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Folder Title:
Global Warming: Articles/Reports [2 of 4] [1988-92]

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support Col. Mengistu

Soviet Union and Israel primarily a littoral (Sea). For the Soviets, old in Africa, a place of influence and power can flow into Kenya or to the countries south. For the Israelis, it is Arab states along the

the Soviets will finally learn that despite Ethiopia's geopolitical value, the game is up. Reportedly, Soviet officers have been pulled out of Asmara to avoid further captures.

The Israelis have also had their losses and their disappointments with Col. Mengistu and, as astute political observers, they too must see the handwriting on the wall. But they also persist. The Tigreans have cut or threatened the roads to Addis

starving millions who must have peace to survive? More practically, can they somehow tame the EPLF and get it to agree not to interfere with their concerns about the Red Sea? Therein lies the rub. The EPLF is the oldest continuously fighting guerrilla movement in the world. It has had very little help from anybody. Even forces as big as the Soviets and as adept as the Israelis should be cautious by now. And as

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Global Warming
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Every page of this prosperity will generate pages of regulation. Regulation in the Fed's good for at least a years, though it will do or the environment.

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that Mr. Bush and his ded to ignore science he economy for the n air. This is almost t the Democrats in

FIFTY REASONS TO DOUBT GLOBAL WARMING

1. Spencer, R., and Christy, J.R., 1990: "Precise Monitoring of Global Temperature Trends from Satellites." SCIENCE V.247 pp. 1,558-1,562. Shows no warming trend in atmosphere 1979-1988.
2. Lindzen, R., 1990: "Some Coolness Concerning Global Warming." Bulletin, American Meteorological Society. V.71 p.288-299. Shows conflict between model forecasts and reality.
3. Angell, J.K., 1986: "Annual and Seasonal Global Temperature Changes in Troposphere and Low Stratosphere." MONTHLY WEATHER REVIEW #107, pp. 1922-1930. Shows no statistically significant trend in N.H. stratospheric temp., despite CO2 buildup.
4. Ramanathan, V., et al., 1989: "Cloud Radiative Forcing and Climate." SCIENCE #243, pp. 57-63. Shows net effect of terrestrial cloudiness is cooling — not warming as models assume.
5. Karl, T.R., and Jones, P.D., 1988: "Urban Bias in Area-Averaged Surface Air Temperature Trends." BULL. AMER. MET. SOC. #70, pp. 265-270. Shows NASA temperature record has a 0.2 degree C. urban bias, cutting actual global warming to 0.2-0.3 degrees, last 100 years.
6. Michaels, P.J., et al., 1988: "Anthropogenic Warming in North Alaska?" J. OF CLIM. #1, pp. 942-945. Using atmospheric pressures to show non-urban temp. trends, shows no warming since 1948.
7. Michaels, P.J., et al., 1989: "Regional 500 Millibar Heights Prior to Radiosonde Era" Proceedings 6th Conf. Amer. Met. Soc. 1989. Extends atmos.press./temperature model to 1885, shows no net non-urban warming and substantial decline since 1940.
8. Elsasser, H.W., et al., 1984: "Global Climatic Trends as Revealed by Record Data." REVIEW OF GEOPHYS. #24, pp. 745-792. Shows all of the temperature rise since 1880 took place PRIOR to trace gas buildup, followed by substantial decline.
9. Sanson, J., 1989: "Antarctic Surface Temp. Time Series." J. CLIMATE #2, pp. 1164-1172. Shows no surface winter temperature trend at the pole, where GCMs predict it most strongly.
10. Seaver, W.L., et al., 1988: "Stat. Exam. of Sky Cover Changes in Contiguous U.S." J. CLIM. APPL. MET #26, pp. 88-95. Documents rising cloudiness offsetting predicted greenhouse effects.
11. Wigley, T.M., 1989: "Possible Climate Change Due to SO2 Derivative Cloud Condensation Nuclei." NATURE #338 pp. 365-367. Suggests sulphate cloud brightening explains lack of warming trend since 1940.
12. Barnett, T.P. and Schelsinger, M.E., 1987: "Detecting Changes in Global Climate Induced by Greenhouse Gases." J. GEOPHYS. RES. #92, pp. 14,722-14,780. Shows natural climate variability is greater than the ability of models to detect trends.
13. Balling, R.C., and Idso, S.B., 1989: "Historical Temp. Trends in the U.S. and Effect of Urban Pop Growth." J. GEO. RES. #84, pp. 3,359-3,363. Shows dramatic drop in U.S. Southeast mean winter temperatures over 60 years.
14. Karl, T.R., et al., 1988: "Urbanization: Its Detection and Effect on U.S. Climate Record." J. CLIM. #1, pp. 1,099-1,123. Shows that urban bias affects temperature record in towns as small as 2,580 in population and could explain entire "warming trend" of Hansen observations.
15. Michaels, P.J., 1985: "Anomalous Mid Atmospheric Heights and Persistent Thunderstorm Patterns over Florida." J. CLIMATOLOGY #5, pp. 529-542. Documents substantial cooling of middle layers of U.S. atmosphere, free of urban bias.
16. Solow, A.R., 1987: "Testing For Climate Change." J. OF CLIM. APPL. MET. #26, pp. 1,401-1,405. Shows climate trends not explained by CO2 trends.
17. Solow, A.R., 1988: "Detecting Changes Through Time." J. CLIMATE, pp. 290-296. Regression tests show unreliability of GCM models.
18. Bradley, R.S., et al., 1987: "Precipitation Fluctuations over N.H. Land Areas Since mid-19th Century." SCIENCE #237, pp. 171-175. Shows while temperatures changed little, precipitation has increased over all agricultural latitudes.
19. Scotto, J., et al., 1988: "Biologically effective ultraviolet radiation: Surface measurements in the U.S." SCIENCE #239, pp. 762-764. Shows UV-B radiation decreasing over the United States, contrary to ozone-hole scare.
20. Idso, S.B., 1984: "Empirical Evaluation of Earth's Surface Temperature in Response to Radiative Forcing." ARCH. MET. GEOPHYS. BIOCLIM SER. B., #34, pp. 1-19. Shows future warming will be far, far below model projections. Accurately predicted current model revisions.
21. Elsasser, H.W., 1984: "The Climatic Effect of CO2." ATMOS. ENVIR. J. #18, pp. 431-434. Shows that deep convection over tropical latitudes will limit warming far below projections.
22. Schlesinger, M.E., et al., 1987: "Climate Model Simulations of Equilibrium Response to Increased CO2." REV. GEOPHYS. #25, pp. 760-798. Shows Drastic inconsistencies between various GCM models.
23. Henderson-Sellers, B., 1987: "Modeling Sea Surface Temperatures CLIM. CHG. J. #11, pp. 349-359. Shows more realistic appraisal of ocean-current dynamics can cut warming by factor of 3.
24. Henderson-Sellers, B., et al., 1988: "Tropical Deforestation and Climate Change." CLIM. CHG. #13, pp. 43-67. Shows GCMs do not account for human impacts on Earth's surface.
25. Henderson, Sellers, A., 1987: "Climate is a Cloudy Issue." NEW SCIENCE #115 (1570) pp. 37-39. Shows general increase in cloudiness, suggesting climate cooling not warming.
26. Roeckner, E., et al., 1988: "Cloud Effects and Climate Modeling." NATURE #329, pp. 138-140. More realistic cloud modeling will slash warming forecasts.
27. Shaw, G.E., 1987: "Aerosols as Climate Regulators." ATMOS. ENVIR. #21, pp. 985-986. Shows ocean surface micro-organisms operate to regulate plankton, and climate effects through aerosols.
28. Charlson, R., & Lovelock, J.E., et al., 1987: "Oceanic phytoplankton, atmospheric sulphur, cloud albedo and climate." NATURE #326, pp. 655-661. Shows how phytoplankton regulate Earth's temperatures, suggesting CO2 buildups and declines may be more effect than cause.
29. Newell, R.A., et al., 1989: "Ocean Climate Records." MIT Technology Review, October 1989. Shows no change in global ocean climate record over 120 years in surface or air temperatures and no lagged effect.
30. Broecker, W.S., 1987: "Unpleasant Surprises in the greenhouse?" NATURE #328, pp. 123-126. Shows unfounded speculations on global warming have reached inordinate levels.
31. Lindzen, R.S., et al., 1982: "The Role of Convective Model Choice in Calc. Clim. Impact of CO2 Doubling." J. ATMOS. SCI. #39, pp. 1,189-1,205. The influence of failure to understand deep convection's role in cooling.
32. Newell, R.A., et al., 1978: "Long-Term Global Sea Surface Temperature Fluctuations and Their Possible Influence on Atmospheric CO2 Concentrations." PURE APPL. GEO. #116, pp. 351-371. Shows no change in global sea temperatures over a century.
33. Elsasser, H., 1986: "Surface Temperature Changes Following 6 Major Volcanic Episodes 1780-1980." J. CLIM. APPL. MET. #25, pp. 1,184-1,185. Shows climate more resistant to radiation shocks than thought.
34. Schneider, S.H., 1988 — on greenhouse effect: "1988 Drought, Cause and Effect or Media Event?" CLIM. CHANGE #13, pp. 113-115. Shows 1988 summer had no relation to CO2 warming and was misconstrued by media.
35. Hare, F.K., 1988: "Jumping the Greenhouse Gun." NATURE #334, p. 646. Warns policy-makers against premature action based on weak science.
36. Maddox, J., 1988: "Jumping the Greenhouse Gun." NATURE 334, 9. Ditto. Warns politicians from overreacting to insufficient science on GW issue.
37. Wood, F.B. Jr., 1988: "The Need For Validation of the U.K. Temp. Trends With Respect to Urban Bias." CLIM. CHG. #12, pp. 297-312. Shows how hard it is to remove urban bias from global records.
38. Wood, F.B. Jr., 1989: "Global Alpine Glacier Trends 1960-1980." J. ARCTIC ALP. RES. #20, pp. 404-413. Shows 55 percent of glacial ice now advancing, not melting, up from 5 percent in 1960. This is opposite to trends predicted by GCMs.
39. Reifsnnyder, W.E., 1989: "A Tale of 10 Fallacies." AGRI. FOREST. MET. A skeptic's analysis of what's wrong with GCMs by top Yale environmental scientist.
40. Trenberth, K.E., et al., 1989: "Origins of 1988 N.A. Drought." TRANS. AMER. GEOPHYS. U.N. #69, p. 1067. Shows 1988 heat and drought entirely caused by change in El Nino ocean current, not CO2.
41. Hansen, K., Karl, T.R., et al., 1989: "Are GH Effects Apparent in Climatic Record of Contiguous U.S. States (1895-1987)?" GEOPHYS. RES. LETT. #16, pp. 49-52. Shows "no significant trend" in U.S. temperatures in 93 years.
42. Namias, J., 1989: "Cold Waters and Hot Summers." NATURE #338, pp. 15-16. Shows 1988 temperatures had no connection with GW or CO2.
43. Idso, S., 1988: "GH Warming or Little Ice Age Demise?" THEORET. APPL. CLIMATOL. #39, pp. 54-56. Shows modest warming trend of 20th century likely due to climbing out of Little Ice Age cold.
44. Wood, F.B. Jr.: "1988 The Need For Systems Research on Global Climate Change." SYSTEMS RES. #5, pp. 225-240. Shows component compartmentalization approach on GCMs is inappropriate and may lead to inaccurate forecasts.
45. Green, K., et al., 1977: "Field Response of Photosynthesis to CO2 Enhancement." ECOLOGY #58, pp. 687-692. Shows how CO2 protects forests from SO2 (acid rain) deposition.
46. Carlson, R.W., et al., 1982: "Photosynthetic and growth response to fumigation with SO2 at elevated CO2." OECOLOGIA #54, pp. 50-54. Shows CO2 protects plants from SO2 deposition.
47. Bryson, Reid, 1988: "Civilization and Rapid Climatic Change." ENVIR. CONSERV. #15, pp. 7-15. A thorough debunking of the predictive power of the GCMs.
48. Grotch, S., 1988: "Regional Intercomparisons of GCM Predictions and Historical Climate Data." U.S. Energy Department Conference. Shows that models do not agree, nor can they explain recent climate cycles.
49. Slingo, A., and Slingo, G.M., 1988: "Response of GCM to Cloud Long-Wave Radiative Forcing." QUART. J. ROY. MET. SOC. #114, pp. 1,027-1,062. Shows cloud effects are completely ignored or misunderstood in GCMs.
50. Bryant, E.A., 1987: "Climate warming, rising sea level and retreating coastline, review and critique." AUSTRIAN GEOGRAPHY #18, pp. 101-113. Finds claimed sea-level rise neither confirmed or confirmable. Shows major areas where levels are falling.

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other Lebanese-based gunslingers, Syrian soldiers do not usually wear masks.) Second, the *Detroit Free Press* is owned by Knight-Ridder, not by Scripps-Howard, as asserted by TRB last week. Third, the fine print at the bottom of last week's table of contents page misstated the issue number as 25. It should have read: "Vol. 201, Number 26." Fourth, the headline on this item should be "Four Corrections."

LADIES' CHOICE:

Black Women Reluctant to Join Pro-Choice Forces

—*Los Angeles Times*, November 27, page A1

ABORTION: Blacks' Pro-Choice Role Increases

—same paper, same day, same story

GOLLY, ARE YOU SURE?:

Warsaw Pact Losing Its Edge, Sources Say

—*Washington Post*, December 2, page A21

WHITE HOUSE WATCH

GREEN THUMB

By Fred Barnes

On October 20 William K. Reilly, administrator of the Environmental Protection Agency, was rebuffed by the White House Domestic Policy Council. Reilly wanted to participate in a November meeting in Holland and announce that the United States would host a conference next year on global warming. No way, said the council (which consists of representatives of seven Cabinet departments, plus the EPA, the Office of Management and Budget, and White House aides). Not only that, but Reilly shouldn't even attend, council members said. His presence would only encourage others to show up. He'd legitimize a meeting of environmental dreamers who advocate overly stringent curbs on greenhouse gases, the source of global warming.

Reilly was chagrined but hardly immobilized. Four days later he and his wife went to the Kennedy Center with President Bush and the First Lady. They sat in the Presidential box to watch *A Few Good Men* starring Tom Hulse. As the two couples chatted, Reilly broached the subject of the meeting in Noordwijk, Netherlands, on

November 6-7. Bush said he thought Reilly should attend. So Reilly went. He didn't get to invite the world to a conference in the United States, but he did officially endorse limits on greenhouse gas emissions. A month later at the Malta summit, Bush announced the international conference in the United States next year to draft a treaty on global climate change. "We've now wrapped it up in a big bear hug," Reilly says.

Reilly is as clever an inside operator as you'll find in the Bush Administration. That's surprising because his background is environmental (he headed a small think tank, the Conservation Foundation, for 17 years), not political. On issue after issue he's swayed Bush and gotten his way. But what makes Reilly unique in an Administration with relatively little infighting is the passionate feelings he generates, particularly when he raises the issue of global warming. Reilly, 49, has serious enemies.

One is Richard Darman, the budget director. He and Reilly clashed in policy debates over Bush's clean air bill last spring. Darman argued for less rigorous environmental regulations than the costly ones advocated by Reilly. Later Darman was enraged by accounts of their disagreement—faulty accounts, he thought—in the *Wall Street Journal* and *New York Times*. He blamed Reilly, who'd taken notes at meetings, for leaking. Last August he wrote Reilly to say he'd no longer do any business with him. Darman skips White House meetings attended by Reilly.

On global warming, Darman's concerns are shared by other White House aides. They believe Reilly lacks the background in science, mathematics, or quantitative modeling to grasp the issue. "All of the predictions on global warming turn on theories of mathematics or modeling," says one official. "Reilly doesn't understand them." As a test, Darman once asked Reilly about "chaos theory." Reilly had never heard of it (John Sununu, the White House chief of staff, had). A more significant complaint involves policy. Darman, economic adviser Michael Boskin, and others think Reilly is pushing for economically ruinous restrictions to remedy an exaggerated problem.

Sununu is not a foe of Reilly's, but he has doubts about the projections of dire consequences from global warming. "We're in a situation where the rhetoric has gotten out front of the sciences," says a Sununu aide. "The more apocalyptic the forecast, the better." Sununu keeps up with scientific literature on global warming. D. Allan Bromley, Bush's science adviser, feeds him articles from science journals. One article circulated at the White House said that rather than a global temperature increase of nine degrees over the next 50 years, as some scientists have predicted, an increase of one degree over 30 years can be expected. Because projections vary so widely, Sununu says, "We're not ready to play the game of you-bet-the-world-economy. We're not ready to make big, big decisions."

Science advisers normally lack clout, but Bromley, a physicist from Yale, is a key figure in global warming policy. He got to know Bush when he served on Rea-

gan's White House Science Council. In 1987 Bush traveled to Yale to dedicate Bromley's new laboratory. Like Sununu, Bromley wants to move on global warming, but slowly. He doesn't dispute the greenhouse effect (nor does Darman). "There is no major difference [among scientists] in the general contention that if we continue to put greenhouse gases in the air at the same rate we are now, we'll eventually experience global warming," he says. Bromley wants more data. He talks excitedly about the White House meeting next spring of scientific, environmental, and economic experts on climate change. The experts will "get to know each other" and "improve the analytic tools," Bromley says.

Until he accompanied Reilly to the Netherlands meeting, Bromley was assumed to be wary of Reilly. Bromley, after all, had presided over the DPC session at which Reilly was urged not to go to Holland. His opposition, Bromley now says, was based on fear that the Netherlands meeting would overshadow the work of the Intergovernmental Panel on Climate Change. The United States is active in the panel's studies on global warming. Once it was clear the meeting wouldn't compete with the IPCC, Bromley became an enthusiast. At one point he called Sununu from Holland to chat about the resolution on stabilizing greenhouse gases. "If we did anything smart," says a Reilly aide, "it was inviting Dr. Bromley to Noordwijk. That's when his education began."

The anti-Reilly faction believes Bromley is now less skeptical about the threat of global warming. Bromley told the *Los Angeles Times* that the White House shift—from balking at a proposal to host a treaty-writing conference on global warming to Bush's proposing just that at Malta—was based on fresh scientific knowledge. "We know a lot more now than we knew even a few months ago," he said. This drew laughs at the White House. "The only advance was in Bromley's education," says a White House official. "He's just getting up to speed." Whatever happened, Reilly sees Bromley as a budding ally.

Reilly's success is all the more amazing because he has so few allies, even counting Bromley. On global climate change, the only senior official to side with him is Secretary of State James Baker. This paid off at Malta. Robert Zoellick, a Baker aide, was one of the officials who drafted Bush's proposals for the summit. In White House talks about the Malta agenda, the environment was scarcely mentioned. But when the White House issued a list of 21 proposals that Bush made to Mikhail Gorbachev, two were Reilly-inspired: the conference next fall "to negotiate a framework treaty on global climate change," and the White House meeting next spring "to discuss global climate change issues." On hearing the news, an aide rushed to tell Reilly. He already knew. "I've been talking to Zoellick all along," he said.

In shaping Bush's environmental policy, Reilly is skillful in exploiting action-forcing events, mostly meetings. The administration doesn't want to be embar-

assed at international gatherings. It needs a position, and Reilly offers one. Last winter Reilly grappled with the White House on CFCs, the chemicals that cause deterioration of the ozone layer. "The White House was determined to work the issue methodically through the Domestic Policy Council process," says a Reilly aide. Reilly insisted he should announce at a London conference in March that the United States would cut out CFC use entirely. Bush agreed. Absent the London meeting, the issue would probably still be under discussion.

In May Reilly was scheduled to attend a global warming conference in Geneva. Again, the administration needed a position. Reilly urged Bush to embrace the concept of negotiations for international rules to cope with climate change. Again, Bush agreed. In a statement, Bush backed "formal negotiations on the establishment of a framework convention on global climate." Sununu sent a cable to the American mission in Geneva. "We should seek to develop full international consensus on necessary steps to prepare for a formal treaty negotiating process," he said. Then there was Noordwijk, for which Reilly got the commitment to restrict greenhouse gas emissions. And finally Malta, at which the plan to host a treaty conference was unveiled.

Smooth as Reilly is, there's a soft spot in his performance. He gets too much credit, Bush too little. Bush really wants to be known as the "environmental President." Instead, he's known as the President with an ardent environmentalist at the EPA. That's not the same. One reason the DPC blocked Reilly's bid to announce the U.S. role as conference host next year was that officials wanted Bush to announce it. He did, but Reilly got more coverage for having been rebuffed. "That's symptomatic of Reilly's biggest problem: he's obsessed with p.r.," says a Bush aide. Good press is fine. If it comes at the President's expense, it's mighty risky. •

East Germans get some payback.

MARXED MEN

By Robert Darnton

BERLIN

Can East Germany find a "third way" between capitalism and socialism? The question was laid squarely on the table at the Institute for Advanced Study in Berlin, and around it gathered a group of social scientists, the first East-West meeting of its kind since the opening of the Wall on November 9, and probably the first since the Wall went up 28 years ago. The chairman introduced the East Berliners as members of "what I believe

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Activity in the other direction includes visits to the Soviet Union, under the same program, by a half-dozen American sociology lecturers. Among them are Neil Smelser of the University of California at Berkeley and Kohn of Johns Hopkins, who will be going to Moscow in December. Soviet universities are also soliciting American Fulbright lecturers.

Kohn adds that Cornell University has made a unique arrangement with Igor Kon, the Soviet Union's leading expert on U.S. sociology, who will have a 2-week-per-year visiting professorship. Kon, says Kohn, has managed to keep abreast of the field while working at an institute in Leningrad—mainly by obtaining review copies of American books. He cleverly managed to convey the meat of the scholarship by beginning and ending his reviews with "Marxist diatribes," says Kohn. So knowledgeable is the Soviet sociologist that when he came to the ASA convention in August 1988, he was able to identify the main accomplishments of every author to whom he was introduced.

Kohn has also been involved in initiating a series of joint conferences, which have been in the planning stage since before Gorbachev took over. IREX and the ASA are supplying funds to support five U.S.-Soviet conferences that are being held alternately in the United States and the Soviet Union. The first, in 1987, was a conference on sociology and the psychology of work, held in Vilnius. This December there will be a conference in Moscow on public opinion research.

All this cross-fertilization—indeed, the blossoming Soviet interest in sociology generally—is regarded as good news both for the discipline and for U.S. Sovietologists in particular. Shelley notes that "academic positions for sociologists trained in Soviet studies have gone unfilled in recent years" and expects that to change.

Further, William V. D'Antonio, head of the ASA, says he hopes eventually to see U.S. students doing graduate work in the Soviet Union.

For its part, the ASA is looking toward bringing over another crop of Soviet students next year, this time including political scientists and economists, with the cooperation of the American Political Science Association and the American Economics Association. "Soviets are acknowledging that American sociology is where it's at," says D'Antonio. Shelley agrees. She reports that the United States—where sociology is a heavily quantitative field—was chosen as the destination for the 17 students because "French sociology is seen as too qualitative and German sociology too philosophical."

■ CONSTANCE HOLDEN

Global Warming: Blaming the Sun

A report that essentially wishes away greenhouse warming is said to be having a major influence on White House policy

A SLIM, UNREFEREED REPORT that many scientists have dismissed as biased and misleading is said to be at least partly behind the White House's recent temporizing on climate change.

And that is causing consternation among climatologists and other greenhouse experts, who are dismayed that this 35-page document by the George C. Marshall Institute, a Washington, D.C., think tank—rather than one of the massive, carefully researched and reviewed expert reports of the past several years—seems to be holding sway in the upper echelons of the Administration.

The report, "Scientific Perspectives on the Greenhouse Problem," is by three prominent scientists—William A. Nierenberg, director emeritus of Scripps Institution of Oceanography; Robert Jastrow, founder and former director of the Goddard Institute for Space Studies; and Frederick Seitz, president emeritus of Rockefeller University and past president of the National Academy of Sciences. The trio's other major foray into public policy was a vigorous defense of the Strategic Defense Initiative a few years ago.

Summing up the abundant uncertainties that surround greenhouse models and predictions, the authors say it is too soon to take any actions to reduce greenhouse gases. And by their reckoning, there is little need to. They argue that there is no evidence that the modest temperature rise of 0.5°C that has occurred this century is correlated with emissions of greenhouse gases, and they predict that decreased solar activity in the next century will lead to a cooling trend likely to offset any greenhouse warming. All of this is couched in ample caveats, but the underlying message is that the entire problem has been overblown.

Several scientists are up in arms. Steve Schneider of the National Center for Atmospheric Research, for one, has denounced

the report as a political document. Nearly 6 months after its release, he is still arguing about the report's scientific basis with Nierenberg, via letters.

"Noisy junk science," says Jerry Mahlman, director of the National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory, where one of the major greenhouse models was developed.

A number of other respected climate researchers have suggested that the National Academy of Sciences review the study. The Academy is likely to weigh into the ruckus in some way—a couple of committees are looking at the report—though it will stop short of giving the document a formal review.

At the Environmental Protection Agency, Alan Hecht, deputy assistant administrator in the office of international activities, says he has "real problems" with the study and recently passed a critique of it onto EPA administrator William K. Reilly. As part of this informal review, Hecht asked Schneider for his comments on the report; Schneider's less-than-flattering letter is now circulating in the scientific community and on Capitol Hill, where Senator Albert Gore (D-TN), for one, is concerned.

The report does have its scientific supporters, including meteorologists like Jerome Namias of Scripps, and Richard Lindzen and Reginald Newell of Massachusetts Institute of Technology—distinguished scientists whose major work is largely outside the greenhouse field. On 23 September, Lindzen and Namias wrote to President Bush extolling the merits of the Marshall report and citing its conclusion that "current forecasts of global warming for the 21st century are so inaccurate and fraught with uncertainty as to be useless to policy-makers."

The message apparently has gotten



High-level proponent. William Nierenberg, one of the authors, briefed White House officials.

Scripps

through, if not to Bush then to his chief of staff John Sununu, who, it is widely believed, is quite taken with the report. Says Schneider: "Sununu is holding the report up like a cross to a vampire, fending off greenhouse warming."

Just what impact the report has had on Administration policy is difficult to pin down, and Sununu's office is mum on the subject. But it has been widely reported that Sununu tried to block EPA head Reilly from attending an international meeting on climate change at The Hague in early November. At that meeting, the United States refused to commit itself to cutting emissions of carbon dioxide.

Nierenberg, for his part, has been working hard to get the message into the White House. He personally briefed senior Administration staff, including representatives from the White House Office of Cabinet Affairs, the White House Office of Policy Development, the Council of Economic Advisers, and the Office of Management and Budget.

"I was impressed with the report," says Juanita Duggan, special assistant to the President in the cabinet affairs office. "Everyone has read it. Everyone takes it seriously. We have a coherent policy in the federal government that is not inconsistent with the Marshall Institute report."

"It is well worth listening to," adds Paul Roelling, a senior analyst in the White House Office of Policy Development. "They are eminent scientists. I was impressed."

But White House Science Adviser D. Allan Bromley, who was not yet in place when the report was released, seems to be distancing himself from it. "It has a distinguished group of authors, but there is no general consensus on the details and it has not been peer-reviewed," he said in a statement to *Science*.

All the critics concede that the first part of the report is a good description of the scientific uncertainties surrounding predictions of greenhouse warming. And everyone, not surprisingly, agrees with the report's plea for \$100 million for more research.

Where the report veers from the mainstream is with the assertion that the warming trend of the past century was probably caused by increased solar activity and not by an accumulation of greenhouse gases—and that, ipso facto, the greenhouse warming next century will be small, perhaps 1°C.

The basis of the report is an analysis of this 0.5°C warming trend, which, the authors point out, does not follow the curve of rising emissions of greenhouse gases. In-



Jay Dickman

Leading opponent. A critique of the report by climatologist Stephen Schneider has been widely circulated.

stead, they look for natural causes to explain the rise and find that solar variation mirrors it rather well. The authors' underlying assumption is that if they can break the connection between that 0.5°C rise and accumulating greenhouse gases, then all bets for future warming are off.

No such luck, says Schneider, who thinks they are setting up a straw man. "Could the sun have done it? Sure," he says, adding that a variety of natural phenomena could explain the temperature rise of the last century. But that, he adds, says nothing about the future greenhouse warming.

"There are uncertainties, but I can't think of any combination of them that could conspire to make the problem go away," says NOAA's Mahlman. Hypotheses are fine, he adds, "but to advise the White House on the basis of this type of argument? Give me a break. That is not responsible."

The reason people are worried about greenhouse warming, Schneider, Mahlman, and others say, is not because of the 0.5°C temperature rise during the past century but because emissions of carbon dioxide, chlorofluorocarbons, and methane are clearly increasing. And it is dead certain that if enough of these greenhouse gases are released into the atmosphere, where they trap heat, global temperatures will rise. The only question is how much, and by when.

Then the Marshall Institute pulls out another card. After analyzing the historical record of solar activity, which can be inferred from carbon-14 in tree rings, the authors predict that solar activity will decrease in the next century, leading to a mini Ice Age that will offset any greenhouse warming.

Preposterous, say solar physicists like John Eddy of the University Corporation for Atmospheric Research in Boulder, who calls their extrapolation "very shaky" at best. We simply don't have the ability to predict future solar activity, he says.

Curiously, Eddy was one of the sunspot

experts Jastrow consulted in writing the report. "Bob Jastrow would call me at work and at home on Saturday and Sunday. I would say 'No, no, you can't make that prediction.' I was shocked when I saw what came out."

Jastrow says the emphasis his colleagues are putting on the solar variability discussion is a "distorted" reading of the report, maintaining, along with Nierenberg, that the solar variation hypothesis is just a minor part of their argument.

"Then why did they put it in?" snaps a senior Academy official.

Their bottom line, Jastrow insists, is simply that no scientific conclusion can be drawn about the future greenhouse warming, "and we have time to find out." They assert that with \$100 million for supercomputers, answers to these questions will be forthcoming in 3 to 5 years, so why not wait before taking precipitous policy action?

"No one in his right mind would say that," counters Hecht at EPA, who, along with everyone else *Science* spoke with, says it will take a decade or more to address these questions.

In 25 years, Mahlman adds, "Congress will still be asking us questions we can't answer. I don't care if you pour \$100 billion at the problem."

The biggest gripe people have with the report is that the authors, in summoning uncertainty to their cause, fail to acknowledge that it cuts both ways. Explains Schneider: "What we don't know is just as likely to make it worse as better."

Solar variability is a case in point. Schneider offers a counter scenario to that in the Marshall Institute report: That during the past 100 years, solar energy output was decreasing rather than increasing. And without that natural cooling, which masked the greenhouse signal, the earth's temperature would have warmed up twice as much. "It's pure speculation," he adds, but since no one really knows what the sun was doing 100 years back, "it is just as likely as theirs." Moreover, says Schneider, if the earth warms up 2° to 4°C, as models usually predict, "it will swamp anything the sun has done in the past 100 years."

John Perry, a meteorologist and staff director of the Board of Atmospheric Sciences and Climate at the National Research Council, agrees. "If the report had just said, in an evenhanded way, 'don't rely on the models because there are hellacious uncertainties,' we all would have applauded. But the way it comes across is that all the uncertainties are on the downside. I don't think that is very democratic."

■ LESLIE ROBERTS

Global Warming
file

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Warm summit climate yields talk of environmental treaty

WASHINGTON (CSM) — Buried among the ideas President George Bush offered Soviet Chairman Mikhail Gorbachev in Malta was a proposal to begin negotiating a treaty next fall to deal with the warming of the global climate.

It marks the strongest White House commitment to international action yet.

The White House has been arguing for months that it is a leading world force for dealing with global warming, although it has been cast in the role of dragging feet.

This week, the White House strengthened its case.

The president's science adviser, D. Allan Bromley, in a speech Tuesday, predicted an international framework convention — which sets the terms of a treaty — within the next 18 months.

Bush also used the proposals to Gorbachev to announce an international meeting this spring of the senior science, economic and environmental officials of what Bromley calls "a large number of the world's nations."

The purpose of this meeting is to put together the world's leading policymakers on the issue to decide how to use the best available expertise on global warming, its effects and its costs.

The White House has been hesitant to take strong policy action against global warming without a better understanding of how serious the problem is and what the responses will cost the economy.

The most prominent skeptic has been chief of staff John Sununu, an MIT-trained engineer.

One administration official, however, says that White House officials, including Sununu, are open-minded on the issue and that many positions are changing as familiarity grows with the science of global warming. Sununu is at least not among the most skeptical — those who see no substantial suggestion of



Mikhail Gorbachev and George Bush reach to clasp hands as they met Dec. 2. A treaty to deal with global warming was among the topics the two discussed during their summit. AP photo

a significant greenhouse effect, says Warren Washington of the National Center for Atmospheric Research. Washington discussed his research with Sununu recently by telephone.

"I don't think you can put Sununu in the camp (that believes) it's flaky or based on bad science," he says.

Bromley, who has been in the White House less than two months, is the administration's lead official on climate change. His own view is that the United States should not wait for more technical knowledge before taking many actions — "in effect as an insurance policy against the possible effects of global warming."

Criticism of the Bush administration for excessive caution was intense last month. The U.S. delegation to a meeting on global warming in Noordwijk, the Nether-

lands, led the resistance to a Dutch-backed agreement to freeze carbon dioxide emissions by the year 2000.

Critics, including some Republican senators, accused the administration of stymieing urgently needed action while Europe took the lead.

The White House response is that it has been committed to action — but through the United Nations-sponsored Intergovernmental Panel on Climate Change. The IPCC offers a methodical, deliberate process for forming policy. Its three working groups are also headed by the United States, the Soviet Union and Britain — three of the more conservative nations in global warming policy.

The final reports of the IPCC working groups are due in November 1990.

A DIGEST OF NEWS FROM MIT

MIT Reporter

Has the Globe Really Warmed?

Since the mid-nineteenth century, merchant-marine captains of all nations have been required to log air and water temperatures every six hours for weather services such as the British Meteorological Office. Crews on each watch have hauled water from the sea in standard buckets, dipped in standard thermometers, recorded the data, and, generally, radioed it back. The result is an incredible storehouse of information about global temperatures since the Industrial Revolution.

Reginald E. Newell, Jane Hsiung, and Wu Zhongxiang of MIT, along with colleagues from the "British Met," as they call it, have collected and analyzed these data. MIT Press intends to publish them in the *Global Ocean Surface Temperature Atlas*. One of the most striking results suggested by the data is that there appears to have been little or no global warming over the past century.

The advantage of ocean readings is that they are not contaminated by urbanization: the growth of structures and roads even in the small towns where many weather stations are located can raise temperatures, Newell explains. Unfortunately, ocean readings are not entirely reliable either. One of the chief problems is that prior to World War II, the buckets for collecting water were made of canvas. As it was hauled onto the deck, the water could be cooled by wind and heated by sun. Christopher Folland of the British Meteorological Office and Jane Hsiung attempted to correct for such problems, for example by measuring the cooling of the buckets at different wind speeds.

Gauging long-term temperature change required more analysis. First, Newell, Hsiung, and Wu needed to measure the cooling caused when volcanoes inject dust and gases into the atmosphere. They discovered an intriguing piece of work that measures the atmospheric "turbidity" from the dust over the past century. Beginning in the late 1800s, weather stations have used devices known as Campbell-Stokes sunshine recorders that burn a track in a paper card each day, indicating how long the sun was up. Researchers at the University of Mainz in West Germany collected and analyzed numerous such cards, noting particularly the beginning and end of the burn, which correspond to sunrise and sunset. Whenever atmospheric turbidity rose, the burn started later and ended earlier. The weather station in Sonnblick, Austria, almost unaffected by urban pollution at an elevation of 3 kilometers in the Alps, provides a record of turbidity back to 1887.

