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ABSTRACT

This booklet, designed to be used in high school classrooms, concerns the technological, economic, and political contexts of the fluorocarbon-ozone depletion controversy. The curriculum is divided into three phases: the scientific dimension, which is a pure science analysis using lab-classroom tools and methodologies; the philosophical dimension, which deals with questions of truth, ethics, and legislative implications; and the career education dimension, which examines the variety of occupations and different areas of knowledge involved in resolving the controversy. A selected bibliography of reference materials is listed, and the appendices include magazine and newspaper articles concerning the controversy. (MH)

THE GREAT SPRAY CAN DEBATE

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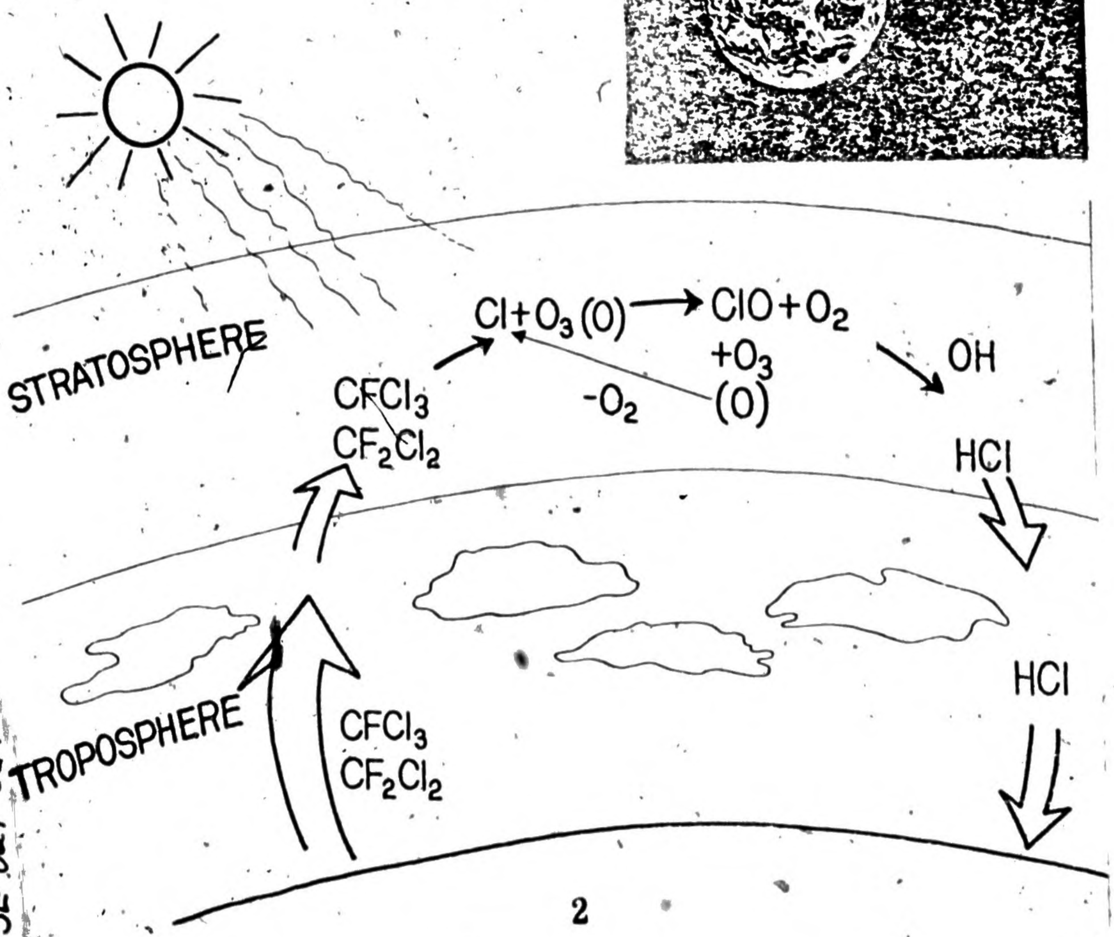
November 1975



ABSTRACT:

This very current debate, generated by publication 18 months ago of the Rowland-Molina fluorocarbon-ozone depletion model, is a scientific phenomenon whose potential dangers are worldwide and long term. Resolution of this debate, in its scientific, technological, economic and political aspects, is dependent at the deepest level on the application of both pure and applied scientific understanding.

In order to guarantee a viable solution to the controversy, and to similar problems that will arise in the future, the citizenry must have sufficient grasp of the scientific concepts, as well as the moral perspective to permit a just application of this scientific knowledge.

The following pages propose a curriculum scenario, for use in high school science classrooms, that takes the problems raised by the technological, economic, political contexts of the fluorocarbon controversy as its point of focus.

The initial phase of this curriculum takes the student through a scientific analysis of the proposed ozone depletion model. This lays the groundwork for two additional perspectives: a philosophical dimension that examines the nature of scientific and other levels of knowledge, and a career education dimension dealing with the range of professions represented by people involved in the controversy.

CONTENTS: Historical Introduction.

Phase 1: The Scientific Dimension.
A pure science analysis using lab-classroom tools and methodologies.

Phase 2: The Philosophical Dimension.
Questions of truth, ethics, legislative implications.

Phase 3: The Career Education Dimension.
The variety of occupations, of different areas of knowledge, involved in resolving the controversy.

HISTORICAL INTRODUCTION

June 1974 marked publication of the first scientific paper indicating potentially catastrophic effects from continued use of such seemingly innocuous products as deodorant and hair sprays. This incredible warning, unbelievable at first even to its authors, led a year ago to Congressional hearings before the Public Health and Environment Subcommittee of the House's Commerce Committee. The Subcommittee chairman, Paul Rogers (Dem., Fla.), introduced those hearings with these cryptic remarks:

> "Since coming to the Congress, I have never begun hearings with such an eerie feeling. The idea that we may in fact be destroying the layer of atmosphere which protects us from the sun's rays is both rather staggering and frightening...
>
> "The entire matter rings of a science fiction tale, one we have all heard, about how a planet now barren was destroyed by its very inhabitants. Had not the evidence been brought forth by such reputable men of science, it would seem like black humor, that every human on Earth may be in danger by billions of aerosol cans."

The relevance of science, the need for the widest possible understanding of its nature and content, was strikingly illustrated later that day by Subcommittee member Richardson Preyer (Dem., N.C.). After listening to the testimony of leading atmospheric scientists, Congressman Preyer responded as follows:

> "Mr. Chairman, when I came over today I thought we would have a hearing that would be a standard conflict between the environmentalists and industry and I can only say I am stunned by what we have heard here.
>
> "There has not been inflammatory rhetoric or alarmist language but here we have some of the most distinguished scientists in America telling us about the problem.

"I think these could be the most important hearings the committee has ever had. It looks like all of us laymen in this country have got to learn a new subject now. We recently had to learn constitutional law and then we had to be economists and now we have to become chemists and mathematicians. No wonder people long for the good old days."

Congressman Preyer is suggesting nothing less than a new moral perspective: science must become an instrument of social values. We see a new urgency, a new relevance, to the study of science. It is not enough that our students— tomorrow's citizens— understand the scientific principles involved in public policy issues. This understanding is important, and methods of gaining it will be addressed in phase 1 of the curriculum proposal that follows.

But these future citizens must also be sensitive to the philosophical and moral issues involved... to the nature and just use of scientific knowledge. Phase 2 of our curriculum will detail how the fluorocarbon- ozone depletion issue may be used to help students lay hands on this concern. The approach will be to focus on the philosophical implications of scientific understanding... how we define and perceive scientific, moral, legal truths... how we arrive at workable definitions of these truths. We shall deal with the nature of a scientific model, and how the different public interest groups involved in the fluorocarbon issue— the academic scientists, legislators, industry people— view and have used this information.

The awareness that very different interest groups are directly involved in the controversy leads naturally into a third, so-called career education phase of the proposed curriculum. This is due to the wealth of occupations and different bodies of knowledge that come into play trying to solve the fluorocarbon problem. This intersection of careers suggests a natural and exciting way for students to study career possibilities that have relation to science. These might include, besides scientific research in an academic setting, law and related legal services, the entire industry- business spectrum, politics and public service careers.

Because the fluorocarbon issue may well be resolved by a public policy decision based on a scientific model, because it will be legislated by politicians, because such legislation will affect a segment of industry and hence the economy, because enforcement involves regulatory machinery and the law, this is an issue that focuses and hence unifies all human knowledge. This knowledge must be brought to bear on a problem that is world-wide and long term.*

TYPES OF EDUCATIONAL ACTIVITIES: A GENERAL CATALOG

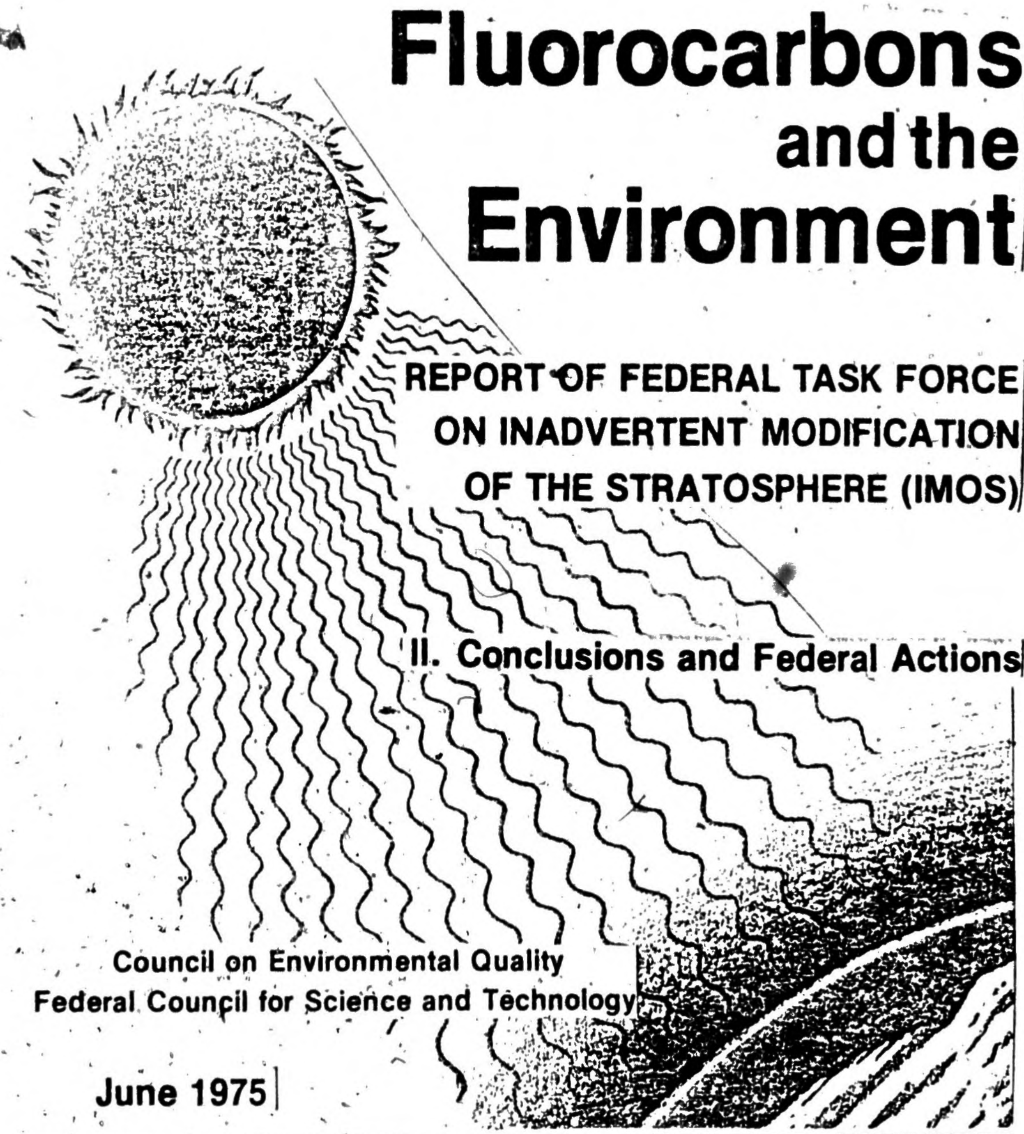
The descriptions that follow are suggestive of the range and type of activities available to the science teacher. As indicated in the introduction, these will be divided into three phases: scientific, philosophical, career education.

