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Conference Report on

Greenhouse Gases and Global Climate Change

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Lawrence Livermore National Laboratory
Livermore, California
March 1–3, 1988

C. Sneider and R. Golden

June 1988

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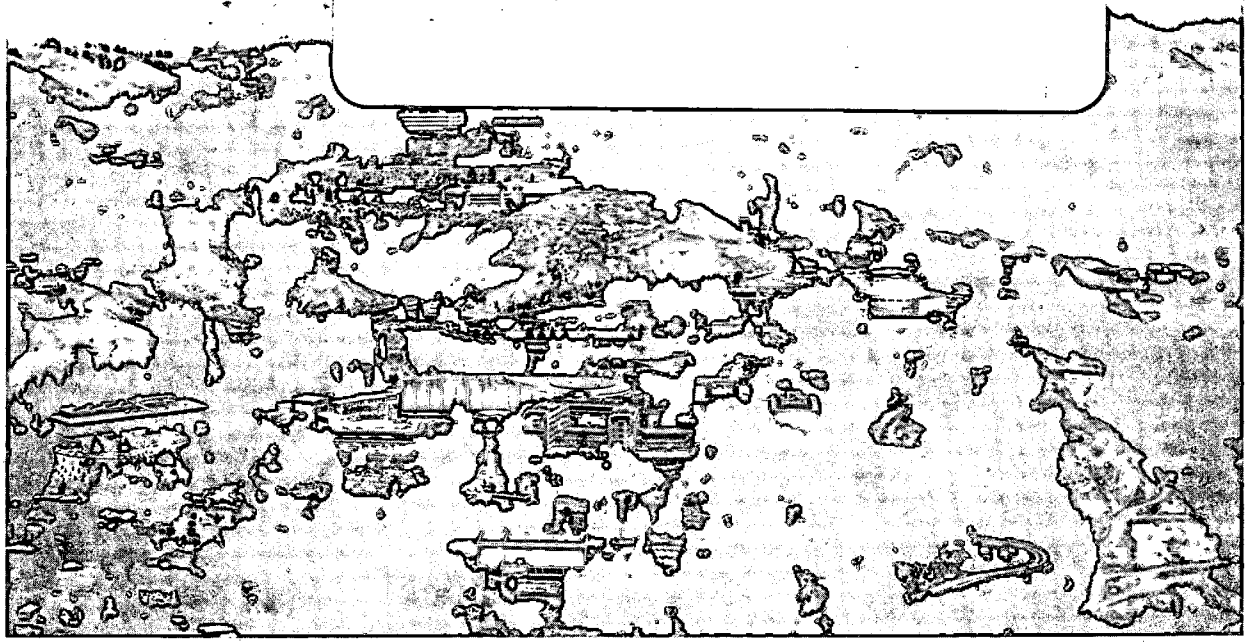

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Greenhouse Gases and Global Climate Change

Conference Report

March 1, 2, 3, 1988

Held at the

Science Education Center
Lawrence Livermore National Laboratory
Livermore, California

In Cooperation with

Lawrence Hall of Science
Lawrence Livermore National Laboratory
Oak Ridge National Laboratory
Oak Ridge Associated Universities
Lawrence Berkeley Laboratory

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June 15, 1988

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Preface

The workshop on "Greenhouse Gases and Global Climate Change" that was conducted at the Science Education Center, Lawrence Livermore National Laboratory on March 1, 2, and 3, 1988, was the first step in a major effort to develop educational programs on this important topic. The workshop was attended by 34 individuals, including scientists conducting research in this area, middle and high school teachers of science and social studies, curriculum developers, and school administrators from national, state, and local levels.

This document is a synthesis of the discussions that occurred among these individuals. However, to simply read the many ideas that were generated by the participants would miss some very important outcomes. These accomplishments were summarized at the conclusion of the workshop by several of its organizers:

• **An alliance of scientists and educators successfully generated a long list of ideas for educational programs in this area.** Scientists and teachers do not typically work together in teams to develop new educational programs. This conference demonstrated the feasibility of such an alliance. Four small groups, each composed of teachers, scientists, curriculum developers, and administrators, worked together effectively to generate the ideas described in this report.

• **The Workshop resulted in a detailed plan for an educational program,** including goals and objectives, ideas for instructional materials, and strategies for curriculum development, teacher education, dissemination, international participation, and classroom implementation. There was general agreement that the most useful materials on this topic would be for middle school and high school students, and that important contributions would be made by teachers with summer appointments in the National Laboratories where research in this field is being conducted.

• **A Group of Advisors for this project has already been formed.** Many of the participants at the workshop have expressed their desire to be kept informed about future developments and to have input at various stages of the work.

• **The drawing power of the topic, "Greenhouse Gases and Global Climate Change" cannot be overestimated.** Many participants expressed their strong support of educational programs which addressed the important issues at the interface of science and society which are central to this topic. Early indications are that a large number of teachers and students are equally interested in learning more about it.

The ideas described on the following pages will form the basis for a three to five-year project aimed at developing instructional materials on "Greenhouse Gases and Global Climate Change." At the end of the project we hope to have a large idea bank of student activities, a series of tested modules for the classroom, participation by educators in other nations who are equally concerned about this global problem, and a dedicated cadre of teachers who helped design the program and are willing to help disseminate instructional materials to their colleagues across the nation.

