAD president for signature.
- Passed resolution of Dr. June Robinson concerning the availability of care for underinsured patients with cancer

which was detected in the AAD skin cancer screening program. This was forwarded to president for presentation to the Board.

## AAD Vision and Mission Statement on the Environment

The skin is the body's major interface with the environment. The dermatologist has a special responsibility for advocating and insuring a healthy environment with respect to those factors which affect the skin. Those factors include the ozone level in the atmosphere, natural plant and animal toxins and allergens, and occupational and man-made chemicals which adversely affect the skin. The AAD accomplishes those missions by a comprehensive program of professional and public education, the encouragement of basic and clinical research into the effects of these agents and the prevention of their effects, and when necessary, the encouragement of new legislation. The AAD works closely with other organizations having similar aims.

## What the AAD has Done Concerning the Environment

1. Suntan parlor legislation
2. Skin cancer screening
3. School curricula on sun protection
4. Medical waste policy
5. Advisory council resolutions on ozone layer; need to seek legislation to decrease release of CFC and encourage substitutes and to support all scientific efforts to monitor UVL levels.
6. National Conference on Environmental Hazards to the Skin.

## AAD Organizational Proposals

It is proposed that the Academy's Committee on Organizational Structure consider the establishment of a Council on Skin and the Environment. Under this Council could be placed all current task forces and committees dealing with this issue.

In addition to the above, it is recommended that a new task force on Cancer as an Occupational Disease be instituted. Again, this entity could be placed under the new Council on Skin and the Environment.

The organizational entities dealing with environmental concerns should seek to establish coalitions with other medical, industrial, governmental and public groups having an interest in this area.

## Atmospheric Effects on the Skin

### I. Introduction

There are ever increasing public concerns that the atmospheric changes leading to a decrease in the ozone layer will lead to further acceleration in the current rapid increases in the rates of skin cancer including melanoma.

Sunlight is one of the natural hazards to our skin and cannot be avoided; however, many of these dangers are also sources of pleasure and balancing and assessing risk and benefit ratios have to be considered. The sun is necessary for life to exist on the earth; it provides joy by warming our bodies and souls on winter days; however, over-exposure to sunshine will surely cook our skin. Children who have had repeated, severe sunburns may develop malignant melanomas 20-40 years later. Today's happy beach boys and girls are tomorrow's dyschromic, wrinkled and wizened older adults who require dermatologic care for their keratoses and skin cancers. Skin cancers including melanoma, and frequent sunburns will undoubtedly become more common in the near future as the ozone is depleted by the chlorofluorocarbons (CFCs) and volcanic emissions, allowing more ultraviolet light B (UVB) to reach the earth's surface. The availability and advertising by the tanning parlor business is a dangerous sop to human vanity. Tanning salons do not give a "safe" tan; 30 minutes under the lamp will cause damage nearly equivalent to three hours of intense sunshine.

#### *Increase in Melanoma and Skin Cancer:*

The incidence of malignant melanoma is now increasing faster than any other cancer in the United States and worldwide. The death rate from melanoma for men is also increasing faster than any other cancer in the U.S.

Of considerable concern is the fact that melanoma is being seen in younger and younger persons. Melanoma is the most frequent cancer in women ages 25-29, and the second most frequent (after breast cancer) in women ages 30-34. Similar increases have been noted in Europe and Australia in this age/gender group.

This worldwide trend of increasing melanoma and nonmelanoma skin cancer rates suggests that global factors are influencing these effects. Although lifestyle changes (e.g., increased leisure time) have provided a significant influence on skin cancer increases, ozone depletion may play an important role for future increases.

#### *Ozone:*

The relationship between ozone depletion and skin cancer is complex. Increased sun exposure leading to skin cancer was noticed first almost 100 years ago. Ozone acts as a filter of ultraviolet radiation from the sun striking the earth. However, the effects of ozone are selective in that it totally blocks the shorter wave ultraviolet C, partially filters ultraviolet B, and provides minimal protection from ultra-

violet A. Therefore, small changes in ozone result in the greatest changes in ultraviolet B. Levels of ultraviolet B penetration in the earth's surface are most important in determining skin cancer effects.

Recent studies have shown that ozone depletion is occurring. This loss is not merely limited to Antarctica, the site where the "hole" in the ozone layer was first noticed. A 3-5% decrease in ozone over the last ten years has been noted in the northern temperate latitudes. The major causes of ozone depletion are related to human activity. Chlorofluorocarbons used as refrigerants and propellant gases catalytically destroy stratospheric ozone. Even with a total ban on the use of these chemicals by the year 2000, it will take 50 to 100 years to achieve resolution of the ozone holes in Antarctica and temperate latitudes. Despite the most stringent controls on CFC emissions, ozone depletion will continue to worsen for at least the next 20 - 40 years.

Quantitative predictions on the effects of ozone depletion on skin have been made since 1971 and are being improved as new data are becoming available. The EPA estimates that 12,000,000 additional cases and 210,000 additional deaths will occur from ozone loss due to CFCs during the next 50 years. The most recent prediction by the United Nations Environmental Program (UNEP) is that a 1% decrease in ozone will ultimately lead to a 2-3% increase in the incidence of nonmelanoma skin cancer. Melanoma rates are also directly related to UVB exposure. However, the dose-effect relationship is complicated and the measurements of ground UVB levels are inconsistent. Pollution, cloud cover and other factors also make these calculations not straightforward. Therefore, specific quantitative predictions of the degree of increase expected in skin cancer are difficult to make at this time.

Ultraviolet B has also been shown to locally and systemically suppress specific immune functions in mice. In model animal systems, UVB radiation suppresses the generation of delayed or contact hypersensitivity responses, including responses to vaccines, infections and UV-induced tumor antigens. UVB can also inhibit the immune response to potent allergens in humans. Of concern is recent information that pigmentation may not be protective against UV effects on the immune response in humans.

#### *Economic Implications:*

The economic implications of ozone depletion and other atmospheric effects on the skin will also continue to grow. Increased medical costs including physician visits and hospitalizations will be seen with the increased incidence of skin cancer, other photosensitivity related disorders and immune suppression.

Nonmedical consumer costs may also be elevated by the increased necessity for the use of sunscreens. Several hundred million dollars are currently spent annually on sun

protection products and this amount will surely increase. Sales of protective clothing and other sun protection devices increase as their necessity becomes more evident.

Increased levels of UVB will lead to increased photoaging of the population with subsequent expenditures on beauty and "anti-aging" formulations also rising.

Finally, there may be impact on the travel and leisure industry as concerns about sun exposure may lead to fewer trips to sunny vacation areas.

There may be additional long-range economic implications for industries in providing extra protection for their fair-skinned workers. The timing of outside work and recreational activities may have to change.

## II. Needs for Future Research

The need for research in ozone depletion and its effects on the skin will become increasingly important in the future. In order to accurately assess the overall impact on health, quantitative analyses are needed to determine UVB radiation effects on mechanisms which regulate the health of the skin. This new phase of quantitative questions will require full utilization of existing research capacity. A major expansion in this direction is essential. More specific research needs include:

### *Dosimetry and Action Spectra:*

1. Quantification of the specific ultraviolet radiation levels that reach the earth's surface using both satellite and ground-based data in a formal national program.
2. Development of dose - effect relationships and action spectra of ultraviolet radiation in terms of melanoma and nonmelanoma skin cancer risk.

### *Epidemiology:*

3. Quantification of specific health risks of ultraviolet radiation injury in terms of mechanisms, incidence, disease/morbidity, and economic costs.
4. Better quantitative measures of melanoma and nonmelanoma skin cancer incidence.

### *Biological Measurement of UV Effects:*

5. In terms of melanoma and nonmelanoma skin cancer, assessment and investigation of the UV dose relationships in animal models and determination of the influence of other parameters such as hormonal, immunological and promotional factors on cancer development.
6. Development and evaluation of prospective markers for future melanoma incidence rates such as age cohort adolescent nevus count studies.
7. Assessment of the role of UV immunosuppression in melanoma and non-melanoma skin cancer development. Clarification of the extent and degree of immunosuppression in humans caused by acute and chronic expo-

sure to natural and artificial light.

8. Evaluation of the role of UV immunosuppression in infectious diseases, AIDS and vaccine program effectiveness.
9. Evaluation of adaptive, repair and biologic mechanisms to ultraviolet damage in the skin.
10. Study of the phenomenon of the long latent period between childhood exposure and the subsequent development of melanoma.
  - a. Understanding in molecular terms how light causes chronic damage to skin.
  - b. Determination of the genetic basis for susceptibility to melanoma and nonmelanoma skin cancer development.
  - c. Identification of genes, cytokines, chemicals, and/or metabolic pathways that can modulate the acute sunburn response.

### *Improved Sunscreens:*

11. Development of improved and more cosmetically acceptable sunscreens with better broad spectrum (UVA & UVB) protection to lessen increased ultraviolet damage from ozone depletion.
12. Development of more accurate measures of UVA and UVB protection in sunscreens. Also consideration of a floor, rather than a cap on SPF values.
13. Development of other (nonsunscreen) methods for sun protection and for reduction of DNA damage, such as new clothing design and materials.

### *Preventive Programs:*

14. Better measures of the effectiveness of mass skin cancer screening programs.
15. Development of a national program to provide a local "sun intensity" index for distribution to the media to alert the public and increase public awareness.
16. Development of appropriate guidelines for sunscreen usage, sun avoidance and protection measures, especially for children, adolescents and teenagers.
  - a. Definition of chemopreventative agents useful in reducing acute and chronic UV effects, including skin cancer production, by topical application and/or suppression.

### *Advanced Melanoma:*

17. Development of a cure for metastatic malignant melanoma given the fact that more of these lesions will be seen as a function of prospective ozone depletion.

### III. Needs for Future Education

Melanoma and nonmelanoma skin cancer are perhaps the most clear cut case of cancers where early detection and treatment are key. If these cancers are caught and treated early, they are virtually 100% curable. However, when the lesions are advanced, morbidity and mortality can ensue.

The best way to detect melanoma early is to increase public and physician awareness of the problem. The "A,B,C,D" rules of early detection in melanoma have helped in this regard. ["A" — Asymmetry. One half of a lesion does not match the other half. "B" — Border irregularity. The edges are ragged, notched or blurred. "C" — Color. The pigmentation is not uniform. "D" — Diameter greater than six millimeters (about the size of a pencil eraser). Any growth in size of a lesion should be of concern.] Programs in Scotland and Australia have shown the value of public education programs and mass screenings in terms of lowering mortality and morbidity from melanoma. The 1992 National Institutes of Health Consensus Conference report on the detection and treatment of early melanoma confirms the value of these screening programs and suggests their increased future use.

Other items that may increase the effectiveness of education in this area include:

- 1) Development of preventive surveillance systems such as melanoma risk models to identify those at highest risk for developing the cancer so that educational efforts can be designed.
- 2) Development of an educational program for pediatric sun protection. Since almost 80% of skin cancer risk occurs prior to age 20, this age group must be targeted. Materials for distribution to mothers during perinatal visits and in newborn nurseries are also needed.
- 3) Creation of a brochure for patients and the public about the relationship of skin cancer and ozone for physicians' waiting rooms and meetings to demonstrate dermatology's concern.
- 4) Development of programs targeted to older Americans. An example of successful dissemination is the SKIN CANCER PREVENTION program of the American Academy of Dermatology which has been ongoing since 1985. Volunteer clinical dermatologists have uncovered a large number of early skin cancers. But this is only a small proportion of the 600,000 skin cancers that are treated each year and the probable 200,000 - 400,000 unrecognized cases. What is needed is a coordinated national program to promote awareness, patterned on the experience in Australia.
- 5) Alerting the public to the dangers of tanning salon use. This warning should be an integral part of all skin cancer prevention programs.

### Prevention:

Both short and long range efforts to improve prevention of melanoma and nonmelanoma skin cancers will also be important in the future. Related areas include:

1. A national education effort targeted to the general population with emphasis on high risk persons.
2. The American Academy of Dermatology Skin Cancer Screening Program has evaluated over 600,000 persons in the past eight years with thousands of skin cancers detected. Enhanced secondary prevention efforts to detect skin cancer and increased public awareness are needed.
3. Support and treatment should be sought for uninsured, economically disadvantaged persons who have skin cancers detected through the screening efforts.
4. Increased involvement in environmental efforts.
5. Initiation of steps to make sun protective products available to all.
6. Encouragement of sun avoidance.
7. Planning of sun protective environments.

### Physician Education:

Increased education at all levels beginning in medical school extending through graduate medical education will be needed in the areas of atmospheric effects on the skin. Only approximately 1/3 of skin problems present to dermatologists. Primary care physicians need to be aware of the problems related to skin cancer. They will need to be involved in assisting both in the screening and treating of these newly occurring lesions.

### IV. Needs for Future Public Action

#### Coalitions:

Because of the magnitude of problems of environmental pollution affecting the skin, the full burden of prevention activities should not be borne by dermatologists alone. It is critical that coalitions be developed with:

1. Research organizations, to encourage increased funding for the types of research previously discussed;
2. Environmental organizations interested in skin related environmental health issues;
3. Other medical specialists concerned with environmental health issues (i.e., pulmonologists concerned with air pollution);
4. New organizations of physicians, (national and worldwide), concerned about these issues. This could include worldwide research activity, as well as policy development.

### *Prospective Legislation and Policy Issues:*

For example, government cannot regulate personal sunlight exposure, but it can regulate UV exposure in tanning salons. Ideally, these salons should be closed. Until that goal is achievable, a national program is needed to: a) fully regulate the industry; b) prohibit tanning parlor use by minors; c) provide adequate enforcement of regulation; d) adequately inform the public of the inherent risks of this dangerous behavior; and e) limit the artificial radiation dose to which citizens can be exposed. Other policy issues include:

1. Increased funding for research. This should include funding for immunologic and epidemiologic studies related to the skin. Also, treatments for the effects of atmospheric changes (i.e., increased rates of skin cancer) need also to be studied.
2. Support for programs for evaluation of public health education effect on behavior modification in terms of skin cancer prevention.
3. Coverage from all third party insurers and medicare for skin cancer examination and prevention.
4. National funding of skin cancer screening efforts. Also, possible tax credits for preventive cancer measures such as screenings need to be evaluated.
5. Support for domestic and worldwide initiatives to ban CFCs and other ozone depleting chemicals.

### *Interaction With Public Agencies and Industry:*

1. At the international level, public agencies such as the WHO, UN, the UICC and others will be critical. It will be important to link our efforts to those in other countries where significant work is also currently occurring (i.e., Australia).
2. On the national front, close cooperation with the Environmental Protection Agency, NASA and others involved in the causes and effects of ozone depletion will also be critical.
3. There needs to be an increase in congressional awareness by providing an educational briefing for new members and staff on issues of ozone depletion and skin cancer in coordination with a skin cancer screening for those persons. Similar programs can be organized with other influential groups such as the National Press Club.
4. Coalitions with other organizations, such as the American Cancer Society, Centers for Disease Control, NIH, Skin Cancer Foundation, and senior citizen groups, to expand and enhance public education and screening efforts need to be established. The environmental concerns of the AAD need to be disseminated to similarly interested groups.

5. At the state and local levels, collaboration with local environmental protection agencies and state health organizations will be critical in a similar way. Coordination with local school systems, especially in sunbelt areas can also be useful. Medicine also needs to work with state education boards to include sun protection issues in school curricula.
6. Coordinated efforts with industry and photobiology researchers to develop more efficacious and acceptable sunscreens need to be encouraged.

## Naturally Occurring Hazards

### I. Introduction

Natural hazards to our skin are everywhere and cannot be avoided. A trip to the beach or park holds many dangers for the vacationer. Marine animals, such as jellyfish, rockfish, and manta rays, contain potent venoms that can give a painful surprise to the unwary bather. Swimmer's itch and swimmer's rash are caused by a flatworm and larval forms of hydroids respectively. Cuts and abrasions from coral and rocks allow entry of bacteria such as *Vibrio* and *Mycobacteria* that infect the skin. Localized profusions of algal growth cause dermatitis and mucous membrane irritation. On the edge of the beach, irritant plants such as wild blackberry brambles, bull nettle, poison ivy and poison oak lurk along with many biting flies and mosquitoes that cause rashes or more severe diseases, such as sand-fly fever.

Poison ivy and poison oak are major hazards and are found at the lower elevations in all parts of the United States. Anyone playing or hiking through the foothills, cool forests, or valleys near streams and waterways, is likely to come in contact with these plants. Close to half of adults in the United States can recall a bout of poison ivy dermatitis in their younger years that caused great distress and discomfort. Other irritant plants exist in the same areas, many being members of the spurge or stinging nettle plant families. People who sit under a Machineel tree in South Florida often get large blisters from the sap that oozes from a leaf or stem. Several plants in the sunflower family have allergenic airborne pollen that causes a contact dermatitis that can become chronic and disabling. Many wild flowers are in this family and some such as *Chrysanthemum*, *Dahlias*, and *Magnolia* have been domesticated for yard and flower gardens and pose dangers to the unwary homeowner. The allergens are naturally occurring chemicals which also are known to poison livestock. Many other plants such as Algerian and English ivy and *Primula obconica* can also cause severe allergic rashes. In the home or office one is not safe, since ornamental plants such as *Dieffenbachia* (dumb cane) have dangerous calcium oxalate raphids that damage the mouth and tongue of children who chew the leaves. Other cases of dermatitis are caused by cuttings of the Florida Holly (Brazilian pepper tree) that are brought in as an ornament at holiday time. One cannot escape the scourge of plant dermatitis when traveling abroad, such as in South America and Asia, since many tropical trees and bushes, such as mangoes, cashew nut shells, etc., contain chemical compounds that are similar to the constituents in poison ivy and poison oak and consequently cause a rash in people who have become allergic to these plants in the United States. In addition, chemicals from poison ivy and other plants can damage DNA and possibly cause other skin

disorders, such as cancer.

Poisonous snakes occupy all ecological zones except the higher altitudes and northern forests. About 8,000 people in the United States are bitten each year and 15 will die; mostly the very young or very old. The brown recluse spider causes dramatic skin damage and can commonly be found in homes, barns, storage buildings and campgrounds; no single treatment has proven to be entirely effective.

Any breaching of the skin barrier can transmit diseases that afflict the skin or the entire body. Lyme disease is spread by bites of several species of ticks and is characterized by skin rashes, arthritis, heart and nerve damage. *Mycobacterial* granulomas are common among people who clean fish tanks and boats. Hot tubs also spread bacteria that cause folliculitis. HIV infections generally enter through the skin from unprotected sex or intravenous drug injections; however, it can also be acquired from the needle of a tattoo artist. Persons infected with HIV suffer from a variety of opportunistic bacterial and fungal infections of the skin.

The economic cost of these natural hazards and problems is enormous in terms of quality of life, time lost from work and expenses for treatment, either by physicians or the use of over the counter medications.

Future trends, if left unchecked, will probably lead to even greater prevalence of these consequences particularly considering the tendency towards shorter work weeks, more time off and more leisure time for working adults and early retirement for many.

### II. Needs for Future Research

#### *Plant dermatitis research should:*

1. Focus on means of preventing or reducing poison ivy/oak sensitivity;
2. Continue to isolate and characterize plant chemicals that cause contact and photocontact dermatitis;
3. Explore means to improve topical barrier preparations that effectively prevent irritant and allergic contact dermatitis;
4. Explain in molecular terms the basis for irritant and urticarial responses caused by plants;
5. Investigate plant genes that can be manipulated to reduce production of irritant and allergenic chemicals;
6. Study the mutagenic and tumor producing potential of plant chemicals that damage DNA; and
7. Develop a reliable patch test screen for sesquiterpene lactone dermatitis.

#### *Future marine biology research should:*

1. Delineate mechanisms by which marine venoms and toxins injure humans;

2. Investigate the human immunosuppression induced by marine envenomation by itself or synergistically with UV;
3. Study the means by which physical or mechanical control procedures can be exerted to prevent these disorders;
4. Measure effects of industrial pollutants upon the reproductive stages of venomous or edible marine life; and
5. Make an increased effort to quantify UV and thermal alterations affecting the marine environment.

*Future research with arthropods and reptiles should:*

1. Develop effective antisera, vaccines, and diagnostic reagents;
2. Detail the molecular sequence of events leading to massive tissue destruction following brown recluse spider bites; and
3. Explore means of neutralizing the toxic effects of venoms by emergency administration of neutralizing agents.

*Research on trauma induced infections should:*

1. Identify generic molecular signals that distinguish infection from skin injury;
2. Identify nonimmune mechanisms of antimicrobial activity that will be useful as topical preventatives; and
3. Develop new broad spectrum antimicrobial agents for topical use.

### III. Needs for Future Education

1. Public education is at the heart of any program to prevent or reduce skin injury by environmental hazards. But to be truly effective, input is required from the interested news media, teachers at all levels of education, private business, philanthropic agencies, state, regional and national agencies involved in public education and the medical scientific community. The interest in the Secretary of Education in designating a coordinator for education of the public about skin hazards from the environment should be encouraged. This activity should be assisted by a centralized registry of qualified volunteer consultants to insure that disseminated information is correct and germane.
2. There should be increased beachside advertising and warnings against exposure to excessive solar radiation and dangerous marine animals. Educational efforts should be coordinated nationally and aimed at those giving instruction in water safety, diving, lifeguard certification, as well as emergency room and paramedical staff. These educational efforts should be based on information from a panel of experts.

3. The public should be instructed on proper identification of poison ivy/oak/sumac and the principles of prevention, first aid treatment and physician referral. Children especially need to learn the risks of injuries from other plants as well. The educational program should be coordinated at the state or regional level.
4. The public needs to learn how to identify dangerous snakes and spiders. Educational efforts should be coordinated nationally and aimed at those involved in outdoor activities. Emergency room and paramedical staff and physicians should be made familiar with appropriate first aid and medical treatment of these injuries. These educational efforts should be based on information from a panel of experts.
5. Education of general physicians and dermatologists should be undertaken by the American Academy of Dermatology under the umbrella of a nationally coordinated education plan.

### IV. Needs for Future Public Action

An area amenable to regulation, or alternatively, deregulation, is prevention of poison ivy/oak dermatitis. FDA regulations need to be amended to allow development of topical blocking agents. The government and industry should be encouraged to develop prophylactic vaccines. Laws need to be written to encourage orphan drug development in this field.

In the field of marine dermatological problems, there needs to be:

1. More legislation and action to curb beachside waste and erosion, and limit pollution and sediment runoff into public waters; and
2. The establishment of better seafood quality.

Finally, advocacy and environmental groups should become more aware of skin hazards from the environment, and they should work with medicine to promote public education and legislation to ease the personal and economic burdens seen in our growing leisure society.

## Man-Made Hazards

### I. Introduction

The skin is the largest organ in the body and is a major interface between humans and their physical, chemical and biological environments. It is a foremost portal of entry of potentially hazardous agents and is a particularly vulnerable target for damage from man-made occupational and environmental diseases and injuries. It is a uniquely accessible model system to detect hazards and to study mechanisms of a wide variety of biologic functions, including adaptive processes and adverse reactions.

This section provides an overview of man-made hazards to the skin, emphasizing occupational conditions, and lists specific needs for future research, education and public action as part of an overall strategy to prevent environmental skin diseases. Dermatological problems arise from exposure from home, work and recreation. Most of the data comes from studies dealing with occupational hazards.

Occupational skin disorders are important causes of morbidity and disability in the workplace. Recognizing this importance, the U.S. Department of Labor commissioned a Standards Advisory Committee on Cutaneous Hazards in 1978 which issued recommendations for improved surveillance, prevention and research. In 1980, the National Institute for Occupational Safety and Health (NIOSH) characterized occupational skin disease as one of the most pervasive occupational health problems in America. In 1982, NIOSH placed skin disorders on its list of ten leading work related diseases and injuries. This list was based on three criteria — frequency of occurrence, severity and amenability to prevention. The list also served as a focal point to develop strategies for preventing these occupational problems. In 1988, NIOSH and the American Academy of Dermatology jointly sponsored a national symposium to discuss specific measures to implement the NIOSH National Strategy for the Prevention of Dermatological Conditions. That document and related reports serves as the basis for further recommendations in this report.

#### *Prevalence, Severity and Importance:*

Effective strategies for the prevention of occupational skin diseases at either state or national levels must be based on systems capable of detecting cases followed by more specific identification of high risk occupations, industries of employment and causal agents. Such systems rely on information reported by three sources: employers, physicians or employees. Employer-based reporting systems such as the Bureau of Labor Statistics Annual Survey of Occupational Injuries and Illnesses are most useful for monitoring trends. Recent data from this survey suggest that incidence rates for occupational skin disease have been slowly increasing; agricultural and manufacturing industries

have the highest relative risks. Occupational skin disorders are the second most common occupational disease in the U.S. Skin disease, the vast majority of which is attributable to effects of toxic chemicals, still accounts for greater than 30% of all reported occupational diseases. The incidence rate in 1990 was 7.9 per 10,000 workers, producing almost 61,000 total new cases.

As many as 25% of all skin disease patients lose an average of eleven days from work annually. Assuming a ten to fifty fold underreporting, the estimated costs of dermatologic diseases due to lost worker productivity, medical costs and disability payments may range between \$222 million and \$1 billion. Accordingly, work related skin disorders are a health problem, a worker productivity problem, and an economic problem. Most important to consider is that they are preventable.

#### *Contact Dermatitis:*

Contact dermatitis is by far the most common occupational skin disease and is also a major nonoccupational, environmental problem. Contact dermatitis is a common reason for consulting a dermatologist and accounts for approximately 5.7 million physician visits per year. Irritant contact dermatitis (as from chemical burns, solvents, soaps, dusts, detergents, oils and greases) accounts for 80% of all cases and allergic contact dermatitis (as from contact with poison ivy, other plants, metals, rubber additives, plastics, resins and biocides) accounts for 20% of cases. The prognosis for occupational contact dermatitis is surprisingly poor. As many as 25% of workers with contact dermatitis develop persistent dermatitis which remains unchanged or even worsens despite discontinuance of exposure or change in jobs. Another 50% improve, but still have some degree of exacerbations. Only approximately 25% of workers requiring medical care completely recover from contact dermatitis.

The diagnosis of allergic contact dermatitis is made by diagnostic patch testing, and at present only 20 allergens are approved for diagnostic use by the FDA. Significant allergens remain in the environment and are largely unregulated. Few diseases receiving public attention rival the presence of nickel allergy which affects nearly one in ten women and approximately 14.5 million Americans. Safe exposure limits for nickel in consumer products have been established, but safe exposure limits for most other allergens are unknown. Three countries in Europe now require labeling of nickel containing objects or regulate the amount of nickel which may be present in jewelry. Good epidemiologic studies on many allergens are unavailable, but reasonable preventive measures can be taken in the form of improved product labeling.



### *Skin Cancer:*

In addition to the number of skin cancers due to ultraviolet light, some chemicals and compounds have been associated with the development of skin cancer. Arsenic, whether present in well water, medicines, pesticides or industrial processes, is a well-known cause of squamous cell and basal cell carcinoma. Polycyclic aromatic hydrocarbon containing substances, such as coal tar pitch, mineral oil or anthracene, have also been repeatedly implicated in nonmelanoma skin cancer formation. The possibility of a relationship between malignant melanoma and PCBs, various organic chemicals, pharmaceutical agents, and vinyl chloride has been raised. Prevention of occupational skin cancer involves the aggressive regulation of the use of cancer-causing chemicals and ultraviolet light exposure, combined with worker education and surveillance.

### *Other Skin Disease:*

Up to 5% of occupational skin disease may be caused by infection from a variety of micro-organisms. Examples include herpes simplex in health care workers and anthrax in wool handlers. Less than 5% of workers compensation claims are due to other disorders such as oil folliculitis and chloracne, pigmentary changes including post-inflammatory hyperpigmentation and chemical leukoderma, and contact and systemic urticaria.

Skin injuries are an important cause of hospital emergency room visits and workers compensation claims. Punctures and lacerations account for 80% of skin injuries, thermal and electrical burns account for 12% and chemical burns another 2%.

### *Percutaneous Absorption:*

Until the 1960's it was generally believed that the integument of man was able to screen out most noxious chemicals from the environment. Since then, with the availability of improved analytic technology, the situation is the exact reverse — very few studies exist that do not demonstrate at least some percutaneous penetration of most chemicals. Skin exposure may occur directly from raw materials, from contaminated work surfaces or from toxins inadvertently generated during the manufacturing process. Important examples include aniline (methemoglobinemia and bladder cancer), cyanide salts (acute cellular asphyxia and death), benzene (aplastic anemia, leukemia), and mercury (central nervous system intoxication, kidney failure). Of the more than 85,000 chemicals listed in the Registry of Toxic Effects of Chemical Substances as of November 1986, less than 1,600 have reported dermal LD50 data, and only 1,300 have any reported cutaneous irritant effects; more specific quantitative dose response data are virtually nonexistent. Numerous human, animal and in vitro models have been developed to study both quantitative and qualitative aspects

of percutaneous absorption. Each has strengths and weaknesses, but with current analytic data it is possible to greatly refine the risk assessment for man from chemical exposure. Most animal studies, in which dosing is by the oral or parenteral route, require percutaneous penetration for extrapolation to use in humans.

### *Pesticides:*

Over 25,000 pesticide formulations are currently available in the U.S. Approximately 750 active ingredients (of which 200 are common) are used in these formulations. Pesticides are the most important chemical class for acute or chronic systemic toxicity due to percutaneous absorption. Thus, skin protection is critical in preventing systemic poisoning. When pesticides cause skin disorders they usually precipitate irritant contact dermatitis. This problem, which may be much more prevalent than is now recognized, is a particular area where proper protective clothing and exposure precautions are not followed. In fact, the presence of contact dermatitis among pesticide-using agricultural workers could be used as an indication of inadequate protection from the pesticide. Plants in the agricultural work-space can also cause dermatitis and may not be suspected if pesticides are also present. The actuarial prevalence of skin diseases in agricultural workers is unknown and requires study. Allergic contact dermatitis from pesticides is uncommon. Chloracne is also rare, but when it does occur, it usually represents an important marker of systemic exposure to highly toxic herbicide chemicals.

### *Cosmetics:*

Cosmetics are remarkably safe products, but their mass public use has resulted in a number of adverse reactions. These include burning or irritation of the skin, allergic contact dermatitis, photosensitivity, acne, contact urticaria and other disorders. Most information on these reactions comes from reports in the medical literature or consumer reports to manufacturers or the FDA. While some individuals with adverse reactions seek medical care, the vast majority change to another product by the trial and error method. From studies of the relation of contact dermatitis to cosmetics in the U.S. and Europe it was found that 1) four to five percent of patch tested patients had contact dermatitis to cosmetics, 2) the cause in many cases was not apparent to either the patient or physician, 3) skin care and hair care products account for most reactions, 4) most reactions occur in adult women, 5) face and periorbital regions were the most commonly involved and 6) fragrances and preservatives were the most common causes of skin reactions. Groups which have been instrumental in reviewing the safety of cosmetic ingredients are: the Cosmetic Ingredient Review Program, the Research Institute of Fragrance Materials, and the North American Contact Dermatitis Group.

### ***Prevention and Control of Man-Made Hazards:***

Environmental engineering control measures such as isolation, enclosure, substitution and ventilation are the first priority in preventing occupational and environmental skin disorders. Replacement of contact allergenic substances with non-allergenic substances has been successfully employed. However, elimination and substitution are not always viable options. Personal protective equipment and clothing (PPEC) are important devices which require prudent selection based on chemical and physical properties of the PPEC and the nature of the chemical exposure. Incomplete criteria for PPEC selection are available for use with mixtures of chemicals. Dermatitis may also be caused or aggravated by CPC use. Recent reports of latex allergy suggest this is a major new occupational health problem involving as many as 7% of health care workers. These individuals are also affected by an array of other medical and consumer latex devices. Consumers and nonmedical workers wearing rubber gloves may also have latex allergy. Severe allergic reactions and death from latex barium enema tips prompted the FDA to issue alerts to the medical profession and latex manufacturers and schedule an international latex conference in Baltimore in November 1992.

The effectiveness of barrier creams remains controversial and unproven, although recent strides have been made with poison ivy sensitive individuals.

### ***Predisposing Factors and the Role of the Dermatologist:***

A number of predisposing factors are important in the development of environmental skin disease. These include environmental temperature and humidity, personal cleanliness, and preexisting or latent skin disease, especially atopic hand eczema. Ultimately, the diagnosis is based not only on medical data, but also on technical information about industrial processes and job performance. Dermatologists are trained to diagnose a vast collection of skin diseases and are able to determine whether a skin disorder is or is not job-related. Prevention is intimately tied to accurate diagnosis and treatment.

Although during the last two decades certain strides have been made in the U.S. in the prevention and control of man-made hazards, there is still much to be done. The creation of OSHA, NIOSH, the EPA, NIOSH and other agencies in the late 1960's and early 1970's, the labeling of over-the-counter cosmetics in 1977, and the more recent availability of Material Safety Data Sheets (MSDS) are examples. However, we are without the necessary motivation, training and equipment to adequately study patients with allergic contact dermatitis, especially those whose disease originates from their occupation. Thousands of Americans each year are left without a correct diagnosis with far-reaching consequences not only for them personally, but for the economy as well.

## **II. Needs for Future Research**

For medical and surgical conditions of the skin the role of the dermatologist is indisputable, as no other physician group has the expertise in diagnosis and management of such diseases.

### **1. Identification of Environmental Dermatoses by their Cause and the Populations at Risk.**

#### **a) General:**

1. Improvement in the use of existing surveillance and reporting data to generate additional information on causes of environmental skin disorders. For example, the Bureau of Labor Statistics will begin to collect OSHA 101 Logs which will provide supplemental data on causal agents as part of their annual survey.
2. Increased epidemiological investigations to identify unrecognized environmental causes of dermatological diseases.

#### **b) Specific:**

1. Characterization of important risk factors and causal agents responsible for high rates of skin disease in the home, at work and in recreation. For example, the prevalence of dermatitis from cosmetics, as well as risk factors contributing to its occurrence, could be surveyed through the National Health Interview Survey.
2. Study of the risk factors which contribute to persistence or chronicity of contact dermatitis.
3. Expanded epidemiological studies of workers exposed to suspected causes of melanoma. Study of clusters of cases of melanoma.
4. Improved tumor registry data and collection of data for skin cancer incidence and mortality to study the association with environmental factors.
5. Identification of specific high risk workplaces through workers compensation claims.
6. Development of better methods to identify other environmental high risk situations such as reports filed in compliance with section 8 of the Toxic Substances Control Act.
7. Use of new surveillance techniques to identify high risk cutaneous exposures such as data collected by the North American Contact Dermatitis Group and the National Occupational Exposure Survey which contains quantitative information on high risk exposures in home, industry and occupation.
8. Use of cohort studies to identify the actual prevalence of pesticide related skin diseases and assess the value of contact dermatitis in pesticide

users as a marker of unprotected exposure.

c) Basic/Applied Research:

1. Study of existing cutaneous toxicology models (animals or in vitro) to characterize dose-response relationships of cutaneous exposure, in order to: a) provide more accurate estimates of actual risk, b) assist health care providers in their diagnosis of probable causal agents and c) facilitate future establishment of cutaneous exposure standards.
2. Development of better and more information about cutaneous and systemic toxicity of newly-developed chemical substances must be obtained before they are widely introduced into the environment.
3. Linkage of priorities for percutaneous absorption research to prioritized multiple causes of environmental diseases and/or widescale exposure (e.g., toxins, carcinogens, mutagens, teratogens, immunosuppressants).
4. Enhanced research on the pathomechanism of all causes of environmental skin diseases, especially irritant and allergic contact dermatitis, pigmentary disorders, acne, immunosuppression and carcinogenesis. The nature of chronic inflammatory processes following environmental exposure, in particular, remains to be delineated. Such work could further primary and secondary preventive actions. Study of the mechanisms of induction and response to skin tumors is needed to provide measures of susceptibility and possible ways to intervene once the process has begun. Biomarkers of susceptibility, if established, could be very useful in counseling workers who might be at risk.
5. Increased interaction with the research grant review committees of NIH on research topics of interest to AAD with regular bilateral and multi-lateral meetings.