PHASE 1: THE SCIENTIFIC DIMENSION. A pure science analysis, using lab-classroom tools and methodologies.

Optimum Use: To deliver a body of basic factual information which will motivate and aid students in understanding and integrating their observations and experiences in science classes.

Content: To illustrate the scope and breadth of scientific facts, concepts, principles involved in the fluorocarbon-ozone depletion hypothesis.

*For a summation of the issues, see Appendix 1.



Fluorocarbons and the Environment

REPORT OF FEDERAL TASK FORCE ON INADVERTENT MODIFICATION OF THE STRATOSPHERE (IMOS)

II. Conclusions and Federal Actions

Council on Environmental Quality
Federal Council for Science and Technology

June 1975

The following excerpts from "Fluorocarbons and the Environment," the Federal Task Force's so-called IMOS Report on the controversy, are each followed by a list of the scientific concepts needed to explain the model, as it is developed in the Report. Teachers are urged to consult lecture demonstration sources (listed) to help teach the concepts. Valuable but less familiar activities are footnoted.

A. Excerpt from Report of Federal Task Force on Inadvertent Modification of the Stratosphere (IMOS):

In June 1974 the first scientific paper was published raising the issue of possible harmful effects from discharges of fluorocarbon gases, principally $CFCl_3$ (fluorocarbon-11) ,and CF_2Cl_2 (fluorocarbon-12), into the atmosphere. Since that time numerous other scientific groups have reported on this issue.

The Interagency Task Force on Inadvertent Modification of the Stratosphere (IMOS) has investigated this subject and found that:

(1) Fluorocarbons are produced in large quantities; ultimately almost all are released into the atmosphere.
   (a) Approximately 13.8 billion pounds of fluorocarbons-11 and -12 (F-11 and F-12) have been produced to date in the world (exclusive of the U.S.S.R. and Eastern European countries).
   (b) 1.7 billion pounds of this total were produced in 1973.
   (c) Total U.S. production has been doubling about every 5 to 7 years since the early 1950's; world-wide production (exclusive of the U.S.S.R. and Eastern European countries) in 1973 was 11% over 1972 production.
   (d) Approximately 50% of the world production and use of these fluorocarbons (exclusive of the U.S.S.R. and Eastern European countries) occurs in the U.S.

(2) F-11 and F-12 are not appreciably chemically decomposed in the lower atmosphere.
   (a) They are virtually inert chemically in the troposphere.
   (b) They have very low solubility in water and therefore are not washed out of the atmosphere by precipitation.
   (c) They are found in the atmosphere in concentrations that seem to be consistent with the total world release to date.

(3) No significant natural "sinks" other than stratospheric processes are known to exist for fluorocarbons in the environment.
   (a) The amount of fluorocarbons contained in the oceans, in soil, in subsurface ground water, and frozen in the polar ice caps is probably insignificant when compared with the atmospheric content.

(4) A significant fraction of the fluorocarbons is expected eventually to move by atmospheric circulation and diffusion up into the stratosphere.
   (a) Recent measurements have detected the presence of F-11 in the stratosphere.
   (b) It is estimated that it would take several years for a significant fraction of the total volume of fluorocarbons discharged in a given year to reach the stratosphere.

B. Scientific Concepts needed to understand the IMOS Report:

(general) chemists' atomic theory, meaning of symbols, formulas.

(1) Conservation of matter; vast growth of chemical technology; Spaceship Earth- substances released to the environment do not disappear.

(2) Chemical reactivity vs. inert behavior; solubility; biodegradability.

(3) Concept of a sink (as a removal mechanism).

(4) Nature and properties of gases, especially diffusion; Structure of the atmosphere.

A. IMOS Report Excerpts:

(5) In the stratosphere above 25 km (about 80,000 ft), fluorocarbons are expected to:

(a) Be reactive due to dissociation by UV radiation from the sun which penetrates only as far as the stratosphere.

(b) Yield chlorine atoms (Cl) and a fluorocarbon radical.

(c) Dissociate within days to months depending upon the altitude.

(6) Although it has yet to be confirmed by direct stratospheric measurements, it is assumed that the fluorocarbon radical will probably dissociate until all of the chlorine atoms are released. Cl may react catalytically with either an oxygen atom (O) or ozone (O_3) before forming less reactive hydrogen chloride (HCl) and diffusing downward to the troposphere.

(a) Under these conditions the chlorine atoms (Cl) or as the free radical ClO for at least several days, and in this interval would be expected to react with thousands of oxygen atoms or ozone molecules.

(7) Ozone is a minor, but extremely important, constituent gas in the stratosphere.

(a) It is generated by the splitting of a normal oxygen molecule (O_2) by ultraviolet (UV) solar radiation and subsequent combination of the liberated oxygen atoms with another oxygen molecule to form ozone.

(b) The rate of formation of ozone is believed to depend almost exclusively upon the amount of incoming UV solar radiation and is therefore virtually independent of human influence.

(8) Ozone is maintained in the stratosphere in a dynamic equilibrium; i.e., there is an approximate balancing of the rate of ozone formation with that of ozone destruction.

(a) The naturally occurring ozone-destroying reactions include the interaction of ozone with oxygen atoms (O), with nitrogen oxides (NO_x), with hydrogen species (H, OH, HO_2) and possibly other natural stratospheric components. The rate of loss to the troposphere by transport into the stratosphere is much smaller than the rate of loss by chemical reaction.

(b) Most of the ozone in the atmosphere resides in the stratosphere.

(c) The concentration of ozone between the earth and the sun at mid-latitudes fluctuates daily on the average of 10% in the winter and 5% in the summer and 25% between seasons.

(d) The total ozone equilibrium concentration of the stratosphere also varies considerably with latitude; ozone occurs in greater amounts over the polar regions than at lower latitudes.

B. Scientific Concepts:

(5, 6) Interaction between matter and energy; chemical decomposition of molecules into reactive fragments; reactivity of odd-electron species such as Cl atoms.

Concept of catalysis, especially regeneration and chain reactions; chemical reactions proceed at different rates.

(7) Use of chemical equations to explain ozone formation.

(8) Concept of equilibrium (closed system) vs. steady state. Bathtub analogy (see footnote a).

A. IMOS Report Excerpts:

(9) Because of the large natural variations in ozone content, a 5 to 10% average decrease, persisting and measured for several years, would be required before a change could be attributed to human activity with any reasonable statistical reliability.

(a) Total ozone levels in the northern hemisphere seem to have increased by about 5 to 10% during the period 1955-1970. The ozone concentration has been on the decline since 1970 (approximately 1 to 2%). These fluctuations probably represent primarily natural variations, possibly related to solar activity.

(10) It is expected that any release to the atmosphere of man-made chemicals that reach the stratosphere and react to destroy ozone would create additional decreases in the stratospheric ozone content over and above those caused naturally.

(12) Other man-made chemicals such as methyl chloroform, perchloroethylene, and other halogenated compounds may also be of environmental concern with respect to possible reduction of stratospheric ozone. However, most appear at this time not to be as important, either because:

(a) They are expected to be removed rapidly in the lower atmosphere, or

(b) They are produced and released to the atmosphere in substantially lesser amounts.

(13) Although there are some uncertainties in the calculations, the best estimates are that fluorocarbon production and release to the environment to date may:

(a) Have resulted in a current reduction in average ozone concentration estimated to be most likely between 0.5 and 1% and possibly as large as 2%.

(b) Eventually result in as much as a 1.3 to 3% reduction in the equilibrium ozone concentration.

(14) Because of slow diffusion of fluorocarbons into the stratosphere, any changes in ozone from fluorocarbon release would be delayed.

(a) Even if no additional fluorocarbons were released after a certain date, further reduction of average ozone concentration would continue, reaching a maximum in about a decade or more later.

(b) It is expected that reduced levels of ozone would last to some extent for as much as a century or more after cessation of fluorocarbon releases.

(15) Current model calculations predict that if release of fluorocarbons were to continue at the 1972 rate, a maximum reduction of about 7% in the equilibrium ozone concentration would be expected after several decades.

B. Scientific Concepts:

(9, 13) Uncertainty in measurements.

(10) Bathtub analogy (see footnote a).

(14, 15) Scientific models and predictions based upon them. Black box analogy (see footnote b).

A. IMOS Report Excerpts.

EFFECTS OF OZONE REDUCTION

(1) Stratospheric ozone screens UV-B radiation in sunlight from the earth's surface.

(a) UV-B radiation has a wavelength range of 280 to 320 nanometers (1 nm = 10^{-9} meters).

(b) An approximately 1.4 to 2.5% (median of 2%) increase in UV-B radiation at the earth's surface at mid-latitudes would occur for each 1% reduction in stratospheric ozone concentration. This relationship holds true for small percentage changes in ozone concentration. For larger reductions of ozone, it is expected that the associated increase in UV-B radiation reaching the earth's surface would be disproportionately greater.

Any significant decrease in the stratospheric ozone layer resulting in increased UV-B radiation reaching the earth would cause environmental effects that are predominantly harmful.

(1) There is persuasive, although not absolutely conclusive, clinical and epidemiological evidence of a direct correlation between solar radiation and the historically observed incidence of several generally non-fatal (non-melanoma) skin cancers in humans. (The death rate in the U.S. is estimated to be about 1% of the non-melanoma cases.) This is strongly supported by the unequivocal induction of skin cancers in animals exposed to increased UV radiation.

(a) There is, for example, an observed doubling of non-melanoma skin cancers with each 8° to 11° decrease in latitude, which is presumed to relate to the correlated increase in UV radiation reaching the earth with decrease in latitude.

(b) Based upon the estimated relationship between ozone concentration in the stratosphere and UV radiation reaching the earth's surface, and between UV radiation and the incidence of non-melanoma skin cancers, an increase of approximately 2% (range 0.7 to 5%) in the incidence of non-melanoma skin cancers in the U.S. is predicted for a 1% reduction in average ozone concentration (with a disproportionately greater increase in cancer for higher percentages of reduction in ozone levels).

(c) The National Cancer Institute estimates the current incidence of non-melanoma skin cancers in the U.S. to be about 300,000 cases per year.

(d) Calculations based upon observed changes in incidence of skin cancer with variations with latitude for each percent ozone reduction range from 2,100 to 15,000 (6,000 median) additional cases of non-melanoma skin cancer per year in light-skinned individuals in the United States at steady state.

B. Scientific Concepts.

(1) Electromagnetic spectrum; wave model and wavelength.

Effect of radiation on living tissue; types of skin cancer, aging.

A. IMOS Report Excerpts.

(2) There is some evidence, although much less conclusive, to support a similar correlation between UV-B radiation and melanoma—a much less common, but considerably more frequently fatal, form of skin cancer (median survival time of 7 years).

(3) Other expected health effects include greater incidence of sunburning in population at risk and earlier onset of skin aging.

(4) Other possible effects that have been less studied are eye damage and excessive synthesis of vitamin D in the skin.

(5) Possible biological and agricultural effects, for which more investigation is required before any definite conclusions can be made, include:

(a) Changes in physiological, biochemical, anatomical, and growth characteristics of certain plant species sensitive to UV-B radiation, including some food crops.

(b) Disturbances in aquatic and terrestrial ecosystems.

(c) Effects on the behavior of insects, including those beneficial to agriculture.

(d) Effects on the stability and effectiveness of agricultural chemicals.

(e) Effects on livestock, e.g., increases in certain types of cancer.

(f) Reduction in the yield of some crops, especially in areas of marginal agricultural production, as the result of any significant climatic changes resulting from reduction of stratospheric ozone levels.

(6) Some scientists postulate that changes in stratospheric ozone levels would cause changes in temperature, wind patterns, precipitation, and other weather elements. The nature and extent of these changes and their effects on the earth's climate, however, cannot be predicted on the basis of present knowledge.

B. Scientific Concepts.

(5) Effects of ultraviolet radiation on humans, plant life. Ecosystem interrelationships; food chains.

(6) Weather and Climate.