-- Cary Sneider, Conference Coordinator

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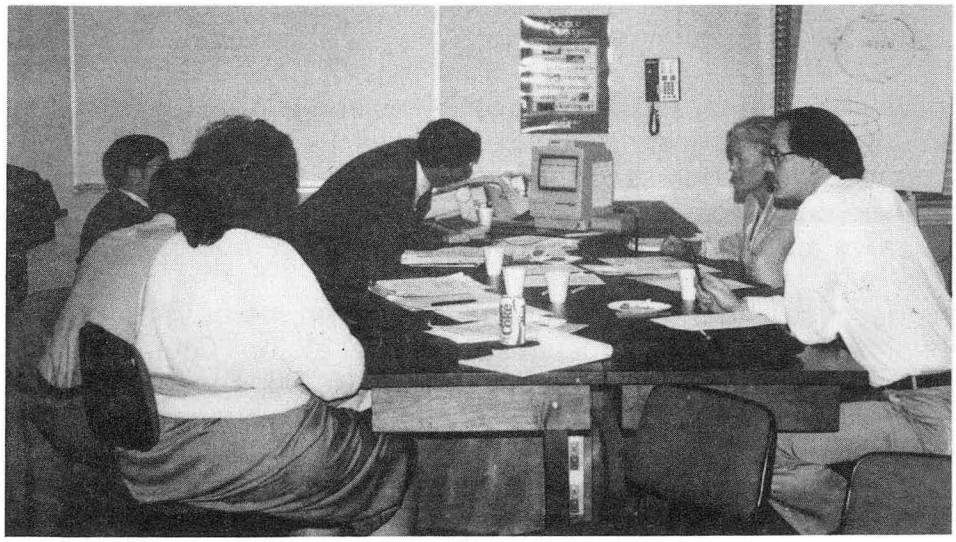

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I. Goals and Objectives

A. Goals

The first brainstorm session to develop curriculum materials on the topic "Greenhouse Gases and Global Climate Change" focused on the learner. The question that guided the small group brainstorm sessions was "What Do Students Need?" The participants agreed on some overall goals that all students should achieve before graduating from high school. These goals and the objectives that follow reflect the interdisciplinary nature of this issue, and demonstrate that such issues at the interface of science and society can form the core of a rich educational experience. This section lists the fundamental goals that have been identified.

Attitudes

- **Students become aware of their roles as global citizens**, recognizing that: 1) The problem of Greenhouse Gases and Global Climate Change cuts across national, racial, economic, and other boundaries that separate people; 2) they have a responsibility to understand the problem and make personal decisions regarding it; and 3) they can have an impact on the future of the world.

- **Students acquire attitudes regarding the nature of science and society**, such as the integrity of scientific processes and products, that science offers experimental results and information but does not produce decisions, and that scientific facts and concepts are open-ended and may change with new discoveries.

- **Students become motivated to explore the careers** in science, social science, and a variety of occupations related to science and society issues.

Skills

- **Students acquire analytical and critical thinking skills** needed to understand and make decisions about this issue, as described in the AAAS list of 8 basic skills.

- **Students improve their decision-making and communication skills** regarding this and other science and society issues.

Concepts

- **Students learn the basic science concepts** related to the global ecosystem and the consequences of human actions on the world's climate.

B. Objectives

In service of these broad goals, the conference participants listed the following objectives:

Attitudes

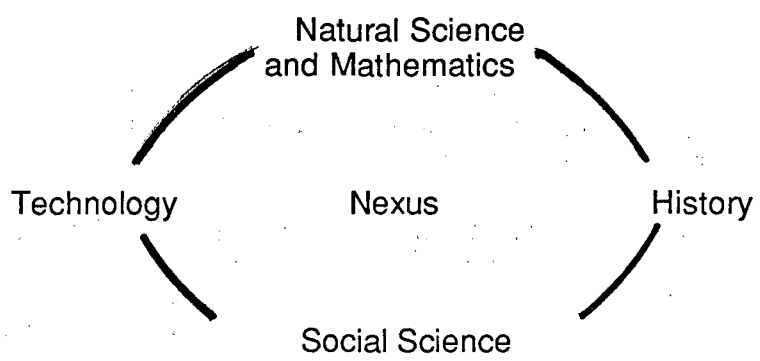
Goal 1: Students become aware of their roles as global citizens, recognizing that: 1) The problem of Greenhouse Gases and Global Climate Change cuts across national, racial, economic, and other boundaries that separate people; 2) they have a responsibility to understand the problem and make personal decisions regarding it; and 3) they can have an impact on the future of the world.

- Teachers need to find out what their students appreciate about the environment and society and help them understand the impact of this issue on what they hold dear (involve emotions).
- Students must learn to distinguish between human needs and wants.
- Become concerned for the welfare of all living things.
- Recognize that the decision to use fossil fuels or nuclear power involves an understanding of politics and economics in addition to technical information. That is, informed citizens can learn about the issues and participate in these decisions, even though they are not professional scientists.
- Students should recognize that they will be voting in just a few years and they will be making these decisions.
- Students need to feel empowered in their ability to make changes.
- Recognize that all parts of the world are interconnected. For example, a small amount of the fallout from Chernobyl wound up in California and Brazil.
- Students should think globally, and act locally, as they move conceptually from the family to the global community.
- Students must learn to put this issue into perspective relative to other global problems, such as nuclear war, the problems of developing nations, and the quality of life.

[Note: While there was general agreement among the participants about the importance and relevance of the societal dimensions of this topic, one participant disagreed. He felt that educational programs about greenhouse gases and global

climate change should only "strengthen technical capabilities of K-12, not improve social studies...Kids have pleanty of social issues to worry about."]

Goal 2: Students acquire attitudes regarding the nature of science and society, such as the integrity of scientific processes and products, that science offers experimental results and information, but does not produce decisions, that scientific facts and concepts are open-ended and may change with new discoveries, that the development of technology and history are intimately related, and that scientific and social issues are interrelated.