Newell, Hsiung, and Wu also assessed the periodic change in tropical temperatures caused by the El Niño-Southern Oscillation, a complex of ocean and air currents. Factoring out the effects of the El Niño-Southern Oscillation and the cooling caused by volcanoes, they found that global temperatures have warmed by only 0.2°C over the past century, which is within the estimated margin of error. In other words, the results leave open the possibility that there has been no warming at all.

In a paper based on the same data in *Geophysical Research Letters*, Nicholas E. Newell (Reginald Newell's son) joins the other researchers to examine a third temperature variation: a roughly 22-year cycle of warming and cooling that has occurred

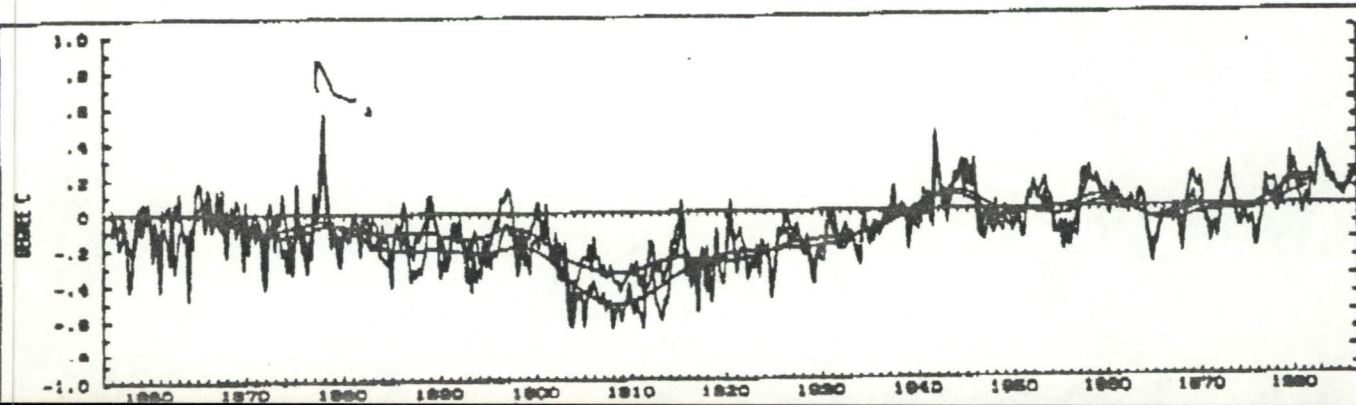
since 1856, when the marine data begin. This may be caused by the 22-year solar magnetic cycle, during which the sun's magnetic field changes polarity and then returns to its original state. The magnetic cycle is reflected in changing sunspot patterns. When the authors subtract from the basic temperature record all cycles of less than 26 years—the chief one being this 22-year warming-and-cooling pattern—they find "no appreciable difference" between temperatures in 1856 and 1986.

Both studies are at odds with some other research. For example, using land data that attempt to factor out effects of urbanization, James Hansen of NASA Goddard Space Flight Center and Sergei Lebedeff of Sigma Data Services Corp. conclude that the globe has warmed 0.5°C to 0.7°C over the past century.

The conflict is far from resolved. Unfortunately, despite all the models of how global climate may change, there is relatively little funding for research on the actual record. A case in point: though the *Global Ocean Surface Temperature Atlas* has passed peer review and been accepted by MIT Press, so far no sponsor has been willing to provide the modest subsidy that such a technical book often requires for publication—in this case \$60,000.

The *Global Ocean Surface Temperature Atlas*, accepted for publication by MIT Press, includes this chart plotting the sea surface temperature (blue line) and night marine

air temperature (red line) since 1856. Researchers who have analyzed the data conclude that there has been little or no overall warming.



No Global Warming Signs Spotted

WASHINGTON, March 29 (AP) — Data from weather satellites show no evidence of global warming in the 1980's, scientists say, but it will take at least another decade of measurements to draw a firm conclusion.

The data, collected from 1979 through 1988 by the Tiros-N series of weather satellites, proved that the earth's temperature can be measured accurately by instruments probing the atmosphere from space, two scientists say in a paper to be published on Friday in the journal *Science*.

"We found that the earth's atmosphere goes through fairly large year-to-year changes in temperature and over that 10-year period we saw no long-term warming or cooling trend," said Roy W. Spencer of the Marshall Space Flight Center in Huntsville, Ala.

Dr. Spencer's co-investigator, John R. Christy of the University of Alabama at Huntsville, said that there were temperature swings "that can be quite dramatic" during the decade, but that on a global basis, the thermal changes tended to even out.

A Net Effect of Zero

"The northern hemisphere goes up slightly during those 10 years and the southern hemisphere goes down slightly," said Dr. Christy. "The net effect for the globe is basically zero."

Detecting a climate trend, the scientists said, will take at least another decade of satellite measurements.

"There is no guarantee that if you take a 10-year segment out of a long time that you'll get the overall trend," said Dr. Christy. "The data cannot be used to say we've got an enhanced greenhouse effect." He said that the findings "are enough to tantalize us, but this is just a start" and that satellite measurements are continuing.

The new data is the first on global temperatures from satellites to enter the scientific debate about the greenhouse effect, Dr. Spencer said. Most other studies of temperature trends, some extending over more than a century, have come from the records of ground-based thermometers. These readings, he said, do not fully reflect the global temperature because there are very few temperature measurements for vast areas of the earth's oceans.

Debate Focuses on Measurement

Some experts say the earth is beginning to warm as a result of carbon dioxide and other gases dumped into the atmosphere over the last 150 years of industrial civilization. This warming, the enhanced greenhouse effect, is a matter of controversy in the scientific community because of the difficulty in measuring small climate trends over a long period of time.

Eric J. Barron, director of the Earth System Science Center at Pennsylvania State University, said the analysis of the Tiros data by Dr. Spencer and

able" in the global warming debate, and he agreed that 10 years is too short a period to determine a climate trend.

What is important from the study, said Dr. Barron, is that it proves studies by satellites eventually may settle the controversy.

Dr. Christy and Dr. Spencer spent two years analyzing old weather satellite records to come up with the decade of temperature measurements.

The scientists used data from Tiros instruments that measure microwave radiation caused by heating of the first six miles of atmosphere above the earth's surface. Accuracy of the data was verified by instrument calibrations and by comparing it with known

temperature deviations detected by ground-based thermometers.

Temperature Rises Detected

Dr. Spencer said the data detected a sharp rise in Pacific Ocean temperature in 1983 and 1987, years when the weather phenomenon El Niño was in play. These events had been detected and analyzed by other instruments. The Tiros data also detected a cooling in the tropics from 1984 to 1986, and a "warm event" in the northern hemisphere during 1987 and 1988.

On a global basis, the study found, the warmest years, in descending order, were 1987, 1988, 1983 and 1980. The coolest years were 1984, 1985 and 1986.

Scientist in 'Cold Fusion' Project Reasserts Claim and Is Disputed

By WILLIAM J. BROAD

Special to The New York Times

SALT LAKE CITY, March 29 — In his first appearance at an open scientific meeting in many months, a scientist who claimed to have achieved "cold fusion" presented no new data today that would be likely to persuade skeptics that the disputed findings were real.

The researcher, Dr. B. Stanley Pons, chairman of the University of Utah chemistry department, said at the meeting here that he had observed excess heat from a simple table-top apparatus and suggested that commercial applications of the process were possible.

But his heat-measuring methods came under attack during a discussion session, and Dr. Pons avoided a detailed reply.

Two hundred or so believers in cold fusion, curious onlookers and skeptics gathered for a three-day conference marking the first anniversary of the announcement by Dr. Pons and Dr. Martin Fleischmann, of the University of Southampton in England, that they had achieved fusion in a simple table-top apparatus at room temperature.

Nuclear fusion is the force that powers the sun, the stars and hydrogen bombs, fusing atoms together rather than breaking them apart, as nuclear reactors do. The process frees vast amounts of energy, but usually requires temperatures of millions of degrees to get started. The controlled release of "hot" fusion in huge machines of vast complexity has eluded scientists for decades.

Although the cold fusion field has been ridiculed and scorned by many scientists, and its ranks have thinned considerably, enthusiasts here contend that prejudice is blinding many researchers to the work's merit.

"The possible technological implications were, and are, enormous," said Dr. Fritz G. Will, head of the National

Cold Fusion Institute, a nonprofit corporation founded by the University of Utah that is sponsoring the conference.

But in opening the program, Dr. Will also alluded to dashed hopes that the table-top apparatus unveiled a year ago could rapidly evolve into a font of nearly limitless energy and profit.

"What was originally believed to be simple experiments that could be readily reproduced in other laboratories," he said, "turned out to be complex phenomena that defied confirmation in many laboratories and which cannot be explained on the basis of classical nuclear physics."

Dr. Will estimated that 40 to 50 researchers in the United States were still actively working on cold fusion research, 20 of them at the institute.

Heat Attributed to Fusion

In their announcement a year ago, Dr. Pons and Dr. Fleischmann said they had used a test tube fitted with palladium electrodes and filled with heavy water. An electric current was then passed through the electrochemical cell, causing excess heat that was attributed to nuclear fusion.

Such a process could revolutionize the world's production of energy, if it could generate great heat. But hundreds of scientists failed to duplicate the Pons-Fleischmann process. In a report today in the journal *Nature*, for example, Dr. Michael H. Salamon of the University of Utah and colleagues reported that they had measured no nuclear byproducts from Dr. Pons's and Dr. Fleischmann's own equipment.

Today Dr. Pons outlined in some detail his team's work at measuring heat produced by the electrochemical cells, asserting that excess heat was generated by "a large number" of palladium electrodes.

A26 FRIDAY, MARCH 30, 1990

THE WASHINGTON POST

Satellites Find No Evidence of Global Warming

Associated Press

Ten years of temperature measurements by weather satellites have failed to find any evidence of global warming from the greenhouse effect, scientists said in a report published today, but they added it will take at least another decade of measurements to draw a firm conclusion.

The data, collected from 1979 through 1988 by the TIROS-N weather satellites, proved that the atmosphere's temperature can be measured accurately by instruments probing from space, two scientists say in a paper in the journal Science.

"We found that the Earth's atmosphere goes through fairly large

year-to-year changes in temperature and over that 10-year period we saw no long-term warming or cooling trend," said Roy W. Spencer of the Marshall Space Flight Center in Huntsville, Ala.

Spencer's co-investigator, John R. Christy of the University of Alabama, Huntsville, said there were temperature swings "that can be quite dramatic" during the decade, but, on a global basis, the thermal changes tended to even out.

"The northern hemisphere goes up slightly during those 10 years and the southern hemisphere goes down slightly," said Christy. "The net effect for the globe is basically zero."

Conventional temperature measurements have found the 1980s to

have been the warmest decade on record but also do not show a strong warming trend within the decade.

Detecting a climate trend from space, the scientists said, will take at least another decade of satellite measurements.

"There is no guarantee that if you take a 10-year segment out of a long time, that you'll get the overall trend," said Christy. "The data cannot be used to say we've got an enhanced greenhouse effect."

Christy said the findings "are enough to tantalize us... but this is just a start" and satellite measurements are continuing.

"By the turn of the century, we should see a trend," said the scientist.

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COMMENTARY

WEDNESDAY, DECEMBER 5, 1990

**WARREN
BROOKES**

Study in political science

First of three articles.

On June 25, 1990, David Pierpont Gardner, president of the University of California, received a warning letter from Albert Meyerhoff of the Natural Resources Defense Council. The NRDC authored the Alar scam of 1989, and its members were the main promoters of the Big Green initiative to ban all pesticides, defeated 2-1 on Nov. 6.

Mr. Meyerhoff had learned the university's agriculture department was preparing a study of the Big Green's impacts on state agriculture. He implied that, because the University of California is "a recipient of both federal and state funds" and because "courts have consistently held that public funds may not be used . . . to influence legislative campaigns," the university could find itself in court.

A meeting between NRDC and Mr. Gardner was followed by an Aug. 9 memorandum of understanding. The university agreed to conditions on this research ensuring that the anti-pesticide viewpoint (no matter how frivolous) was equally presented.

Mr. Gardner received a simultaneous threatening letter from State Sen. Nicholas Petris and Assemblyman Robert Campbell. The letter said, "We strongly urge you to reconsider this research project." The letter added ominously, "It is evident that we are entering a period of austerity in which various institutions will be asked to eliminate programs."

Two weeks later, Kenneth Farrell, University of California vice president for agriculture, discouraged faculty members from publishing their findings. A compromise was finally reached, and in late October a carefully worded research paper by three faculty members warned that a pesticide ban could have serious consequences for the state's food industry, but made no mention of Proposition 128.

While the UC agriculture department was almost silenced, Big Green took its biggest hits from

three of UC's most prominent cancer researchers — Dr. Bruce Ames, Dr. Lois Gold and Tom Jukes — who told the world what food toxicologists universally understand: Pesticide residues on food have a biological risk of zero, and Big Green was the legislative equivalent of the Alar scam.

But all three of these top researchers have been savaged for their outspoken stands. Drs. Ames and Gold, who finally were recognized by Science magazine and the National Academy for their research that blows away the premises of rodent testing, now are under attack by researchers who are funded to do such tests.

This ugly episode demonstrates why scientists like Dr. Ames now believe that one of America's most potent assets, its massive lead in basic science and technology, now is being threatened by politics, which is not only misallocating scientific resources but is undermining the credibility of the profession.

The overwhelming share of funds for scientific research now come from government — federal and state. This means the direction and scope of scientific effort is increasingly shaped by the political agenda of the country.

In the past, this meant a tendency to put too much money into defense and space, and perhaps to skew too much into cancer and not enough into less-popular disease issues. Yet on balance, those distortions did not in any significant way slow the relentless tide of U.S. scientific exploration but reinforced it.

But now the political agenda has changed, from unrestrained pursuit of technological breakthroughs, to environmentalism and a Luddite fear of new science, technology and growth, itself. Where chemical and biological scientists once were saluted for quadrupling U.S. agricultural productivity, they now are under research attack for allegedly poisoning our food and water chain. Where geniuses of biogenetics once were promising breakthroughs in everything from agriculture to medicine, they now are facing boycotts from ice cream makers and dairy state politicians and kooky ecogadflies like Jeremy Rifkin, and have to hold conferences like the one this week to defend their research methods. (See tomorrow's column on bovine sematropin.)

Furthermore, a growing share of funding is going to environmental research, which itself is conditional upon the perspective of the researcher, which is to say anti-growth, anti-technology. For example, if you are a climatologist who is skeptical of the claims of global warming, you won't get any part of the \$1 billion the United States will spend on climate change research this year. Worse, if you do get the grants and your research fails to support the policy thesis, you face non-renewal, and even difficulty in getting your research published, let alone used.

Congress spent \$540 million having 700 of the nation's best environmental scientists, agronomists, water and soil chemists, study the relationships between sulfur dioxide deposition (in acid rain) on plants, trees and lakes. When their report failed to support the president's and the environmentalists' policy prescriptions, they simply were ignored — or worse, abused.

When the Centers for Disease Control studies of dioxin agreed with research around the world that shows it could not have caused cancer in Vietnam veterans, the Veterans Administration and Congress simply paid off those whose average dioxin concentrations are the same as the nation's.

When case after case of alleged illness due to atomic testing fallout was thrown out of court because they could not survive the expert testimony of scientists from the National Academy of Sciences and the National Cancer Institute, Congress simply declared 200,000 people victims whose average exposure was barely above natural background.

Yet, when scientists do try to challenge this nonsense in public, they are immediately attacked as "shills for industry," even when their research was publicly funded. To make sure they know where their political bread is buttered, there is a none-too-subtle war being waged to make all private (that is to say non-political) funding of research too suspect to be accepted by academic or research institutions.

Fortunately, there are signs that the science community now recognizes the threat of this growing political censorship and funds misallocation and is fighting back.

They see a Clean Air Act that will spend nearly five times as much per year pursuing a few hundred theoretical cancer risks as the nation spends for its entire health research budget on 1 million premature deaths. Rules are routinely made that cost \$400 million per single cancer risk avoided. The total budget of the National Cancer Institute is \$1.8 billion for 500,000 deaths.

They see all this, and they wonder what the president's estimable science adviser, Alan Bromley, and White House Chief of Staff John Sununu, himself a first-rate scientist, will do about it, because I have a hunch scientists would really like to help. In the meantime, they have to take the eco-freaks seriously, because the press and the administration still do, even as the public increasingly and clearly does not.

see BROOKES, page G4

EPA backs new plan to halt global warming

By Joyce Price
THE WASHINGTON TIMES

The Environmental Protection Agency says it "fully supports" a proposal that would take a market approach to global warming and give nations flexibility in deciding how to control greenhouse gases.

The plan, prepared by a subcommittee of the Domestic Policy Council Working Group on global change, would not set mandatory reduction levels for emissions of carbon dioxide and other fossil fuels. Instead, it would allow nations to buy and sell emission rights, provided the transactions kept them within overall global warming performance standards, which would be set for each country and the world.

"It's a very creative approach and we're very enthusiastic about it," said EPA spokesman Dave Cohen. "With this plan, you can still get reductions in emissions. But it offers flexibility you might not get under a more rigid plan."

The plan recently was submitted to the Intergovernmental Panel on Climate Control, an international group that will make recommendations about what nations should do to reduce potential problems of global warming.

Allan D. Bromley, White House science advisor and chairman of the working group, said the proposal "is not part of any formal policy at this

point" and is merely one of a number of response options being considered.

An EPA official, who asked not to be identified, said, "the ideas in this proposal reflect input from a variety of agencies and clearly reflect overall administration policy."

The plan was drafted by Assistant Attorney General Richard Stewart, who is an environmental lawyer. The EPA, the State Department and White House science advisory staff also were involved, the official said.

The official acknowledged there were other global warming proposals before the IPCC, but said this plan was the primary focus. He said he expected it to be discussed extensively at an IPCC conference to be held in Washington next month.

Ambassador Peter de Vos, a deputy assistant secretary of State who is knowledgeable about the plan, said, "It's... an idea many people feel has possibilities as a way of achieving our goals."

In the greenhouse effect, the atmosphere traps some sunlight in the form of heat, rather than letting it all escape into space. With build up in the atmosphere of certain gases, such as carbon dioxide, methane, and chlorofluorocarbons, more heat is trapped.

Some scientists predict that if industrial production and fossil fuel use continue at current levels, it will result in a global temperature in-

crease of 4 to 6 degrees Fahrenheit during the next century. Warming, they say, could upset climate patterns, turning "breadbasket" farming areas into deserts. It could also melt polar ice, flooding coastlines.

But there also are many experts who either reject the global warming theory outright or say that warming, if there, is any, won't amount to much.

Patrick J. Michael, a professor of environmental sciences at the University of Virginia, said, "it appears they are predicting too much warming. I feel there's a large body of evidence that is, perhaps, being ignored in the arguments for drastic action."

Because there's so much uncertainty about global warming, some top administrative officials, including White House Chief of Staff John Sununu, have opposed some countries' calls for a 20 percent cut in 1988 carbon dioxide production levels. Excess carbon dioxide, produced by burning petroleum, coal and natural gas, is responsible for 50 percent of the atmospheric pollution that traps solar radiation and contributes to atmospheric warming.

"Mr. Sununu's concern has been that the computer models used to make these global warming forecasts have not been scientifically tested to the point of making trillion-dollar decisions," Sununu spokesman Ed Rogers said.

Unlike previous proposals, the new plan does not single out carbon dioxide for proposed controls. Instead, it calls for establishment of an overall performance goal — or "global warming potential index" — and it would be up to each nation to decide how to meet it. In setting an index, all resources that affect global warming would be considered.

The concept also includes provisions for "international trading" of global warming liabilities ("sources") and assets ("sinks").

Columnist Warren Brookes wrote: "The United States might be willing to pay Brazil for preserving the Amazon rain forests [warming reducers] and use those 'sink credits' to allow more carbon dioxide emissions from the United States."

John S. Perry of the National Academy of Sciences said the trading concept is similar to a program offered by the EPA that allows industries in some regions to barter air pollution emission rights.

"The idea seems to work reasonably well in that context," he said. "But can you transplant this idea to an international environment, where political situations and issues of national sovereignty are quite different? And could you really specify exchange rates for different types of emissions as accurately as would be necessary?"

Washington Times
Jan 4, 1990

Assuming 'Global Warming' Exists

Benefits of Worldwide Warmup Far Outweigh Risks

By WARREN T. BROOKES

In February, President Bush took heat for not telling the Intergovernmental Panel on Climate Change what he would do to stop global warming.

Yet last September 11 to September 14, an Intergovernmental Panel on Climate Change workshop of world-class agronomists, geologists and environmental scientists meeting at Coolfont (Berkeley Springs, W.Va.) concluded the benefits of warming, should it even occur, far outweigh its costs. (An IPCC panel in Finland said the same.)

The U.S. panel assumed the carbon-dioxide level in the atmosphere would double by 2050 and raise temperatures by 2 degrees Celsius. (See Table.) Even so, using sophisticated models from the National Oceanographic and Atmospheric Administration and the Agri-

now be weighed against the positive benefits of a warmer, moister climate (should warming even occur) with higher levels of carbon dioxide, one of Earth's most powerful fertilizing agents.

In his exhaustively documented book, *Carbon Dioxide and Global Change*, Agriculture Department research physicist Sherwood Idso writes, "As a result of well over a thousand laboratory and field experiments, scientists have known that increasing the carbon-dioxide content of the air around a plant's leaves nearly always leads to a significant increase in vegetative growth and development."

"In the mean, [these experiments] suggest that a 330 to 600 parts per million doubling of the air's carbon-dioxide content will increase plant productivity by about one-third, while



The Intergovernmental Panel on Climate Change report would be an excellent addition to President Bush's investigation of "global warming."

warming will take place at high latitudes at night. That lengthens the growing season without risk of evaporation or more drought."

The Soviet Union's internationally renowned climatologist Mikhail Budyko argues that carbon-dioxide doubling will bring "an Eden" and shouldn't be stopped. The Coolfont workshop confirms his argument.

Climatologist emeritus Robert Pease of University of California at Riverside wrote in the *Wall Street Journal* the other day, "The higher temperatures combined with more carbon dioxide will favor crop and plant growth and could well provide more food for our burgeoning global population."

"Geologic history reveals warmer global temperatures produce more, not less, precipitation, a fact reflected by recent scientific investigation that shows the Greenland icecap to be thickening, not melting."

"Why then are the evangelists of environmentalism so frantic because President Bush suggested we investigate global warming further before we close down our factories and power plants? The question deserves an answer." Indeed, it does.

But Mr. Bush won't get it from his own White House Task Force on Global Change, whose first draft uses the Environmental Protection Agency's ludicrous assumptions of massive declines in U.S. crop yields and forest volumes.

Mr. Bush had better tell his science adviser Allan Bromley to get the Coolfont Intergovernmental Panel on Climate Change report and then thank his Chief of Staff John Sununu for keeping him from making a really bad mistake.

Continued on page 16

The Effects of Doubled Carbon Dioxide by 2050

Country	Temp. rise (degrees)	Food prod. (percent)	Water resources (percent)	Forestry urea (percent)	Forestry volume (percent)	Shoreline costs (billion \$)
United States	2.5	+15	+9	+5	+10	25
Soviet Union	3.0	+40	-1	-10	+20	1
EEC	3.0	+20	+6	+2	+10	25
China	2.5	+20	-1	+1	-0	5
Australia	2.5	+25	+15	+0	+0	2
Brazil	2.0	+15	+17	-2	-3	3

Source: Climate Impact Response Functions, report of a workshop held at Coolfont, W.Va., Sept. 11-14, 1989, auspices of the Intergovernmental Panel on Climate Change.

culture Department, the panel found this climate change would:

- Increase total U.S. food output 15 per cent more than the natural trend, a present value of \$12 billion per year.

- Increase total U.S. water resources by about 9 per cent, worth \$30 billion to \$50 billion per year at current water prices.

- Increase total U.S. forest volume 10 per cent or 80 billion cubic feet, with theoretical stumpage value of more than \$500 billion.

Against such benefits, the scientists assigned a total cost of \$25 billion per year of losing or protecting our shorelines against a 20-inch rise in sea level. That number is supported by Yale economist William Nordhaus in a paper for the National Academy of Sciences' climate change panel, which puts the "net economic damage" at a tiny 0.25 per cent of gross national product, or \$13 billion per year.

The net benefits of global warming would be equally big for the Soviet Union, China, Europe, Australia and South America. What's more, these Intergovernmental Panel on Climate Change cost estimates were made before scientists at the American Geophysical Union last December cut forecasts of sea-level rise from global warming from four feet to only one foot.

That rapidly declining danger must

reducing plant [water use] by approximately the same amount."

As a result, Idso argues, "The whole face of the planet will likely be radically transformed—rejuvenated as it were—as the atmosphere carbon-dioxide content reverses its long history of decline

and returns...to conditions much closer to those characteristics of the Earth at the time when the basic properties of plant process were originally established."

As biologist Boyd Strain noted recently, "We are moving from a carbon-starved back to a carbon-fertilized world."

Idso says, "The increasing carbon-dioxide content of the Earth's atmosphere is like a breath of fresh air for the planet's close-to-suffocating vegetation." It may explain a confounding rise in food output the last 40 years.

Another reason is that so far in the Northern Hemisphere the only "warming" trend has been in nighttime lows, while daytime highs have in fact fallen since 1940. Virginia's climatologist Patrick Michaels points out, "The new climate model run at the National Center for Atmospheric Research now predicts the majority of

"CORRESPONDENCE TRACKING"

TYPE: Action Item

DOCUMENT NUMBER: 8920473

FROM: Stephen I. Danzansky
Director of Cabinet Affairs

TO: Bromley

DATE OF
CORRESPONDENCE: 11/20/89

SUBJECT: Global Warming: science, economics, environment

ASSIGNED TO: Nancy Maynard

ACTION REQUIRED: Acknowledge

SENDER'S DUE DATE: OSTP DUE DATE: 12/11/89

DATE COMPLETED:

COPIES TO: D. Allan Bromley
JUDY BOSTOCK
NEOB files

REMARKS:

DATE RECEIVED: 11/22/89

FILE: **EOB**

THE WHITE HOUSE,

WASHINGTON

November 20, 1989

MEMORANDUM FOR ALAN BROMLEY

FROM: STEPHEN I. DANZANSKY
Director of Cabinet Affairs

SUBJECT: Global Warming: science, economics, environment

The enclosed is the latest of several recent articles beginning to focus upon the cost/benefit/science of the global climate change issue. It is becoming clear that despite the short-term public relations deficit created by our braking action at the Noordwijk meeting, the Working Group's insistence that research and analysis catch up with political rhetoric and one-upsmanship is beginning to pay some dividends in terms of the public's awareness of the complexity of the issue.

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Economic Watch

Staggering Cost Is Foreseen To Curb Warming of Earth

By PETER PASSELL

World political leaders may be rushing to broad accord on the urgent need to halt global warming. But since the mid-1980's, economists have been warning about the bill. Their misgivings have been deepened by recent estimates of the cost of limiting emissions of carbon dioxide, which is the primary cause of the problem.

Economic analysts do not speak with one voice on the issue. But all recent studies, including those carried out by environmentalists, implicitly share one conclusion: unless it proves remarkably easy to adapt technologies that drastically cut the need for oil, natural gas and coal, the price of correcting the carbon dioxide problem will run to trillions of dollars within the next century.

By one pessimistic but not implausible estimate, the United States' annual cost of holding the line on carbon dioxide production could rival the current level of military spending.

Economists also agree that the benefits of reducing carbon dioxide are sure to vary greatly from place to place. That will make it difficult for countries to develop a consensus for a collective response to the problem.

Carbon dioxide and other pollutants trap infrared radiation from the sun in the earth's atmosphere. In much the same way a greenhouse works.

Some effort to curb carbon dioxide

Continued on Page 18, Column 1

Steep Cost Seen on Curbing Earth's Warming

Continued From Page 1

bons, are also byproducts of modern civilization, and are being spewed out faster than the biosphere can neutralize their effects. It is now generally if not universally believed that a resulting warming effect is overwhelming natural processes that tend to cool the atmosphere.

How fast the greenhouse gases are heating the air is not known. Neither the heating effect nor the accumulation of carbon dioxide in the air is thought to have direct effects on human health. But there is at least a chance that another century or perhaps less of unchecked "accumulation" would melt polar ice and alter weather patterns, leading to coastal flooding and radical changes in land fertility patterns.

For many environmental advocates, those who believe in the ethical obligation to pass on the biosphere intact to future generations, the policy message is clear and simple: move quickly to reduce the production of carbon dioxide, which accounts for about half the greenhouse effect.

Using Fear to Get Action

The cause has drawn support from diverse interests who share what David Harrison of the National Economic Research Associates consulting firm, calls "the Christmas tree view." These groups hope to use greenhouse worries as a lever for everything from promoting nuclear power to tightening automobile mileage regulations.

This month, all 68 nations taking part in a high-level conference in the Netherlands agreed that carbon dioxide emissions would have to be stabilized. Only objections from the United States, the Soviet Union and Japan prevented the conference from endorsing a goal of cutting emissions to 1988 levels by the year 2000. But William Nitze, a State Department official coordinating Bush Administration policy, acknowledges there is now heavy diplomatic pressure for an accord next year.

Simulations by Computer

Greenhouse politics have yet to be influenced by sober economic analysis, however. And while environmental groups would generally be inclined to draw different lessons from a new utility-financed simulation by Alan Manne of Stanford University and Richard Richels of the Electric Power Research Institute, almost everyone agrees that the computer model does illustrate the potential cost dimensions of carbon-dioxide containment.

The Manne-Richels model compares a hypothetical future of unconstrained carbon dioxide output with one in which carbon emissions are limited to the 1980 rate through 2000 and then gradually cut by 20 percent.

Even if no technological adaptation

Could the cure be worse than the disease?

to break the link between energy production and fossil fuels proved possible for a while by switching to natural gas, which delivers 70 percent more energy per pound of carbon effluent. But the carbon limit begins to bite deeply around the year 2010.

With cheap supplies of gas exhausted, the model estimates that a twenty-fold increase in the price of coal would be needed to force sufficient changes toward energy conservation. Annual losses in output would reach about 5 percent of national income, or about \$500 billion, in the year 2030.

Optimists, including the economist Irving Minzer of the World Resources Institute, argue that technological innovations might sharply cut these costs. And the computer model bears him out. Some reasonably priced way of trapping smogstack carbon would reduce the economic impact by one-tenth.

A low-cost source of electricity from non-carbon fuels, providing solar, nuclear or geothermal energy, would trim it further. Technical change that increased the efficiency of energy use for the entire economy by 1 percent each year at low cost would do yet more.

Drop in American Incomes

But even the happy circumstance of technological victories on every front would still permanently reduce American incomes by about 1 percent, according to the Manne-Richels model. And 1 percent in a \$5 trillion economy is a \$50 billion loss.

By the same logic, Mr. Schelling says, the appealing idea of bequeathing the biosphere intact seems arbitrary. The quality of life in 100 years, he suggests, will be less than the quality of life in 1989.

Adjusting to Climate Changes

While changes in rainfall, temperature and sea level could be dramatic, there is yet no reason to believe that the process would be completed too quickly to allow evolutionary responses — expanding irrigation, for example, or building dikes. The cost of growing food might conceivably rise by 20 percent, Mr. Schelling speculates. But this loss, he argues, is almost certain to be overwhelmed by a century's worth of improvements in seed strains and growing techniques.

For example, according to the Environmental Protection Agency's coastal cities of protecting America's coastal cities against a three-foot rise in sea level would be \$73 billion to \$111 billion, a lot of money but not so much compared with the likely cost of prevention.

A doubling of atmospheric carbon dioxide, likely to occur by the middle of the next century if output is not constrained, would dramatically reduce yields for some crops in some regions. But according to a 1989 study by three Agriculture Department economists, the net losses would be less than one-tenth of 1 percent of income in industrial countries. Argentina and Australia would actually be economic winners, since the likely fall in yields would be smaller than the increases in world prices.

Curbing Pollution: Three Price Tags

Projections of the cost of limiting carbon emissions through the year 2100 as a cumulative lump sum, or present-value figure.

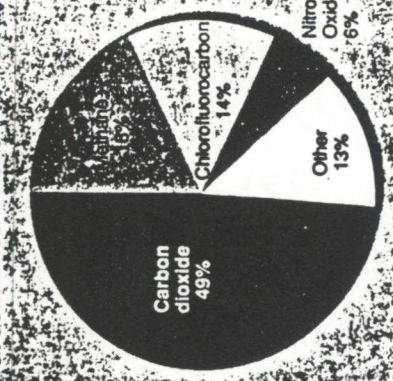
Scenario I (Pessimistic)	Scenario II	Scenario III (Optimistic)
\$3.6 trillion	\$1.8 trillion	\$900 billion
No practical way to shift to clean energy technologies; no automatic increase in economy-wide energy efficiency	Automatic energy-efficient adjustment of 1 percent per year	Cost-effective substitutes for fossil fuel energy available; 1 percent automatic energy-efficiency adjustment per year

Source: "CO₂ Emission Limits: An Economic Analysis for the U.S.A.," Alan S. Manne, Stanford University, and Richard G. Richels, Electric Power Research Institute.

Sources of the Smothering Gases

Figures for 1989

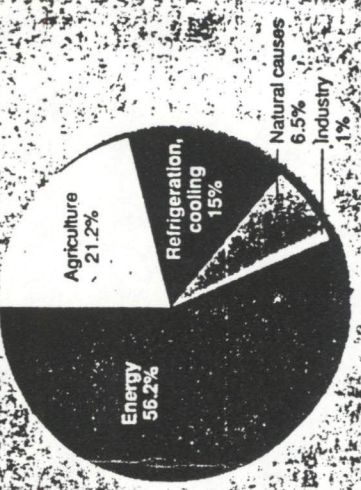
The Gases Creating the Greenhouse Effect



Source: "CO₂ Emission Limits: An Economic Analysis for the U.S.A.," Alan S. Manne, Stanford University, and Richard G. Richels, Electric Power Research Institute.

Where They Come From

Percent of gases contributing to the greenhouse effect from each economic activity



Trillions of dollars may have to be spent.

pects, will depend as much or more on the endowment of technology and capital as on the percentage of carbon dioxide in the air. And if money to contain carbon emissions comes out of other investment, future civilizations could be the losers.

This hardly means that the greenhouse effect can be safely ignored. But it does imply that it should be viewed as a problem in balancing costs against benefits. And here, crude initial estimates suggest that for the next half-century or more it may be cheapest to deal with the effects of global warming rather than the causes.

For example, according to the Environmental Protection Agency's cost of protecting America's coastal cities against a three-foot rise in sea level would be \$73 billion to \$111 billion, a lot of money but not so much compared with the likely cost of prevention.

A doubling of atmospheric carbon dioxide, likely to occur by the middle of the next century if output is not constrained, would dramatically reduce yields for some crops in some regions. But according to a 1989 study by three Agriculture Department economists, the net losses would be less than one-tenth of 1 percent of income in industrial countries. Argentina and Australia would actually be economic winners, since the likely fall in yields would be smaller than the increases in world prices.

Nations Most at Risk

This illustrates a looming problem in prevention strategies. The benefits from controlling greenhouse gases would be far greater in some countries than in others. Bangladesh, India and the Netherlands are at great risk from coastal flooding. But many countries would be able to expand farming into regions that are now too cold or too dry to support it. And a few, like Saudi Arabia,

at minimum cost. Electric utilities might, for example, buy the right to emit carbon from existing emitters, or plant a sufficient number of trees to absorb an equivalent amount of carbon effluent.

Mr. Nordhaus offers a different rationale for action soon. The potential damage from the greenhouse effect has not been pinned down yet, he concludes; but some damage is almost certainly being done. And any sensible approach to balancing costs and benefits in the future will almost certainly involve a limited attempt to control greenhouse gas emissions, along with parallel efforts to sequester carbon and mitigate the effects of global warming.

