Report Urges Greenhouse Action Now

An international report says action, beginning now, is required to avert the clear danger of greenhouse warming; the U.S. droughts only highlight the hazards

As Earth stands on the brink of a global temperature increase unprecedented in the history of human civilization, the international scientific and policy communities are mobilizing to minimize the effects of a greenhouse warming. Scientists' views of the future are as murky as ever, but there is a new sense of urgency, fueled in part by disquieting surprises in the stratosphere.

The U.S. droughts and the century-long global warming culminating in the 1980s (*Science*, 5 February, p. 559, and 13 May, p. 883) are catching the public's attention, despite scientists' refusal to link any one climate extreme to the greenhouse. Even the claim by a lone expert that the greenhouse has arrived has failed to gain support from other scientists. Instead, it is basic scientific understanding, the dearth of time for effective action, and a growing uneasiness about man's fiddling with the atmosphere that is driving a new international organizing process. This movement is akin to the one that recently produced agreement on how to deal with destruction of stratospheric ozone.

Robert J. Bennett/FPG

How much more will the sea rise in the future?

The international approach to greenhouse control took on a high public profile with the release of a report this month calling for more study but also immediate action. The report is the product of a process initiated and monitored by three major international organizations—the United Nations Environment Program (UNEP), the World Meteorological Organization (WMO), and the International Council of Scientific Unions. The three sponsored a conference in Villach, Austria, in 1985 that led to two 1987 workshops, one in Villach and the second in Bellagio, Italy. UNEP and a half dozen private organizations sponsored the workshops. A steering committee of ten experts then produced the report,* which was published by UNEP and WMO and was released at press conferences in Geneva, Stockholm, Toronto, and Washington, D.C.

The Bellagio report does not draw on any fundamentally new evidence, but it does project the future warming in some novel ways. Instead of emphasizing the oft-quoted 1.5° to 4.5°C global warming expected with a doubling of carbon dioxide, the primary greenhouse gas, the report estimates rates of temperature increase due to carbon dioxide plus other greenhouse gases. In a worst case scenario, in which greenhouse gas emissions are unrestrained and the climate is highly sensitive, the estimated rate is 0.8°C per decade. That is 16 times faster than the average rate of past century's warming.

An extrapolation from present emission trends and moderate climate sensitivity yields a rate of 0.3°C per decade. At that rate, after 20 years Chicago's summers would be as warm as New Orleans' are now. A lower bound scenario that assumes strong global restraint of emissions and low climate sensitivity produces only 0.06°C warming per decade, or about the rate of the past century. That would still carry Earth by late in the next century into a climate as warm as any for hundreds of thousands of years.

The warming could hardly go unnoticed. The sea would warm and expand while glaciers melt, pushing up sea level about 30 centimeters by the middle of the next century and possibly as much as 1.5 meters. Even the more modest rise would erode most sandy beaches along the U.S. Atlantic and Gulf Coasts at least 30 meters. The heat and some regional dryness would disrupt agriculture in some places, especially semiarid regions where agriculture is marginal to begin with.

Unmanaged ecosystems would not be as lucky as agriculture, according to the report. Each 1°C of warming pushes climatic zones 100 to 150 kilometers northward. By the mid-21st century, the climate that nurtures Yellowstone National Park could be well into Canada. The tundra of the Arctic National Wildlife Refuge could be pushed into the sea. If forests are pushed too fast, they would not migrate northward fast enough to keep up. As Michael Oppenheimer of the Environmental Defense Fund, a steering committee member, has noted, the conservation ethic would not pertain to a world in which there is no stability, only change.

Uncertainties remain, the report notes, but the assumption that the climate of the past century is a reliable guide to the future "is no longer valid." A prudent response would be twofold, the report says. The first, adaptation to climate change, may already be under way. Beach front property owners are building sea walls or abandoning the beach altogether. The second, limitation of climate change by reducing greenhouse gas emissions, will be inevitable as the cost of adapting becomes prohibitive.

And policy-makers cannot wait to act, argues the report. "If decision-makers were to wait until the scientific uncertainty is 'acceptably' small, most policy responses would be too late." That is because the lead times involved are huge by society's standards. The thermal inertia of the oceans delays the warming itself by several decades. On top of that are the 30- to 50-year delays inherent in society's responses, such as intro-

*The report is available from the Environmental Defense Fund, 257 Park Avenue South, New York, NY 10010.

ducing alternatives to burning fossil fuels.

The Bellagio report recommends some immediate responses to the greenhouse threat, many of which can be justified solely on other grounds. At the top of the list is prompt approval and implementation of the Montreal Protocol on ozone. Chlorofluorocarbons both destroy stratospheric ozone and act as a greenhouse gas. The Protocol's provisions would lead to a 15% to 25% decrease in the rate of warming.