- Students recognize that science learning relates to everyday, real world issues and the environment that the student is familiar with.
- Recognize that scientists are people, with biases and personal values.
- Recognize that the problem of global warming as recognized and analyzed by scientists, has social, economic, and political consequences at both global and local levels.
- Recognize that the world is uncertain, and that there is not always a single right answer.
- Learn how technology affects society (including positive spinoffs such as health benefits, etc. and problems such as the greenhouse effect and toxic chemicals).
- Understand information sharing in the scientific community, both within and across disciplines -- how scientists in different fields collaborate and build on each other's work.
- Learn how research results have been translated into social change -- e.g. banning of chlorofluorocarbons to preserve ozone in the atmosphere.
- Recognize that experiments are not intended to prove claims, but to test hypotheses -- and that experimental designs reflect this intent.

- Science opens up new avenues of thought -- new questions are as important as finding answers.

- Science is a way of knowing which can be applied to an immense variety of subjects and issues.

- Recognize that society and institutions are resistant to change -- unique ideas are suspect.

Goal 3: Students become motivated to explore the possibility of careers in science, social science, and a wide variety of occupations related to science and society issues.

- Students recognize that understanding and solving the problems of the global greenhouse effect requires people who work in a wide range of occupations in science, technology, social science, communications, economics, politics, etc.

- Recognize that people of both genders and all different races are needed in a wide variety of professions. (Role models might include Roger Revelle, Wally Broecker, and some 19th century figures, such as Callender, John Imbrie, Dave Keeling. Females, minorities, and the handicapped should be represented.)

Skills

Goal 4: Students acquire analytical and critical thinking skills needed to understand and make decisions about this issue, as described in the AAAS list of 8 basic skills.

- Students acquire the ability to formulate hypotheses, design experiments to test hypotheses, take measurements, and record data.

- Learn how to make sense out of data by graphing, applying statistics, displaying information, and drawing appropriate conclusions.

- Gain skill in making inferences based on data, and recognize that decisions about what to do about it come only after the evidence is carefully interpreted.

- Acquire skill in problem solving -- learn to ask questions, apply scientific and mathematical methods to analyze problems, generate ideas and alternative solutions, make connections between things they already know and new problem situations

- Use critical thinking in many different contexts (When teaching any of these concepts we must place them into context that is meaningful so that our students can integrate the information)

- Able to analyze complex problems in terms of systems, and recognize the synergistic effects of multiple factors (as, for example, the global ecosystem composed of all life and the earth, ocean, and atmosphere.)

- Students need to learn techniques in social research, such as oral histories and interviews, opinion surveys, etc.

- Students learn to construct and use models -- recognize the limitations of simple and complex, static and dynamic models, their value in understanding natural and social processes, and their role in predicting trends and future events.

- Acquire skill in the use of cognitive mapping to organize and understand complex problems.

- Use and understanding of statistics.

- Understand the relationship between quantitative and qualitative methods to analyze problems, and acquire skill in selecting the best approach.

Goal 5: Students improve their decision-making and communication skills regarding this and other science and society issues.

- Students learn the importance of a balance between economical and political needs and environmental needs. (There is no such thing as a free lunch, expressed as the Second Law of Thermodynamics. One participant noted that a metaphor for decision-making might be that some lunches are better than others!)

- Recognize that unlike natural systems, which can be modeled, humans may decide to make changes that will affect the future.

- Need to understand concept of rate of change -- historical trends -- renewable and non-renewable, reversible vs. non-reversible. (e.g. forests can be replaced, petroleum cannot.)

- Issue of deforestation to raise cattle to make cheap hamburgers for fast food restaurants -- good illustration of political economic considerations.

- Do we have the right to decide which organisms are dispensable? -- value judgements (regarding issues such as spraying, etc. as examples to address more complex issues that are much more long term and harder to change.)

- Willing to consider alternative courses of action and modification of lifestyle.

- Recognize the need for negotiation in resolving conflicts of interest ("One person's meat is another person's poison.")

- Recognize the difficulty of solving the greenhouse gas problem, which is created as a result of filling human needs for energy, agriculture, land development, etc. in contrast to the ozone depletion problem, which may be solved by substituting CFC's with other chemicals.

- Students need to be able to evaluate risks and benefits of alternative actions.

Concepts

Goal 6: Students learn the basic science concepts related to the global ecosystem and the consequences of human actions on the world's climate. [Note: In reviewing this report, one conference participant pointed out that the following list needs to be reorganized to separate basic concepts from issues and examples.]

- Students learn about the properties of CO_2, its presence in the atmosphere, ocean, and terrestrial environment, and in complex biochemical systems.

- Students need to realize the implications of climate change -- what would happen if the sea level were to rise? what if rainfall patterns changed? or if the temperatures changed? what would be the health effects of more very hot days? (heat stress and brownouts, etc.)

- Understand the relationship between the natural climatic variability and changes induced by people

- Able to apply the concept of rate of change to the vastly different spatial and temporal scales of global processes.

- Appreciate how what people around the world do will affect the problem -- What will be the effects of increased deforestation? How much do we have to reduce our own use of fossil fuels before we expect China to do so?

- Students should become aware that their actions have effects elsewhere, and visa versa -- interconnectedness of global interactions
-- economic systems, geography, etc.

- Recognize the implications of our decisions on the rest of the world -- how our actions will affect rice farmers in China and farmers in Canada.

- Students need to recognize potential effects on their particular areas -- that they might turn on the tap and find no water!

- Grasp the importance of biological diversity, the role of the food chain, and how changes bring about other changes.