A Financial Incentive

A modest tax on greenhouse gases, one targeted at heavily damaging chlorofluorocarbons as well as carbon dioxide, would thus be very likely to increase economic efficiency; it would also give emitters a financial incentive to search for alternative carbon-free technologies. And it could provide billions in taxes to offset the Federal deficit.

Virtually all economists seem to agree on the need to get beyond what Mr. Lave calls the "Earth Day come back" syndrome. The symbol of greenhouse effect, they argue, cannot be allowed to obscure the dimensions of the perplexing, high-stakes problem that lies beneath.

Traveling?

Check the weather... from Albany to Acapulco.

The New York Times

Projected Sea-Level Rise Scaled Back by Scientists

Polar Ice Sheets Not Melting but Growing

By William Booth
Washington Post Staff Writer

Sea-level rise in the next century because of global warming is now expected to be far less drastic than previously believed, according to scientists who have made new calculations based on the surprising observation that the polar ice sheets are not melting, but growing in size.

A rising ocean, with its attendant flooding of coastal areas and river valleys, has been one of the most feared consequences of global warming. Many scientists expect the Earth to warm by 4 to 6 degrees Fahrenheit in the next century because of an accumulation of gases such as carbon dioxide and methane in the atmosphere. The gases trap heat and cause the "greenhouse effect."

Scientists who are assessing the prospect of global warming and sea-level change now believe that the oceans will rise by only 12 inches by the year 2050. A previous study by the National Academy of Sciences estimated that the seas would rise by more than three feet by the middle of the next century. The margin of error in each estimate was 12 to 18 inches in either direction.

"We are definitely scaling back our projections of sea-level rise," said Mark Meier of the Institute of Arctic and Alpine Research at the University of Colorado in Boulder. Meier organized a recent meeting of scientists at the American Geophysical Union in San Francisco, where the consensus of the assembled experts was that estimates needed to be reduced.

The latest predictions for the rise in sea level are based on new information about the accumulation of ice and snow in Greenland and Antarctica—the Earth's two largest areas of ice resting on land—and on new calculations about the ability of glaciers to take up their own meltwater runoff and refreeze it.

A study published in today's issue of the journal *Science* shows that the vast ice sheet of Greenland has actually been growing in the last decade, not diminishing. H. Jay

Zwally and his colleagues at NASA's Goddard Space Flight Center in Greenbelt used a pair of satellites to measure the elevation of the Greenland ice sheet and surprised their colleagues by showing that the snow and ice appear to be accumulating at the rate of about nine inches a year.

"It was the first study of its kind to use satellites to assess snow accumulation," said Zwally. "It is certainly contributing to the feeling that estimates of sea-level rise need to be revised downward."

Another study by Charles Bentley and coworkers at the Geophysical and Polar Research Center at the University of Wisconsin at Madison shows that ice and snow are also accumulating in Antarctica.

The concern for the health of the Antarctic and Greenland ice sheets is based on the enormous amount of water stored in these vast glaciers. In the unlikely event that the entire Greenland ice sheet melted and flowed into the ocean, sea levels would rise by about 20 feet. If all of the Antarctic ice were to melt, seas would rise by 230 feet.

The observed accumulation of snow on the ice sheets may be caused by increased winter temperatures at the poles, say the scientists. As the temperature increases in those regions, so does precipitation.

If temperatures increase in the future because of an enhanced greenhouse effect, more snow would be expected to fall on the ice sheets. It is uncertain whether enough snow will fall in the winter to compensate for the increased melting that would occur in the summertime, Meier said.

It appears that although the snow would accumulate on the glaciers early in the next century, continued warming later in the century might cause it to begin to melt off and raise the sea level.

The 12 inches of sea-level rise that the experts are predicting for the year 2050 would come chiefly from the expansion of the Earth's oceans, which, like most objects being heated, will swell as temperatures increase.

*Global Warming
File*

THE WASHINGTON POST

FRIDAY, DECEMBER 22, 1989

Energy Dept. Awards 13 Clean-Coal Grants

Program to Fund Demonstration Projects

By Thomas W. Lippman
Washington Post Staff Writer

The Energy Department yesterday selected 13 energy companies and utilities in 10 states to receive \$540 million in federal funds for demonstration projects in the cleaner and more efficient use of coal.

The recipients and some of their state governments will provide another \$777 million for the "flagship projects [that] represent environmentally superior ways to use U.S. coal," Energy Secretary James D. Watkins said. "They are this country's best hope for using its most abundant energy resource, coal, while preserving and improving the quality of our environment."

Coal is abundant in the United States, which has 29 percent of the world's reserves, but emits air-polluting particles of sulfur dioxide and nitrogen oxide when burned in conventional furnaces. The Energy Department's Clean Coal Technology Program, an outgrowth of the 1985 U.S.-Canada agreement on acid rain, is an ambitious attempt to prime private industry's research pump with federal funds in a search for cleaner and more efficient ways to use coal.

The grants announced yesterday are the third of five rounds of awards. Overall, Watkins said, the projects will represent a commitment of \$5 billion to \$6 billion in federal and private funds. Watkins called this a "ma-

jor national commitment" to environmentally sound energy and "an investment unmatched by any other nation." The department's goal, he said, is to demonstrate that energy use and economic growth are not incompatible with a cleaner environment.

Under the clean-coal technology program, private companies propose projects designed to reduce emissions, make more efficient use of U.S. coal, make financial sense and show potential for widespread commercial use. Projects selected by the Energy Department are eligible for partial federal funding. Those announced yesterday bring the total for the first three rounds to 40.

None of the awards announced yesterday is for a facility in the Washington-Baltimore area. The nearest is at the Seward Station power plant in central Pennsylvania, where Bechtel Corp. and Pennsylvania Electric Co. will split with the Energy Department the estimated \$8.5 million cost of a complicated project that will use lime slurry to remove sulfur dioxide from exhaust gases.

In the most expensive project, the department will pay \$121.1 million of the projected \$403.6 million cost of a coal-fired power plant to be built in Tallahassee, Fla., using a process that converts coal to a fuel gas, burns the gas to drive a generator and uses the hot exhaust to produce steam to drive a conventional steam-powered generator.

Key Gene in Immune Defenses Is Believed Found

By HAROLD M. SCHMECK

Scientists have discovered a gene that they believe is crucial in the development of the human immune defenses, possibly a central genetic switch for the process by which the body generates a wide array of protective antibodies.

The discovery is expected to throw important new light on the complexities of the immune system, which is vital to almost every aspect of human health and development. The discovery may help scientists better understand some genetic diseases in which the body's defense systems fail. Experts say that the research is important but that it is far too early to tell what practical applications may result.

Scientists involved in the studies are already testing patients who suffer from genetic disorders in which immune defenses are lacking to see if any such immunodeficiency cases may be linked to failures of the gene.

The normal immune system generates an immense variety of antibody types. These act as specialized weapons, attacking virtually every type of infection or irritant to the immune system, natural or synthetic, that an individual is likely to encounter. It is an armory of prefabricated weapons against every conceivable invader.

Genetic Recombinations

This profusion of different antibody types is known to be produced by a complex genetic process in which parts of genes are shuffled and recombined. As a result, the immune system produces millions of cell clones, each capable of producing a unique variety of antibody.

The newly discovered gene is believed to play an important role in that genetic recombination process. The scientists have named the gene RAG-1 for recombination activating gene.

The research is being reported today in the journal *Cell* by Dr. David G. Schatz, Dr. Marjorie A. Oettinger and Dr. David Baltimore of the Whitehead Institute for Biomedical Research at the Massachusetts Institute of Technology in Cambridge. Dr. Baltimore,

who heads the institute, will leave later this year to become president of Rockefeller University in New York.

The scientists said they believe the gene provides the blueprint for all or part of the enzyme that carries out the shuffling of gene parts that gives rise to the diversity of antibodies. Or, they say, it may serve as a regulatory gene that switches on other genes vital to the process.

In either case, the RAG-1 gene is believed to act on cells of the bone marrow that give rise to two types of cells vital to the immune defenses: B cells, which are responsible for antibody production, and T cells, which have many functions in immunity. In the T cells

Research is described as 'a very elegant piece of science.'

specifically, the gene is thought to help generate diversity in the receptor through which the cell recognizes foreign substances.

'Elegant Piece of Science'

In a telephone interview, Dr. Frederick W. Alt of Columbia University's College of Physicians and Surgeons, described the research as "a very elegant piece of science."

A possibly related discovery was reported in *Nature* this week by a group of Japanese scientists led by Dr. Tasuku Honjo at Kyoto University. Dr. Honjo's group discovered a gene that they believe to be central to the genetic recombination process in bone marrow cells.

Dr. Alt and two colleagues at Columbia published in *Nature* an analysis of the research by both teams, working

from advance texts. They said the gene found by the Japanese is different from the RAG-1 gene, but may be part of the same complex recombination process. The scientists do not yet know how the two discoveries relate to each other.

The Japanese scientists reported that their gene is related to certain genes of bacteria, and they suggest in their report that it might have a long history in the evolution of life.

The scientists at the Whitehead Institute said that genes almost identical to RAG-1 exist in rabbits, dogs, goats and horses and that a similar gene exists in species as far distant from the mammals as chickens and frogs. The implication, the scientists said, is that it is vital to many or all species that have highly developed immune systems.

The scientists have found RAG-1 gene activity only in the progenitors of B cells and T cells.

The RAG-1 gene was discovered in a complex succession of experiments conducted over several years. The key finding came in experiments in which the gene was transplanted into fibroblasts, connective tissue cells, growing in the laboratory. These cells do not usually engage in the genetic shuffling that leads to the diversity of antibodies. But the fibroblasts under the influence of a transplanted RAG-1 gene carried out that same kind of recombination of gene parts. The scientists considered that evidence the clearest proof that the RAG-1 gene was a key to the recombination process.

In a telephone interview, Dr. Schatz and Dr. Oettinger said the availability of the RAG-1 gene may make it possible to reproduce in the laboratory the main features of the process that gives rise to antibody diversity. This would be valuable for study of immunity.

"This is really a central aspect of the development of B cells and T cells," Dr. Oettinger said of the genetic recombination process.

Immune System's Controller Found, Scientists Say

Gene Allows Disease-Fighting Blood Cells to Recognize a Huge Variety of Germs

Associated Press

CAMBRIDGE, Mass., Dec. 21—Scientists think they have discovered the master controller of the immune system, a gene that allows disease-fighting blood cells to recognize and remember an ever-changing and virtually unlimited number of different germs.

The gene ceaselessly reshuffles segments of genetic coding inside newly made white blood cells. This way the body can use a limited amount of genetic material, made of DNA, to concoct an endless assortment of antibodies capable of zeroing in on bacteria, viruses and other disease-causing agents that it has never before encountered.

The process is analogous to taking a few standard pieces of an Erector set or a Lego set and reshuffling the combinations to make structures of many different shapes.

Researchers described the work as an important discovery that should greatly improve understanding of how the body arms itself against infection. Although it does not immediately open up new ways to treat disease, it may someday allow medicine to fine tune the body's weapons.

The gene—dubbed the recombination activating gene (RAG-1)—was discovered by David G. Schatz and Marjorie Oettinger, graduate students at the Whitehead Institute for Biomedical Research. They describe their work in Friday's issue of the journal Cell.

"It's one of the top 10 or 20 discoveries in the history of immunol-

ogy," said Michael Lieber of Stanford University. "It deals with the basic way that our bodies make antibodies in the most fundamental sense."

The researchers think that the gene makes all or part of an enzyme called recombinase, which cuts and splices bits of DNA. These segments of old genes are assembled into new genes, which dictate the structure of the infection-fighting molecules called antibodies, which are made by the blood's so-called B cells.

Occasionally, an antibody encounters a microbe with a spot on its surface that is a mirror image of the antibody. When this happens, the antibody latches onto this spot, known as an antigen. This marks the invader for destruction by other soldiers in the immune system.

Other components of the immune system, called T cells, attack invad-

ers directly, looking for them with distinctively shaped structures on their coats that are known as antigen receptors.

The body constantly pumps out B cells and T cells equipped with an ever-changing assortment of these distinctive shapes. And each requires the work of a distinctive gene. The body gets these genes by randomly piecing together scattered bits of DNA from throughout the cell's genetic archives.

Two years ago, Susumu Tonegawa of Japan was awarded a Nobel Prize for discovering that this shuffling creates the diversity of antibodies.

"Since then, we have learned surprisingly little" about how the body achieves this rearrangement, said Nobel laureate David Baltimore, a co-author of the latest work. "This is the first step toward finding a chemical basis of diversity."

Schatz compared the immune system to an automobile factory. In this analogy, RAG-1 is the assembly line worker who puts together the cars' engines.

"This reaction is the very heart of what makes the immune system go," he said.

Schatz said it may soon be possible to watch and manipulate this assembly process in the test tube and someday even in the human body. One potential, though distant, application is in replenishing the immune system cells ravaged by AIDS.

The AIDS virus selectively seeks out and destroys a particular variety of blood cells called helper T cells. "Maybe in time we will be able to specify the production of these particular cells," replacing those lost to the disease, Schatz said.

Scientists Find Gene That Triggers Formation of Different Antibodies

By DAVID STIPP

Staff Reporter of THE WALL STREET JOURNAL

CAMBRIDGE, Mass.—Scientists here identified a gene that triggers the immune system's formation of different antibodies, a milestone in immune research.

The finding sheds light on how the immune system responds to a myriad of different invading microbes, which has been "one of the great mysteries of biology," said David Baltimore, a Nobel laureate who directed the research at the Whitehead Institute of Biomedical Research, which is affiliated with Massachusetts Institute of Technology.

While the discovery probably won't have near-term medical uses, the newly found gene provides a broadly useful tool for studying immune functions in infectious diseases and other disorders.

The discovery concerns the process by which immune cells make antibodies, Y-shaped molecules that float in the blood looking for foreign microbes. The prongs of each antibody are shaped to fit a molecule on the surface of a specific invading microorganism. Once an antibody latches onto a microbe, it attracts other immune molecules that destroy the invader.

Previous Discoveries

The latest discovery builds on two previous findings. In the 1970s, researchers discovered that immune cells called B cells combine a relatively small set of genes in different ways to create the genetic codes needed for millions of different antibody shapes. More recently, scientists found that immune cells called T cells employ a similar gene-shuffling process to make antibody-like molecules, called receptors, that they use to recognize foreign invaders.

Now the Whitehead researchers have found that in both cases, the gene shuffling

is activated by a single genetic master switch, which they isolated and named recombination activating gene No. 1, or RAG-1. The gene "is at the very heart of what makes the immune system go," said David G. Schatz, co-author of the study, which is reported in today's issue of the journal *Cell*. The researchers still don't know, however, whether RAG-1 triggers gene-shuffling directly or acts through intermediary genes.

But with RAG-1 in hand, researchers can probe for gene recombination in different tissues. Cells in the olfactory system, for example, may shuffle genes to create many receptors for recognizing different odor molecules.

By blocking RAG-1, scientists may be able to produce immune defects in animals that would elucidate similar defects in human diseases, said Marjorie A. Oettinger, another author of the study. The RAG-1 finding also may help researchers devise better ways to bolster the immune system in diseases such as acquired immune deficiency syndrome.

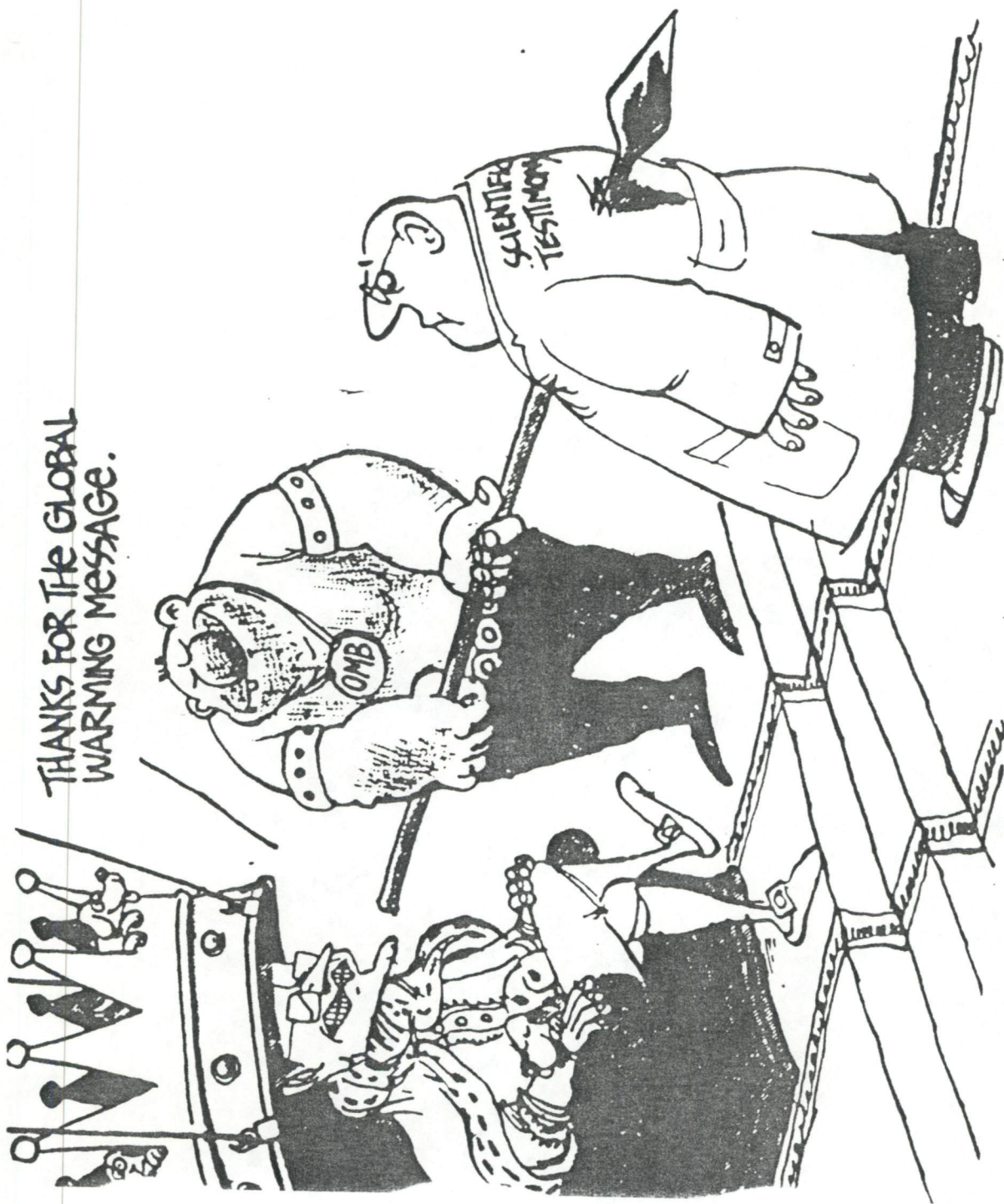
Role of Protein in AIDS Virus

Separately, researchers at the Whitehead Institute and at Johns Hopkins University reported that a previously discovered protein made by the AIDS virus may play an unexpected role in the disease's immune suppression.

The finding concerns the transactivator, or TAT gene, of the AIDS virus. Scientists earlier discovered that it amplifies production of the AIDS virus within infected cells. In the latest finding, researchers found that the protein made by the gene may have a second, more direct damaging effect on the immune system.

In test-tube studies, they showed that the protein lessened the ability of infection-fighting white blood cells to respond to in-

THANKS FOR THE GLOBAL
WARMING MESSAGE.



SCIENCE AND THE CITIZEN

Not So Hot

New studies question estimates of global warming

When editors and newscasters routinely bandy about the term "global warming" without bothering to explain it, then the idea could be said to have entered the body of public knowledge, accepted by most as immutable fact.

Yet the public's acceptance of global warming caused by the greenhouse effect belies the fluid nature of the science. The conclusion that the buildup of carbon dioxide and other greenhouse gases might lead to catastrophic warming of the earth's climate continues to generate debate among scientists. As investigators refine the computer models on which global climate projections are based, some estimates of probable warming are being lowered. Moreover, new data suggest that human activity may influence the climate in ways that have previously been neglected.

Few climatologists doubt that the rapid increase of trace gases in the atmosphere resulting from human activity will produce some warming, with potentially severe consequences. Estimates of how much and how soon are made with climate models run on supercomputers. Earlier models projected that global temperature would increase from three to 5.5 degrees Celsius during the next century, but they included only crude estimates of the roles cloud cover and oceans play in mediating climatic change.

Clouds seem to have a net cooling effect, so if cloud cover increased it might, other things being equal, partly offset any warming brought on by the buildup of carbon dioxide and other greenhouse gases. Oceans, for their part, act as a vast heat sink, dissipating and circulating heat.

Two recent climate-model studies have incorporated more sophisticated representations of clouds and oceans than previous models. One such model, described in *Nature* by John F. B. Mitchell and his colleagues at the British Meteorological Office, accounts for the fact that ice clouds have different properties than water clouds do. According to the model, even if levels of carbon dioxide and other gases effectively double by the middle of the next century, the atmosphere will warm by



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only 1.9 degrees C, as opposed to the 5.2 degrees C predicted by a comparable model that does not distinguish between ice and water clouds.

The second model, described in *Climate Dynamics* by Warren M. Washington and Gerald A. Meehl of the National Center for Atmospheric Research in Boulder, Colo., includes more sophisticated calculations of ocean circulation and heat exchange. Their findings suggest that 30 years after an instantaneous doubling of carbon dioxide in the atmosphere (an admittedly unrealistic scenario) the earth would have warmed by only 1.6 degrees C, substantially less than models with a simpler ocean would predict.

Human activity may also affect climatic change in a way that has been previously unrecognized. Analyses of satellite data suggest that sulfate aerosols formed from pollutants (such as the sulfur dioxide that rises from urban centers) can significantly increase the earth's albedo (the light and heat that the earth and its atmosphere reflect back into space). Robert D. Cess of the State University of New York at Stony Brook says his analysis of satellite data indicates a significant increase in the albedo of stratocumulus clouds over the ocean for thousands of miles downwind of major population centers such as Southeast Asia and the east coast of North America. It is thought that the sulfate particles provide nuclei around which cloud droplets form and so increase cloud reflectance.

Similarly, Philip A. Durkee of the Naval Postgraduate School in Monterey, Calif., has found threefold increases in the reflectance of stratocumulus clouds over the ocean hundreds of miles downwind from San Francisco and Los Angeles. Such results suggest that anthropogenic in-

creases in albedo caused by greater numbers of droplets might be large enough to affect the global radiation balance. Thomas M. L. Wigley of the University of East Anglia in England has even suggested that an increase in albedo in the Northern Hemisphere might explain why the warming trend in this century has been smaller than was predicted by earlier and more simplistic climate models.

Patrick J. Michaels of the University of Virginia, a vocal critic of what he sees as premature policy responses to global warming, points out that studies by Thomas R. Karl of the National Climatic Data Center in Asheville, N.C., show that in the U.S. and Canada during the period from 1941 to 1980 there was a marked decrease in the daily temperature range, attributable mainly to an increase in nighttime and early-morning temperatures. Michaels thinks the finding supports the notion that global cloud cover may be increasing. An increase in cloudiness would increase nighttime temperatures by trapping heat emitted by the earth but decrease temperatures during the day by increasing cloud reflectance. According to Michaels, the greenhouse effect might therefore be more benign than has been supposed—or perhaps even beneficial. Growing seasons might be lengthened and the frequency of droughts reduced. Michaels's views are not widely shared: Kevin E. Trenberth of the National Center for Atmospheric Research counters that the decreasing daily temperature range might be a consequence of urban development near measuring stations.

Another participant in the debate is the Marshall Institute in Washington, D.C. Founded in 1984 and privately funded, the institute's most notable previous contribution to public policy discussion was a stout defense of the Strategic Defense Initiative. Now under the Marshall banner, Frederick Seitz, a past president of the National Academy of Sciences, Robert Jastrow, the founder of the Goddard Institute for Space Studies and William A. Nierenberg, director emeritus of the Scripps Institution of Oceanography, have seized on another weak link in current climate models. They suggest (with no firm evidence) that fluctuations in the sun's brightness during the past 100 years may be responsible for the uneven course of global warm-

ing in this century. If so, they argue, the planet's response to the buildup of greenhouse gases has been smaller than climate models suggest, and expectations of warming should be scaled back accordingly.

Michaels thinks projections of global warming will become even more moderate as models become increasingly sophisticated and incorporate more climate feedbacks. Cess, for one, disagrees: he believes improvements to models are as likely to make projections worse as they are to make them better. Only more research is likely to settle the arguments. —Tim Beardsley

Ningún Nombre Identifying Argentina's desaparecidos

In late September Argentina's new president, Carlos Saúl Menem, bowed to pressure to pardon some 20 police and military officers accused of killing dissidents during the 1970's. But some of the victims—the *desaparecidos*, or "disappeared

ones"—are emerging from anonymity to bear silent witness against their executioners, if not in court then in history. The Argentine Forensic Anthropology Team, a group of seven investigators working out of a small office in Buenos Aires, is quietly extending its efforts to identify the remains of persons murdered during the military regime. In collaboration with colleagues in the U.S., the Argentine workers are developing ways to apply DNA-fingerprinting techniques to the identification of badly decomposed corpses. The team is also exporting its expertise to other countries where political repression has been widespread.

The National Commission on the Disappeared, established by President Raúl Alfonsín in 1983, has estimated that more than 9,000 Argentines were illegally detained and killed under military rule, most of them between 1976 and 1978. Although many bodies were cremated or dumped at sea, others were buried in graves marked "N.N."—*ningún nombre* ("no name"). The forensic anthropology team, which was spawned by a workshop given in Bue-

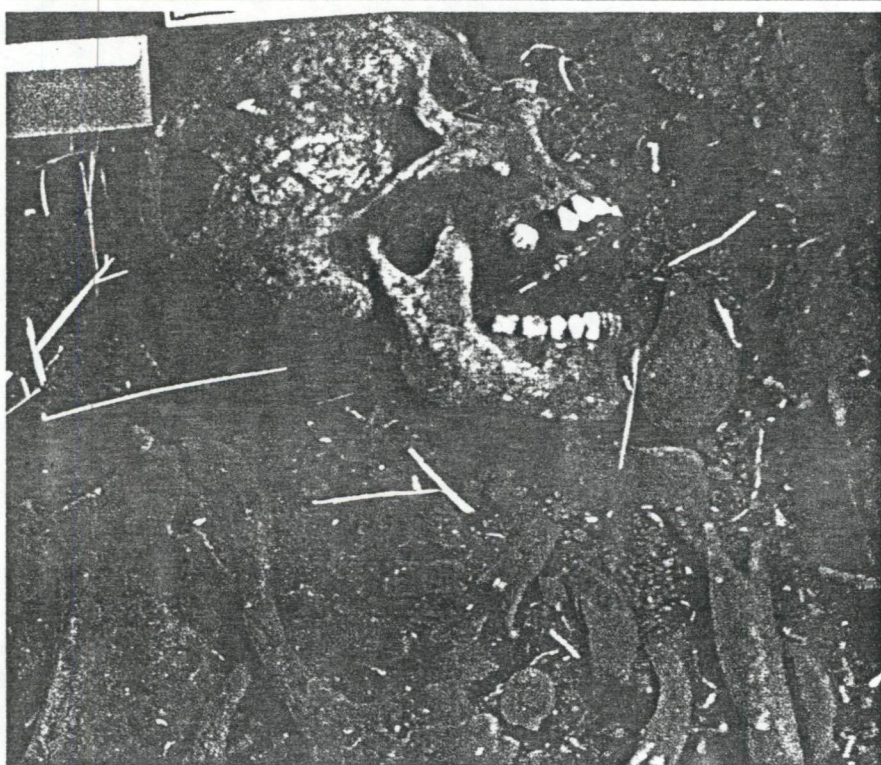
nos Aires by the American Association for the Advancement of Science, has so far exhumed some 120 bodies and has positively identified 30; some of the identifications have already served as evidence in trials that produced convictions.

The team gathers data by examining skeletal remains and also by studying records of prisoner transfers from illegal detention centers and burial records from cemeteries. Clyde C. Snow, an American forensic anthropologist based in Norman, Okla., taught the Argentine workers many of their techniques: how to determine age, sex, stature, handedness, race—even a woman's childbearing history—from fragmentary remains. Frequently, dental records or details of healed fractures will clinch an identification.

According to Mercedes Doretti, one of the team's founding members who visited Washington, D.C., in September, brain tissue has recently been found in skulls exhumed from a mass grave near Buenos Aires. The team hopes to extract DNA from the brain tissue or from the cranial bones to obtain DNA fingerprints—detailed analyses of the victims' DNA that can then be compared with the DNA of living relatives. By doing so, the team thinks it can identify the *desaparecidos* with a high degree of certainty. Cellmark Diagnostics in Germantown, Md., has offered to help by analyzing bone samples. Karen R. Rubenstein says the company is cautiously optimistic that it will be able to obtain DNA fingerprints from samples sent by the Argentine team. Immunologists at the Hospital Duran in Buenos Aires are already using specific genetic markers in the blood to identify children of *desaparecidos* who were kidnapped and secretly adopted by military families.

Laws passed in 1987 and 1988 by the Alfonsín government—which operated under the constant threat of military rebellion—reduced the number of trials of those who allegedly authorized the killings, from about 300 to 17. When President Menem announced his intention to pardon the accused, he also said he would consider granting pardons to some of the senior officers and junta leaders who were previously convicted. Nonetheless, the forensic anthropology team intends to continue its investigations, Doretti says, both for the sake of the families of the *desaparecidos* and for the historical record. Interest in the team's work is spreading: members have visited human-rights groups in the Philippines and Chile and are cur-

Most of the scores of exhumed Argentine victims are impossible for investigators to identify



REMAINS of an unidentified male, estimated to have been 40 to 45 years of age, were unearthed by the Argentine Forensic Anthropology Team. Six bullets were found in the skull and elsewhere in the skeleton. The official death certificate records the cause of death as "acute hemorrhage."

Science, Not Rhetoric, Should Show How Serious the Problem Is

by Bill G. Aldridge

I was pleased to be invited to Greenhouse/Glasnost, the Sundance Symposium on Global Climate Change, or Sundance Summit for short. The symposium was held at actor Robert Redford's Institute for Resource Management in Sundance, Utah, in a beautiful mountain canyon owned by Redford. (The area also serves as a small winter ski resort and a summer institute for the performing arts.) The symposium's topic was the problems of global warming through carbon dioxide and other emissions and what has been termed the greenhouse effect. Also discussed was the depletion of the ozone layer by chlorofluorocarbons.

The list of conference attendees was unusual and impressive. Along with Redford were Senators Bill Bradley, Timothy Wirth, and John Heinz. Carl Sagan, Tom Brokaw, Jane Pauley, and Garry Trudeau were also there. A very interesting mix of scientists included atmospheric scientists Steven Schneider and Jim Hanson, as well as environmentalists Mike Oppenheimer of the Environmental Defense Fund and Jay Hair, president of the National Wildlife Federation. A Soviet delegation came, led by Roald Sagdeev, former director of the Space Research Institute of Moscow. Also attending were representatives of power companies, coal producers, and such major corporations as Dupont.

Because of this remarkable collection of participants, the symposium received widespread publicity. CBS did a live three-hour series of interviews one

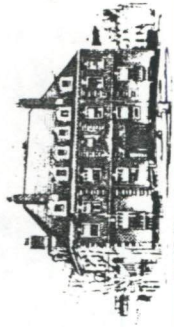
morning during the symposium, and many TV stations and newspapers carried stories about it. PBS filmed the entire proceedings for a future documentary, *The State of the World*.

Unfortunately, I came away with many reservations about the meeting. Though I may seem critical of the symposium, my criticism stems from my concern about science education. I want to stress that I'm not questioning the participants' sincerity or the problems that may result from neglecting the environment. The process that occurred at the meeting—the way "evidence" was presented and discussed—disturbs me.

If the conference taught me anything, it is that so-called science and society approaches to science education are filled with dangers. I became increasingly uncomfortable during the symposium—which at times felt more like a religious revival than a scientific meeting—because what I observed is symptomatic of what is wrong with science education in the United States.

Too many people offered simple solutions and glib explanations, without really understanding the science or the evidence behind their assertions. Assembled were experts and authorities who warned about the dire consequences facing the world if we don't change immediately. Slick descriptions and explanations were backed up by elaborate visual and computer models.

On the one hand were zealots pushing for change around the world, while on the other hand scientists summarized the results of the models and expressed their concern. Also expressing their



NATIONAL SCIENCE TEACHERS ASSOCIATION
1742 Connecticut Avenue, N.W.
Washington, D.C. 20009
202 328 5800

Oct 25, 1989

Dear Allan,

I want you to know that I, personally, support your position on the greenhouse issue. You might be interested in an article I have coming out this month.

In John Sumner:
There are rational
folk out there
still!
Shan

Global Warming Becomes Hot Issue for Bromley

A disagreement within the Administration over plans for an international meeting on global change was aired in the press and on Capitol Hill last week

PRESIDENTIAL SCIENCE ADVISER D. Allan Bromley last week found himself in the hot seat when he was called before a Senate subcommittee to explain his views on global warming. The Senators were angered by press reports that Bromley had opposed sending a U.S. delegation to an international ministerial meeting on global change, to be held in The Hague next week.

Bromley was recently appointed by President Bush to chair a Domestic Policy Council working group on global change, a position that gives him a prominent role in formulating U.S. policy. According to Administration sources, at the working group's first meeting on 20 October, Bromley and White House chief of staff John Sununu opposed a recommendation by Environmental Protection Agency administrator William Reilly and the State Department that the United States attend The Hague conference, which will be held on 6 and 7 November.

At the meeting, which will draw together environment ministers from some 60 countries, the Netherlands is expected to propose that carbon dioxide emissions be stabilized at present levels by the year 2000 and that the feasibility of a 20% cut worldwide by 2005 be studied.

The Netherlands is hoping that the meeting will produce a consensus statement on global warming. But Bromley, Sununu, and others are reportedly worried that the United States, which produces one-fifth of the world's carbon dioxide emissions, could suffer economic damage if stabilization levels or reductions are agreed to.

Administration officials are also divided over whether the United States should honor a pledge made by Bush last year to host an international conference in 1990 on global change. At the 20 October meeting, Bromley, Sununu, and others opposed the proposal while Reilly and the State Department pushed for it. On 30 October, 40 U.S. senators, all Democrats, signed a letter to Bush, urging him to keep his commitment to convene the conference.

At the congressional hearing last week, Bromley dodged, for the most part, repeated questioning by Senators Albert Gore (D-

TN) and John Kerry (D-MA) about his views on global warming and whether he approved of U.S. participation at The Hague meeting. Bromley would only say, "My belief is that we should not move forward on major programs until we have a reasonable understanding of the scientific and economic consequences of those programs."

Asked by Gore whether the scientific evidence is inadequate to justify curbs on

New responsibility. Bromley now chairs a global change working group.



Ken Heinan

greenhouse emissions, Bromley responded that recent adjustments to climatic models by British climate modeler John Mitchell have made him uneasy about the reliability of predictions that the earth is warming up significantly.

Mitchell's model of the climate system previously predicted that the earth's temperature would rise 5°C when greenhouse gases double sometime in the next century. But he recently halved this figure after he added a new factor to his model—the effects of ice crystals. Bromley said, "That such simple and obvious changes in [Mitchell's] model can make major changes in predictions underscores my own feeling and many of my colleagues in the scientific community that we have a substantial distance to go yet."