Bibliography:

Richardson, John S., and G. P. Cahoon, "Methods and Materials for Teaching General and Physical Science," McGraw-Hill Book Co., Inc., New York, 1951.

Alyea, Hubert N., and Frederic B. Dutton, "Tested Demonstrations in Chemistry," Journal of Chemical Education, Easton, Pa. 1960.

Footnotes to Phase 1.

[a] Bathtub Analogy. Widely used by atmospheric scientists when discussing ozone depletion, Dr. Michael B. McElroy, professor of atmospheric sciences at Harvard University referred to it in a telephone interview with The New York Times, published July 8, 1975:

> "He likened the ozone layer to a bathtub partly filled with water, with the drain open and enough water flowing in to make up for what goes down. The drain represents all of the effects that deplete ozone. The intake represents the processes reconstituting that gas.
> "If the drain is enlarged even a bit, the water level is bound to drop, he said, and this is the effect feared from fluorocarbons."

[b] Black Box Analogy. See excerpt (below) from Bassow, H., "Construction and Use of Atomic and Molecular Models," Pergamon Press, Oxford, England, 1968:

NATURE OF A MODEL: THE BLACK BOX ANALOGY

THIS is a book about scientific models, particularly the construction and use of models of different chemical substances. We might very well begin by considering just what such a model is anyway, or—even better—the scientific meaning and use of the term "model".

The dictionary defines "model" as "... a representation to show the construction, or serve as a copy, of something". The problem for the scientist is that he does not know what the "something" looks like, and therefore cannot copy it. Thus the scientists' model is not a model in the dictionary sense, since it clearly can NOT be a copy of the real thing.

As we try to understand just what a scientific model is, it may help to imagine you have been handed a sealed box, and asked to construct a mental picture of what an object contained in the box might be like. It would help even more to have a friend prepare such a box for you—without identifying the object he has placed inside—so that you can have the actual experience of trying to evolve an idea of what it might look like.

Suppose, for example, that as you tilt the box gently from side to side you hear a distinct rolling sound. "Aha," you say, "it's a marble! ! " What you mean, of course, is that it rolls like a marble would, so that it could be LIKE a marble at least in this respect. It could also be like a golf ball, or a ball bearing, or perhaps a large wooden bead, and this is why it is better to say it is LIKE a marble instead of it IS a marble. But wait a minute—a pencil would roll, too, in one direction! Perhaps the object is like a pencil. How could you tell? "Why," you say, "tilt the box in the OTHER direction of course!" A rolling sound then would indicate a round, marble-like object, while a sliding sound might suggest the pencil-like possibility. Let us assume, in our example, that the sound is once again of something rolling.

Notice what a remarkable thing you have done here. First, you performed an experiment: tilting the box. You made an observation: you heard a rolling sound. This led you to evolve two mental models for the object in the box: marble-like or pencil-like. These models did three things: (1) they explained your initial observation, since either marble or pencil would roll in one direction; (2) they suggested further experimentation (i.e. tilting the box in the other direction); and (3) they predicted the possible results of such an experiment (either a rolling, or a sliding sound). Finally, you perform this second experiment, and on the basis of further observation (more rolling sound), you choose the marble picture.

This is not bad, and is completely analogous to what scientists do. The point, of course, is that the marble is a MODEL because it would behave as the object did in the situations described above. The fact that a golf ball, ball bearing, wooden bead, or indeed any other spherical object, would behave in a similar manner, only serves to emphasize that the object is in some ways LIKE a marble, but not necessarily a marble after all.

Thus the statement that a marble is a good model for this object brings home the meaning of the term "model", as we use it in science. It is NOT necessarily an enlarged copy of anything, simply a scientific model of it. And if such a model explains and predicts some of the behavior of the actual thing, this is all we have a right to expect.

PHASE 2: THE PHILOSOPHICAL DIMENSION. Examination of the interface between science and social values... the philosophical and moral perspectives raised by the fluorocarbon issue.

Optimum Use: To increase student awareness of the (1) scope and nature of human knowledge; (2) limitations of scientific knowing— the meaning and use of scientific models; (3) moral issues involved in attempts to resolve the controversy. To use this totality of knowing to evolve a just, workable solution to the fluorocarbon problem.

Content: To use projective techniques, experiments, role-play activities in exploration of various versions of "the truth" and the influence of subjective perception.

Philosophy traditionally tackles those questions not yet reduced to scientific enquiry, not yet answerable but the potential area of science... what science is trying to close in on. The following are suggestive of activities to aid students in laying hands on this most difficult phase.

(1) Show color slides of various subjects: a hazy New York City skyline, the Grand Canyon, closeup of a leaf or flower, other scenes likely to evoke wide areas of response. For each slide, ask students to write one sentence that, for them, defines its truth. The hazy New York skyline might, for example, evoke responses about the pollution, the beauty or ugliness of the buildings.

(2) Ask students to read their sentences out loud, using them to initiate discussion about the different levels of knowing. An artist or poet will know a leaf in ways biologists cannot; a geologist will "read" and know the Grand Canyon in ways lay people cannot.

(3) With reference to discussion outcomes from (2), attempt to isolate the categories of knowledge. Address questions such as how we arrive at workable definitions and perceptions of scientific, legal, moral truths; how we come to know these truths; how much of this knowing comes from within the individual.

(4) Provide each student with a "black box" (see footnote b, phase 1), and ask them to evolve models of the objects within. Require that they specify the experiment(s), observation(s), reasoning that led to their proposed model.

(5) Use the outcomes from (4) to discuss the nature and meaning of a scientific model. Introduce the classic fable of the blind king of a blind kingdom asking blind aides to describe an elephant. Use the responses "spearlike" from the aide touching a tusk, "treelike" from the aide touching a leg, "snakelike" from the trunk toucher, etc., to emphasize the lack of absolute truth.

(6) Ask students to read excerpts from Congressional hearings, industry statements on the fluorocarbon issue (refer to Appendix 2), to prepare them for the role-play activity described in (7).

An interesting example within the present controversy of how an individual's truth gives direction to his work: James Lovelock, the British scientist who first detected widespread presence of fluorocarbons in the atmosphere, subscribes to what he terms the "Gaea Hypothesis." Named for Gaea, the Greek personification of the earth as a goddess, it postulates an idyllic equilibrium between man and nature, evolved over the million-odd years of man's existence, enabling nature to compensate and adjust to any man-made environmental disturbance. A comforting, if unprovable belief, but one that helps to illuminate Lovelock's (and the aerosol industry's) view of fluorocarbons (see Appendix 2).

(7) Ask class to imagine they are a Congressional sub-committee charged with legislating an effective but just solution to the issue. Using the awareness gained so far, this group must draft a workable, enforceable bill. Perhaps they will go beyond a bill and create a Department of the "Exterior" (national? U.N.?) to deal with this and future world-wide environmental issues.

(8) Have students read the texts of several existing bills (see Appendix 3), and compare their solution to real ones presently under consideration.

PHASE 3: THE CAREER EDUCATION DIMENSION. A study of the wealth of occupations and different bodies of knowledge involved in resolution of the fluorocarbon issue... an intersection of careers that relate to science.

Optimum Use: To acquaint students with the variety and nature of careers touched and influenced by the aerosol-ozone controversy, and to direct student attention to science-related careers available to them.

Content: To involve students in role-play and interview activities of working adults presently involved in these science-related careers, which provide means of exposing youngsters to adults in work settings that carry them beyond the confines of the science classroom into the world of working professionals.

This final phase of the curriculum scenario suggests the following activities to help direct student attention to a variety of science-related careers in the world of work.

(1) Ask students to survey the documents contained in the appendicies, and from this survey, to create a list of careers that come into play in this controversy. Each student is then asked to role-play a working adult engaged in one of the listed careers. Invite guest speakers engaged in some of these careers to support this activity.

(2) Direct students to set up and conduct a Congressional hearing on the controversy, in which each student plays his/her career role as they imagine it to be in an actual hearing. The range of chosen careers should include several Congressmen, from which a committee chairman would be selected; industry public relations people, engineers, legal staff, executives, businessmen; academic scientists; Federal government representatives from regulatory, environmental, other agencies.

The aim here would be to focus on the job titles, the specific careers being role-played, as students try to imagine how the adults being represented would react and respond in such a hearing.

(3) With reference to actual Congressional hearings (see Appendix 2), a student discussion should focus on the extent to which the role-play was real.

(4) Each student is asked to talk about their current career plans, and to then choose one career from the above listing and role-play experience that most closely fits their present career plan.

(5) Each student is asked to create a set of interview questions that will illuminate the dimensions of a single career.

The intent is to force the student to think of the kinds of questions which, when answered, would give one a feel for the career— make it understandable. Some guidelines:

(a) Career context: what kind of organization would offer such a career? A university? Government? Private Industry? What is the goal of this organization? To develop consumer goods? Influence public policy? To regulate? To make money?

(b) Operational characteristics of the career: what does one do daily in this job? What specific tasks and responsibilities are associated with it? What social status does it bring? Purpose here is to aid student in picturing the career in action.

(c) Practical employment information: how and where do I train for this job? How do I apply for it? How do I insure my getting it?

(d) Attitudes toward the present fluorocarbon issue that such a job might require: are you aware of the attitudes required? Do they coincide with your own? This forces the student to define his/her own position.

(6) Ask students to form small groups (of 3 or 4) by career interest: all "lawyers" in one group, "academic scientists" in another. Each group now evolves a questionnaire from the questions listed in (5), sets up and keeps an appointment with an adult now involved in their career, administers the questionnaire.

(7) Each group is asked to write up and present to the entire class a report distilling the responses to the interview questionnaire, and including their reactions to those responses. Each student needs to ask: do I want this career for myself? Why or why not?

(8) Initiate a large group discussion, evolving from (7), airing additional insights and attitudes about the fluorocarbon issue. What influence did the controversy have on each student's career plans?

REFERENCE MATERIALS

BACKGROUND INFORMATION

Craig, Richard A., "The Edge of Space," Anchor S 55, Doubleday & Company, Garden City, N.Y., 1968. Paper, 150 pages. Part of the Science Study Series, designed as background reading for high school physics students.

Williamson, Samuel J., "Fundamentals of Air Pollution," Addison-Wesley, Menlo Park, Cal., 1973. Hardcover, 472 pages. A college text, suitable for able high school students.

Climatic Impact Committee, "Environmental Impact of Stratospheric Flight," National Academy of Sciences, Washington, D.C., 1975. A report of the biological and climatic effects of aircraft emissions in the stratosphere. Part of the Climatic Impact Assesment Program.

MAGAZINE ARTICLES ON THE AEROSOL-OZONE CONTROVERSY

Popular Articles for the Layman:

Ahmed, A.Karim, "Unshielding the Sun... Human Effects," Environment, April/May 1975.

Alexander, Tom, "What We Know- and Don't Know- About the Ozone Shield," Fortune, August 1975.

Brodeur, Paul, "Annals of Chemistry- Inert," The New Yorker, April 7, 1975 (Appendix 1).

Chernow, Ron, "Should We Ban the Aerosol 'Bomb'?", The Philadelphia Inquirer's Today Magazine, December 8, 1974.

Crossland, Janice, "Aerosols," Environment, July/August 1974.

Drosnin, Michael, "Not with a bang but with a pssssst!", New Times, March 7, 1975.

Mitchell, Sean, "The Politics of Freon," The Nation, June 28, 1975.

Semi-technical Articles:

Crutzen, Paul J., "Estimates of Possible Variations in Total Ozone Due to Natural Causes and Human Activity," Ambio, Vol III No 6, 1974.

Kolb, Charles E., "The Depletion of Stratospheric Ozone," Technology Review, October/November 1975.

Lubkin, Gloria B., "Fluorocarbons and the Stratosphere," Physics Today, October 1975.

Technical Articles: Early Work

Chapman, S. A theory of upper atmospheric ozone, Quart. J. Roy. Meteorol. Soc., 3, 103, 1930.

Curran, R. K., Positive and negative ion formation in CCl_3F, J. Chem. Phys., 34, 2007-2010, 1961.

Marsh, D., and J. Heiklen, Photolysis of fluorotrichloromethane, J. Phys. Chem., 69, 4410-4412, 1965.