- Be able to apply the concept of carrying capacity of the environment -- as environmental conditions change, then the amount of life that can be supported in that environment changes.

- Organism diversification in oceans and how that changes over time -- significance of those changes to people's food sources and jobs.

- Rate of human adaptation -- People can make artificial environments. In contrast, other species will not adapt as rapidly.

- Understand paleoclimatology -- prehistorical changes, what life was like in different periods of the earth's history (and compare millions of years in time scale with the rapid change taking place in the industrial age). Recognize the significance of the reduction in the size of glaciers.

- Meteorological concepts - cloud formation and effects, albedo effects.

- Atmospheric chemistry -- ozone chemistry, photochemical reactions, catalytic cycles in the atmosphere, chemical lifetimes (what happens to carbon dioxide, vs. what happens to other gases?)

- Electromagnetic spectrum (infrared, ultraviolet, visible light, etc.) and selective absorption by gases and biological organisms

- Relationship between temperature, volume, and pressure (Charles' Law, Boyle's Law, etc.) to this issue.

- Differences between continental and ocean response to solar radiation.

- Understand relationship of sea level to climate change.

- Need to understand basic biological processes underlying the response of living organisms.

- Understand positive and negative feedback controls in biological and physical systems. Can be communicated through models.

- Need to know what processes give us added carbon dioxide and other greenhouse gases and how they affect the global climate.

- Relationship between heat and temperature and the nature of heat energy flow in the earth's ecosystem.

- Relationship between weather and climate.

- Distinction between flows and pools.

- Concept of measurement (as opposed to calculation).

- Concept of dynamic equilibrium, cycles, and steady state -- as applied to global energy flow

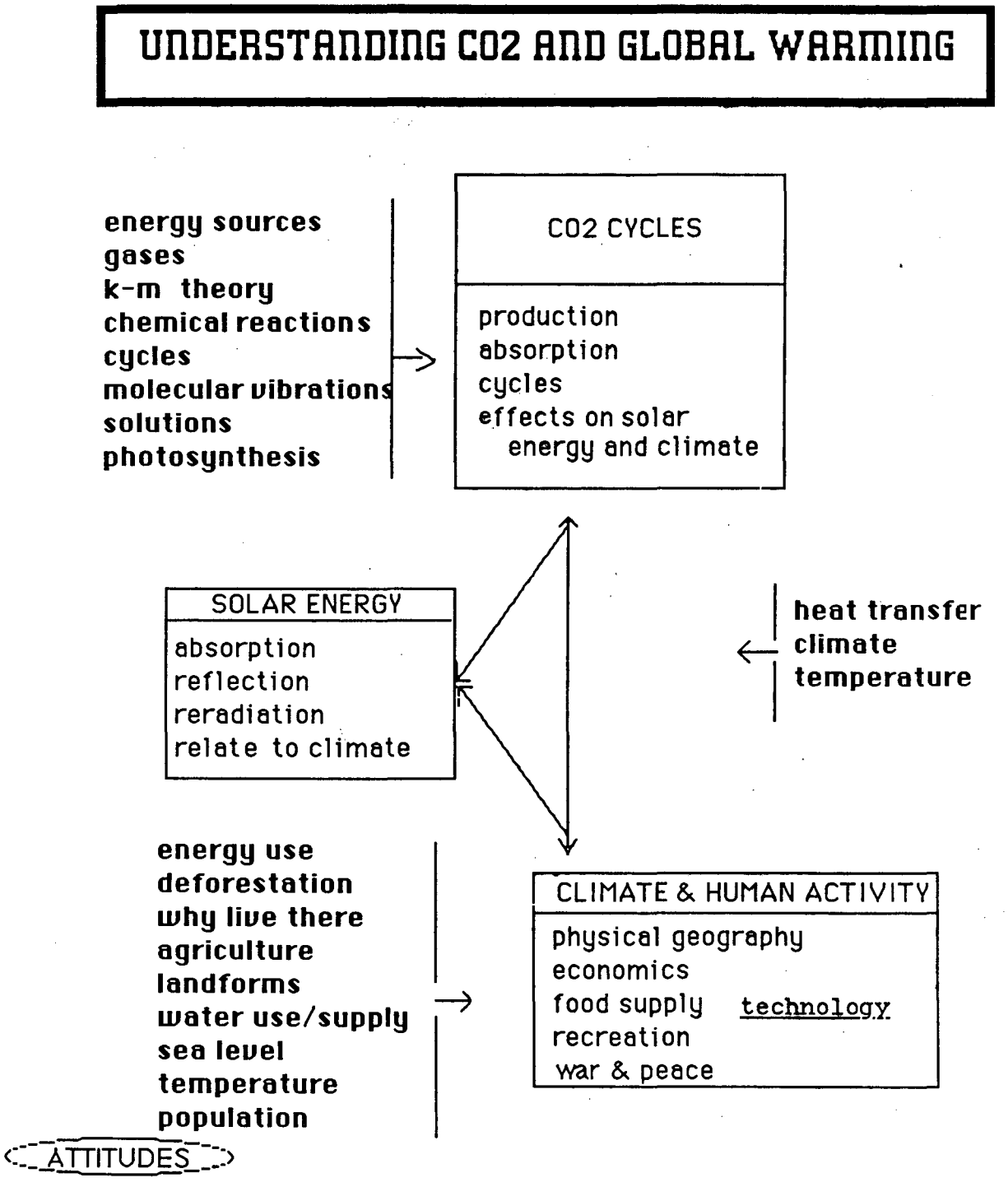
- Relationship of ocean circulation and other factors related to the global climate.

- Understand the multiple effects of CO_2 on plant growth, including the difference between food production and utilization, and the response of stomata.