Gore asked, "Do you believe that the doubling of carbon dioxide in the atmosphere, which will occur in the next 40 years or so, is likely to result in global warming?" Bromley replied, "It's certainly possible, and probable to some degree, but that's as far as I can say on the basis of the evidence." Given the changes in the Mitchell model, he said, "my answer is that I simply don't know."

Steven Schneider of the National Center for Atmospheric Research and many other atmospheric scientists have said that while current models are relatively crude and flawed in some ways, their predictive reliability has been validated to a substantial degree. Moreover, they point out that the fundamental theories of how greenhouse gases trap heat have been substantiated by billions of observations of the atmosphere.

Thomas Lovejoy, an ecologist and assistant secretary for external affairs of the Smithsonian Institution, said in an interview that the Administration "could be taking a

San Andreas fault approach" in formulating national policy on global warming. "It's resisting change until it's catastrophic."

Lovejoy, whom Bromley has

nominated as a member of the White House science council, last week wrote a letter to Bromley himself, urging that the President and the Cabinet be given a full briefing by scientists on global warming. "There are a lot of actions associated with cutting greenhouse gases that will make us more competitive," Lovejoy says.

At the congressional hearing, Bromley also repeatedly stressed the importance of allowing a United Nations group, the Intergovernmental Panel on Climate Change, or IPCC, to finish a report on evaluating greenhouse effects. The report could lead to an international framework convention acknowledging the problem of global warming and then to a protocol with specific goals to cut emissions of greenhouse gases. This process is similar to the one that led to an international agreement on a phaseout of chlorofluorocarbon gases.

But a few other countries, including the Netherlands, together with environmentalists and some members of Congress, contend that the IPCC process is moving too slowly. Although the IPCC report is due out at the end of next year, they say that the IPCC may take several years to arrive at specific goals for emission reductions.

As for The Hague meeting, Reilly has won a partial victory: the United States will be sending a delegation, which Reilly will head. But an Administration source says that Reilly "is going with a bare portfolio." Bromley will be part of the delegation.

■ MARJORIE SUN



ALLEN RUSSELL—PICTURE GROUP

Keeping a Weather Eye on the Mercury

Even sophisticated formulas used to predict the greenhouse can't account for all of nature's forces. Several variables may make the climate mild or hellish.



LARRY DOWNING—NEWSWEEK

More data, please: *Sununu*

Silver Linings

Clouds: Higher temperatures increase evaporation and hence clouds, which are made of water vapor and help cool the planet.

Volcanoes: Eruptions spew tiny particles into the atmosphere that deflect sunlight, causing cooling.

Plankton: Warmth and extra CO₂ might promote the growth of these tiny marine organisms, which absorb CO₂ and take it out of circulation.

Oceans: Their heat-absorbing capacity might delay warming for more than a century.

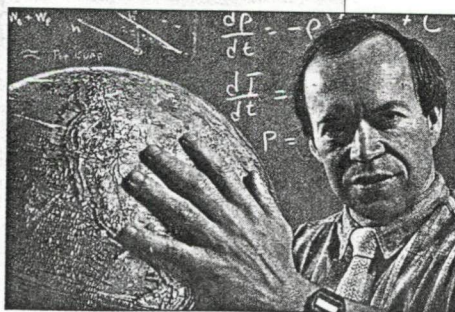
Start Building an Ark

Sea ice: Once it starts to melt, less sunlight will be reflected away, exacerbating the warming.

Acid rain: Sulfur dioxide, which causes acid rain, also cools the earth. Controlling acid rain might thus accelerate the greenhouse effect.

Permafrost: Warming might melt the frozen soil, releasing buried methane—a greenhouse gas.

Soil: Warming ordinary soil would increase the rate at which bacteria convert dead organic matter into CO₂, intensifying the man-made greenhouse.



JACQUES CHENET—NEWSWEEK

Early warnings: *Hansen*

have all 25 in there, greenhouse predictions may get worse."

Caution like Sununu's may be prudent; unbridled optimism is not. He cites another new study that lowers projections of greenhouse warming. Warren Washington and Gerald Meehl of the National Center for Atmospheric Research in Boulder, Colo., used more sophisticated simulations of the oceans' circulation and heat exchange than did earlier computer runs. In their worst-case scenario—an overnight doubling of CO₂—the pair found that the world would warm 1.6 degrees Celsius within 30 years, again a more mild greenhouse. But Meehl points out that their model did not run long enough to show *all* the warming CO₂ would produce. Some remained bottled up in the great heat sink of the ocean. (The seas absorb most of the CO₂ produced on the planet.) Running the models out another few decades would produce more heating. Says Meehl, "It may take longer to see climate change, but you do see it."

Stormy weather: Even increases of a degree or two can have unpleasant effects. Droughts would be more likely. Storms would be more severe and frequent, because the atmosphere holds more energy. Agricultural belts would shift, possibly causing crop failures. Although many skeptics argue that crops would thrive on the extra CO₂, in fact plants have responded to past CO₂ increases by developing fewer of the tiny pores that breathe in this gas. Most worrisome, while a mild greenhouse may not be a great place to live, no one can rule out the chance of a hellish tomorrow. "Although a 1-degree warming is much more probable," says climatologist (and skeptic) Robert Balling of Arizona State University, "it is ludicrous to say 5.5 degrees cannot happen."

But when? Current inhabitants of the White House don't have to worry. Because the oceans absorb so much heat, it will be decades before the world gets appreciably hotter because of CO₂ already loosed on the planet—unless some of the unknown forces that shape climate bring on more warming more quickly (table). Says climatologist Michael Schlesinger of the University of Illinois, "Our children will ask why their folks didn't do something about greenhouse warming when they had the chance."

That leaves society with a painfully familiar choice: how to act in the face of uncertainty. As NCAR climatologist Stephen Schneider puts it in his new book, "Global Warming," "Can we base trillion-dollar decisions about global economic development strategies on ... these admittedly cloudy crystal balls?" He says yes—procrastinating would be reckless. But MIT's Lindzen recommends wait-

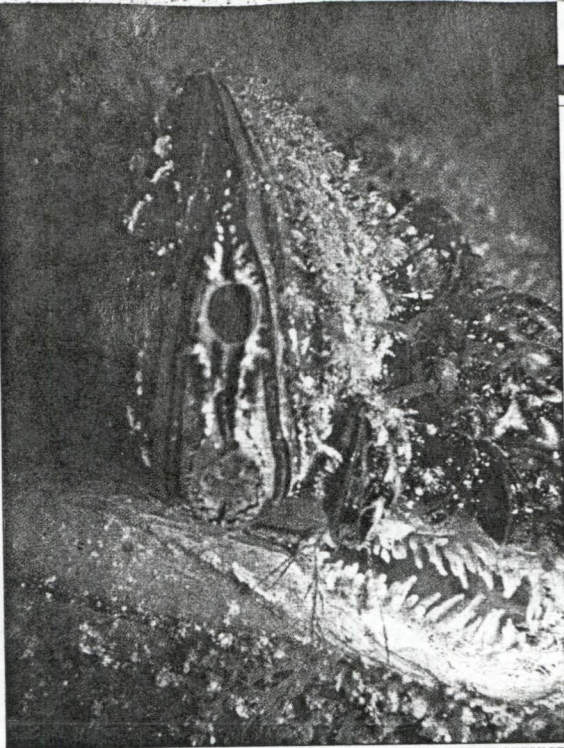
ing, since "most of these questions will be on significantly surer ground in five years." Other experts think 10 or 20 years is more like it, and that what we learn is as likely to point to a worse greenhouse. Says Mohammed El-Ashry of the World Resources Institute, a Washington think tank, "When we waited for more research on acid rain, we ended up realizing that everything we knew 10 years earlier was true." And waiting exacts a price. Gradually replacing oil with solar energy, for instance, is much less painful than a sudden switch. And the longer greenhouse gases are emitted, the more warming we may ultimately confront.

How we respond to the greenhouse threat will depend not only on science but also on the palatability of the required changes. The industry-sponsored Global Climate Coalition opposes singling out American companies to "cure" the greenhouse. Ford Motor Co., for instance, points out that U.S. passenger cars account for 1.2 percent of global CO₂ emissions; doubling fuel efficiency would cut that to .6 percent. "It would throw industry into a tailspin and have minimum environmental impact," argues Ford's Kelly Brown. But vehicles account for 32 percent of America's CO₂ emissions; utilities, for 34 percent. Of course, America alone cannot stop the greenhouse, but if a rich, technologically advanced nation won't put its own house in order, then developing countries—potentially worse greenhouse villains—have a perfect excuse to do nothing.

Foreign oil: Changes that would mitigate the greenhouse would actually bring other benefits. Energy conservation reduces dependence on imported oil; fuel-efficient cars and planting trees clean the air. Some changes would improve competitiveness. At least the Japanese, whose models show a temperature increase of 1.5 to 3 degrees Celsius by 2030, seem to think so. They are researching ways to recycle CO₂ released in industrial processes, develop energy sources to replace fossil fuels and capture CO₂ by using marine algae to "fix" it.

For those who fear that the greenhouse will arrive—and no responsible scientist denies that possibility—it seems imperative to take immediate steps to mitigate it. For those who fear such changes, it seems more prudent to postpone action until the effect is indisputably upon us. The Bush administration has budgeted \$250 million this fiscal year for climate modeling, money that would go to both scientific camps. Some of the uncertainties might be resolved by the next world climate conference, in late 1990. But the debate will not be over by then. Society will have to face its demons and decide which it fears most.

SHARON BEGLEY with MARY HAGER
in Washington, LARRY WILSON in New York
and bureau reports



K. BRUSATE—COMMERCIAL DIVING SERVICES

From the deep: Mussel magnified three times

ENVIRONMENT

Showdown at Mussel Beach

Marauding crustaceans terrorize Great Lakes

It may lack the girth of the Blob or the menacing chirp of Hitchcock's birds, but the zebra mussel is staging a classic creep-show routine on the western shores of Lake Erie. The striped freshwater clam invaded North America just three years ago, when a European tanker flushed its ballasts into Lake St. Clair. Since then, populations have spread through the Detroit River and into Lake Erie at a clip of 160 miles a year. The prolific crustaceans are now entombing boat hulls and beaches, disrupting a large fishing industry and clogging waterlines that support cities and factories. Unless the invasion is stopped, experts speculate, 26 million people could lose their water supplies within five years.

For Great Lakes fishermen, the immediate threat is not the thumb-size grown-ups but the subvisible larvae they spawn by the tens of thousands. Off the shores of Toledo and Cleveland and near Leamington, Ont., a single cubic meter of water often contains a half-million mussel larvae. "I don't think it has reached its peak even there," says Gerry Mackie, a biologist at the University of Guelph. The voracious youngsters have increased water clarity threefold—but they've done it by gobbling up the plank-

ton and algae that support the rest of the aquatic food chain. Food shortages are already affecting the walleyed pike, a perchlike species that accounts for most of Ohio's \$500 million sports-fishing industry and is harvested commercially in Canada. This year Ohio's catch will be off by an estimated 600,000 fish (down from 4.9 million to 4.3 million), and Canadian fishermen say the walleyes they're catching are smaller than usual.

That's just the beginning. Mature zebra mussels use tough, threadlike membranes to latch onto hard surfaces in layered colonies, and they seem particularly fond of the huge intake pipes that provide water supplies throughout the Great Lakes Basin. The town of Monroe, Mich., had to ban

lawn sprinklers this summer, after the crustaceans colonized its 30-inch-wide, 10-mile-long intake pipe, reducing its capacity by a third. Musselbound waterlines have brought a halt to development in the town of West Lorne, in southwest Ontario, and caused a series of equipment failures at the Ford Motor Co.'s Windsor (Ont.) Casting Plant, where engine blocks are cast from molten iron.

Ford officials were able to kill the invaders with 300-pound doses of chlorine, leaving cleanup crews to contend with mountains of malodorous dead. But municipal officials have to think about purity as well as quantity. Since chlorine and mussel proteins can mix to form suspected carcinogens, Monroe officials are trying to develop a whirling scrubber that will unseat the intruders mechanically. Other communities are trying to concoct filters that will keep the mussels from entering the pipes in the first place. These devices will cost an estimated \$50 million apiece, and dozens of towns may require them. "Many of us are moving quickly to contain this mussel," says Michael Donahue of the Great Lakes Commission, an eight-state consortium of governments. "But I can tell you that the cost will be much more than the Exxon oil spill."

Natural predators may offer the best hope of all. No amount of garlic or butter will turn a zebra mussel into restaurant fare, but the striped pests have turned up in the stomachs of several species of fish. Diving ducks like them, too, and large flocks will spend the next two months in the Great Lakes, en route from Canada to the southern United States. Let us hope they're hungry.

GEOFFREY COWLEY with
LOUIS AGUILAR in Detroit

Global Change
File

Is It All Just Hot Air?

New computer models question the severity and timing of the greenhouse effect

How worried should we be about the greenhouse effect? Last week British Prime Minister Margaret Thatcher, hardly an eco-freak, called on the United Nations to adopt a binding treaty restricting emissions of gases that threaten to warm the planet, causing deadly floods and food shortages. Yet just the day before, at an international meeting in a Dutch seaside resort, only 30 of the 68 nations in attendance supported a Dutch proposal to freeze the level of emissions of greenhouse gases by the end of the century and cut them 20 percent by 2005. Japan, the Soviet Union, China and the United States—which together account for 58 percent of the world's output of these gases—agreed only that stabilizing them "should be achieved as soon as possible."

Environmentalists lambasted the empty statement as "either a failure of nerve or a cynical ploy," as Brooks Yeager of the National Audubon Society put it. Perhaps, but it also reflects the uncertainty of greenhouse science. Predictions of global warming rest on the observation that certain gases—carbon dioxide (CO₂), nitrous oxides, methane, chlorofluorocarbons (CFCs)—act like glass in a botanical greenhouse, trapping heat and thus warming the planet. That much remains unquestioned: a greenhouse of some magnitude is coming some time. The debate turns on three points:

- Have greenhouse gases affected our weather yet?
- How much will temperatures rise once greenhouse gases in the atmosphere reach twice their current levels, around 2030? A degree, or an apocalyptic 5.5 degrees?
- How long does it take for the mercury to shoot up?

For answers, climatologists turn to computer models. But these mathematical formulations are crude approximations at best, as the modelers are the first to admit. For instance, greenhouse contrarians charge, the models do not even "predict" the past very well. Gases released since the

19th century should have warmed the planet 3 degrees Celsius, according to the models—but the world has warmed no more than half a degree. The discrepancy may be due to a delay between the emission of greenhouse gases and their warming effect, a delay determined in part by how much CO₂ the oceans absorb and by how long it takes the waters to warm up. But critics don't accept that. "The most conservative climate model overestimated warming by a factor of six," says climatologist Patrick Michaels of the University of Virginia. "Isn't that enough to give you pause about [forecasts of] the end of the world?"

Although computer models say greenhouse warming has begun, the data are controversial. Climatologist James Hansen of NASA's Goddard Institute for Space Studies, using global-temperature data covering the last 100 years, concludes that the greenhouse effect has indeed kicked in: the readings have gone up an average of 0.4 degree Celsius. But skeptics argue that the tiny warming is due largely to urban heat islands—cities heating their surroundings. And since the thermometers are on land they may not reflect the (mostly watery) planet as a whole. "Ocean temperatures show no change since the 19th century," contends geophysicist Richard Lindzen of Massachusetts Institute of Technology.

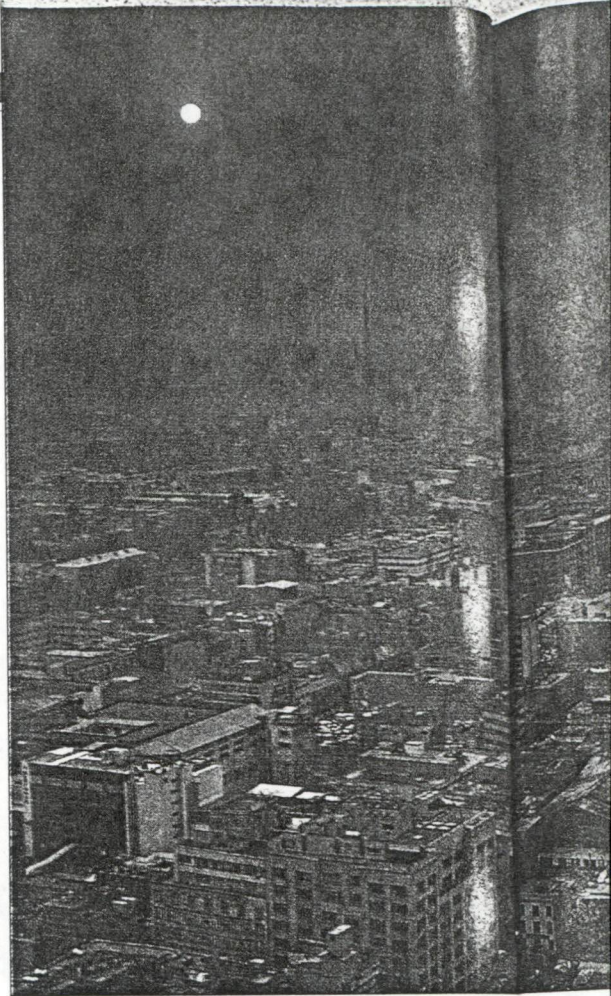
Tibetan glacier: New data, however, strengthen the case for the greenhouse. Next month, at a meeting of the American Geophysical Union, mathematicians from AT&T Bell Labs will report that, by ruling out other explanations of global warming—from chance to solar oscillations—they were able to conclude that "there is a 99.99 percent chance that the warming and the CO₂ rise are causally related," says David Thomson. And researchers from Ohio State University announced this month that ice cores from a glacier in Tibet show that Central Asia has warmed 1 to 3 degrees Celsius in the last 100 years—something that cannot be attributed to warm cities.

The more pressing question is what the

Villainous CO₂: Polluted Mexico City

climate will be like by, say, 2030. To answer that, researchers are making their models more realistic. In one recent fine-tuning, researchers led by J.F.B. Mitchell of the British Meteorological Office rewrote their equations to simulate clouds containing ice crystals, not only water vapor as before. The effect: overcast increases, which cools the world just as does a passing cirrus on a July afternoon. The result, the BMO group wrote in the journal *Nature*, is a global warming of 1.9 degrees Celsius, not the 3 to 5.5 degrees predicted by most current models. (In Fahrenheit, that's a warming of 3.4 degrees, rather than 5.4 to 9.9 degrees.)

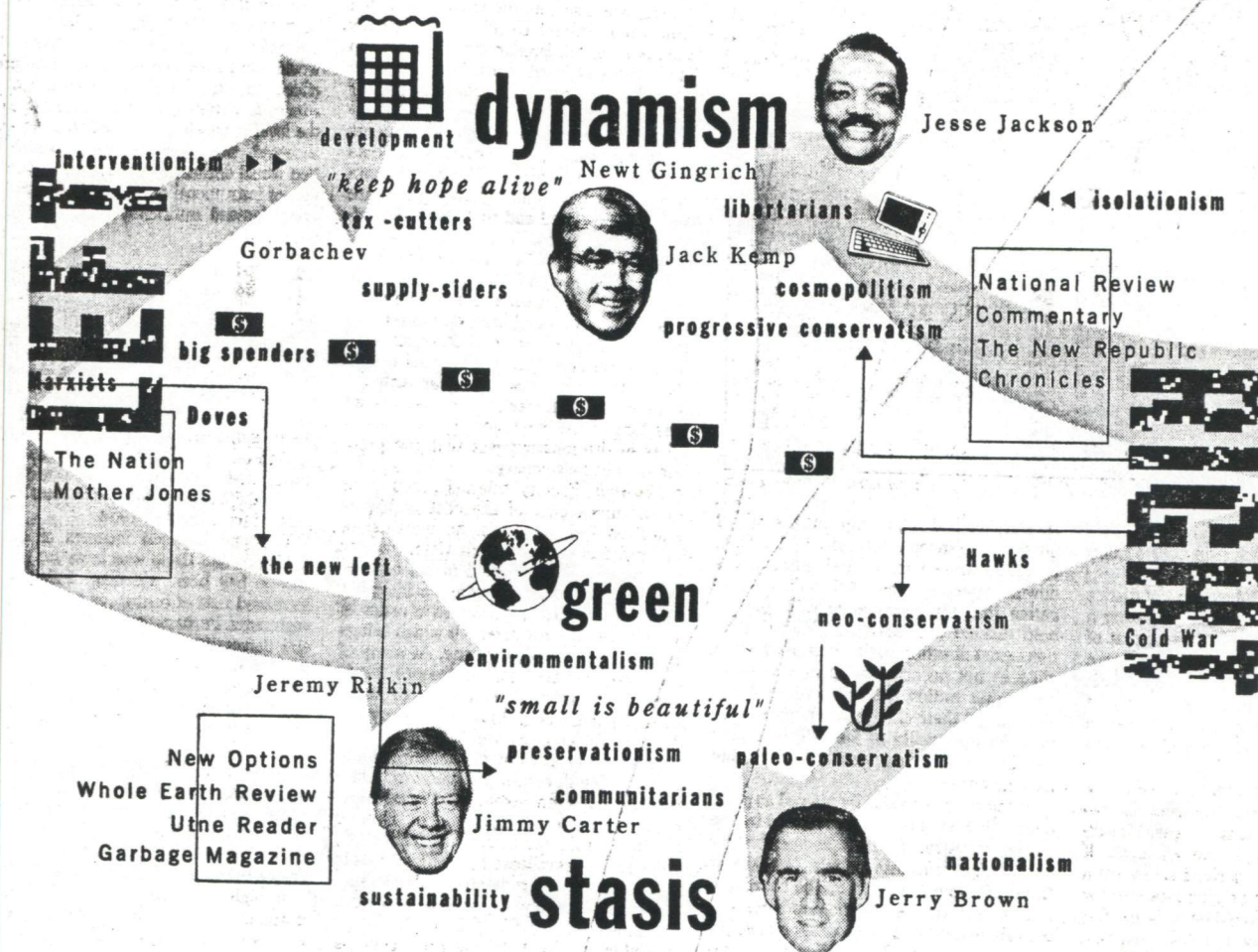
White House chief of staff John Sununu (an MIT-trained engineer) and science adviser D. Allan Bromley (a physicist) have seized on this result to argue against taking steps to mitigate the greenhouse. "You do not establish policies on the basis of incomplete models," Sununu told *NEWSWEEK*. "We have the time and obligation to find out what's going on. We're going to do the right thing. We want to know what the right thing is." True enough. But the White House may be taking more comfort from the new results than is warranted. V. Ramanathan, a University of Chicago geophysicist not noted for apocalyptic rhetoric, explains that cloud behavior "involves about 25 different interactions, and our models simulate only one or two. When we



Global Warming
DoWg.

OUTLOOK

Commentary and Opinion



NANCY BROOKE SMITH—THE WASHINGTON POST

The Ideology Shuffle

Forget Left and Right—Our Politics Are Breaking Down Into Growth vs. Green

By Virginia I. Postrel

A NEW IDEOLOGICAL fissure is rapidly reshaping American politics, one that is displacing the notions of "left" and "right" that have dominated our politics for decades. In fact, it is reshuffling leftists and rightists, creating surprising and sometimes bizarre new alliances between former opponents. This divide isn't over defense, spending, law and order or communism; it is between the proponents of economic dynamism and the advocates of stasis.

Although it has major implications for domestic and foreign policy, this new division is now particularly pronounced at the state and local level. Ultimately, it will define the most contentious issues of the coming decade: trade, immigration, urban growth and, above all, environmentalism.

On one side are those who see economic growth as fundamentally desirable. They accept,

Virginia Postrel is the editor of Reason magazine.

indeed relish, capitalism's "creative destruction." They glory in human ingenuity, extolling the virtues of immigrant shopkeepers and Silicon Valley entrepreneurs. They see economic opportunity as the only hope for the poor, and growth as the key to that opportunity. They view American individualism as a source of strength and a certain amount of disorder as the price of creativity.

On the other side are the prophets of "sustainability." They warn of limits to growth and decry the pace of modern life. They are suspicious of new technologies, seeing in them the seeds of future problems. They view the economy as essentially zero-sum, unable to bring prosperity to some without depriving others. They mourn the loss of community and the despoilation of the earth. Deriding their opponents as "techno-optimists," they prophesy worldwide disaster if we do not substantially alter our economic system.

This rift first appeared in the 1970s, with Jimmy Carter and Jerry Brown. This new kind of Democrat was not only willing but eager to preach limits and call for austerity and sacrifice. Simultaneously, and perhaps in response, the Re-

publican Party dropped its tradition of cautious naysaying and embraced dynamism as a fundamental principle. Hence, the rise of the supply-siders and of the Jack Kemp-Newt Gingrich idea of "progressive conservatism."

Since the '70s, peace and prosperity have changed the political background. Voters can now afford to grumble about oil spills, traffic and trade deficits, since they no longer face oil embargos, gasoline lines and stagflation. The '80s marked a decade of rapid economic change and restructuring.

The politics of stasis evokes a calmer, gentler America, one less subject to the hurly-burly of "merger mania" or foreign competition. After a decade in which dynamism has been in ascendance, those who call for a static economy can look less like malaise peddlers and more like moderates.

"Too many of us now tend to worship self-indulgence and consumption," said Carter in his "malaise" speech. "But we've discovered that owning things and consuming things does not satisfy our longing for meaning." In 1979, these

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sentiments sounded self-righteous and gloomy, an excuse for a lousy economy and a call to accept living with less. Ten years later, they would have fit into just about any review of the decade—or, indeed, into George Bush's inaugural address.

In this favorable environment, the old pro-stasis voices are speaking out with renewed vigor. "Most people do not recognize that, at least in rich nations, economic growth is the disease, not the cure," as Paul and Anne Ehrlich put it in their new book, "The Population Explosion."

Meanwhile, new advocates of dynamism are emerging, often bridging the traditional ideological categories. Joel Kotkin, coauthor of "The Third Century: America's Resurgence in the Asian Era," freely quotes Marx and criticizes as narrowly Eurocentric those who promote college courses on Western civilization. Yet his pro-entrepreneur, pro-immigrant, anti-protectionist message has found some of its most receptive audiences on the pro-capitalist right.

And lawyer Clint Bolick, of the Landmark Legal Foundation's Center for Civil Rights, is mounting a "conservative" campaign for a positive approach to civil rights. Rather than litigating to block affirmative action plans, Bolick tries to break down barriers to economic mobility.

Some of the most interesting pro-dynamism alliances are occurring not in the United States but abroad. Peruvian writer Hernando de Soto, whose book "The Other Path" is a bestseller throughout Latin America, calls himself a libertarian; his pro-capitalist analysis of the Peruvian economy's "informal sector" would put him on the American right. But he works with leftist unions of illegal entrepreneurs and sharply criticizes Peruvian conservatives. They are, he says, "mercantilists" hostile to economic dynamism, deregulation and the rule of law. (De Soto's analysis has reached as far as South Africa. Aggrey Klaaste, editor of The Sowetan, finds striking parallels between "The Other Path" and his description of Peru and life in South Africa, where many black entrepreneurs must operate illegally.)

Obviously, the familiar left-right dichotomy doesn't quite capture the emerging division. Advocates of dynamism are individualists and cosmopolitans, comfortable with displacement of the old order—liberals in the classic sense. Yet they increasingly set the tone of what has been the "conservative" movement.

Meanwhile, the proponents of stasis have congregated on the left's environmentalist fringe. They often call themselves "progressives," while in fact opposing progress as it is usually defined. Theirs is fundamentally a conservative vision: They oppose change and call forth a nationalistic, land-oriented order reminiscent of the European right.

It is not surprising, then, that some odd associations have emerged. Jesse Jackson's praise for Michael Milken—an abomination from the usual leftist viewpoint—makes

perfect sense when both men are seen as advocates of economic dynamism. So, on the other side of the divide, does the picnic for Jeremy Rifkin held last fall by the staff of *Chronicles*, a monthly published by the Rockford Institute.

Now that the right's anticommunist glue is evaporating, and with it the centrality of the neoconservatives, Rockford's "paleo-conservatives" hope to mount a comeback. Their message combines a dollop of limited-government rhetoric with a communitarian, anti-immigrant, anti-free trade, anti-technology agenda. It doesn't fit in very well with the Republican Party's pro-dynamism platform, but it has garnered some environmentalist friends.

This ideological realignment has ramifications in the world of practical politics. The question for both the Democratic Party and mainstream environmentalists is whether to adopt the politics of stasis as their prescription for economic and ecological health. The worldwide "green" movement offers a seductive—and inspiringly purist—alternative to accepting some risks, some changes and some pollution.

"I see the day in our lifetime that reverence for the natural systems—the oceans, the rain forests, the soil, the grasslands and all other living things—will be so strong that no narrow ideology based upon politics or economics will overcome it," said Jerry Brown in 1979. Many people think that day has come, at least in California. And Brown, back from exile, is now chairman of California's Democratic Party.

Green ideas are by far the most vital and exciting today's left has to draw on. (After only six years of publication, the green-oriented *Utne Reader* boasts a paid circulation of more than 200,000—twice that of *The New Republic* or *The Nation*.) Green ideology speaks of slowing life down and of viewing life whole. It evokes a world of natural beauty and human scale, in which people will fully understand the tools they use and will provide for themselves without depending on experts or specialists. It speaks not of "protectionism" but of "self-sufficiency," not of "regulation" but of "community control."

The politics of stasis is especially powerful at the state and local level. Although it has suffered electoral setbacks, "no growth" remains a rallying cry for both affluent home-owners and radical environmentalists. In 1988, New Jersey became the first state to adopt statewide growth controls. Over the last three years, 76 growth-control measures have appeared on local ballots in California; 70 percent have been approved.

Now an omnibus environmental initiative dubbed "Big Green" (with petitions printed on green recycled paper) is wooing California voters. Assemblyman Tom Hayden, whose political career is stymied, hopes his backing for Big Green will propel him to statewide office—the post of "Environmental Advocate," which the initiative would create.

Among its many draconian provisions, Big Green would decree that total carbon

dioxide emissions be cut by 20 percent by the end of the decade and 40 percent by 2010. In a state growing by half a million residents a year—with the concomitant increase in automobiles, electricity demand and backyard barbecues—that is a prescription not just for stasis but for economic depression.

The politics of stasis has proven it can win backing from grassroots activists. Indeed, a whole new movement has emerged, composed of local activists working to ban chemicals, oppose incinerators and control urban growth. It began with neighborhood protesters but quickly took on green ideological coloring.

"These activists were strongly attached to the notion of community; deeply mistrustful of corporate, governmental, and environmental elites; and willing to entertain the notion that the way to deal with a particular dump site ultimately led to the notion of industrial restructuring and dramatic political change," writes Robert Gottlieb in the March/April issue of *Tikkun*. Like the grassroots activists with whom he sympathizes, Gottlieb slams the large, mainstream environmental groups as too concerned with containing pollution, not enough with radical economic change.

Will stasis play as long-term politics? Such activists constitute an alluring constituency for Democratic politicians, but embracing

stasis as a political philosophy could cost the party what remains of its traditional constituencies.

As Jesse Jackson's move toward the politics of dynamism demonstrates, "keeping hope alive" doesn't necessarily square with keeping things the same. And green prescriptions have a way of taking their toll on the upwardly mobile poor. The Los Angeles area's much-touted Air Quality Management District plan to reduce air pollution threatens to all but wipe out the region's flourishing furniture business—a major employer of Latino immigrants—while producing plenty of jobs for college-educated consultants.

And given their open hostility to "industrialism," it isn't surprising to find greens less than sympathetic to manufacturing jobs. Yet those are the jobs that have provided middle-class lives for the Democrats' already-diminishing blue-collar constituency. The green solution is redistribution, which, at best, offers the poor a less-bad life, not a good one.

And, of course, there's the South—a region that remembers what it's like to be poor and is none too eager to return to that status. Green advocates of "steady-state economics," such as World Bank economist Herman E. Daly, deplore capital mobility, not only among nations but among regions. Without such mobility, the South would never have become the Sunbelt, and southerners know that.

Finally, embracing the politics of stasis could mean cutting the Democratic Party off once and for all from what is most appealing about liberalism: its optimism. The Republicans will quite happily become the party of hope—they do, after all, claim a classical-liberal wing—and the Democrats may find themselves with nothing to offer but fear itself.

Mainstream environmentalists, too, face a choice about aligning themselves with those whose goal is to dismantle industrial society. Clean air and water, lovely places to hike, protection for endangered species—these are the environmental goals most Americans embrace. But average citizens do not long for the world of subsistence agriculture or localized economies envisioned by greens.

Asked to select the two most urgent problems facing the country today, respondents to a Los Angeles Times poll ranked the environment fifth—well behind crime, education, low morals and government spending. Fifteen percent of those polled included the environment among their top two concerns; by comparison, 14 percent selected unemployment, even though the unemployment rate is at its lowest level in two decades. The poll suggests that Americans value a clean environment, but not at the expense of prosperity. At the ballot box, dynamism is likely to be far more successful than stasis.



EXECUTIVE OFFICE OF THE PRESIDENT
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THE DIRECTOR

April 3, 1990

NOTE FOR MSSRS: SUNUNU
BOSKIN
✓BROMLEY
PORTER
ZOELICK
AND OTHER FRIENDS OF THE EARTH

SUBJECT: "GLOBAL WARMING"

In case you missed it, I enclose an annotated bibliography FYI. This deals only with the question: Is there evidence of significant warming? This selection of 50 studies suggest: No. I will forward a more complete bibliography that treats both sides.

For those who believe there is significant warming -- notwithstanding these studies -- there remains the interesting question: What to do? I've sent you the Schelling piece. More will follow.

Richard G. Darman

cc: Grady

FIFTY REASONS TO DOUBT GLOBAL WARMING

1. Spencer, R., and Christy, J.R., 1990: "Precise Monitoring of Global Temperature Trends from Satellites." *SCIENCE* V. 247 pp 1,558-1,562. Shows no warming trend in atmosphere 1979-1988.
2. Lindzen, R., 1990: "Some Coolness Concerning Global Warming" *Bulletin, American Meteorological Society*. V 71 p 288-299. Shows conflict between model forecasts and reality.
3. Angell, J.K., 1986: "Annual and Seasonal Global Temperature Changes in Troposphere and Low Stratosphere." *MONTHLY WEATHER REVIEW* #107, pp 1922-1930. Shows no statistically significant trend in N.H. stratospheric temp., despite CO2 buildup.
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5. Karl, T.R., and Jones, P.D., 1988: "Urban Bias in Area-Averaged Surface Air Temperature Trends." *BULL. AMER. MET. SOC.* #70, pp. 265-270. Shows NASA temperature record has a 0.2 degree C. urban bias, cutting actual global warming to 0.2-0.3 degrees, last 100 years.
6. Michaels, P.J., et al., 1988: "Anthropogenic Warming in North Alaska?" *J. OF CLIM.* #1, pp. 942-945. Using atmospheric pressures to show non-urban temp. trends, shows no warming since 1948.
7. Michaels, P.J., et al., 1989: "Regional 500 Millibar Heights Prior to Radiosonde Era" *Proceedings 6th Conf. Amer. Met. Soc.* 1989. Extends atmos.press./temperature model to 1885, shows no net non-urban warming and substantial decline since 1940.
8. Elsasser, H.W., et al., 1984: "Global Climatic Trends as Revealed by Record Data." *REVIEW OF GEOPHYS.* #24, pp. 745-792. Shows all of the temperature rise since 1880 took place *prior* to trace gas buildup, followed by substantial *decline*.
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10. Seaver, W.L. et al., 1988: "Stat. Exam. of Sky Cover Changes in Contiguous U.S." *J. CLIM. APPL. MET* #26, pp. 88-95. Documents rising cloudiness offsetting predicted greenhouse effects.
11. Wigley, T.M., 1989: "Possible Climate Change Due to SO2 Derivative Cloud Condensation Nuclei." *NATURE* #338 pp. 365-367. Suggests sulphate cloud brightening explains lack of warming trend since 1940.
12. Barnett, T.P. and Schelsinger, M.E., 1987: "Detecting Changes in Global Climate Induced by Greenhouse Gases" *J. GEOPHYS. RES.* #92, pp. 14,722-14,780. Shows natural climate variability is greater than the ability of models to detect trends.
13. Balling, R.C., and Idso, S.B., 1989: "Historical Temp. Trends in the U.S. and Effect of Urban Pop Growth." *J. GEO. RES.* #84, pp. 3,359-3,363. Shows dramatic drop in U.S. Southeast mean winter temperatures over 60 years.
14. Karl, T.R., et al., 1988: "Urbanization: Its Detection and Effect on U.S. Climate Record." *J. CLIM.* #1, pp. 1,099-1,123. Shows that urban bias affects temperature record in towns as small as 2,580 in population and could explain entire "warming trend" of Hansen observations.
15. Michaels, P.J., 1985: "Anomalous Mid Atmospheric Heights and Persistent Thunderstorm Patterns over Florida." *J. CLIMATOLOGY* #5, pp. 529-542. Documents substantial cooling of middle layers of U.S. atmosphere, free of urban bias.
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33. Elsasser H., 1986: "Surface Temperature Changes Following 6 Major Volcanic Episodes 1780-1980." *J. CLIM. APPL. MET.* #25, pp. 1,184-1,185. Shows climate more resistant to radiation shocks than thought.
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40. Trenberth, K.E., et al., 1989: "Origins of 1988 N.A. Drought." *TRANS. AMER. GEOPHYS. U.N.* #69, p. 1067. Shows 1988 heat and drought entirely caused by change in El Nino ocean current, not CO2.
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National Institutes for the Environment

A Proposal

"It is time for the U.S. to treat the environmental health of the nation and the planet with the same seriousness it devotes to the health of its citizens."