2. Development of Improved Preventive Techniques and Control Technology.

- a) Increased research on physical and chemical engineering to improve handling of toxic substances for workers.
- b) Further studies to optimize protective clothing.
- c) Coordination of existing guidelines for proper use, decontamination and disposal of protective clothing.
- d) Encouragement of development of more effective protective creams.
- e) Setting of threshold limits for allergen release from consumer and environmental products known to be significant cutaneous hazards.

- f) Encouragement of development of maximum allowable levels of exposure to irritants by a coalition of the interested academic, industrial and governmental parties.

3. Implementation of Prevention and Control Measures.

- a) Evaluation of effective approaches to health care delivery for environmental skin conditions.
- b) Development of computer-linked data bases to disseminate and exchange information among health professionals.

### III. Needs for Future Education

Dermatologists often have a key role as primary educators. Better educational tools and methods could improve the effectiveness of their role. In prevention and treatment dermatology should foster education of physicians in training as well as other health professionals.

1. Development of programs to educate the public, including workers and management, on proper techniques for personal hygiene to minimize environmental risks of skin disease.
2. Education of health care professionals in dermatology, pediatrics, family practice, internal medicine, emergency medicine and occupational medicine by improving core curricula of various residency training and CME programs.
3. Stressing the importance of environmental health in dermatology training programs.
4. Requiring training in occupational dermatology by well-trained individuals to include patch testing (including photo-patch testing) and contact dermatitis for dermatology residents.
5. Addition of environmental health and safety concerns into existing health curricula in schools and colleges.
6. Encouragement of motivational research and application of innovative techniques to increase compliance with effective measures to prevent environmental skin disease.
7. Development of educational campaigns for the mass media should be directed at increasing the overall awareness and prevention of environmental cutaneous hazards.

### IV. Needs for Future Public Action

Dermatologists should play a key role with other cognate professionals and scientists involved in the field of environmental health in formulating priorities and public policy.

1. Interaction with Public Agencies.
  - a) Support of the 1988 NIOSH strategy document.
  - b) Labelling the ingredients of those products that are expected to come in contact with human skin in

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routine use. For example, over-the-counter drugs (including sunscreens) and salon products (CPSC, FDA, EPA, etc.).

- c) Increasing the supply of allergens available for diagnostic contact dermatitis work by requesting an exemption of FDA regulations for registration of patch test allergens so that additional allergens currently available in Europe may be made available for diagnostic use in the United States. Alternatively, in the absence of existing, approved allergens for diagnostic contact dermatitis testing, the FDA should be petitioned to evaluate its existing legal authority to determine if there is a mechanism by which approved allergens for diagnostic purposes may be imported into the United States from countries which have regulated, licensed suppliers.
  - d) Establishment of a task force to develop standards for reporting new medical findings to appropriate governmental agencies when new allergens are detected.
  - e) Continued support of NIOSH efforts by the AAD to include an occupational dermatologist on its staff who can also facilitate the transfer of information between the two organizations.
  - f) Urging of adequate support for extramural research on occupational and environmental skin disease.
2. Coalitions - Interaction with public and private interest groups and medical organizations to provide education and liaison with communities.

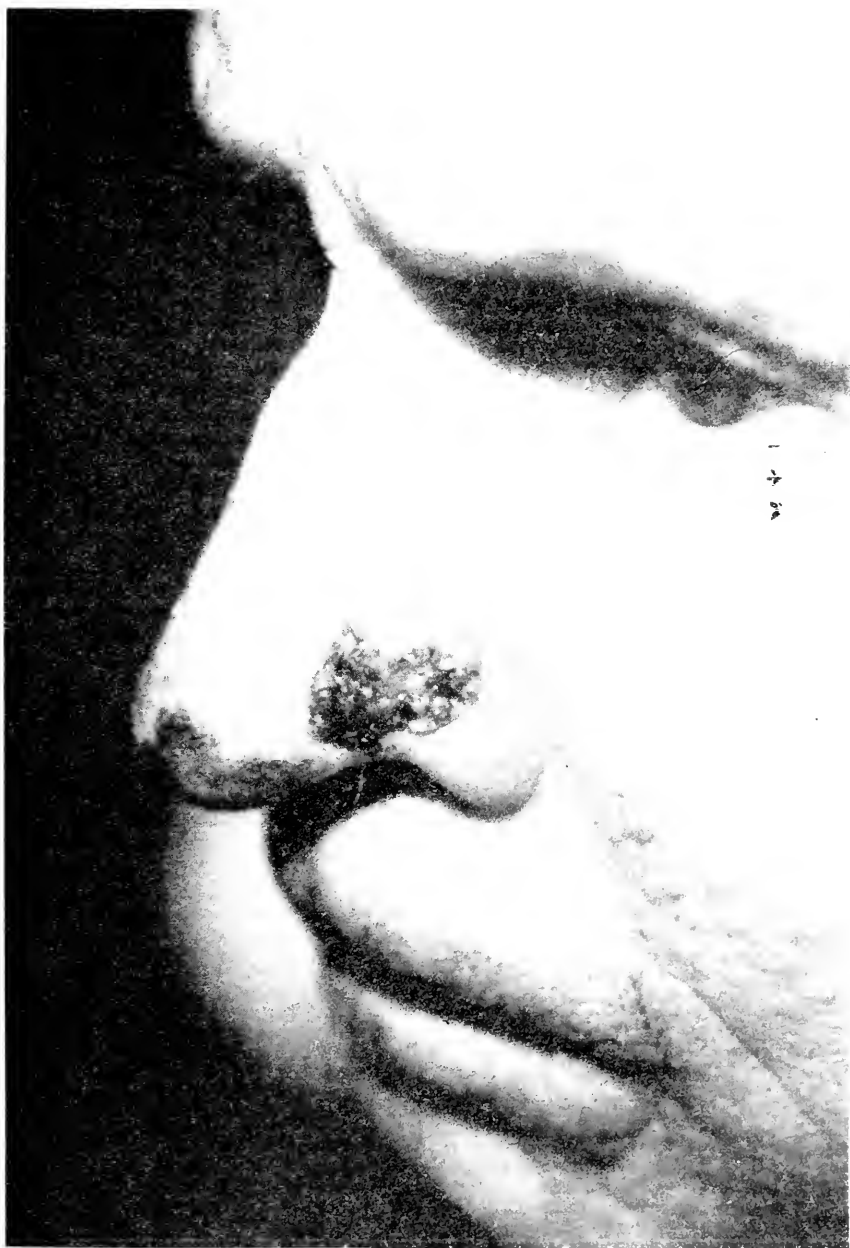
















American Academy of Dermatology



NATIONAL CONFERENCE ON  
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## FOREWORD

Wilma F. Bergfeld, M.D.

As the 1992 president, American Academy of Dermatology, one of my major initiatives during the presidency was to organize and sponsor the first comprehensive interdisciplinary meeting to discuss the effects of the world's deteriorating environment on the skin. This was the first National Conference on Environmental Hazards to the Skin, held in Washington, D.C., October 15-16, 1992. The theme of the meeting was to develop an action plan to conquer the growing problem, as depicted by an imaginative introduction video and developed in depth by thirty experts in the field of medicine, environmental issues, government regulations and research. The major role of the meeting was to identify and define the environmental problems, establish a need for monitoring and surveillance, and ultimately address prevention or control of environmental hazards to the skin. The conference explored three different environmental areas: (1) hazards of ozone depletion and ultra violet light; (2) naturally-occurring hazards; and (3) man-made hazards. Concerns common to all of the areas included adverse events of immunosuppression and tumor production; secondary concerns included infection and contact dermatitis.

The consensus panel of experts addressed the needs and opportunities for increased research, education, presentation and legislative action in their final consensus report which represents a strategic action plan for the American Academy of Dermatology.

### AAD Environmental Mission Statement

The skin is the body's major interface with the environment. The dermatologist has a specific responsibility for advocating and insuring a healthy environment with respect to those factors which affect the skin. Those factors include the ozone level and the atmosphere, natural plant and animal toxicants and allergens, and occupational and man-made chemicals that adversely affect the skin. The American Academy of Dermatology accomplishes those missions by a comprehensive program of a professional and public education, the encouragement of basic and clinical research into the effects of these agents and the prevention of their effects, and when necessary, the encouragement of new legislation.

### Current AAD Action

The American Academy of Dermatology has already formed meaningful coalitions with the American Cancer Society, the American Academy of Otolaryngology-Head and Neck

Surgery Foundation, Inc, and the National Association of Physicians for the Environment. In addition, through the 1992 visionary strategic plan, a Section on Communication and the Environment was established which placed environmental issues as a high priority of the American Academy of Dermatology. Under the Section of Communication and the Environment, chaired by Wilma F. Bergfeld, M.D., are two major councils: the Communication Council, chaired by Patricia K. Farris, M.D. and the Environmental Council, chaired by Lowell A. Goldsmith, M.D. This reorganization strengthens and coordinates specific environmental committees, namely contact dermatitis, epidemiology, melanomas/skin cancer (atmospheric) and occupational dermatology. Other continuing environmental initiatives include suntan parlor "protection" legislation, skin cancer screening programs, school and public educational programs regarding sun, sun protection and skin cancer. The development of the waste disposal policy, the formation of the industrial roundtable discussion, and greater interaction with the FDA regarding sunscreens and contact allergy, have been most successful. The American Academy of Dermatology is certainly on the forefront of the single most current public issue and that is the deteriorating environment.

### Executive Summary: Environmental Hazards on the Skin

The following executive summary of the consensus document titled Environmental Hazards to the Skin represents the American Academy of Dermatology's action plan.

This report summarizes the deliberations of the two-day meeting. The objectives of the conference were:

- To define a set of wide-ranging issues related to skin and the environment;
- To begin to define the magnitude of the problem; and
- To have a set of consensus panels address the needs and opportunities for increased research, education, prevention and legislative action.

The first half-day was devoted to the status of ozone depletion in the atmosphere which leads to increased ultraviolet B (UVB) at the earth's surface with consequent increases in skin neoplasms, including melanoma. The next half-day, speakers discussed some of the natural plant, marine animal and terrestrial animal effects on human skin. On the final half-day, experts discussed the man-made (especially industrial) hazards that affect the skin.

- ~ A supplemental meeting report summarizes scientific

deliberations and has more detailed versions of the recommendations. The needs summarized are in research, public and professional education which relate to educational programs, preventive programs, and research applicable to more than one set of these environmental hazards. These needs offer the AAD new opportunities to educate the public-at-large. This summary highlights the major recommendations of the supplemental report and includes recommendations for the atmospheric hazards, other natural hazards and man-made hazard sections of the report. The detailed body of the report should be reviewed to obtain supporting data and for more detailed versions of the initiatives which should be addressed.

#### A. Research Needs:

1. Better definition of environmental changes and the extent of dermatology-related problems due to environmental factors.
  - Improved quantification of the changes in UVB at the earth's surface related to alterations in the ozone layer.
  - Improved surveillance reporting and investigation of environmentally- and occupationally-caused skin diseases. Identification of the pertinent risk factors for disorders such as irritant and allergic contact dermatitis and skin tumors including melanoma. Use of cohort studies to find the real prevalence of pesticide-induced skin disease.
2. Definition of the basic mechanism of environmentally-caused disease.
  - Definition of the action spectra for the production of melanoma.
  - Further evaluation of action spectra for nonmelanoma skin cancer.
  - More precise definition of the effects of acute and chronic exposure to UVB and ultraviolet A (UVA) on skin, the immune system, and adaptive and repair functions of skin after UV injury.
  - Determination of the genetic factors predisposing to skin cancers and melanoma, contact dermatitis and irritant dermatitis, and definition of their molecular basis.
  - Characterization of the plant allergens causing contact and photocontact dermatitis and urticaria, and definition of the molecular basis of their action. Development of new patch tests for plant agents including sesquiterpenes.
  - Delineation of the mechanism by which marine venoms and toxins (eg, brown recluse spiders) injure the skin.

- Development of better information about the cutaneous and systemic toxicity of agents before they are introduced into the environment. Development of systems for reporting on the toxicity of new agents to the appropriate governmental agencies.
- Encouragement of motivational research to get optimum acceptance of prevention programs.

#### B. Development of New Protective, Preventive and Therapeutic Agents:

- Development of better sunscreens and other photoprotective agents including establishing optimum guidelines for their use.
- Development of new barrier preparations for contact and irritant dermatitis.
- Development of new plant varieties which lack highly allergenic compounds.
- Development of new antisera vaccines and diagnostic agents for toxic arthropod reptile toxins.
- Development of new broad-spectrum antimicrobial agents for topical use, including the development of new preservatives for skin preparations.
- Increased research on physical and chemical engineering to improve the handling of toxic substances by workers.
- Further studies to optimize protective clothing.

#### C. Prevention by Education and Early Disease Detection:

- Development of better measures to assess the effectiveness of mass skin cancer screening programs.
- Encouragement of sun avoidance and avoidance of sunburn. Determination of the effectiveness of programs to have daily "sun intensity" measures broadcast by local media to decrease sun exposure.
- Continuation and increased emphasis on skin cancer screening programs, including more active participation of senior citizen groups. Encouragement of programs which will allow treatment of skin cancers in patients who are underinsured or economically disadvantaged.

#### D. Public Education:

- Development of a major program in public education on the "ABCD" rules for detecting melanoma with media, milk carton panels and mass media.
- Development and coordination of enhanced programs in sun education, plant hazards and marine hazards for the pediatric age group. This should include support of education by pediatricians and

school nurses with pamphlets, videotapes, game kits, etc.

- Establishment of goals that by graduation from the eighth grade students should know principles of sun protection, be able to identify the most allergenic plants and know how to identify and avoid the major poisonous and venomous creatures in the United States
- Incorporation of health and safety concerns about the workplace environment in school and college health programs.
- Education pamphlets and videos for waiting rooms on the environment and effects of changes in the ozone layer.
- Special education programs for older Americans (especially for men who in the past, in contrast to women, have neglected to examine their skin). Determination of medical specialties, (internal medicine, urology, etc.) and community sites having potential for such education.
- Alerting the public to the danger of tanning salons.
- Development, support and encouragement of programs for workers and management on proper techniques of personal hygiene to minimize occupational risks in the workplace.

#### E. Physician Education:

- Increased education on the effect of the environment (including the work environment) on the skin, at all phases of undergraduate and postgraduate medical education.
- Development of computer-linked databases for occupational and environmental hazards with listing of resource individuals for usual and serious conditions.
- Emphasis of all environmental education in dermatology residency training programs and strong encouragement of active programs in patch testing in the residencies.

#### F. Public Action:

##### Coalitions

- Leadership in coalitions to increase funding for health research related to the environment. Association with all national and international medical organizations actively working to improve the environment.
- Involvement with senior citizen groups with respect to setting standards for environmental health. Active support of skin cancer screening efforts.

Inclusion of preventive care as a guaranteed part of the Medicare program

- Participation with groups such as the American Cancer Society, Centers for Disease Control, Skin Cancer Foundation, and senior citizen groups to expand and enhance educational efforts. Institution of a formal clearinghouse or a formal coalition of these groups and organizations for this purpose.
- Establishment of "Industry-AAD" roundtable with the sunscreen and sun protective manufacturers and the AAD (FDA could also be included) so that the needs and specifications for new products can be discussed.

##### Legislative and Regulative Action

- Tighter regulation of the tanning booth industry, including prohibiting the use of tanning facilities by minors, informing the public of the risks, and limiting total dose people can be exposed to.
- Testimony at all the appropriate congressional committees to get increased funding for those governmental/regulatory agencies which support research on the environment.
- Support of all national and international measures to decrease the production and spread of ozone-depleting chemicals into the environment.
- Modification of FDA rules to encourage the development of new topical agents and vaccines for poison ivy and poison oak.
- Setting of threshold limits for allergen release for consumer and environmental products known to have significant skin hazards. Development of maximum allowable levels of exposure to irritants.
- Support of the 1988 National Institute on Occupational Safety and Health (NIOSH) strategy document.
- Detailed labelling of all products which come in contact with human skin, including beauty salon products and over-the-counter products.
- Increased supply of allergens available for diagnostic contact dermatology testing.
- Assurance of a full-time occupational dermatologist on the staff of NIOSH.

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*Wilma F. Bergfeld, M.D., is past president of the American Academy of Dermatology. The National Conference on Environmental Hazards to the Skin was convened during her term as AAD president and she served as the Conference's presiding officer. She currently chairs the AAD Section on Communications and the Environment.*

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## INTRODUCTION

Lowell A. Goldsmith, M.D.

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Depicting the effects of the environment on man, and man on the environment, requires a large canvas and a rich palette. Focusing on the effects of the environment on the skin, one organ system, permitted us to describe the complexity of the skin's interactions with physical, chemical and biological agents in the environment. In the coming decade, these interactions will be defined in a much more sophisticated fashion. The interactions between various environmental agents is just beginning to be defined. The role of genetic diversity and an individual's reaction to the environment will be a major factor to consider. The skin contains biological systems for protecting against environmental damage and also has systems that may accentuate biological damage or may transfer those deleterious effects to other organs. Our authors, in a series of papers, have outlined these effects and processes and their potential for damage.

It was the consensus of this conference that dermatologists, other physicians, and scientists, in addition to all citizens, have the responsibility to be activists in the process of protecting and repairing our environment. This will entail major commitments to public education and public policy development at the local, state, national, and international levels. This is no small task, but the conferees were confident that the American Academy of Dermatology can be a major and important force so that the world will have an improved environment because of our efforts.

I would like to thank all of the authors and the American Academy of Dermatology, especially Ginny Thiersch and Tom Pearson, for their assistance, and Darrell S. Rigel, M.D. for his role in implementing the computerized real-time consensus portion of the conference. I appreciate the faith that Wilma F. Bergfeld, M.D. had in giving me a role in conference planning, implementing consensus portions of the conference and in the editing of these proceedings.

Lowell A. Goldsmith, M.D.

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*Lowell A. Goldsmith, M.D., served as co-chair of the 1992 AAD National Conference on Environmental Hazards to the Skin. He currently chairs the Academy's Council on the Environment and serves as a member of the AAD Board of Directors.*



## KEYNOTE ADDRESS

## UNDERSTANDING EARTH'S ENVIRONMENT: THE VIEW FROM SPACE

Richard Truly, VADM (Ret.)

I have spent most of my professional days in America's space program. My experience has extended from flying aboard the space shuttles *Enterprise*, *Columbia*, and *Challenger*, to managing various space endeavors both in the national security arena and at National Aeronautics & Space Administration (NASA). Most recently, I served as the NASA Administrator, a post I left April 1st of this year (1992). It may not seem at first glance that there is a logical and direct connection between my work in space and yours with threats to the human skin, but in fact there certainly is. For example, just a few days ago the most recent results were publicly released about the current ozone depletion, which can best be described as the "mother of all ozone holes." This vital information is only obtainable and trackable on a global basis via satellite. Today the atmospheric physics of this ozone fanning are analyzed routinely and in large part by scientists in or sponsored by NASA and the National Oceanic and Atmospheric Administration (NOAA). They will be a part of your discussion the better part of this morning.

My good friend, Dr. Bob Watson, will update you this morning as to how NASA sees this issue as a part of the upcoming subject. I look forward to the upcoming discussion as I am sure you do. I'm also hoping to be joined with you this evening at the reception by another friend of mine and an astronaut, Dr. Kathy Sullivan. Kathy has flown several times in space and is the first woman to ever make an extra vehicular activity, or space walk. She is currently the chief scientist at NOAA. Just 22 short years have passed since Neal Armstrong made that final step off of the bottom ladder rung of the lunar module named *Eagle* onto the dusty surface of another body of our solar system. I personally believe that the Apollo exploration of the moon will be the event for which this century will be remembered. Not the World Wars, not Vietnam, but Apollo, for Apollo represents the final achievement of the first baby step of the human dream of ultimate exploration. I further believe that the exploration of the planet Mars, not by America but by a future coalition of nations, will dominate the history books that chronicle the exploits of the 21st century. I must add that I have also always thought that Apollo's most significant contribution to history was not the view that it gave us of the moon, but the view it gave us of our fragile precious

earth. That is where the connection between our professions comes into play.

For more than 30 years, humans have made space the proving ground for expanding the human potential. For more than 30 years, our activities in space have embodied the human urge to explore the unknown, to open new horizons, and to push back frontiers that limit our goals here on earth. Our early missions from planet earth have expanded our understanding of the solar system, the galaxies, and the universe, and we have seen strange new worlds as never before. We have come to realize that space flight holds the key to understanding our own world, planet earth, in its entirety as a global system. Going into space has opened our eyes to what we know and what we don't know about the earth. In less than half the span of a human lifetime, (largely through the findings of the spaceborne sensors) humankind has transformed its view of the earth's land masses, its oceans, its atmosphere, and its solar environment.

These words about the unique view of earth as seen from above are not figurative to me. I am one of those lucky mortals who have seen earth literally from a global perspective. From orbit, the everchanging nature of the planet earth is startling, on scales ranging from seconds and hours to thousands and millions of years. From the perspective of space, there are no national boundaries. From out there, the dynamic nature of our global environment is as dramatic as it is visible. Mountain peaks reach up that have evolved over hundreds of millions of years, while eddies visible in ocean currents change minute by minute as you watch them. From out there, earth's land and sea, the ice and atmosphere driven from above over untold millennia by the solar environment are seen to come together as a system — a very, very complex and fragile system. But recent developments are robbing this system, not from above but from below.

Your space program today has many parts, unlike the early days when Apollo was the central and driving theme. From space station *Freedom* to the exploration of the outer planets, your space program is a national jewel. A vital part of the program, which deals with the earth sciences, helps to provide to the policy makers the answers on why and how our planet is changing and what we can and must do to cope

with future global change. Having analyzed the earth with this space data, we see a complex and dynamic world that is more than the sum of its parts. It is a fragile system in which disruptions at any point reverberate throughout the whole. But unlike times past, many of these disruptions have recently been brought about by human activities. We now know that the economic and technological activities over the past few generations have undoubtedly contributed significantly to global change. Humans are most definitely now a critical part of earth's balance. It is clear that we have a lot to learn about how to be constructive in this equation. To our collective great discredit, we have contributed in large measure to depleting the ozone layer, to transforming once fertile lands to arid forests and deserts, to deforestation of tropical and other forests and to creating acid rain, and possibly, possibly, we have introduced a new and unstable factor into the equation of the earth's long-stable and natural greenhouse effect.

Certainly the effects of human activities amount to an experiment on our own home without complete knowledge of the experiment's effect. The good news is, (and principally, I believe, as the direct result of the impact of those early Apollo photographs of our blue planet) that we are now positioning ourselves to understand the consequences of our actions. Once sufficiently understood, I trust we will be able to do something about them together. Every nation will have a role to play in solving these problems, because global problems will require global solutions executed on an international scale. It is imperative that we join together to correlate and integrate measurements from space and the ground all over this globe.

At the heart of these efforts, and essential to their success, is NASA's leadership through its Mission to Planet Earth program. The aim is to provide comprehensive observations from space requiring, in large part, concentrations of orbiting, advanced remote sensing instrumentation, and in some cases, mission lifetimes extending over a decade or more. I am very proud to say that the first satellite of the Mission to Planet Earth program left the launch pad while I was NASA Administrator. The principle thrust of this Mission to Planet Earth is called the Earth Observing System, which is well underway and will fly beginning in this decade. Polar orbiting satellites will utilize improved sensors for simultaneous observations of global variables.

In our long human history, continents have been mapped, mountains have been climbed, the great ice expanses of our poles have been discovered and trekked. Brave men and women have lost their lives for a purpose as simple as peeking over the next hill, climbing to the next precipice, or diving to a new and crushing depth. Always the next achievement was made possible by new technolo-

gy. Today, through America's space program, our society has set into motion a unique use of new technology on a scale never before attempted, first to understand and then to affect the very home on which we all depend. At the same time, and also using new technology, you have a huge and interim responsibility to understand the detrimental medical effects of the ill-advised actions already taken. You have the daunting task of dealing with health effects that have not yet matured and are not yet well understood today.

I admire your work and that of the Academy and know that your very presence at this vital national conference will be a part of the difference you will make. I fervently believe that together we have the opportunity to ensure that the precious gifts of our bountiful earth can be passed on to future generations. America's space program intends to continue to play a leading role in helping to secure our future for the sake of the entire world community and future generations.

I want to thank you again for the opportunity to be here with you this morning.

# ATMOSPHERIC HAZARDS TO THE SKIN

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## ENVIRONMENTAL ATMOSPHERIC ISSUES AND THEIR EFFECTS ON SKIN CANCER

Darrell S. Rigel, M.D.

### Introduction

The most commonly diagnosed cancer in the world is skin cancer. One in three of all cancers diagnosed is a skin cancer. At current rates, 1 in 6 Americans will develop skin cancer during their lifetime. In 1993, over 700,000 new cases of skin cancer will be diagnosed in the U.S. and 9,100 persons will die of this malignancy (Figure 1). The incidence of the most dangerous type of skin cancer, malignant melanoma, is increasing faster than any other cancer in the U.S. and worldwide, and has doubled in the U.S. over the last decade. Given these numbers, skin cancer is a serious public health problem that will only increase in magnitude into the next century.<sup>1</sup>

### Causation Issues

Most of the risk factors associated with skin cancer have been well documented. The key risk factors for skin cancer are primarily phenotypically related. Persons with fair skin, light eyes, red or blond hair, those who tan poorly and sunburn easily are at the highest risk.

All of these risk factors have a common theme that points to the etiology of skin cancer. Increased susceptibility and exposure to ultraviolet B (UVB) radiation (290 nm-320 nm) is directly related to greater risk for the development of skin cancer. UVB intensity increases with proximity to the equator. Queensland, Australia, an area with fair-skinned persons living closest to the equator, has the highest skin cancer rate in the world. Also, increased altitude allows for a greater UVB intensity. UVB intensity increases about 4% for every 1,000 feet of elevation. Populations in mountainous areas, therefore, have disproportionately high skin cancer rates.

### Environmental Factors Influencing Skin Cancer Rates

It is clear that factors influencing the degree of UVB irradiance on the earth's surface should, directly or indirectly, influence skin cancer rates. The most important environmental factor regulating this phenomenon is the stratospheric ozone layer.

Ozone ( $O_3$ ) is the primary filter that reduces the levels of UV radiation reaching the earth's surface. However, ozone is a selective filter; it blocks all of the shorter UVC band radiation, more of the longer wave UVA radiation, and only part of the UVB band. This selectivity becomes

important in that small decreases in ozone levels can result in a significant increase in the amount of surface UVB radiation (Figure 2).

Stratospheric depletion was first suggested in 1969 by Dr. Sherwood Roland and his associates. NASA studies showed a 3%-9% depletion in the temperate zones during the 1980s. A recent NASA report using data from the Nimbus satellite showed a significantly increased rate of ozone depletion in 1992, especially in the mid-latitude areas.<sup>2</sup>

The U.S. Environmental Protection Agency (EPA) estimates for each 1% decrease in ozone (Figure 3), melanoma mortality worldwide will increase 1%-2%. In 1987, the EPA estimated that if no attempts were made to stop ozone depletion, 145 million cases of skin cancer and 2 million additional deaths between then and the year 2075 would be directly attributed to this problem. Because of these concerns, in 1987 the Montreal Protocols were ratified by 46 countries. This treaty limits the production of ozone-depleting chemicals, such as chlorofluorocarbons (CFC), and promotes increased development of "ozone-safe" substitutes. The terms of the treaty were strengthened in 1990 and again in 1992 to phase out CFC products more rapidly. Under the current rules, the U.S. must end CFC production by the end of 1995.

However, even an immediate total ban on CFC products will not stop the rise in skin cancer rates into the next century. CFCs are relatively inert and act as catalysts in the reaction that destroys ozone. Due to their inertia, CFCs persist at the stratospheric level for decades. One molecule of CFC can destroy hundreds of thousands of molecules of ozone over many years. Also, CFCs may continue to escape into the atmosphere from old space refrigeration and air conditioning units unless rigorous recovery rules are adopted. Finally, from 10 to 20 years may elapse from the time a person is damaged from UVB radiation until a skin cancer becomes clinically apparent.<sup>3</sup> Therefore, even with the most aggressive measures, it is clear that skin cancer rates will continue to rise well into the 21st century.

Other environmental factors also will influence skin cancer rates. If global warming continues, the warmer weather will lead to more outdoor time with less clothing coverage, resulting in more UVB exposure. On the other hand, increased ground-level pollution in urban areas

produces some protection from UVB irradiance. It will take computer models more sophisticated than those currently available to determine more accurately the net effects of these confounding factors.

### Measures to Combat Environmental Effects on Skin Cancer Rates

Both short- and long-range action plans must be developed to combat the effects of the environment on future skin cancer trends. Recognizing this need, the American Academy of Dermatology organized this conference on environmental hazards to the skin. Physicians should be conscious of the environmental effects on health in general and should support local, national and international legislation and regulations that promote "ecological soundness." The projected rise in skin cancer rates means that primary care physicians may need more and broader training in the recognition and diagnosis of early lesions. Skin cancer is perhaps the most clear-cut case for neoplasm where this early detection and treatment are key. When found and treated early, even melanoma is virtually 100% curable. However, no current effective treatment exists for advanced melanoma. For these reasons, expanded education of physicians at the medical student level through post-graduate levels will be increasingly important.

In addition to education of medical professionals, the lay public's baseline knowledge of this problem must be increased. This will happen indirectly, as more people will know persons who will develop skin cancer as the rates rise. However, mass public education efforts such as those that have already been successful in Australia need to be developed worldwide.

In the United States over the past eight years, more than 3,000 dermatologists voluntarily screened about three quarters of a million Americans for skin cancer as part of the American Academy of Dermatology's National Skin Cancer Screening program. Thousands of skin cancers have been detected, most in their early treatable phase.

Mass screenings provide more than the immediate benefits of detection. Screenings allow an opportunity to present a "teachable moment" to attendees regarding skin cancer issues. As a result, mass screening programs can also raise public awareness of the increasing problem.

Improved methods of protection from UVB radiation need to be developed. Broader spectrum, more cosmetically acceptable sunscreens will be important. In addition to topically applied formulations, other forms, such as long-acting oral and parenteral preparations, will be developed. Better forms of lightweight, tighter weave fabric may be needed to deal with the warmer temperatures and increased UV radiation that may be present in the next century. Finally, and perhaps more importantly, there is a need to

think of sun protection in broader, more creative ways. For example, the planting of more shade trees would fit within the guidelines for these creative needs.

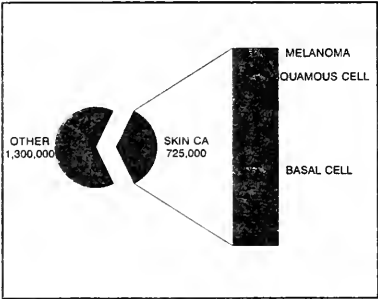
### Summary

Current environmental trends forecast a continued significant rise in skin cancer rates well into the 21st century. Better environmental regulation and physician and public awareness of this problem may partially ameliorate this problem.

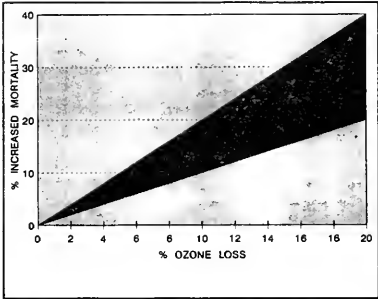
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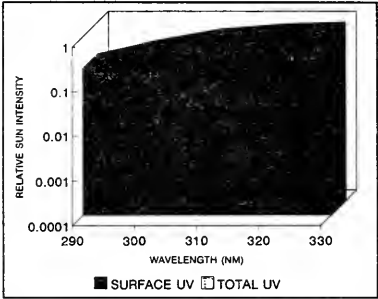
Figures



**Figure 1:**  
Skin cancer accounts for approximately 2/3 of cancers in the U.S., although only 5% of these skin cancers are malignant melanoma. This group accounts for 75% of the deaths from skin cancer.



**Figure 3:**  
Each 2% decrease in ozone projects to a 1%-2% increase in worldwide melanoma mortality.



**Figure 2:**  
The most important protection the ozone layer provides from solar ultraviolet radiation occurs in the UVB (290 nm-320 nm) band. Shorter wavelengths of UV (UVC band) are almost fully absorbed, while the larger UV (UVA band) are virtually unblocked. Because of this selective filtration in the UVB band, small changes in ozone concentration can lead to greater changes in ground UVB levels.

# ATMOSPHERIC EFFECTS ON THE BIOLOGY OF THE SKIN

Margaret L. Kripke, Ph.D.

Human activities associated with increasing industrialization and population growth over the last century have dramatically altered the atmosphere surrounding our planet. These changes are modifying our immediate environment in significant ways. Specifically, decreases in the concentration of stratospheric ozone are expected to increase the amount of UVB radiation in ambient sunlight; urbanization and industrialization are increasing the concentration of chemical pollutants in the air we breathe; and increases in CO<sub>2</sub> production may be increasing global temperatures and altering global climate by means of the greenhouse effect (Table I). Because skin is our primary interface with our environment, all hazards present in the environment as a result of these atmospheric changes have the potential to interact with the skin. This paper will focus on the effects of UV radiation on the skin because this is the area where we have the most information and where the most recent progress has been made.

## Ultraviolet Radiation

The most thoroughly studied environmental hazard to the skin is ultraviolet (UV) radiation. Wavelengths in the UVB (280 nm-320 nm) region of the solar spectrum are the most deleterious for human skin; they cause sunburn, skin cancer, and immunological alterations. These wavelengths are also the most strongly affected by ozone depletion. UVA (320 nm-400 nm) radiation also has deleterious effects on human skin, including sunburn, photoallergic responses, changes associated with aging, and possibly skin cancer induction; however, it is much less efficient than UVB radiation, and its presence in sunlight is much less affected by the concentration of ozone. Solar UVC (200 nm-280 nm) radiation does not normally reach the surface of the earth because it is filtered out by ozone and moisture in the air.

The deleterious effects of UVB radiation on human skin are well documented (Table II). Decreases in the concentration of stratospheric ozone are expected to increase the incidence of sunburns, accelerate changes in the skin associated with aging, increase the incidence of basal and squamous cell carcinomas, and decrease their age of onset. The incidence of cutaneous melanoma and its mortality rate are also expected to increase. UV radiation also alters the immune system and causes immune suppression under certain circumstances. However, the significance of these changes for human health is still unclear.

## Immunological Effects of UVB Radiation

The most recently described and perhaps the most important effect of UVB radiation on human skin is its ability to modify certain immune reactions. The immune system is the body's primary defense mechanism against infection and plays a role in resistance to certain cancers. Any factor that reduces immune function, whether external (radiation, toxic chemicals) or internal (stress) is potentially detrimental for human health.

Because the main immunological organs (spleen, thymus, and lymph nodes) are internal and are not directly exposed to UV radiation, the finding that UV radiation could suppress systemic immune responses was initially quite surprising. However, we now know that all effects of UV radiation on immune function described to date are mediated through the skin.