Norrish, R. G. W., and George H. J. Neville, The decomposition of ozone photosensitised by chlorine, J. Chem. Soc., 412, 1864-1872, December 1934.

Technical Articles: Current

Cicerone, R. J., R. S. Stolarski, and S. Walters, Stratospheric ozone destruction by man-made chlorofluoromethanes, Science, 185, 1165-1167, 1974.

Lovelock, J. E., R. J. Maggs, and R. J. Wade, Halogenated hydrocarbons in and over the Atlantic, Nature, 241, 194-196, 1973.

Lovelock, J. E., Atmospheric Halocarbons and Stratospheric Ozone, Nature, 252, 292-294, 1974.

Molina, M. J., and F. S. Rowland, Stratospheric sink for chlorofluoromethanes: Chlorine atom catalyzed destruction of ozone, Nature, 249, 810-812, 1974a.

Rowland, F. S., and M. J. Molina, Chlorofluoromethanes in the Environment, Reviews of Geophysics and Space Physics, Vol. 13, No. 1, 1-35, February 1975.

Stolarski, R. S., and R. J. Cicerone, Stratospheric chlorine: A possible sink for ozone, Can. J. Chem., 52, 1610-1615, 1974.

Wofsky, S. C., M. B. McElroy, and N. D. Sze, Freon consumption: Implications for atmospheric ozone, Science, Vol. 187, No. 4176, 535-537, February 14, 1975.

U. S. Government Publications:

Council on Environmental Quality and Federal Council for Science and Technology, "Fluorocarbons and the Environment," Report of Federal Task Force on Inadvertent Modification of the Stratosphere (IMOS), June 1975.

Report available from Superintendent of Documents, or from Warren Muir, Council on Environmental Quality, 722 Jackson Place, N.W., Washington, D.C. 20006.

A "Transcript of Proceedings," 27 February 1975, hearings leading to the IMOS Report, is available only from the latter address.

Reports of Congressional Hearings are available from sub-committee Chairmen. Hearings held to date are listed below:

December 1974, Subcommittee on Public Health and Environment of the Committee on Interstate and Foreign Commerce, House, Paul Rogers, Chairman.

May 1975, Subcommittee on the Environment and the Atmosphere of the Committee on Science and Technology, House, George E. Brown, Jr., Chairman.

September 1975, Subcommittee on the Upper Atmosphere of the Committee on Aeronautical and Space Sciences, Senate, Dale Bumpers, Chairman.

A good ongoing source of information about legislative developments is the weekly newsletter "Conservation Report," published by the National Wildlife Federation, 1412 Sixteenth Street, N.W., Washington, D.C. 20036.

Industry Publications:

"At Issue: Fluorocarbons," Kaiser Aluminum & Chemical Corp., 300 Lakeside Drive, Oakland, California 94643. A review of the controversy, available from their Public Relations Department.

"Halocarbons and Their Possible Effect on the Stratosphere," and "Scientific Evidence Against the Fluorocarbon/Ozone Depletion Hypothesis", both available from Chemical Specialties Manufacturers Association, 1001 Connecticut Avenue, N.W., Washington, D.C. 20036.

Various Aerosol Product pamphlets available from: Aerosol Education Bureau, 300 East 44th Street, New York, N.Y. 10017

Environmental Information on the issue available from: Natural Resources Defense Council, Inc., 15 West 44th St., New York, N.Y. 10036. To date, this organization has petitioned the Consumer Products Safety Commission to ban fluorocarbons, and sued them in May 1975.

APPENDIX 1, PAGES A1-1-7 WERE REMOVED
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EDRS DUE TO COPYRIGHT RESTRICTIONS

The truths of

APPENDIX 2

C Hon. Marvin L. Esch, Congressman

Professors T. M. Donahue, F. S. Rowland, Academic Scientists

Dr. Igor Sobolev, Industry Scientist

Thomas B. Stoel, Jr., Environmental Lawyer

A. Karim Ahmed, Environmental Scientist

.... excerpts from:

FLUOROCARBONS—IMPACT ON HEALTH AND ENVIRONMENT

HEARINGS

BEFORE THE

SUBCOMMITTEE ON PUBLIC HEALTH AND ENVIRONMENT

OF THE

COMMITTEE ON INTERSTATE AND FOREIGN COMMERCE HOUSE OF REPRESENTATIVES

NINETY-THIRD CONGRESS

SECOND SESSION

ON

H.R. 17577

A BILL TO AMEND THE CLEAN AIR ACT SO AS TO ASSURE THAT PRODUCTS DISCHARGING FLUOROCARBON COMPOUNDS INTO THE AMBIENT AIR WILL NOT IMPAIR THE ENVIRONMENTAL OZONE LAYER, TO PREVENT ANY INCREASED SKIN CANCER RISK, AND OTHERWISE TO PROTECT THE PUBLIC HEALTH AND ENVIRONMENT

AND

H.R. 17545

A BILL TO PROHIBIT THE MANUFACTURE OR IMPORTATION OF FREON AND SIMILAR SUBSTANCES UNLESS A STUDY FINDS SUCH SUBSTANCES ARE NOT HARMFUL TO HUMAN LIFE, AGRICULTURE, OR THE NATIONAL ENVIRONMENT

DECEMBER 11 AND 12, 1974

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STATEMENT OF HON. MARVIN L. ESCH, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MICHIGAN

Mr. Esch. Thank you very much, Mr. Chairman and members of the subcommittee.

First let me express my appreciation for the timely scheduling of these hearings. The question of whether the Earth's ozone shield is indeed threatened by manmade chemicals is very complex and it must be examined carefully but expeditiously.

Certainly, the warnings from some of the Nation's top scientists are of considerable concern to all of us. The studies raise important questions the scientific community should be asked to explain. Consequently, I am confident that this panel is doing our Nation a great public service by initiating the congressional inquiry into the scope of the potential risk posed by fluorocarbon compounds.

I believe very strongly that we must examine all aspects of this potential problem and that we should avoid government intrusion where none is necessary. In this regard, I am very pleased the subcommittee has asked for testimony from a broad cross section of representatives of the scientific community, industry, and government so that Congress and the public can better understand the impact of fluorocarbons on health and the environment.

Let me state, Mr. Chairman, that I would hope testimony will be requested for the record from many other industry and scientific sources who are not scheduled for testimony today or tomorrow. It is my understanding that fluorocarbons are in widespread use not only in aerosol sprays but also as coolants for refrigerators and air conditioners and in the manufacture of insulating and packing foams and other products.

I would like to emphasize, Mr. Chairman, that I appear here today as a layman without any special knowledge about stratospheric ozone destruction. As a nonscientist I make no claims about the validity of the studies being examined by this subcommittee. But I do want to note that these studies indicate there is a grave danger to the Earth's population from gases known as fluorocarbons or by the trade name Freon 11 and Freon 12. However, I should also note that fluorocarbons are produced by some 2 dozen companies throughout the world and that the chemicals are sold under various other trade names.

In view of the worldwide use of these chemicals, I believe the potential problems posed by use of fluorocarbons must be considered with an international perspective, not just as a matter for concern in the United States. Hopefully, some of the expert witnesses testifying here will be able to tell the subcommittee the extent of the research in other countries. The subcommittee might also consider writing to the United Nations or to some of our Government agencies to determine what information regarding this matter might be available from scientists abroad.

While this matter has been widely discussed in scientific publications in the United States, these reports have only recently been receiving much attention in the news media. This is due in part to the complexity of the theories as well as the conservative nature of some of the conclusions.

I should point out that Dr. Ralph J. Cicerone and Dr. Thomas M. Donahue, both from the University of Michigan, are here as witnesses today and they are anything but alarmists. Dr. Cicerone is a senior author of an in-depth study on the relationship between ozone depletion and fluorocarbons. Dr. Donahue is probably known to many of you as one of America's space research pioneers as well as Chairman of the Atmospheric and Oceanic Sciences Department at the University of Michigan. These are men of prestigious reputation who would not be party to inflammatory rhetoric. It is their caution in approaching the fluorocarbon controversy that has impressed me as much as their analysis of the threat.

I would like to note, for example, that Dr. Cicerone has said he hopes other scientists can prove his conclusions wrong. For he and his colleagues do not welcome the prospect of an increase in the incidence of skin cancer.

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Furthermore, the implications of fluorocarbons taking over chemical control of the stratosphere are as disconcerting to the scientists as to the rest of us. That is why I believe we must immediately begin a comprehensive study so that steps can be taken to defuse this potential time bomb if a health hazard is proven.

To delay could invite tragedy and suffering which, because of the unusual nature of this problem, might not be fully upon us for 10 or 15 years. Yet we are told that it may already be too late to prevent serious depletion of the ozone shield. In fact, we are faced with the unnerving prediction that ozone destruction will almost certainly result in an increased incidence of skin cancer—no matter what steps we take within the next 12 months. In short, if the initial studies are correct, we must be prepared with a plan to control the use of these chemicals to reduce the possibility that the Earth will receive deadly overdoses of the sun's ultraviolet rays.

With this background, let me now turn to a brief description of the legislation Chairman Rogers and I have introduced.

First, it provides authorization for a full-scale inquiry by the National Academy of Sciences. Let me say parenthetically that I know they utilize the services of other groups such as NOAA. It mandates the Environmental Protection Agency will enter into contract with the National Academy of Sciences for the study with a report to Congress not later than 9 months after enactment of the bill.

Second, it provides the Administrator of the Environmental Protection Agency with a regulatory mechanism to control and perhaps ban the chemicals if such action is necessary to safeguard public health and the environment. However, the EPA Administrator may, by rule, waive the certification of safety process if he finds, after consideration of the NAS report and public hearing, that there is no significant risk posed by discharge of fluorocarbon compounds.

Finally, the EPA Administrator may rule—after a public hearing—that other substances substituted for flourocarbons should undergo the certification process if they are found to pose a significant risk to health and the environment.

Mr. Chairman, I am certain that members of the subcommittee and others in the Congress will have suggestions to improve this measure. Let me say that I am not personally wedded, and I don't think you are either, to every word and provision. However, I do believe it provides us with a vehicle for action; and action may be vitally necessary—without any delay—if the National Academy of Sciences concludes the Earth's population is indeed in grave danger because of partial destruction of the ozone layer. In taking steps to control ozone depletion, the Congress, our Government, the fluorocarbon industry and the American public must realize that there is reportedly a substantial lag between the release of fluorocarbons and the impact on the ozone layer. Indeed, the scientists estimate that only a fraction of the fluorocarbons thus far released have reached the stratosphere because this inert chemical rises so slowly through the atmosphere.

In fact, according to the University of Michigan study, ozone destruction would not be maximized until about 1990 even if all emissions were halted now. There are even estimates the subcommittee should consider that this ozone destruction will result in an additional 8,000 cases of skin cancer annually by 1990 and at least one prediction that the incidence of skin cancer could be much higher.

In conclusion, Mr. Chairman and members of the committee, I know you will proceed in an objective and analytical but expeditious manner on this crucial question. While it is essential that we do not raise false fears, I believe it is also important that we in Congress not shirk our responsibilites. For the sake of future generations, we must make a definitive determination regarding the possible harmful effects of this substance.

If the scientific community concludes that fluorocarbon compounds constitute a major threat to our health and environment, I believe we must be prepared to protect the Earth from further harm. I would urge, therefore, that the committee act as soon as possible on the Rogers-Esch bill.

STATEMENTS OF T. M. DONAHUE, PH. D., CHAIRMAN, DEPARTMENT OF ATMOSPHERIC AND OCEAN SCIENCE, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICH.; F. S. ROWLAND, PH. D., PROFESSOR OF CHEMISTRY, UNIVERSITY OF CALIFORNIA, IRVINE, CALIF.

Mr. DONAHUE. Thank you, Mr. Chairman. I am T. M. Donahue.

Mr. Chairman and members of the subcommittee, the air we live in on the surface of this planet, the Earth, is made up mainly of two kinds of gases, nitrogen and oxygen. Both are essential to us: oxygen because it provides the energy for respiratory forms of living things such as man and other animals, nitrogen because it ultimately is converted into nitrates in the soil where it nourishes plants. These plants furnish the food and the chemicals that make amino acids and proteins necessary for living organisms. The gases, near the surface of the Earth, are in molecular form. That is, each particle or molecule of oxygen is made up of two atoms called atomic oxygen; likewise for nitrogen, two atoms of nitrogen for each molecule.