National Institutes for the Environment

Tropical deforestation. Mass extinction. Global climate change. Ozone depletion. Acid rain. Pollution and toxic wastes. Rapid human population growth and dwindling natural resources. We face a world in which accelerating social change and global deterioration threaten our security and very survival, especially that of our children. These changes present us with historic opportunities and challenges. Solutions to many environmental problems still lie within reach. But we cannot delay. The problems we face will grow unimaginably more difficult and costly to fix with time.

In the 1940's the United States created the National Institutes of Health to attack serious health problems like cancer and polio. NIH sponsored the pioneering research that led to many of the medical advances that we enjoy today.



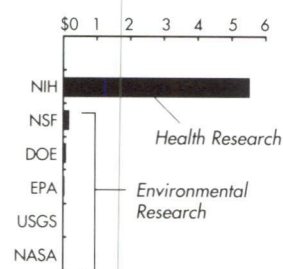
*Tropical deforestation in Brazil to create pasture for cattle ranching.
Photo: S. P. Hubbell.*

It is time for the U.S. to treat the environmental health of the nation and the planet with the same seriousness it devotes to the health of its citizens. It is time to create the National Institutes for the Environment (NIE). The NIH was created from the peace dividend at the end of World War II. The NIE can be created from the peace dividend at the end of the Cold War.

The NIE is an idea whose time has come. A broad national consensus is emerging that more effective action on the environment is needed. We do not own the Earth; we are merely trustees. If we do not manage the Earth more wisely, our children will hold us accountable for its destruction.

The Need for the National Institutes for the Environment

Research on Health vs. the Environment
(\$ Billions)



The United States currently spends billions on health and environmental research, but most of this money is directed at improving human health. In fact, the U.S. spends about 2200% more on health research than on research to cure all environmental problems combined. This imbalance cannot continue. The graph lists total FY 1991 projected expenditures for investigator initiated research grants by each agency.

Almost everyone today acknowledges that the environment is in trouble. Recent polls reported in the *New York Times* indicate that the environment is now the No. 1 concern of a majority of Americans.¹

But there is disagreement about the extent of the environmental crisis and even the nature of the problems. We still suffer from a profound ignorance about the true state of the environment. This lack of scientific knowledge is hindering our ability to develop and implement sound national policy and management plans for the environment.

Our government can't enact enforceable regulations and policies to solve environmental problems unless a national consensus has been reached about fundamental issues and values. As a result, the U.S. faces a tidal wave of environmental litigation. Poorly conceived environmental regulations based on limited or faulty data can cost the nation billions of wasted dollars, and may even be environmentally damaging.

The U.S. needs better ways within the Federal government to assign priorities to environmental problems and search for their solution. We need the National Institutes for the Environment to set the priorities, provide the critical environmental data, and do the targeted research to solve the priority environmental problems.

Environmental research efforts currently are largely fragmented, ad-hoc reactions to environmental crises, rather than carefully planned efforts to protect the environment through wise management. We need the NIE, because the U.S. needs a better understanding of the environment and the means to anticipate and prevent problems.

At present no Federal agency effectively sets national environmental research priorities or

targets research to find solutions to problems. We need the NIE to assess and assign priorities among the many environmental problems facing us today. We need the NIE, because we need an agency that can foster mission-oriented research to find solutions to the most critical environmental problems.

Most environmental research today is short-term and narrowly focused, because of grossly inadequate and unpredictable funding; but national and global environmental problems demand long-term commitments and truly multidisciplinary research that the NIE would provide.

Much present environmental research is of uneven quality and is often conducted by government and the private sector to defend or attack proposed regulations. The NIE would seek scientific knowledge and lasting solutions to environmental problems without bias or pre-conceived notions.

Currently there is no single, coordinated source for environmental data and information. Monitoring information of vital environmental importance is reported piecemeal, or is restricted or simply unavailable. Development of a successful national and global environmental management effort depends critically on having accessible and accurate information. The NIE would build a national library on environmental issues, open and accessible to all, and would create and maintain a program in environmental statistics and risk assessment.

Finally and most importantly, the U.S. faces a serious shortage of environmental scientists. We are unprepared to properly manage and protect the environment, because there is no one to do the work. The NIE would provide funds to train the next generation of scientists.

¹ *New York Times*, January 25, 1990, page B9.

The Proposed National Institutes for the Environment

The Unique NIE Mission

The NIE would create a new forum for environmental scientists, managers, and policy makers in the U.S. Although the NIE would increase funding for environmental research targeted on critical problems, it would not replace existing research efforts; it would complement and strengthen them. There are many established environmental research efforts currently under way among government agencies. The critical missing link in this research has been communication and coordination among diverse scientific disciplines and particularly among scientists, environmental managers, and policy makers. The NIE would supply this missing link.

The 4 main functions of the NIE would be to 1) sponsor environmental research via grants to universities and other qualifying research organizations; 2) increase the U.S. production of environmental scientists; 3) develop a global environmental data base and national environmental library; and 4) promote public environmental education.

Environmental research would be sponsored through competitively awarded, panel-reviewed grants to individual investigators as well as to multidisciplinary investigatory teams. The NIE would sponsor fundamental and applied research among the natural, engineering, and policy sciences. Research would focus on complex issues such as global climate change, sustainable resource use, inventory of biotic resources, habitat destruction, species extinction, and the degradation of the human environment.

Creation of NIE Institutes

A major focus of the NIE would be to satisfy the critical need for more research and better coordination and communication among scientific researchers, environmental managers, and policy makers. To do this the NIE would establish a number of research institutes focused on major environmental problem areas, and whose research would be targeted and coordinated through the administrative umbrella of a guiding scientific committee that would set research targets and policy for all institutes.

Effects of Establishing the NIE

Through these research institutes, guided by a scientific oversight committee, the NIE would forge a new way for all stakeholders in the environment—academic and government research organizations, environmental groups, industry, and policy analysts—to work together

and serve society's environmental needs. This new partnership would lead to:

Improved Environmental Research and Policy Decision-Making

The NIE would promote research among government agencies, academic institutions and industrial scientists, collaborations that currently are difficult to form under our present system of environmental research. Such collaborations would work on common high-priority projects and strengthen the partnership among scientists, managers, and policy makers.

Establishing the NIE would also improve the process of identifying and ranking problems to set a national environmental agenda. The NIE would help set uniform standards and national strategies for environmental action.

Accelerated Progress Toward Solving Environmental Problems

The NIE would foster mission-oriented research based on its agenda of critical environmental problems. It would help determine which problems could be remedied or mitigated, and assess research progress toward solutions. It would monitor the success of practical applications in order to guide future research directions.

It would create an environmental database, a library on the environment, and create an environmental statistics and risk assessment program that would serve the research and policy needs of the nation.

Finally, it would provide graduate fellowships to train the next generation of environmental scientists.

The Proposed Organization of the NIE

To stimulate national discussion of the NIE concept, we propose the following organization for the agency. The NIE would house 5 problem-oriented Institutes to fund extramural research and 4 Intramural Centers to provide information and management support for the Institutes.

Institute of Biotic Resources

The Institute of Biotic Resources would support research to inventory the biological diversity of the U.S. and the world and to explore its practical values for humanity. It would support taxonomic research and biogeographic surveys. Research topics would include the causes of extinction, methods of conserving germplasm and the maintenance of captive populations in zoos and arboreta. It would support research to discover and develop unutilized sources of useful natural products such as new medicines and pesticides and new sources for food, fodder, fiber,

firewood, timber and other products. It would also sponsor research on the economic valuation of biodiversity.

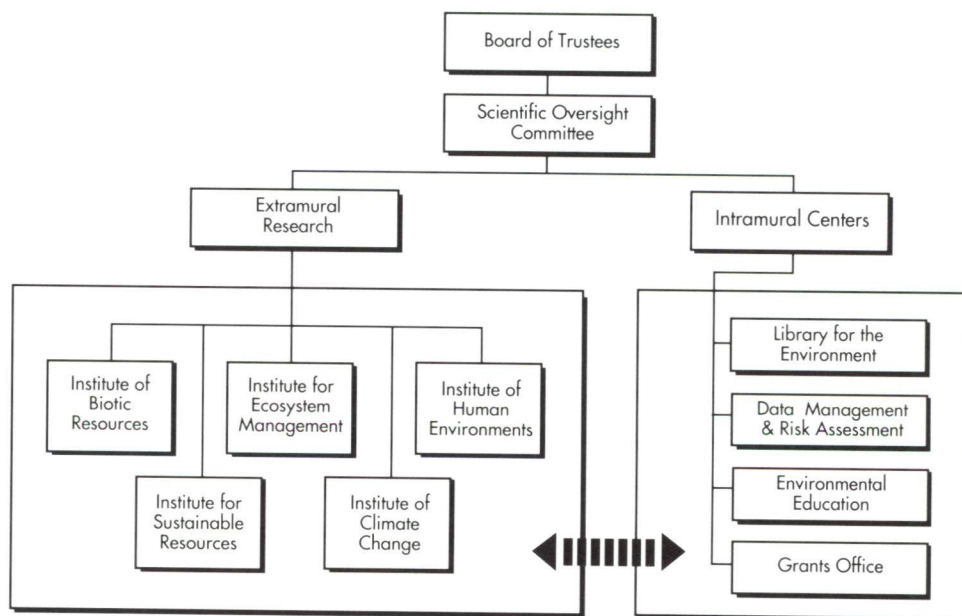
Institute for Ecosystem Management

The Institute for Ecosystem Management would sponsor research on the interactions of organisms with each other and with their physical environment. Research topics would include ecosystem function in natural, stressed, and managed systems, responses of plant and animal species to environmental change and the causes and consequences of habitat destruction.

Institute for Sustainable Resources

The Institute for Sustainable Resources would sponsor research on the sustainable exploitation of energy, land, soil, water, mineral and biotic (e.g. forest) resources. Research topics would include sustainable agriculture and forestry,

Reporting to the Board of Trustees would be a Scientific Oversight Committee made up of eminent scientists selected on a rotating-term basis from each of the Institutes and from other federal agencies engaged in environmental research and management. At-large members from the public, industry, nongovernmental environmental organizations, and academic institutions would also be represented. The Committee would establish overall research policy and conduct or commission studies of environmental problems for possible adoption as targeted research areas.



environmental engineering, restoration ecology, and energy and renewable resource engineering and policy.

Institute of Human Environments

The Institute of Human Environments would sponsor research on the interactions of human societies with their environment. Research topics would include pollution, waste disposal, the economics of environmental degradation and restoration, population growth in relation

to resources, conflict resolution over resources and environment, and cultural survival.

Institute of Climate Change

The Institute of Climate Change would support research addressing the effects of climate change on biotic systems, economic development and policy issues. It would monitor biotic responses to climate change and conduct research to anticipate the effects of climate change on ecosystems, food and agriculture.



Ecologist studying the pollination system of a rare tropical tree.

Photo: S. P. Hubbell.

The Intramural Centers

We envision a series of intramural centers in the NIE that would meet needs shared by all of the NIE institutes. We propose the following 4 centers:

- ***Center for Environmental Data Management, Risk Assessment, and Statistics*** would fill the critical need for a national database on the environment. It would maintain environmental monitoring records and support methods to catalog and inventory changing patterns of environmental use. It would also analyze trends and assess the hazards of environmental change. It would conduct economic and policy analyses for all the institutes and assist in the process of assigning research priorities.
- ***The National Library for the Environment*** would provide a center for information on the environment.
- ***Center for Environmental Education*** would provide information services to all NIE institutes as well as other agencies, nongovernmental institutions and the general public.
- ***Center for Environmental Education*** would support programs on environmental education to improve public and policy-maker understanding of environmental issues and options for environmental management.
- ***Office of Fellowships and Grants*** The Office of Fellowships and Grants would administer fellowships and sponsored research programs for all the institutes.

The Cost of the NIE

Estimated Annual NIE Budget in 5 Years (\$ Millions)

Item	Cost
Extramural Research Grants	\$400
Graduate Fellowships and Grants	\$50
Intramural Programs and Centers	\$50
Total	\$500

In comparison to military spending, the proposed annual NIE costs are modest. One to five years of full NIE support could be provided for the cost of a single Stealth bomber (\$500 million each). The possibility of an environmental catastrophe currently poses a much greater long-term threat to U.S. security and health than war. The U.S. must redirect its financial resources to the intensifying problems of the environment.

Cost estimates for the NIE are presently being prepared, but ball-park figures can be given. It is estimated that about \$100 million per year would be required as a minimum starting budget for research (\$50 million), graduate training (\$30 million), and intramural centers and administration (\$20 million). What would this \$100 million buy?

Fundamental and Targeted Research

A single-investigator award costs between \$100,000 to \$200,000 per year, including overhead. A multidisciplinary environmental project involving 10 senior scientists costs \$2-5 million per year. Thus \$50 million would buy between 250-500 individual-investigator grants, or 10-25 teams of scientists working on multidisciplinary projects, or some combination of individual investigators and research teams. If we assume that there are 10 broad fields of environmental research supported by the NIE, then we can fund at most 25-50 grants per field per year, depending upon the mix of awards to individual scientists and interdisciplinary teams.

Training More Environmental Scientists

Today the cost of training one environmental post-graduate scientist through the Ph.D. degree is between \$18,000-\$25,000 per year (tuition plus stipend, excluding research costs), or a total of \$100,000-\$125,000 per Ph.D. Assuming a 4-5 year degree program, a funding level of \$30 million per year would produce 240-300 new Ph.D's per year, with a standing number of about 1200 students in the pipeline. Assuming there are 10 broad fields of environmental research supported by the NIE, then we can produce at most about 24-30 new Ph.D's per field per year.

Intramural Centers and Administrative Costs

Central to the function of the NIE are the intramural centers, including the library for the envi-

ronment, the environmental data center, and the education center. These centers and administrative offices should be located in the Washington, D.C. area. The startup cost of these operations is about \$20 million per year, exclusive of new construction and equipment costs.

Projected Costs of the NIE in 5 Years

The figures above are ball-park minimal startup costs. They fall short of the funds that the NIE will need to train the numbers of environmental scientists that will be required to monitor the environment and solve environmental problems. The NIE will also need funding to support the research of these newly trained scientists in the coming decade. We estimate that the budget of the NIE will grow to about \$500 million per year within 5 years (table at left).

Where Will the Money Come From?

If the U.S. hopes to deal effectively with environmental problems, new federal money must be allocated to solving them. The estimated costs of the NIE (\$100-\$250 million) are very modest by health research (\$5.5 billion) or military (\$200+ billion) standards.

One source of new money comes from the present collapse of the Cold War. This presents the U.S. with an historic opportunity to redirect funds towards solving serious environmental problems. What better time is the nation likely to have than now to create the NIE?

The NIE could also be created as part-public and part-private institution, creating opportunities for nongovernmental endowment support, as has been done with the Smithsonian Institution. This approach would help to foment the partnership among industry, government, and academic institutions on research to solve environmental problems.

**We, the undersigned, call
for serious study of the NIE
concept by Congress.**

Dr. Stephen P. Hubbell (Co-chair)
Princeton University

Dr. Henry F. Howe (Co-chair)
University of Illinois

Dr. Dean Abrahamson, Humphrey Institute for
Public Affairs, University of Minnesota

Dr. A. Kareem Ahmed, Partner, Environ Corp.

Dr. James Brown, University of New Mexico

Dr. Lester R. Brown, Director, Worldwatch
Institute, Washington, D.C.

Dr. Paul R. Ehrlich, Director, Center for
Conservation Biology, Stanford University

Dr. Mohamed T. El-Ashry, V.P., World
Resources Institute, Washington, D.C.

Dr. K. Elaine Hoagland, Association for
Systematic Collections, Washington, D.C.

Dr. Malcolm Gillis, Vice Chancellor,
Duke University

Dr. Bernard Goldstein, Director, Institute of
Environmental Health Sciences, Rutgers
University

Dr. Jonathan Haas, Vice President
for Research, Field Museum, Chicago

Dr. Theodore Hollar, Chancellor
University of California, Davis

Dr. William Jordan, President, Society of
Restoration Ecology, University of Wisconsin

Dr. Thomas Lovejoy, Assistant Secretary for
External Affairs, Smithsonian Institution,
Washington, D.C.

Dr. John Matson, Director, Office of Operation
Technology, The Johnson & Johnson Co.

Dr. Theodore Panyotou, Harvard Institute for
International Development, Harvard University

Dr. George Rabb, Director, Brookfield Zoo

Dr. Robert Repetto, World Resources Institute,
Washington, D.C.

Dr. Daniel I. Rubenstein, Princeton University

Dr. William D. Ruckelshaus, Chairman,
Browning-Ferris Industries, Houston, Texas

Dr. Arthur Sacks, Director, Institute for
Environmental Studies, University of Wisconsin

Dr. Stephen H. Schneider, National Center for
Atmospheric Research, Boulder, Colo.

Dr. Robert Socolow, Director, Institute for
Energy and Environmental Studies,
Princeton University

Dr. Gus Speth, President, World Resources
Institute, Washington, D.C.

Dr. Joseph Travis, Florida State University

Dr. David Wake, Director, Museum of
Vertebrate Biology, University of California,
Berkeley

Dr. Frederic Wagner, President, Association of
Ecosystem Research Centers, Utah State
University

Dr. Leonard Weinstein, Director, Ecosystems
Research Center, Cornell University

Dr. Edward O. Wilson, Harvard University

Dr. Julian Wolpert, Woodrow Wilson School,
Princeton University

Creation of the National Institutes for the Environment

National and global environmental change will be a dominant issue that shapes the economic and geopolitical agendas of the next century. The National Institutes for the Environment will help guide the nation and the world to a more secure and sustainable relationship between humanity and the global environment. Through an innovative feedback of science and policy development, and sponsorship of individual research and multidisciplinary task forces, the NIE will provide a new and better way to assign environmental priorities, focus research, develop policy and educate the public on environmental problems of immense practical significance to human progress. The United States should dedicate itself to the environmental welfare of its citizens. A commitment to the NIE will be a legacy for the 21st century of which the nation can be proud and for which the community of nations will be grateful.

About the Committee for the National Institutes for the Environment

In December, 1989 a group of about 30 scientists from many disciplines concerned about the need for a more effective U.S. response to national and global environmental problems, met in Washington, D.C. to draft this white paper. Our goal was to put the discussion of the National Institutes for the Environment on the national agenda as soon as possible.

For further information on the NIE, contact:

Dr. Stephen P. Hubbell
Department of Biology
Princeton University
Princeton, NJ 08544
(609) 258-6797

Dr. Henry F. Howe
Department of Biological
Sciences (M/C 066)
University of Illinois
P.O. Box 4348
Chicago, IL 60680
(312) 996-0666



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U.S. Intends To Oppose Ozone Plan

Sununu and Darman Are Said to Reject Third World Program

By Michael Weisskopf
Washington Post Staff Writer

U.S. delegates to an international conference on chlorofluorocarbons (CFCs) have been instructed to oppose a plan supported by European governments that would provide \$100 million to developing nations to help them reduce the use of the ozone-depleting chemical, informed sources said yesterday.

The plan, expected to be proposed in Geneva today, is designed to encourage such modernizing giants as India and China to join a 1987 treaty calling for drastic reductions by the year 2000 of CFCs, a versatile gas used widely for refrigeration, production of polystyrene and cleaning of computer parts.

Environmental Protection Agency Administrator William K. Reilly and top State Department officials recommended that the United States support the plan, which was developed by a working group of treaty signatories in recent months, sources said.

But their recommendation was overridden by White House Chief of Staff John H. Sununu and Office of Management and Budget Director Richard G. Darman, who are opposed to providing any additional funds outside the existing programs of international organizations such as the World Bank, the sources said. The U.S. share of the fund would be \$25 million over three years.

The U.S. position at the United Nations-sponsored meeting is likely to prompt fresh criticism that the Bush administration is lagging behind other governments in proposing solutions for global environmental problems.

Last year the administration endorsed a phaseout of CFCs only after the Europeans had proposed it

first. On global warming, President Bush continues to emphasize the scientific uncertainties of the threat while some European nations already have begun taking steps to curb emissions of man-made gases that trap solar heat.

At an international conference in Washington last month called by Bush, European participants severely criticized the administration for failing to take concrete action to reduce global warming.

The United States did assume a leadership role at the end of the Reagan administration when it pushed for the international accord signed in Montreal in 1987 that called for reducing world-wide con-

sumption of CFCs by 50 percent by 2000.

Even though 54 nations have ratified the protocol and most have pledged to move for elimination of CFCs during treaty revisions this June, efforts to preserve the stratospheric ozone layer that screens out harmful ultraviolet rays will be frustrated if the Third World does not curb its use of CFCs, according to scientists.

China and India, which together make up more than a third of the world's population, have ambitious plans to provide their citizens with refrigerators and other consumer goods that use CFCs, and they question why they should deprive themselves of the cheap, plentiful chemical.

The protocol anticipated such concerns and included a provision in which signatories pledged to "facilitate bilaterally or multilaterally the provision of subsidies, aid, credits, guarantees or insurance programs . . . for the use of alternative technologies and for substitution products" in developing nations.

According to sources, the proposal expected to be introduced today calls for a \$100 million fund to help Third World industries that use CFCs convert to alternative chemicals, cover the extra costs of alternatives and identify additional ways to replace CFCs.

The fund would be administered by an international lending authority, such as the World Bank, and

could be replenished after the first three years of activity.

Sources said Sununu and Darman were adamantly opposed to the plan out of concern that it might become a precedent for demands on the United States to provide far more aid to the Third World to compensate for curbs on global warming gases.

The White House press office did not return a reporter's call.

The administration's opposition is expected to renew congressional criticism of Bush's environmental record. The Senate last month voted overwhelmingly for a proposal by Sen. John H. Chafee (R-R.I.) that called for financial assistance to the Third World to expedite world-wide phaseout of CFCs.

Global
Change
files.

In the Ebb and Flow Of Ancient Glaciers Clues to a New Ice Age

Greenhouse effect could delay the onset of
the cold, glaciologists say.

The New York Times January 16, 1990

By WILLIAM K. STEVENS

THE climatic history of the last half-million years is largely a history of ice and cold, punctuated every 100,000 years or so by brief, glorious intervals of unusual warmth called interglacials. If nature takes its course, scientists say, the current interglacial — the one in which human civilization developed — should begin to end within the next 2,000 years or sooner.

But nature may not take an unaltered course.

Unprecedented concentrations of heat-trapping carbon dioxide in the atmosphere could extend the present interglacial by a millennium or more and transform it into a "super-interglacial" with average global temperatures higher than any seen in the last million years, say a number of scientists who study the advance and retreat of the great glaciers.

Putting off the next ice age might seem an attractive prospect; in the depths of the last one, 18,000 years ago, global temperatures averaged almost 10 degrees colder than today's and much of North America was buried under ice averaging a mile thick. Some experts say, however, that such a delay carries its own risks and uncertainties. There has never been more carbon dioxide in the air than now, they say, and since the burning of fossil fuels is causing the concentration to rise with no end to the increase in sight, there is no reliable guide to the climatic changes and disruptions it might cause.

"We're going outside what nature has experienced in the recent past," said Dr. Nicholas Shackleton of Cambridge University in England, who has long been in the forefront of research on the glacial periods. "It's scary."

In the last decade or so, scientists have made great strides in understanding the causes and workings of the great glacial cycles. But how much the globe will warm up is a matter of intense argument, and some glaciologists who believe that a super-interglacial is on the way say it may not last long enough to delay the world's turn to a new ice age. How all this will

play out is one of the major questions faced by the interrelated sciences of glaciology and climatology.

The present interglacial is 10,000 to 13,000 years along, and scientists say that in at least the last half-million years, no interglacial has ever lasted longer than 13,000 years. Over the last few years, scientists have generally come to agree on what determines the timing of these warm cycles and of the long, uneven cold spells that culminate in full ice ages.

The glacial cycles are set in motion by periodic wobbles in the Earth's rotation and changes in the tilt of its axis and the shape of its orbit, occurring over tens of thousands of years. The three overlapping cycles control the timing of global warming and cooling, and the long-term advance and retreat of the glaciers, by altering the angles and distances from which the Sun's energy strikes the Earth.

The shortest cycle, which is repeated mainly in periods of 19,000 and 23,000 years, is that of the wobble in the Earth's rotation. The wobble, or precession, is much like that of a spinning top as it loses speed. In the second cycle, the tilt of the Earth's axis as it orbits the Sun varies from about 22 degrees to about 25 degrees over 41,000 years. In the longest cycle, the Earth's orbit stretches slightly from nearly circular to elliptical and back again every 100,000 years or so.

To some degree, said Dr. John Imbrie of Brown University, a leading glaciologist, the two shorter cycles appear to exert a direct force on the climate, much as the Earth's movement about the Sun exerts a direct influence on the change of seasons. By itself the 100,000-year cycle does not appear strong enough to bring about direct alterations in the Earth's climate. But scientists believe it sets off complex and far-reaching changes in the ocean-atmosphere system that drives the climate.

This astronomical theory of glaciation, as it is called, was first set forth in the

1920's by Milutin Milankovitch, a Yugoslav mathematician, but confirmed only in the 70's and 80's. Researchers did so by analyzing ocean sediment in which the glacial cycles were reflected in the remains of plankton-like animals that live at particular temperatures, and by studying the ancient distribution of isotopes of oxygen whose proportions vary with the temperature.

The focus of research now is on understanding how all three cycles affect the workings of the dauntingly complex ocean-atmosphere system and how they will be affected by rising concentrations of carbon dioxide and other greenhouse gases.

Ice ages and interglacials differ from each other in their duration and internal fluctuations, partly because the interaction of the three astronomical cycles is rarely the same. The ice ages cannot be forecast exactly;

Cold Times, Warm Intervals

The cause of these little ice ages, which have about one-tenth the impact of a full ice age, is uncertain, although some scientists believe they may be related to variations in the Sun's energy output. Smaller climatic oscillations also take place on scales of a century or less, and even smaller ones last a few years. There were warm intervals in the last little ice age, for instance; and in the United States, the relatively warm 1930's gave way to the colder 50's, 60's and 70's, to be followed again by the warmer 80's. Some climatologists say an overall warming trend can be detected over the last century, but others dispute this.

The causes of these shorter-term oscillations are poorly understood, said Dr. Imbrie. Scientists believe that among the factors involved are volcanic eruptions and the periodic back-and-forth shifts in the surface temperature of the equatorial Pacific Ocean that have become known as the El Niño-La Niña cycle.

Climatologists and glaciologists are sure that both the oceans and atmospheric carbon dioxide figure strongly in the longer-term climatic shifts. One of the great discoveries of the last decade, said Dr. Imbrie, was the finding by French and Soviet scientists in 1987 that atmospheric carbon dioxide rose and fell in rough parallel with the ice-age cycle over the last 150,000 years, covering two interglacials. The scientists made

their findings by analyzing core samples of Antarctic ice.

Whether the carbon-dioxide fluctuation is a cause or an effect of warming and cooling is an unanswered question of the chicken-and-egg sort. "One of the really fundamental problems to be solved is why the carbon dioxide changes, because that clearly is involved in this ice-age change," said Dr. Imbrie. "Nature herself has been changing carbon dioxide substantially, and a Nobel Prize question is why that happens."

In one way or another, he and other scientists believe, the Milankovitch cycles probably influence the way the ocean circulates, setting in train a complex chain of climatic interactions, involving carbon dioxide, ice, air temperatures, clouds, vegetation patterns, dust, atmospheric methane and a host of other factors.

Cycles and Currents

Studies of ocean sediment indicate that in glacial times, carbon dioxide is transferred from the upper waters of the ocean to the depths, said Edward A. Boyle, a planetary scientist at the Massachusetts Institute of Technology, in a paper at the American Geophysical Union in San Francisco last month. One consequence, he said in an interview, is that the ocean becomes more alkaline and draws more carbon dioxide from the atmosphere. Lower levels of carbon dioxide are associated with lower global temperatures. "There is probably something about the Milankovitch cycles that alters the chemical redistribution within the ocean," he said.

The Milankovitch cycles may also cause the pattern of ocean currents to change abruptly, altering the global distribution of heat, say Wallace S. Broecker, a geochemist at the Lamont-Doherty Laboratory, and George H. Denton, a geologist at the University of Maine. They believe this sudden "flip," in which the ocean-atmosphere system drastically reorganizes, sets off glacial periods and interglacials.

Dr. Broecker and Dr. Denton say a global "conveyor belt" of ocean currents now carries warm air to the

North Atlantic, warming the northern latitudes and preventing glaciers of ice-age scale from developing. Studies of the ancient climate seem to show that the conveyor belt ceases in glacial times, the scientists say. They believe that this is related to changes in the intensity of the seasons induced by the changes in the Earth's orbit and attitude.

Coming: Global Cooling

Scientists calculate that in the normal course of the cycle, apart from any warming induced by humans, the present interglacial should give way within no more than 2,000 years to a gradual, uneven decline in global temperature that would bring moderate cold about 5,000 years from now and major ice ages about 23,000 and 60,000 years from now.

The interplay of the cycles means that each glacial period follows an uneven course, with relatively colder periods interspersed with relatively warmer ones, but none of them as warm as an interglacial. Average global temperatures in the past have reached about 60 degrees at the peak of an interglacial, and declined to about 50 degrees in the depths of an ice age. Nor does cooling or warming happen at the same time everywhere in the world. In the most recent climatic cycle, the coldest point in the Northern Hemisphere came about 18,000 years ago, after which the climate rapidly warmed.

Life persisted even in the depths of that last ice age. But ice buried much

of Europe and North America, and locked up so much water that the global sea level fell by 350 feet, exposing broad stretches of the continental shelf. A band of dry, windswept tundra bordered the southern fringes of the glaciers, and summers south of that were shorter and cooler than now. In the Southern Hemisphere, small ice sheets covered parts of Australia, New Zealand and Argentina.

Smaller fluctuations are superimposed on these grand swings of climate. In the present interglacial, for instance, a warming trend about 1,000 years ago, called the Medieval Maximum, enabled the Vikings to settle Greenland and vineyards to flourish in Britain. On the other hand, scientists say that about every 2,500 years, a "little ice age" cools the globe. In the most recent of these, lasting from the 15th century to the 19th, the average temperature in Europe was nearly 3 degrees lower than today and mountain glaciers advanced all over the world. Crops failed and villages

starved in parts of Europe. The Hans Brinker story in Holland was set in this period, as was the ordeal of Washington's army at Valley Forge. In 1779-80, New York Harbor froze solid.

The pattern of ice ages over the last half-million years is that the ice advances over periods of 100,000 years and then recedes more rapidly, over 10,000 or 7,000 years. Dr. Broecker says the climate itself changes even more rapidly, and that the melting of the ice follows more slowly. "A lot of things occur abruptly and more or less together," said Dr. Imbrie.

The end of the interglacial and the beginning of the gradual decline into ice-age cold may also come with relative suddenness, Dr. Broecker says. "The way I would count this interglacial," he said, "it's already 13,000 years along," and the onset of the decline is overdue. "You can say we're approaching that precipice now," he added.

The effect of the expected global warming from carbon dioxide produced by humans remains a major uncertainty. Dr. Shackleton, of Cambridge University, said carbon dioxide levels are now higher than they were at the height of the last interglacial, more than 100,000 years ago.

"There is clearly going to be more carbon dioxide in the atmosphere than there has been in any previous

interglacial," he added. "It will soon be way above any previous natural level, and it will disappear into the oceans on a time scale of 1,000 or 2,000 years."

Some say this means that the plunge into a new ice age could be delayed by a similar interval. The peak of the super-interglacial, Dr. Broecker said, would probably occur no later than the year 2200; after that would come a long, slow decline over centuries. But the timing is uncertain. James Hays, another leading glaciologist at Lamont-Doherty, said "we could go through the whole greenhouse episode and come back to normal" before the decline to the next ice age begins.

An unusually high level of atmospheric carbon dioxide, Dr. Broecker said, might cause the ocean-atmosphere system to flip into a new superwarm state as easily as it can flip to a glacial state, with unforeseen and unprecedented consequences.

"We're living in a system that can do strange things," he said. "Small forcings have produced large things, and to say a priori that this gas can't produce large changes is just bloody insanity."

Memory Chip Cooperative Is Officially Declared Dead

By ANDREW POLLACK

Special to The New York Times

SANTA CLARA, Calif., Jan. 15 — U.S. Memories, a ground-breaking attempt by American computer companies to cooperate in producing memory chips, was officially declared dead today by its organizers.

Some electronics industry executives said the bad experience in trying to organize the consortium might discourage others from trying to form similar ventures as a way of making American industry more competitive.

"The inability to achieve consensus does not augur well for similar efforts in the United States," said Wilfred Corrigan, the chairman of U.S. Memories and also the chief executive of the LSI Logic Corporation, a Silicon Valley semiconductor company.

But executives of computer companies that did not join say the failure of U.S. Memories was related to particular problems with market conditions and its business plan, and did not

mean other kinds of ventures should be ruled out.

Mr. Corrigan spoke at a news conference here about the decision to dissolve U.S. Memories because not enough computer companies were willing to invest in the venture.

The failure of U.S. Memories, which was intended to reduce the reliance of American computer companies on Japanese chip suppliers, is likely to undermine moves in Washington to provide Government assistance in areas like high-definition television.

Opponents of such efforts are likely to ask why the Government should help the industry when it appears unwilling to help itself.

"I think the Hill is going to be very disappointed," said Richard Iverson, president of the American Electronics Association, referring to Congress.

In an emotional speech here, Sanford L. Kane, the president of U.S. Memories, criticized the computer industry for shortsightedness and a

lack of cooperation.

"What happened today does not bode well for an industry that has made a decision that is a tactical one rather than a strategic one," he said.

"We're kind of like an all-star sports team. The industry has a lot of superstars who are spectacular in their own way but don't know how to work together."

The Japanese have teamwork, he said. "As a result, they keep winning while we get knocked off one by one until it's too late to mount a counter-attack."