The effects of UVB radiation on immune function are generally divided into two types: local and systemic. Local effects are defined as alterations in immune function to antigens introduced into the UV-radiated sites. The experimental model originally described by Streilein, Bergstresser and colleagues involves exposing mouse skin to four suberythral doses of UVB and applying a contact sensitizing chemical onto the site of irradiation. This results in a reduction of the CHS response and the appearance of antigen-specific suppressor T lymphocytes in the lymphoid organs. The suppressor cells prevent the subsequent initiation of a CHS response at an unirradiated site. The mechanism of this effect of UVB radiation is still under investigation, but it seems to involve at least two components: an alteration in the function of antigen-presenting cells in the skin (called epidermal Langerhans cells), and the release of immunologically active molecules from UV-irradiated skin (TNF- $\alpha$  and perhaps CIS-urocanic acid). Note that although the effect is local, in the sense that the antigen must be applied to the site of irradiation, it results in systemic immune suppression by virtue of the circulating T suppressor cells (Figure 1).

A second local immunological alteration is illustrated by injecting melanoma cells and cells of other antigenic tumors into UV-irradiated ear skin. This results in an enhanced outgrowth of the tumors and inhibition of tumor rejection in immunized mice. The mechanism of this effect is not known.

Systemic immune suppression is defined as a reduction in immune responses initiated at non-irradiated sites. The

experimental models involve exposing mice to UVB radiation and immunizing them by injecting an antigen subcutaneously, or painting a contact sensitizing chemical on the skin at an unexposed site. Exposure to UVB radiation results in a reduction of the delayed hypersensitivity or CHS response and the induction of antigen-specific suppressor T lymphocytes. Recent evidence suggests that these effects of UV radiation are mediated by immunological mediators produced by keratinocytes in response to DNA damage (Figure 2).

The relationship between local and systemic effects of UV irradiation is not clear, but it is possible that small doses of UV radiation bring about the local release of cytokines that alter immune function within the irradiated site. On the other hand, higher doses of or continued exposures to UV radiation cause the release of these and perhaps additional cytokines into the circulation, where they affect immune responses initiated at distant sites (Figure 3). Strategies for preventing these effects of UV irradiation include the use of substances that limit DNA damage (UVB sunscreens), increase DNA repair (DNA repair enzymes), inhibit the activity of specific immunosuppressive cytokines (anti-IL-10, TNF- $\alpha$ , and CIS-UCA antibodies), or prevent cytokine release (Table III).

#### Implications of UV-Induced Immune Suppression for Humans

Although most information on UV-induced immune alterations comes from studies of laboratory animals, studies on human subjects are increasing (Table IV). In general, these studies support the findings from animal models. For example, suberythral doses of UVB radiation alter the appearance of epidermal Langerhans cells in human skin. Recent studies by Streilein and by Cooper demonstrated that contact sensitization of UV-irradiated human skin also results in a reduced CHS response, and that some individuals are unresponsive to re-sensitization, suggesting that suppressor cells may have been induced. The Streilein study suggested, in addition, that there are differences in individual susceptibility to UV-induced immune suppression, and that such susceptibility may constitute an additional risk factor for the development of skin cancer. Importantly, skin pigmentation seems to have relatively little influence on susceptibility to UV-induced immune suppression, implying that the population at risk of immune suppression from UVB radiation is not limited to the light-skinned population that is susceptible to development of UV-induced skin cancers. Identification of the genetic factors associated with susceptibility to UV-induced immune suppression is obviously a priority. Recent studies by Streilein, et al., in the mouse model suggest that genes controlling the production of TNF- $\alpha$  and the response to

bacterial toxins are key elements in determining susceptibility to UV-induced immune suppression.

Other immune alterations associated with exposure of humans to UVB radiation include changes in the proportion of white blood cells and decreased responsiveness of lymphocytes to stimulation *in vitro*. It should be noted that immune suppression by UVB radiation is selective, in that not all types of immune responses are affected. Delayed and contact hypersensitivity responses and resistance to skin tumors is impaired, but other responses such as antibody production and graft rejection do not appear to be altered.

The most important question for human health raised by these studies is: Do these UV-induced immunological alterations contribute in any significant way to the pathogenesis of infectious diseases? Unfortunately, no information is available on this question in humans. However, recent animal model studies of infectious diseases have demonstrated that under the appropriate conditions of UV irradiation and infection, acute exposure to UV radiation can inhibit the delayed hypersensitivity response to a variety of microorganisms, both locally (herpes simplex virus, Leishmania) and systemically (Candida, mycobacteria). More importantly, UV irradiation has been shown to cause more severe disease from herpes simplex virus, to activate HIV transcription *in vitro* and *in vivo*, to impair the clearance of mycobacteria, and to accelerate death from chronic infection with *Mycobacterium lepraemurium* (Table V). Because UV radiation appears to cause similar alterations in immune function in humans, it is important to investigate the potential of increased UVB radiation to magnify certain infectious disease processes.

#### Implications for Other Atmospheric Hazards

One of the most important implications of the effects of UV radiation on the immune system is the illustration of the intimate connection between the skin and the immune system. Skin serves not only as a barrier to the external environment and a sensor for the central nervous system, but also as a sensor of the external environment for the immune system. Thus, factors that directly affect the skin have the potential to affect not only the physiology of the skin itself, but the immune system as well. It is, therefore, possible that chemical pollutants in the air and in the workplace, particularly those with the ability to cause DNA damage, may also cause immunological alterations by means of their interactions with the skin.

How global warming will affect the structure and function of the skin can only be surmised at present. Because of the enormous adaptive ability of humans to survive in different climates, a few degrees' rise in global temperature will probably not cause undue stress on the physiology of the skin. It has been reported, however, that a small



increase in ambient temperature increases the rate of skin cancer production in a mouse model; the mechanism of this effect is unknown. More importantly, global warming is predicted to change the geographic distribution of certain infectious diseases. Changes in local conditions of rainfall, humidity, and temperature are expected to alter the distribution pattern of infectious agents and disease vectors and to cause the migration of human populations. Such disruptions would probably be reflected in the appearance of cutaneous diseases not normally present in the immediate environment.

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Table I

| Sources of Atmospheric Hazards for Skin |                |
|---|----------------|
| Event                                   | Consequence    |
| Ozone depletion                         | UVB radiation  |
| Urbanization, industrialization         | Air pollution  |
| CO <sub>2</sub> (Greenhouse Effect)     | Global warming |

Table III

| Strategies for Prevention  |                          |
|----------------------------|--------------------------|
| Approach                   | Methods                  |
| Limit DNA Damage           | UVB Sunscreens           |
| Increase DNA Repair        | DNA Repair Enzymes       |
| Inhibit Specific Cytokines | Anti-IL-10, TNF, CIS-UCA |
| Prevent Cytokine Release   | Chemical Mediators (?)   |

Table V

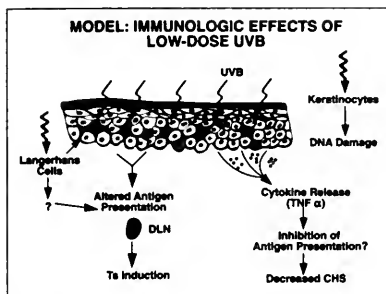
| <b>Infectious Agents Influenced by UVB Irradiation</b><br><b>(Murine Models)</b>  |
|---|
| <i>Herpes Simplex Virus</i><br><i>Leishmania Major</i><br><i>Candida Albicans</i><br><i>Mycobacterium Bovis (BCG)</i><br><i>Mycobacterium Leptraemurium</i><br><i>HIV, Maids Retrovirus</i> |

Table II

| Harmful Effects of UVB Radiation on Human Skin        |
|---|
| Sunburn<br>Aging<br>Skin Cancer<br>Immune Suppression |

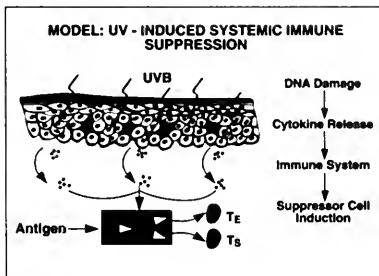
Table IV

| Immune Alterations in Humans   |
|--|
| Altered Langerhans Cells<br>Altered Antigen Presentation in Skin<br>Decreased Contact Hypersensitivity Response<br>Decreased Circulating T Lymphocytes<br>Reduced Lymphocyte Function in Vitro |



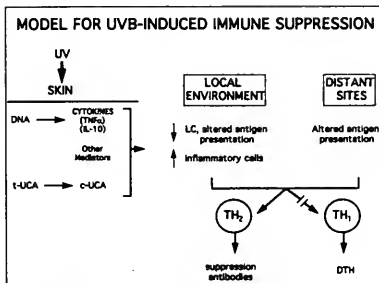
**Figure 1**

Local suppression of contact hypersensitivity (CHS) by low-dose UVB-radiation. UVB exposure impairs the antigen-presenting function of epidermal Langerhans cells (LC). This could occur by means of direct DNA damage to the LC, which migrates to the draining lymph node (DLN); alternatively, or in addition, UV-induced cytokines or factors (e.g., cisurocanic acid) may alter the activity of LC. UVB radiation causes the release of immunomodulatory cytokines, particularly TNF- $\alpha$ . DNA damage has been implicated as an initiator of this effect. Application of a contact sensitizer to the UV-irradiated skin results in a decreased CHS response and induction of suppressor T lymphocytes.



**Figure 2**

Systemic suppression of delayed or contact hypersensitivity responses by UVB radiation. UVB radiation causes DNA damage and cytokine release in keratinocytes. Immunomodulatory cytokines (e.g. IL-10) shift the immune responses from an effector ( $T_H$ ) to a suppressor ( $T_S$ ) pathway in response to antigens introduced at non-irradiated sites.



**Figure 3**

Model for UVB Induced Immunosuppression. Figure 3 presents one possible model for how various factors and events operate in UVB induced immunosuppression. Immune responses initiated or elicited in UV-irradiated skin are influenced by alterations in cutaneous antigen presenting cells and cytokine production. With sufficient UV radiation, cytokines reach the circulation and later immune responses at distant sites. Cytokines released in response to UV shift the immune response from a  $T_H$  (delayed type hypersensitivity) response to a  $T_H$  (antibody, DTH suppression) response.

## ATMOSPHERIC EFFECTS ON THE EPIDEMIOLOGY AND INCIDENCE OF SKIN CANCER

Arthur J. Sober, M.D.

Dr. Paul Unna reported the observation of a relationship between exposure to sunlight and the occurrence of non-melanoma skin cancer (NMSC) in 1894. This relationship has been amply confirmed since. Over the past 40 years there has been a remarkable increase in the incidence rates for both non-melanoma skin cancers (basal cell carcinoma and squamous cell carcinoma) and malignant melanoma. At the present time, approximately 700,000 NMSC and 33,000 malignant melanomas are diagnosed annually. Both increases appear to relate to increases in occupational and/or recreational solar exposure.

The anatomic distribution of the non-melanoma skin cancers fits a chronic sun exposure model, in that most of these tumors occur on areas of greatest sun exposure. Brodtkin and Kopf demonstrated that approximately 90% of the basal cell carcinomas occur on the head and neck. From the SEER data of Scott, three out of four squamous cell carcinomas in males and three out of five squamous cell carcinomas in females occur on the head and neck. For lentigo maligna melanoma, as studied by Koh, et al., nearly all occur on the head and neck in chronically sun-exposed skin. While the distribution of melanoma overall does not fit the area of maximum sun exposure, nonetheless, areas that are chronically protected from sun exposure, such as the underpants or bra areas in females and the boxer shorts area in males, are less frequently affected. The differences in occurrence on male ear and scalp (increased compared to females) has also been related to solar exposure. Areas covered by bathing suits appear to be spared in both genders, and the increased frequency of melanoma on the lower leg in women has been related to differences in clothing pattern compared to the male. The distribution of melanomas in xeroderma pigmentosum, in which a defect in the repair of ultraviolet damage to DNA exists, shows a distribution of melanoma similar to those for melanoma patients in general.

### UV Dosimetry

Ultraviolet B intensity varies with latitude. There is a strong latitude gradient in the United States for the incidence of squamous cell carcinoma, basal cell carcinoma and melanoma. The steepest of these latitude gradients is for squamous cell carcinoma and the least steep is for malignant melanoma. Figures 1-4 show the latitude gradient existing

for squamous cell carcinomas in men and women and for basal cell carcinoma in men and women. A direct relationship between the intensity of ultraviolet B in an area and the incidence of these two types of skin cancer has been shown. A similar but less steep gradient exists for malignant melanoma. Within the United States, a two and a half to three-fold difference exists in melanoma incidence rates between Massachusetts and southern Arizona.

### Effect of Altitude

UVB increases approximately 15% every 3000 meters of altitude. The dosimetric effect on humans can be seen in the study by Dr. Robin Marks in which the incidences of actinic keratoses were compared in Melbourne, Australia versus Maryborough, which are at similar latitudes but differing altitudes. The rate of occurrence of actinic keratoses in Maryborough was about 14% higher than Melbourne, reflecting the former's higher altitude.

### Effect of Cloud Cover

Clouds can reduce the amount of ultraviolet B reaching the surface of the earth by both reflection and light scatter. Nonetheless, a good portion of ultraviolet B can traverse cloud cover, even on a cloudy, cool day, substantial amounts of UVB reach the earth's surface.

### Other Factors

As important as the above relationships are, the percentage of population that falls into "at-risk" groups is crucial. Constitutional susceptibility plays a major role in determining the rates of incidence of all three forms of skin cancer at any given geographical location. For example: for non-melanoma skin cancers, the annual incidence in black South Africans is reported as less than one per hundred thousand per year, whereas for white Australians with similar solar exposure, the rate is greater than 800 per hundred thousand per year. Similarly the rates for white Anglo-Saxon males in New Mexico was 485 per hundred thousand per year; for Hispanic males living in the same region, 64 per hundred thousand per year for the years 1977-78. Equally important to constitutional factors is the behavior pattern of the population. Is the population outdoor-oriented, sun-seeking, or have educational and behavioral modifications resulted in ultraviolet protection measures?

### Effects of Ozone Depletion

The effects of ozone depletion will result in increased ultraviolet B reaching the earth's surface and will thereby increase all skin cancers with etiologies related directly or indirectly to ultraviolet B. The Environmental Protection Agency (EPA), in October 1986, estimated that for each 1% depletion of ozone, the squamous cell carcinoma rate will increase 2% to 5%, and for each 1% depletion of ozone, the basal cell carcinomas will increase 1% to 3%. The same 1% decrease in ozone concentration is estimated to increase melanoma mortality by 0.8% to 1.5%.

A recent paper by Moan and Dahlback reaffirms the inverse relationship between latitude and incidence rates of basal cell carcinoma and squamous cell carcinoma in Norway and for melanoma in Norway, Finland, and Sweden. They estimate that for a 10% ozone reduction, a 16%-18% increase in squamous cell carcinoma rates will occur. This magnitude of ozone decrease would also be associated with a 19% increase in melanoma in males and a 32% increase in females. The EPA estimates that a 2.5% per year increase in chlorofluorocarbon (CFC) production will result in an additional one million skin cancers and 20,000 additional deaths over the lifetime of the existing U.S. population. The EPA has also predicted that over the next 50 years 12,000,000 additional cases of skin cancer, and 210,000 skin cancer-related deaths in the United States will result from ozone depletion.

These dire predictions assume the "at-risk" population will not change the amount of time spent out-of-doors nor change behavior in either active or passive ways. Active changes in behavior includes reduction of absolute outdoor time or reduction of exposure time during peak ultraviolet intensity (10:00 am to 3:00 pm), the use of protective clothing, and increases in application of sunblocks of high sun protection factor value. Passive responses include the increase in structural protection against ultraviolet exposure, such as planting shade trees, or the use of awnings or pergolas, or changing schedules of sporting events to avoid times of peak UVB.

From this discussion, it is apparent that there are important carcinogenic consequences on the cutaneous human surface from increased amounts of ultraviolet exposure. However, most of these health problems for humans can be prevented by currently available technology.

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(Note: Figures used in the current manuscript were originally published in Scotto, et al. above and shown as Figures 15, 16, 17 and 18).

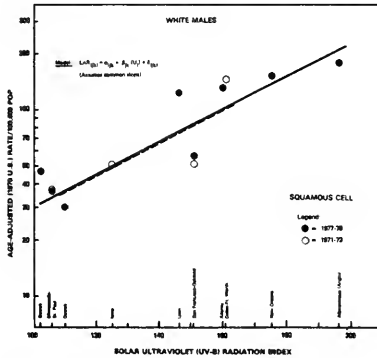


Figure 1

Annual age-specific incidence rates (1971-72 and 1977-78) for squamous cell carcinoma of the skin among white males, according to annual UVB measurements at selected areas of the United States, with regression lines based on exponential models (from Scotto<sup>6</sup>).

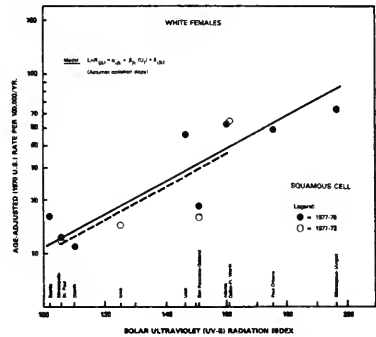


Figure 2

Annual age-specific incidence rates (1971-72 and 1977-78) for squamous cell carcinoma of the skin among white females, according to annual UVB measurements at selected areas of the United States with regression lines based on exponential models (from Scotto<sup>6</sup>).

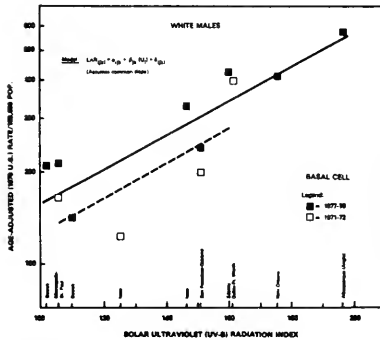


Figure 3

Annual age-specific incidence rates (1971-72 and 1977-78) for carcinoma of the skin, basal cell only, among white males, according to annual UVB measurements at selected areas of the United States, with regression lines based on exponential models (from Scotto<sup>6</sup>).

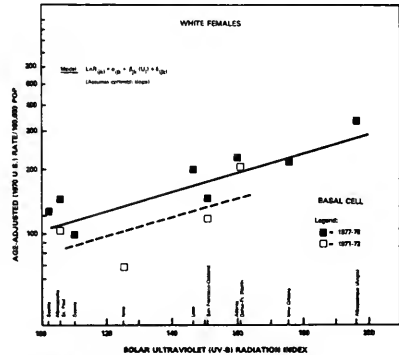


Figure 4

Annual age-specific incidence rates (1971-72 and 1977-78) for carcinoma of the skin, basal cell only, among white females, according to annual UV-B measurements at selected areas of the United States, with regression lines based on exponential models (from Scotto<sup>6</sup>).

## PREVENTION AGAINST THE RESULTS OF THE LOSS OF ATMOSPHERIC PROTECTION

John H. Epstein, M.D.

What can we do to prevent the damage that a reduction in atmospheric protection might cause to our collective skins due to rays from the sun?

The primary rays that cause cutaneous injury fall in the ultraviolet region. In the early 1930s this region was divided arbitrarily into three spectra: UVC, which extends from either 100 or 200 nm to 280 nm; UVB, including rays between 280 and 315 nm, and the UVA spectrum, between 315 and 400 nm. No rays shorter than 290 nm reach the earth from the sun, primarily because they are absorbed by ozone in the stratosphere. The UVB rays comprise the most effective damaging rays from the sun that do impinge on our skins.<sup>1</sup> The UVA rays also are responsible for injury.<sup>2</sup> The atmosphere allows us to survive not only by supplying O<sub>2</sub> for us to breathe and CO<sub>2</sub> for plants on which we live; it also absorbs UVC radiation that would destroy us and at least half of the UVB that arrives at our stratosphere. However it generally absorbs very little of the UVA radiation. At present calculations, no increased UVC will get through, and there is obviously no expected effect on UVA. However, increased amounts of UVB and shorter UVB will be expected to get through to us with a reduction in the ozone protection.<sup>3</sup> This increase has been detected in Antarctica during the time of ozone depletion.<sup>4</sup> This increased UVB penetration has recently been recorded over North America.<sup>5</sup> Thus far, we are concerned with probabilities, rather than specific information on damage. Our primary concern is what could or perhaps is happening, when more UVB gets to us. Since this is a cutaneous problem-oriented symposium, this paper will review potential hazards to the skin and their prevention.

Let us start a discussion of what UVB does to the skin. It is, of course, primarily responsible for the initial type of injury, the acute sunburn response.

The damage that occurs extends well beyond the erythema and edema we see clinically. This includes inhibition of DNA, RNA and protein synthesis and mitoses formation, labilization of lysosomal membranes with release of and/or formation of inflammatory factors such as hydrolytic enzymes, prostaglandins and the interleukins.<sup>6</sup>

Cell death is prominent, resulting in the sloughing of dead cells that we know as post-sunburn "peeling". A more serious effect than cell death is mutation formation. With repeated acute injuries chronic photo-cutaneous damage and skin cancer induction can occur.<sup>6</sup>

Two positive aspects of UVB exposures are that (1) protection may be enhanced by new pigment formation; and (2) vitamin D synthesis is initiated in the epidermis. We should note that if the skin received enough UVB energy to induce new pigment formation, it has received enough to produce cell damage.<sup>6</sup>

The UVA rays can augment the acute phototoxic effects of the UVB rays.<sup>7</sup> In experimental animals they have been shown to augment the carcinogenic effects of UVB rays, and in large enough amounts, the UVA rays can induce skin cancers by themselves.<sup>7</sup> Thus, although a reduction in the ozone layer won't influence UVA penetration, the present amount of UVA could further augment the potential increase of UVB penetration.

Certain people are at greater risk than others. These include patients with a lack or loss of pigment, such as those with oculocutaneous albinism and vitiligo, or people with a pigment dilution problem, such as patients with the Chediak-Higashi syndrome or phenylketonuria (PKU). Also at risk are those with a defect in their DNA repair mechanisms, such as we see in patients with xeroderma pigmentosum.

But the most common concern is found with light-complected people, especially those of Celtic origin. Their basic problem is that they sunburn easily. With repeated injuries they develop chronic actinic damage, actinic keratoses, and skin cancers. Such persons start with acute sunburn reaction, progress to the chronic leathery appearance with subsequent development of actinic purpura and stellate scarring, actinic keratoses, and ultimately skin cancer formation.<sup>8</sup>

An increased amount of UVB would be expected to aggravate certain diseases such as the polymorphous light eruptions, lupus erythematosus, and certain infections such as herpes simplex, as well as, perhaps, to suppress the immune system.

This leads next to prevention of the UVB induced damage. There are three main avenues of approach: (1) avoiding the noonday sun, primarily between 10 am and 3 pm or 4 pm, since the UVB rays drop off markedly towards the edges of the day because of the increased distance they must travel through the atmosphere; (2) wearing protective clothing; and (3) using potent sunscreens.

Considering first the time of day, the edges of the day are safest. Thus, sunrise and sunset are not only beautiful

but from a UVB point of view are relatively safe. Of course the night air is safe and will continue so, even with increased UVB penetration. Avoiding the midday sun can reduce your UVB exposure by around 60%.<sup>9</sup>

Though the sun reaches more people at the edges of the day, you can tell by your shadow that the rays have farther to travel, which markedly reduces the amount of the shorter UVB rays reaching the earth. We should note that sunburn rays may reach us through a variety of circumstances, including reflection from appropriate surfaces, exposure at high altitudes and skylight distribution.

The white sands of a beautiful beach are excellent reflectors of UVB rays but water is not. The snow on a high mountain top is even more dangerous, because one is closer to the sun at such altitudes and the UVB reflection is also immense. Even hiding under a parasol or a shade tree will not exclude the sky light, which can contain a lot of UVB, especially in an equatorial location.

It should be noted that, in general, water does not reflect much UVB radiation, and in the same vein, it does not protect. Thus, we can get sunburned on an overcast day or when we are swimming with most of our bodies submerged under water. This may lead to a severe injury, because the water and the overcast sky reduce the heat and allow us to spend more time in the sun because of a lack of discomfort. Mechanical protection is the mainstay in preventing UVB damage. This includes clothes, hair styles, sunscreens and sunblocks.

The classic "cowboy look" shows a significant appreciation for sun protection. Wide-brimmed hats protect much of the face, as well as the scalp. Hats are also especially important to people with sparse hair covering, since the scalp is the site of greatest potential exposure. Wearing a wide-brimmed hat can reduce the UV radiation to the head and neck by about 70%.<sup>9</sup> Long-sleeved shirts are also of great value. A tightly woven garment is much more effective than loosely woven material. New garments promise even greater protection than those already available. Actually appropriate clothing should reduce UV penetration by 100%.<sup>9</sup>

Appropriate hair styles may provide significant protection. The trend to long hair may be, dermatologically, a very wise preventive procedure. This brings us to sunscreens and sunblocks. These materials protect the viable cells of the skin against sun damage by absorbing or reflecting the injurious rays. Most sunscreens contain chemicals such as PABA, PABA esters, benzophenones, cinnamates, salicylates and anthranilates, which are incorporated into cream lotion or gel vehicles. The chemicals absorb the offending rays and prevent them from reaching skin cells. They can be applied in invisible films that are cosmetically acceptable as well as effective.

Sunblocks such as zinc oxide, titanium dioxide and iron oxide reflect and scatter the offending rays. Thus, a thick layer of zinc oxide will act as a barrier against UV penetration. Unfortunately, until recently, for sunblocks to be effective, they had to be applied in thick, cosmetically unacceptable coats. However, the development of micronized techniques has allowed the use of these sunblocks along with sunscreens to supply excellent cosmetically acceptable sun protection. The only effective sunscreen is a strong sunscreen. This refers to the concept of sun protective factors or SPF. The SPF represents the amount of time or UVB energy that is required to produce a mild erythema with the sunscreen in place, divided by the time or amount of UVB energy required to produce a mild sunburn without the sunscreen. Thus, if one burns mildly in 20 minutes, the use of a sunscreen with an SPF of 15 would prevent such mild burning for up to 5 hours. Since there is no advantage in getting damaged by the sun now versus in the future, when potentially we will be exposed to even more UVB radiation, everyone, even people with dark skin, should reduce their risk factors by using sunscreens with SPF values of 15 or more. A sunscreen with an SPF of 16 will reduce UVB radiation penetration to the skin by 94%.<sup>9</sup>

In summary, the bottom line is that if — or perhaps 'when' would be a better word — the increased UVB penetration of the atmosphere occurs due to ozone depletion in the stratosphere, protection will be even more necessary than it is now. The most important issue then will be the same one we are facing now: convincing people to protect themselves with the measures already available.

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## CURRENT STATUS OF NATIONAL PROGRAMS FOR EARLY DETECTION AND SCREENING FOR MELANOMA/SKIN CANCER

Howard K. Koh, M.D.

### The Conceptual Basis of Screening

Not all cancers are amenable to screening. Screening is most effective when:

- 1) The disease is highly prevalent and causes considerable morbidity and mortality;
- 2) The natural history of the disease is known;
- 3) Early treatment can prevent morbidity and mortality; and
- 4) An acceptable, safe, and inexpensive screening test exists.<sup>1</sup>

By these criteria, many would contend that cutaneous melanoma has theoretical appeal for screening. The disease is increasingly prevalent, with death rates rising faster than any other cancer (except lung cancer). Compared to other types of cancer, the natural history of invasive melanoma is fairly well understood, and early treatment can prevent death. Melanomas can arise from a preexisting melanocytic nevus and the tumor is accessible. The screening examination (a visual examination by a qualified observer) is safe, acceptable, takes several minutes and regarded by many as reliable in diagnostic situations. Finally, since some melanomas affect the back and posterior legs (which cannot be viewed easily by the person with the lesion), screening examinations could theoretically improve detection of these lesions.<sup>2,3</sup>

In an attempt to stem the rising incidence of melanoma, the AAD began an annual free skin cancer screening and education program in 1985. In May of each year, local and national media publicize risk factors and warning signs for skin cancer (particularly melanoma), and publicize the availability of free screening clinics. Volunteer dermatologists staff these screenings and provide examinations to those who attend. Since the program's inception, the number of persons screened has risen steadily. Through 1993, about 600,000 Americans have been screened in this process. Millions more have learned about the warning signs of melanoma/skin cancer and received educational material by way of pamphlets, newspapers, or radio and television.<sup>4</sup>

Skin cancer screening is unique because in addition to being a screening, it is an inherently educational process. The occasion allows the dermatologist to teach the examinee about the possible signs of cancer, especially with respect to his or her moles. One of dermatology's challenges is to

exploit the unique visibility of the skin and align education and screening to enhance early detection.<sup>5</sup>

In the absence of formal skin cancer screening studies, examination and evaluation of the AAD program can yield critical initial data.

### 1) How does publicity affect mass screening?

The AAD experience qualifies as "mass screening" a large segment of the public. Once the organizers decide to target a large scattered population, methods used to inform this group are newspaper, radio, and television publicity. These methods have a variety of public health effects. In addition to promoting the screening itself, the publicity campaign may lead to some undetected constructive behavior, through both primary prevention (such as modification of sun exposure behavior) and early detection outside of mass screening (such as increased self examination of the skin or scheduling a visit to a personal physician for a skin examination). As a result, AAD mass screening for melanoma is inextricably part of a larger cancer control effort that includes a publicity and public education campaign.<sup>1,2</sup>

### 2) Which populations should be screened?

In other cancers, such as cervical cancer, sometimes the inappropriate population, (i.e., people at low risk) show up for screening. To determine if a similar problem affected AAD skin cancer screening, those who attended screenings in Massachusetts in 1987 were surveyed to test the hypothesis that persons selecting themselves to be screened have a higher risk for skin cancer than the general population.

Test data showed that the AAD program in Massachusetts predominantly attracted persons with risk factors (e.g., personal or family history of melanoma, high numbers of moles, tendency to burn when exposed to the sun, or a history of severe or blistering sunburn) and with greater risk estimates for the screened, population when compared with controls. Fully 86% of those screened had at least one risk factor for melanoma, partly because 81% said they were sun-sensitive; 78% had at least two of the risk factors.<sup>6</sup>

Additional analysis found that the screening population was 98% white, about 66% women, and well-educated (51% had some college education). In addition, the examinees' median age of 53 is similar to that of melanoma cases in the general U.S. population.<sup>6</sup>

Targeting screening to high-risk persons should be the

most efficient form of cancer screening. Screening family members of melanoma patients may increase both the yield and predictive value of the screening test. Studies of family kindreds in the United States and Europe have shown that active surveillance resulted in the detection of disease at an early, thin stage.<sup>7,8</sup> However, since one of the primary goals of screening is to prevent death, the program should make special efforts to reach persons who are at risk for advanced diseases. New data demonstrate that melanoma mortality is rising fastest in older white men (over age 50), for reasons unclear.<sup>9</sup> Thus, until further data accrue, the AAD will begin to focus future screening and educational efforts on older white men as a strategy to prevent death from melanoma. Also, some preliminary data indicate that white persons of higher socioeconomic status (SES) are at risk for melanoma, but those of lower SES may be more likely to die of the disease.<sup>10</sup> Hence white low SES populations may also be appropriate target groups.

### 3) What is the yield of screening or how many confirmed skin cancers are found?

The AAD screening protocols contain no formal mechanism for following patients in these scattered populations to obtain the definitive diagnosis. Persons with suspected skin cancers are encouraged to consult their own physicians or dermatologists to undergo biopsy and appropriate treatment. In Massachusetts, comprehensive follow-up of people who have come into screening sessions has been ongoing since 1986. For the period 1986-1989, the final diagnosis on about 85% of the 5644 persons who were screened was confirmed. In this group, 16 melanomas (of which 7 were in situ lesions), 176 nonmelanoma skin cancers and 75 dysplastic nevi were confirmed. This is a yield of 1 melanoma for every 352-627 persons screened (159/100,000 to 284/100,000) depending on inclusion or exclusion of in situ lesions.<sup>11</sup> Similar yields of melanoma have been reported from other screening programs. Skin cancer screening of 2564 persons in the Netherlands found 10 confirmed melanomas (including 1 lentigo maligna), a yield of 1 melanoma for 285 persons (excluding the lentigo maligna from analysis). Overall, these high yields depend on whether in situ lesions are included or excluded and represent data from a prevalent screen; if people came back for repeat (incident) screening, the yield should drop. However, these data also support the earlier conclusion that high-risk people are appropriately selecting themselves to be screened, thereby boosting the yield.

We have also begun to document and analyze the pathology-confirmed melanomas found nationally in AAD screening (Table I). In 1992-93, 195,660 persons were screened and 3285 of them (1.6%) has suspected melanoma. As a first attempt at follow-up, we contacted these persons

and their treating physicians by mail and telephone. We successfully contacted 97% of these persons and received complete pathology data for 72% of participants. Among 257 persons with melanomas found in screening, more than 98% were local (AJC Stage 1 and 2) lesions. Of the 253 Stage 1 and 2 lesions, 45% were in situ. Of the 139 invasive lesions, 62% were less than 0.76 mm thick and 25% were between 0.76-1.50 mm. Only 7% of the lesions were equal to or greater than 1.51 mm thick. We compared screen-detected cases to the United States Surveillance, Epidemiology, and End Results (SEER) population-based cancer registry and noted trends suggesting fewer advanced cases in AAD screenees (8.6% AAD, 16.8% SEER,  $p < 0.001$ ).<sup>4</sup>

These results are preliminary. Without a formal control group, accurate projections about improved mortality are impossible. Furthermore, these data are subject to bias. Screening may tend to detect the least aggressive tumors (length bias). It is possible that some, or many, of the 43 in situ lesions would never have progressed to invasive cancer. Advancement of diagnosis through screening may not prevent death (lead time bias). In addition, individuals whose cases were detected through screening programs are self-selected and perhaps more health-conscious than the general population. As already mentioned, it remains to be seen if these programs can attract older men and persons with low SES (individuals both at risk for advanced disease and most likely to die from their disease). In summary, we can say that most of the melanomas in AAD screening are thin Stage 1 lesions with high projected five year survival, but the impact of screening on mortality remains unknown.

### 4) Can we prove that screening saves lives? Should melanoma/skin cancer screening be general health policy?

Ultimately, it is critical to test in a rigorous fashion whether or not melanoma/skin cancer screening can save lives. At present, with AAD mass screening of scattered populations, there is no appropriate control group. Ideally, decreased mortality in a randomized controlled trial needs to be demonstrated, as was done in the Health Insurance Plan of New York (HIP) study of mammography and physical examination for breast cancer. (This randomized study showed a consistent decline in mortality after long follow-up for those who were screened and received mammography as opposed to those who did not.) Another alternative may be studies to demonstrate decreasing mortality rates after widespread initiation of screening practices, such as with cervical cancer and pap smear in Scandinavia and Iceland. Finally, once skin cancer screening becomes more prevalent, case-control studies might be worth investigating further.<sup>14</sup>

While skin cancer screening has theoretical appeal, little data and no definitive evidence exist that screening saves lives. It should be emphasized that the AAD program represents only one type of screening - episodic mass screening by dermatologists on self-selected individuals. Ultimately, screening as part of a routine physical examination by the primary care provider (case-finding) may be the most comprehensive way to decrease melanoma mortality.<sup>2</sup> Opportunities to improve case-finding exist, since Massachusetts data indicate that most persons with newly diagnosed melanoma have a physician and see that physician in the year prior to diagnosis. However, there is no clear consensus as to whether skin cancer screening should routinely be incorporated into the physical examination.