The gases that comprise the atmosphere become less and less dense as we ascend in altitude because of the pull of gravity on them. High above the Earth, at an altitude of about 60 miles where the atmosphere is a million times or more less dense than here in this room, this situation changes. The Sun radiates much light that is invisible, some of it very energetic called ultraviolet radiation. This radiation is capable of tearing molecules of oxygen apart into atoms. The ultraviolet radiation does not get down to us on the Earth's surface because most of it is absorbed above 50 miles by the oxygen molecules as it turns them into atoms.

Above 120 miles practically all of the oxygen in the air is in atomic form. Now, most of these atoms drift downward, eventually collide with other oxygen atoms and are reconverted to the familiar molecules consisting of two atoms each. But some of them collide with molecules of oxygen and make a very reactive form of oxygen called ozone—molecules made up of three atoms of oxygen. There are not many of these ozone molecules and they are concentrated mostly between 10 miles and 40 miles of altitude where they are nicely shielded by the molecules above them from the very energetic ultraviolet radiation of the Sun. Only about five parts in a million of the atmosphere is ozone at 15 miles where the ozone density tends to be at its greatest.

However, despite its scarcity ozone is essential for the survival of life as we know it. For it, too, absorbs energetic ultraviolet radiation from the Sun—not as energetic as that which splits molecular oxygen, but energetic enough to break up ozone and energetic enough to destroy or damage living cells. Because of the ozone most of the light that arrives on the Earth's surface is visible—violet, blue, green, yellow, red. The little bit of ultraviolet that arrives is what causes sunburn—and sometimes skin cancer in mammals such as man.

Another thing the ozone does is to make the air that lies in a region called the stratosphere, 10 to 30 miles above the Earth's surface, hotter than the air below 10 miles. This is because of the energy absorbed by ozone. Thus, a minimum in temperature occurs near 10 miles.

A situation is then created in which gases, and other light substances, introduced into the atmosphere find it relatively easy to rise upward, being mixed with the atmosphere by a stirring process called turbulence, until they reach a barrier near 10 miles called the tropopause where the temperature begins to rise and the stratosphere begins.

Strange substances, gases or otherwise, introduced above this stable layer tend to be trapped a long time up there, or if introduced below the barrier tend to fill up the lower atmosphere as they leak slowly through the tropopause into the stratosphere where the ozone is concentrated. But, of course, once they get into the stratosphere they have a hard time getting back down again. As those who follow me will point out, this trapping is quite an important element in determining the time scales associated with the pollution problem you have asked us to discuss with you today.

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It is not a foregone conclusion that a planet like Earth will have a nitrogen-oxygen atmosphere like ours. Our sister plant Venus has an atmosphere of carbon dioxide with a surface pressure 100 times as high as the Earth's atmosphere and a temperature of about 700°. Both of these atmospheres have come out of the interior of these planets during the 4½ billion years of their existence. Fortunately for us, Earth has a lot of water that has caused much of the Earth's carbon dioxide to be converted into limestone. Part of the rest of the carbon dioxide has been changed slowly during the past 600 million to 1 billion years into oxygen by a process called photosynthesis, engaged in by green plants and phyto plankton in the oceans.

An interesting bootstrapping kind of operation has occurred during this time in which living things have slowly created the oxygen they need for respiration, evolving as the process has proceeded to their present level of development and shielded even more effectively by the growing blanket of ozone above them. Destroy part of this system and you inevitably perturb seriously or destroy the rest of it.

It is only during the past 4 years or so that we have begun—and I emphasize "begun"—to understand deeply how this system works and to recognize that man has been in the process of introducing substances into the atmosphere that may seriously threaten to change it drastically. In particular several threats to the vital ozone shield have been recognized—just in the nick of time, we hope. The first of these to come to our attention as a potential threat was an effluent of jet engines called nitric oxide. Introduced into the stratosphere it catalytically destroys ozone, one nitric oxide molecule destroying thousands of ozone molecules before it finds its way (after being converted to nitric acid) through the barrier of the tropopause. We now believe that a fleet of 500 supersonic transports such as we proposed to build a few years ago would have reduced the ozone content of the stratosphere by more than 20 percent, causing at least 40 percent more ultraviolet to reach the Earth's surface.

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The significance of this increase in radiation can be appreciated if we talk about small increases in ultraviolet. One percent decrease in ozone would cause a 2-percent increase in ultraviolet, and a 2-percent increase in the number of skin cancer cases in the United States. Since there are 2,000 deaths and 600,000 new cases of skin cancer diagnosed among whites every year in the United States, a 1-percent decrease in ozone would produce 40 more deaths and 1,200 new cases of skin cancer every year. That would extrapolate to at least 800 more deaths and 240,000 new skin cancer cases in the United States every year due to the proposed SST fleet and you can do the arithmetic for the rest of the world.

However, the effect would not only be on skin cancer. Viability of grain crops and other living things would be affected, and when large changes occur effects are, as we say, nonlinear, or self-magnifying.

In fact, a 40-percent increase in ultraviolet radiation would probably drive life on the globe back toward a state it had several hundred million years ago, if there were time enough for adjustment. More likely it would probably result in the destruction of almost all forms of life very quickly if the change were to occur very rapidly.

The threat posed by nitrogen oxides from SST's has alerted us to other dangers. Those who follow me will discuss these others that have turned up during the past few months. The horror is that we are not sure that we have exhausted the inventory.

It might even be that in the effort to grow grains to feed the ever-growing mass of humanity we are affecting the creation of substances on Earth—nitrous oxide—that threaten the ozone shield protecting that mass of people from injury or destruction. I refer to a very interesting suggestion made to me recently by Professor McElroy of Harvard, to whom much of the progress in understanding these problems must go. We appear to be on the verge of a period of great peril to life on this globe produced by the development of the very technology designed to make life more pleasant, tolerable, and even possible for all of this human kind. It is time to step back and take a very careful look at what we may be doing to ourselves and our planet, and that is what we congratulate you gentlemen for doing today.

STATEMENT OF F. S. ROWLAND

Mr. ROWLAND. I am Prof. F. S. Rowland from the Department of Chemistry, University of California in Irvine.

The large-scale release of the chlorofluoromethane gases, often known by their duPont trademark Freon, has been increasing very rapidly over the last 25 years and is now approaching 1 million tons per year on a worldwide basis. Last year, Dr. Mario Molina and I began a detailed study of the possible chemical and physical processes which might remove these molecules in the terrestrial environment. From this study we concluded that the only important removal process for these molecules is through the absorption of ultraviolet light in the stratosphere above 15 miles altitude.

We further concluded from this work that the absorption of this light would release chlorine atoms and that these chlorine atoms would initiate a chlorine-atom-catalyzed chain reaction which would remove substantial quantities of the protective ozone layer which surrounds the earth in the stratosphere. One consequence of depletion of this ozone layer will be an increase in human skin cancer from increased penetration to the earth's surface of ultraviolet radiation. Other possible effects which are beyond the present capabilities of scientific evaluation and prediction include additional biological reactions and climatic changes.

The scientific description of these processes was outlined in our article in the scientific journal "Nature" on June 28th of this year and has been developed more fully in additional publications by our group at the University of California Irvine and by other scientific groups at Michigan, Harvard, the National Center for Atmospheric Research, the University of California, Riverside, and elsewhere. A scientific symposium on this topic will be held tomorrow in San Francisco during the annual meeting of the American Geophysical Union.

In this oral presentation, I shall outline very briefly the broad outlines of the scientific situation. Other members of the panel will testify in more detail concerning specific aspects. As an attachment to my testimony I am including the text of my article published last week in "The New Scientist," titled "Aerosol Sprays and the Ozone Shield."

Mr. ROGERS. May I say this will also be made a part of the record without objection [see p. 22].

Mr. ROWLAND. Dr. Molina and I are also furnishing copies of several journal articles which have already been published, and of a long review article "Chlorofluoromethanes in the Environment," which will appear in the February 1975 issue of "Reviews of Geophysics and Space Physics."

Mr. ROGERS. All of the articles you mentioned will be made a part of the record following your statement [see p. 22].

Mr. ROWLAND. The key steps in the original scientific analysis are these:

The chlorofluoromethane gases have long atmospheric lifetimes since their chemical and biological inertness as well as their relative insolubility in water prevent rapid removal by processes in the lower atmosphere, the ocean or on land. Much of the incoming solar ultraviolet radiation is removed by absorption in the upper atmosphere by ozone and by molecular oxygen; ozone is itself initially formed by the reaction ow ultraviolet radiation with molecular oxygen. Essentially all of the ultraviolet radiation capable of reacting with and destroying the chlorofluoromethane molecules has been removed from the radiation which penetrates below an altitude of 15 miles.

Consequently, the chlorofluoromethanes do not decompose in the lower atmosphere, but will, after diffusion to the stratosphere at an altitude of 15 miles or higher, absorb short wavelength ultraviolet radiation and break apart. Ultraviolet photolysis of these molecules released chlorine atoms in the stratosphere, and these initiate a very long chain reaction removing ozone. The 1972 world production rates of about 500,000 tons per year of dichlorodifluoromethane and 300,000 tons per years of trichlorotrifluoromethane are already large enough to have major effects on the ozone level when the atmosphere becomes saturated with them.

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Two other aspects of the scientific situation are worth special mention.

First, there is a delay period between release of the material at ground level through use in aerosol sprays or during the repair or discard of refrigeration units and the arrival in the middle stratosphere of these molecules. Therefore, the full effect of the material already released is not felt until about 10 years after the actual release. In other words, even if further release were to be discontinued abruptly at some point, the situation will always continue to become worse for about another decade before it begins to get better.

Second, the rate of removal of these molecules from the Earth's atmosphere requires a very long time on the human scale, although not long on a geological time scale—the molecules will last an average of 50 to 100 years in the atmosphere. While these lifetimes are calculated, estimates can also be obtained directly by measurement of the amounts present in the atmosphere in comparison with the total amount manufactured, and the lifetime by actual measurement is certainly longer than 20 years.

Estimates have now been made by at least four research groups of the worldwide average ozone depletion for various models of continuing atmospheric release of the chlorofluoromethanes. The calculated average ozone depletion for saturation at the 1972 usage rate has varied from 7 percent to 18 percent. When more realistic estimates of technological intentions—for example, a continuation of the 10 percent per year growth characteristic of the last 20 years—are put into these calculations, considerably higher eventual ozone depletion rates are predicted. These calculations also indicate that the chlorine atoms now in the stratosphere from breakdown of the chlorofluoromethanes already there are causing about a 1 percent average depletion in the ozone shield, and would increase to two percent over the next decade even if we were to discontinue use immediately. Predictions of the near future indicate three to six percent effects in the 1980's, depending to some extent on whether usage continues to increase in the future as it has in the past.

Calculations indicate that a 5 percent average depletion in the ozone layer will cause about a 10 percent increase in the incidence of skin cancer. As I stated earlier, the other possible biological and climatic effects are beyond calculation at the present time, although being too difficult to calculate is no guarantee that nothing will actually happen.

I shall next direct my remarks to the present state of knowledge of the chemistry of the stratosphere. The United States is now in the final stages of an intensive 3-year investigation of the stratosphere—the climatic impact assessment program, or CIAP, of the Department of Transportation. The CIAP program has been focused on the closely related chemical problems involving the reactions with ozone in the stratosphere of nitrogen oxides, including the nitrogen oxides which would be emitted from a fleet of supersonic transports, or SST's.

Prior to the beginning of the CIAP program, Professor H. S. Johnston of the University of California at Berkeley and Dr. Paul Crutzen of the University of Stockholm independently calculated that oxides of nitrogen must be present in the stratosphere to account for the observed amounts of ozone actually present. (Less is found than is expected in the absence of nitrogen oxides, and the shortage in ozone is explained through a nitrogen oxide-catalyzed chain removal of ozone.)

At the completion of the CIAP program, actual measurements of the nitrogen oxides in the stratosphere have confirmed that they are not only present, but the amount had been predicted with remarkable accuracy from knowledge of the laboratory chemical behavior of these molecules. The cost of the CIAP program has been variously estimated from $30 million over a 3-year period to $1 million per week in the later stages when the costs of related research not directly funded by CIAP were included. The number of scientists involved has been in the hundreds.