Mr. Kane said it was evident that the venture would fail at a meeting on Wednesday in Dallas attended by the seven initial members as well as by four computer companies still thinking of joining — the American Telephone and Telegraph Company, the Compaq Computer Corporation, the

NCR Corporation and Tandem Computers Inc.

At that meeting Mr. Kane made a last-ditch effort to salvage U.S. Memories, presenting a plan that would require \$350 million instead of the \$500 million initially envisioned.

Mr. Kane also said he was willing to start with only \$150 million from the companies, with the rest to be raised on Wall Street.

Inadequate Commitment

But when the prospective contributions from each company were put on the board, it was clear that an adequate commitment would not be forthcoming even to meet the vastly reduced target, Mr. Kane said. He said he was disappointed by the small commitment the Hewlett-Packard Company, one of the original seven investors, was willing to make. "The other six members maintain their commitments," he said.

The other six members were the International Business Machines Corporation, the Digital Equipment Corporation, Advanced Micro Devices Inc., the Intel Corporation, the National Semiconductor Corporation

and LSI Logic.

Some computer industry executives have indicated over the last few months that ideological opposition to the idea of consortiums was not behind the decision of companies like Apple Computer Inc. and Sun Microsystems Inc. to shun U.S. Memories.

Rather, many computer companies have thought that such a venture is not needed. In the last few months a shortage of memory chips has turned into a surplus and prices have plunged.

A Faster and Cheaper Path

Moreover, some computer companies found it faster and perhaps more economical to arrange their own supplies by signing long-term contracts with Japanese or American suppliers. In addition, I.B.M. has said it is willing to license its chip technology to individual companies.

In addition there was widespread skepticism over the business plan for U.S. Memories, which was revised.

There is some chance that a memory chip consortium will be formed. Ralph Thomson, a trade consultant in Palo Alto, Calif., said he was working on a deal involving a chip supplier, neither American or Japanese, that would enter an alliance with American computer companies.

But U.S. Memories executives said they had no plans to revive their efforts. "If this is a difficult idea today, I don't see what will make it a better idea two years from now," Mr. Kane said.

NOAA's New Pilot Charts Course for the 1990s

Expanded Agency Role Likely on Global Warming, Ozone Depletion, Coastal Pollution

By William Booth
Washington Post Staff Writer

It is not difficult to recall that the new administrator of the National Oceanic and Atmospheric Administration (NOAA) was a professor of oceanography.

Snowy haired, bespectacled, tweedy and wearing a bow tie, John A. Knauss (pronounced KAN-ouse) was recently being given a tour of a NOAA ship that had just returned from a voyage to map the ocean floor. Ever the academic, Knauss dawdled over a new chart that showed the twisting canyons that lie beneath the waters of Monterey Bay in California. His tour leader seemed to want to move on. Knauss didn't seem to care. His finger traced with admiration the submerged canyon on the map.

"This was a river once," he said to a couple of journalists tagging along. "You can see how the river cut this canyon. You can see the ancient riverbed. Oceanographers are going to love this!"

The former 64-year-old educator from the Graduate School of Oceanography at the University of Rhode Island, with degrees from MIT and

PLAYERS

the Scripps Institute of Oceanography, has taken the helm of a low-profile Washington agency that is being called upon increasingly to take leading roles in the government's response to such threats as global warming, ozone depletion and degradation of coastal environments.

Knauss believes NOAA will face its greatest challenges in the 1990s, when policymakers will be clamoring for level-headed and authoritative information about the health of the planet's air and water.

"In the previous administration, it was no secret that environmental issues were not a high priority," Knauss said in a recent interview on his plans for NOAA. Knauss said that scientists with NOAA and particularly those at the Environmental Protection Agency suffered under the Reagan administration. But, Knauss said, "it is clear that President Bush feels quite differently about the environment."

"The environment has reached center stage in this country and in the world," he said. "I've been telling people we are the Earth systems agency. We are it. Independent of good or bad budget years, we will take on increasing importance."

A part of the Commerce Department, NOAA is one of the broadest and most unusual agencies in the federal government. With a budget of \$1.2 billion and 2,200 oceanographers, meteorologists and other scientists, as well as a uniformed corps of 400 sailors and pilots, NOAA operates 23 ships, a small squadron of aircraft and a half-dozen satellites in orbit.

The agency is responsible for monitoring solar flares, operating meteorological and Earth-imaging satellites, mapping the ocean floor, fore-



John Knauss says "the environment has reached center stage in this country and in the world."

casting the weather, tracking hurricanes, keeping tabs on coastal pollution, chasing fish poachers, measuring atmospheric ozone, assessing oil spills and predicting and detecting global climate change.

One of the areas of most immediate interest is global warming, which many scientists think will develop gradually during the next century as greenhouse gases such as carbon dioxide and methane accumulate in the atmosphere. On this issue Knauss appears to share the conservative views of the White House science adviser, D. Allan Bromley. Knauss takes the threat of significant warming seriously, he said, but he thinks that there is still great uncertainty over its magnitude.

"There are a lot of highly credible scientists who have a range of opinions on how great the warming will be," said Knauss, who produced a simple graph that shows that while some scientists predict little or no warming, and others predict dramatic heating, most appear to fall in the middle range, forecasting a global average tem-

perature rise of between 4 and 6 degrees Fahrenheit.

Knauss said he feels it is not his role to be an activist, but "to provide President Bush with the best technical information we can." NOAA scientists based at Princeton University are among the five groups who are producing large computer simulations of what climate will be like in the next century, when greenhouse gases are expected to be double their current concentrations. Other NOAA scientists are examining climate records and watching sea level so as to detect the first signal that the Earth is indeed warming because of the accumulation of greenhouse gases.

Beyond monitoring and predicting global warming, NOAA is also responsible for keeping tabs on the health of marine habitats and coastal environments.

"Given the amount of oil in Alaska, I'd say overall the health of our coastal waters are pretty good. But given places like the Houston Ship Channel, I'd say we have a long way to go," Knauss said.

"Because of the concern that people have had for ocean pollution and coastal pollution, we have made considerable progress. We are in much better shape than if nothing had been done. Whether we have turned it around, and made improvements, or whether we are like the Red Queen in Alice in Wonderland, where we have to run like hell just to stay in place, is a little less clear," he said. "While we are making considerable improvements in respect to sewage systems and what you're allowed to dump and put into the bays and estuaries, on the other hand you have an increasing population that is moving to the coasts."

Despite its broad mandate, funding for NOAA remained relatively flat throughout the 1980s, with most additions in the budget earmarked for big-ticket items. Indeed, NOAA regularly pleads that it is too bankrupt to keep operating the Earth-observing Landsat satellites. In addition, about half of NOAA's 23 ships lie idle in port, while four of its weather satellites are blind, and can take only minimal data. Knauss says the agency, which was once run by attorneys, has come to terms with its regulatory role. "In retrospect, I think NOAA overreacted to its regulatory responsibilities. It ought of itself more and more of a regulatory agency and less as a service agency," he said.

He also said he hopes to beef up the agency's ability to use its own vast sources of data. As it stands now, "it's like a library, where there is no arrian, no card catalog, no book shelves." In the late 1960s, Knauss served on the presidential commission that gave birth to NOAA. NOAA, with its perennial budget problems, ended out as Knauss had hoped? "I'm not despondent," Knauss said. "We're on up."

The Japanphobes Want Disclosure? OK, Let's Disclose

Pat Choate is a passionate critic of Japan. He's also a vice president of TRW Inc., a U.S. high-tech company that would certainly benefit from less Japanese competition. Should this personal interest disqualify Mr. Choate from debating U.S. trade policy?

Or how about Clyde Prestowitz? As a Reagan-era trade official, Mr. Prestowitz negotiated a cartel in computer chips that created a windfall for U.S. chip makers. Now the chip industry's lobbying arm, the Semiconductor Industry Association, pays him \$2,000 a pop to speak at trade "symposia." Does this make Mr. Prestowitz or Mr. Choate a corporate toady?

The fair answer is no. The pair's policy arguments should stand or fall on their merits. But this new Conflict of Interest Standard has been put on the table by Messrs. Choate and Prestowitz themselves. They're two of the leaders in a campaign to discredit American free-traders as sissies beholden to Tokyo. Long-simmer-

Potomac Watch

By Paul A. Gigot

ing in the background here, the campaign is now breaking into public view. Mr. Choate is writing a book about it. Lloyd Bentsen, the Texas Democrat and erstwhile free-trader, plans to air the subject in Senate hearings. Washington's Nippon neurosis is looking more and more like clinical paranoia.

This bogeyman theory of trade relations is laid out in the latest issue of the *New Republic* magazine. (The piece had been rejected earlier by *U.S. News* for not meeting its journalistic standards.) It seems that Japan pays a great deal of money to hire Washington lobbyists. Japanese also contribute to American think-tanks and universities. Somehow, the article says, all of this "is creating a subtle climate of corruption."

So subtle, in fact, that the Japanese must wonder what they're paying for. Japan's triumph in last year's trade-sanction spat was to be cited by its "friend," the U.S., for a mere three trade violations. When Japanese money bought a minority share of the Rockefeller Center last year, a hue and cry rose about the "buying" of America. Try to find a politician on Capitol Hill who'll say something nice about Japan these days. If this is their best, maybe the Japanese should think about hiring Mikhail Gorbachev's lobbyists.

Another complaint is that the Japanese hire former U.S. government officials to represent them—the notorious "revolving door." In other words, the Japanese do what every domestic lobby does. Motorola Inc., a major trade lobbyist, has perfected the revolving door. At least three of its senior employees are former U.S. trade officials, while a former employee is now an assistant secretary of Commerce, as is the son of Motorola Chairman Robert Galvin. Subtle corruption?

At the jingo-level, it's possible to argue that Motorola is red-white-and-blue while the Japs want to dominate the world. But in today's global economy, does it make sense to distinguish between a Honda that makes cars in Ohio and a Texas Instruments that exports computer chips from Japan?

On trade issues at least, foreign interests often coincide better with American consumer interests. And if foreigners are excluded from public debate, the dominant voice left will be that of U.S. producers—namely, the organized business and labor lobbies. So long as all of Washington remains a special interest bazaar, the only fair policy is to let every interest compete.

The critics do have a point about truth-in-advertising; funding for U.S. experts in Japan isn't always apparent. But if Canada is the issue, then let it all hang out. The Economic Policy Institute, a think-tank promoting trade protection, receives about \$500,000 a year from labor unions. The steel and textile lobbies also contribute. Perhaps every EPI study should come with a consumer warning label: The policies contained here would allow companies and unions to extort monopoly profits and wages.

Let's include trade "experts" too. Chalmers Johnson, an academic critic both of free trade and the Japan lobby, has been affiliated with the Berkeley Roundtable on the International Economy. The Roundtable won't accept foreign money, but does take grants from such U.S. corporations as National Semiconductor and Intel. Full disclosure should cut both ways.

Disclosure is not of course what this Japanphobia is about. Its real intention is to taint and discredit any American who doubts the wisdom of picking trade fights with Japan. This is the only possible motive, for example, behind the recent attack by Rep. Richard Gephardt (D., Mo.) on White House economics adviser Michael Boskin.

The House Majority Leader and 11 other House Japan-bashers released a letter implying a conflict of interest between Mr. Boskin and Japan's Ministry of Finance. While a Stanford professor, Mr. Boskin had been an unpaid member of an economics research institute loosely affiliated with the MOF. The institute had no policy role and he'd resigned before he joined the White House. The implication is tawdry, even by Mr. Gephardt's standards, but he knows Mr. Boskin is a powerful internal advocate for open trade. (As it happens, even Mr. Prestowitz has had his own "study" relationship with the MOF; he offers "thanks" in his 1988 book.)

Japan's evolution from ally to adversary is Washington's most disturbing trend. The "debate" has moved through self-criticism into jingoism and now into what seems a form of know-nothingism: It's all right to be associated with Japan, so long as you also attack it. What the U.S. needs are more people who understand Japan and economics, not more conspiracy theorists.

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THE NEWSPAPER FOR THE SCIENCE PROFESSIONAL

September 14, 1994

Plant Science Job Horizon Dimmed By Lack Of Funding

Researchers are perturbed by the weak support being given to a discipline that they consider vital to planet Earth's survival

By MARTA CLEMMETT

The job market for agricultural scientists has shown little or no net growth over the past several years. Fortunately, in a sense, the same weak economic climate that's slowed job creation has also slowed the flow of students through the agricultural science departments, say university officials nationwide.

Thus, the production of Ph.D.'s today generally matches the number of jobs available for most graduates, even in a period when few new pos-



WARREN WESSELS: Sees career landscape as pretty flat.

sitions are being created. But while the current downturn in the quantity of graduates may suit today's weak employment picture, it may damage the field in the long run, some agricultural scientists say. These researchers project a possible shortage of qualified agricultural scientists if the economy strengthens during the coming decade.

Warren Wessels, assistant dean of the College of Agriculture at the University of Arkansas, says the field is not as strong as it once was. "I think the field is being eroded," he says. "I think the field is being eroded by the loss of people who are trained in the field."

(Continued on Page 4)

After 5 Years, Heated Controversy Persists In Science Copyright Case

Weissmann v. Freeman battle is revived as Dingell subcommittee decides to launch a new investigation

By RON KAUFMAN

Since the age of two, Heidi Weissmann says, she always wanted to be a doctor. She started college when she was 15, began medical school

when she was 19, and by age 20 her supervisor was calling her one of the nation's premier authorities on billiard imaging in nuclear medicine.

Yet now, at age 21, Weissmann is unemployed. Since 1987, she has



HEIDI WEISSMANN: Still unemployed

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Observers See Healy Tenure At NIH Helm In Jeopardy If Clinton Is Elected President

Officials, scientists, and others agree that her close ties to Bush policies could cost the agency director her job

By SCOTT VORHEBERG

More than ever before, the future direction and leadership of the National Institutes of Health will hinge on the outcome of a United States presidential election. There is strong feeling among many key congressional staffers and other Washington observers that NIH director Bernadine Healy, because she appears to be inextricably linked to the Bush administration and its policies, will be removed if Arkansas Gov. Bill Clinton is elected.

Although early in her tenure, Healy was widely thought of as someone who would have remained at the agency's helm no matter who might be elected in the fall of 1992, times have changed.

Congressional aides, who are generally constrained from making attributed comments, were

Rep. Louise Slaughter: Healy is "hamstrung by political considerations."



BERNADINE HEALY: Position on fetal tissue research cited

jected to the bill's language requiring attention to women's health issues when that initiative was already under way. Another sore point for many in Congress and the biomedical community was her assertion in the letter that a fetal tissue bank depending on ectopic pregnancies, instead of elective abortions, as a source was feasible and should be tried out for a year.

Those voting against the bill used the letter to justify their "no" vote, and that angered bill supporters, who on June 24 failed, by a slim margin, to override the Bush veto.

Rep. Louise Slaughter (D-N.Y.) says that following the letter, "it's so hard to trust her now." Slaughter says she will not support Healy's retention as NIH director if Clinton is elected. "I think a scientist is a scientist, and if a scientist is so ham-

strung by political considerations, they shouldn't be heading up the National Institutes of Health."

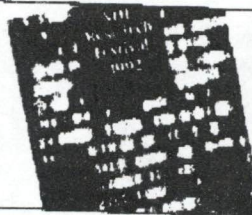
Rep. Patricia Schroeder (D-Colo.), who is chairwoman of the bipartisan Congressional

Caucus for Women's Issues, is apparently still upset over the letter incident. However, Schroeder and other congressional representatives, including caucus chairwoman, Rep. Olympia Snowe (R-Maine) declined to speak on the record concerning their degree of support for Healy. But, at the time of the letter-writing incident, Schroeder was quoted in a June 10 article in the *Chronicle of Higher Education* (S. Burd, page A21): "We felt double-crossed. She [Healy] has come for help when [Rep.] Dingell has been on her case; she has come to us for more funding, and we always did it; and she has told us how great all these women's-health goals are; and the next thing we know everyone was running around with this letter."

A staffer with the House Subcommittee on Health and the Environment, says that nowadays,

(Continued on Page 4)

'NIH Week' To Showcase Advances In Biomedicine



By FRANKLIN HOKKE

The fifth NIH Research Festival, an in-house showcasing of hundreds of research projects supported by the 13 institutes operating under the National Institutes of Health aegis, will be held at the Bethesda, Md., campus September 21-25. Events scheduled for NIH's 16,000 researchers and other staff include five symposia, 31 workshops, three poster sessions with more than 450 presentations, and a scientific equipment show.

Although originally planned to serve the intramural research

community at NIH, the festival has proved to have a wider draw, appealing to many regional biomedical researchers.

NIH director Bernadine Healy will deliver an opening talk, marking the first time a director has addressed festival participants. Healy is expected to speak about upcoming organizational changes at the institutes, in particular, the October 1 merger into NIH of three research institutes formerly allied with the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA).

Organizers hope the planned events will bring together researchers who may be working in different laboratories but on aspects of the same problem, allowing them to compare notes.

"Mostly, it's aimed at basic scientists," says Tom Flavin, NIH special projects officer. "The point is to try and be crosscutting, to take an area of research and then [bring in] scientists from var-

(Continued on Page 4)

Will NIH Seek A New Director If Clinton Wins In November?



HEALY ON THE HILL: "She doesn't have a great many allies here," says an aide.

(Continued from Page 1)

"She doesn't have a great many allies here." When one combines Healy's previous position as deputy director of the White House science office during the Reagan administration with the letter, which "showed where her loyalties lie," he says, it would be inconceivable for her to stay on if Clinton is elected.

But Healy is by no means bereft of congressional support, especially in the Senate and even among Democrats. "On this end, [Sen.] Barbara Mikulski is a very strong supporter of Dr. Healy," says a spokesman for Mikulski, a Democrat from Maryland. The aide will not speculate, however, on whether Mikulski would support Healy in a Clinton administration.

And, says one Senate Labor and Human Resources Committee



PHILIP SHARP: "I find Dr. Healy a purely political person," making the director's job "a more political position."

has apparently divided the biomedical community into opposing camps of supporters and detractors. Among issues that have stirred strong sentiments in the past have been Healy's support of the NIH effort to patent partial DNA sequences, and the forcing out of James Watson as head of the

Human Genome Project. Lately, it's been the strategic planning process that's been rolling the waters.

Among those providing accolades is Dani Brioguesi, director of the Center for AIDS Research at Duke University Medical Center, who has been involved in formulating the strategic plan for NIH. "I think she's doing a great job and will get better and better if she stays in the job longer," he says.

Many researchers have expressed strong reservations about the strategic plan on grounds that it was at first a chaotic process and that it potentially imposes too much top-down management (B. Metheny and S. Haley, *The Scientist*, May 11, 1992, page 1). But Brioguesi, who is part of a panel of researchers working with NIH on the plan's formulation, thinks the strategic planning process is a great way of focusing and defining NIH to itself and to Congress.

"You can't go to Congress and say you just want to support good science," he says. "You do have to have a plan. NIH has to stand for something."

staffer. "I think everyone is impressed with what Healy is doing at NIH." His prediction is that, even if Clinton is elected, Healy will "stay in place." The staffer acknowledges, however, that there is lingering ill will over the letter. "There's a feeling that she turned her back on people who supported her," he says. "But she really has made an effort to address the concerns that people have had about the NIH." He particularly lauds her leadership on women's health issues and efforts to produce a strategic plan.

The strategic plan is being developed by NIH staff and incorporates

comments from some of the hundreds of biomedical researchers. The plan is intended to set forth a clear mission and prioritized goals for the institutes gathered under NIH and, in doing so, act as a kind of marketing tool with Congress. Hundreds of pages of reports from the series of meetings that went into the plan's formulation were gathered, but the final product of that process will be a 100-page document due for release in October after being cleared by the Department of Health and Human Services, NIH officials say.

Just as congressional sentiments are divided, Healy's forceful style



SID GILMAN: It would be a "real pity" if Healy is sacked following a Clinton victory.

strategic plan, has nothing but praise for Healy. "She's done a great deal of innovative work, and she has vision and insight," he says. He adds that it would be "a real pity" if she were asked to leave office following a Clinton victory.

But not everyone involved in the NIH strategic planning process has good things to say either about the plan or about Healy. One researcher from a prominent East Coast institute, speaking on the condition of anonymity, says the strategic plan-

George Abraham: "Can you remember any NIH director that's gotten such notoriety?"

The process of drawing up a plan for the future direction of NIH research has been a valuable contribution by Healy, says George Abraham, an immunologist at University of Rochester School of Medicine. "You have to give Healy credit for trying to do something like this," he says. "To be quite frank, something like this should have been done sooner."

Abraham unabashedly likes the assertive director. "Can you remember any NIH director that's gotten such notoriety? She's given NIH a new face and a new identity," he says. And that "new face" has been showing up outside the usual science venues, in such places as *Working Woman* magazine, which features Healy on its September cover.

Sid Gilman, chairman of the department of neurology at University of Michigan Medical School, also on a panel involved in drawing up the

strategic plan, says the strategic planning meetings were hardly the open forums for discussion they were billed as. "I felt it was a complete waste of time," she says. "I felt unfree to say what was on my mind. And virtually everyone I have talked to had the same experience." As for NIH director Healy: "I'd be happy to see her go."

Philip Sharp, head of the depart-

CLARIFICATION

The article "Survey: More Women Entering Chemistry. But Career Advancement Poses Problems" (*The Scientist*, Aug. 17, 1992, page 1) imprecisely characterized Bryn Mawr College in Pennsylvania as a coed institution. While many men earn credits by attending classes at the institution, Bryn Mawr matriculates only women students on the undergraduate level.

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ment of biology at the Massachusetts Institute of Technology, is not pleased with the over-politicization of the office of NIH director. And Sharp sees Healy as the ultimate expression of a process that's been under way ever since the directorship became a presidential appointment in the 1970s.

"I find Dr. Healy a purely political person and very much identified with the political aspirations of this administration, and that has made it a more political position," he says. While he favors the strengthening of the director's position—as Healy has helped achieve—he would like to jettison the political baggage that's been loaded on board.

So what does Clinton have to say about Healy's future? "There's no answer to that," says a campaign spokesman. He says decisions on who would be requested to submit a pro forma letter of resignation in the event of a Clinton victory are "not



REP. LOUISE SLAUGHTER: She says that, in light of Healy's letter on Bush's fetal tissue research policy, "it's so hard to trust her now."

even on the map yet."

Healy's press aide, Johanna Schneider, when asked what might happen under a Clinton presidency, says, "I don't think there's any way to respond to that question." But as for the strategic plan, she says, "No matter what happens, the strategic

plan will be of value to the next director."

One troublesome issue for some in the science community is whether a Clinton victory would equate to another long period of interim leadership for NIH, as happened after the Reagan-appointed James Wyn-



HEALY IRREPLACEABLE?: One observer says many are qualified to be NIH director.

garden stepped down following Bush's election. Robert Rosenzweig, president of the Association of American Universities, says that's not probable. Two things led to the 20 months of vacancy before Healy was appointed, he says: For one, the Bush administration was generally slow in filling posts and did not make the search for a new NIH director a high priority. In addition, many qual-

ity potential candidates were excluded because they would not take or could not pass the "litmus test" on opposition to abortion and the use of fetal tissue in research and treatment, he says.

But if Healy were to step down, "there's no reason to panic," he says. "I think there are people out there who can fill that job quite satisfactorily."

Of course, similar confidence in the ease of filling the post was expressed by White House science officer director Allan Bloomer back on June 27, 1991, almost a year after Wyngaarden left the post (Jeffrey Mervis, *The Scientist*, July 23, 1991, page 10). "There is a clear recognition throughout the administration that [the NIH directorship] is a position we must fill and fill quickly," he said. And Healy was not confirmed by the Senate as the new director of NIH until nine months later, on March 21, 1991.

Research Festival Draws NIH Investigators, Regional Visitors

(Continued from Page 1)

ity institutes who are all approaching the same area from different perspectives. There's a deliberate attempt to get cross-fertilization going."

Titles of some papers to be presented at the symposia and workshops suggest the range of topics to be covered. The first symposium, the "NIAID [National Institute of Al-

lergy and Infectious Diseases] Alumni Symposium in Honor of Dr. Sheldon M. Wolff" on Sept. 21, will feature a talk by Wolff, an NIH alum and pioneering researcher in immunology, now chairman of the department of medicine at Tufts University, Medford, Mass. His subject will be "Mechanisms of Host Defense: Recollections on the Development of an Intramural Program."

Other talks at the symposium will be "The Origin of Plagues," "The Role of Interleukin-1 in Disease," "Antigen Processing and Presentation," "Topology and Chemistry of T-Cell Recognition," and "The Activation of CD4 T-Cells."

Workshops will have four or five speakers each and two chairpersons, according to Elaine Blume in the National Cancer Institute's office of communications. Some of the 31 workshops being offered on Sept. 21 and 22 are "AIDS Vaccine Development Workshop," "Transcriptional Control," "Genome Mapping and Sequencing," "DNA Mutagenesis and Repair," "Molecular Structure and Its Prediction," "Transgenic Systems," and "Genetic Response to Environmental Damage."

The festival is planned primarily for the benefit of NIH intramural investigators, but researchers from the Food and Drug Administration and ADAMHA will also participate. Although visitors are generally welcome, organizers do not widely advertise the festival outside the NIH community. One reason is that the auditoriums where Healy's address, the symposia, and the workshops will be held are relatively small.

"The whole thing started for the internal community," says Gregory Roe, an NIH communications official, "but, of course, it's drawn people from outside. One year we advertised, and because our auditorium only seats 500, [when] other scientists from Johns Hopkins University [in Baltimore] and Georgetown [University, Washington, D.C.] and other places came, there were only a couple of seats left [for NIH scientists] by the time it started."

Better able to accommodate non-NIH visiting scientists will be the remaining two attractions, the poster sessions and the scientific equipment show. These events will be held inside a pair of large tents set up in Parking Lot 10-D, near Building 10, the NIH clinical center, which is also

the largest building on campus and site of the speeches, workshops, and symposia.

"The tents—two of them, side by side—are 100 by 180 feet," says Flavin. "We're talking Ringling Brothers here, the Big Top."

In her opening address, NIH director Healy is expected to discuss the imminent merger of three new institutes into NIH on October 1.

"The ADAMHA is being disbanded," says Flavin. The service aspects of ADAMHA—providing drug abuse prevention information and collecting data, for example—will be incorporated into a new agency, the Substance Abuse and Mental Health Services Administration (SAMHSA). Research aspects

of ADAMHA programming will come into NIH as the National Institute on Alcohol Abuse and Alcoholism (NIAAA), the National Institute on Drug Abuse (NIDA), and the National Institute of Mental Health (NIMH).

In describing the anticipated atmosphere at the poster sessions, and the research festival generally, Flavin picks up on the theme of encouraging information exchange among researchers from the 13—soon to be 16—NIH institutes.

"Probably the most apt analogy is a beehive," he says. "When you walk into the tent, [the researchers] are buzzing around that thing. There's literally cross-pollination going on."

1992 NIH RESEARCH FESTIVAL: INVESTIGATOR "CROSS-POLLINATION"

Opening Address:

- Bernadine Healy, Director, NIH (8:30 A.M., Sept. 21, Bldg. 10, Mear Auditorium)

5 Symposia:

- NIAID Alumni Symposium in Honor of Dr. Sheldon M. Wolff (8:45 A.M., Sept. 21, Bldg. 10, Mear Auditorium)
- Depositor: Molecules, Membranes, Movement, and Mind (2:30-5:30 P.M., Sept. 21, Bldg. 10, Mear Auditorium)
- Transgenic Animals in the Study and Treatment of Human Disease (2:45-5:30 P.M., Sept. 22, Bldg. 10, Mear Auditorium)
- The Extracellular Matrix in Development and Pathology (2:45-5:30 P.M., Sept. 22, Bldg. 10, ACPH, Lipson Amphitheatre)
- Structural Biology (2:45-5:30 P.M., Sept. 22, Bldg. 1, Wilson Hall)

31 Workshops:

- Workshops 1-16 (8:30-11 A.M., Sept. 22)
 - Workshops 17-31 (1-3:30 P.M., Sept. 22)
- (See program booklet, available at the festival, for subjects, times, and locations of the specific workshops)

3 Poster Sessions, With 450+ Posters:

- 12-3 P.M., Sept. 21
 - 5:30-7:30 P.M., Sept. 21
 - 11-1 P.M., Sept. 22
- (In festival tents, Parking Lot 10-D, southwest of Bldg. 10)

Technical Sales Association (TSA) Equipment Show:

- 9:30 A.M.-4 P.M., Sept. 24 and 25
- (In festival tents, Parking Lot 10-D, southwest of Bldg. 10)

For more information about the NIH Research Festival, call Gregory Roe at (301) 495-1776.

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EDITORIALS
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COMMENTARY

CLASSIFIED
STARTS ON PAGE F5Environmental leap
into the identity voidData don't
matter'

Perhaps I'm a bit naive, but I think that environmental policy should be commensurate with science, and if it is to be the case, any expensive disruptive policy to fight the enhancing greenhouse effect is simply not based on enough science.

The normal process of science involves the generation of hypotheses (today, often called models) and the test of those hypotheses with data. Hypotheses that are supported by data can (and should) be the basis for public policy.

The greenhouse problem isn't much different. In this case, the models are computer-driven projections of changes in climate resulting from an enhancement of the earth's natural greenhouse effect, and the data are observed characteristics of the atmosphere as this enhancement is taken place.

As is often the case in science, disparities arose between the models and the data. The mid-1980s General Circulation Models (GCMs) for climate change stated, in aggregate, that the planet would warm up some 2 degrees centigrade for a doubling of the natural carbon dioxide (CO₂) greenhouse effect. Further, they predicted that warming should be greater and sooner in the Northern Hemisphere (it contains most of the world's land, which warms up faster than water), and soonest in the high latitudes of our hemisphere, because of the combined effect of all the greenhouse gases that we have emitted to the atmosphere, we have already gone half way to effectively doubling the background CO₂ concentration.

According to ground-based temperature records, the globe has only warmed up around a quarter of a degree since most of the greenhouse gases were emitted after World War II, and the distribution between hemispheres is curious.

The disparity between the data and the models is immediately apparent in the accompanying graphs, extended from a 1990 article by herwood Idso and Robert Balling in the journal *Theoretical and Applied Climatology*. The top plot is a history of global carbon emissions, and the dramatic increase following World War II is obvious. The middle and bottom graphs are the land-based northern and Southern Hemisphere temperature histories. Even these are probably too warm in the latest years because exponentially increasing population is increasing the local warming effect of cities on near weather stations.

In the Northern Hemisphere, every reading after 1950 falls below the trend line established in the previous 70 years, which was before the major greenhouse emissions.

On Aug. 13, 1991, under the auspices of the U.N. Intergovernmental Panel on Climate Change (IPCC), a meeting of climatologists was held at the National Climatic Data Center in Asheville, N.C., to hear arguments of the so-called skeptics on global warming. Actually, "global-warming skeptic" is hardly an apt description of the scientists convened in Asheville, as everyone there acknowledges that the planet has warmed some in the last 100 years. Note, however, last month's Gallup Poll of the

American Meteorological Society and the American Geophysical Union, in which roughly two-thirds of the sampled membership of these two societies felt our century's warming was not attributable to an enhanced greenhouse effect, which is obvious on the accompanying graphs. The skepticism of the Asheville scientists is about the expected climate apocalypse, which is the popular vision of our future.

The meeting was convened by Christopher Folland of the British Meteorological Office. Mr. Folland, who has made a considerable reputation based upon his studies of ocean temperature data, is one of the senior authors of the 1990 IPCC report. As such, he could carefully pick, choose and modify submitted text from the 200 contributors and 100 reviewers. The IPCC document, along with its 1992 update, represents the ostensible scientific basis for the global warming proposals

ately, upon the United States), he replied that "the data don't matter." The presenter was incredulous and asked Mr. Folland to repeat his response, and he said again that "the data don't matter." Further, he said, "We're not basing our recommendations upon the data; we're basing them upon the GCM climate models."

When pressed, he replied that climate models in which the greenhouse gases are not enhanced sometimes produce random coolings of .4 degrees centigrade, and if one of

these had occurred since 1950, expected warming would have been mitigated during the time in which greenhouse emissions went ballistic. In fact, a 100-year run of the NASA climate model, without an enhanced greenhouse effect, indeed produces one random cooling of .4 degrees centigrade in a 25-year period. That's one-fourth of the time.

But an equal and opposite random warming is just as likely, so that the likelihood that any quarter century would show a cooling of such magnitude is actually one-half of one-fourth, or one in eight. Our hemisphere shows no statistically significant net warming trend since the mid-1930s, or some 55 years, which is more than twice the length of the phantom random cooling in the NASA model. Therefore, the probability of such a suppression of warming for so long is less than one-half of one-eighth, which is less than one in 16, or a probability of .065.

That's right: Even if these models are accurate, the chance that unusual (good) luck would cancel all the warming in our hemisphere for over a half a century is approximately one in 20. It is this probability that explains away the disparity between the models, which are called the basis for policy, and data that "don't matter."

So what really happened with global warming? The political process, fueled by what has to be the fastest growing cash cow in the sad history of lobbyland (\$600,000,000 was contributed to the largest environmental organizations in 1990) commandeered this issue before the normal tension between data and models had been resolved. As a result, we're probably on our way to the most wrenching energy policy in history, one with the potential to reduce the GNP by several percent per year. President Bush can assure this by acquiescing to environmentalist demands at the Rio summit, and they will surely demand this of him if he shows up.

What's most ironic is that these same environmentalists get all riled up when they read that apocalypse forecasts are busto. Why aren't they happy, like a normal person would be? The facts are that they need disastrous global warming like Democrats need a recession, and that their policy isn't commensurate with the scientific data.

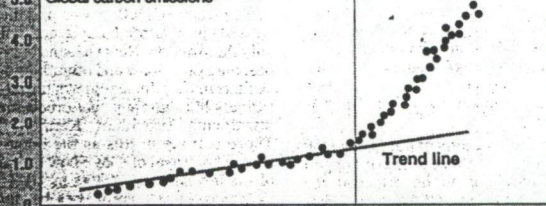
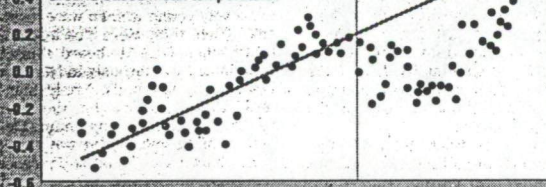
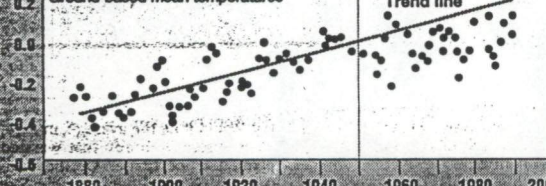
MICHAELS

From page F1
at the upcoming Rio conference on the environment. On Page 27 of its "policymakers' summary," it states that "we have substantial confidence that models can predict at least the broad-scale features of climatic change."

When Mr. Folland was asked if the behavior depicted in our graphs would alter calls for expensive reduction in emissions of carbon dioxide (which would fall disproportionately

TRACKING THE DATA

The trend line has been placed through the temperature data from when it begins until the emissions begin their dramatic increase. The misplacement of the Northern Hemisphere's warming — to the era before emissions became important — is obvious.