In light of this, should skin cancer be general public health policy? Presently, the major public health policy organizations differ in their recommendations. The American Academy of Dermatology and American Cancer Society support general skin cancer screenings, while the UICC Project on Evaluation of Screening for Cancer does not. However, the U.S. Preventive Services Task Force and others recommend screening for specific high-risk groups. Targeted screening, self-screening, screening at work sites and health fairs are other strategies that have to be properly investigated.<sup>5</sup>

### Conclusion

Over the next few decades, screening and education for melanoma/skin cancer will receive increasing worldwide attention. The unique visible aspects of skin cancer enhance the potential of combining screening and education for melanoma control. Theoretically, appeal for screening exists but no specific evidence shows at the present time that it is effective. We need more data and information to prove definitively that these efforts improve early detection and save lives.

### Acknowledgement

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Table 1

**Stage and thickness of melanomas found in AAD screening (1992-1993)  
compared to those recorded in SEER Registries (1990)**

|                              | <b>AAD Screening</b> | <b>SEER Cases</b> |
|------------------------------|----------------------|-------------------|
|                              | <b>#(%)*</b>         | <b>#(%)*</b>      |
| All cases (with known stage) | 257                  | 3050              |
| LOCAL                        | 253 (98.4)           | 2864 (93.9)       |
| In situ                      | 114 (45.0)**         | 851 (29.7)**      |
| Invasive                     | 139 (55.0)**         | 2013 (70.3)**     |
| <0.76 mm                     | 84                   | 928               |
| 0.76-1.50 mm                 | 34                   | 375               |
| 1.51-3.99 mm***              | 15                   | 245               |
| 4.00 mm+****                 | 3                    | 83                |
| Unknown                      | 3                    | 382               |
| DISTANT AND REGIONAL***      | 4 (1.6)              | 186 (6.1)         |

\* Percentages by stage and thickness are computed among cases of known status (unknowns excluded)

\*\* Percent of local disease

\*\*\* Advanced cases less common in AAD screening (22/257) (8.6%) than in SEER (514/3050) (16.8%) ( $p=0.001$ , chi-square)

## ULTRAVIOLET EFFECTS ON HUMAN IMMUNE RESPONSES

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Introduction into the environment of compounds that have now been found to catalyze the destruction of stratospheric ozone has resulted in ozone depletion in the stratosphere of not only the Antarctic, but now also the Arctic. Ozone depletion is now distinctly measurable over populated areas in both the Southern and Northern Hemispheres. Combined with human societal/behavioral trends, humans have been, and will continue to be, exposed to significant and increasing flux densities of UV radiation, in particular UVB. However, as yet it has not been possible to extrapolate from murine studies the impact of increased UVB radiation on immune suppression, nor to quantitate to what degree immune suppression results in altered infectious disease patterns, vaccine effectiveness, photoaging, or even skin cancer incidence.<sup>1</sup> Furthermore, it is not clear how much of our population is at risk. Are pigmented segments of the population protected against UV-induced immunosuppression or not? Do sunscreens really protect against immune suppression as well as they do against sunburn erythema? A quantitative assessment of dose effects of UV irradiance on human immune reactivity is needed to begin to address these issues. Toward that end, we have utilized a human bioassay in which normal volunteers are exposed to UV radiation at the immunization site with a potent immunogen, (dinitrochlorobenzene, DNCB).<sup>2</sup> Groups of subjects with Types I-III skin (fair-moderately fair skin) who received varying doses or schedules of UV radiation from a bank of FS20 fluorescent sunlamps (rich in UVB), were compared in their ability to mount an immune response to DNCB following the immunization.<sup>2</sup> The investigators found a linear UV-dose-responsive inhibition of immune responsiveness, with a detectable decrease first occurring at 0.75 of the individual's minimal erythral dose (MED) and reaching complete inhibition of responsiveness for 95% of subjects if 2 MED was administered every day for four days prior to immunization. Similar inhibition occurred if sensitization to DNCB was administered through skin that received a single 4 MED exposure three days prior. The effect did not carry to a distant site; that is, immunization with another, unrelated immunogen (diphenylcyclopropanone, DPCP) at a site distant from the sunburn was essentially unaffected by the UV exposure. There was no distant immunosuppression even if total body exposure to 4 doses of either 0.75 MED or 1.5 MED were administered prior to sensitization (the DPCP sensitization site and the elicitation sites were protected prior to sensitization). Approximately

25-30% of the subjects receiving erythemagenic doses of UV were rendered tolerant (long term active unresponsiveness) to the DNCB; that is, even if the DNCB was provided as subsequent immunization through skin that had not been UVB-exposed, these subjects could no longer be immunized to DNCB, indicating an active effect on the immune system. The degree of immunosuppression correlated with both the degree of Langerhans cell depletion that occurs after UVB and the occurrence of macrophage infiltration in the sunburned site.<sup>3-13</sup>

These data indicate that humans are immunosuppressed at highly relevant levels of UV exposures commonly encountered by the population. They also indicate that the immunosuppression is not likely to result in immunosuppression of responses to agents encountered in other organ systems or distant sites. Of interest is that in a similar type of assay, subjects with a past history of skin cancer were all found to be the most susceptible to UV-induced immunosuppression.<sup>14,15</sup> Furthermore, immunosuppression by UVB was not limited to fair skinned subjects, indicating that tanned Caucasians, as well as more deeply pigmented subjects, are contained within the "at risk" population.<sup>10</sup> To determine if the UV doses resulting in immune suppression in humans might be sufficient to increase the risk of certain adverse health effects in humans, extrapolations from murine data will be needed. Comparison of the relationships between human and murine dose response curves for suppression of contact sensitivity can be performed with currently available data.<sup>24</sup> The relationship to other disease processes, such as tumor susceptibility or infectious disease alteration, may also be able to be determined, but careful attention to dose response relationships, light sources, and the relevance of the murine models must be given.<sup>17,23</sup>

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## OZONE DEPLETION, INCREASED UVB INTENSITY, AND SKIN DAMAGE

Thomas B. Fitzpatrick, M.D., Ph.D.

It is a truism that when considering a potentially deleterious environmental change, one should anticipate the worst case, and prepare for it. Ozone depletion has already occurred in the Antarctica and would continue in the future, even if CFC production were stopped today; the 100-year half-life of chlorine in the stratosphere means the problem of increased UVB intensity will be around for another century.

### Historical Considerations

For over past two decades many in government (U.S. Congress, the executive branch, the EPA) and in science and medicine (photobiologists and photodermatologists) yawned when the question was raised: would ozone depletion result in increased UVB intensity on the earth's surface and lead to harmful human effects, especially increased incidence of melanoma and nonmelanoma skin cancer? Two decades ago, the commonest types of the serious fatal skin cancer (superficial spreading and nodular melanoma) were not believed to be related to sun exposure. This disbelief in the role of solar UVR in the etiology of melanoma has now been turned around as a result of extensive epidemiological studies, most specifically the large case-control studies in Australia. The prevailing belief now is that melanoma of the skin is, in part, caused by sun exposure in certain populations at risk.

### Future Outlook

The EPA now predicts 12 million more skin cancers and 210,000 additional skin-cancer deaths in the U.S. during the next 50 years. In 1991, the UN Environment Program released a report containing two dire predictions: (1) 1.75 million additional cases of cataracts by the year 2000 if the ozone layer diminishes another 10% by the end of the decade and (2) a worldwide skin cancer rate increase of 26% by the year 2000 if the earth's ozone layer continues to be depleted at current rates.

Therefore, we must now prepare the population for increased UVB intensity. While this will be important for all latitudes, it is especially a problem in high latitudes where cooler summer temperatures prevail at midday, when UVB intensity is highest. With cool temperatures, people are recreating or working outside during the midday. It must be remembered that UVB exposure, unlike heat, does not provoke any immediate warning signs; the exposure experience is silent, surreptitious, and the skin reactions (sunburn) are delayed for 15 to 20 hours later. Those high-risk persons will be facing the prospect, in 10 to 20 years, of

summer UVB intensities in heavily populated northern cities of the same magnitude as summer UVB intensities that in 1992 prevailed in Tucson, Arizona. But people in Tucson generally avoid the midday summer sun, because of the intense heat; in the northern latitudes the population elects to recreate in midday sun. In the words of Noel Coward:

*At twelve noon the natives swoon*

*And no further work is done*

*But mad dogs and Englishmen*

*Go out in the midday sun.*

This ominous combination of cool temperatures and high intensity UVB now prevails in certain parts of Borneo; Caucasians who live there develop solar keratoses before puberty! Solar keratoses can be regarded as a biological dosimeter for cumulative UVB damage.

The skin is the major human surface to be attacked, and dermatologists and researchers in collaboration with industry need now to explore every possible method of helping high-risk UVR-induced skin cancer-prone patients protect against the development of disfiguring epithelial cancers and fatal malignant melanomas.

The major skin cancers (basal cell and squamous cell carcinomas and malignant melanoma) have diverse etiologies. However, the evidence for sunlight as a major etiology for nonmelanoma skin cancer (NMSC) is unequivocal. NMSC has the highest incidence in a high-risk population of white skinned people with inability to tan (Skin Phototypes I and II) and occurs much more frequently in outdoor workers such as telephone linemen, sailors, farmers, ranchers, and in older persons who have been exposed to sun for many years. A good example would be golfers who spend months in Florida in the winter and then summer in northern latitudes. The sites of NMSC (exposed areas of the head and neck, dorsum of the forearms and hands) also are strong evidence that sunlight is a major cause.

### Melanoma Etiology

Primary malignant melanoma of the skin has varied expressions and some types seem to have little or no relation to exposure to sunlight, such as malignant melanoma arising in congenital nevocellular nevus; acrolentiginous melanoma, which occurs on unexposed areas (feet and hands) and which is also most common in populations with brown and black skin.



Therefore, a cursory view of the causation of melanoma would suggest that primary melanoma has little to do with sunlight exposure except for lentigo maligna melanoma, which all agree is similar to NMSC with respect to a sun-induced etiology. Some major arguments against the solar cause of melanoma are:

- 1) Primary melanoma of the skin of white persons has the highest incidence in young and middle-aged persons (primarily malignant melanoma is the second most prevalent malignancy of males age 30-49).
- 2) The site of origin is not on the most exposed areas (head and neck) but on the upper back and on the legs of females.
- 3) Melanoma in whites is seen not in outdoor workers but in indoor professionals who, in fact, have only weekend, albeit often intense, exposures.

Nevertheless, five special committees of the National Academy of Sciences over a period of 6 years (1976-1982) carefully examined the role of sunlight in malignant melanoma and concluded that UVR is unequivocally a major etiologic factor in NMSC, and the UVR may play a role in the development of some malignant melanomas of white persons. The EPA sponsored a complete two year study by a committee of statisticians and epidermatologists concentrating on the role of sunlight in the etiology of malignant melanoma and concluded that solar radiation does play a role in the development of malignant melanoma of the skin in whites.

Two major factors cited in this EPA committee report were:

- 1) The rising incidence of melanomas with changes in patterns of exposure, particularly with respect to increasing, intermittent, intense sun exposure of certain anatomic sites. Consistent with this fact is an increased incidence in higher socioeconomic classes (professionals) and in indoor workers. The dramatic increase in the incidence of malignant melanoma in the skin of whites in the last two decades (more than 600%) is explained by changes in lifestyle — affluence, shorter work week, more leisure time and more trips to the beach, more sun exposure in winter in the sunny parts of the world, and a striking emphasis on outdoor sports activities.
- 2) The data reporting that individuals who move to sunny climates (Australia, California, Israel) have higher rates of melanoma than those who remain in their country of origin. This is particularly accentuated in individuals arriving at or just before the age of puberty (10 to 14 years). A recent large study from Australia has revealed that in deaths from melanoma among immigrants to Australia compared to Australian-born residents by region of birth, the highest mortality was for persons

born in Australia, next England, and then Ireland/Scotland/Wales. These groups are largely a population with Skin Phototypes I and II. Mortality was lowest in people from Central and Eastern Europe and from Western and Eastern Asia, populations with Skin Phototypes III, IV, and V.

Looking at the ozone depletion-increased UVB deleterious effects on the global biosphere, indirect effects on humans include UVB damage to: (1) zooplankton, which are important in the aquatic food chain, critically affecting the supply of fish for human consumption; and (2) phytoplankton, which fix carbon dioxide. If this reservoir were reduced there would be an increase in global warming by the "greenhouse" effect.

Of more immediate interest are the direct effects on humans, which are dose-dependent, cumulative and irreversible causing: (1) increased incidence of skin cancers of melanocytes and keratinocytes; (2) damage to the eye, leading to age-related nearsightedness, deformation of the lens capsule and nuclear cataracts; and (3) damage to T-lymphocytes, thus reducing defenses against infections (such as herpes simplex or cutaneous leishmaniasis).

#### Recommendation:

The dermatologist is the primary physician for the management of the patient with skin cancer, and for this reason, needs to be involved in the ozone depletion problem on a national and international level.

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NATURALLY OCCURRING HAZARDS  
TO THE SKIN

## DILEMMAS AND OPPORTUNITIES TO PREVENT POISON IVY, OAK, AND SUMAC DERMATITIS

William L. Epstein, M.D.

Poison ivy and poison oak, together, represent the single most common cause of itchy allergic skin reactions in the United States, and they are biologically inseparable.<sup>1,2</sup> If you are allergic to one, you will certainly react to the other. Approximately half the adult population in the United States is clinically sensitive to poison ivy/oak. This means that half the population will get a rash if they have contact with poison ivy/oak leaves. Another 35% are subclinically sensitive; if they come into contact indiscriminately and/or have a heavy exposure, they will get a rash. This leaves only 10-15% who are truly immune, either by early exposure to the allergen or a tolerogen or by some genetic happenstance. Poison ivy/oak dermatitis is, perhaps, the most important clinically relevant skin disease that can be unambiguously and completely related to the environment. Furthermore, it is a uniquely North American affliction.

Although weeds, plants and trees containing similar and cross-reacting allergens exist in other parts of the world, (especially South America and Asia), these plants are either not so ubiquitous as poison ivy/oak, and/or their chemicals are not so allergenic for humans, so that relatively few people in the rest of the world are naturally sensitized by exposure to the urushiol oil. For example, the weeds did not grow naturally in Europe until they were transplanted there, around the time of World War II. Now the plants are slowly spreading across Europe. On the other hand, poison ivy-sensitive travelers from the United States can develop surreptitious eruptions after exposure to urushiol-containing exotic plants, trees and foliage and artifacts made from them.

Despite minimal governmental support over the years, much has been learned about the plants, the offending chemicals (urushiol) and the immunological response of humans to these obnoxious weeds. Botanists inform us that in spite of being widely distributed in nature, these plants are very selective in their growth habits. Also, there is no such thing as a "generic" poison oak or poison ivy leaf. One cannot rely on the old saying "leaves three, leave it be". Often leaves occur in fives, sevens, nines, etc. and their shapes are distinctive only for the region where they grow. If the plants are transported to other habitats, they will grow in different forms. Thus, poison ivy tends to develop as a vine crawling up trees and poles to reach the sun, whereas poison oak has the propensity to form a shrub or small tree,

sometimes with limbs suitable for carving a gavel or spear. In another environment, however, poison oak becomes a crawling vine and presumably poison ivy would form a shrub in the desert. Another biological problem is that the allergenic chemical (urushiol) is a light, colorless oil that courses throughout the veins just under the surface or epicarp of the weeds. It runs through all levels, from the roots to the tips of the fruit and the leaves, much like the lymphatic system in humans. Although the urushiol oil recedes from the leaves in autumn, when they dry up before falling off, it flows back into the stalk and roots. As a result, the stark formless sticks are booby traps for outdoorsmen in the dead of winter. The good news is that their growth patterns are more limited than omnipresent. For instance, they do not grow above 4000 feet, so the Rockies and Sierras are safe havens. They also do not naturally grow in rainforests, in hot humid climates such as Hawaii, nor in Alaska, and they abhor the desert unless it rains. They do grow luxuriously in temperate climates where it is hot and wet in the summer, along lakes and streams in the Midwest, Northeast, and Southeast, and the seashores on the East and West. The country is permeated with these bothersome weeds in the very places where most of the populace goes to vacation.

An equally large corpus of knowledge is available about the chemistry of urushiols, so that one could easily invent strategies to prevent or interdict their actions on human skin. However, as is the case with the HIV virus, extensive knowledge has not led to clinical solutions. We know that urushiols are a group of catechols, with a long carbon side chain at ring position 3, ranging from c-13 (characteristic of poison sumac) to c-15 (characteristic of poison ivy) to c-17 (characteristic of poison oak). The differences among the catechols are in the saturation of the side chain, which ranges from fully saturated (least antigenic) to 3 unsaturated bonds, with the diene being the most antigenic. These side chains determine specificity of the response and the carbons at ring positions 4, 5 and 6 determine protein bonding and whether the chemical will be a sensitizer or a tolerizer. If the carbon positions 4 and 5 are available for protein binding, they will preferentially attack amino bonds on proteins and act as sensitizers. However, if the sixth ring position is available, it will preferentially bind to cysteine moieties on proteins and cause tolerance or non-reactivity.<sup>3</sup>

Potentially, this chemical information could be useful in devising tolerizing compounds to prevent people from becoming sensitized to the weeds.

As indicated above, approximately one-half of the 250 million-plus population of the United States is clinically sensitive, and more than two-thirds could react, so a major need exists for effective treatments and/or preventive measures. Approximately 10%, or somewhere between 15 and 25 million people, are so sensitive that they require treatment by dermatologists, usually injection or ingestion of large doses of corticosteroids. This treatment is palliative and generally results in healing over a 10 to 14 day period, but the annoyance and disability is staggering. Nearly 1% of Workman's Compensation in the state of California is spent in the care of poison oak dermatitis. Although avoidance is the best preventive, it is seldom practical, especially in the industrial setting of outdoor workers, so that other approaches must be sought. Despite the immense amount of knowledge available about the botany, biology, immunology, and chemistry, the government has provided very little financial support for prevention or adequate treatment of the disease. To date, pharmaceutical manufacturers of corticosteroids, the main systemic treatment for severe poison ivy/oak dermatitis, have been the major contributors to our citizens' health. In recent years methods of prevention have become popular, particularly with outdoor workers. Some effective barrier creams have been developed but these came strictly at the behest of industry, not in the public good. The FDA is required by law to investigate the safety and efficacy of all preventive preparations that would be applied to the skin with the aim of preventing poison ivy/oak dermatitis. This ruling has blocked a number of useful compounds from the market, and some of these are sold through industrial supply houses without any claims other than skin protection. This could be changed by a specific edict, making development of such topical agents an exception to the law. Considering the enormity of the problem and the recognized safety of these chemicals, some of which are used in cosmetics, our society would be well served. In addition, government agencies such as the Department of Agriculture should contract with the clothing industry to develop light, poison ivy/oak retardant clothes for use by firefighters and other outdoor workers at high risk for exposure to these weeds.

Other approaches being carried out without government support include: (1) the development of chemicals that could act as tolergens;<sup>3</sup> and (2) strategies to take advantage of the more recent observation that when people are hyposensitized by ingestion of the urushiol oil, they actually produce an immunoglobulin that seems to block the T cell receptor.<sup>4</sup> With this information, it should be possible to develop a "vaccine" that might, temporarily or for long

periods of time, prevent people from getting the rash.

In plain words, it is abundantly clear that the potential to prevent or interdict poison ivy/oak dermatitis is near at hand, because we have enough basic information. What we need, however, is the financial and administrative support of appropriate governmental agencies to make this a reality for the large number of American citizens, including teenagers, outdoor workers and enthusiasts and others who suffer the scourge of poison oak and poison ivy.

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## THE EFFECTS OF SUNLIGHT ON THE YOUNG AND ELDERLY

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Other presenters at this symposium have discussed the adverse effects of sun exposure, including nonmelanoma skin cancer (basal cell and squamous cell cancer) (NMSC), photodamage, and melanoma.<sup>1</sup> Strong evidence exists that increased exposure to the sun increases the likelihood or extent of NMSC and photodamage.<sup>2,3</sup> Both NMSC and photodamage are most often manifested in older persons. Photodamage is defined as wrinkling, irregular pigmentation and, perhaps most importantly from a societal perspective, changes in the actual function of skin, including increased permeability, decreased ability to withstand trauma, and diminished capacity to heal. The role of childhood exposures to the sun in causing these changes is probably substantial. A variety of alterations in immune functions, both in the skin and systemically, appear to be mediated by exposure to sunlight.<sup>4</sup> The clinical consequences of these alterations in humans remains controversial.

### Risks and Benefits of Light Exposure

In considering the consequences of sun exposure in the young and elderly, it is important to remember that sun exposure is associated with benefits as well as risks. Many individuals feel good when they are exposed to the sun. The warm glow one gets at the beach is largely a consequence of infrared radiation. Exposure to full spectrum visible light may also have a salutary effect on mood. Completely separating exposure to that part of the solar spectrum that is beneficial or pleasurable from that which is harmful is difficult, if not impossible. Further, the relative risks and benefits vary between individuals and with age. In addition, we need to remember that certain effects of the sun (i.e., tanning) that dermatologists may devalue are, in fact, a source of pleasure to many. In older age groups, exposure to the ultraviolet radiation from the sun may be an important source of vitamin D, critical to proper calcium metabolism.<sup>5</sup> Even if dermatologists believe that tanning is not desirable, we should not discount that which makes people happy and is not socially destructive or tremendously risky. The value of other persons' pleasures cannot be dismissed merely because dermatologists disapprove.

The risks of sun exposure are modified by a patient's health and medication use. Exposure to certain photosensitizing drugs or chemicals increases the risk of both acute and chronic adverse effects of the sun. Not only does the use and, hence, risk of potentially photosensitizing chemicals vary with age, but the health consequences of such reactions may be especially important in the young or

elderly. Also, strategies to limit the adverse effects of sun exposure may have different impact on the quality of daily life in the young and elderly.

Clearly, the cost of either treating or preventing adverse effects of sun exposure vary with age. The cost of avoiding or reversing adverse effects of sun exposure are also likely to vary with age, and are especially important to the young and elderly. The special importance of sun exposure in youth and the older age groups is related to quantitative differences in exposure, to qualitative differences in effect per unit of exposure and, particularly for older persons, to past exposures.

One reason sun exposure in childhood and older age is so important, compared to other stages of life, is the amount of time available for exposure to the sun during these periods, especially compared to the middle years. In a temperate industrial society such as ours, the number of days available of exposure per year is far higher in childhood and after retirement than during working life. During childhood an individual spends an average of about three times as much time in the sun per year compared to middle age.<sup>6</sup> The adverse effects of greater exposure per year during childhood than adult life may, in fact, exceed this simple quantitative difference in exposure level.

### Sun Exposure and Skin Malignancies

The exact relationship between total or cumulative sun exposure and the risk of melanoma is not yet clear. Exposure to sunlight in childhood appears to be an especially important determinant of the risk of melanoma. Homan<sup>7</sup> found that individuals migrating to Australia before puberty had a risk of melanoma comparable to native Australians, whereas those who migrated after age 18 maintained the far lower risks of lifelong residents of their native northern countries. At least two other findings suggest that childhood sun exposure patterns may be particularly important determinants of lifelong melanoma risk. An association between multiple painful sunburns in childhood and a higher risk of melanoma has been reported.<sup>8</sup> An association between the amount of sun exposure during childhood and the number of nevi that develop has been established.<sup>9</sup> A greater number of nevi is a risk factor for melanoma.<sup>10</sup>

For nonmelanoma skin cancer, epidemiologic data suggest that the risk increases exponentially with increased total exposure to UVB.<sup>6</sup> Doubling exposure increases risk about four-fold. Therefore, a halving of childhood exposure would result in a more than 50% decrease in lifetime risk.<sup>6</sup>

There is also a delay or latency period between exposure and the development of skin cancer. Therefore, reducing exposure in childhood reduces lifetime risk and increases the age of onset among those who develop a tumor. The impact of a skin tumor in a young person is likely to be greater than the impact in an older or elderly individual with respect to cost, disfigurement, and years of life lost. Nonmelanoma skin cancers that develop in younger persons may also be more aggressive than those seen in older persons.<sup>11</sup>

Classic theories of carcinogenesis suggest there are two important steps in cancer development, initiation and promotion.<sup>12</sup> Ultraviolet from sunlight may be both an initiator and a promoter. As a result, exposure in older individuals might be especially important in promoting the final development of nonmelanoma skin cancer in individuals with substantial prior exposure to the sun. In this way, sun exposure in the elderly may be especially important in tumor formation. We know that persons with a prior history of nonmelanoma skin cancer in a sunny climate are about 50% more likely to develop an additional tumor than are persons living in a less sunny area of the United States.<sup>13</sup> Premalignant lesions known as actinic keratoses may regress in winter and appear to be more likely to progress when exposed to the sun. This clinical observation supports the possibility of an especially important role for exposure late in life on the development of nonmelanoma skin cancer in those with substantial exposure to ultraviolet radiation (or other carcinogens) early in life. More recently, an Australian study of persons with actinic keratoses demonstrated that regular use of sunscreen over one summer decreased the rate of formation of actinic keratoses.<sup>14</sup> Therefore, sunscreen use may decrease the risk of squamous cell cancer in persons who have or are at high risk for the development of premalignant actinic keratoses. These are most often the middle-aged or elderly.<sup>14</sup>

Dr. Margaret Kripke pointed out the immune effects of sunlight and their possible adverse consequences. In mice, young animals seem especially susceptible to developing immune alterations, leaving them at higher risk of skin cancer as a consequence of ultraviolet exposure early in life.<sup>4</sup> Whether these observations in animals are relevant to humans is not yet known, but prudence suggests that we consider such potential adverse immune effects of childhood exposure.

We are, in general, a medicated society and the number of medications used increases with age. Many medications to treat hypertension, arthritis, and irregular heart beat are photosensitizers. Clearly, their use is greatest in older Americans, making phototoxic reactions with sun exposure particularly problematic for the elderly.

Abundant evidence exists that the extent of

photodamage or photoaging is a function of cumulative sun exposure, especially among fair skinned Caucasians.<sup>2</sup> Most attention has focused on the cosmetic consequences of photoaging. The importance of these changes to our population is evident in the billions of dollars spent each year to cover or reverse them. Less often noted is the functional impairment resulting from photodamage combined with aging. For example, loss of skin integrity can occur with less trauma and ulcers and infections can occur as a consequence. Wound healing takes longer. The cost of these injuries is enormous. Not yet known is the relative importance of recent exposure versus childhood exposure to the sun on the cosmetic or functional degradation in skin. Neither do we know the extent to which these problems can be ameliorated or reversed by subsequent sun protection.

### Economic Implications

There is no question that sun exposure leads to substantial health consequences and economic costs. Most of the 600,000 nonmelanoma skin cancers that develop each year in the United States could have been prevented.<sup>6</sup> The treatment of these lesions costs hundreds of millions of dollars. Given the exposure patterns detailed above, mathematical models tell us that a substantial majority of these tumors could have been prevented with sunscreen use in childhood. Based on mathematical modeling, the cost of each nonmelanoma skin cancer prevented by childhood sunscreen is about five thousand dollars.<sup>6</sup> Clearly this cost far outweighs the cost of treating these tumors. Other types of sun avoidance may also have substantial health consequences. In the elderly, discouraging outdoor activity may result in decreased physical activity with subsequent impact on psychological and physical well being, including increased risk of cardiovascular disease. It is common practice to advise individuals who have developed a nonmelanoma skin cancer (who are often elderly) to be especially prudent in avoiding the sun.<sup>15</sup> Although the higher risk of a new squamous cell cancer in populations in more southern parts of the United States argues that sun exposure subsequent to a first squamous cell cancer impacts upon subsequent risk, the increase in absolute risk is relatively modest.<sup>15</sup> Whether reducing the rate of actinic keratosis formation will substantially reduce the risk of cancer over the long-term is not yet established.<sup>14</sup> Clearly, loss of time outdoors may have an especially great impact upon older individuals. As little as we know about the relationship between sun exposure within particular periods of life and the risk of melanoma and nonmelanoma skin cancer, we know even less about the relation between exposure to the sun at various periods during a lifetime and photoaging.

In spite of the clear adverse effects of sun exposure both in childhood and older age groups that I have detailed, the

ways we have to avoid these adverse effects are not without cost. So far, we have only two ways of reducing sun exposure: (1) staying out of the sun; and (2) using sunscreens. Both approaches are problematic to many. Staying out of the sun usually means less outside activity, with subsequent loss of enjoyment and less cardiovascular fitness. Sunscreens are expensive, inconvenient, may be uncomfortable or have adverse effects. Perhaps most worrisome, the use of a sunscreen may be used as a justification to increase actual time in the sun, with little net reduction in total cumulative exposure to carcinogenic radiation. The possible result is increased exposure to longer wavelengths of ultraviolet.<sup>16</sup> Of greatest concern is the possibility that as individuals spend more time in the sun without burning (which is possible for fair skinned persons who use sunscreens), exposure to ultraviolet-A (UVA), especially longer wavelengths of UVA, will increase. Recent animal experiments suggest UVA may be particularly important in the etiology of melanoma.<sup>17</sup>

### Future Research

The points I have raised indicate the need for further clinical and epidemiologic research. First we need a better definition of the relationship between dose and wavelength, timing and age to the adverse effects of the sun exposure. Second, we need better ways to identify individuals who are susceptible to ultraviolet damage. If we can identify those individuals, efficient preventive strategies can be developed and persons not at substantial risk from sun exposure need not forego the pleasures and benefits of the sun to the same extent. Clearly, we also need to develop photoprotection methods that are more acceptable to the user. These should be more economical and without substantial adverse risks. Unfortunately, at present, there are few candidate agents likely to meet all these requirements.

Although preventive strategies are inherently appealing, we also need clinical research on the risks and benefits of alternative approaches to reversing, limiting, or treating the adverse effects of long-term exposure to sunlight. Evaluation of the ultimate consequences of the use of topical retinoids and other agents that are claimed to reverse photoaging are still needed. Although there have been some promising results in special high-risk groups, to date the experience with oral chemoprevention of nonmelanoma skin cancer in humans with retinoids and antioxidants such as beta-carotene has been largely disappointing.<sup>18-20</sup> We need to consider new, safe, and effective strategies for chemoprevention, and to develop methods to identify those persons who would benefit from their use. More immediately, we need to measure better the adverse consequences of long-term sun exposure. This includes measuring the impact of nonmelanoma skin cancer on an individual's life,

determining the relative cost and benefit of different therapeutic approaches to treatment of skin tumors and photodamage, and developing a better understanding of how patients' preferences can be better incorporated into preventive strategies and treatment.

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## TANNING SALONS

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### Introduction

Tanning, or hyperpigmentation by solar radiation, of itself is not deleterious to skin. It is, however, a marker of toxicity or skin damage. Since depth of tan is, within a given skin type, directly related to the quantity of radiation absorbed by the skin, it represents a fairly accurate record of recent, cumulative toxicity.

Solar or natural tanning is the effect of a natural environmental hazard, ultraviolet radiation from the sun. Technological advancement has allowed humans, however, to produce and deliver this light with artificial sources. Although "sun lamps" have been in use for years, the fad for artificial tans and development of places of business (the sole purpose of which is to sell tanning) are relatively recent.

The first artificial source used to treat humans was the carbon arc lamp. Introduced by Finsen to treat TB, this invention resulted in his being awarded the Nobel Prize in 1903. The introduction of mercury vapor lamps of various pressures with the addition of phosphor-containing glass housing for fluorescent tube sources followed. Such sources were probably first used for purely cosmetic purposes, that is, to induce tanning, when tanning came into vogue in Western Europe and the Americas within the last 40 years. Early "sunlamps" were broad spectrum sources that induced pigmentation with UVB (290-320 nm) radiation. Their utilization was limited by the capacity of that radiation to induce acute toxicity or sunburn.

In the 1970s modern photomedicine was born with the development of fluorescent sources that could deliver high-intensity ultraviolet A (320-400 nm) or longwave radiation. Such sources were used for psoralen photochemotherapy, and psoralen ultraviolet A (PUVA) has been extensively utilized to treat, more or less successfully, an array of dermatologic diseases. The downside of the technological advance was that such sources could induce tanning with relatively little burning. Since such sources were primarily UVA in output, the minimal pigmentation dose was less than the minimal erythema dose, unlike UVB sources or natural solar radiation. The manufacturing of such sources to produce so-called "safe tans" increased rapidly and sun-tanning parlors or solariums were born.

### Usage Patterns

The tanning industry grew 300% annually from 1980-1985, and in 1987 advertising for salons in the Yellow Pages grew at an astonishing 55% — making it the fastest growing

listing category that year. In its advertisements for new franchise owners, a leading sun lamp manufacturer estimated that "annual equipment sales have already grown to three hundred million dollars (\$300,000,000). Retail sales of tanning services are estimated to be above a billion dollars per year".<sup>1,4</sup>

By 1989 it was estimated by the industry that 200,000 sun-tanning units were in operation, half of them in 18,000 tanning parlors and the other half in health and fitness clubs, resorts and beauty parlors. Today, an estimated one million individuals visit such institutions on any given day and probably 12-24 million people (at least 5% of the population) in the U.S. are regular users. Surveys in the UK, Denmark and the Netherlands show that 10% of the population use solariums yearly.<sup>5,7</sup>

Two survey studies of tanning salons, one in the UK in 1985<sup>5</sup> and one in Michigan in 1989,<sup>7</sup> found that the mean estimated age of the user was 26 years in the U.S.; 50% of the UK users were between 16 and 30 years old. Shockingly, the Michigan study found a two-year-old child was the youngest user and only half of the salons had age restrictions. Over 80% of the UK users were women. The most commonly cited reasons for visiting the salons was to prevent burning from subsequent natural exposure and for "appearance," that is, to achieve tanning. A smaller percentage of customers claimed to visit the salon for treatment of skin diseases, including psoriasis, acne, and eczema.

The median number of sessions for each individual was less than 30 in the UK, but almost 10% of users reported between 100 and 1000 visits. Almost half of the users classified themselves as having Type I or II skin. In other words, these are the individuals at greatest risk for photodamage, who are least likely to actually benefit cosmetically for their risk and expense. Extrapolating the data in an admittedly unscientific way, one could estimate that of the 10 to 15 million Americans who visit solariums yearly, 5 million at least are light skinned individuals at great genetic risk for developing photoaging and skin cancer. Probably 1 to 2 million users are "tanning junkies" who visit salons twice or more per week on average.

### Sources

There are no data as to exactly what artificial sources are presently being utilized in tanning salons in the USA. Certainly the majority use predominantly UVA-emitting fluorescent tube sources. So-called Type I sources contain UVA 1 (340-400 nm) and UVA 2 (320-340 nm) and a

relatively large quantity of UVB. Type II sources contain primarily UVA 1 with little UVA 2 and less UVB<sup>8</sup>. While primarily UVA in output, many sources also produce significant UVB irradiation. In fact, the percentage of UVB in such sources is estimated to range from 0.04% to 6.9%, and in one study done in Arkansas<sup>9</sup> where output was surreptitiously measured in actual salons, UVB content ranged from 0.03% to 3.5%. While a few UVA metal-halide sources are utilized in Europe, these are not common in the U.S. (less than 1%).

The irradiance of Type I sources in the UVA range is about 8 mW/cm<sup>2</sup> and 25 mW/cm<sup>2</sup> in the Type II sources. In the Arkansas study, the measured irradiance in the 16 salons ranged from 5-19 mW/cm<sup>2</sup>. Utilizing the same probes at midday in June in Arkansas the solar irradiance was 3.8 mW/cm<sup>2</sup> with about 6.5% UVB. While some salons limit exposure to 15 minutes on first treatment, the most popular exposure was 30 minutes. Depending on the source, the UVA exposure could be equivalent to 3 hours (or 14 to 45 J/cm<sup>2</sup>) of natural UVA and exposures of UVB that would certainly exceed minimal erythema doses.<sup>9</sup>

### Acute Adverse Effects

It is scientifically accepted that solar radiation is damaging to human skin. Such radiation is responsible for acute effects, including sunburn and immune modulation and the delayed effects of carcinogenesis and photoaging. In select individuals or under the influence of certain exogenous chemical factors, such radiation also produces abnormal responses called photosensitivity. The ability of artificial sources to produce all of these effects can be postulated based on knowledge of the emission spectra of the sources utilized and the action spectra of the adverse effects.