- Blackbody radiation, absorption, and reradiation.

- Physiochemical and biogeochemical cycles (fluxes, reservoirs, budgets, cycles)

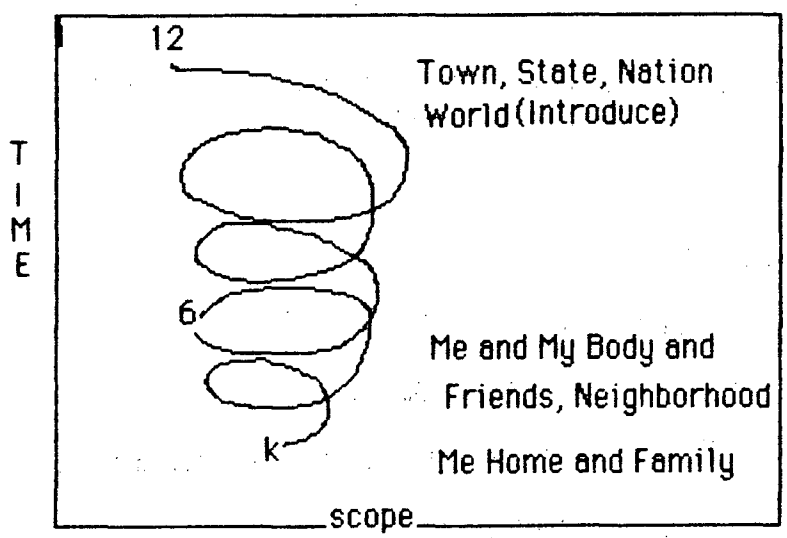
One group summarized the conceptual objectives for understanding CO2 and global climate change as follows:



II. Framework

Several of the small groups brainstormed ideas for a framework that could be used to develop and assess different programs on this topic. The most common comments in this area were that school materials should:

- Be a hands-on, heads-on, and bodies-on experience.
- Be fun, intellectually challenging, and exciting.
- Focus on this issue as an opportunity for students to learn how they can act as global citizens.
- Be appropriate for the student's age, developmental level, experience, and background. This idea is illustrated in the following diagram.



Several groups considered the issue of the potential audiences. They suggested the following:

STUDENTS and PARENTS

Students: Elementary School, Middle School and High School

Exceptional Children (Gifted, LD and EMR)

Minority: Students and Communities

International and Multilingual

EDUCATORS

Teachers

State and Local School Administrators

COMMUNITY

Community Groups (Womens Clubs, LW Voters, Business Service Groups)

Professional Societies

Political Communities: Local, State, National

Urban/Rural and Suburban Communities

Minority: Students and Communities

International and Multilingual

Nontraditional Students (Linked to Business and Industries)
(For example auto workers from Ford/UAW)

Museum Visitors

PARENTS and CHILDREN

Parents/Guardians (Grandparents) and Kids (6-12yrs)

EDUCATION BROKERS AND DISSEMINATORS

Publishers and Material/Curriculum Developers/Disseminators

Networks/ Computer Networks/Data Bases

Most groups expressed the opinion that the most important concepts regarding this issue should be covered at the middle school and high school levels, when students are mature enough to understand them. Further, the most promising level for development of new programs may be at the 6th - 9th grade levels, since high school courses are difficult to change. Nonetheless, some excellent suggestions for high school level students and younger students were also brainstormed during the conference.

III. Instructional Materials

Middle School Level (Grades 6-9)

1. A one semester course on "Greenhouse Gases & Global Climate Change"

(This course is liberally sprinkled with topics from the basic sciences and social studies. Activities mentioned are examples only. The actual course would have many more activities.)

Theme: Humanity's effect on the environment

Opening Grabber: The Voyager TV introduction (a Walt Disney Production) -- a scenario of a world in which everyone uses "breathers" and old people have a hard time surviving. The question is asked: "What went wrong?" (note: There was considerable controversy over this particular selection because it may not be accurate. Its purpose is to illustrate the idea of beginning with a dramatic scenario depicting the long term consequences of global warming. All participants agreed that the opening grabber must be based on a realistic scenario.)

The Basic Issue: A description of North America before industrialization, comparing it to the present.

Causes of detrimental change: Population increase, deforestation, increase in industrialization, pollution.

Positive Changes that result from industrialization: recognition that change is not always detrimental.

Basic Science Concepts: Gaseous pollution, water pollution, solid waste products. Composition of the atmosphere, the balance of nature and the unbalancing of nature.

(activity: Exhaling into bromthymol blue at rest, then after exercise "measuring" CO_2 content by drops of ammonia -- Relate this activity to other kinds of energy production. This is what happens in a power plant.)

The Greenhouse Effect: (see list of Goals and Objectives in Section I. of this report.)

Consequences of the Greenhouse Effect:

(activity: replot coastlines after sea level change)

Economic and political effects and population disruption that may result from global warming:

What can kids do?

(Activity: A mock global conference of decision-makers. Students would research the countries from which they come. The potential outcomes are international cooperation, need for conservation, recycling, public awareness, out of which may come production of video, news releases, play, posters, or actual participation in recycling or other energy conservation programs. Another general outcome might be individuals' decisions for career opportunities in this field, and a recognition of personal responsibility.)

Video: Middle School Level, with cartoon characters, to animate the process of greenhouse concept -- cycles trace Mr. and Ms. Carbon Atom through their cycle.

Video: The life and work of scientists in this field, including what scientists and technicians do when they are not at work!