Whole earth
Global carbon emissionsNorthern Hemisphere
Ground-based mean temperaturesSouthern Hemisphere
Ground-based mean temperatures

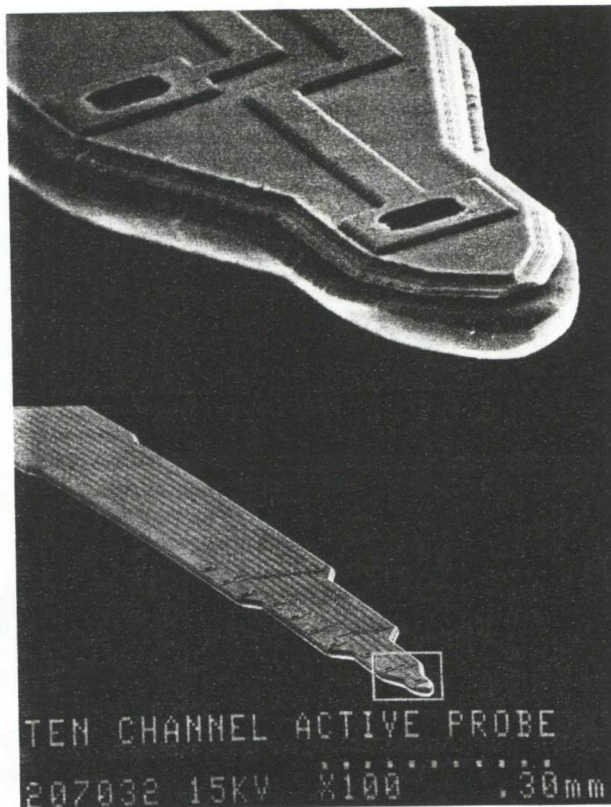
CORPORATE ASSOCIATES MEET AT GM, FOCUS ON COMPETITION

Each year the American Institute of Physics sponsors a meeting for its Corporate Associates—corporations and organizations that provide advice to AIP on the role of industry in the physics community and pay dues in support of AIP activities. The meeting provides participants from universities, government and AIP an opportunity to become better acquainted with the Corporate Associates and with industrial research, and it provides industry researchers a window to the academic world.

This year General Motors hosted the Corporate Associates meeting, which took place at the GM Research Laboratories in Warren, Michigan, on 3–4 October. Robert A. Frosch, the GM vice president in charge of the research labs, delivered the welcoming address. The conference was organized by AIP management, Praveen Chaudhari, the chair of the Corporate Associates Advisory Committee, and John R. Smith of General Motors.

This year's meeting was marked by an unusually timely and informative series of talks addressing the relative competitive status of science in the United States, Japan and Europe. D. Allan Bromley reported on new initiatives he is taking or planning to take as Assistant to the President for Science and Technology. Shoji Tanaka of Japan's International Superconductivity Technology Center (ISREC) and Henry Durand of the University of Paris discussed Japan and Europe respectively.

In a fourth public policy talk that addressed the greenhouse effect and ozone depletion, Michael B. McElroy of Harvard University tailored his remarks—it seemed—specially for Bromley. Coincidentally, the day the Corporate Associates convened for the meeting at GM, the subcommittee on health and the environment of the US House Committee on Energy and Commerce voted unanimously to extend California's strict auto emission standards to the entire United States.



Thin-film microelectrode array made for exploring signal processing in cortical neural systems. The probe, which enables researchers to sample cell discharges, was developed by Khalil Majafi, Ken D. Wise and Jin Ji at the University of Michigan. Wise said at the Corporate Associates meeting that sensors and actuators will be increasingly integrated into chips in the coming decade.

The auto industry—its past and future, its reliance on research and its contributions to research—was never far from the conference agenda. The opening morning's technical talks were devoted to the creation of new materials, or "physics with an economic perspective." Topics included new magnet materials, the creation of graphite fibers from natural gas, high-temperature materials, and micro-machining and sensors.

The second day opened with an early-morning tour of GM's highly automated Hamtramck plant—originally a single tour was to start at 7:30 AM, but interest was so high that GM and AIP had to arrange for a second at 6:00 AM. In the concluding pair of talks at the end of the second day—the part of the conference regularly devoted to "frontiers of physics and

technology"—participants were invited to stray far from the freeway and the assembly line: H. Jeffrey Kimble of Caltech talked about squeezed light, and Marcia Neugebauer of the Jet Propulsion Laboratory about the Sun and the solar wind.

Bush's science office

Opening his talk about plans for the President's Office of Science and Technology Policy, Bromley said that since the establishment of OSTP in 1976, for some reason the four Senate-confirmed associate directorships had never been completely filled. He said one of his first priorities was to fill them: James B. Wyngaarden, the former director of the National Institutes of Health, has been nominated for the life sciences; Thomas Ratchford of AAAS has been nominated for

international affairs; a senior physical scientist will be nominated for the engineering and physical sciences; and a senior industrial research executive will be named for industrial technology. (At this writing, Bush had yet to nominate anyone for the latter two positions.)

Regarding his own authority and the position of his office, Bromley said that he sits on a newly created Cabinet-level committee, the Competitiveness Council, which is chaired by Vice President Dan Quayle. Bromley said he has reached an agreement with Budget Director Richard Darman, which will assure that he is consulted in the preparation of the budget, insofar as it pertains to science and technology. He said a new Presidential Council of Advisers on Science and Technology is being formed as a revived version of PSAC, and that Bush has made a commitment to meet regularly with it.

In international science, Bromley said he regarded it as his function "to prevent megaprojects from destroying small science." Foreign participation in the Superconducting Super Collider is essential, Bromley said. He complained about a recent action by Congress to cut funding for the Space Station: Treaties may be necessary to secure US funding commitments to international projects, he said.

On energy, Bromley said we need to take another look at alternative energy sources—modular nuclear, solar, biomass, and so on. He alluded to President Bush's proposed international meeting on the global environment, and he said he personally was putting together a meeting of the G-7 ministers—Cabinet-level officials from the top non-communist industrial countries—to develop a coordinated global environmental research program. (In a recent meeting on the global environment in the Netherlands, the US government refused to commit itself to reducing CO₂ emissions, pending action by the Intergovernmental Panel on Climate Change, a body sponsored by the United Nations and the World Meteorological Organization; this position was reportedly based on the recommendation of Bromley and White House Chief of Staff John Sununu.)

In education, Bromley said that at the graduate level, "We still set the world standard." But he also told his audience, mainly representatives of the industrial world: "You will have to play a much larger role in the education of the people you want to hire than you have ever done before."

Returning to the main theme of the

Corporate Associates meeting, Bromley praised the National Research Council's recently released report on the materials sciences. Bromley said he would like to put together a coherent national program in materials science under the aegis of PCAST. Robert L. Post Jr, the assistant director of OSTP, will have special responsibilities for the materials sciences.

Japan and Europe

Tanaka, a professor emeritus at the University of Tokyo and vice president of ISTE, started his talk by observing that the share of his government's expenditures in total R&D is relatively low: 19.4% in 1985, versus 46.8% in the United States (28%, excluding defense R&D) and 53.5% in France. Japanese private sector R&D spending, on the other hand, is high: It accounted for 2.19% of Japan's GNP in 1985, compared with 1.45% in the United States.

In a candid account of how Japan emerged as the world leader in electronics, Tanaka drew attention to several government-coordinated programs:

▷ The VLSI project, 1976–80, in which the lead institution was the Cooperating Laboratory for Basic Technology and expenditures were \$500 million.

▷ The Optical Electronics and Optical Communications Project, 1979–85, led by the Cooperating Laboratory for Basic Research, involving expenditures of \$120 million. "The concept of optical electronics in integrated circuits, honestly speaking, was 'made in Japan,'" Tanaka said.

▷ New Functional Devices, 1981–91, \$120 million, devoted to three-dimensional devices and superlattice devices.

▷ The Superconductivity Project, involving ISTE and the Cooperating Laboratory for Materials Research, with an emphasis on international cooperation (see PHYSICS TODAY, December 1987, page 53).

The Superconductivity Research Laboratory was established in Tokyo in 1988, reached almost full operation by May 1989, and already has filed some 100 patent applications, Tanaka said.

Speaking equally candidly about Europe's status, Durand—a professor of energy science at the University of Paris—said that "Europe does not yet exist, especially in the field of science and technology." Until recently, he said, only the multinational companies were trying to coordinate European research. (Before joining the University of Paris in 1978, Durand was manager of research operations at

Philips France, GE Telespace and St. Gobain.)

Durand pointed out that the scale and structure of R&D efforts varies among the European countries: In West Germany, for example, there are 4.8 R&D personnel per 1000 persons employed, versus 2.8 in Ireland; the ratio of public to private R&D spending is 40:60 in Germany, and the reverse in France; in Great Britain, the military accounts for 51% of R&D spending, in France it is 34%, and in West Germany, 12.5%.

Europe as a whole, according to Durand, allocated 1.9% of its gross domestic product to research and development in 1985, while Japan allocated 2.6% and the United States 2.8%. Taking exports as a ratio of imports, he said, Europe lags behind the United States in every major category of products except pharmaceuticals.

Turning to joint European programs, Durand said that the European Community's European Commission in Brussels accounts for a small but rapidly increasing share of R&D expenditures, and the impact of EC programs has been disproportionately high.

Addressing the question of whether the elimination of tariffs in 1992 will mean the erection of a "fortress Europe"—a Europe that excludes other countries by means of special regulations and other "non-tariff barriers"—Durand said he had heard from Japanese colleagues that they welcome the unified European market, because the more uniform standards become, the more readily Japanese goods can penetrate the market.

Greenhouse effect, four

In an abrupt shift of gears, the last of the four public policy speeches was devoted to the global environment. McElroy, a participant in Antarctic and Arctic ozone expeditions (see PHYSICS TODAY, July 1988, page 17), said that methane levels are higher now than at any other time within the range of earlier ice and warming ages.

In terms of reducing nitrogen oxides, current research indicates, McElroy said, that even if we were to switch from oil to natural gas as a source of automobile fuel, the effect would be neutral; if coal were used, the effect would be unfavorable; and, taking the whole fuel cycle into account (including fertilizers), if we were to convert to biomass, the effect would not be obviously favorable.

McElroy said that universities need to be much more heavily involved in global climate research. Alluding to

his experience on ozone expeditions, he said that small numbers of researchers have been working literally to the point of exhaustion.

The second half of the first day was devoted to a tour of the GM Research Laboratories, with stops at 12 locations. In many places the work being done was much as one would expect in a facility dedicated, ultimately, to the manufacture of automobiles. For example, Galen B. Fisher, a senior staff research scientist in the physical chemistry department, described research into the mechanisms of catalytic CO-CO and NO-CO reactions over rhodium, a process crucial to the development of catalytic converters.

In other locations, physics of a surprisingly basic character was being done. Gary L. Eesley, a senior staff research scientist in the physics department, gave a tour of GM's ultrafast laser laboratory, in which time-resolved measurements in the femtosecond range provide information about how conduction electrons ballistically transport thermal energy over distances of several hundred angstroms.

At many stations it was evident that the advent of a Cray supercomputer was revolutionizing the design, testing and manufacture of automobiles.

The automotive future

"Advances in automotive technology" was the subject of an after-dinner speech delivered at the end of the first day by Nils L. Muench, the executive director of GM Research Labs. Muench opened his talk by describing, to considerable hilarity, how he barely made it to the banquet because he discovered upon leaving work that he had locked himself out of his own car (a new Chevy Lumina APV, which was parked in the darkened GM Research garage). He solved the problem, he said, by what increasingly seems to be the American way: "I stole a car."

Muench said there is now a real acceptance of new technology at GM in contrast to 25 years ago, when he arrived. For example, anti-lock braking systems have been developed that rely on electronic speed sensors to regulate braking and acceleration spin. (Now he would like to see superconducting materials worked into such a system, he said, so that he can call it the Superconducting Anticollider.)

The typical GM engine now has an electronic control capability equivalent to two personal computers; soon the hydraulically controlled transmission will also be electronically

controlled, he said.

In the future, Muench said, we might look for an active suspension, for greatly improved ride and handling; active sound suppression systems, capable of reducing internal noise by up to 15 decibels; and adaptive cruise control, to regulate spacing

on highways.

In response to a question, Muench said he thought gasoline would still be with us for a long time to come, and that the transition then would be to methanol, then maybe to electric cars.

—WILLIAM SWEET

AIP AWARDS MADE TO AMALDI, HOLTON, REDINGTON AND LITTMANN

Four awards were presented at the AIP Corporate Associates meeting banquet, which was held on 3 October in the Detroit Renaissance Center.

Edoardo Amaldi of the University of Rome received the John T. Tate International Award, Gerald Holton of Harvard University was presented with the Andrew Gemant Award, Rowland W. Redington of General Electric received the Prize for Industrial Applications of Physics and Mark Littmann was given the AIP Science Writing Award in Physics and Astronomy.

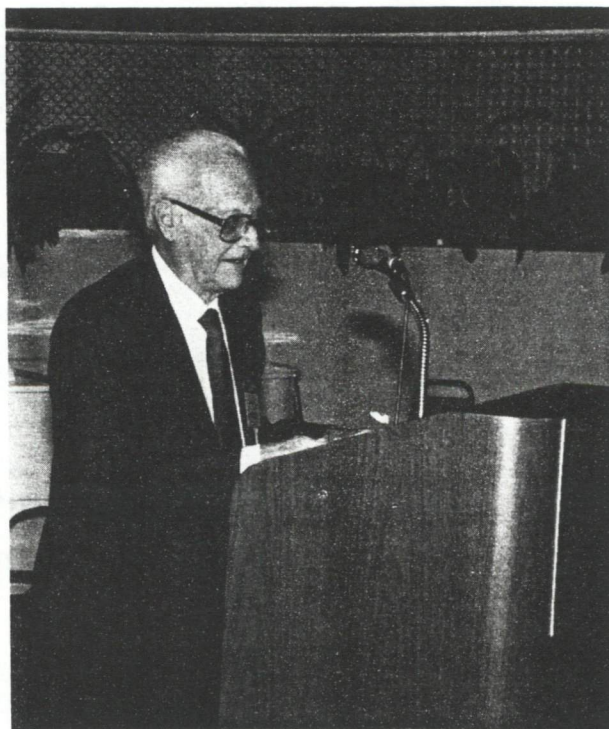
Amaldi, a professor of physics at the University of Rome, has long been involved in promoting both Italian and international physics research. He received the Tate Award "for his crucial role in the rebuilding of Italian and European physics following the devastation of World War II, for his leadership in the establishment and operation of CERN as a great international laboratory, and for his many other contributions to interna-

tional physics." The Tate award is given every few years by AIP to a foreign national in recognition of distinguished service to the profession of physics. Amaldi was presented with a medal, a prize of \$5000 and an award certificate.

In accepting the award, Amaldi said that over the years, he had made about 35 trips to the United States and had always learned a great deal.

Amaldi received his doctorate in physics from the University of Rome in 1929, and continued his postdoctoral work at the University of Lipsia, then at the Cavendish Laboratory at Cambridge, Columbia University and the Carnegie Institution of Washington. Since 1937 he has been at the University of Rome.

This year's Gemant award was presented to Gerald Holton "for his own work at the interface between the humanities and physics as a leading historian of science" and "for his major contributions in interpreting physics to the public through his



LORRAINE DECANDITIS/AIP

Edoardo Amaldi accepts Tate Medal at banquet in Detroit's Renaissance Center.

PHYSICS AND SOCIETY

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LETTERS

The Future of Fusion

Jan Beyea's contribution to the fusion discussion (January 1990) seems to me to present a plank in the environmentalist platform rather than to give a penetrating analysis of actual public attitudes. While environmentalists do have strong allies in the media, in academia, and in the leadership of influential lay organizations, the public has been known to go in a different direction when it at last senses that its own interests are not being served by the orthodoxy.

Many years ago the head of the local labor union said to me "Let's face it, there's no industrial hazard that can't be eliminated by a dollar an hour wage increase!". Nowadays this observation would be considered too crass to be openly expressed. Nevertheless, the stacks of unsold radon detector kits gathering dust in hardware stores suggest the continued willingness of members of the public to discount even widely publicized hypothetical hazards. We are constantly warned of the need to protect "Spaceship Earth." But the public may come to realize that, on a perilous journey, the agonizing decisions must be based on more objective analyses of the comparative risks of alternative courses of action and more attention to technological constraints than has been customary in the environmental movement.

With respect to fusion power, the real issue seems to me to be whether or not fusion power plants can be as safe and economical as the advanced fission plants that are being designed by U.S. vendors for off-shore use. I don't know whether or not Beyea and friends would consider these plants to be "melt-down-free." But, having the ability to perform my own risk assessments, I would rather my grandchildren live near an advanced LWR than in one of the sealed up homes prescribed by proponents of energy conservation.

It will admittedly be more difficult for fusion power plants to compete with advanced LWR's than with a duplicate interstate highway system covered with expensive PV devices, installed and maintained by an army of workers whose enthusiasm for solar energy is not guaranteed to lead to unprecedented restraint at the bargaining table. If fusion scientists and engineers are willing to accept the greater challenge, they deserve our continuing support. On the other hand, I question the wisdom of devoting major societal resources to the pursuit of standards of safety that are far more rigorous than those utilized by members of the public in making their own "real life" decisions.

Henry Hurwitz, Jr.
827 Jamaica Road
Schenectady, NY 12309

The January issue carried four articles that dealt with the "Future of Fusion." These articles, and others on this subject that I have seen elsewhere, make no mention of what I feel is the reality that will prevent nuclear fusion from having a major impact on our national energy scene for several decades. By "fusion" I mean fusion that might be achieved by the traditional mechanisms that are being explored in mega-machines that heat plasmas or that implode pellets. The "reality" to which I refer is the complexity of commercial power systems that might evolve from those experiments.

Most of the proposals that I have seen for commercial fusion power would use the fusion process as a source of heat which would convert water into steam which would drive turbines which would then drive electric generators. The primary commercial product of the

fusion systems would be power for the nation's electrical grid.

We have had over one hundred years of experience with the production of electricity from steam plants that burn fossil fuels. The dependability and reliability of these steam plants is one of the marvels of the age in which we live. In my memory I can't recall one of these plants exploding. Their concept is simple, their design and engineering are superb, and their output has reshaped our society. Our society now requires absolute dependability of our electricity as to voltage, frequency, and capacity and outages of electrical power have a severe economic impact on all who are affected. Fortunately outages are rare. This is the game in which any new source of electric power must compete. Increasing complexity of a system is a major adverse factor in the ability of the system to compete. Nuclear fission power plants are one or two orders of magnitude more complicated than the fossil fuel plants with which they must compete. It is a credit to all involved that nuclear fission electric plants have done remarkably well in spite of their inherent complexity. But there have been disasters, and the political problems surrounding the disposal of the waste from these plants remains unsolved. It may well be that today's nuclear fission power plants are about as complex as can be managed by humans where the requirements of reliability are so stringent, and where the societal costs of even occasional catastrophic failure are so high.

It seems reasonable to predict that nuclear fusion power plants will be one or two orders of magnitude more complex even than nuclear fission plants. As a consequence, the probability seems low that they could supply reliable 60 Hz power 24 hours a day for years at a time.

I don't recommend that we stop our research on nuclear fusion. However, the combination of the inflexibility of our high performance requirements for electric power systems and the almost certain complexity of possible nuclear fusion power plants, leads me to make an observation and a prediction.

Observation: It would be unwise for energy planners to count on any schedule of proposed or predicted availability of commercial quantities of electric power that is generated by nuclear fusion.

Prediction: Children born today will not live to see ten percent of our national energy consumption being supplied by terrestrial nuclear fusion power plants.

Albert A. Bartlett
Department of Physics
University of Colorado
Boulder, CO 80309-0390

Global Warming Causes: Population or Lifestyle?

Recently two quite different prestigious sources have commented on the causes of global warming, but with quite different root causes:

1. The University of California held a workshop on global climate change during the summer of 1989. The workshop combined the strengths of the nine UC campuses and the three DOE labs under UC management (Lawrence-Berkeley, Lawrence-Livermore, Los Alamos). They concluded that "Population growth is the single most important force driving global environmental changes" (from *Global Climate Change Newsletter 1*, #4, p. 9, Nov 1989).

2. The Pope also has spoken out on the global ecological crisis, but on the other hand the Pope stated that "The seriousness of the

ecological crisis lays bare the depth of man's moral crisis." He appealed to modern society to take a "serious look at its life style" in a world given to "instant gratification and consumerism." He called for "simplicity, moderation, discipline as well as a spirit of sacrifice" as ingredients of a healthier global society (*Los Angeles Times*, 6 Dec 1989, p. A6).

The juxtaposition of these two studies is most interesting. Is the cause of the global greenhouse population growth or lifestyle? Why does one study name population growth (and not lifestyle) and the other study name lifestyle (and not population)? Is one correct and the other wrong, are they both correct, are they both wrong, or are they both partly correct and partly wrong?

As an old adage has it, "we stand where we sit." The University and DOE scientists feel that conservation by denial is impossible politically, so they refrain from attacking the superfluous use of energy. They conclude that we should (1) use energy more efficiently, and (2) use fuels that produce less CO₂. On the other hand, the Pope attacks the superfluous use of carbon fuels, but does not wish to support birth control. Thus he too is silent on one part of the problem, population growth.

In fact, annual global carbon dioxide production (C) can be written as

$$d(\text{CO}_2)/dt = C = PE/h + N.$$

where P is the global population of about 5 billion people, and E is annual average per capita consumption of energy. The product of P and E is presently about 100 million barrels of oil/day, or 200 quads (1 quad = 10¹⁵ Btu) of energy/year. The symbol h represents the average amount of usable energy produced per unit energy. The value of h for a particular process varies between almost zero (house fire) to almost infinity (fission, photovoltaics, fusion). Improved end-use efficiency can help a great deal; for example, new refrigerators are now using one third as much energy as before the oil embargo, increasing h by a factor of three. At present, E divided by the average

value of h is about 5 giga-tonnes per year of carbon. The last term, N, is the net production of CO₂ by natural causes.

The logarithmic derivative of this equation gives us the fractional rate of increase of C:

$$(dC/dt)/C = (dP/dt)/P + (dE/dt)/E - (dh/dt)/h$$

For simplicity, we have ignored man's impacts on the natural production of carbon, by assuming that $dN/dt = 0$. Actually man's impacts should not be ignored since the cutting and burning of trees can be large, and increased global warming can release methane, a very effective greenhouse gas, from the tundra. The fractional increase in population, $(dP/dt)/P$, is the large term at about 1.8% per year. However, the large use of energy by the industrialized states is clearly part of the problem since the world is aspiring to attain our life style.

Thus, it looks like both reports are partially correct. UC/DOE favors the first term, the fractional growth of population $(dP/dt)/P$, as the most important term in the equation. On the other hand, the Pope considers the second term, the excess consumption of fossil fuels $(dE/dt)/E$, as the most important term. On the other hand, the energy conservers, the nuclear power advocates, and the photovoltaic fans all agree that the diminished use of fossil fuel through either end-use efficiency or alternate, nonfossil power sources is the most important.

I congratulate the two groups for pointing out the two leading terms as the main cause of global warming. I agree that a global population increase of 1.8% per year is large, but I also recall that our life-style got us into trouble in the first place. We are all part of the problem as well as part of the potential solution: I confess to contributing to $(dP/dt)/P$ by having three children, and to $(dE/dt)/E$ by visiting our son in Paris this coming summer at his new job.

David Hafemeister
Physics Department

California Polytechnic State University
San Luis Obispo, CA 93407

ARTICLES

The Case for Civil Defense in Nuclear War Education

Robert Ehrlich and Jane Orient

[A copy of the original lengthier version of this article, including 48 footnotes, can be obtained from the first author.]

A majority of educators teaching courses on nuclear war and peace profess to believe in the importance of presenting both sides of controversial issues. Yet the pro side of the civil defense issue is seldom presented without the ridicule often used by its detractors. In fact, many nuclear war courses do not include *any* significant amount of material about civil defense. This may be because most educators feel very strongly that nuclear war is unsurvivable, or perhaps that thoughts of nuclear war survivability are an obstacle to peace. This article argues that civil defense advocates should be allowed to make their own case, so that students can decide for themselves whether or not the idea deserves to be ridiculed.

This essay defends the proposition that civil defense measures (shelters, food and medicine stockpiles, evacuation plans, and most importantly, education about protective measures) could save many millions of lives in the event of a nuclear war. We stress the word "could" because skeptics can always come up with some condition under which any given protective measure will fail to work.

For example, consider the idea of evacuating "high risk" areas prior to an attack—a particularly controversial civil defense measure. Evacuation of "high risk" areas would be futile in the event of an attack without warning, even though most observers believe that such a "bolt-out-of-the-blue" attack would be highly unlikely. Likewise, skeptics can point to the extreme difficulty in evacuating particular

cities such as New York even given several days notice, but New York is far from typical in terms of its ease of evacuation. Skeptics also note that an attacker can simply retarget fleeing populations, but this would only be an effective tactic if the attack occurred relatively soon after the start of the evacuation, and before the population dispersed. Finally, skeptics note that even if evacuation "succeeded," no place in the nation is safe given the lethal levels of fallout radiation, "nuclear winter," or other such global threats to life. A detailed rebuttal will be given later. For now we reemphasize that the issue of how well city evacuations would work is undecidable, short of an actual nuclear war. Circumstances under which it *could* save many lives include (a) most likely nuclear war initiation scenarios, (b) most cities, (c) most strategies of an attacker, and (d) most realistic estimates of seriousness of the long-term threats to life (fallout and "nuclear winter").

For most Americans, civil defense is an issue of very low saliency. If reminded in a poll that the Soviet Union spends far more on civil defense than the U.S., most Americans favor increasing U.S. expenditures. However, it is not an issue about which most citizens are particularly concerned, especially now that the perceived risk of nuclear war seems to have diminished greatly. Those few civil defense enthusiasts that do exist are regularly derided as kooks or Dr.

Robert Ehrlich is with the Physics Department at George Mason University, Fairfax, Virginia 22030-4444. Jane Orient is an M.D. in Tucson, Arizona.

Strangelove types who actually would relish the prospects of a nuclear war. Some psychiatrists believe that "denial," the unconscious suppression of unpleasant facts, is a motivation for believing that nuclear war could be survivable. We believe, however, that the reverse is more likely the case, and that the term "denial" better fits the belief in nuclear war *unsurvivability*. For many Americans the thought of experiencing the kind of unpleasant hand-to-mouth existence prevalent in 90 percent of the Third World today, a realistic prospect for survivors, is simply unimaginable. It is more comforting to imagine one's instantaneous annihilation in a nuclear war. In reality, of course, far more people would suffer slow, painful deaths, especially those who died from radiation sickness — deaths that could be prevented by taking precautions, some of a relatively simple nature.

For example, fallout radiation (present on dust particles) can simply be washed off food without the food being contaminated afterwards, and contaminated water can easily be decontaminated by simply filtering it through an earthen filter. Another simple protective measure unknown to many civil defense skeptics who think in terms of special purpose fallout shelters is the simple expedient of survivors staying in their own home basements for a week or two following a nuclear war. This measure wouldn't work for everyone: those without home basements, those not at home when the attack occurs, those whose homes burn down, etc. But for those living in perhaps 75 percent of the nation's land area, a ten to twenty-fold reduction in the radiation level (as a below ground basement provides) is enough to make survival possible. Of course some areas of the country would become "radioactive wastelands" in the sense that a very long time would be required before radiation levels decayed to safe levels. In those very "hot" areas, survivors would need shelters with a protection factor much higher than 10 or 20, and shelter stays longer than a week or two would be required. But such areas occupy a relatively small percentage of the nation's land area.

Civil defense critics often portray the situation otherwise by speaking of the vast land area that can be "contaminated" by a single nuclear explosion. In making this claim, they are either using the word "contaminated" to refer to any amount of radioactivity, however small (in which case everyone on earth is contaminated right now), or else they are referring to the present day peacetime radiation standards used by the government for limits on radiation exposure. These limits are 5 rems in one year for occupational exposure or 0.5 rems in one year for the general public. Such peacetime exposure limits are extremely stringent in terms of the health risks (primarily excess cancer deaths) faced by people exposed. The health risks faced by people receiving a given dose of radiation are reasonably well-known (at least for high doses), based on studies of the survivors of the Hiroshima and Nagasaki bombings. For example, the rate of increase in cancer deaths (most 20 or more years later) was found to be about 8 percent for every 100 rads a survivor received.

In discussing the dangers of fallout from nuclear weapons, people often mention the islands in the Pacific that remain "uninhabitable" as a result of U.S. nuclear testing, despite a radiologic clean-up operation. In fact, the radiation on the Marshall Islands is somewhat higher than it was before the testing. But it is still not very high. The Northern Marshall Islands Radiological Survey conducted in 1978 showed that on most of the islands the annual dose due to fallout was about 0.006 rems from all exposure pathways, including food, or about 4 percent of the average annual external background dose in the U.S. On Bikini Island, one of the most heavily contaminated areas, the maximum annual dose to those eating locally grown food was less than 2 rems.

One other greatly-feared effect of radiation on humans and animals is genetic mutations. Studies on the survivors of the Hiroshima and Nagasaki bombings have, however, shown no evidence for an increase in the 10 percent spontaneous rate of genetic defects among survivors' offspring. This does not mean that no increase occurred, only that it was too small to be seen given the size of the group studied. Extrapolations from studies with mice indicate that a small increase would probably be expected, but certainly nothing like the popular misconception, shared by many nuclear war educators, of radiation

producing a new breed of "monsters" among nuclear war survivors — a favorite theme of science fiction and editorial cartoons.

Radiation is only one of numerous threats to human survival in nuclear war. Other immediate or early sources of casualties would include blast, thermal radiation, and fires. Later, people might perish from starvation, disease, climate change ("nuclear winter"), or other factors. Yet none of these factors, singly or in combination, has been shown to pose such an overwhelming threat that all protective measures would necessarily be useless.

Consider, for example, the "duck-and-cover" drills of schoolchildren in the 1950's, which are still taught to all Soviet citizens today. Although widely ridiculed, such simple action could save many people outside the lethal blast area who might otherwise be severely injured from flying glass or from the intense thermal radiation which could cause severe burns or temporary blindness.

Obviously, inside the lethal blast zone, measures to protect lives would need to be much more elaborate (blast shelters), but it should be noted that the cumulative U.S. area subject to such lethal blast damage (over 5 psi) is probably less than 5 percent (and for the U.S.S.R. it is probably less than 1 percent). These figures will probably surprise most people who may have heard the widely repeated assertion that we and the Soviets have enough nuclear weapons to kill each other 10 or more times over. Other variations on this theme are that the world's arsenals equal one million Hiroshimas, or three tons of TNT per person on Earth, or our favorite: a hand grenade for every square foot of the Earth's surface.

If these latter "statistics" are true how is it possible that less than 5 percent of the U.S. (or 1 percent of the Soviet) land area would probably be subject to lethal blast damage in an all-out nuclear war? The early calculations of deaths per megaton were based on a "cookie cutter" model. Each nuclear detonation is assumed to result in lethal blast damage inside a circle of specific radius. One then imagines nonoverlapping circles to be placed over the areas of greatest population density. In this way, it was estimated that perhaps 400 one-megaton weapons could kill about 25% of the population. This 25% fatality level was considered by strategists in the 1960's to represent a level of damage that no nation would tolerate — the "assured destruction" level. "Assured destruction" does *not* mean that everyone would be killed with 400 megatons. Moreover, the present U.S. megatonnage of ten times this amount would not kill everyone either, even in the simplified "cookie cutter" model. The reason is that a point of diminishing returns is reached fairly quickly after the major population areas are targeted, and each additional megaton used would kill fewer and fewer people; the major urban areas of the nation occupy no more than 2 percent of the U.S. land area, and no more than 0.2 percent of the Soviet land area.

In fact, on a worldwide basis all the weapons in all the world's arsenals would subject less than 1 percent of Earth's land area to lethal blast pressures. Thus, the "overkill" statistic about being able to kill each other ten times over is at best a metaphorical use of numbers that has no relation to actual casualties, and at worst a deliberate attempt to mislead people into believing nuclear war survival is impossible. That statistic (as well as all the others: 3 tons of TNT per person, one million Hiroshimas, etc.) have as little bearing on the actual estimate of casualties as the observation that the explosive power in the world's nuclear arsenals is comparable to that released in one very large volcanic explosion.

The fact that only a relatively small percentage of the nation's land area would be subject to lethal blast damage makes evacuations of cities prior to nuclear attack a conceivable strategy. This, of course, is not nearly as effective a strategy as having in-place blast shelters that can be occupied on short notice, but for a nation that doesn't wish to pay the expense (estimated at 60 billion dollars or \$250 per blast shelter occupant) it is the next best possibility. Obviously, an evacuation of cities would pose extraordinary problems for people residing in the "host" areas. And even outside the "high risk" areas, there still would be many other hazards, especially fallout.

Often, the ability of people to survive the short-term effects of nuclear weapons is portrayed as "meaningless" in view of the long-

term environmental effects. One example of such predicted effects is the depletion of the ozone layer which supposedly has been linked to various human activities. The primary human hazard of a depleted ozone layer would be an increase in skin cancers due to ultraviolet radiation. Calculations by the National Academy of Sciences estimate the rate of increase following a nuclear war to be about 10 percent for Northern Hemisphere survivors — roughly one tenth the increase in danger faced by someone who today chose to move from Minnesota to sunny Texas!

The long-term consequence of nuclear war that has received the widest publicity as being possibly serious enough to bring about mankind's demise has been "nuclear winter," originally proposed in 1983. More recent studies by Thompson and Schneider, however, using more sophisticated models than the 1983 study, show that the duration and magnitude of the maximum expected temperature declines (about 200 degree-days of cooling rather than 22,000), might justify the term "nuclear autumn" better than nuclear winter. Moreover, the magnitude of the climatic effect is highly dependent on factors under the control of the initiator of the nuclear war (the choice of weapons, their altitude of detonation, the targets, and the time of year). Any attacker seriously concerned that nuclear winter is a remote possibility need only choose his weapons and tactics accordingly to avoid "nuclear winter's retaliation." For example, calculations of the maximum temperature depression averaged over northern hemisphere mid-latitudes yield 15 °C for a war in the summer but only a few degrees for a wintertime war. The idea of a "threshold" for nuclear winter if one percent of the world's arsenal is used, or that any attacker would suffer as badly as his victim because of nuclear winter, are additional myths created by those who see in these positions further justifications for their long-held views on nuclear disarmament.

Given the present (and probable future) uncertainties in nuclear winter calculations it would be foolhardy to claim that worldwide climatic changes following a nuclear attack would certainly be negligible, only that they almost certainly would not be catastrophic. As S. L. Thompson and S. H. Schneider note: "On scientific grounds the global apocalyptic conclusions of the initial nuclear winter hypothesis can now be relegated to a vanishingly low level of probability" ("Nuclear Winter Reappraised," *Foreign Affairs*, Volume 64, 1986, pp. 981-1005). Of course, even with climatic changes of less than catastrophic dimensions, large numbers of people might suffer starvation from the disruption of domestic agriculture and food imports from other countries. But then the civil defense measure of prior food storage could partly ameliorate such suffering in the event of a nuclear war (or other natural and man-made hazards prevalent in many parts of the world.)

Disinterest in civil defense is not a global phenomenon. The Soviet Union, for example, spends over 20 times as much as the U.S. does on civil defense every year. Despite assertions about the unsurvivability of nuclear war made by Mikhail Gorbachev in his 1987 book, there is no sign of slackening in Soviet civil defense efforts. Soviet civil defense is often dismissed as a sham by many Americans and by selected Soviet officials by pointing to specific problem areas, using ridicule, or by citing the response to the Chernobyl accident and the Armenian earthquake. In fact, while considerable problems were encountered in the Chernobyl and Armenian earthquake disasters, Soviet civil defense also had some notable successes. Moreover, those who regard Soviet civil defense as a sham rarely cite specific details about the program, including the existence of more than 20,000 blast shelters to protect up to 175,000 party leaders, the blast doors in every subway system in the land (present in cities of one million or more population), the more than 100,000 full-time and 20 million part-time civil defense personnel, and the civil defense classes that are required of all Soviet citizens. Although the Soviet civil defense system would probably fall short in many respects if actually put to the test, CIA estimates of its effectiveness suggest that Soviet casualties in an all-out nuclear war that occurred following a week of heightened tension during which preparations could be made would probably be "in the low tens of millions," namely about 10 percent of the population.