We know from animal studies and some human data that while UVB is most efficient at producing erythema, immune modulation, carcinogenesis, and photoaging, UVA can act alone to induce these effects and can potentiate the induction of these effects by UVB radiation. This suggests that tanning salon radiation, even with Type II sources that contain only small quantities of UVB, can cause these effects.

Actual data on salon toxicity is sparse but growing. In a controlled study, 33 hospital staffers in Scotland underwent ten 15-minute exposures over a 2 week period for tanning<sup>10</sup>. A full 60% experienced at least minimal sunburning and one-third complained of itching. A similar study from the UK in which 31 individuals were delivered twelve 20 minute -30 minute Type II lamp exposures, revealed 85% of individuals experiencing burn and 77% complained of itching. In the UK survey study of sun-bed users in a positively biased population, 19% reported episodes of sun burning and 28% complained of itching<sup>5</sup>. In 1989, the

Centers for Disease Control and Prevention (CDCP) surveyed physicians in Wisconsin; 31 of 43 dermatologists and 41 of 301 emergency room physicians responded.

Those 72 physicians reported treating a total of 220 patients for tanning device burns in the previous 12 month period. Thirty-nine of the reported burns were second degree burns, all of sufficient extent to warrant seeking medical attention. Sixty percent of the patients sustained their injuries in tanning salons and 40% at home. "Sunburn" in tanning salons is certainly not an unusual event<sup>11</sup>.

Another acute effect of tanning salon usage is induction or exacerbation of abnormal photosensitivity responses. Such responses occur naturally to solar exposure and include photochemical sensitivity to agents taken systemically or applied topically to the skin; reactions to radiation caused by genetic or metabolic conditions, including the porphyria and rarer conditions like xeroderma pigmentosa and Bloom's Syndrome; diseases of other organ systems associated with cutaneous photosensitivity, like collagen vascular disease and HIV infections; and diseases of unknown cause, in which the primary response is limited to the photosensitive eruption, like polymorphous light eruption. The critical difference between these cutaneous responses and the more normal responses of sunburn and photoaging is that the action spectra for the vast majority of these responses fall within the UVA range. They, therefore, are more likely to occur in reaction to tanning salon light than to natural sun exposure, where the dose rate in the range is considerably lower.

The linkage between tanning salon exposure and such reaction is for the most part anecdotal. It is possible that some of the sunburns reported in the previous discussion were clinically photosensitized responses, since an "exaggerated-sunburn" response is one type of photodrug reaction. Considering the exposure of our population to these chemicals, coupled with 1 million visits to salons per day, the incidence of photochemical adverse effects must be significant.

In the prospective controlled study among Scotland hospital workers, 12% (4/33) individuals developed polymorphous light eruption (PMLE); in the controlled UK study, 42% (13/31) were affected<sup>5,10</sup>. This idiopathic photosensitivity has been reported to occur in approximately 10% of the normal population of young adults in this country. Since 75% of all affected patients are sensitive in the UVA range, 12% in the controlled study is probably a reasonable incidence rate. In the UK survey, 28% of patients developed itching and 8% developed rash<sup>5</sup>. Neither rash or itch was more clearly defined, but in all likelihood were either polymorphous light eruption or photochemical sensitivity.

The field of photoimmunology is a relatively new one.

Scientists working in this area have heightened our awareness of skin as an immune organ. As for sunburn and carcinogenesis, the action spectrum for suppression peaks in the UVB range, but UVA alone is active.

Twelve 30-minute tanning sessions suppressed skin test response to DNCB, decreased Langerhans cell number, decreased the number of circulating T4 helper lymphocytes and reduced natural killer (NK) cell activity. Decreased lymphocyte response to mitogen and decreased ability to repair DNA lesions by unscheduled DNA synthesis were found in peripheral lymphocytes after a single salon tanning session. Most of the responses, with the exception of suppression of NK cell activity, were attributed to the UVB present in the tanning sources.<sup>12-15</sup>

### Chronic Adverse Effects

As might be expected, it is more difficult to obtain data concerning the chronic effect of tanning salon usage. Present information about the effect of such radiation on skin cancer and photoaging is, therefore, based on extrapolations from *in vitro* studies, animal studies, retrospective case controlled studies and anecdotal reports.

*In vitro* cell culture studies in a variety of cell types reveal that UVA-induced DNA damage is mutagenic and can affect important second messenger systems with activation of lipases and kinases and expression of important gene products. In animals, UVA alone is carcinogenic and can act to promote photo- or chemically-initiated nonmelanoma skin cancers. Kligenman and her colleagues have shown that UVA alone can induce dermal toxicity, including elastosis and alterations of dermal matrix constituents contributing to photoaging.

Recently, Bech-Thomsen and colleagues reported a study in which mice were treated with 3 commonly used UVA tanning sources at normally utilized doses. All three sources, even a Type II source with very little UVB and UVA 2 contamination, were capable of inducing skin cancer alone. In an attempt to reproduce the client pattern of utilizing tanning salons before vacationing for "protection," the mice were treated with tanning light followed by solar simulated light. The two Type I sources actually enhanced, rather than suppressed, tumor development. The Type II source was not protective but neither did it enhance tumor development.

Diffey has developed a statistical model for risk assessment for carcinogenesis from tanning salon use<sup>17,18</sup>. This model is based on the assumption that the spectrum for nonmelanoma skin cancer is similar to the spectrum for erythema, and the risk assessment is based on total cumulative dose, corrected for erythematous effectiveness. It does not consider more than additive augmentation, which might occur if UVA acted in a promotional manner in the carcinogenic process. Utilizing Type II sources with little contami-

nating UVB, Diffey estimated that ten 30 minute sessions per year used annually from 20 years of age increase the risk of developing nonmelanoma skin cancer by only 5% at middle age. Increasing usage to once per week increases the risk to 30% above baseline; for chronic users or "tanning junkies" with more than 100 sessions per year, the risk of developing skin cancer by middle age is doubled.

The risk for development of melanoma from tanning salon use is more troublesome. No widely accepted animal model for melanoma is available, so the action spectrum for that more severe tumor is undefined; it may not mimic the spectrum for erythema. Statistically modeled risk assessment is, therefore, impossible. A patient was reported by Roth and colleagues with UVA-induced lentigines after 1.5 years of two tanning sessions per week<sup>19</sup>. A similar patient was reported by Jones and colleagues<sup>20</sup>. Anecdotal reports of melanoma after artificial tanning include 9 of 270 patients in a London melanoma clinic<sup>21</sup> and one Danish patient with a melanoma beneath the watchband, skin exposed only during artificial tanning.<sup>22</sup>

In a detailed case-controlled study of 583 patients with melanoma, Walter and colleagues<sup>23</sup> reported that the odds of having used an artificial tanning device was 1.88 and 1.45 higher in males and females respectively with melanoma as compared to normal controls. The risk of artificial tanning and melanoma was increased with increased usage of the devices.

All of these data support the concept that usage of tanning salons should be considered risky behavior. Such usage certainly induces skin burning and various types of cutaneous pathology that require acute medical attention. That attention, other than causing discomfort to the individual, results in a cost to society both for treatment of the toxicity by our health care system and in terms of days lost in the workplace.

### Beneficial Effects

And what is the benefit of tanning salon usage to the population? Patients go to tanning salons primarily for three purposes: (1) for cosmetic tanning; (2) to "pre-tan" in an attempt to protect skin before outdoor exposure; and (3) to treat disease. Tanning does occur with artificial sources but not so much as one might probably expect. Only 60% of the hospital staffers who received 10 exposures developed a noticeable tan in the Scottish study; in the UK controlled study, all patients developed some tan after 12 exposures<sup>3,10</sup>. As expected, those who tan poorly in natural sun (Type I & II skin) also tan poorly with artificial sources. The tans achieved, however, were not very photoprotective. SPF-like determinations on artificially tanned skin revealed mean protective factor for sunburning to be only 3.2 and 3.9 in those two studies.

In a survey of tanning salon users who claimed usage for disease treatment, all 61 respondents reported subjective improvement in psoriasis, acne and eczema. Other controlled studies make such claims appear to be placebo effect, since the therapeutic action spectra for psoriasis and eczema are primarily in the shorter wave range. Recent reports of UVA 1 treatment of atopic eczema still do not warrant unsupervised UV exposure in the salon setting.

In the user survey, 82% of solarium users claimed to "feel more relaxed, more self confident or happier" after using the sunbed. Seasonal affective disorder, or SAD, is certainly a real entity that can be treated with light. The therapeutic action spectrum for that disease is in the visible range, however, not the UV. The psychological effect of artificial tanning is, therefore, more likely related to perceived cosmetic benefit<sup>6</sup>.

Photoreactivation, that is, UVA-visible light induced repair of UVB damaged DNA, has been extensively studied and may be important in human skin. The UVA-invisible induction of the reparative enzyme, however, must follow the UVB-induced lesion production. Since artificial tanning routinely precedes and does not follow natural sunbathing, such a benefit from tanning salons is purely theoretical.

Finally, the single known beneficial effect of UV exposure of the skin is vitamin D production. The action spectrum for that response is in the UVB range. Devgun and colleagues in their controlled tanning study measured increased serum 25-hydroxyvitamin D in their subjects after artificial tanning. In this era of vitamin D-fortified dairy products, however, this benefit seems of minimal importance<sup>24</sup>.

### Summary

In summary, artificial tanning is of no benefit other than cosmetic. The acute risks of such activity are known, and evidence exists that long term risks are significant. What should we do, therefore, to prevent this man-made environmental hazard from damaging our population? An easy answer is to prevent the utilization of ultraviolet light sources for tanning. Such devices are monitored by the Center for Devices and Radiological Health of the Food and Drug Administration. The regulations concerning use of these devices are given in the 1985 Federal Register publication entitled *Sunlamp Products; Performance Standard; Final Rule*. The monograph gives standards for the irradiance of the sources. Interestingly, pure UVB sources are acceptable. It regulates timer setting (although it is permissible for the times to be reset by the user); protective eyewear is mandated. A warning statement is required and instruction for use to "avoid or minimize potential injury"<sup>25</sup>. These regulations are similar to those regarding tobacco usage. Further regulation at the federal level is unlikely.

The most effective measures, first and foremost, are consumer education. Through established programs developed by the AAD, the Skin Cancer Foundation, the American Cancer Society and the Skin Phototrauma Foundation, consumers should be educated about the deleterious effects of all UV radiation. Stress should be placed on the fact that the tanning of any type, including tanning salon usage, is dangerous. The educational process must begin in infancy and be strongly reinforced through the risk-taking adolescent period. The focus should not just be on skin cancer, but on the unattractiveness of photoaging. Our colleagues in pediatrics and the public school systems must become more involved in the process. The press, especially leisure, fitness, and beauty magazines, along with radio and television entertainment programs, should be our greatest allies in this process.

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## PLANT DERMATITIS

Jere D. Guin, M.D.

### **PARthenium DERMATITIS (*Parthenium hysterophorus* Linn):**

#### **A. PARthenium DERMATITIS IN INDIA (The Scourge of India)**

##### **Transmission in Contaminated Seed from Texas**

About 1958 the United States shipped seed wheat to India as a humanitarian gesture. After it germinated, *Parthenium hysterophorus*, an American weed alien to India, grew out with the wheat. It was first seen near Bombay (in the Poona area) but spread rapidly from there. After a dam broke, the ensuing flood carried the seed downstream over the region.<sup>1</sup> This weed is extremely aggressive in India, crowding out useful vegetation and causing problems, especially in the dairy industry and in agriculture.<sup>2</sup> This plant is called wild feverfew or carrot weed in the United States, but in India it is called "Congress weed." (Reports differ as to how that started, but one can imagine.) *Parthenium hysterophorus* is a member of the family Compositae, which includes many of the daisy-like flowers, (dandelion, asters, and chrysanthemum) as well as ragweed, cocklebur, and a wide variety of garden plants.

The new resident in the flora of India threatens the human as well as the plant population, as it causes an allergic dermatitis in epidemic numbers and can be life ruining in its severity.<sup>1,2</sup> The allergens are found in glandular tissue in hair-like structures on the surface of the plants. Because it looks like something has been blown onto the skin, many people assume one rash results from contact with the pollen.

##### **Widespread Distribution has Produced Extensive Exposure**

Originally the disease was seen in the southwestern United States<sup>3</sup>; it was recognized and described in the early writings of a Dallas dermatologist, Bedford Sheldine, M.D. The plant is distributed along the Gulf Coast and lands surrounding the Caribbean to northern Argentina. It has now been reported in not only India, but also China, Vietnam, certain Pacific Islands, South Africa, Mozambique, Madagascar in Africa and Australia.<sup>4</sup>

The eruption usually starts in exposed areas but may involve almost the entire body surface, producing thickening of the skin of the face to cause a "leonine facies" as seen in lepromatous leprosy. In the United States it occurs especially in agricultural workers. This is probably also true in India, although there it occurs in all walks of life and causes many cases of exfoliative erythroderma, an eruption essentially covering the entire skin surface, head to toe.

While in the U.S. the eruption from this plant is largely seasonal (May to December)<sup>3</sup>, it grows all year in India. Lonkar<sup>2,5</sup> describes the progression from eyelids to patches on the face to neck, antecubital and other exposed sites to involvement of the total skin surface. The eruption may spare areas where pigment is lost from vitiligo.<sup>6</sup> The reason for this phenomenon is not clear.

##### **Attempts at Control**

Eradication efforts have been unsuccessful with additional exposure. Many assume that herbicides are not used because they are not effective, but the problem is more economic than scientific. Budgetary constraints have permitted only the hiring of persons to pull the weed, and this has, perhaps, compounded the problem.

##### **Gender and Age Specificity**

The eruption largely affects older males. Children employed to uproot the plant in the "destroy *Parthenium*" campaign apparently did not become allergic, while over half the adult males hired to uproot the weed were found to be allergic on testing and 4% had the rash. Sharma reported that 11 of 55 Compositae-allergic persons were female.<sup>7</sup> The percentages vary, probably on the basis of exposure, but the incidence in males is regularly higher.

##### **Putative Specificity of the Antigen and its Diastereomer**

Rao, et al.<sup>8</sup> found parthenin in *P. hysterophorus* to which costus-sensitive persons reacted. That chemical is also found in other related plants. This is probably because *P. hysterophorus* also contains the chemical abrosin, but so does ragweed. If one is allergic to that chemical he or she would break out to both plants. The structure of that type chemical is sometimes very slightly different when the plant grows in a different hemisphere producing a stereoisomer, with a rearranged structure of the same formula. While the chief allergen is thought to be parthenin, there are at least three allergenic sesquiterpene lactones, which can cause allergy<sup>9</sup> and perhaps more.<sup>4</sup>

##### **Airborne Spread**

There are arguments for and against the theory of airborne spread. The most cogent for pollen as a cause is the location of the rash in exposed sites, at least primarily. While it has been suggested that dust can spread the eruption, there is strong evidence against the idea, as most species causing the allergy do not have the causative

chemicals in their pollen. Also most sufferers improve on moving from the farm to the city, despite high urban pollen counts. This has recently been discussed at length.<sup>30</sup>

### Treatment

Picman and Picman<sup>30</sup> reported prevention with cysteine in experimental animals, but this may not be practical in people (it is malodorous). Guin described successful treatment with PUVA.<sup>31</sup> and azathioprine is reported to be beneficial.<sup>32</sup> Oral hyposensitization is a classic treatment, but nonavailability in the United States prevents current use in this country. However, it has recently been used with success in India.<sup>33</sup>

### B. DERMATITIS SECONDARY TO RAGWEED AND OTHER COMPOSITAE<sup>14</sup>

#### Disease Patterns and Differential Diagnosis

Reactions occur to more than one plant in many cases, because multiple plants make the same chemical and many of the causative chemicals are so closely related that the patient may break out from plants to which he/she has never been exposed.

#### Patterns of the Rash

##### Atopic Eczema Pattern

Weed sensitivity can very closely mimic the pattern of childhood eczema, involving the bends of the arms, legs, wrists and ankles as well as the face and neck with thickening of the skin similar to what is called "atopic" eczema.<sup>35</sup> The differences suggesting weed allergy are onset later in life, failure to respond to treatment, worsening in the summer and clearing in the winter (the reverse of atopic eczema) and sparing of the feet where shoes would protect.<sup>35</sup>

##### Photodermatitis

These patients for some reason also become light sensitive; i.e., when exposed to test doses of light they react to much less light than it normally takes to burn.<sup>36</sup> The pattern of the rash in weed allergy usually is a little different from photodermatitis in that areas protected from direct light exposure, such as the under surface of the chin, the eyelids and the areas back of the ears, are involved in weed allergy but not initially in light sensitivity. About 46% of persons diagnosed as photoallergic are also weed allergic, so routine testing for both is done for either diagnosis.<sup>37</sup>

##### Hand Eczema Pattern

This may occur from ragweed or perhaps Chrysanthemum, but in our area it most commonly is seen with allergy to bitterweed.<sup>39</sup> Often it is not suspected until screening tests show weed allergy, or until the patient develops a more typical eruption elsewhere.<sup>38</sup>

##### Exfoliative Dermatitis<sup>20</sup>

This pattern is a rash from head to toe sparing very few, if any, areas, and scaling so severe that scales cover the sheets on the bed. Patients lose weight and their skin becomes thick, especially from chronic rubbing. The pattern is more typical of Parthenium dermatitis, but it can also occur with other Compositae.

##### Localized Pattern

This is typical of cocklebur and, perhaps, Magnolia.<sup>21,22</sup> The localized pattern can mimic poison ivy dermatitis in the acute phase or neurodermatitis in the chronic phase.<sup>22</sup>

##### The Geographic Location

The problem is largely rural but there are exceptions.<sup>23,24</sup> Some who assume the allergens are airborne because of the pattern, claim that these cases are caused by pollen, but the evidence does not substantiate that concept.<sup>21,25,26</sup> Dust is a factor in a few cases, but most occur from direct contact with weeds or the oleoresins from them.

##### Age/Gender Difference

This allergy typically involves older males, but both sexes and all races are susceptible. It is rare in children. The reason is not known, but it may be something other than exposure, since children used as weed pullers do not seem to have the same risk as older adults.<sup>27</sup> Ragweed dermatitis primarily occurs in agricultural workers, but may affect city dwellers occasionally. Ragweed dermatitis is now reported in Australia, having imported the weed from the United States. Incidence is greater in men, with older data showing about 20:1 between males/females and more recent data about 4:1.

##### Underlying Causes and Methods of Confirming Diagnosis

In some cases the incidence is related to the opportunity for exposure. Certainly no one in India would have the problem had the weed not been transported in seed wheat. Also, the condition seems to clear in farmers who change occupations and move to town.<sup>23,24</sup>

Older males are more at risk, and certain occupations, such as farming or logging, are particularly likely to be associated with such allergies, as the plants to which the workers are exposed are quite sensitizing. Weed pullers hired to try to eradicate a sensitizing weed are, of course, at risk. Hobby gardeners also develop allergy to some plants more often because of opportunity.

##### Treatment and the Environment

Weeds abound in disturbed areas. With so much of the land developed, the number can be very high, and for some species the opportunity for transport in world commerce has increased providing that species with a new, more compati-

ble location where it can thrive. Removal of the person from exposure is effective, once the condition is recognized. Attempts to tamper with the ecology using natural enemies have so far been ineffective.

Medical treatment so far comprises medications affecting the immune system and light in the form of UVA with a sensitizer (PUVA = P for psoralen, the sensitizer, and UVA for longer wave length ultraviolet light).

#### PROBLEMS WITH FLORIDA HOLLY (*SCHINUS TEREBINTHIFOLIUS*):

In the mid 1920's, Henry Nerling, a writer and horticulturist, reported an exciting new and effective ornate shrub produced dense masses of scarlet berries at Christmas time.<sup>28</sup> This species, *Schinus terebinthifolius*, seems to be especially suited to Florida. Although it and a close relative, *S. molle*, were both introduced into California, only the latter is now naturalized there. As early as 1891 this species was introduced into Bradenton, Florida and was readily cultivated from seed. The plant was introduced into Ceylon at about the same time and spread rapidly to Hawaii. This plant was also spread through the commercial seed trade.<sup>29</sup> *S. terebinthifolius* is often erroneously called the Brazilian pepper tree. However, *Schinus molle* is used to produce pepper, while the fruits of *S. terebinthifolius* do not have that quality.<sup>1</sup>

Because *S. terebinthifolius* is eaten by many species of birds, it has been rapidly disseminated, becoming an aggressive weed where established, impinging on the natural ecosystems in much of the state of Florida. Hazards include asthma and sinus problems, as well as skin irritation, which has been attributed to N-alkylphenols.<sup>30,31</sup> Skin "irritation" has also been attributed to cardanol and the fruit of the plant. The plant also contains delta-3-carene and phellandrene in some quantity. The cardanol supposedly causes a delayed type of skin "irritancy".<sup>32</sup>

The aggressive spread of this plant throughout the tropical portion of Florida has become a major problem for individuals in that region who are concerned with the native ecology. *S. terebinthifolius* apparently will not grow where the soil has a salt content greater than five parts per thousand, and it does not tolerate freezing well.<sup>33,34</sup> While an N-alkylphenol has been blamed for the skin eruption, several investigators have not found that type chemical. Brian Meyer, then at Purdue University, found a nonadecyl phenolic, but could not publish this because no other specimens from the same species, fruiting or flowering, contained a similar chemical. Certainly, it was there one time, but it was not there at other times. What this means is not clear.

Many dermatologists in Florida believe that this plant will cross-react with poison ivy or at least produce a poison ivy-like dermatitis in some members of the population.

This needs to be confirmed in an animal study, but it may not be easy to do if the chemical content of the plant is as variable, as has been reported. The plant is unquestionably a major problem in Florida ecologically, if not medically. *S. terebinthifolius* is much less allergenic than several irritant species found in Florida, but the widespread distribution of this plant and its tendency to expand its territory is a major worry, particularly for individuals living and working in this area.

A number of methods of plant eradication have evolved in the recent past, including burning, which tends to reduce the number of colonies, and various herbicides.

#### LIVERWORTS

In the Pacific Northwest a moss-like plant growing on decaying logs causes numerous cases of allergic skin eruptions. Interestingly it contains the same family of chemicals found in the garden Compositae and related weeds, even though it is not related botanically. This eruption can be severe in woodcutters. Some species of this family are so allergenic that patch testing the patient can cause the allergy.<sup>35</sup> Feverfew cross reacts with frullania as does elecampane, so testing to those plants will often detect frullania allergy.<sup>36</sup>

#### GARDEN COMPOSITAE

Many species of garden plants, both domesticated and wild, can cause the same type of rash. Wild plants include bitterweed (*Helenium amarum*), cocklebur (*Xanthium subsp.*), marshelder (*Iva xanthifolia*), dandelion (*Taraxacum officinale*), yarrow (*Achilles millefolium*), etc. Domesticated (and sometimes wild) plants include sunflower (*Helianthus annuus*), *Chrysanthemum subsp.*, feverfew (*Tanacetum parthenium*), tansy (*Tanacetum vulgare*), Arnica, elecampane (*Inula helenium*), and many others. Unrelated plants causing dermatitis from similar chemicals include magnolia, laurel and a liverwort, frullania.

Mayweed, *Anthemis cotula*, can cause severe irritant (and sometimes allergic) reactions in farm workers. In a recent report from California, O'Malley and Barba<sup>37</sup> described a blistering eruption in 42 farm workers that had qualities suggestive of a nonallergic (irritant) reaction. The severity paralleled time of exposure, and covered areas were commonly involved. These workers had been employed pulling weeds in a beet field. The causative plant has a licorice-like odor, and is called "dog fennel" or stinkweed as well as mayweed, a name derived from the usual time it blooms.

The progression from redness at 19 hours to prominent lesions at two days and blisters at six days might suggest an allergic contact, but the evidence is better for a delayed irritant, as it can be produced in volunteers never previously



exposed. The irritant component has been reported to be valeric acid (pentaenoic) acid, but no proof is given.<sup>38</sup>

#### PRIMULA DERMATITIS

In Europe, where poison ivy, oak and sumac are not native, the leading cause of plant dermatitis may be caused by *primula obconica*, the German primrose. Is this relevant to the United States? Probably. In a single dermatologist's practice, Epstein<sup>39</sup> recently saw nine patients with primula dermatitis in the San Francisco area in a two-year period.

The primrose is a house plant in most of the United States, as it requires a warmer climate to survive outdoors. The plant contains a chemical called primin, and in those who are allergic it causes a patchy rash on the hands, often with streaks of vesicles (watery bumps), and a rash on the face, not unlike poison-ivy dermatitis. Milder cases can be difficult to recognize. The usual sufferer is an older woman with house plants. In the San Francisco area, *Primula obconica* may be seen growing outdoors; therefore, working in the garden is sometimes a risk factor. So many persons in Europe develop primula reactions that dermatologists at many centers routinely test for allergy to it. Overall about 1% are allergic,<sup>40</sup> but over 2% of women are allergic.<sup>41</sup> Primin, a paraquinone (the same type chemical found in most allergenic woods), is a stronger sensitizer than similar plant allergens.<sup>42</sup>

#### IRRITATION FROM SPURGES (EUPHORBACEAE)

Members of this family are variously affected ecologically by the activities of humans. The manchineel tree, perhaps the best known member, is decreased. (At least its numbers are fewer in the United States.) The botanical name is *Hippomane mancinella*, which means "little apple that drives horses crazy." The latex (sap) released from injuries to the plant cause severe irritation to the skin, often with pain and blistering. The putative individual susceptibility has not been adequately investigated. The lore of this plant is extensive. For example, native Americans repaid the Spanish conquerors by adding a few branches of manchineel to their well water. Lord Nelson almost died from being poisoned by the natives who used sap from manchineel to poison supplies for the British navy. Although the pollen and nectar of the manchineel are not toxic, Selika, the heroine in the opera "L'Africaine," supposedly died from inhaling its deadly blossoms on Madagascar. Unfortunately, Madagascar is several thousand miles distant from the nearest manchineel tree, but it nevertheless made for a good story. The irritant material in the latex is a cocarcinogen, and this is a danger to those exposed. A drop of the latex in the eye causes excruciating pain and blindness for about a month. Repeated exposure can result in permanent blindness.

The manchineel is related to a number of plants introduced to the house or yard, including the candelabra cactus, *Euphorbia lactea*, often grown as a houseplant, the monkey pencil tree, *Euphorbia tirucalli*, sometimes grown in warmer climates as an exotic, and many others. All of these plants are extremely irritant.

The bull nettle is not a nettle but comes from the same family as the manchineel. It inhabits the coastal sands over a wide range, although the plant taxonomy changes from the Southeast to Texas to Mexico and beyond. It has stickers with irritant hairs that can cause severe pain. The nature of the irritant remains to be elucidated.

#### NETTLE RASH

Nettles are increased in disturbed areas; some are alien species introduced into this country many years ago. The species around the United States vary with the geographic location, but the mechanism of activity is probably the same. These plants cause hives (rather than an eczematous eruption) on contact, by introducing chemicals into the skin through tiny stinging hairs on the surface which, according to Oliver, et al.,<sup>43</sup> are fine tubes with a bulb at the tip. The bulb breaks off on penetrating the skin, releasing the fluid contents into the skin. Inflammatory mediators found in these hairs include histamine, acetyl choline,<sup>44</sup> serotonin,<sup>45</sup> leukotrienes,<sup>46</sup> and a mitogen for lymphocytes through interleukin-1 and receptor production,<sup>47</sup> perhaps inducing a lymphocytic response.<sup>48</sup> The triad of mast cell, mast satellite cell,<sup>49</sup> and lymphocyte was noted by Goncalo.<sup>35</sup> A number of plants cause mechanical irritation and many are greatly increased in areas disturbed by man. A good example is blackberry (*Rubus subsp.*), also called brambles. Some cause granulomatous reactions, as seen in sabra dermatitis from *Opuntia microdasys* and other species.<sup>50,51</sup>

Another form of irritation occurs in plants containing calcium oxalate, such as dumb cane or dieffenbachia. Species with significant levels have been found in at least 215 plant families.<sup>52</sup> Typical reactions occur from dieffenbachia and *Arisaema* (Jack-in-the-pulpit). The name "dumb cane" acknowledges the severe lesions in the mouth resulting from chewing the stem, which prevents the victim from speaking. Esophageal erosions can occur after swallowing.<sup>53</sup>

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## TROPICAL AND TEMPERATE PLANT CONTACT ALLERGENS

Eloy Rodriguez, Ph.D.

Allergic contact dermatitis (ACD) is considered to be the result of reaction between a reactive low molecular weight compound (a hapten) and a protein present in the skin. This combination of the skin protein and plant product will result in the formation of a novel molecular structure not recognized by the body's immune system.<sup>1</sup> The immune system will attempt to eliminate this novel protein hapten combination through the inflammation responses it has developed to eliminate the foreign proteins of bacteria, or other infectious disease-causing organisms. These defensive reactions cause the swelling, itching, and redness associated with ACD. Prolonged interaction between the lymphocytes of the immune system will ultimately result in pus-filled vesicles that characterize severe allergic response.

The types of plant chemicals that cause ACD share several characteristics:<sup>2</sup>

- 1) They are comparatively small (low molecular weight).
- 2) They are lipophilic (soluble in fats or lipids), which facilitates penetration of the skin.
- 3) They are extremely reactive chemicals that combine easily with skin proteins.

The fact that the reactions of ACD require mediation by the immune system is made evident by the delay (generally 12-72 hours) required for the symptoms to occur.<sup>3</sup> This delay is contrasted with the more immediate reactions of irritant compounds that do not require processing by the immune system. These irritant compounds can be found in many species of the Euphorbiaceae, Brassicaceae, and Ranunculaceae.<sup>4</sup>

The family of plants that cause the greatest number of cases of ACD is the Anacardiaceae, a predominantly tropical family with a few members in the temperate regions (poison ivy, poison oak, and poison sumac). The genera of the Anacardiaceae reported to cause allergies are given in Table I.<sup>5</sup> The chemical compounds that cause the allergenicity of this family are a series of phenolic compounds (Figure 1) with an attached side hydrocarbon chain or alkyl group. Phenolic compounds with two adjacent hydroxy groups are termed alkyl catechols - (Structures A and B). Phenolic compounds with a single hydroxy group are termed simple alkyl phenolics (compound type C). Phenolic compounds with two hydroxyl groups that are separate are termed alkyl resorcinols (compounds D and E). A phenolic compound with an acidic carboxyl group is termed anacardic acid (compound F).

The alkyl catechols are strong irritants and strong

allergens. The allergenic constituents in poison ivy and poison oak are catechols with alkyl side chains with 15 or 17 carbons, respectively (Figures 2, 3).<sup>6</sup> Most of the genera of the Anacardiaceae that have been reported to be allergenic contain alkyl catechols (see Table II).<sup>7</sup>

Alkyl resorcinols, simple alkyl phenolics, and anacardic acid type compounds are also highly reactive chemicals and strong irritants. However, they are responsible for a much smaller number of cases of ACD than the alkyl catechols found in poison ivy. Still, the alkyl resorcinols do present a significant problem stimulating cross-reactions in people who are allergic to the alkyl catechols. There apparently is enough similarity in structure to stimulate the immune system of many people who are allergic to the alkyl catechols. These cross reactions with the alkyl resorcinols explain the allergic responses of many travellers to tropical fruits such as mangoes, or the fruit of cashew trees. Alkyl resorcinols can also be found in other groups of plants that occasionally cause problems in people who are allergic to poison ivy.<sup>8</sup> These plants include members of the Proteaceae, a tropical plant family that includes the macademia nuts and various ornamentals such as *Banksia*. Many tourists who go to Hawaii get a severe ACD from the leis (flower garlands) that include flowers of *Grevillea subsp.*<sup>9</sup>

Another tropical plant family, the Araceae, contains alkyl resorcinols that cross react with the alkyl catechols. The common ornamental tropical foliage plants from the genera *Philodendron*, *Dieffenbachia*, *Spathiphyllum*, *Colocasia*, and *Caladium* are all members of this family. These particular plants are the most common decorative plants found in restaurants and doctors' offices.<sup>10,11</sup>

### DNA Damage from Contact Sensitizers

Recent research has revealed disturbing evidence about the alkyl catechols and alkyl resorcinols. In vitro studies have established that these chemicals will cut DNA in the presence of a metal catalyst.<sup>12</sup> Damage to DNA could result in irreversible damage to the cells' genetic machinery and could ultimately lead to skin cancer (Figure 3). It appears that the semiquinone radical will break the sugar phosphate bonds that form the backbone of the DNA molecule. The author's laboratory is following up on this important research to discover the full significance of this threat to the skin. If these alkyl resorcinols and alkyl catechols do pose a serious threat to the DNA of skin cells, it will stimulate new ideas about the role of ACD. It is possible that ACD is a

response of the immune system to rid the skin of dangerous chemicals that threaten the DNA of the body.<sup>13</sup> Chemical combinations between skin proteins and particularly dangerous chemical haptens could be recognized by the immune system, which would then dispose of the threatening chemicals in the fastest and most effective manner possible. In other words, the symptoms associated with ACD are the results of attempts of the immune system to destroy any hapten protein combination or cell contaminated with these dangerous DNA-threatening chemicals.

To follow up and further evaluate the threat to skin DNA posed by the chemicals that cause ACD, we tested other allergens for their capacity to damage DNA. The allergenic prenylated hydroquinones from the plant family Hydrophyllaceae have many chemical similarities to the alkyl catechols and alkyl resorcinols. *In vitro* tests have established that prenylated hydroquinones will also cleave DNA under similar conditions and consequently pose threats to the DNA of the skin cells.<sup>14,15</sup>

Another important group of chemicals that cause many cases of ACD around the world is the sesquiterpene lactones.<sup>16</sup> These chemicals are found in several plant families, such as Magnoliaceae (the Magnolia family), Apiaceae (the carrot family), and the very large Asteraceae (sunflower family). The initial perusal of the structure indicates few similarities between the sesquiterpene lactones and the alkylated phenolics. However, *in vitro* experiments indicate that the sesquiterpene lactones also damage DNA by breaking the sugar and phosphate bonds.<sup>15</sup>

This capacity to damage DNA is not a characteristic of all contact allergens, since other experiments have shown that allergenic polyacetylenic compounds (a minor class of contact allergens) do not damage DNA.<sup>15,17</sup> However, the fact that the three most common and conspicuous causes of ACD do damage DNA should cause us to investigate this question more seriously. The suggestion that the allergic response is a defense against the small molecules that threaten DNA should not be dismissed too easily as an overly facile explanation. Research at the author's laboratory will continue to assess the threat posed by the identified allergens and any new allergens isolated from previously investigated plants. Several examples of plant allergens that are less notorious can be investigated. Numerous cases of ACD have been reported from carpenters, cabinet-makers, and sawmill employees who work with wood from tropical trees.<sup>18</sup> Others coming in contact with these trees undoubtedly suffer from ACD; however, these people live in the remote areas of underdeveloped tropical countries and have little contact with doctors. *Paratecunda*, *Jacaranda*, *Tabebuia* from the Bignoniaceae and *Tectona* from the Verbenaceae contain quinones such as lapachonone and lapachol that cause problems.<sup>19</sup> Other cases of ACD are

caused by quinones from several species in the legume family. These include bowdichione from *Bowdichia* and the methoxydalbergione from several species of *Dalbergia*, and *Machaerum*. Other cases of ACD have occurred with workers in furniture factories that use wood from species of *Khaya*. From the Meliaceae, anthothecol, a triterpenoid, was identified as the hapten. *Chlorophora* from the Moraceae contains phenolics that cause outbreaks of ACD, and *Mansonia* from the Sterculiaceae contains mansonins, orthoquinones that cause many cases of ACD. *In vitro* experiments will be conducted to investigate the potential of these compounds to damage DNA.