High School (Grades 9-12)

1. The "Sprinkle" Approach

The "Sprinkle" approach consists of lessons and activities that would illustrate the concepts usually taught in the traditional Biology, Chemistry and Physics courses but which would have content material related to global climate change. Developing sprinkle materials involves reviewing existing concepts and skills in standard science programs in order to see where CO2-related activities and information can be substituted for standard problems.

An example: Rather than doing a standard solubility lab, one could do a lab on solubility and the change of pH, to illustrate acid rain. The reading material describes how the lab activity simulates the world. Another example is that when doing word problems on solubility, the problem includes real data and real life problems. The approach correlates the content with the real life situation. This enriches the currently accepted lab material.

Supplemental Teaching Guides could be developed to explain the enriched material. This would provide enrichment material for standard textbooks.

2. A School-Wide Project

This semester-long after-school project would involve all students in an investigation of a CO2 related problem. Students would collect data, research the history of this problem, develop possible solutions, determine the legislative constraints, and perhaps formulate policy decisions.

The teacher would set the tone for this project, help students research background, etc. This can be done outside the class.

3. A History Class on this topic

A History Class would look at what has happened to the "virgin world" over time. Mechanisms that would be used in teaching would include:

- Role Playing
- Simulation
- An activity in which students carry around a balloon globe -- to recognize what it is like to be in control of the fate of the earth (based on the idea of carrying an egg to see what it is like to have total control over a life.)

3. A Global Ecology course

This course would provide a second year of science for those students not taking Chemistry or Physics. The course would introduce students to concepts from those sciences as they relate to climate change, and would address science and society issues as well.

Middle School and High School

1. T-Shirts

Include silk screen design for a T-Shirt on global warming (cohesion, center for discussion) Could form the focus of a unit -- banner, T-Shirt business, school song, etc.

National competition for design of T-Shirts which communicates various aspects of the global warming problem

2. Science Fiction

Produce audio tape of aliens who come to earth and view it as a series of protective bubbles -- discover that the entire landmass is covered with bubbles. Students could also develop their own science fiction scenarios of the world of the future to grasp the meaning of the impacts. The TV movie "Voyager" is a good example. (Again, science fiction scenarios would need to be reasonable extrapolations -- not simply fantasy.)

3. Greenhouse Calendar

Important events on the birthday of their occurrence -- We produce a calendar with events such as: discovery of periodic table, discovery of greenhouse effect, first coal-fired plant, introduction of CFC's, signing of Montreal Protocol. Could feature individuals such as the person who invented nozzle on spray can.

4. Simulation Exercises for Decision Making

Present a scenario, such as: sea level rise of 1 meter; problems in agriculture such as growth of cotton vs weeds; local climate changes. In each scenario, provide

background and problem definition and present relevant and appropriate data. Define the issues and identify the constituencies affected.

Student teams then develop alternatives and make presentations to each other. The entire group discusses and decides on the best alternative, taking into account risks and benefits. This could be done through role playing, and also through a national teleconference, or an international teleconference as in a mock UN.

5. Biosphere Model Development

Create physical models of the biosphere, such as a terrarium which illustrates the greenhouse effect, and if possible illustrates the roles played by changes in levels of different gases, the ocean, etc.

6. Critical Evaluation of Newpapers , Magazines, & TV News Reports

- for bias
- for scientific fact
- for inference
- for priority (Where is it featured?--page 1 or page 38?)

7. Ideas for Projects

- Sea water and the carbonate buffer system (for example testing carbonate in sea water and its ability to absorb more CO_2)

- Combustion chemistry (measuring the amount of CO_2 given off for each unit of energy generated, using different fuels)

- Earth's atmosphere as a convective heat engine (experiments with gases and fluids demonstrating atmospheric circulation). Other aspects might include earth's interior as a heat engine, the role of tectonic plate movement in atmospheric composition, and how CO_2 levels have changed throughout earth's history. (Current increase may not be as much as in the past, but is high in comparison with low levels of CO_2 that we have been used to.)

Computer Software

1. Role playing Scenarios

Scientists --Team A do computer modeling to predict change in climate due to CO_2 with some uncertainty

Scientists --Team B make measurements and discover that there is a variation in climate, and maybe a trend, but a lot of noise. They must make sense of this data and

interact with the A group to: 1) test predictions; and b) feed parameters into the model to make it more accurrate.

Politicians from different countries meet to discuss the results, what range of effects they might experience based on the uncertainties, determine alternative actions for mitigating the effects, and decide what they want to do.

Structure: Students work in small groups and play each role sequentially. Different groups could have different sets of data, different models which predict different rates of change and effects of different magnitudes, different levels of noise, and probably come to different conclusions. At the end, the entire class compares their experiences. Guidance may be given to students regarding background of their countries (economics, history, politics) suggestions for handling different levels of risk, etc. (Some may conclude that eating today is more important than global warming in the next century -- Specific conclusions are less important than understanding the issues.)

2. The Role of Feedback & Non-Linear Effects

Feedback: Positive feedback mechanisms amplify effects due to increased CO2. Negative feedback mechanisms mitigate the effects. We envision a program that models global warming in which the CO2 levels and rates can be manipulated, and these feedback mechanisms can selectively be turned on or off.

For example, ice albedo feedback -- as the world warms it melts ice, which then reflects less of the energy it receives from the sun, and therefore warms further. The program would allow students to discover these effects, and possibly be able to control for these factors and see what would happen if ice albedo were not a problem.

Another positive feedback factor is water vapor/temperature feedback -- As the temperature increases, the amount of water vapor in the atmosphere increases. Since water vapor is a greenhouse gas, it traps radiation and the temperature increases further.