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I make these remarks in part because the most common criticisms of the scientific work on the chlorofluoromethanes can be summarized in these two statements: First, the work is only an hypothesis and must be verified by experimental measurements before it should be believed. Second, we still know very little about chemical reactions in the upper atmosphere and should wait until the first results of industry research become available before drawing any conclusions.

I believe that much more is known about the stratosphere by the scientific community than industry spokesmen have acknowledged so far; much of this information has been obtained through the CIAP program. I must add, too, that the stratosphere has not been, at least until the latter part of 1974, an area of scientific interest for the manufacturers of chlorofluoromethanes, or for aerosol spray manufacturers or the refrigeration companies. In the hundreds of papers on stratospheric chemistry which I have examined over the last year or two, I do not remember any which originated from the industries which are involved here, and the number of such papers is certainly very small.

If it were true, and I think that it is not, that we do not understand very much about stratospheric chemistry after a 3-year program costing tens of millions of dollars and involving hundreds of scientists, including most of the leading atmospheric scientists in this country and in the world, then I think the conclusion readily follows that improved understanding through the efforts of the industries concerned, and presumably also the U.S. Government, is not likely to be obtained without an even larger additional effort involving many tens of millions of dollars. Without such investment in stratospheric research, our conclusions 1 year from now or 5 years from now are going to be based on the same essential understanding of the stratosphere which we now have, patched up here and there with a few specific measurements and observations particularly related to the chlorofluoromethanes.

Scientific predictions of the future are always hypothesis. Some are based solidly on fact; others less solidly. Our original predictions, and the subsequent elaborations by ourselves and others, are consistent with all of the known laboratory facts and with the known atmospheric facts. They are also very closely related to the analyses by which Professor Johnston successfully predicted both the presence and the approximate quantity of nitrogen oxides in the stratosphere.

In our original paper, we predicted both that the chlorofluoromethane would rise into the stratosphere despite being much heavier than air, and that they would decompose with the loss of chlorine atoms when photolyzed with 2000Å light. While these predictions have not been challenged in scientific journals, both were questioned by others in articles published in late September in the New York Times and in Chemical Marketing Reporter. However, in November Dr. Lovelock in England reported observing chlorofluoromethanes in the stratosphere, and Dr. Krey of the U.S. Atomic Energy Commission reported finding them well into the stratosphere, at altitudes of 12 miles, in both the Northern and Southern Hemispheres.

Clearly, the molecules will also rise to 15 miles and will then be exposed to the ultraviolet radiation which will lead to their decomposition. The second part of this prediction has also been confirmed—we have demonstrated in our laboratory that the molecule dichlorodifluoromethane always decomposes after absorption of this kind of ultraviolet radiation with the loss of chlorine atoms. Similar results have also been obtained at the University of California Riverside. In making these statements of confirmation of predictions, I am not claiming that these were remarkable predictions. The situation is rather just the opposite—they merely represent a further demonstration that application of laboratory and atmospheric knowledge can provide reliable predictions of the behavior of the chlorofluoromethanes in the Earth's atmosphere.

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Finally, I shall read a quotation taken from the Los Angeles Times of Friday, October 4, 1974:

"A spokesman for the Du Pont Company, the largest manufacturer of these gases, * * * said that Rowland's hypothesis was an interesting one, but a hypothesis nevertheless.

"'We welcome the scientific interest to develop hard, experimental facts about fluorocarbons and the atmosphere,' the Du Pont spokesman said. 'We believe that when this data is in hand, it will exonerate fluorocarbons.'

"'If the data should, however, corroborate Rowland's theory,' the Du Pont spokesman said. 'I doubt that we would continue to manufacture or sell a product that poses a hazard to life.'"

This quotation presents an alternate hypothesis to ours—basically that some important factor has been so far left out of the calculations, and in addition that this "missing factor" will not turn out to make the situation worse for the ozone but will apparently make the chlorofluoromethanes innocuous insofar as the stratosphere is concerned. Such an hypothesis is always possible in the scientific world, but it does not become a plausible hypothesis capable of test until some indication is made of the possible nature of the important missing factor, with some estimate of its quantitative implications for ozone depletion.

We have been seeking such missing factors for a year and have not found any. Some of the scientists interested in the proposed space shuttle have also been looking at stratospheric chlorine atom chemistry for about 2 years, and agree with the proposed chemistry. The fundamental problem is simply this—how long should we wait for someone to find this missing factor which might then serve as the basis for an alternative scientific hypothesis before we act upon the conclusions which we readily derive from the only hypothesis now available.

The New York Times characterized this attitude in its editorial of November 12, 1974: "It is comparable to a child skipping through a minefield on the theory that he won't necessarily step on a mine, and if he does it won't necessarily prove fatal."

IGOR SOBOLEV, HEAD, ORGANIC CHEMISTRY SECTION, CENTER FOR TECHNOLOGY, KAISER ALUMINUM & CHEMICAL CORP.

STATEMENT OF IGOR SOBOLEV

Good afternoon, Mr. Preyer and Dr. Carter.

My name is Igor Sobolev. I am head of the organic chemistry section at the center for technology, the research organization of Kaiser Aluminum and Chemical Corp. Kaiser Aluminum is incorporated in the State of Delaware, has its headquarters in Oakland, Calif., and maintains plants and offices in 26 States and 22 foreign countries. In addition to aluminum and aluminum products, we produce industrial chemicals. These include fluorocarbons 11, 12, and 22, which are produced by the industrial chemicals division.

I am a chemist by training. I received my Ph.D. in chemistry from Syracuse University in 1958, and have worked in industrial research ever since.

At the center for technology in Pleasanton, Calif., I am in charge of a group of research chemists and technicians responsible for the development of new chemicals and chemical processes. Some of our work has involved processes for the manufacture of fluorocarbons—thus, I am fairly familiar with the properties and chemistry of these products. I also represent Kaiser Aluminum on the Chemical Manufacturers Association's Technical Panel for Fluorocarbon Research. As you know, this is a group of representatives from virtually every fluorocarbon producer in the non-Communist world which, for the past 3 years, has sponsored research on the effect of fluorocarbons on our environment.

I am here today because as a citizen and scientist I am concerned that we may be about to extrapolate an unproven speculation, one that is open to serious question, into conclusions and laws that would disrupt our economy and, indeed, our way of life.

As you know, our industry has developed fluorocarbons 11, 12, and other fluorocarbons because they were superior products. Limitation of their use would force us to return to inferior, more toxic and hazardous refrigerants and propellants such as sulfur dioxide, ammonia, and nitrous oxide.

In the next few minutes I would like to indicate for you why we believe the assumptions underlying the ozone depletion theory are open to serious question, and why we believe the environment will not be seriously impaired for a few years while we learn more about the ultimate fate of fluorocarbons in the stratosphere.

During the last several months, a number of researchers such as Drs. Rowland, Molina, Cicerone, Crutzen, McElroy, and others have proposed a new theory of ozone depletion, which you have heard discussed earlier today and yesterday.

Gentlemen, I respectfully submit that the increase in the incidence of skin cancer predicted by the theory is highly uncertain. The theory is really an unproven hypothesis. There is no question that these investigators who proposed the theory have made a commendable attempt to treat a difficult and very complex subject. In proposing the thory, they have made a real contribution. The value of their contribution lies in drawing our attention to the fact that we know so little about the chemical composition and the processes that go on in the stratosphere.

Our knowledge is limited because it is difficult and expensive to make measurements in the stratosphere, and because until the advent of the SST and the space shuttle we had no pressing need for detailed data. As a result, scientists studying the stratosphere have had had to work with too few facts, and thus often had to rely on estimates and assumptions. This is an acceptable way of pursuing scientific research, unless and until we draw conclusions and take action that has far-reaching consequences for our economy and our way of life. And this is where we are now—from a number of unproven assumptions about the behavior of fluorocarbons in the stratosphere, conclusions have been drawn that have led to the proposal to severely restrict the use of these important products.

With your permission, I would like to submit later to the committee a technical paper in which I discuss the 10 most significant assumptions open to question in the ozone depletion theory.

Mr. PREYER. That will be fine. Without objection that will be admitted into the record when you are able to supply it.

Mr. SOBOLEV. Thank you [see p. 391].

Since my time here is limited, I will cite only six of these examples.

1. The rates of diffusion of fluorocarbons into the stratosphere are unknown, as they are for many other gases, and have therefore been assumed in the development of the ozone depletion theory. This means that if the fluorocarbons rise into the stratosphere more slowly than predicted, other processes may destroy them before they can affect the ozone.

2. The chemical behavior and the reaction rates of the chlorine-containing products from the decomposed fluorocarbons are unknown in several cases, yet again assumptions were made regarding their magnitude. If these assumptions are incorrect, the damage to ozone would be less than predicted.

3. The concentrations of important reactants in the stratosphere such as the hydroxyl radical are not well known, but have been assumed. If these assumptions are incorrect, again less depletion of ozone could occur.

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4. The assumption has been made that there are no other stratospheric processes that will destroy fluorocarbons and their decomposition products before they affect the ozone level. There is a distinct possibility that ammonia and sulfuric acid aerosol, for example, may represent such so-called sinks.

5. The assumption is made that the present concentration of chlorine compounds in the stratosphere is so small that there is a negligible effect on ozone. The total concentration of chlorine compounds is as yet unknown; the definite possibility exists that it is appreciable—of the order of 1 ppb—and that the stratosphere has been successfully coping with them.

6. The self-healing potential of ozone in the stratosphere may have been seriously underestimated; it is quite conceivable that fluorocarbons will merely move the more concentrated layer of ozone to a lower altitude.

In conclusion, we feel that restriction of fluorocarbon production and use at this time is premature and not justified by the available evidence. We strongly recommend that the National Academy of Sciences, the Manufacturing Chemists Association and other organizations be given a period of 3 years to determine, through measurements in the stratosphere and laboratory experiments, whether fluorocarbons pose a real threat.

The risk of waiting for this limited period is small. We estimate that total ozone concentration would decrease less than 2 percent during this period if the ozone depletion theory were correct. This change is not measurable at the present state of the art. The benefits are large, if we can avoid the serious disruption of our economy that a ban on fluorocarbons would produce. Thank you very much for giving me your time and attention.

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STATEMENT OF THOMAS B. STOEL, JR., AND A. KARIM AHMED, NATURAL RESOURCES DEFENSE COUNCIL

Mr. STOEL. Thank you, Mr. Chairman.

I am Thomas B. Stoel, Jr., an attorney in the Washington, D.C., office of the Natural Resources Defense Council, commonly known as NRDC. Accompanying me is Dr. Karim Ahmed, a scientist in our New York office. We prepared the written statement jointly and will both speak very briefly to summarize the parts we think are most important.

Mr. ROGERS. Thank you. I think it would be helpful to the committee if you could give us a quick rundown on the Natural Resources Defense Council and how it is funded.

Mr. STOEL. NRDC is a national membership organization which is dedicated to protection of the environment by legal and scientific means. NRDC is a charitable organization supported by public donations. We appreciate your invitation to testify at these hearings.

Mr. ROGERS. We are delighted to have you.

Mr. STOEL. On November 20 of this year, NRDC filed a petition with the Federal Consumer Product Safety Commission asking the Commission to issue a rule declaring pressurized products—that is, aerosol-type products—which contain ozone depleting propellants to be banned hazard products, thereby prohibiting their manufacture and distribution. We believe that the available scientific evidence which Dr. Ahmed will summarize a little later strongly indicates that continued use of these products will deplete the stratospheric ozone layer and allow more cancer producing ultraviolet radiation to reach the earth's surface.

In my part of the statement, which I will summarize, I assume that the scientific case has been made out for rapid Federal action, and I address myself to the existing Federal statutes which may enable agencies to act on the legislation which is now before this committee.

It appears to us that three Federal agencies might have power to act: the Consumer Product Safety Commission, the Food and Drug Administration, and the Environmental Protection Agency. Without going into detail, the jurisdictional situation is quite tangled. Some of these agencies may have partial jurisdiction. Because of the interrelationships of the statutes, some may have jurisdiction only if others do not. We chose to file our petition with the Consumer Products Safety Commission because we felt on the basis of our preliminary legal research that it is the agency with the clearest statutory mandate to deal with this problem, and is the only agency which might have jurisdiction at least over all pressurized products containing these propellants.