There are many other examples of plants that cause ACD in which the hapten has not been identified. Preliminary work with *Asimina* of the Annonaceae indicated that unidentified acetogenins from this family are potential sensitizers.<sup>20</sup> Reports that another plant from the Annonaceae, *Ylang Ylang* (*Cananga odoratum*), causes ACD are widespread and resulted in its removal from many cosmetics. Future research should be conducted to identify the allergenic principles of these plants and to evaluate the threat that these compounds might pose to the DNA of human skin.

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Table I

Poisonous Anacardiaceae of The United States,  
West Indies, Mexico and Central America

*Anacardium*  
*Campnosperma*  
*Mangifera*  
*Cotinus*  
*Spondias*  
*Comocladia*  
*Toxicodendron*  
*Schinus*  
*Mauria*  
*Astronium*  
*Metopium*  
*Pseudosmodium*  
*Toxicodendron*

J.D. Mitchell. *Advances in Economic Botany* 8, 103 (1990)

Table II

Principal Allergenic Chemistry  
of Poisonous Plants

Pentadecyl-Catechols

*Gluta*  
*Holigarna*  
*Lithrea*  
*Metopium*  
*Semecarpus*  
*Smodium*  
*Toxicodendron*

Heptadecyl-catechols

*Gluta*  
*Lithrea*  
*Metopium*  
*Semecarpus*  
*Toxicodendron*

Pentadecyl-resorcinols

*Anacardium occidentale*

Heptadecyl-resorcinols

*Mangifera indica*

Salicylic Acid Derivatives (anacardic acid, etc)

*Anacardium occidentale*  
*Pentaspadon subsp.*

Pentadecyl-phenols

*Anacardium occidentale*

Quinols

*Campnosperma auriculatum*

J.D. Mitchell. *Advances in Economic Botany* 8, 103, 1990

## Principal Chemistry of Allergens

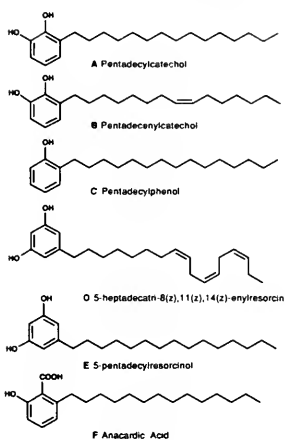


Figure 1

## Allergenicity of 3-heptadecylcatechols

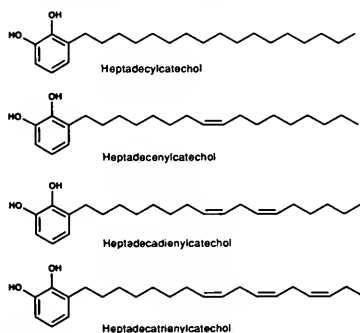
*Toxicodendron diversilobum*, Anacardiaceae

Figure 3

## Allergenicity of 3-pentadecylcatechols

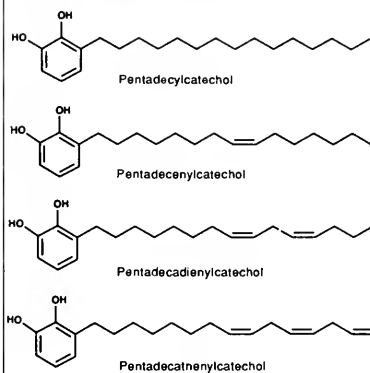
*Toxicodendron radicans*, Anacardiaceae

Figure 2

## MARINE ERUPTIONS

Joseph W. Burnett, M.D.

### Introduction

Water covers three-quarters of the earth's surface and is distributed over many climates containing diverse animal species, which are arranged in progressive food chains. The earth's aquatic area should not be regarded as a simple system, but rather as a dynamic, multiphased environment with diverse specific events occurring at the surface and at various depths. Indeed, other ecological alterations can determine saline content, temperature, currents and wind forces. The most superficial film surface exposed to the earth's atmosphere is a "microcosm" of its own. The interaction of living organisms, water, and air is in constant, delicate balance and flux. Alterations in the shoreland affect sedimentation runoff, integrity of the benthic layers, and the entrapment of solar energy within the aquatic phase. This dynamic environment can be accidentally or dramatically affected by human pollution, especially since humans can contaminate water because of an "out of sight, out of mind" philosophy.

### Scientific Background

Many factors in the marine environment affect human skin structure and function. Acute ultraviolet light exposure produces erythema, increased cutaneous blood supply, and rupture of the epidermal barrier, and is known to promote radiation-induced diseases. Venoms from marine animals can produce a spectrum of diseases that primarily involve the skin but may be accompanied by immediate or delayed constitutional or systemic problems. Marine envenomations occurring worldwide are caused by a multitude of different stinging animals and are extremely common. During Christmas week, 1990, approximately 100,000 Portuguese man-of-war stings were experienced in the two counties closest to Miami. It is estimated that approximately one half to one million envenomations occur annually in the Chesapeake Bay from a single animal. At least four human fatalities from jellyfish stings have occurred in the continental United States in the past twenty-five years.

Bacterial-induced disorders in human skin can occur following hematogenous dissemination or local inoculation during bathing. *Vibrio* and mycobacterial infections, as well as bacterial folliculitis, afflict bathers at American beaches. Algal blooms result in disruption of marine organisms into the air, where they release toxins into the environment. These agents cause irritation of mucosa as well as the central body. Protozoa and immature larval forms of hydroids induce "swimmers' itch" and "swimmers' eruption," respectively.

Small crustacea can produce cymothodism. Parasitic or viral diseases can be spread between persons through aquatic media by contact with polluted effluents, or even proximity to nearby swimmers. Increased deposits of both chemical and physical pollutants can produce mechanical injury to the skin, as well as serious external and internal diseases. Seafood ingestion is thought to cause human disease in approximately 0.1% of fish meals. These diseases may be induced by bacteria or toxins, the concentration of which in the fish can be increased as a consequence of their feeding period. Mollusks, which transmit human disease, can carry large amounts of pathogens or toxic material as a consequence of their filter-feeding practices.

The hazards of these disorders to humans and their skin is increased by secondary factors, such as environmental climate. Additionally, climate and solar irradiation directly influence the protective effect of the skin's mechanical barrier and the immune system. Also, the genetics of the host and the effect of and current medications may adversely affect the patient's ability to ward off marine-induced disorders.

In order to understand the environmental hazards to the skin we must increase our knowledge of the effect upon marine ecology of water climate, which may be associated with global warming, nuclear power plant cooling, and solar energy absorption in the water layer.

Rainfall deletion effects appeared in the ecology of the Chesapeake Bay, 1972, following Hurricane Agnes, resulting in a decreased population of crabs and jellyfish. During that particular storm, the saline content of the 90-foot channel under the Bay Bridge dropped from 1.2‰ to zero. Eutrophication of large marine bodies, as well as lakes, has affected our country along the coastlines and in the northern Midwest. Water bodies afflicted with this problem show altered photoplankton and bacterial contents. Consequent changes in the food chain, the quantity and quality of fish, and the presence of dinoflagellate toxins released to the air were noted. Increased sedimentation occurring after storms and resulting from highway construction and agricultural practices is a significant problem in the upper Chesapeake Bay and other areas. Sedimentation within the water alters the solar energy absorption and changes the phototropic response of marine animals. Acid rain has polluted the northern portions of our country for several decades, resulting in demonstrated alterations in the fish and unknown alterations in other marine organisms.



Industrial effluents and pesticides can be concentrated in many marine animals. Investigators studied the effect of pesticides in the Chesapeake Bay upon jellyfish and found that these venomous animals could concentrate chemicals and be used as early warning detection systems for increased adverse chemical concentrations. The increased presence of sediment, chemicals, industrial pollution, and alterations in the pH can affect larval settling, early reproduction, and growths of several animals. Ozone depletion and/or global warming, if real, will dramatically affect the marine environment with alterations in both marine life and their environmental hazards. The role of ultraviolet energy on human cutaneous immunological integrity is of current interest of many dermatologists. It is quite possible that ultraviolet light-induced cutaneous immunosuppression may play an additive or synergistic role in human response to marine-induced rashes. The investigators have shown that jellyfish envenomation may cause significant acute immunosuppression and have speculated upon an additive effect of sunlight on this abnormality.

### Economic Loss

The economic loss resulting from marine-induced eruptions is vast. It must be calculated in terms of loss of work time, deterioration of specific industries, depressed seashore property values and consequent tax loss, loss of recreation and resort usage, and soil erosion. The exact cost is difficult to determine, because most of the eruptions and disorders associated with the marine environment are entities producing low mortality but high acute morbidity. Because of the transient nature of the resulting disorders, exact case incidence figures are impossible to record.

### Future Research Needs

Future research is needed to better delineate the methods by which humans can be injured by the varied venoms and toxins within marine animals. There should be an increased effort to quantitate the ultraviolet and thermal alterations affecting the marine environment as well as humans. Second, the degree of human immunosuppression induced by ultraviolet light and marine envenomation singly or synergistically needs quantification. Third, increased efforts to understand the effect of sedimentation, agricultural runoff, and industrial pollutants upon the reproductive stages of venomous or edible marine life should be instituted. Finally, efforts should be designed to study the means by which physical or mechanical control procedures can be exerted to prevent these disorders. Such procedures could be instituted at the shoreline, at sewage effluent sites, at resort areas, and at the sites of industrial production at the water's edge.

The primary research priority on the cutaneous pathogenicity of marine environmental hazards should be the

quantification of the extent of ozone depletion effect and global warming. The control of bacterial or physical material dumped into the sea should be of high priority, since it may be an easier matter to control.

### Educational Needs

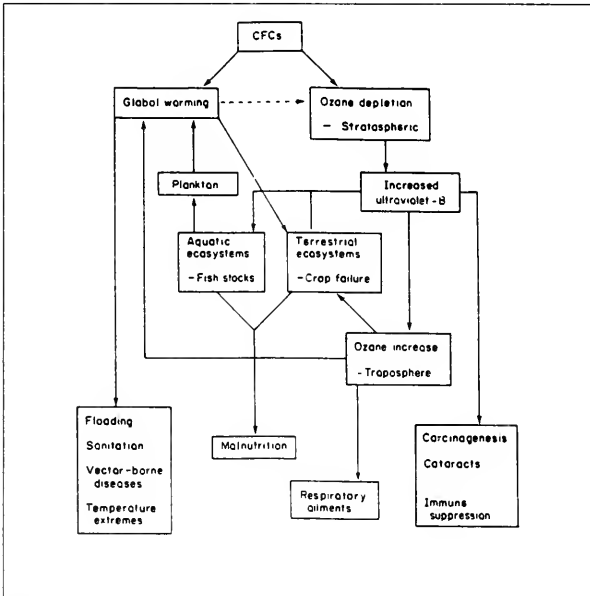
Increased education of the public as well as the medical profession should be a primary aim. Beachside advertising and warnings have been helpful in Australia and should be increased in America. Increased public awareness will follow as increased communication within our society occurs. The American news media already does an excellent job of reporting many of the factors in major newspaper articles, lay journals, talk shows, and local television clips. Many physicians, particularly dermatologists at beachside areas, are aware of local marine-induced diseases. Nonetheless, there is a considerable lack of expertise in this field among medical specialists. The advocacy groups interested in this environmental problem comprise environmental preservation groups and industrial societies. There are no appropriate advocacy groups composed of patients with activities directed toward medical treatment and prevention in this regard. Thus, the allies in this area would be groups such as the United States Life Guard Association, the California Surf Riders Association, the Sierra Club, Greenpeace, hotel and resort associations, beach operator societies, and municipalities having beachfront activities.

### Legislative Examples

Past examples of successful legislation enacted in this area include numerous conservation proposals for beachside erosion and seafood quality. Legislation to affect venomous marine animals includes the Garmatz Jellyfish Control Act passed in the late 1960s in the United States Congress, and the Jellyfish Action Plan instituted by the UN Environmental Control Program for the Mediterranean passed in the 1980s. These two programs illustrate the possibility of interaction of public agencies between various countries and various states within a single country in order to produce both funding and policing of environmental goals.

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**Figure 1**

The effects of atmospheric CFCs on global warming and ozone depletion and their subsequent effects on man (see reference 1).

## DERMATOLOGY AND THE ENVIRONMENT

Neal S. Penneys, M.D., Ph.D.

Most of us do not appreciate the remarkable way our skin protects us from the random acquisition of an endless array of infectious agents. Because of the skin's tough exterior, it represents an uncommon portal for entry of serious infectious processes in healthy persons. All of us, however, have suffered the superficial bacterial, viral and fungal infections that can follow disruption of the external layers of the skin. Many of the infections described below can be acquired globally, at work or at play, but are classified in the area where they are most often encountered.

### Infections Acquired in the Workplace

In general, the majority of cutaneous infections acquired in the workplace follow some form of traumatic disruption of the skin that permits entry of the pathogen. Characteristic risks are associated with certain work activities. For example, gardeners who work with thorned plants or who do potting with sphagnum moss are at risk for infection by sporotrichosis, a fungal disease that produces characteristic linear spread. Following inoculation, the primary infection develops slowly, usually as a cratered sore on the finger or extremity. After a period of time, this fungal infection spreads through the regional lymphatics, producing a characteristic linear array of nodules progressing centrally. Once recognized, treatment is relatively simple, using systemic antifungal medications. Gardeners and others who work in relatively unclean situations associated with risk of trauma can also acquire a variety of common superficial bacterial infections following cutaneous disruption.

Characteristic cutaneous infections can also follow contact with animals or fish. Dairy workers acquire a form of pox virus known as "milker's nodules" on their hands, after contact with infected udders. Sheep handler's can develop a similar affliction known as "orf." These infections are clinically characteristic and self-limited. These examples represent a small sample of the most recognizable and clinically characteristic infections acquired at work; the list of possible infections is as diverse as is the array of work environments.

### Infections Acquired During Leisure Activities

A wide spectrum of infections can be acquired at leisure. One of the most well-known is the tick-borne Lyme disease. This is a potentially serious systemic infection acquired through a tick vector. During feeding, the tick transmits the agent, a spirochete, that causes Lyme disease. The tick is quite small and easily missed. Children playing in wooded

areas and hikers are at significant risk of exposure to the tick in certain regions of the United States at certain times of the year. Once implanted, inoculation of the spirochete produces a characteristic skin lesion known as erythema chronicum migrans. Early recognition of the lesion leads to appropriate therapy, before more advanced stages of Lyme disease ensue. A second tick-borne serious systemic infection acquired through the skin is Rocky Mountain spotted fever. Once the agent gains entry, a complicated series of symptoms follows; a characteristic skin rash frequently permits early diagnosis and therapy. Rocky Mountain spotted fever can be fatal if not recognized and treated expeditiously.

Other classes of infective agents are acquired during leisure activities. Certain types of infection, primarily atypical mycobacterium, can be inoculated through the skin from brackish water. Persons who have and maintain aquariums or boats are at risk for these infections. The initial lesion is similar to that of sporotrichosis, in that a nodule is formed with a crater at the site of entry. These infections can spread, generally in a linear array up the lymphatic chain. As with many of these infections, early recognition leads to effective therapy. Other bacterial processes can also be associated with typical leisure time activities. One of the best known is pseudomonas folliculitis acquired in hot tubs, a characteristic follicular disease associated with a recent history of hot tub use. Culture of water from the spa generally confirms the presence of the infectious agent.

Other life-threatening and fatal infectious processes can be inoculated through the skin. The most pertinent example is acquisition of HIV. HIV infection can be acquired in a number of well-known ways, including passage of the virus through the skin. In the work environment, accidental puncture with infected needles and surgical instruments leads to an HIV infection rate of approximately 0.2%. This is significant, considering that it represents the acquisition of an irreversible infectious process. HIV transmission through the skin has also been documented in other circumstances, including the use of contaminated tattoo needles and by means of open genital sores at the time of intercourse.

### Governmental Goals

As with all of the multitude of interactions in life, it is not possible to eradicate potentially dangerous interactions between man and the environment. Reasonable goals include the dissemination of information concerning

avoidance to populations at risk for acquisition of the infection. Dairy workers should know about milker's nodules; gardeners about sporotrichosis; hikers, about Lyme disease. An innovative mechanism of information dissemination could be developed with the assistance of the American Academy of Dermatology. For example, pamphlets detailing the risks of acquisition of sporotrichosis, the modes of acquisition, the appearance of the skin lesions, and the recommended treatments could be made available at nurseries and garden stores. Pamphlets describing the modes of acquisition of tick-borne diseases could be available at sporting goods stores. A flexible program of vector control should be available and in use. If an epidemic of Lyme disease is occurring, then the infected host population should be defined and controlled. If mosquito-borne diseases are prevalent, then mosquito control is the most efficient way of preventing disease.

To reiterate, a collaboration between dermatologists and government could lead to a more efficient dissemination of information regarding acquisition of infections through the skin. Inevitably, this would lead to decreased incidence of infection, increased worker productivity and better enjoyment of our leisure time.

## MAN-MADE HAZARDS TO THE SKIN

## RECOGNITION, SURVEILLANCE AND TRENDS IN MAN-MADE HAZARDS IN THE WORKPLACE

C.G. Toby Mathias, M.D.

Occupational skin disorders are important causes of morbidity and disability in the workplace. In 1982, the National Institute for Occupational Safety and Health (NIOSH) included skin disorders on its list of ten leading work-related diseases and injuries.<sup>1</sup> Effective strategies to prevent occupational skin disease caused by man-made hazards in the workplace must be based first on recognition of occurring cases, followed by more specific identification of high risk causal agents, occupations, and industries of employment. Surveillance systems for monitoring occupational skin diseases must rely on information reported by employers, physicians and workers.

### Employer-Based Reporting Systems

The Annual Survey of Occupational Injuries and Illnesses, conducted by the Bureau of Labor Statistics (BLS), has monitored the occurrence of occupational skin diseases since 1972. This survey is based on a representative, random probability sample of approximately 280,000 employers in private industry selected across all 50 states, the District of Columbia, and U.S. territories and possessions. The survey covers civilian private sector employers but excludes the military, public sector employers, small farms with fewer than 11 employees, private household industries, and self-employed individuals. Participation is mandatory for selected companies, which must record all new cases of occupational skin diseases that occur during the survey year. Incidence rates are expressed per number of full-time employees, where 2000 hours (40 hours per week x 50 weeks) worked by any combination of employees equals one full-time employee. Data from this survey are most useful for monitoring trends and identifying high risk industrial classifications.<sup>2</sup> Incidence rates measured in this survey declined gradually from 16.2 per 10,000 full-time workers in 1972, to a low of 6.9 per 10,000 workers in 1986, but have increased steadily since then. The incidence rate in 1990 was 7.9 per 10,000 workers, or almost 61,000 total new cases. There are no readily apparent explanations for this trend.

Agricultural and manufacturing industries have consistently had high relative risks, almost five and three times greater respectively, than other industrial classifications. Within the major industrial classifications of agriculture and manufacturing, agricultural crop production and leather

product manufacturing have the highest incidence rates, measured at 39.4 and 27.4 per 10,000 full time workers in the 1984 annual survey. Despite a lower incidence rate of 8.1 per 10,000 full time workers, the health services industry ranks number one in incurring the largest number of cases, with an estimated 3,900 cases in 1984.

### Physician-Based Reporting Systems

Workers' compensation insurance is mandated by federal law to cover all legitimate medical and lost work-time expenses resulting from occupational injuries and illnesses. Administrative boards exist in all states and are run by state agencies. Although originally intended for economic analysis, data routinely collected by these state agencies on workers' compensation claims (WCC) may be adapted for surveillance of occupational skin diseases. All cases are seen and reported by physicians in accordance with various state laws. In addition to the obvious advantages of confirmation of occupational causation determined by physicians, such reporting systems collect more specific information on types of skin disease, causal agents, and occupations, in addition to industries of employment.

In the state of California, a physician diagnosing and treating an occupational skin disease is required to file a "doctor's first report of injury" with the California Department of Industrial Relations immediately following the initial evaluation. The filing of this report results in prompt payment for services rendered. Data on occupational skin diseases for the reporting year 1977 were extensively analyzed, and the results published in 1982.<sup>3</sup> In 1977, the state received 17,462 doctors' first reports for an estimated 8.5 million workers covered by the state Workers' Compensation Act. The case rate was 21 per 10,000 workers, twice the national average rate of 10.5 per 10,000 workers recorded in the BLS annual survey for the same reporting year. Contact dermatitis accounted for 92.2% of all reported cases, skin infections for 5.4%, and miscellaneous skin conditions for the remaining 2.4%. Of all reported cases, 19.5% lost at least one day from work. Agricultural and manufacturing industries had the highest relative risks with incidence rates of 86 and 41 per 10,000 workers respectively, compared to national rates of 44.3 for agriculture and 24.5 for manufacturing recorded in the BLS annual survey. The leading man-made causes were cleaning compounds

(including soap, water, detergent), solvents, particulate dusts (including fiberglass), plastic resins, petroleum products (excluding solvents), agricultural chemicals, textiles, acids, metals, and cutting fluids.

The Supplementary Data System (SDS) is a national database maintained by the BLS and abstracted from information reported on WCC filed in individual states that voluntarily participate in the system. Unlike the annual survey, injury and illness data are derived from costs occurring in both the private and public sector and reported to state workers' compensation agencies. The SDS provides supplementary information on a number of variables associated with occupational injury and illness, including type of illness, occupation, causal agent, part of body affected, age and gender. Identities of affected workers and employers are not entered into the SDS file. Although the SDS is a pool of data from participating states, reporting criteria for entering cases into the SDS are not uniform from state to state. While some states enter all their WCC into the SDS, others enter only those cases associated with a specified number of lost work days (e.g., at least one lost work day, or at least eight lost work days). In spite of these variances, the SDS contains a sizable national cross-section of information on WCC. An analysis of 1981 SDS data found excellent correlation of risk ranking, based on incidence rates, for both major and two-digit standard industrial classifications between SDS and annual survey data.<sup>4</sup> Thus, further analysis of SDS data for specific industries of employment identified with high incidence rates in the more reliable annual survey may provide useful insights into important variables associated with occupational skin disease. For example, further analysis of the 1981 SDS data for agriculture found that 48.2% of occupational skin disease cases were caused by naturally occurring plants, trees, or vegetation, and another 10.1% by miscellaneous food products. Only 19.1% were caused by chemicals, including pesticides.

The Health Examination Survey is a series of programs conducted by the National Center for Health Statistics in which health data are collected on segments of the general U.S. population by direct physical examinations, tests, and measurements on selected representative samples of the civilian, noninstitutionalized population. From 1971 to 1974, the National Health and Nutrition Examination Survey (NHANES I) collected data on the prevalence of skin conditions from a national probability sample of 20,749 selected persons, aged 1 to 74 years.<sup>5</sup> Each individual was examined by a dermatologist. Although the study was designed primarily to obtain data on the general population, limited information on occupational skin disease was obtained. Approximately one-third of all survey participants were found on examination to have

significant skin disease, and almost 10% of these persons considered their conditions to be a handicap to their employment or housework (1% severe, 9% minimal). Nearly one-fourth (23.9%) of adults aged 18 to 74 with significant skin diseases associated their conditions with occupational exposure to chemicals, fumes, vapors, oils, insecticides, or prolonged immersion of hands or feet in water. The proportion of skin conditions associated with occupation exposure was more than twice as high among men (32.4%) than women (14.4%).

### Worker-Based Reporting Systems

The National Health Interview Survey (NHIS) is an annual statistical sampling survey conducted through personal interviews of household members by the National Center for Health Statistics at selected sites across the country. This survey is designed to make national estimates of health characteristics for the civilian, noninstitutionalized population. Each year, special health surveys may be added to the core survey. In 1988, the National Institute for Occupational Safety and Health (NIOSH) added an occupational health survey, focusing on individuals aged 18 and older who had been employed in a civilian job at any time during the preceding year. This supplemental survey contained a series of questions about dermatitis, defined as "dermatitis, eczema, or any other red, inflamed skin rash" occurring in the 12 months prior to interview; acne was excluded from the responses. Contact dermatitis was defined as dermatitis "caused by chemicals of any other substance that had gotten on the skin" of participating subjects. If subjects with contact dermatitis had gotten the chemicals or other substances on their skin while at work, contact dermatitis was considered occupational. Data on dermatitis from this survey are self-reported, and no attempt was made to confirm or corroborate any response by direct physical examination, review of the medical records, or any other method.

Extrapolating the survey results, we can project that of the approximately 127 million people employed in civilian jobs in the U.S. during 1988, 14.9 million (11.7%) have experienced dermatitis. Of those reporting dermatitis, 22.7% reported that the rash was caused by skin contact with chemicals or other substances, i.e., contact dermatitis. Of those reporting contact dermatitis, 68% (representing 2.3 million) reported that they had gotten the chemicals or substances on their skin while at work. This translates into an estimated prevalence rate of 181 per 10,000 workers. Assuming cases which lasted less than 365 days at the time of interview to be new cases, the corresponding incidence rate would be 136 per 10,000 employees. Further analysis of this data confirms suspicions of serious underreporting of occupational skin diseases in other health surveys.<sup>6</sup> Only

22.4% of individuals in this survey who experienced occupational contact dermatitis reported their conditions to their employers, and only 1.6% filed a WCC.

### Surveillance and Prevention

The ultimate goal of all occupational disease surveillance programs should be prevention of further occupational illnesses. National surveillance programs such as the BLS Annual Survey, the SDS, and the NHIS, hold the identities of participating workers and employers as confidential; only high risk occupations and industries of employment are described. These surveys offer opportunities only for indirect intervention primarily through educational efforts aimed at large occupational groups (e.g., unions), employers (e.g., trade associations), or occupational physicians caring for these large groups. State workers' compensation agencies, on the other hand, include the identities of affected workers and employers as part of the WCC databases. Thus, state workers' compensation databases offer potential opportunities for surveillance systems to direct information to employment sites where cases are actually occurring.

In order to determine the feasibility of using state WCC data for such a purpose, an analysis of WCC data filed in Ohio for the five year period 1980 to 1984 was undertaken.<sup>7</sup> This analysis assumed that limited federal or state resources would be available for direct intervention, and focused on companies filing the highest number of claims for skin disease. The analysis further assumed that preventive strategies would be most effectively focused on occupations or causal agent exposures frequently associated with claims from any one company. During the five-year study period, 102 Ohio companies filed six or more claims (average > 1 claim per year). Within 85 (63.7%) of these 102 companies, either the same occupation or causal agent was implicated in over 50% of claims filed. This suggests that active intervention strategies to prevent occupational skin disease can be both feasibly and economically directed at employment sites following primary identification of companies filing high numbers of occupational skin disease claims, and secondary identification of high-risk occupations or causal agent exposures within these companies.

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## PERCUTANEOUS ABSORPTION OF HAZARDOUS SUBSTANCES FROM THE ENVIRONMENT: SYSTEMS VALIDATION

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### Introduction

Contamination of ground water, surface water and soil, and the transfer of contaminants to the human body, are of major concern. The obvious first assumption is that contaminants are ingested in drinking water. However, when the large surface area of skin is exposed to contaminated water by bathing and swimming, skin absorption may also be significant. Brown, et al., suggested that skin absorption of contaminants in water has been underestimated and that ingestion may not constitute the sole, or even the primary, route of exposure.<sup>2</sup>

Industrial growth has resulted in the production of organic chemicals and toxic metals, the disposal of which results in contamination of water supplies. For swimmers or bathers, the skin, the largest organ of the body (surface area approximately 18,000 cm<sup>2</sup>) acts as a lipid sink (stratum corneum) for lipid soluble contaminants. The skin also serves as transfer membrane for water and whatever contaminants may be dissolved in it.

Hazardous substances can cause adverse effects in humans only if exposure occurs. Soil, recently recognized as a potentially important medium of exposure, is a medium with which human skin has constant contact. This can be work-related (farming; waste hazard disposal), recreational (gardening), or a child's delight (beach; sand box).

A major dilemma in establishing regulatory limits for environmental pollutants is the establishment of standards or limits for chemical concentrations in soil at industrial and residential sites. Factors and assumptions used to predict the bioavailability of a chemical from soil significantly affect the establishment of a virtually safe dose or acceptable daily exposure level of a compound in soil. The two major concerns in setting relevant contamination levels are public safety and cost/feasibility of cleanup. Public safety depends upon the inherent toxicity of the hazardous chemical and its bioavailability (rate and extent of systemic absorption). The cost of remediation varies dramatically with the level to which soil must be decontaminated; excessive remediation means that limited resources will be spent without providing additional protection of public health.

The cost, thus, in human health welfare and dollars to safeguard people and the environment is tremendous. Decisions regarding this should be based on fact, and

accurate, useful scientific data can provide the facts to make appropriate judgments. The key to accurate, useful scientific data is validation of the systems. This paper will briefly discuss some validation points relevant to percutaneous absorption.

### Percutaneous Absorption Systems

Table I summarizes *in vitro* and *in vivo* percutaneous absorption of some environmental hazardous substances from water, soil and model vehicles (acetone, mineral oil, trichlorobenzene). The percent dose absorbed was determined *in vitro* with human skin mounted in glass diffusion cells, and *in vivo* in the Rhesus monkey.<sup>11-16</sup>

Note that dose accumulation within the receptor fluid (either human plasma or buffered saline) is relatively nonexistent. If decisions were made based only on receptor fluid accumulation, the concept of percutaneous absorption of hazardous substances would not exist. This is because most of the compounds are very lipophilic and will not partition into the receptor fluid. Table II gives the octanol: water partition coefficient for some of these chemicals. The receptor fluid simply cannot solubilize these compounds; thus the receptor fluid is not validated for percutaneous absorption of these compounds.

Table I also gives skin content for doses absorbed *in vitro*. Assuming that a chemical will penetrate skin and not be soluble in receptor fluid, then perhaps the skin content might predict percutaneous absorption. In fact, this seems more predictive; skin contents of chemicals compare more favorably with *in vivo* values for lipophilic chemicals.

The *in vivo* percutaneous absorption shows that these chemicals are highly absorbed. This suggests that these environmental hazardous substances can readily partition out of their environmental vehicles (water, soil, spray) and be absorbed through skin. The *in vivo* data are from the Rhesus monkey. Table III shows that the Rhesus monkey is validated as an *in vivo* animal model relevant to humans for percutaneous absorption.<sup>6,7</sup>

Therefore, there appears to be some sense of security in using data generated from the Rhesus monkey *in vivo* and from human skin content *in vitro* (especially where *in vitro* absorption data are produced concurrently with validated *in vivo* data).

### Material Balance: Accountability

The preceding discussion pointed out the importance of examining skin content as well as receptor fluid accumulation. It is possible in an *in vitro* study to achieve material balance. Table IV shows the *in vitro* percutaneous absorption of alachlor over time (0-8 hours). Data are represented as dose accumulation in receptor fluid, skin digest, skin wash (soap and water), apparatus wash, and final accountability.<sup>9</sup> The same type of material balance can be achieved *in vivo* (Table V), and the animal need not be sacrificed.<sup>13</sup> The system of accountability is, thus, validated for material balance. Again, there is a sense of security in knowing where all of the dose resides.

### Assumed Default Absorption

Percutaneous absorption values are a necessary component of health hazard assessment. However, chemicals are being produced at a rate faster than regulatory agencies can assess their absorption. The United States Environmental Protection Agency<sup>7</sup> rightly is trying to develop predictive equations to assess percutaneous absorption. This, then, gives an assumed default absorption value. Default value is a number for which values greater than it are considered excessive. An example is Table VI, where the assumed default absorption equation for metals from water is a  $K^w$  (permeability coefficient for absorption from water) of  $1 \times 10^{-3}$  cm/hr. For cadmium, the default value is 3x that of the measured value, but 250x above that of the arsenic measured value. Thus, the system of assumed default values lacks proper validation.

### In Vivo Skin Decontamination

Table VII gives Aroclor 1242 removal *in vivo* from Rhesus monkey skin with five successive washes following a 15-minute skin application time. Soap and water, trichlorobenzene, and mineral oil were able to remove all of the Aroclor 1242 on the skin with five washes, and at least 80% was removed with successive washes. Ethanol was not very effective, removing only 63% of the PCBs in five successive washes.

Table VIII gives the *in vivo* skin decontamination of Aroclor 1242 for time periods beyond the initial 15-minute application time. With trichlorobenzene vehicle no differences were seen through 1 hour. However, at 3 hours the amount of Aroclor 1242 removed was decreased, and this compromised ability to remove Aroclor 1242 continues at 6 and 24 hours. By 24 hours, only about 25% of the PCBs can be recovered from the surface of the skin. With mineral oil as the vehicle, soap and water was able to remove about 70% of the PCBs over a 3-hour period. This decreased to 50% at 6 hours, and only 30% of the PCBs could be removed at 24 hours. Mineral oil was more efficient in

removing the PCBs following the initial 15-minute period (the PCBs were in mineral oil on the skin). This decontamination ability quickly disappeared in 10 minutes. By 24 hours only 45% of the PCBs could be recovered from the surface of the skin.<sup>11</sup>

Thus, it is important to know if soap and water will remove a chemical from skin. It is paramount to know that percutaneous absorption *in vivo* is an ongoing process, subject to change with time. Regulations in terms of safety decontamination need take into account the above when validating for human safety guidelines.

### Toxicokinetics

The percutaneous absorption of pentachlorophenol (PCP) from acetone vehicle was 29.2  $\pm$  5.8% of total dose applied for a 24 hour exposure period. Compared to other compounds<sup>12</sup> the absorption of PCP would be considered high. *In vivo* absorption from soil was 3.3% for DDT, 13.2% for benzopyrene, and 4.2% for chlordane. Additionally, the <sup>14</sup>C excretion for PCP in urine was slow, measured at a half-life of 4.5 days for both intravenous and topical application. If biological exposure is considered in terms of dose X time, the PCP biological exposure can be considered high.

The percutaneous absorption of PCP from soil vehicle was also high (24.4  $\pm$  6.4%) and not statistically different from acetone vehicle (Table IX). The study of Reigner, et al.,<sup>4</sup> and this study, show PCP to have good bioavailability, both topical and oral; PCP also exhibits an extensive half-life. This suggests that PCP has the potential for extensive biological interactions.

Thus, percutaneous absorption can be expressed as *in vivo* topical bioavailability where pharmacokinetic data such as half-life can be integrated with toxicological data. Validation of such a system gives an integrated meaning to the interactions of chemicals in a living system.

### Discussion

Table I lists an impressive collection of chemicals that contaminate the environment. Potential human health hazard assessment requires a bioavailability section where absorption into the human body is calculated. It is important that the parameter(s) used to gather bioavailability data be validated, because the costs in dollars and human health can be very large. It is paramount that any percutaneous absorption data, preferably both *in vitro* with human skin and *in vivo* in humans or a relevant animal model, be derived from validated systems.