The main negative feedback factor is that as temperature increases the earth radiates more energy. This means that as the earth warms, a larger amount of energy is needed to increase the warmth of our planet by the same amount. This must be included in the model so it is realistic. Again, students could see what happens to the earth with and without this feedback factor.

Complementary activities in mathematics could illustrate how the computer model is constructed, since the equations are algebraic. Students could study non-linear effects -- such as what happens when the temperature drops below freezing and the ice albedo effect is dramatically increased. This will illustrate why computers are needed -- if the world could be described by linear equations alone, pencil and paper would be adequate. Computers allow you to take into account non-linear effects.

Goldilocks Effect . This program could be used to explore why Venus is too hot, Mars is too cold, but Earth is just right.

3. CO2/climate change and the scientific method

This project would utilize a National/International CO2 Telecommunications Network, like KidNet. Students would perform offline experiments that would involve: making observations, collecting data, drawing conclusions, making inferences, predicting, graphing, communicating information, and decision making for action.

After recording their data, students would share the data and their interpretations of it through a computer network. They could also explore historical data bases and analyze the materials, regarding the past history of the earth. Based on this data, they could predict future trends in the areas of: the global biosphere, weather vs. climate, scale of activity, periodicity and spatial cycles of CO2 and water, etc.

The students would also replicate other students' experiments and gain a working knowledge of what is meant by theories, hypotheses, and the role of the scientific community. They would find that science is not infallible, and that theories and even "facts" change.

4. Interaction Story Simulation with Computers and Videos

The story could focus on life styles and include a series of "what if" scenarios with branching complexities. For example, what if:

- there were no cars
- people insisted on a high life style with high growth
- all energy came from nuclear power
- 3rd world development were fully realized
- the program for injecting CO2 to get secondary oil recovery were implemented
- we planted more trees

Adults

Program for administrators -- An informative presentation for administrators, counselors, and school board members

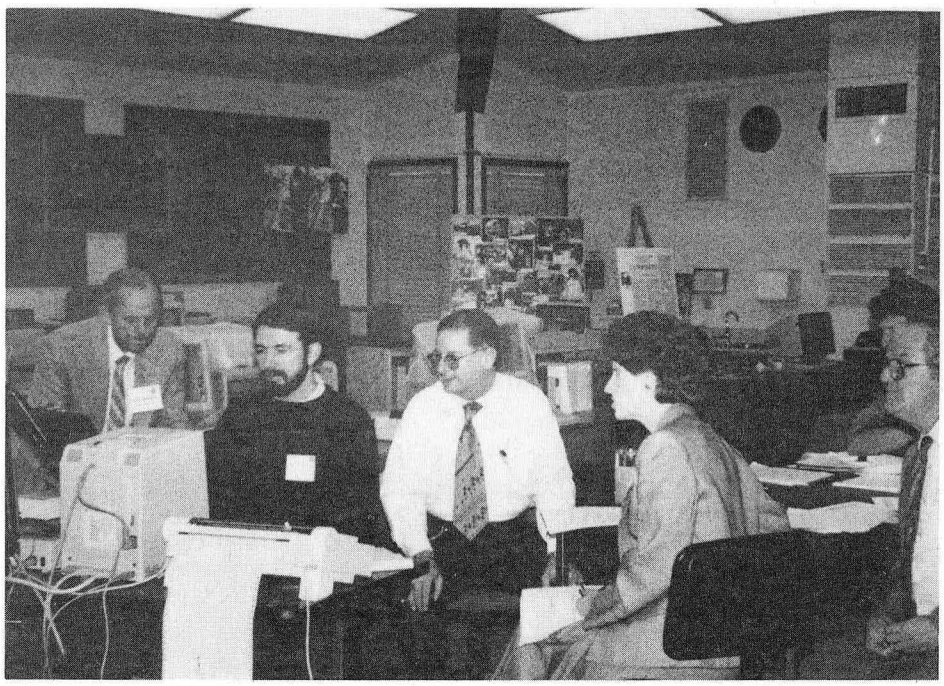
Programs for Teachers

- Workshop presentation to make teachers aware of the problem and the possibilities of classroom activities on the topic. This workshop would serve as an introduction to the curriculum materials available at conventions and staff development meetings.
- Inservice programs
- Preservice programs
- Programs should emphasize conceptual knowledge behind the factual data, and laboratory skills.
- Materials on the general problem for teachers of social science, math, science, history, technology, economics, etc.
- Produce a guide for teachers to enable them to develop other STS materials based on other topics, utilizing Global Warming as an example.

- *AAAS Science Resources for Teachers*, either as a model, or to include a packet on this topic
- Develop a teacher resource manual and data base with: articles, bibliography, references to classroom materials, laboratory activities and demonstrations, topic lists, field trip ideas

Programs for Teacher Educators at Colleges and Schools of Education

Family Science Program: Develop a manual that includes readings, problems, experiments, other teacher's guides. A teacher would teach parents and kids together in evening, following the Family Math model.



IV. Strategies

During the last part of the workshop, small groups discussed strategies for curriculum development, teacher education, dissemination, and classroom implementation. Large group discussions also focused on these strategies. Following is a synthesis of the various ideas.

Curriculum Development

• The many ideas for developing educational materials suggested at the current workshop may be viewed as an iterative process -- at each step, the ideas are prioritized, improved, and further refined by an expanding circle of individuals and classroom environments.

• A subset of people who attended this three-day workshop should synthesize the ideas for instructional materials into a "wish list." (as in the previous section of this report!) The list should include educational materials both for students bound for scientific and technical careers as well as for average students. The materials should be designed to touch at least a few students deeply enough to do something about this set of issues! (This is one educational program that has the potential of enabling individuals to eventually contribute to handling these very difficult global problems.)