We hope very much that the Commission and perhaps the other agencies I just mentioned will act quickly and effectively. However, this is a complex subject. It involves use of ozone depleting substances not only in pressurized products but in other products, such as refrigerators and air-conditioners. It involves use of these products not only in the United States but in the rest of the world. About 50 percent of manufacture and use of these substances is estimated to occur outside the United States, yet the impact on the ozone layer is the same and is worldwide. Therefore, we agree that it is proper for this committee to be considering a legislative solution to this problem.

I would like to summarize our comments on the bill before the committee, H.R. 17577. We think this is an appropriate approach to the problem, namely, requiring a study by the National Academy of Sciences, a report to the Congress by a specific date, and following that a certification procedure by which no manufacture or importation of any product which might discharge fluorocarbons into the air could occur except pursuant to a certificate from the Administrator of EPA. We are especially happy that the bill places on the applicant the burden of providing to the Administrator's satisfaction that the product poses no significant risk to public health or the environment.

We have only three suggestions to offer. First, ozone depleting substances are used in large quantities in refrigerators and air-conditioners. Of the two most commonly used propellants which are thought to have the ozone depleting effect, we estimate 25 to 28 percent are used in refrigerators and air-conditioners. In those uses, the substances commonly are discharged into the atmosphere only at the end of the product's life when it is junked. We think that the bill's language which specifies discharge into the atmosphere in normal use or operation should be modified to make it clear that discharges of this kind are included.

Second, as I stated earlier, we estimate that 50 percent of these substances are produced and used outside the United States. Yet these discharges affect the worldwide ozone layer and are just as harmful to residents of the United States as discharges here in the United States. Consequently, we suggest that the bill should prohibit manufacture or distribution by U.S. corporations or their subsidiaries anywhere in the world.

Third, we feel that the risks are so immediate that the bill should require that the National Academy of Sciences report to the Congress by June 1, 1975, and that the EPA certification procedure should be in effect by September 1, 1975.

That concludes my summary.

Mr. AHMED. I imagine by this time you have heard a lot of scientific evidence by various different experts. So I will not go into any of the details. I will just try to highlight what the evidence is and the nature of the evidence.

According to present scientific evidence, there are compelling reasons to believe that the manufacture and use of fluorocarbon propellant gases used in aerosol products constitutes an environmental and human health problem of major proportions. Since the publication of the first report by Drs. Rowland and Molina of the University of California at Irvine in the highly respected British journal NATURE in June of this year, several independent research groups in this

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country have confirmed their prediction that increasing use of these propellant gases will substantially reduce the level of atmospheric ozone in the next few decades.

It is important to recognize that the discoveries by these highly competent atmospheric scientists were not and are not an academic exercise of only theoretical importance. For the past few years, under the climatic impact assessment program of the Department of Transportation, a considerable amount of research has been conducted by numerous investigators on atmospheric ozone and possible impacts on it, including the impact of SST emissions which originally generated interest in these studies. Without this impressive history of research work, and the development of sound theoretical models and accurate measurement techniques, much of the present knowledge of the effect of fluorocarbon gases on the ozone layer would not be available.

There are essentially two lines of evidence that lead to the disturbing conclusion stated above. One is the worldwide measurements of the concentration levels of these fluorocarbon gases in the atmosphere. Extensive studies carried out by Dr. John Lovelock and his associates at the University of Reading, England, and by Drs. Wilkniss and Swinnerton and their coworkers at the Naval Research Laboratory, Washington, D.C., have measured concentration levels of one of these propellant gases, trichloromonofluoromethane (commonly known as P-11), ranging from 40 parts per trillion to 70-80 parts per trillion at latitudes in the northern and southern hemispheres from the southern coast of England to Antarctica.

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Similar measurements carried out by the Scripps Institute for Oceanography over a desert region in southern California indicate a comparable concentration level for this fluorocarbon compound. It is important to note here that these concentration levels when summed together on a global scale, equal the net world production of P-11 up to 1971 approximately 2,700 million pounds when these measurements were made. This is convincing evidence that little if any of these propellant gases are removed from the lower atmosphere by physical, chemical, or biological processes.

Based on theoretical considerations, it has been known that these propellant gases are unusually inert and do not react readily with other chemical agents. It has been estimated that the lifetimes of these fluorocarbon compounds range between 40 and 150 years.

During the past year, measurements of these fluorocarbon compounds have been carried out in the upper atmosphere, in the region above 12 kilometers in altitude where the stratospheric ozone layer is present. Studies conducted by the Statewide Air Pollution Center at the University of California, Riverside, and by the Atomic Energy Commission's Health and Safety Laboratory, have shown that these propellant gases are present in the stratosphere at concentration levels comparable to those found in the lower atmosphere. The most recent measurements made by the AEC last month show the presence of these gases at an altitude nearly 20 kilometers above the Earth's surface.

Details of these studies are included in the NRDC technical report attached as an appendix to our written statement.

Mr. ROGERS. All of those will be made a part of the record. [see p. 433].

Mr. AHMED. The second line of evidence is the diffusion models that have been used by several atmospheric scientists to calculate the effects of these fluorocarbon gases on stratospheric ozone. Following the initial work Drs. Rowland and Molina, Dr. Paul Crutzen of the National Center for Atmospheric Research in Boulder, Colo., Dr. Ralph Cicerone and his associates at the University of Michigan's Space Physics Laboratory, and Drs. McElroy and Wofsy at Harvard University conducted detailed atmospheric diffusion model studies to examine these effects. From their studies carried out during the past year, we have a remarkable unanimity of scientific opinion that the effects of these propellant gases on atmospheric ozone is significant and poses a threat to human and animal life on earth.

If one assumes the growth in the use of these fluorocarbon compounds to continue to annual rates of about 10 percent, the most recent Harvard study predicted that we may achieve a loss of atmospheric ozone of about 16 percent by the year 2000. However, it is important to note that, because it takes years for these compounds to reach the stratosphere, this loss will be inevitable if use trends are allowed to continue into the 1980's.

This global loss of ozone will allow greater amounts of ultraviolet radiation to reach the Earth's surface, causing an increase in the incidence of skin cancer and other detrimental biological effects on animal and plant species. It is estimated that such a depletion of the ozone layer will cause 100,000 to 300,000 additional cases of skin cancer each year in the United States, and 500,000 to 1,500,000 additional cases each year and 20,000 to 60,000 additional deaths each year worldwide. Recently, the National Academy of Sciences convened a special ad hoc panel to study the issue of ozone depletion by fluorocarbon gases. At their meeting on October 26, they concluded unanimously that the above problem "is serious and should be given immediate attention by the Academy".

From our contacts with all the leading atmospheric scientists who have studied this problem, there appears to be a general consensus that a strong case, based on firm scientific evidence, has already been established. In light of the gravity of the environmental and health problems which will face us in the very near future, if use trends are allowed to continue, there is no justification for waiting several year before taking action.

To be sure, if we wait several years, further atmospheric measurements and model studies may confirm the present findings and provide a more conclusive case. However, sound scientific judgment calls for immediate action to prevent major and possibly catastrophic harm in the future. In a recent article, Dr. Donald Bunker, professor of chemistry at the University of California at Irvine, stated:

> Scientific truth is never unanimous. It advances collectively and in spite of colorful and stubborn individual divergencies. To propose that we require total scientific agreement before blowing the whistle on something a corporation or agency wants to do is to agree to wait forever. If the board of directors desires to hear a sincere opinion exonerating them from the probable consequences of their actions, they will always be able to find one.

This is the essence of the present situation in terms of public decisionmaking. Moreover, in this case we do not have widely divergent views among the scientists who have studied the problem in detail. This is almost unprecedented in our experience of scientific and public issues.

Mr. AHMED. Briefly, you have heard that one of the measurements that will be required is the measurements of concentration levels of the intermediate species in the stratosphere, chlorine oxides and chlorine radicals. Apparently, from what I have been able to find out, techniques have not been developed yet. These species are in low concentrations. It is unlikely that the techniques can be developed in the next year to the point that you can get good evidence and good concentration.

It may take 2 or 3 years before these measurements are made, and you have enough confidence that these measurements stand up to expert scrutiny. In the meantime, we don't have assurance that these techniques will be developed.

As you noted, Dr. McCarthy from Du Pont mentioned having contracted work with Dr. Davis at the University of Maryland to make measurements and Dr. Cicerone at the University of Michigan. Obviously, they are capable of doing these measurements, but I have no reason to believe that it can be done in the very foreseeable future.

The same thing with ozone. It is very difficult to measure ozone. The fluctuation in ozone is large enough, maybe 4 or 5 percent, for us not to be able to tell in the next year or two whether there has been really the effect you are looking for. So I don't think in 2 or 3 years we are going to be able to get the kind of evidence that everyone has been talking about.

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Mr. ROGERS. What should we do until we get the evidence?

Mr. AHMED. It seems to me that the burden is on those who feel that if there are mechanisms, reactions, pathways and other things that the models have ignored. Much of the disagreement could be purely at the theoretical levels on whether the models use the right assumptions, whether these diffusion models are accurate, and so forth. Other people could perhaps do similar studies, perhaps three-dimensional studies, to see if they come to conflicting predictions. So far we have not seen any conflicting predictions.

Mr. STOEL. We feel that a prima facie case has been made out that this effect occurs. As Dr. Ahmed stated, there is a remarkable, almost an unprecedented consensus among the scientists. It has been estimated by Dr. Rowland that we have already suffered a 1-percent ozone loss. Dr. Urbach testified that that means a 2-percent increase eventually in skin cancer. Every year we wait there is an increase of a fraction of 1 percent in the ozone loss, and a greater increase, twice as great, in skin cancer.

We feel that waiting beyond some time in 1975 would be highly irresponsible. We believe it would be appropriate for the Congress to set a deadline by which, if this theory is not disproved, the kind of certification procedure that the bill provides for would go into effect. This would give industry every incentive to undertake the best possible research program—and Government agencies should certainly cooperate—to disprove this theory if it can be disproved within the time period we can tolerate in terms of the possible public health effect.

We feel this would be an appropriate way of dealing with the problem. The concerned industry would have every incentive to bring forward whatever evidence it could within that time period, yet the public would be assured that its health will be protected if that evidence is not forthcoming. For Congress to wait until the end of that period before it acts would be to risk further delay which might have tragic effects on public health and on ecosystems of great importance.

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The truths of

Professor J. E. Lovelock

Dr. Mario J. Molina

.. Academic Scientists.

... Personal communications:

J. E. LOVELOCK
Bowerchalke Salisbury Wiltshire
Telephone 0722 78 387

31st July 1975

Dr Herbert Bassow
Chairman
Science Department
German Town Friends School
31 Coulter Street
Philadelphia Pennsylvania, 19144

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Dear Dr Bassow,

Thank you for your letter which I have just seen on returning from a visit to Colorado for a meeting of the National Academy of Sciences Panel on the fluorocarbon problem.

There is no real disagreement on anything other than emphasis and policy. The hypothesis of ozone depletion by chlorine from halocarbons is plausible and gives cause for concern. It would certainly be unwise to assume that the unrestrained release of halocarbons can continue indefinitely without something unpleasant taking place. Where I differ from my colleagues is that I do not accept the need for instant legislative action, especially if this is a result of emotional fears of skin cancer rather than a consequence of reasoned scientific debate based on sound evidence.

At present the depletion of ozone by freons is still small compared with the depletion from natural chlorocarbons such as methyl chloride and perhaps CCl_4 and also small compared with the natural fluctuations of ozone concentration. I think that we have at least three possibly five years to investigate and base our decisions on fact rather than fear. It is true that the freons will accumulate in the atmosphere because of their long residence time and that their effects will be manifest for sometime after they cease to be released. I have taken this into account in making the comments above.

It is possible to view the consequences of a substantial increase in ultra violet radiation at the surface simply by visiting other parts of the world. Thus most places in the southern hemisphere have higher UV levels at the surface at comparable latitudes. I know of no signs whatever of crop damage, algal destruction or other gloom predictions concerning UV increase in such places as South Africa, Australia or New Zealand. It is true that the white skinned suffer more skin cancer in these regions but this is not yet a problem sufficient to discourage immigration to those countries.