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Table I

| <i>In vitro</i> and <i>In vivo</i> Percutaneous Absorption |                  |                 |                |             |
|--|------------------|-----------------|----------------|-------------|
| Compound   | Vehicle          | % Dose Absorbed |                |             |
|  |                  | <i>In vitro</i> | <i>In vivo</i> |             |
|  |                  | Skin            | Receptor       | fluid       |
| DDT  | acetone<br>soil  | 18.1 ± 13.4     | 0.08 ± 0.02    | 18.9 ± 9.4  |
|  |                  | 1.0 ± 0.7       | 0.04 ± 0.01    | 3.3 ± 0.5   |
| Benzo(a)pyrene   | acetone<br>soil  | 23.7 ± 9.7      | 0.09 ± 0.06    | 51.0 ± 0.06 |
|  |                  | 1.4 ± 0.9       | 0.01 ± 0.06    | 13.2 ± 3.4  |
| Chlordane  | acetone<br>soil  | 10.8 ± 8.2      | 0.07 ± 0.06    | 6.0 ± 2.8   |
|  |                  | 0.3 ± 0.3       | 0.04 ± 0.05    | 4.2 ± 1.8   |
| Pentachlorophenol  | acetone<br>soil  | 3.7 ± 1.7       | 0.06 ± 0.09    | 29.2 ± 5.8  |
|  |                  | 0.11 ± 0.04     | 0.01 ± 0.00    | 24.4 ± 6.4  |
| PCBs (1242)  | acetone          | a               | a              | 21.4 ± 8.5  |
|  | TCB <sup>b</sup> | a               | a              | 18.0 ± 3.8  |
|  | mineral oil      | 10.0 ± 16.5     | 0.1 ± 0.07     | 20.4 ± 8.5  |
|  | soil             | 2.6 ± 2.8       | 0.04 ± 0.05    | 13.8 ± 2.7  |
| PCBs (1254)  | acetone          | a               | a              | a           |
|  | TCB <sup>b</sup> | a               | a              | 14.6 ± 3.6  |
|  | mineral oil      | 6.4 ± 6.3       | 0.3 ± 0.6      | 20.8 ± 8.3  |
|  | soil             | 1.6 ± 1.1       | 0.04 ± 0.05    | 14.1 ± 1.0  |
| Arsenic  | water            | 1.0 ± 1.0       | 0.9 ± 1.1      | 2.0 ± 1.2   |
|  | soil             | 0.3 ± 0.2       | 0.4 ± 0.5      | 3.2 ± 1.9   |
| 2,4-D  | acetone          | a               | a              | 8.6 ± 2.1   |
|  | soil             | 1.4 ± 1.2       | negligible     | 15.9 ± 4.7  |
| Cadmium  | water            | 12.7 ± 11.7     | 0.6 ± 0.2      | a           |
|  | soil             | 0.13 ± 0.05     | 0.07 ± 0.03    | a           |

<sup>a</sup> Study not done

<sup>b</sup> Trichlorobenzene

**Note:** PCBs exist in transformers in trichlorobenzene and mineral oil vehicles.

Table II

**Octanol:Water Partition Coefficient of  
Environmental Hazardous Substances**

| Chemical          | Log P o/w <sup>a</sup> |
|-------------------|------------------------|
| Benzo(a)pyrene    | 6.1                    |
| Chlordane         | 5.54                   |
| DDT               | 6.19                   |
| Pentachlorophenol | 5.01                   |
| PCBs (mixture)    | very lipophilic        |

- <sup>a</sup> Log partition coefficient between octanol and water.

Numbers above 0 (zero) are lipophilic; large numbers such as these make the compounds extremely lipophilic

Table III

***In vivo* Percutaneous Absorption in Rhesus Monkey and Man**

| Compound                              | % Dose Absorbed |         | Difference |
|---------------------------------------|-----------------|---------|------------|
|                                       | Rhesus monkey   | Man     |            |
| 2,4-Dinitrochlorobenzene <sup>a</sup> | 52 ± 4          | 54 ± 6  | 0          |
| Nitrobenzene <sup>a</sup>             | 4 ± 1           | 2 ± 1   | x2         |
| Cortisone <sup>a</sup>                | 5 ± 3           | 3 ± 2   | x2         |
| Testosterone <sup>a</sup>             | 18 ± 10         | 13 ± 3  | 0          |
| Hydrocortisone <sup>a</sup>           | 3 ± 1           | 2 ± 2   | 0          |
| Benzolic acid <sup>a</sup>            | 60 ± 8          | 43 ± 16 | 0          |
| Diethyl maleate <sup>b</sup>          | 66 ± 7          | 54 ± 7  | 0          |
| DDT <sup>c</sup>                      | 19 ± 9          | 10 ± 4  | 2          |
| Retinoic acid <sup>d</sup>            | 2 ± 1           | 1 ± 0.2 | x2         |
| 2,4-D                                 | 9 ± 2           | 6 ± 2   | 0          |

<sup>a</sup> Wester et al (1989a)

<sup>b</sup> Bronaugh et al (1990)

<sup>c</sup> Wester et al (1990b)

<sup>d</sup> Franz and Lehman (1989)

These are data collected over the years from many laboratories. The rhesus monkey is a good animal model to predict potential percutaneous absorption in man.

Table IV

***In vitro* Human Skin Absorption and Distribution of Alachlor  
from Water over Time**

| Parameter               | Percentage applied dose |         |         |
|-------------------------|-------------------------|---------|---------|
|                         | 0.5 hours               | 4 hours | 8 hours |
| Receptor fluid (plasma) | 0.01                    | 0.28    | 0.82    |
| Skin digest             | 19.6                    | 30.5    | 33.1    |
| Skin wash               | 77.0                    | 61.4    | 43.3    |
| Apparatus               | 0.3                     | 1.0     | 9.0     |
| Total accountability    | 96.91                   | 93.2    | 86.2    |

The distribution of dose within the parameters of the study give a sense of security as to validation of the study.

Table V

***In vivo* Percutaneous Absorption of Chlordane  
in Rhesus Monkey: Dose Accountability\***

| Parameter                           | Percent applied dose<br>(mean $\pm$ SD)<br>for vehicle |                 |
|-------------------------------------|--|-----------------|
|                                     | Soil   | Acetone         |
| <b>Soap-and-water wash sequence</b> |  |                 |
| Soap                                | 14.3 $\pm$ 11.6  | 33.6 $\pm$ 13.4 |
| Water                               | 3.7 $\pm$ 34.9   | 15.3 $\pm$ 3.6  |
| Soap                                | 1.8 $\pm$ 0.9  | 10.6 $\pm$ 2.9  |
| Water                               | 0.2 $\pm$ 0.1  | 1.8 $\pm$ 0.4   |
| Chamber                             | 2.8 $\pm$ 3.6  | 4.2 $\pm$ 1.8   |
| Residue soil/membrane               | 56.5 $\pm$ 15.9  | 1.0 $\pm$ 0.3   |
| Systemic absorbed                   | 4.2 $\pm$ 1.8  | 6.0 $\pm$ 2.8   |
| Accountability*                     | 80.3   | 72.0            |

\* No fecal or tissue analyses.

Dose accountability in vivo is possible without sacrifice of the animal. Similar accountability would thus be possible in human studies.

Table VI

| Assumed Default Absorption<br>Metals $KW_p$ of $1 \times 10^{-3}$ cm/hr |                                |                                |            |
|---|--------------------------------|--------------------------------|------------|
| Compound  | Default value                  | Measured value                 | Difference |
| Arsenic   | 10.1 $\mu\text{g}/\text{cm}^2$ | 0.04 $\mu\text{g}/\text{cm}^2$ | x250       |
| Cadmium   | 1.8 $\mu\text{g}/\text{cm}^2$  | 0.6 $\mu\text{g}/\text{cm}^2$  | x3         |

"Working" default values should be validated by scientific study, rather than accepted at face value.

Table VII

**Aroclor 1242 Removal from Rhesus Monkey Skin  
with Successive Washes Following Initial  
15-Minute Application Time**

| Successive<br>wash number | Percent dose removed |                  |             |            |
|---------------------------|----------------------|------------------|-------------|------------|
|                           | Soap and water       | Trichlorobenzene | Mineral oil | Ethanol    |
| 1                         | 62.4 $\pm$ 13        | 79 $\pm$ 12      | 64 $\pm$ 5  | 51 $\pm$ 7 |
| 2                         | 19 $\pm$ 9           | 14 $\pm$ 4       | 21 $\pm$ 6  | 8 $\pm$ 2  |
| 3                         | 7 $\pm$ 2            | 5 $\pm$ 1        | 10 $\pm$ 2  | 2 $\pm$ 1  |
| 4                         | 3 $\pm$ 1            | 3 $\pm$ 1        | 5 $\pm$ 1   | 1 $\pm$ 0  |
| 5                         | 2 $\pm$ 1            | 1 $\pm$ 1        | 3 $\pm$ 2   | 1 $\pm$ 1  |
| Total                     | 93 $\pm$ 7           | 102 $\pm$ 7      | 102 $\pm$ 9 | 63 $\pm$ 4 |

**Note:** Application vehicle is trichlorobenzene.

Table VIII

***In vivo* Skin Decontamination of Aroclor 1242 PCBs  
as Percent Applied Dose Removed**

| Time interval<br>of washing<br>postapplication<br>of PCBs <sup>a</sup> | Trichlorobenzene vehicle    |                          |             |         | Mineral oil vehicle |             |
|--|-----------------------------|--------------------------|-------------|---------|---------------------|-------------|
|  | Soap and Water <sup>b</sup> | Trichlorobenzene vehicle | Mineral oil | Ethanol | Soap and water      | Mineral oil |
| 0.0  | 93 ± 7                      | 102 ± 7                  | 63 ± 4      | 102 ± 9 | 71 ± 18             | 90 ± 10     |
| 10 m   | 87 ± 10                     | 66 ± 9                   | 68 ± 5      | 95 ± 8  | 71 ± 27             | 68 ± 19     |
| 1 h  | 81 ± 11                     | 92 ± 8                   | 72 ± 8      | 79 ± 11 | 71 ± 33             | 63 ± 28     |
| 3 h  | 63 ± 17                     | 74 ± 12                  | 49 ± 3      | 74 ± 8  | 68 ± 13             | 64 ± 15     |
| 6 h  | 57 ± 26                     | 58 ± 15                  | 52 ± 7      | 56 ± 12 | 51 ± 30             | 65 ± 22     |
| 24 h   | 26 ± 13                     | 25 ± 19                  | 26 ± 7      | 36 ± 8  | 30 ± 14             | 45 ± 40     |

Note: Mean ± SD for 4 Rhesus monkeys.

<sup>a</sup> Following 15-min skin application interval.

<sup>b</sup> with 20% (v/v) Ivory Liquid soap/water.

It is important to realize that *in vivo* percutaneous absorption/decontamination is an ongoing process, subject to change with time.

Table IX

***In vivo* Percutaneous Absorption of  
Pentachlorophenol In Rhesus Monkey**

|                               | Percent dose <sup>a</sup> |            |             |
|-------------------------------|---------------------------|------------|-------------|
|                               | Topical                   |            |             |
|                               | Soil                      | Acetone    | Intravenous |
| Percent dose absorbed         | 24.4 ± 6.4                | 29.2 ± 5.8 | —           |
| Surface recovery <sup>b</sup> | 38.0 ± 13.4               | 59.6 ± 4.1 | —           |
| Half-life (days)              | 4.5                       | 4.5        | 4.5         |

<sup>a</sup> Mean ± SD for four animals.

<sup>b</sup> Includes chamber, residue, and surface washes.

Pentachlorophenol exhibits extensive skin absorption and a long half-life. Thus the dose X time says interactions between pentachlorophenol and biological tissues/cells is extensive.



## CONTACT DERMATITIS

Robert L. Rietschel, M.D.

Contact dermatitis is an altered state of skin reactivity induced by exposure to an external agent. Substances that produce this condition after single or multiple exposures may be irritant or allergic in nature. Direct tissue damage results from contact with irritants. Tissue damage by allergic substances is mediated through immunologic mechanisms. The most common morphologic presentation is dermatitis (eczema), but other patterns are encountered including urticaria, purpura, and erythema multiforme. Chemical burning is a paradigm for acute irritant contact dermatitis, while poison ivy is a paradigm for allergic contact dermatitis.

### Epidemiology

Contact dermatitis is a common reason for consulting a dermatologist and constitutes approximately 5.7 million physician visits per year. All age groups are affected, but there is a slight female predominance of the condition, as reflected in patients seen for diagnostic patch testing.

The complex nature of the chemical environment in which we live (natural and synthetic) brings the skin into contact with many potential exposures. These may or may not pose a hazard, depending on individual susceptibility.

Over 2800 agents have been identified as potential allergens, and the number of potential irritants is countless, since humans are potentially exposed to over 65,000 substances. The severity of contact dermatitis ranges from a mild, minor nuisance to job-threatening and even life-threatening situations.

With over 2800 potential allergens in the environment, designing a simple test to screen patients with rashes and identify the cause is a bit like developing a single blood test to screen for all causes of cancer or all forms of infection. The patch test, which is the only reliable aid to diagnosis, requires non-irritating concentrations of each suspected allergen or mixes of categories of allergens. About 200 different allergens or groups of allergens are available worldwide, but only 20 are available under FDA license for purchase and diagnostic use in the United States (Table I). An increase in the availability of diagnostic materials would expand the ability of practicing physicians to identify accurately the environmental causes of contact dermatitis.

Once a new cause of contact dermatitis is identified in a physician's office, it is difficult to identify the magnitude of the problem in the population at large. This is true even for groups of physicians carefully tabulating their collective patient data. Good epidemiologic surveys of U.S. population groups are sorely lacking. Only one study of four

allergens in a U.S. general population gives some estimate of the magnitude of the environmental problems. The four allergens studied were neomycin, benzocaine, nickel and ethylenediamine. The prevalence of positive reactions was: nickel 5.8%, neomycin 1.1%, ethylenediamine 0.43% and benzocaine 0.17%. Nine percent of women were nickel-sensitive, compared with 0.9% of men. Few diseases receiving public attention rival the prevalence of nickel allergy, which affects nearly 1 in 10 women and approximately 14.5 million Americans.

While dermatologists can produce lists of the allergens most frequently encountered in an office practice setting, there has been little interest in further environmental surveillance of these materials. Denmark established a national data base of chemical products that contained 47,400 products, 27,800 of which were fully computerized. A list of 43 skin sensitizers was developed from medical reports, and the number of products containing each of these materials varied from 30 to more than 1300.

This level of use of potential sensitizers guarantees the public will repeatedly be exposed to potential skin allergens. Since only some people will express allergy, while others remain immune or tolerant upon exposure, it will be necessary to protect those who must avoid contact with a specific substance. Banning materials with high sensitizing rates would be a sound business practice, since no one would want their product to have the reputation of being as user-friendly as poison ivy. Premarket testing usually keeps such products off the shelf. But most sensitizers affect a much smaller segment of the population and with varying degrees of severity. How can a technologically advancing society keep the benefits of new chemicals and at the same time protect citizens who might risk allergy by further exposure? An excellent model exists in the Fair Packaging and Labeling Act, which requires ingredient disclosure on consumer products. This legislation, initiated by a desire to provide comparison-shopping information for consumers, has played an important role in consumer health by allowing people with specific allergies or simple health concerns to choose products that will do no harm or provide less risk. The European dermatologic community is pushing for adoption of a U.S.-style law for health reasons at this time.

While the United States did well with consumer products, it has not been as successful with salon-care products distributed for "professional use only." A voluntary labeling program was recently adopted by industry but appears to be falling short of its goals.

### Preventive Approaches

Is it possible to identify problems and generate preventive medicine strategies in the field of contact dermatitis? The Danes have provided two examples of how this can be done with major industries and high-frequency allergens.

Chromate in cement causes a great deal of contact dermatitis in the construction industry and was a frequent cause of occupational disability among men in this trade. The addition of iron in the form of ferrous sulfate makes chromate in cement less likely to penetrate skin and cause dermatitis. A requirement that ferrous sulfate be added to cement in Denmark has drastically reduced the number of affected workers over the past 11 years. In Denmark, nickel, the leading cause of contact dermatitis among women there, as it is in our country, was attacked head-on by establishing a standard for nickel release in consumer products that would be unlikely to induce allergy. Statutory Order No. 472, June 27, 1989, required that nickel-containing objects release no more than  $0.5 \mu\text{g}/\text{cm}^2/\text{week}$ .

### What then can be done to help the public prevent contact dermatitis?

- 1) Label for the presence of known sensitizers those products expected to come in contact with human skin in routine use. Which sensitizers? We could start with the 20 FDA-approved items as reasonably problematic based on years of experience and medical reports (a paradigm for this exists with tartrazine, a yellow food dye the presence of which is declared on products).
- 2) Set threshold limits for allergen release from products known to be significant cutaneous hazards. Standards for both nickel and chromate exist in Denmark and have been found workable.
- 3) Increase epidemiologic surveys to establish safety profiles for materials on the market for which a body of medical literature suggests problems exist.
- 4) Establish a task force to develop standards for reporting new medical findings to appropriate government agencies when allergens are detected by groups such as the North American Contact Dermatitis Group and the International Contact Dermatitis Research Group.
- 5) Increase the supply of allergens available for diagnostic contact dermatitis work. It is very difficult to identify allergens without diagnostic tools.

### Table I

#### The current twenty allergens approved by FDA:

benzocaine  
mercaptobenzothiazole  
colophony  
p-phenylenediamine  
imidazolidinylurea  
cinnamic aldehyde  
lanolin alcohol  
carba mix  
neomycin sulfate  
thiuram mix  
formaldehyde  
ethylenediamine  
epoxy resin  
quaternum 15  
p-tert butylphenol formaldehyde resin  
mercapto mix  
black rubber mix  
potassium dichromate  
balsam of Peru

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## PESTICIDES AND SKIN DISEASE

Frances J. Storrs, M.D.

A pesticide is a substance or mixture of substances intended to prevent, destroy, repel or mitigate any pest. A pest is described as any plant or animal (bacteria, fungi, mammal, or virus) detrimental to man. Other definitions exist as well, but the one just mentioned is that presently used by the Environmental Protection Agency (EPA).

As of 1991, the EPA estimates that 25,000 pesticide formulations exist. These formulations contain approximately 750 active ingredients, of which 200 might be described as leading ingredients. Over 2.7 billion pounds of active pesticide ingredients are used each year in the United States. This information, as well as information concerning the toxicity of these 25,000 formulations, what protective clothing might be worn to protect against them, and what sorts of re-entry periods are necessary for crops being sprayed with these pesticides, can be obtained by contacting the Pesticide Hot Line (1 800/858-PEST). This Hot Line is an EPA-funded resource located at Texas Tech University in Lubbock, Texas. The individuals who answer the phone are knowledgeable and helpful. Another resource for information about pesticide use in the U.S. is the Farm Chemicals Handbook published by the Meister Publishing Company, 37733 Euclid Avenue, Willoughby, Ohio 44094, 216/942-2000.

### Agriculture and Occupational Skin Disease

California is a good place to look for information about the association of pesticide exposure and industry. Approximately one-third of all the agricultural workers in the U.S. work in California. California is also a state that has well-kept statistics for work-related diseases. These data are not always current, but by and large, they stay within the same range from year to year.

According to the California data, approximately 45% of all occupational illness in all work classifications involves the skin. About 4% of the California work force is employed in agriculture. Fourteen percent of all occupational skin disease in California is in agriculture. Agriculture and manufacturing present the greatest occupational skin disease risk in California and in all of the United States. In the mid-1970s, these rates were 6.1/1000 employees in agriculture, 3.5/1000 in manufacturing, and 1.8/1000 in all other industries. Furthermore, 70% of all agricultural occupational disease is found on the skin, whereas in manufacturing, 43% of occupational disease is on the skin.

In 1988 O'Malley MA and Mathias CGT, collected information concerned with the distribution of lost work-

time claims for skin disease in California agriculture from 1978 to 1983.<sup>2</sup> Of 2,355,802 employees working in agriculture during that period 2722 lost-work-time claims for skin disease were identified. This is a rate of 11.5 cases/10,000 individuals employed in agriculture. Seventy-eight percent of these individuals were men, with a median age of 27.8 years. Further, O'Malley and Mathias note skin disease that was associated by the workers with plants accounted for 52% of the disease, chemicals for 20%, food products for 13%, and miscellaneous explanations in 15% of the instances.

It is widely believed that the vast majority of skin disease that might be associated with agricultural work and in particular with pesticides is not reported. Some studies estimate that only one in five of all affected workers consult medical help of any sort. In a most unusual study in 1992 Gamsky TE, et al., visited and closely examined 759 Hispanic workers in the grape, citrus, and tomato fields.<sup>3</sup> These individuals were either tipping, pulling, or turning grape canes or harvesting citrus and tomatoes. Five pesticides were used on the grapes, 8 on the citrus, and 11 on the tomato crops. Seven hundred forty-seven of the 759 workers were Hispanic, 98% were interviewed in Spanish, and only 1% had more than a high school education. Depending on the crop, between 59% and 89% were male. The nature of agricultural workers makes complete reporting very difficult and unless actual visits are made to work places, as was done in the Gamsky study, very little specific information about the actual presence of skin disease in these work places can be accurately assessed.

### Pesticides and Skin Disease

Pesticides can cause many different sorts of skin problems, though it is widely believed that contact dermatitis of either an irritant or allergic sort is that most often associated with pesticide exposure. When Gamsky and his co-workers visited these agricultural work places, they discovered that 12% of the workers interviewed had had some sort of a "rash" lasting more than 2 days in the past 12 months. When they examined the workers from the waist up, they found that 27% had pustules, 17% acne, 14% lichenified hand dermatitis, 13% keratosis pilaris, 10% conjunctival erythema, 8% paronychia, 8% excoriations, 2% contact dermatitis, and 0.5% other kinds of dermatitis. None of the citrus workers had contact dermatitis, but 0.8% of the tomato workers and 5.5% of the grape workers had contact dermatitis. This spread of physical findings highlights the

importance of actually examining individuals with complaints attributed to pesticides or to other substances in the workplace. Many of these findings were most likely unrelated to work and occur in all populations to some degree.

When Gamsky, et al., looked specifically at patients with lichenified hand dermatitis, they discovered that the vast majority of these people were grape workers; in some work crews, as many as 50% of the workers had lichenified hand dermatitis.<sup>3</sup> Only 12% of tomato workers and 4.2% of citrus workers had this problem. Individuals working with grapes were not harvesting, but manipulating the grape canes. When the workers wore gloves, they had less difficulty. It was noted that there was more contact dermatitis in grape fields treated with multiple pesticides, whereas lichenified hand dermatitis was tremendously increased in grape areas that used sulfur only (34% vs 17%) as opposed to multiple pesticide use.

In 1989, O'Malley, et al., noted that some agricultural areas have almost no reported pesticide association with skin disease, whereas others have a significant amount.<sup>4</sup> This was the case with forestry, where there were no complaints of pesticide-associated disease, despite the fact that many pesticides are used in forestry. In forestry, 600 cases per 10,000 workers were attributed to plants, and these plants were almost always poison oak. This was in contrast to horticulture and crop-related workers, who had a rate of skin disease of 23/10,000 workers, which was associated with pesticides, and 36/10,000, which was associated with plants (both poison oak and other plants that were mostly irritant).

Pesticides can cause many different skin diseases:

- 1) Irritant contact dermatitis has been associated with Omite (propargite), methyl bromide, petroleum products, sulfur, captan and glyphosphate. O'Malley noted that propargite (Omite®) was the #1 pesticide associated with skin disease in California in the 1978-83 case material and accounted for 18.7% of the cases. Sulfur and glyphosphate (Round-Up®) accounted for 15.1% and 4.1% respectively of the cases. It was felt that all of these cases most likely induced an irritant contact dermatitis, which is almost always the most common form of contact dermatitis.
- 2) Allergic contact dermatitis has been associated with carbamates, thiurams, organophosphates, captan, organomercurials, pyrethrum, and triazines (anilazine or dyrene).
- 3) Chloracne has been associated with pentachlorophenol and dioxins present as degradation products in some halogenated aromatic compounds (chloracneagens).
- 4) Folliculitis has been associated with various oils, with

kerosene, and with chlorinated hydrocarbons.

- 5) Depigmentation has been associated with various phenolics, such as carbyne.
- 6) Photo-allergic contact dermatitis has been attributed to ethoxyquin and other growth-stimulating compounds, as well as to salicylanilides. The salicylanilides as well as phenothiazine have been precipitants of photosensitivity, but mostly in the past, as they are little used at the present time.
- 7) Nail changes have been associated with skin diseases; paraquat is the chief culprit.
- 8) Contact urticaria has been associated with DEET.
- 9) Ulcerations of various sorts can be caused by any pesticide that causes severe irritation or a chemical burn.
- 10) Hemorrhagic necrosis has been attributed to coumarin derivatives.
- 11) Porphyria has been precipitated by epidemics of hexachlorobenzene exposure in the past, and has also been rarely associated with phenoxyacetic acid exposures.
- 12) Paresthesias have been attributed to synthetic pyrethroids.

Other pesticides that have appeared on the list of pesticide-associated skin diseases generated by O'Malley, Mathias and Coye in 1989 include methyl bromide (3.3%), captan (2.0%), paraquat (1.2%), diazinon (0.9%), carbaryl (0.6%), malathion (0.6%) and zineb (0.4%). The nature of the disease attributed to these pesticides is not described. A few of them may have been allergic.<sup>4</sup>

Pesticide-associated skin disease is much more common in individuals directly working with pesticides. These include people such as ground applicators and actual field workers. Nursery workers have low associations of pesticide-related skin disease, as do people working in forestry.

An important thing to highlight is that in these studies, few if any instances of scientific documentation exist that directly indict a pesticide as causing a large group of cases of allergic contact dermatitis. The vast majority of such reports are very rare and exist as isolated case reports. There are better studies documenting the association of pesticide and irritant contact dermatitis. A particularly well known one is that of Saunders DL, et al., which described an outbreak of Omite-CR® induced dermatitis among more than 100 orange pickers in Tulare County, California.<sup>6</sup>

### Chloracne

Certainly one group of chemicals that is well-studied in association with skin disease includes the chloracneagens. These halogenated aromatic compounds include

polyhalogenated biphenyls (for example, PCBs), polyhalogenated dibenzofurans, contaminants of polychlorophenyl compounds such as 2,4,5-T (a phenoxyacetic acid), pentachlorophenol and trichlorophenol. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) does appear as a contaminant of these chemicals and can be associated with chloracne.

These chemicals are potent teratogens as well as acneagens and the skin is of particular interest in their study, in that changes in the skin can be one of the earliest indicators of their presence in the environment. Chloracne is note-worthy clinically in that it presents with many straw-colored cysts that look like simple blackheads and occur classically lateral to the eye, behind the ear, on the cheeks, forehead and neck, and on the external genitalia (particularly the scrotum). Individuals with chloracne itch, sometimes develop hypertrichosis and hyperpigmentation, and complain of skin fragility. The onset of this problem can occur within weeks of exposure to the substances and can last for years.

### Pesticides are Also Used Non-Agriculturally

Pesticides used in agriculture often are used non-agriculturally as well. Dithiocarbamates may find use in the rubber industry, as may thiurams. Captan can be used in cosmetics and has been used in the past in popular shampoos. Dinitrochlorobenzene is used by physicians to treat some diseases and to detect the ability to mount an allergic reaction. Mercurials are used as preservatives. Pyrethroids are used to treat diseases such as lice and scabies, as is lindane. Warfarin is used as a medical anticoagulant and isothiazolinones are used as preservatives in cosmetics and in the workplace, in paints and coolants. Malathion is used topically in some countries to treat cutaneous infestations. Formaldehyde is used as a preservative in cosmetics, paints and coolants and also finds use in many construction environments, such as in insulation in a polymerized form. Phenothiazines have medicinal uses.

### Plants as Actual Cause of Some Pesticide-Suspected Dermatitis

It is important to remember that all agricultural skin disease is not pesticide-induced. The lack of a suspicion of pesticide-induced disease in the California forestry industry has already been noted. Of the other sorts of explanations for agriculturally-associated skin disease, plants must be placed very near the top of the list. By and large, the vast majority of diseases that are at first attributed to pesticides are finally associated with plant exposure in the workplace. Chemicals containing furocoumarin are an excellent example of plant-associated agricultural dermatitis. In Oregon and in California, small epidemics of phyto-photo-dermatitis have been

associated with fennel and celery. "Mayweed" or "dog fennel" (*Anthemis cotula*) has been reported to cause severe irritant dermatitis in fields where it grows as a weed. In these instances, workers were exposed to plants that had been treated with pesticides, but it was the alkaloids in the weeds (*Anthemis cotula*) that correctly explained the extensive bullous diseases that many experienced.

In addition to these instances of phyto-photo and irritant dermatitis, there are also cases of allergic contact dermatitis that can be traced to plants after having been attributed at first bluish to pesticides. Plants containing sesquiterpene lactones in the Compositae family of plants are particularly suspect here. These plants are often weeds (sagebrush, ragweed, sneeze weed), but can also be ornamental plants (the common florist's chrysanthemum). People working with these plants, such as florists and gardeners, often erroneously suspect pesticides as the source of their problems. In short, the entire working environment of the agricultural worker must be examined before pesticides are absolutely indicted as the cause of skin complaints.

### Future Studies

A problem with pesticide-associated skin disease is that the actual prevalence of skin disease in workplaces where there is a significant amount of pesticide exposure has not been studied first-hand. Dr. Michael O'Malley and his co-workers at the Worker Health and Safety Branch of the California Department of Food and Agriculture in Sacramento are making efforts to do exactly these sorts of studies at the present time. It is suspected that irritant contact dermatitis associated with pesticides is much more widespread and probably much more disabling than has been appreciated. The usual nature of this working population (migrating, and relatively uneducated) makes it particularly difficult to study. Good studies in the future will need excellent funding that will allow access to stable, identifiable populations. Those employers who have the means of tracking their workers and who will allow access to them, will be able to provide the populations that will be most profitably explored. Case-controlled studies that have controlled populations and a prospective cohort will be most valuable.

In addition to these stable populations, future studies will need to examine the possible presence of enhancing factors in the workers, such as atopy (asthma, hay fever or eczema in the worker or a first-degree relative). It is increasingly appreciated that an atopic diathesis in workers can predispose them to dermatitis, particularly in wet-work environments. Towards this end, funding for clinical studies directed towards contact dermatitis and especially toward hand dermatitis should be sought.

It is important that the background of other skin diseases—

es that have nothing to do with pesticides or plant exposure be documented, and that cases not be inappropriately attributed to pesticides. Self-medication also needs to be considered. Environmental determinants such as temperature and humidity, the presence of wet-work and other irritants in the workplace, plants and insects that are present, and protective clothing that is worn are all features that need to be known in order to impact the prevalence of this complaint. Even the limited studies that have been done to this date show that protective clothing has greatly diminished the prevalence of pesticide-associated complaints.

In addition to actual skin diseases, it is important to appreciate that pesticides are readily absorbed through the skin. It is believed that in addition to the respiratory and oral routes, percutaneous penetration is a prominent explanation for acute and chronic organophosphate poisoning. There have even been instances of deaths associated with the percutaneous penetration of unusually potent pesticides such as paraquat.

All agricultural skin disease is not pesticide-induced. Scientific documentation of definite pesticide-induced skin disease is not presently available, but can be acquired, particularly if well-mounted studies are appropriately funded. In instances where pesticide dermatitis is documented, there is little question that irritant dermatitis is the most common pesticide-induced skin disease. It is important to remember that chemicals used as pesticides are also used elsewhere. Patch-testing can document the presence of these chemicals as allergens, but this testing must be done very cautiously; at the present time, accurate patch-testing concentrations do not exist. California Department of Food and Agriculture patch-testing studies are in progress now.

Well-supported studies that rely on scientific methodology and that have direct access to involved workers, are most likely to document the magnitude of this problem. The magnitude of pesticide-associated skin disease is suspected to be greater than is presently described. The nature of the working population makes these studies difficult, but they are greatly needed and the working population deserves them.

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## COSMETICS

Wilma F. Bergfeld, M.D.

Cosmetics are defined by the Federal Food, Drug, Cosmetic Act of 1938 as substances or preparations used for cleansing, altering appearance, or promoting attractiveness. Soaps used for toiletry and household cleansing are excluded. The Cosmetic, Toiletry, and Fragrance Association (CTFA) broadly defines this \$19 billion US industry as toiletries 33%, hair care 22%, skin care 18%, fragrances 15%, and face makeup 14%.

The 1993 International Cosmetic Ingredient Dictionary lists 6,105 different ingredients and 25,605 chemical synonyms and trade names. This dictionary represents an international collaborative effort by the CTFA, *Comitee De Liaison Des Associations Europeennes De Illes 3 De La Parfume De Produits Cosmetiques De Toilet* (COLIPA), European Community (EC) and the Japanese Cosmetic Industry Association (JCIA). "This collaborative effort was initiated so that: (1) Consumers are assured that ingredients are identified by single labeling name regardless of source of raw materials or nationality of the original product; (2) Dermatologists and other specialists are assured of widely disseminated scientific information which helps identify agents responsible for adverse reactions; (3) Scientists are assured that information from scientific and other technical publications will be referenced under a uniform name and that multiple names for the same material will not lead to confusion, misidentification, or loss of the essential information; and (4) The cosmetic industry is able to track the safety and regulatory status of ingredients' efficacy on a worldwide basis, enhancing its ability to market safe products that are in compliance with a variety of national regulations". (*International Cosmetic Ingredient Dictionary* 5th ed. VIII)

It is estimated that persons use one cosmetic product daily. These are applied once to multiple times daily to skin, mucus membranes, eyelids, hair, and nails. Products are described as "leave-on" or "rinse-off" and may be in aerosols or ingested.

Cosmetics can be separated into two broad groups, those that are used mainly to beautify and those that have therapeutic or preventive properties. The degree of allowable change to the skin as a therapeutic or preventive property in a cosmetic product is solely dependent on the view of the Federal Food and Drug Administration (FDA). In cosmetics, the active ingredients are present in lower concentrations than in over-the-counter (OTC) preparations and/or prescription products. Products controlled by the FDA, OTC Division, include sunscreens, OTC microbials,

keratolytics and wart preparations.

### Regulations

The cosmetic industries are regulated primarily by two federal laws: The Federal Food, Drug and Cosmetic Act of 1938 with its color additive amendment of 1962, and the Fair Packaging Label Act of 1966. The important food additive amendment of 1958, often referred to as the De Laney Amendment, is probably one of the most important regulatory amendments for cosmetics. The amendment states "no additive will be deemed to be safe if it is found to induce cancer when ingested by man or animal or if it is found, after testing appropriate for evaluation of the safety of food additives, to induce cancer in man or animal." This amendment emphasizes that cosmetics and foods are to be safe for consumer use. The regulation of these acts and laws is the responsibility of the FDA and the Federal Trade Commission (FTC). Under the Federal Food and Drug Administration Act, a voluntary FDA registration has been initiated in regard to new products, ingredients within products experienced in the market, and warnings of possible adverse events. In the 1980s, a number of domestic issues concerning animal testing and cosmetic labeling arose. In 1986, Proposition 65, the California Safe Drinking Water Intoxicant Enforcement Act, required manufacturers to prove that the ingredients in their products contained no significant risk of causing cancer or reproductive toxicity. If not, a manufacturer would be required to include a warning label on any product containing an ingredient "known to cause cancer or reproductive toxicity." The warning requirements took effect in February 1988.

In 1987, the color additive amendment of 1960 was interpreted to mandate a strict interpretation of the De Laney anticancer clause as it applied to cosmetics. In 1988, Oregon Congressman Ronald Weyden held a series of hearings concerning cosmetic safety and inadequate federal regulation. In response to those hearings, the CTFA launched three initiatives: (1) a voluntary ingredient labeling program for cosmetic products sold exclusively in salons; (2) an effort to increase industry participation in the voluntary reporting program; and (3) the preparation of a report that listed the status of each of the approximately 1,000 allegedly toxic chemicals contained in cosmetics. Existing FDA safety regulations programs include: (1) a cosmetic product ingredients statement program; (2) a cosmetic establishment registration program; and (3) a product experience group for adverse reactions. Other non-

federal regulated controls include the CTFA's safety committee, the Cosmetic Ingredient Review Panel (CIR) developed in 1972, Consumer Federation of America, scientific publications of adverse reactions, industries' product development and premarketing testing, and industrial competition. The majority of safety monitoring of cosmetics is voluntary and includes FDA, the industry, the consumer, the scientist, and industrial competition. International industry also sponsors a self-regulatory group, The International Fragrance Association located in Geneva, Switzerland.