Long-term energy policies should be reexamined, the report says. Increased efficiency in the consumption of energy would reduce carbon dioxide emissions. So would a shift toward alternative energy sources such as solar energy and nuclear power. Emissions per unit of energy would decrease with a shift away from coal, a high carbon dioxide–emitting fuel, toward natural gas.

Deforestation has numerous drawbacks, the release of carbon dioxide being one that should now be considered. Reforestation would remove carbon dioxide from the atmosphere, among other benefits.

The report also advocates immediate steps to improve understanding of the greenhouse effect and clarify the options for dealing with it, including consideration of a law of the atmosphere, like the Law of the Sea, or a convention such as the one for ozone. The likely effects of the greenhouse are so large that "a coordinated international response seems inevitable and rapid movement towards it is urged," the report concludes.

Momentum in that direction seems to be building. The biggest push has come from a surprise in the stratosphere, the Antarctic ozone hole. No computer model of ozone destruction included the voracious chemical reactions mediated by ice particles that are wiping out half the ozone over Antarctica each spring. Scientists even had trouble noticing that anything was amiss. The hole has everyone wondering whether greenhouse models might be missing a surprise as well.

The ozone hole is among the reasons that major environmental groups such as the Environmental Defense Fund and the World Resources Institute are starting to put time and money into the problem. But environmentalists will still have their hands full raising the public's consciousness. A recent poll found that two-thirds of Americans believe that the greenhouse effect presents a somewhat to very serious danger. But that placed it thirteenth out of 16 problems, beating out only x-rays, indoor radon, and radiation from microwave ovens. What would be handy is a crisis. No one is willing to call the current drought a greenhouse effect, but it could still become the ozone hole of the movement to control the greenhouse. ■ RICHARD A. KERR

Blood-Forming Stem Cells Purified

Having a pure population of bone marrow stem cells opens the door to treatments for blood diseases and basic research advances

ONE OF THE MAJOR OBSTACLES to understanding how different types of blood cells are formed has been not knowing what cells produced them. Now researchers have found a way to isolate the bone marrow stem cells in mice that give rise to all blood cell types. On page 58, Irving Weissman and Shelly Heimfeld of Stanford University School of Medicine in California and Gerald Spangrude, presently of the Royal Melbourne Hospital in Victoria, Australia, report that as few as thirty of these stem cells can restore blood cell production in a mouse subjected to a lethal dose of radiation.

The new findings represent a culmination of ideas and efforts by many investigators to identify which cells in the bone marrow ultimately form the eight or nine different lineages of cells in circulating blood. "This is the end of the particular road that was the search for the stem cell," says Weissman. The information should lead to better treatments for blood disorders as well as advancing basic research on blood-forming tissues.

For example, if a similar cell can be identified in humans, researchers may be able to transplant stem cells instead of whole bone marrow into people who receive large doses of radiation. Also, it may be possible to maintain the stem cells in vitro, transfer genes into the cells, and then reinject the altered cells into a person who has a specific genetic or acquired blood cell defect such as sickle cell anemia, thalassemia, severe combined immune deficiency, or leukemia.

Weissman and his colleagues had to separate the stem cells from many other populations of cells in the bone marrow. "It was like searching for a needle in a haystack," says Heimfeld. "These stem cells are incredibly rare [about 0.05% of total bone marrow cells] and they have no other distinguishing characteristics."

To obtain the stem cells, the researchers used monoclonal antibodies against surface proteins. First they selected out bone marrow cells that were already differentiated or committed to become a certain kind of blood cell—T or B lymphocytes, macrophages, or granulocytes, for example. They then enriched the remaining cells for blood-forming or hematopoietic stem cells, which are not yet differentiated and which can regenerate themselves throughout the animal's lifetime.

They also tracked the fate of the stem cells in mice given a dose of radiation that, under usual experimental conditions, would be lethal. After intravenous injection, the cells divided, differentiated, and migrated to different blood-forming tissues, including the spleen and thymus gland. In the spleen one cell could form an entire colony of precursors for red blood cells, macrophages, and granulocytes. Thirty stem cells could rescue 50% of lethally irradiated mice, and 6 weeks after receiving the cells, about half of the circulating blood cells were from the donated stem cells.

Ron May

Irving Weissman. *"This is the end of the road that was the search for the stem cell."*

Jan Klein and Yukoh Aihara of the Max Planck Institute in Tübingen, West Germany, generated the monoclonal antibody that ultimately allowed the Stanford group to isolate a population of pure stem cells. "They were trying to find T cell precursors in the bone marrow and they gave us a whole set of antibodies," says Weissman. The German group's Sca-1$^+$ antibody