Yours sincerely,

J. E. Lovelock

UNIVERSITY OF CALIFORNIA, IRVINE

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO   SANTA BARBARA • SANTA CRUZ

DEPARTMENT OF CHEMISTRY   IRVINE, CALIFORNIA 92664

October 6, 1975

Mr. Herb Bassow, Chairman
Science Department
Germantown Friends School
31 West Coulter Street
Philadelphia, Pennsylvania 19144

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Dear Mr. Bassow:

I am enclosing a copy of Heicklen's old article on $CFCl_3$, as well as a review article by Rowland and myself which contains many more references to earlier studies.

As you mention in your letter, much of the chemistry on which we based the fluorocarbon-ozone projections is not at all new, and is very well documented. Nevertheless we are in the process of updating our review, since much work has been accomplished in the past year. Most of the important reaction rate constants have been remeasured: as expected, some reactions turned out to be slower while others turned out to be faster (all within a factor of two), the net effect being that the predictions of ozone depletion remain essentially unchanged from our original calculations.

The only major change in the overall picture since last year is that actual measurements of various chlorine containing species in the atmosphere have been performed: so far, the results of all of these measurements give strong support to the original predictions.

I am enclosing a few newspaper articles which describe some of these measurements, and I will send you the update of our review as soon as it becomes available.

Sincerely,

Mario J. Molina

Mario J. Molina
Assistant Professor of Chemistry

MJM/pk

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The truth of Dr. R. J. Cicerone, Academic Scientist.

..excerpted from his statement for U.S. House of Representatives Committee on Science and Technology, subcommittee on the Environment and the Atmosphere, George E. Brown, Jr., Chairman, during hearings on H.R. 4652, "Upper Atmosphere Research and Monitoring Act of 1975," H.R. 3118 and H.R. 3916, both entitled "Ozone Protection Act of 1975." May 20, 1975

I mention all of these studies to document the fact that the hypothesis that man-made chlorofluoromethanes lead to ozone loss is in perfect accord with all experimental measurements and all calculations performed so far.

Now the major uses of these fluorocarbons are as aerosol propellants, refrigeration fluids and foam-blowing agents, 55%, 28% and 15%, respectively. So on the one hand we face the situation where a larger ozone loss will result each year we continue their usage (and as all the calculations show, the ozone loss will not be repaired for several decades after we cease to use these chemicals). Thus, whatever biological and climatic effects ensue will get worse the longer we wait before encouraging or forcing the producers to halt. And on the other hand your representatives in Congress and the leaders in business realize that there are uncertainties in our calculations. For example, recent laboratory studies (by Drs. Davis, Watson and co-workers at the University of Maryland and by Drs. Kaufman, Anderson and co-workers at the University of Pittsburgh) show that two key chemical reactions proceed at different rates than previously reported. Consequently, the ozone-loss projections that had been calculated through February, 1975 are too large by about 300%. Appendix 13, a news story by Dr. Hammond summarizes these new findings. Such sudden changes in scientific projections do not please those of you who are charged with decision-making responsibilities, I'm sure.

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Industry truths: Statements to shareholders

PENNWALT CORPORATION

3 Parkway
Philadelphia, Pa. 19102

To ban or not to ban

Since this is such a topic of discussion these days, possibly it would be helpful to express our posture on this matter.

Should fluorocarbon propellents like our Isotrons be banned? There are those who would say "Yes," while others would say, "Let's first find out to what extent the scientific hypothesis that fluorocarbons *may* present a potential problem is confirmed with factual data before over-reacting to this well-intentioned warning."

We in Pennwalt commend the scientific community for calling this potential danger to the world's attention. We believe that we should allow that same scientific community sufficient time to prove or disprove their *theory* that fluorocarbons do, in fact, reduce the ozone layer in the stratosphere and thereby constitute a danger to mankind.

If scientific studies conclude factually that fluorocarbons adversely affect the ozone in the stratosphere and, therefore, endanger human beings on this earth, we shall of course, endorse their ban. But, in the meantime, we believe we should not encourage a political solution to a scientific question.

Cordially yours,

William P. Drake
Chairman of the Board and President

March 4, 1975

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E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
STOCKHOLDER RELATIONS SECTION
WILMINGTON, DELAWARE 19898

NEGATIVE BURDEN OF PROOF

A growing and disturbing trend is the tendency of some government agencies to ban the sale of products thought to present some dangers (cranberries and cyclamates are examples well-known to consumers) on the basis of fragmentary or inconclusive evidence. The burden of proof is then shifted to industry to prove a total absence of harm. This attitude colors much of the discussion regarding the proposed Toxic Substances Act.

The ozone/fluorocarbon controversy is another case in point. This controversy stems from a computer-based theory predicting that some fluorocarbon propellants and refrigerants, rising slowly to the stratosphere, partially deplete the ozone layer which moderates the intensity of ultraviolet rays present in sunlight. There have been, both in and out of government, many advocates of the "ban now, find facts later" philosophy.

Meanwhile, new information has reduced considerably the estimate of the impact of fluorocarbons on the ozone even if the hypothesis should prove valid. Research programs to determine the validity of the fluorocarbon/ozone depletion hypothesis have been funded by industry at fourteen major universities and additional government studies are under way.

Eminent scientists believe there is no significant health hazard in waiting the two-to-three years needed to get the facts on which an informed judgment can be made. In cases like the fluorocarbon controversy, we believe that in the absence of a risk of immediate harm Du Pont should oppose any precipitous action that adversely affects the consumer and our business, and in turn damages the nation's economy.

July 1975

PAGES A2-21,22 WERE REMOVED FROM THIS DOCUMENT PRIOR TO ITS BEING SUBMITTED TO EDRS DUE TO COPYRIGHT RESTRICTIONS

Legislative truth:

Wording of bill growing out of December 1974 hearings before Paul Rogers' subcommittee on Public Health and Environment of the Committee on Interstate and Foreign Commerce, U.S. House of Representatives.

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94TH CONGRESS
1ST SESSION

H. R. 3118

IN THE HOUSE OF REPRESENTATIVES

FEBRUARY 10, 1975

Mr. ROGERS (for himself and Mr. ESCH) introduced the following bill; which was referred to the Committees on Interstate and Foreign Commerce and Science and Technology

A BILL

To amend the Clean Air Act so as to assure that aerosol spray containers discharging chlorofluoromethane compounds in the ambient air will not impair the environmental ozone layer, to prevent any increased skin cancer risk, and otherwise to protect the public health and environment.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SHORT TITLE; TABLE ON CONTENTS

SECTION 1. This Act may be cited as the "Ozone Protection Act of 1975".

TABLE OF CONTENTS

AMENDMENT OF CLEAN AIR ACT

SEC. 2. Title 1 of the Clean Air Act (42 U.S.C. 1857 and following) is amended by adding at the end thereof the following new subtitle:

"Subtitle B—Ozone Protection

"FINDINGS

"SEC. 150. (a) The Congress finds, on the basis of presently available information, that—

"(1) discharge of chlorofluoromethane into the indoor or outdoor ambient air threatens to reduce the concentration of ozone in the stratosphere,

"(2) ozone reduction is likely to lead to increased incidence of solar ultraviolet radiation at the surface of the Earth,

"(3) increased incidence of solar ultraviolet radiation may cause increased rates of disease in humans (including increased rates of skin cancer), threaten important food crops, and otherwise damage the natural environment,

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"(4) the release of chlorofluoromethane may pose a danger to the public health, safety, and welfare, and

"(5) unless research proves the safety of choloro-fluoromethane, continued use of chlorofluoromethane compounds in aerosol spray containers should not be permitted.

"(b) For purposes of this subtitle the term 'chloro-fluoromethane' means the chemical compounds $CFCl_3$ and CF_2Cl_2 and such other chlorinated fluorocarbon compounds as the Administrator determines by rule may threaten to contribute to reductions in the concentration of ozone in the stratosphere.

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"STUDIES AND REPORTS

"SEC. 151. (a) NATIONAL ACADEMY OF SCIENCES STUDY.—The Administrator shall undertake to contract with the National Academy of Sciences to study, and prepare a report, concerning the nature and likelihood of potential effects (direct and indirect) on public health and the environment of the discharge of chlorofluoromethane into the ambient air. Such report shall also include information on the availability of (1) methods to recover and recycle chlorofluoromethane from products which have been sold to the ultimate consumer, (2) methods of preventing the escape of chlorofluoromethane into the ambient air in various uses, and (3) safe substitutes for chlorofluoromethane in various uses. Such report shall be transmitted to Congress not later than one year after the date of enactment of this subtitle.

"(b) NATIONAL AERONAUTICS AND SPACE ADMINISTRATION REPORT.—Within twelve months of the date of the enactment of this subtitle, the Administrator of the National Aeronautics and Space Administration shall report to the Congress and to the Administrator on the evidence then available concerning the nature and likelihood of potential effects (direct and indirect) on public health and the environment of the discharge of chlorofluoromethane into the ambient air.

"RECOMMENDED STANDARDS

"SEC. 152. Not later than fifteen months after enactment of this subtitle, the Administrator shall report to the Congress on recommendations for control of chlorofluoromethane discharges into the ambient air from sources other than aerosol spray containers. Such report shall include recommended standards to limit such emissions from major sources (other than aerosol spray containers) to the maximum extent which the Administrator determines will be feasible (taking into account the cost of achieving such limitation), and recommended effective dates for such standards.

"WAIVER AUTHORITY

"SEC. 153. If the Administrator finds, after—

"(1) consideration of the reports under section 151,

"(2) consultation with appropriate Federal agencies and scientific entities, and

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"(3) opportunity for public hearing,

that no significant risk to the public health, safety, or environment is, or may be posed, or contributed to, by the discharge of chlorofluoromethane compounds (or any class thereof) into the ambient air from aerosol spray containers, then he or she may, by rule, waive the prohibition of section 154 in whole or in part.

"ENFORCEMENT

"SEC. 154. (a) PROHIBITION.—Except as provided in section 153, it shall be unlawful for any person to manufacture, sell, deliver for introduction into commerce, or offer for sale any aerosol spray container which in normal operation discharges chlorofluoromethane into the ambient air, more than two years after the date of enactment of this subtitle.

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"(b) SANCTIONS.—

"(1) The Administrator may apply to any United States district court in the judicial district in which the person alleged to be engaged in conduct prohibited by subsection (a) is located or conducts business to obtain a temporary restraining order, a preliminary or permanent injunction, and other appropriate equitable relief to restrain any act prohibited by subsection (a).

"(2) Any person engaged in conduct prohibited by subsection (a) may be subject to a civil penalty of not more than $10,000 per day of violation in the discretion of the district court.

"AUTHORIZATION OF APPROPRIATIONS

"SEC. 155. (a) NATIONAL ACADEMY OF SCIENCES STUDY.—For the purpose of sections 151 (a) and 152, there are authorized to be appropriated to the Administrator, $500,000 for the fiscal year ending June 30, 1975, $1,500,000 for the fiscal year ending June 30, 1976, $250,000 for the fiscal period ending September 30, 1976, and $500,000 for the fiscal year ending September 30, 1977.

"(b) NATIONAL AERONAUTICS AND SPACE ADMINISTRATION STUDY.—For the purpose of section 151 (b), there are authorized to be appropriated to the Administrator of the National Aeronautics and Space Administration, $1,000,000 for the fiscal year ending June 30, 1975, $1,000,000 for the fiscal year ending June 30, 1976, $250,000 for the fiscal period ending September 30, 1976, and $750,000 for the fiscal year ending September 80, 1977.

"(c) For the purpose of carrying out other provisions of this subtitle, there are authorized to be appropriated to the Administrator such sums as may be necessary for the fiscal years ending June 30, 1975, June 30, 1976, September 30, 1977, and for the fiscal period ending September 30, 1976."

CONFORMING AMENDMENT

SEC. 3. Title 1 of the Clean Air Act (42 U.S.C. 1857 and following) is amended by inserting immediately before section 101 the following:

"Subtitle A—Air Quality and Emission Limitations".

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