### Cosmetic Ingredient Review

The Cosmetic Ingredient Review Panel, established in 1976 by the CTFA, has a primary mission to look at specific ingredients and their safety. It has seven official members with expertise in dermatology, toxicology, chemistry and pathology, and includes representatives from consumer groups, industry and the FDA. The panel considers chemistry, use, biology, animal toxicology, phototoxicology, mutagenicity, carcinogenicity, teratogenicity, clinical assessment of safety and epidemiology. Panel reviews and final reports are published in the *Journal of the American College of Toxicology*. Presently serving on the Committee are Wilma F. Bergfeld, M.D., Chair, dermatologist and dermatopathologist; Donald V. Belsito, M.D., dermatologist and immunologist; Curtis Klassen, Ph.D., toxicologist; William W. Carlton DVM, Ph.D., animal toxicologist and pathologist; Arnold L. Schroeter, M.D., dermatologist, dermatopathologist, and immunopathologist; Thomas Slaaga, Ph.D., toxicologist; and Ronald Shank, Ph.D., toxicologist.

As of 1993, 404 ingredients had been reviewed for safety. Of these 404 ingredients, 11 were deemed unsafe; information for 27 was insufficient to determine safety, and 87 were found to be safe with restrictions, leaving 279 safe as used (Table I).

In review, of the 381 ingredients listed by Rep. Weyden that are used in cosmetics, nine appear on the CIR priority list and 40 have been reviewed. Thirty-one of the 40 have had their reviews completed. Of these, three hair dyes were found unsafe due to possible carcinogenicity. Data on urocanic acid and arachanotic acid were deemed insufficient to determine their safety. Both these ingredients are suspect for immunosuppression, carcinogenicity, or photocarcinogenicity.

### Adverse Events — Clinical Experience

Cosmetics are considered extremely safe, representing less than a 2% risk of contact dermatitis or allergy in the general population. Possible immunosuppression, carcinogenicity, photocarcinogenicity are new issues for some of the lesser-

used cosmetic ingredients currently under review by the CIR.

The classic adverse reactions to cosmetics have been contact allergy (the most common), irritation, acne, pigmentary changes and nail and hair damage. The prevalence of these reactions has been assumed to be between 2% and 26% of the population as reported by dermatologists and the public respectively. The major allergens that have been identified are mainly preservatives, fragrances, emulsifiers, and occupational exposure. The most common culprits in the occupational exposure group are paraphenylenediamine (hair dye), glyceryl, thioglycolate (hair straightener) and nickel sulfate (instruments). A major occupational irritant has been secondary to ammonium thioglycolate (cold wave chemical) and detergents. Skin allergies have been noted primarily in skin care products 56%, nail cosmetics 13%, perfumes 11%, hair cosmetics 8%, deodorant 7%, lip cosmetics 5%.<sup>6</sup> The common profile for cosmetic reaction is as follows: female>male, white>non-white, with primary involvement of the head and neck, 60% in individuals with normal skin. Only 21% of individuals have concomitant other skin disease such as atopic dermatitis. In addition, the cosmetic reaction is known to last eight days, in 86% of the individuals [North American Contact Dermatitis Group (NACDG) report]. The at-risk individuals are those with (1) presence of a dermatitis, and (2) Celtic, Mediterranean or black derivation.

### Consumer Opinion

In 1992, the American Academy of Dermatology (AAD) conducted a public opinion survey of 1,800 individuals prior to its National Conference on Environmental Hazards to the Skin. This survey, which polled clinical case experience, found that females were at greater risk than males for cosmetic adverse events (21% in females and 3% in males) with metal allergy (20% female versus 6% males). Occupational-induced, adverse reactions similarly were higher in females (9%) than males (1.3%).<sup>1</sup>

### Conclusions

Cosmetics are remarkably safe products, but their mass public use has resulted in a number of adverse reactions. These include burning or irritation of the skin, allergic contact dermatitis, photosensitivity, acne, contact urticaria, and other disorders. Most information on these reactions comes from reports in the medical literature or consumer reports to manufacturers or the FDA. While some individuals with adverse reactions seek medical care, the vast majority change to another product by the trial and error method. Studies of the relation of contact dermatitis to cosmetics in the US and Europe found that: (1) 4% to 5% of patch-tested patients had contact dermatitis to cosmetics; (2)



the cause in many cases was not apparent to either the patient or physician; (3) skin care and hair care products account for most reactions; (4) most reactions occur in adult women; (5) face and periorbital regions were the most commonly involved; and (6) fragrances and preservatives were the most common causes of skin reactions. Groups instrumental in reviewing the safety of US cosmetic ingredients are: Federal Food and Drug Administration, the Cosmetic Ingredient Review Program, the Research Institute of Fragrance Materials, and the North American Contact Dermatitis Group.

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Table I.

## Ingredients Deemed Unsafe By CTFA

### Antimicrobial/Antioxidant

chloracetamide  
formaldehyde  
P-hydroxyanisole  
\*Methamine

### Dyes

HCBlue #1  
4 methoxy-m-phenylenediamine  
4 methoxy-m-phenylenediamine sulfate  
4 methoxy-m-phenylenediamine Hcl  
\*Hydroquinone

### Others

\*\*monoethanolamine  
\*\*polyoxymethylene urea

### Restricted Use:

\*Only rinse off  
\*\*Limit concentration

PERSPECTIVES ON ENVIRONMENTAL  
HAZARDS TO THE SKIN

## ONE DERMATOLOGIST'S INVOLVEMENT IN LOCAL ENVIRONMENTAL ISSUES

Robert M. Soderstrom, M.D.

President Bergfeld, fellow members of the Academy and guests, I am honored to address this conference on the environment convened by the American Academy of Dermatology. I have been asked today to describe my experience as chair of the environmental committees for both the Genesee County Medical Society of Flint, Michigan, and the Michigan State Medical Society. It has been an interesting, in some cases eye-opening, in all cases stimulating and rewarding involvement. Over time, we have learned some valuable lessons, and I think we have developed some guidelines that might be useful for those of you considering local involvement in environmental issues. I am happy the Academy has had the insight and determination to give these issues the focus they deserve.

### Grass Roots: Local Medical Societies

My involvement as a physician began in earnest in the fall of 1989. The issue was one peripheral to most dermatologists: the landfill disposal of so-called low-level radioactive waste. Michigan had been selected as one of the repository states, and several midwestern states were to send their radioactive waste there for disposal. One of the rural communities selected as a potential disposal site was not far from Flint. Several people from that community approached our county medical society when they were told by the state that it was American medicine that was responsible for the need to establish a dump site in their midst, and one that would be radioactive, it was estimated, for at least 500 years. They wanted to know what in the world American medicine was doing that would require such a site.

When they first came to us, frankly, we didn't know the answer to that question. As physicians providing them with care, however, we felt we had a responsibility to find out. We appointed an environmental committee, which I agreed to chair, and we began to investigate the issue.

To make a long story short, we soon found out that American medicine contributes very little, indeed, to a 500-year radioactive waste dump. Clinical medicine produces virtually no long-lived radioactive waste. Research medicine produces a tiny amount and even those isotopes are ones that, for the most part, dissipate in a year or two. Virtually all the long-lived radioactivity in a radioactive dump site was, in fact, a byproduct of the power industry, but the powers-that-be were happy to let medicine seem to

be the reason such a dump was being established.

The process we followed served us well, and it is the process I wish to focus on, not the issue. We had a small committee, six people, and we insisted that one of them be a radiologist, given the nature of the problem. We decided to develop a fully referenced position paper, just like we would if we were planning publication in a medical journal. It outlined the different types of radioactive waste and discussed our concerns with trying to store it for hundreds of years in a water-logged environment like Michigan's. It addressed the health concerns of possible exposure of the community to long-lived radioactive isotopes, and it concluded with our reasons for opposing such a site in Michigan and our proposals for alternatives. We gained approval for the position paper from the environmental committee and then we asked for the approval of the 23-member county society board. Again, we made a special effort to involve two radiologists who happened to sit on the county society board. One thing I will say here: I have been very impressed with the expertise and enthusiasm of my medical colleagues when I have called upon them for help on these issues, and I think you will be, too.

The opposition of the Genesee County Medical Society to a low-level radioactive waste site in Michigan has been pivotal in the debate. Our position paper was crucial: we distributed it at our initial press conference, and we made endless copies available to members of the public, environmental groups and politicians. The dump site was not opened; the state ended up leaving the Midwest program, and much of our effort since then has been directed toward changing poorly designed federal legislation. Our work has been very well received by the public and we have testified on this issue before the Michigan and Ohio legislatures as well as Congress.

Our next effort began about a year ago. Advisories against fish consumption in the Great Lakes, especially for pregnant women and children, have been in effect for years. We decided that Michigan's physicians have a responsibility to attack the root cause: the pollution that makes fish unsafe in the first place. Again, we developed a position paper, fully documented. In it we discussed the nature of the pollutants and the mountains of scientific research showing developmental problems among exposed wildlife. We focused on recent human research suggesting learning

impairments among children of women who were regular fish eaters. We ended by endorsing the goal of zero discharge for chlorinated hydrocarbons, PCBs and dioxin in the Great Lakes basin.

Again we sought approval of the environmental committee and the county society board, but this time, we went further. We sought and achieved approval of a resolution endorsing zero discharge for PCBs and dioxin in the Great Lakes basin from the Michigan State Medical Society. This effort brought the state society considerable attention from a number of sources: the public at large, journalists, state government, environmentalists. The Michigan State Medical Society is now intimately involved with groups around the Great Lakes working for better water quality and a safe fishery for our children. The response of the public to seeing their physicians involved in issues of this kind has been overwhelmingly positive.

## Recommendations

### So what general advice might I give?

1. Look for a local issue. Environmental issues run the gamut and some can be esoteric. We have tried to prioritize issues of importance to our community, and we have tried to focus on one a year. It is easy to dissipate your efforts.
2. Use your local medical library. Computer searches can find anything. Just as you can search for articles discussing psoriasis and cyclosporine, you can run requests for toxic landfills and bladder cancer or high voltage lines and leukemia or air pollution and childhood asthma or ozone depletion and melanoma. I have found our local librarian to be an endless resource.
3. Develop a position paper before going public. It provides your colleagues with the same reference points and it is an excellent way to provide the press and the public with the information you consider important.
4. Use the expertise of your medical colleagues. Physicians are a talented group. In many communities across America we are the only trained scientists in town. I have found physicians happy and eager to contribute to and to unite behind these issues.
5. Focus on community health, especially the health of our children. Do not compromise on this. As physicians, we must be health advocates. Some people will not like what we say, just as the tobacco industry doesn't like to hear us criticizing cigarettes, but we have great credibility on these issues, and we must speak for our community's health.

6. Involve organized medicine. Our professional organizations should be leaders on these issues. Every environmental issue I have looked at becomes, in essence, a health issue, and we should be leading advocates.
7. Once you have taken a position, let policymakers know and let them know again and again. They hear from polluters, they hear from statisticians doing risk analysis, they hear from bureaucrats, and they need to hear from us. And when they do, we need to advocate for the health of our communities.

In closing, let me urge you to become involved. Our experience has been an overwhelmingly positive one. People do want to hear from their physicians on these important issues. Thank you.

## THE ENVIRONMENT AND MEDICINE

Bernard D. Goldstein, M.D.

Physicians have long recognized the role of the environment in human disease. The notion that residents of different cities had different health problems was recognized by physicians of antiquity, including Hippocrates. Ramazzini's work in the late 17th century led him to become known as the father of occupational medicine, through his clear description of the role of the work environment in human disease. He also briefly described a community environment problem that has remarkable resonance for today. It included a local physician using parish death records to show an increase in wasting diseases of the chest which, he contended, was caused by acid emissions from a nearby industrial plant. In the resulting lawsuit, the defendant industrialist successfully brought in expert witnesses, including government physicians, to rebut the claim.

The situation briefly described by Ramazzini inevitably focuses our attention on the issue of attribution. Today we recognize that chronic pulmonary disease can be caused by long term exposure to acid aerosol; but we also recognize that poorer people, who presumably have a higher risk of tuberculosis unrelated to industrial exposure, are more likely to live in areas with industrial emissions. Hindsight in this case does not permit us to determine which side was correct in its attribution of the cause of wasting disease of the chest. However, we still have the same problem: with the exception of a few endpoints (eg, mesothelioma), environmental conditions cause disease for which there are many other causes. Thus, we know that lung cancer can be caused by radon, asbestos and, most likely, diesel exhaust. However, we have difficulties in attributing the extent to which any of these factors is responsible for overall lung cancer rates or for disease in a specific patient. Similarly, we know that renal disease can be caused by a variety of chemicals, sometimes in an idiosyncratic manner. However, for the unfortunate many who have idiopathic end-stage renal disease, we do not know the extent of chemical causation.

Chemical and physical agents may also be responsible for interaction with disease processes, including possibly exacerbation of auto-immune disorders such as lupus erythematosus, based on analogy to drug-induced models of lupus. The role of ultraviolet light in producing skin cancer is unquestionable, but its role in affecting immunity is only now being explored.

One of the more regrettable aspects of increased public awareness and concern about the environment is the loss of credibility of almost all the organizational stakeholders. Through a series of public relations debacles, industry has

lost almost all believability by the general public, and government is not far behind. Even environmental groups have come in for some degree of public distrust from their overuse of "the sky is falling" pronouncements. This loss of credibility has greatly complicated response to environmental problems, and has driven up the costs of environmental controls to often prohibitive levels. Polls show that the public ranks physicians very high in terms of credibility, but very low in terms of their knowledge about environmental matters. Thus, knowledgeable physicians have an opportunity to provide a public service of great societal value by serving as an effective source of information about environmental matters.

Unfortunately, public concern about physician expertise in the area of environmental health has been well merited. There are few specialists in the area: most are found in academic programs and have expertise in occupational health. More importantly, studies have shown environmental health issues are a negligible part of the undergraduate, postgraduate or continuing medical education of generalist or specialist physicians.<sup>1</sup>

Opportunities for physician involvement in environmental issues are many. Every community has one or more environmental issues of concern to the public, ranging from the over 100 million Americans who live in areas where ozone levels exceed the allowable health standard, to the close to 1000 localities that have Superfund waste disposal sites in their backyards. Many local organizations would welcome physician involvement, from advice on a specific issue to a general discussion of environmental health. In my experience the feedback from groups such as the garden club, the local chapter of the Sierra Club or a local church or synagogue has been excellent and gratifying. As in anything else we do as physicians, when we do not know the answer to a specific question, it is important to say so.

An area where physicians can be of particular help is in the communication of the extent of the health risk. Risk communication is a particularly problematic area. Often an attempt is made to compare the risk of an environmental hazard with other risks, such as smoking, automobile accidents, lightning, etc. While such comparisons can be a useful conceptual ruler, they are fraught with difficulties and are often perceived by an affected public as inappropriate to their concerns. For example, cigarette smoking or hang gliding are voluntary risk exposures, while exposure to a noxious effluent from a nearby factory is not. For personally controllable risks, such as automobile accidents, individu-

als often believe that the risk relates only to those who are bad drivers or drunk drivers and does not pertain to them.

At the Environmental and Occupational Health Sciences Institute we try to use like measures, rather than unlike, in describing risk to the public. For example, in a Valdez, Alaska study of risk due to benzene exposure from the oil tanker terminal at the end of the Trans-Alaska pipeline, we compared the risk of leukemia from terminal activities to the risk of leukemia from all other sources of benzene in the community, which were much greater. In response to questions as to whether this represented a public health or medical risk, we pointed out that the measure "personal benzene exposure from all sources" for nonsmokers was far less than occurred in those who smoked cigarettes or were exposed to significant amounts of environmental tobacco smoke. It should be noted that public health authorities had not publicized the threat of leukemia due to benzene in tobacco smoke as a means of encouraging people to stop smoking, presumably because the risk was too low to be of public health or medical significance.<sup>2</sup>

A risk comparison we use is the lifetime risk of death due to an airplane hitting you while you are on the ground. That risk is about four in one million, far higher than most people guess.<sup>1</sup> The risk is not a function of one's own skills, is not voluntary or optional, is of no benefit to anyone, is not an act of nature, but is understandable by the public. We particularly use this comparison for situations in which individuals contemplate specific lifestyle changes, such as moving from a community where publicity about low level risk (eg, one in 100,000 or 1,000,000) has raised concern about the health of themselves or their families. Public authorities may decide to act on the risk because millions are exposed, but are loathe to explain that the risk is too small to guide individual activities. Although it would be effective, people do not attempt to lessen the risk of airplanes hitting them on the ground by such activities as putting the bedroom in the basement or reinforcing the roof with steel. This is because one risk is recognized as being too small to guide our daily activities. However, as citizens we do want to support governmental actions that lessen this risk to all of us.<sup>3</sup>

In conclusion, rapid advances in basic biological science, particularly in molecular biology and neurosciences, will provide us with new tools of unprecedented power to allow estimation of environmental health risk. Developing, understanding and translating this information for public use will be of utmost importance if this planet is to survive. As physicians we have both an opportunity and an obligation to ensure that this happens.

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## DERMATOLOGY AND THE ENVIRONMENT: A LEADERSHIP OPPORTUNITY

John T. Grunenhoff, Ph.D.

In March, 1990, in the *Journal of the American Academy of Dermatology* (JAAD), an editorial appeared under my name regarding the opportunity for dermatology to take a leadership position in relation to present environmental degradation around the world. Opening comments indicated that:

- Dermatology is being presented with a unique opportunity to serve the needs of its patients and the public worldwide.
- The skin is a major barrier to insults from a disturbed and polluted environment and will become increasingly besieged.
- Dermatologists have already developed warning systems in a public information structure to deal with several environmental insults. By building on these, a program that deals more widely with these problems can be fashioned to the benefit of patients, the public health, and the status of dermatology.

The editorial noted that the Academy has considerable experience in environmentally-related activities and cited the successful skin cancer/melanoma screening program established by the Academy in 1984. That program, enhanced by Congressional resolutions and presidential proclamations, has created one of the best public education programs any medical specialty has ever developed.

A dermatologist (Dr. Darrell Rigel) brought to the attention of the Congress the potential threats of a diminished ozone layer and its implications for potential increases in skin cancer.

The problems of occupational carcinogens and dermatosis were raised by the Academy in Washington at a national symposium for the prevention of occupational skin conditions in April, 1989.

Also, it was indicated that the appropriate disposal of medical waste was then the subject of deliberation by an Academy committee (a document has since been promulgated).

Finally, my editorial indicated that Academy leaders readily took on the issue of dangers of tanning machines, which showed their concern about man-made, indoor environmental threats and their willingness to protect the public health in this regard.

Those examples illustrated my point that dermatologists are already in the forefront on environmental issues. They also illustrate the opportunity to incorporate those programs, and others, into an overall systematic and consolidated environmental policy thrust to position dermatologists as

leaders in environmental protection.

Questions raised in that editorial remain important: What are the known environmental impacts of polluted air, water, and land on the skin or on other organs that may be first expressed in the skin? Which of them need immediate action or further research (and which agencies should fund such research)? What can be learned about environmental problems from other medical disciplines and allied scientific disciplines (eg, marine biologists and veterinarians, who are confronting the rapidly increasing incidence of skin tumors and similar skin diseases in fish and other sea animals, including crustacea that have diseased shells such as "burnspot" or "hotspot") that has relevance for human skin? What can be learned from the growing bases of research data at the Environmental Protection Agency and other agencies about the impact on the skin of human populations near toxic waste sites or near river or ocean discharge pipes of chemical pollutants? What can be learned, to take a more far-ranging example, from skin reactions during NASA space flights that can be applicable to our earthbound human population? What can interested researchers and agencies tell us about the environmental deterioration in the Eastern bloc or in underdeveloped countries, and the dermatologic problems there that might be present here in the United States, now or in the future? How can the international dermatologic community become involved to deal with these issues?"

### National Association of Physicians for the Environment (NAPE)\*

Dermatology can also work in conjunction with other medical societies on these issues.

In March, 1990 I wrote an editorial carried simultaneously in the *Journal of Environmental Health* and the *American Journal of Industrial Medicine*, calling for the establishment of a National Association of Physicians for the Environment (NAPE). Dermatology can have a major role to play in that activity.

That organization has now applied for 501(c)(3) non-profit organization status, which it expects shortly. Dr. Peyton Weary, a long-time leader in dermatology, has agreed to become a member of the organizing board of NAPE, and has been elected to the position of president-

\*NAPE is the designated United States member of the recently formed (1990) *International Society of Doctors for the Environment (ISDE)*, organized by national chapters.

elect. At the same time that NAPE is being organized, a similar international organization is forming, the International Society of Doctors for the Environment (ISDE). Late in 1990, a Swiss physician named Dr. Werner Nussbaumer wrote to 12,000 Swiss practitioners expressing his concern about the deterioration of the world's environment and its impact on human health. Over 3,000 doctors joined the organization. Surprised and pleased at the response, Dr. Nussbaumer contacted medical colleagues in other countries. In less than three years, over 20 national organizations of Doctors for the Environment have formed or are forming, and active physicians are attempting to organize their colleagues in nearly 30 other countries. NAPE is a member of ISDE.

American dermatology has an immense influence on dermatology worldwide; perhaps by working with the ISDE we can bring to physicians' organizations worldwide materials developed by this Academy.

Let me now deal with the structure and intentions of the National Association of Physicians for the Environment.

NAPE has been developed to: (1) work with the national medical specialties and subspecialties, with national, state, and local medical societies, and with individual physicians to deal with the impacts of environmental pollutants on the organs, systems or disease processes best known to them; (2) inform physicians, patients and the public about the impact of pollutants and the necessary personal and public health steps that should be taken to reduce or eliminate those pollutants; and (3) involve physicians in environmental issues global in nature, such as protection of biological diversity. Health professional organizations, non-profit environmental and public interest organizations concerned with environment and health issues are invited to become organizational members. All individuals, not only physicians, can join.

### Background

In recent years, physicians have become increasingly interested in and concerned about our deteriorating environment, and the potential impact of that deterioration on human health; physicians are the most widely distributed scientifically-trained professionals in the U.S. Although several organizations, especially those concerned with public health and environmental and occupational health, have been leaders in these matters for many years, physicians generally have not had access to organizational structures closely tied to their specialties through which to participate actively.

Also, no association of medical societies has existed to pull together, in an interdisciplinary fashion, these growing environmental concerns of the specialties. What is needed is a group that will act as a convener, a transfer agent of

information, a forum to debate and build consensus on the issues, and to develop public information and education programs, as well as physician education and action programs both nationally and locally. NAPE was formed to fill that need.

The potential influence of NAPE is considerable.

Nearly all U.S. physicians (about 500,000) belong to one or more medical specialty or subspecialty societies, as well as national, regional, state and local generic medical organizations. Many serve on hospital boards and many are also active leaders in their communities.

Physicians are much more likely to involve themselves in environmental issues if their medical specialty or other medical organizations are involved. They depend upon, and trust, these medical specialties for judicial policy development and continuing professional education and information.

Medical specialty organizations already have in place a national physician education process for their membership. Their peer-reviewed journals and other periodicals assure scientifically solid information upon which physicians base their medical activities. These publications are focused on specific bodily organs or systems, or diseases.

Medical societies have a systematic policymaking apparatus and have experienced, intelligent and able leadership working through strong volunteer committee systems. They all have communications and information materials development teams. They have staff to help analyze policy proposals and make recommendations in an effective way to policymakers.

All specialties have close relationships with the National Institutes of Health (NIH) — most institutes are organized to deal with such specialties. The National Cancer (oncology) Institute and the National Heart (cardiology), Lung (thoracic) and Blood (hematology) Institutes are examples. The NIH maintains an enormous computerized information retrieval system with vast amounts of scientific literature that can be accessed by individual physicians anywhere in the world. Much of that information can be utilized to deal with environmental health issues.

Many medical specialty societies also have close connections with other government agencies, such as the National Science Foundation, the Environmental Protection Agency, and the National Institute of Occupational Safety and Health. All medical societies seek to enlarge their contacts with the public, and are perceived to be eager to work with environmental and other organizations on environmental health issues.

All medical specialties have international components: many foreign medical leaders have trained in the U.S. and continue those close ties.



## Dermatology and Seniors

Dermatology has an opportunity for leadership not only in the National Association of Physicians for the Environment, but also with regard to seniors. Since many pollutants are cumulative over a lifetime and cause toxic effects, physicians should generally be especially concerned about seniors and the environment. In addition, as is now known, UV radiation and some chemicals induce dermatosis over time, potentially impacting on seniors more severely than other populations. Therefore, I see a major opportunity for dermatologists to become involved working with the senior centers across the country (of which there are 1300), and with the American Association of Retired Persons (AARP), in terms of melanomas and skin cancer education and skin problems in the senior community.

In 1990, I wrote a paper calling for a Senior Environment Corps, which has now been established. One of the major issues of that group is to study and respond to environmental impacts on body organs and systems of seniors, to inform and to work with them. Dr. Weary serves on the board of directors of that organization as well. The American Association of Retired Persons (AARP), the Environmental Protection Agency, and about 15 national environmental organizations and federal agencies are now developing the Environmental Alliance for Senior Involvement (EASI). Dermatology could take a major role in this effort as well.

## National Council on Health Care and the Environment

Recently I developed the concept of a National Council on Health Care and the Environment. The goal of this organization is to form an association of all health providers, their scientific colleagues and suppliers. It would also seek to promote and support environmental responsibility within the health care field. Such an organization would have the following objectives, among others:

1. To promote responsibility for the environment as an integral part of the healing mission of health care;
2. To encourage the use of environmentally-sensitive products and packaging in health delivery;
3. To promote policies and technologies for medical waste management that are sensitive to the environment of the community; and
4. To encourage conservation and the efficient use of energy in the operation of health facilities.

Membership would be open to all health care providers, including physicians, their associates (such as nurses and physicians' assistants), hospitals, other health facilities, health industry suppliers, waste management service providers, health and life insurance groups, medical media, pharmaceutical organizations, biotechnology associations,

coalitions of voluntary health organizations, energy efficiency and conservation suppliers, as well as policy makers and environmental and other interest groups.

## NAPE Activities since the AAD National Conference on Environmental Hazards to the Skin

Since the conference was convened, NAPE has undertaken the following activities:

- Co-sponsored a national organizational conference, developed its proceedings, developed conference videotapes and audiotapes, and initiated publication of a newsletter.
- Testified four times before Congressional committees (about relationships to EPA, NASA, DOD, NIH). One Congressional appearance already has generated an important document — the National Institutes of Health has just released a report indicating its willingness to work with NAPE. Eleven institutes and offices of NIH described potential relationships as a result of a legislative request by the Senate Subcommittee on Labor-HHS-Education. Two proposals made in Congressional testimony in April 1993 regarding an international conference on the protection of biological diversity and its importance as the source for new pharmaceuticals and other medical products are being acted upon in the Congress.
- Briefed the American Medical Association's Long-Range Planning Council and the Council on Research; NAPE wishes to collaborate with the AMA on issues of environment and health.
- Welcomed 13 medical societies to membership as of June 6, 1994. These include American Academy of Dermatology, American Academy of Otolaryngology - Head and Neck Surgery, Inc., American Academy of Hematology, American Society for Head and Neck Surgery, the Society of Nuclear Medicine, the Wilderness Medical Society, the American Medical Association, the American Academy of Otolaryngic Allergy, the International Foundation for Dermatology, the Association of University Environmental Health Science Centers, the Pennsylvania Medical Society, the Genesee County Medical Society (Michigan), and the American Society for Dermatologic Surgery, Inc.

The following major projects are being undertaken by NAPE, in addition to other organizational matters described above:

- *Air Pollution Conference:* Under a grant from the National Institute of Environmental Health Sciences (NIEHS), NAPE will be holding a national conference on November 18, 1994, at the National Press Club on

**"Air Pollution: Impacts on Body Organs and Systems."**

A preconference bringing together nearly all of the speakers for the November conference was held at the American Medical Association Washington Office on April 29, 1994. It is expected that approximately 25 speakers, most from medical specialty societies, will comment upon air pollution impacts on each organ and system of the human body (not only the lung, which has been well studied).

At the conclusion of the conference, a "white paper", which will be composed of "chapters" containing each speaker's paper, will be utilized in the medical community. A major public education effort will be undertaken, and hopefully pamphlets will be developed by the various medical specialty societies for distribution to patients and the public from the conference. Funding for a 10-minute video will be sought.

- **Protection of Biological Diversity:** The U.S. Senate, in its appropriations bill of 1993, included language calling for the National Institutes of Health to have an international conference on biological diversity, particularly as it impacts on pharmaceuticals and biological products derived from the natural world. The Fogarty International Center at the NIH will be the lead agency. The Smithsonian Institution is the likely venue, perhaps at the auditorium of the "Old Castle." A steering committee met in mid-April, 1994 to begin organization of the conference, and outstanding speakers from various fields relating to biological diversity, including pharmaceuticals, biotechnology, legal issues, agriculture, etc., will be included. It is hoped that the conference proceedings will be published. The main focus of the publicity will be on medical specialty organizations so that specialists can understand which drugs that they are using are derived from the natural world, and thus can understand better the need for protection of biological diversity.

- **UV Index/Sun Radiation Protection:** Under a grant from the EPA, NAPE is organizing an effort to reach out to all of the medical specialty organizations, public health groups, other medical and health organizations, as well as the medical and environmental news media, to alert them to the upcoming development of a national UV Index, which is being developed by the National Weather Service (NWS) and the Environmental Protection Agency (EPA). Expected target date for public announcement is summer 1994, though some scientific issues remain to be ironed out relating to measurements by satellite, and whether to present the forecast as "clear sky" or to incorporate local cloud conditions. The information will be provided by the NWS to media

outlets in over 170 cities, just as information is now being sent for daily weather briefings.

NAPE has constructed an educational plan for continuous health profession, patient and public education. It is expected that this will be at least a two year project.

- **"Greening" of Medical and Health Professional Community:** A proposal has been developed, and likely will be funded, for the development of manuals, education programs, and other educational materials for the medical and general health professions community (including the research community, veterinarian organizations, etc.) to make practices in all these offices more environmentally sound, from recycling to cleaning solvents, to energy savings. It is projected that this project will come on line in September, 1994, and will take about a year. Already two medical specialty organizations have indicated a willingness to join in this effort, and the AMA has indicated considerable interest in involving itself. Indications are that elements of the American Hospital Association will also join the effort. NAPE also will be working with Concurrent Technologies, Inc., part of the National Defense Center for Environmental Excellence of Johnstown, Pennsylvania, which has a Department of Defense (DoD) grant to "green" all hospital and medical facilities of the DoD from hospitals through to battlefield and other field situations. There is a possibility that the American Veterinary Medical Association will also join in the effort.

## Summary

Dermatology has an enormous range of opportunities to make itself better known to the American public in terms of protection of the environment and of individuals suffering from the impacts of environmental pollutants of various forms.

## HEALTH PROMOTION FOR OLDER AMERICANS

Jeanne Snodgrass, Ed.D.

My role this morning is to talk a little about why dermatologists should be interested in older people. Who are these folks? And where are they? As well, we'll consider some suggestions of how to reach older folks and provide some time for questions.

As a member of the Executive Board of the Health Promotion Institute of the National Council on Aging (NCOA), my interest is in advocacy and education related to all aspects of health in older people. The HPI has already worked with the Optometric Association on a project related to vision; it has also worked with pharmaceutical associations on the use of medicines and high blood pressure education; and it is beginning an association with the Senior Environment Corps regarding the relationship of environmental education and health issues.

I found very little in any of the resources I consulted related to health promotion dealing with dermatology. Yet you know and I know that:

- Skin changes are a natural part of aging;
- Melanomas and other skin cancers are increasing at an alarming rate;
- Excessive sunlight as a result of the decreased ozone layer creates greater exposure for the skin;
- The toxic nature of our polluted environment is absorbed through the skin; and that all these things are concerns for our older population.

I believe you have tried to impact future generations of older people about care of the skin, and I am pleased that you are interested in taking a look now at health concerns related to dermatology and those who have already aged. Demographically speaking, you no doubt know that the size of this cohort is increasing dramatically as the Baby Boomers reach middle and old age, that we are living longer, and that the numbers of those 85+ and even over 100 years old are increasing rapidly. Many of these older people are living in the "Sun Belt", in Florida and California and Arizona, and as a result should be more concerned about skin care.

What else do we know about this age group called older? Perhaps the primary characteristic is its varied constituency: no longer is the myth of "poor, ill, and institutionalized" accurate.

Many are active and involved in all of life — many for longer years.

But we are concerned because we know that older

bodies are more vulnerable to disease:

- Food and medicines are utilized differently in older people;
- Many, especially women, live alone and have no-one to help them with various health checks;
- Most want to make their own decisions affecting their lives;
- All want to be treated with dignity and acceptance; and
- Most go to a doctor only when something is definitely wrong. Most older people rely on their doctors to recommend tests or screenings and listen to advice given by their primary physicians.

Important also to consider is that Medicare offers only limited coverage for preventive services. So where does that leave dermatologists in terms of what you can do and how you can reach older people with education and health promotion related to skin care?

You are the ones knowledgeable about what information or service needs to be transmitted to folks 50 or 60 and older. Perhaps the few suggestions I have time for can help you get that information to the people who would benefit from it.

### Health Promotion Programs

In the older adult network are organizations working for the well-being of our older population. These are organizations involved with direct services, advocacy groups, research groups, publications oriented to older folks, etc. A broad network exists.

Health promotion programs are found in:

- a) Group health plans
- b) Hospitals
- c) Recreation departments
- d) Universities
- e) National organizations such as the National Council on Aging (NCOA) and the American Association of Retired Persons (AARP).

The NCOA is an umbrella organization of practitioners assisting the elderly in rural areas. They work in senior centers and have volunteers helping seniors maintain their independence in their own homes. There are different groups working with some aspect of aging. Hopefully, dermatologists will become involved with the Health Promotion Institute (H.P.I.) of the NCOA in some joint

project. The AARP has an Eldercare Institute that is working nationally as well. Others included the Administration On Aging, a federal agency within the department of Health and Human Services; the National Institute on Aging, at the National Institutes on Health, (part of the Department of Health and Human Services); ODPHP National Health Information Center; the National Women's Health Network; and the American Society on Aging and the American Gerontological Association — both professional organizations.

A number of sports organizations also might prove valuable channels for education:

- a) The National Senior Women's Tennis Association
- b) The United States Tennis Association
- c) The National Senior Sports Association
- d) Senior Games and Senior Olympics (usually organized on state levels)

On the local level, Area Agencies on Aging mandated through the national Older Americans Act work through county and state governments as Departments on Aging, within Departments of Health or Social Services, or otherwise titled. The organizational patterns vary widely across the country. In addition, of course, are individual health promotion programs at senior centers, churches, in recreation programs, etc., and educational work with primary care physicians regarding the importance of monitoring skin health and early referral as is needed. The journal publications of the professional organizations provide a channel for information, as do the specialty magazines directed to the older persons themselves, such as *New Choices*, *Modern Maturity*, *Perspectives on Aging*, etc.

It would seem to me that three efforts on the part of the Dermatology Academy would be effective and are needed:

- 1) Becoming actively involved with education and primary preventive measures that older persons can take on their own;
- 2) The provision of preventive services for early detection of problems; and
- 3) Involvement with the promotion efforts to achieve Medicare coverage of preventive services.

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