• Provide the teachers who will be working on Carbon Dioxide research at LLNL and ORNL this summer with resources, a suitable working environment, support network, and the above "wish list" of products that they might develop.

• Provide teachers at the National Labs with a workshop (perhaps in Tennessee) to examine models of good science and society educational programs, and suggestions for developing new materials. Suggestions might include: starting a unit with something dramatic, thinking of ways to accomodate a variety of student learning styles, taking a "project" approach, and being prepared to answer the student's question: "So what?--Why is this important to me?"

• Teachers selected for summer work at the National Labs could also include social studies teachers -- perhaps a team of one science teacher and one social studies teacher who go to the lab together and work together to develop an STS unit on the global climate change problem. The social studies teacher could work at many different offices in the labs that deal with public information, and could also work at nearby Universities in the departments of History, Economics, Political Science, and with environmental groups and others interested in STS issues. (We later decided to initiate this idea in the second year of the project, since first-year funding only allows five teachers at each site.)

• Provide the scientist who will mentor the teachers during the summer with an orientation workshop, so they will be prepared to: involve the teachers in contributing to research, increase the teachers' self-confidence in science, help them understand the context of the research and grasp the broad outlines of the field, and assist the teachers in developing educational activities.

• Bring together all teacher-developed ideas in an "activity bank" which will be accessible to other curriculum developers and additional teachers.

• Write proposals to DOE and NSF to fund a major curriculum development effort to carry this process to the next step: forming a team of curriculum developers to pull together activities from the activity bank, write teacher's guides, involve other teachers in classroom testing and developing new materials, and continue the process of revising materials, editing, illustrating, etc.

• Instructional materials should be developed that will be useful both by experienced science teachers and by teachers who are new to science instruction, or who do not feel comfortable with lab courses -- could include video and computer software, texts and readers that would be more likely to be used by these teachers, and very easy-to-do labs.

• Teachers and their scientist mentors continue to work with curriculum developers to refine activity materials and procedures so they are feasible in typical classroom environments at the elementary, middle school, and high school levels, even with teachers who have very little experience in teaching science.

• The number of teachers involved in the curriculum development process will expand as pilot tests lead to field trials and finally broad national testing in many different states. At each round, the curriculum development team will be responsible for revising the materials according to the feedback.

Dissemination & Teacher Education

• The teachers who contributed ideas to the activity bank, or who tested the modules during the development phase may choose to become lead teachers who can then assist with dissemination.

• Involve scientists on a continuing basis in educational programs -- utilizing directories of scientists (from the national labs, universities, and industries) who can visit classrooms in their area, serve as speakers and role models for students, possibly communicating with students in schools via modem and electronic bulletin boards. Good models for this interaction include the IISME model based at Lawrence Hall of Science, or the *National Geographic Society* project. Take advantage of the excellent research facilities that are involved now, and that might be drawn into this project.

• For schools in remote areas, not near national labs, create videotapes of scientists at work -- depict them as real people with outside interests, and feature scientists of different genders, races, and interests.

• Prior to broad dissemination the core staff will create programs for administrators, teacher educators, and other teachers. These programs can then be used by the lead teachers, who present the workshops to other leaders, until the program is broadly disseminated. These programs should get the teachers excited as well as knowledgeable about the instructional materials, central issues, and relevant teaching techniques.

• Inservice programs will be most effective if they involve the teachers in activities which they can then do with their students. It is also a plus if the presenters can be teachers themselves, and therefore speak of personal experiences and knowledge about the difficulties of presenting effective lab activities.

• Preservice teacher instruction is also important because the average age of science teachers is very high. Many more teachers will be brought into the profession soon, and it would be best if they learn how to present effective laboratory activities on this topic as part of their college preparation.

• Teacher education activities can be through regular college programs, summer institutes, weekend and after-school workshops, DOE national lab programs and centers, and professional conferences.

• Information about instructional materials and teacher education opportunities can be disseminated through teachers' magazines and journals, the Council of State Science Supervisors, the National Science Teachers Association (NSTA) and its state and regional organizations, Elementary School Science Association (ESSA), and other organizations of science and social studies teachers, commercial publishers, word of mouth, newsletters, the Climate Protection Institute, environmental groups, the International Cogeneration Society, UNESCO, the Environmental Education Coordinators, the Association of Science Technology Centers (ASTC), Schools of Education and Teachers' Colleges, and the State Departments of Education.

• Various means will be found to link these efforts with local approaches: state credit systems, state frameworks, staff development mechanisms, teacher organizations, state, regional, and national conferences, etc. Dissemination proposals can help in this.

• The program will be widely publicized through teacher magazines including *Science and Children, The Science Teacher, Social Education.*

Implementation

• Set up a Watts line.

• Create and maintain a national or international newsletter like the *Greenhouse Gasette*, now being published by the Climate Protection Institute.

• Form regional support groups, possibly as a subset of teacher's organizations, but which include social studies and others as well as science teachers.

• Materials for teacher use will be most effectively implemented if they are inexpensive and easily replaced, preferably from local sources or by purchase of kits.

• Implementation will be greatly aided if creators of educational tests (such as the Educational Testing Service, developers of state tests such as California's CAP Test,

etc.) became aware of the problem and include questions about the problem of greenhouse gases and global climate change.

• For each state, create a map showing how the goals and objectives of an educational program on this topic relates to the goals and objectives in the state mandated frameworks for science, social studies, mathematics, etc. Also inform commissions charged with revising these frameworks, so that relevant items can be included at the outset.

• Establish support for teachers by presenting workshops on this topic and an orientation to the materials for school principals, curriculum directors, superintendents, and school board members.

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