At the same time that many deride civil defense as being incapable of coping with an all-out attack by the Soviet Union, there is a growing perception that better U.S.-Soviet relations make such an attack less likely, perhaps even the least likely, of potential nuclear threats. If that is the case, civil defense deserves reconsideration even by Doomsday theorists. The proliferation of nuclear weapons (and worse, long-range delivery systems) to Third World nations, or even to terrorist groups, poses a growing though clearly nonapocalyptic threat. Civil defense could also make a considerable difference in coping with the aftermath of the accidental launch of a few weapons.

This article cannot answer every one of the literally endless stream of arguments advanced to "prove" that nuclear war would be unsurvivable: firestorms, mass epidemics, societal collapse, insects inheriting the earth, just to name a few. Rather, it has addressed some of the commonly stated arguments in order to illustrate a general approach, to highlight some of the factual material that should be considered in reaching a conclusion, and to suggest specific sources of additional information.

If civil defense advocates are correct, then decisions about this issue could affect the lives of many millions of people in the event that nuclear weapons are ever used. Thus, a serious consideration of this viewpoint is worthy of inclusion in all courses related to nuclear war and peace.

Trees Can Sequester Carbon, Or Die And Amplify Global Warming: Possible Positive Feedback Between Rising Temperature, Stressed Forests, and CO₂

Arthur H. Rosenfeld and Daniel B. Botkin

Global facts: good news and bad

Forest biomass plays an important role in the global carbon cycle. Forests store billions of tonnes of carbon in plants and soil. This is why there is currently so much discussion about planting trees to sequester a significant fraction of the carbon added to the atmosphere by human activity. The idea of forestation to offset carbon emissions was first proposed by Dyson and Marland (1, 2). To assess the viability of massive tree planting, we need to understand how planting trees and deforestation relate to the current global carbon release.

We will make a rough estimate of how much carbon could be sequestered by planting trees, and how much carbon could be released by deforestation or global warming. For the purpose of the discussion we make the following assumptions concerning the order of magni-

tude of various quantities and rates, some of which, unfortunately, are poorly known:

1. World combustion of fossil fuel produces about 5 Gt of carbon (as CO₂) each year:

A. Rosenfeld is Professor of Physics, University of California, and Director, Center for Building Science, Lawrence Berkeley Laboratory, Berkeley, CA 94720. D. Botkin is Professor of Biology and Environmental Science, University of California, Santa Barbara, CA 93106. This work was funded by the Assistant Secretary for Conservation and Renewable Energy, Office of Buildings and Community Systems Division of the U.S. Department of Energy, under Contract No. DE-AC03-76SF00098. The authors thank Robert J. Mowris for help with research, editing and graphics.

Fossil Fuel Rate = 5 Gt/year. (1)

Figure 1 gives the Mauna Loa (Hawaii) data on the buildup of atmospheric CO_2 . We will use it to give a simplified carbon accounting. We also need to know that the atmosphere contains about 700 Gt of carbon (as CO_2). This gives us the right-hand scale of Figure 1. We see that the average concentration of carbon in the atmosphere is now rising about 15 Gt every 5 years or 3 Gt/yr. This is 60% of the fossil fuel rate in Eq. 1. The remaining 40% is apparently removed by the oceans (Bert Bolin, University of Stockholm).

2. We know that for the last 160,000 years there has been an astounding correlation between temperature and atmospheric CO_2 and methane concentration (Figure 2).

3. Living biomass, mainly trees, contains about 500 billion tonnes (Gt) of carbon, comparable with the 700 Gt of carbon as CO_2 in the atmosphere. In the soil there are an estimated 2000–4000 Gt of carbon.

4. The carbon turnover rate from the 500 Gt of living biomass is on the order of 1%/year, i.e. each year about 5 Gt of carbon are sequestered by photosynthesis, and another 5 Gt are returned to the atmosphere by respiration of living biomass and by decaying biomass.

5. If we deforest 1% of the world's 4 billion hectares (Gha), we will promptly (within a few years) add 5 Gt of carbon to the atmosphere.

6. If we add an additional 1% to our forests, which will eventually sequester 5 Gt (but only over 100 years), we will have net sequestering for 100 years, but only at 1% of 5 Gt/year. In other words, in terms of delaying the greenhouse threat for 20 years while we develop non-fossil sources of energy, we have the problem that dead trees decay in a short time span compared to 20 years, but young trees grow in a long time span compared to 20 years. Thus, for a 20 year time-horizon, we must plan 5 ha to offset the carbon released by deforesting 1 ha. Thus, it is better to save 1 ha of forest than to plant 1 ha. This is an important consideration in dealing with nations which need incentives to slow their deforestation.

7. Returning to point 5, that 1% dead and decayed forest biomass represents 5 gt of carbon, we now cite a serious danger. If global warming takes place too fast for forests to adapt to changes in temperature and humidity, it is conceivable that an additional 1% of the forests could die per year. This would be very damaging positive

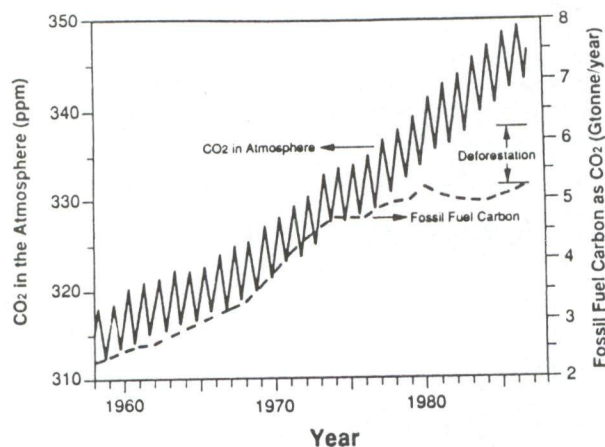


Figure 1. Carbon Dioxide Concentration in the Atmosphere and Fossil Fuel Carbon Emissions, 1958 to 1987. The figure shows monthly concentrations of atmospheric CO_2 at the Mauna Loa Observatory, Hawaii. The yearly oscillation is explained mainly by the annual cycle of photosynthesis and respiration of plants in the northern hemisphere. The slowly increasing concentration of atmospheric CO_2 at Mauna Loa since the 1950s is primarily caused by carbon emissions from fossil-fuel combustion (dashed line). The current annual rate of fossil fuel emissions is about 5 gigatonnes (Gt). Also shown is the estimated 1 Gt of carbon emissions from deforestation. Source: Charles D. Keeling, Mauna Loa, Hawaii.

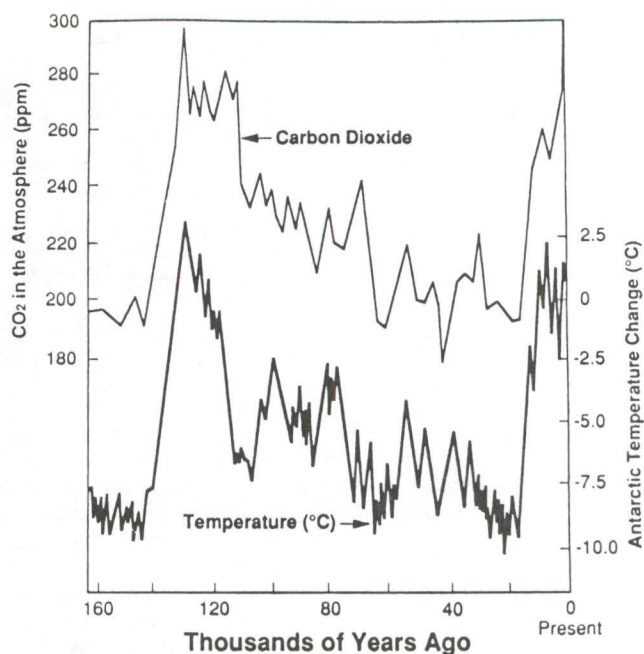


Figure 2. Inferred Atmospheric CO_2 Concentration and Temperature Change from 160,000 Years Ago to the Present. CO_2 and temperature are very closely correlated over the past 160,000 years. The long-term record, based on evidence from Antarctica, shows how atmospheric CO_2 and local temperature rose nearly in step as an ice age ended about 130,000 years ago, fell almost in step at the beginning of a new glacial period, and rose again as the ice retreated about 20,000 years ago. Source: Stephen H. Schneider, *Scientific American*, September 1989—from Claude Lorius *et al.*, Laboratory of Glaciology and Geophysics of the Environment near Grenoble.

feedback.

How fast will forests have to migrate if fossil fuel combustion continues to rise by 1.5%/year? At this rate the carbon dioxide concentration in the atmosphere will double in about 50–70 years. Climatologists are in general agreement that a doubling of CO_2 and an equivalent increase in other trace gases will warm the earth's average surface temperature by 3–5°C. About a dozen research groups around the world have developed computer models to help predict how global climate will be affected by increasing greenhouse gas emissions, and Figure 3 shows the results of one of these models (3).

If greenhouse gases double by 2050, Figure 3 shows an average warming of 3.5°C. In the summer, for temperature latitudes, average temperatures change by about 1°C for every 200 km north-south latitude change. If Figure 3 is correct and average temperatures rise 3.5°C, then this would be equivalent to moving summer temperate zones 600–700 km north over 60 years. If the temperature increase is linear, the move would have to be about 10 km/year. Unfortunately, Figure 3 is more nearly quadratic—the slope starts at zero, and then increases linearly (e.g. $T = t^2$, $dT/dt = 2t$)—so that by 2050 the rate of change might be closer to 20 km/year. If the predicted global temperature increase is correct, then forests will have to migrate at a rate of 200 km per decade, by 2050. This could result in massive forest destruction. (During the last period of glacial retreat, forests had to migrate at a rate of only about 0.2 km/decade.) So a “business as usual” approach over the next 60 years is a severe threat to unmanaged forests or wilderness areas. We will discuss this quantitatively below. Massive human intervention to “help” the forests migrate north might be possible. Unfortunately, without being able to predict how rainfall patterns will change with temperature, it is doubtful that such a huge and unprecedented project would ever even get started.

8. An additional danger is that as the atmosphere heats up, biomass will decay at an accelerated rate, releasing additional carbon into the atmosphere. Aerobic decay yields carbon dioxide, and anaerobic decay yields methane, an even more serious greenhouse gas. An area

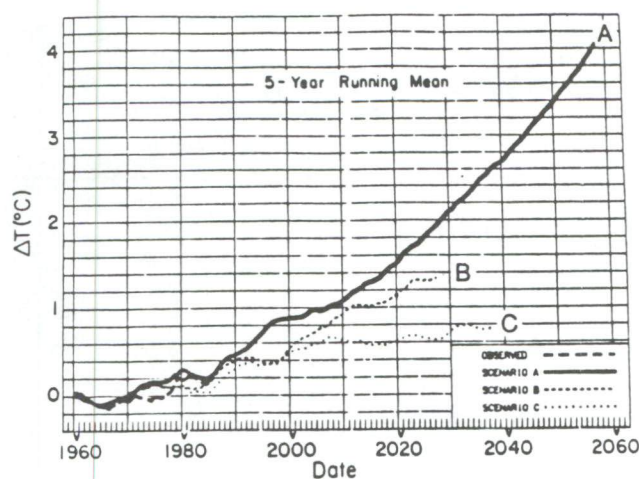


Figure 3. Five-year Running Mean Global Surface Air Temperature Computed for Scenarios A, B, C, 1960-2060. Scenario A—exponential trace gas growth, 1.5%/year; Scenario B—reduced linear growth of trace gases; Scenario C—rapid curtailment of trace gases, no increase after the year 2000.

of concern is the arctic and antarctic boreal forests and tundra where soils are believed to contain 2-5 times more carbon per unit than soils closer to the equator (4). Arctic and antarctic soils have higher concentrations of carbon because of the greater rate of vegetative growth that occurs during the warm, long days of summer relative to the slower rate of decay that occurs during the cold, short days of fall and winter. Increasing temperatures from global warming could increase the decay rate in the soil and release billions of tonnes of carbon into the atmosphere that are now stored in the soils of arctic and antarctic boreal forests and tundra.

Photosynthesis: the good news

Next we note the oscillations in Figure 1, and remember that Hawaii is in the Northern Hemisphere, along with most of the land and vegetation. For simplicity, in the rest of this note we will assume that all the biomass in vegetation is in forests, and that all of it is in the Northern Hemisphere. The dips of the annual oscillation correspond to summer, when warmth and sunlight cause growth, increasing the rate of photosynthesis, and pulling CO_2 from the atmosphere faster than respiration and decomposition put it back. Then, each winter, the balance switches to excess decomposition and CO_2 release. We note that the summer pull-down is about 12 Gt. Only a part of this is yearly net incremental growth in the long-term storage of biomass of typical trees, the rest is leaves and twigs which fall off or are eaten, and small roots which slough off. To a first approximation we assume that,

$$\text{Growth of trees, northern hemisphere} = 5 \text{ Gt/year} \quad (2)$$

This doesn't mean that the forests are sequestering an extra 5 Gt/year of carbon, but that carbon stored in new organic matter in forests is approximately 5 Gt/year. This increase offsets carbon release from decay. We would only get a net sequestering of carbon if we plant new trees or allow now unforested areas to become forested. Ecologists believe that the mass of carbon in vegetation is comparable with, but less than the 700 Gt of carbon in the atmosphere. Our estimate is 500 Gt, and for simplicity, we assume that all of it is forests, so that

$$\text{Forest biomass} = 500 \text{ Gt} \quad (3)$$

By comparing Eq. (1) and Eq. (2) we see that if we wanted to plant enough forest to offset 100% of current annual fossil fuel combustion, we would have to double the forested area of the world, i.e. add 5 times the U.S. land area.

Deforestation: the bad news

We return to point 6. Remember that 4 Gha of forest contain 500 Gt of carbon, so each hectare contains 125 tonnes of carbon. Suppose that we kill or clear one hectare. Then the trees will burn or decay within a few years. This is a short time compared to the time necessary for the world to switch to renewable sources of energy, and hence to the time scale of the CO_2 threat. For bookkeeping purposes, let's call this decay time one year. Then we see the bad news:

$$1 \text{ dead ha/year} = 125 \text{ tonnes of carbon released/year} \quad (4)$$

Since trees take 100 years to sequester this 125 tonne/ha

$$1 \text{ newly planted ha/year} = 1.25 \text{ t carbon bound/year} \quad (5)$$

In summer, it takes 100 years of growth to offset the damage of clearing the same area of forest.

Worse than that, suppose we let the temperature rise too fast, so that forests cannot migrate fast enough to keep up with the changing climate (or cannot adapt). Then maybe 1% of the forest would start dying each year. But 1%/year of 500 Gt of biomass corresponds to 5 Gt/year, which in turn corresponds to our fossil fuel rate in Eq. 1. If this were to happen we would double the rate of CO_2 release, and introduce a damaging and potentially irreversible positive feedback. We are playing with fire.

Fortunately, current estimates of human-induced deforestation is only 0.2%/year, which corresponds to 20% of the current fossil fuel rate.

Tree planting or tree farming to sequester carbon

We can now see that it's impractical to plant trees fast enough to offset deforestation—we'd have to plant 800 Mha (1/5 of the world's forests) one time to offset killing 8 Mha/year. So let's assume that the developed world can induce the developing world to slow deforestation. Then we have a chance, and tree planting can become a useful tool.

In the industrialized countries, before the first oil crisis, energy use grew at the same rate as the Gross World Product, about 3.5%/year. After the first oil crisis, from 1973 to 1986, the industrialized countries held their energy use constant while their economies grew 2.5%/year. For a 13-year period the industrialized world proved that it could keep energy use constant and maintain economic growth. With the proper political leadership, we could reduce energy intensity in industrial countries by 50%, using existing technology, and still maintain the same quality of life—i.e. comfortable, well-lighted buildings, comfortable and safe automobiles, etc. If we reduce energy intensity by 50% over the next 20 years this is equivalent to a 2.5%/year improvement in energy efficiency. If economic growth continues at 3.5%/year however, a 2.5%/year improvement in efficiency translates into a 1%/year increase in energy use. Suppose this increase came from fossil fuel. This means just to keep world carbon emissions constant, we would have to plant enough trees to offset 1% of the 5 Gt/year fossil fuel rate.

According to Eq. 2, growing trees sequester 5 Gt/year, so we only have to add 1% annually to world forests. This would require planting 40 Mha/year of forests. This doesn't solve the problem, but it gives us an estimate of a reasonable use of trees to help keep carbon emissions constant to reduce the impact of global warming.

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Symposium: The Forum Energy Study

The following three papers are shortened versions of background papers which will appear as part of the report of the Forum Study Group on Energy. They address important energy-related topics which have not lately been the subject of widespread public discussion. By publishing them, Physics and Society hopes to stimulate debate on these important issues. The study is chaired by Ruth H. Howes, Department of Physics, Ball State University, Muncie, IN 47306, and Anthony Fainberg, 643 G Street, NE, Washington, DC 20002.

Energy and Transportation: Our Achilles' Heel?

Alan Chachich

Introduction

A balanced analysis of energy issues must consider energy end-use as well as power generation. Transportation is a critical end-user. It claims 28 percent of the energy consumed in the United States and this fraction is increasing. The nature of this energy use is also significant as it accounts for almost two-thirds of our petroleum consumption. In fact, 97% of our transportation depends on oil. That brings us to our fundamental energy problem: a nearly total dependence on petroleum. The vulnerability of our commerce implies a direct security issue on top of the financial and environmental costs.

There are two solutions to this problem: drive more efficiently, and drive less.

I say "drive" because as the Table shows, 85% of our transportation energy is consumed on the highway. Obviously improvements to auto and truck efficiency are crucial.

TABLE: Transportation Energy Consumption by Mode

Mode	Quads	%
Total domestic transportation	18.61	100.0
Highway sub-total	15.90	85.4
auto	8.92	47.9
truck	6.83	36.7
bus	0.15	0.8
Air sub-total	1.65	8.9
commercial	1.50	8.1
general	0.15	0.8
Pipeline	0.50	2.7
Rail sub-total	0.40	2.1
passenger	0.01	<.1
freight	0.39	2.1
Water	0.14	0.8
Mass transit	<.02	<.1

Compiled from the "National Transportation Statistics Annual Report, 1988," DOT-TSC-RSPA-88-2.

Driving more efficiently

Transportation efficiency increased substantially in the last decade. Automobile fuel efficiency almost doubled from 1975 to 1986 (16 to 28 mpg). Light truck efficiency improved similarly (14 to 22 mpg). Unfortunately, this saving was offset by a 31 percent increase in highway travel. The technology for further great improvements exists or is on the horizon. It can basically be considered in two groups: advances in efficiency that will help conserve our petroleum supplies, and advances that make alternative fuels possible. Many developments of course will do both.

Of all the improvements that will reduce, but not eliminate, our consumption of petroleum, those to internal combustion engines are most critical. The primary focus here falls on leaner-burning combustion, higher compression, lower inertia for moving engine parts, shifting rejected heat from the cooling system to the exhaust stream, and recovering more energy from the exhaust. Stratified combustion is a lean burn technique that attempts to combine the higher efficiency of diesels with the greater responsiveness of gasoline engines. Advanced knock suppression techniques will determine the success of these strategies to improve combustion.

Advanced cooling techniques such as evaporative cooling and oil cooling will improve efficiency by: eliminating pumps and fans and so reducing parasitic losses, lowering engine friction via higher temperatures, improving aerodynamics (use of heat exchanger or smaller radiator), reducing warm-up time (less coolant), and lowering weight. Low heat rejection (LHR) or adiabatic engine technology may increase efficiency by 10-20%. The ongoing evolution of the LHRE has recently been discussed (1). The higher temperature operation necessary to shift heat to the exhaust will require materials to withstand the more severe environment and significant advances in high temperature lubrication. Multiple level systems employing liquid and solid lubricants together are likely. Gas lubrication is a much more distant possibility. Many schemes exist for recovering exhaust energy electrically and mechanically. They range from simple turbocharging to complicated turbocompounding systems that return energy directly to the driveshaft.

Future transmissions will keep engines operating closer to their most efficient load ranges through the use of more gears, continuously variable belts (CVT), and electronic controls. The greater stresses in the transmissions of the heavier American cars will hamper CVT application here. Electronic controls may save energy that is currently lost to inefficient shifting by drivers.

Electronic controls can save energy in many areas. The most obvious one is electronic engine control (EEC). Advanced sensors will supply instantaneous data in place of the cycle averaged data from present sensors. The myriad of electronic subsystems will eventually be integrated into cohesive fail-safe or fail-soft systems. Electronics outside the engine will also enhance efficiency. Two examples are electronic braking and sound cancellation systems. The latter could make mufflers obsolete, eliminating their load on the engine. Higher costs will be the greatest drawback of the advanced controls and sensors.

Advanced materials will reduce fuel consumption through lower weight, lower inertia parts, reduced friction, advanced sensors and increased adiabaticity. Weight reduction will make the first and likely the greatest contribution. Note that new materials may offset their higher cost through lower manufacturing and assembly costs.

The author is a member of the technical staff at Lincoln Laboratory, Massachusetts Institute of Technology, Lexington, MA 02173-9108.

Improvements in rolling resistance and aerodynamics have been significant this past decade and will be in the next. The efficiency gains from both, particularly aerodynamics, will diminish as practical limits are reached. Engine improvements will overtake them in significance by the end of the next decade.

Work in alternate fuels falls into both groups. Developments to apply low-grade oils, natural gas and butane will help conserve petroleum supplies. Alcohols, coal, vegetable oils and hydrogen provide options which may replace petroleum. Methanol, which is actually petroleum-related, may be practical before the others. Incompatibility with the existing fuel distribution systems may be the greatest barrier to the use of alternative fuels.

Gas turbines suffer lower fuel economy and higher cost so most development will be for aviation. Road application is further hampered by the additional efficiency penalty from converting exhaust stream energy to shaft power. They are lighter, quieter, produce lower emissions and have a substantial capacity for alternative fuels and so may eventually find a place on the road.

A Stirling engine vehicle is getting 10% better fuel efficiency than the internal combustion engine version. Stirling engines are also quiet and can have multifuel capability. Mass producibility and reliability remain to be demonstrated. Its much lower emissions may become the greatest incentive for further development.

Dramatic developments in the past decade showed that fuel cells can provide the most efficient power plants for transportation, (60-80% efficient). Other advantages include quiet operation, negligible pollution and alternative fuel capability. This technology also falls into both groups. Petroleum-based fuels are the easiest to apply to current fuel cells, yet in the long term they have great promise for alternative fuels. Methanol would be the most likely fuel for a transportation power plant. Poor response time is currently the greatest obstacle. Fuel cells are a high risk but high pay-off technology that can address our fundamental petroleum dependence in the longer term.

Other alternatives include electric/hybrid and solar vehicles. Mechanical and electric power storage systems under development will be crucial to many of the alternate power plants, such as electric motors and fuel cells. Recent developments in photovoltaics make it hard to judge the potential for solar vehicles, especially for the near term. Solar powered vehicles certainly would be more desirable in terms of petroleum dependency and pollution. Efforts are underway to produce electric and solar commuter vehicles. The current market may be a greater obstacle than the technical problems of cell efficiency and light-weight storage.

Driving less

Technology can alter our transportation requirements as well as consumption. Trips can be made more effective, shorter or unnecessary. For starters, operational factors can be studied and improved at all levels. Fuel can be saved by improving individual vehicle operating practices, traffic management, and infrastructure design. An example of each would be cab heaters to reduce the idling of trucks, retiming traffic lights, and airports designed for maximum fuel efficiency.

Our transportation requirement can be analyzed as a whole, and our use of the various modes to meet it can be optimized. This would be a departure from the past as the impact of improvements in one mode on the other modes would be considered, as well as energy security, total cost, environmental impact, and safety. For example, does it make more sense to build more airports in the Northeast, or to slow air traffic growth with a magnetic light rail system or expanded highways?

We can also replace or eliminate transportation requirements directly, for example by videoconferencing, telephone banking and other telecommunication advances. Any energy use extracts a financial and environmental cost so conservation is the most beneficial solution.

Technology is but a team member in the solution to our energy problems. Public understanding and policy are others. Policies for *both* setting research priorities and applying technologies are crucial.

Automobiles that achieve 60 to 100 mpg exist but await more favorable markets. The time constant of petroleum price swings is too short for the free-market interaction between consumers and industry to thwart a crisis. Consumers also discount the value of future energy savings heavily (20-30%) weakening the incentive for industry to concentrate on energy efficiency. In fact, as vehicle fuel economy increases, its significance to the consumer diminishes. That is because fuel costs become a smaller fraction of the total operating cost. At current gasoline prices a 10 mpg improvement to a 30 mpg auto saves the typical driver less than \$100 a year. On the other hand, a 0.1 mpg improvement to the U.S. auto fleet would save 20,000 barrels of oil per day. That is the estimated production from the controversial Georges Bank fishing grounds off of the East Coast. Policies to resolve this conflict between the short term benefit to the individual and the long term needs of the nation present a formidable challenge which must be overcome.

The long term security of the nation is involved so the federal government has responsibility here. Policies must be evolved in cooperation with industry to be most effective. The free market alone may not be sufficient but the government is not likely to be able to operate an automobile company better than its board of directors. Both the industry and the government share responsibility for their past antagonistic relationship. Both must strive to leave that behind.

The government may also have to solve the "chicken and egg" dilemma posed by the automotive and petroleum industries. The major automakers do not want to invest in alternatively fueled vehicles without being certain that customers will have sufficient access to the alternative fuel. The petrochemical industry does not want to invest in the distribution network for an alternate fuel without being certain that there will be a market for it. The government may need to assume some of the risk. One option would be to subsidize centrally fueled vehicle fleets and phase out the subsidy as the market grows. Fuels could be subsidized instead. In either case, care must be taken to prevent loud but narrow political constituencies from squelching superior alternatives for their own gain.

Federal planning and action has been reactive. Consider that our contingency response policy is a few months supply of oil in the strategic petroleum reserve. That must change. We need preventive policies that will lower the probability of a supply disruption and mitigate its effects if one occurs. Policy questions that should get public attention include:

- What will it take to achieve petroleum-independent transportation?
- What will it take to achieve hydrocarbon independence?
- Then what should our long-term research goals and priorities be?
- How can we provide stable and consistent research funding?
- How do we reduce consumption? CAFE (Corporate Averaged Fleet Economy) standards?
- Can we improve the CAFE?
- Tax policies (gasoline, hydrocarbon, vehicle)?
- Incentives (reward or rebate for purchasing efficient vehicles, R & D support)?
- How can we improve public transportation?

Readers interested in detailed policy options are referred to the thoughtful discussions in references (2-4).

Finally, education must be mentioned. Without question a well informed electorate will lead to better decisions by our government and the individual consumer. The scientific community has needs here too. Specifically, we need to base our strategy for the future on our past successes. The problem is that there has been very little evaluation of what worked, what did not, and why during the last energy crisis. If we are fated to repeat that history it will not be for any good reason.

Much of the energy savings we realize now are due to programs

initiated in the 1970s. The choices we make now will determine our vulnerability to the petroleum supply in the next decade or longer. We must revisit this question with urgency now while oil prices are low, especially as most experts predict a supply disruption within the next 10 years. Too much is at stake to allow ourselves to be lulled by low oil prices, when we know better.

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Wind as a Utility Generation Option

Jamie Chapman

[An annotated list of selected references is available from the author upon request.]

Introduction

As a bulk power generating option for utilities in the nineties and beyond, wind turbine electric power generating systems are among the most attractive of the renewable energy generation technologies. In their current form, wind-driven power stations represent not a replacement for conventional power stations but rather a complement, forming a part of the total generation mix. In principle, wind systems could replace a part of the existing conventional generation capacity. More realistically, they will preclude the need for or delay the addition of conventional capacity in order to meet the demands of load growth.

Wind-driven power systems represent a renewable technology which may be described as mid-course in its development and maturation. It is a renewable power technology which has evolved rapidly over the last decade and has accumulated significant, large-scale utility-connected experience, principally in California.

As a result of the impetus provided by the oil embargo of 1973, the 1978 National Energy Act, the later implementation of PURPA and by tax credit support through 1985, concerted development of modern wind turbine power systems began in the mid-seventies. Both public and private sector funding has been used to develop this technology.

The first large-scale, utility-connected installations appeared in California in 1981. Since then, private sector investment capital in excess of two billion dollars has resulted in the construction and commercial operation of wind-driven power stations whose capacity was rated at more than 1300 megawatts by the end of 1989. Thus in this country, by the end of 1989, grid-connected wind systems had provided capacity equivalent to a large nuclear or coal-fired power station.

The early experience revealed severe shortcomings in the designs of the first-generation wind turbine components. These deficiencies can be traced largely to a lack of knowledge about the extreme dynamic range and attack times of the wind and its gust structure. Second-generation designs, introduced in the mid-eighties, generally have proven themselves able to accommodate and harness these wind forces. These systems have generated substantial quantities of electricity. For example, during 1989, these systems delivered about 2 billion kilowatt-hours of electrical energy, enough to meet the residential needs of a city the size of Washington, DC or San Francisco.

Utility-scale wind turbine power systems

Wind-driven power stations. Large-scale, utility-connected, wind-driven power stations frequently are referred to as wind farms, wind parks or Windplants, a trade-marked term used by U.S. Windpower, Inc.

These large-scale power generating systems are comprised of a large number of arrayed wind turbines. The power from each wind

turbine is collected and combined with that from others by a wiring network similar to a utility distribution system. The collected power is then delivered through a substation to the utility grid for use by consumers. A small, central control facility monitors and controls the status of each wind turbine as well as the total delivered energy.

Except for the wind turbine components themselves, all components and subsystems which make up a wind farm are the same as used in conventional utility applications. This includes the pad mount transformers used to combine the power from several wind turbines and step-up the voltage for transmission to the substation. The substation itself, with its associated monitoring, control, switching and protective devices is purchased from the same vendors who supply utilities.

Integration and compatibility. The integration of wind-driven electrical generation systems with the balance of a utility system is straightforward and is accomplished using standard utility components and practices. Control and monitoring capabilities of modern wind power systems are analogous to those used for similar functions in conventional utility systems.

For current systems, there is a limitation on the amount of wind power capacity which can be integrated with conventional power sources. Based upon the second-generation wind technology currently in use, the ratio of wind to conventional power systems is thought to be in the range 5-15%. This limited range arises from the time variability and other technical characteristics of the power delivered by wind systems.

Third-generation wind systems, now in their earliest stages of development, will allow wind utilization to twice this range (i.e., 10-30%) while still maintaining existing utility standards of power quality and system stability. In certain applications, the third-generation wind systems, when augmented with moderate amounts of energy storage, will allow the conventional power sources to be turned off.

Advantages and characteristics. Compared with either fossil-fueled or nuclear power stations, wind-driven power stations have the advantages of modularity and much shorter construction times. Due to the distributed nature of the generation sources (the wind turbine components), wind-driven power stations are inherently modular. Capacity can be added incrementally, as required, with a short planning horizon.

In addition to their inherent modularity, wind-driven power stations can be installed and placed into operation very quickly. Therefore the cost of funds used during construction is correspondingly less. For non-renewable power stations, this cost of funds can be a significant component of the installed capital cost, and therefore of the cost of energy.

In their operation, wind-driven power plants utilize no fossil fuels or radioactive materials. Therefore there is no associated risk of environmental degradation or contribution to global warming. The capital and maintenance costs associated with scrubbers and other

The author is a power systems consultant, 15 Sleeper Street, No. 402, Boston, Massachusetts 02210.

pollution control devices are eliminated. The costs and continuing risks associated with decommissioning nuclear power stations are eliminated.

Finally, the best of the second-generation wind systems currently in operation are economically competitive with newly-constructed nuclear and coal-fired power plants. The life-cycle cost of energy is 7-9 cents/kWH. Measured on a rated power capacity basis, the installed, all-in capital cost is in the range \$1000-\$1400 per kW. As a result of integrating research advances with the significant operating experience gained over the last decade, these cost values are expected to decrease to 4-6 cents/kWH and \$600-\$1000 per kW.

How wind-driven power stations differ

Wind-driven power stations differ from conventional power stations in two principal ways, each with an associated consequence. These are (1) the distributed generation sources and the associated land use, and (2) the nature of the fuel and associated characteristics of the generated power.

Configuration and land use. Conventional utility power systems consist of a relatively small number of generation units each having a relatively large power capacity. Wind-driven power stations are comprised of a large number of geographically-distributed generating units (the wind turbines) each of moderate capacity. Whereas the size of a conventional generating unit is measured in units of hundreds of megawatts and may occupy only a few acres, an individual wind turbine typically is rated in units of hundreds of kilowatts. The array of wind turbines, which when interconnected, have a capacity equivalent to that of a conventional generating unit, may occupy a land area of hundreds of acres.

Although wind-driven power stations do inherently require more geographical area or acreage than conventional stations, the land on which wind power stations are situated can continue to be used for its original purpose. This is because the individual wind turbine sites, the service roads, substations and other supporting infrastructure actually occupy and disturb only a small fraction, typically about 10 percent, of the total area containing the wind power station. For example, the large wind installations in northern California are located on ranch land. The ranchers continue to graze cattle on their land. As another example, the 2000 wind turbines in service in Denmark are distributed throughout the country, the majority in small clusters associated with an industrial facility or group of residences.

Fuel and power characteristics. The fuel for conventional power generating units typically is either a fossil fuel (coal, oil or gas) or a material supporting nuclear fission. The availability of this fuel is not a function of the vagaries of nature but of production capability, logistics and storage capabilities.

The fuel for wind turbines comes without requiring industrial support and without cost. However the availability of wind, while statistically predictable, is not subject to our control. It is variable in time on various time scales: short-term (minutes and hours), diurnally and seasonally.

The energy in the wind and therefore the electrical energy delivered is reasonably predictable seasonally and diurnally. It is predictable enough so that California utilities with large amounts of wind capacity routinely factor the expected wind production into their generation planning and dispatch.

Short-term time variability is not as predictable. Thus the short-term power output from a single turbine mirrors the fluctuations of the wind. There is however some smoothing owing to inertial effects of the turbine rotor. Power electronics and adaptive control systems now being investigated for third-generation wind turbines will further smooth wind-induced fluctuations in the output electrical power.

Surprisingly, the short-term variability of the output power from an array is quite smooth relative to that from a single turbine. This is because the short-term wind time series at nearby wind turbine sites are relatively uncorrelated. When the outputs from a large ensemble of geographically-distributed wind turbines are combined, the resultant, summed power delivered to the grid can be quite smooth. The

short-term fluctuations are significantly reduced, but still present.

The extreme short-term variability (minutes to tens of minutes) is the principal reason why the fraction of wind power systems delivering power to a total utility system is limited. In the simplest case, in order to deliver the constant level of power required by a constant load, the time-variability of the wind-derived power must be compensated for by increasing or decreasing the power from conventional generating units. Even if technically possible, frequent, short-term ramping up and down of these units increases their required maintenance and complicates the control and coordination of the entire power system.

In addition to the time-variability of the real (or useable) power delivered to the grid, there is a second characteristic of the power delivered by most of the second-generation wind turbine generators currently in use. Most of the wind turbines now in use incorporate (for very good design and economic reasons) a generator which requires some electrical support from the conventional power sources also on the utility grid. It is a sort of symbiotic relationship. The particular class of generators, called induction generators, require for their operation both an external voltage source and a source of reactive (or non-work-producing) power. The requirement for the so-called excitation voltage poses no difficulty and carries no economic penalty since the wind turbines must be connected to the grid anyway. However, to the extent that the wind turbines require reactive power, there is an economic penalty. This is because the conventional generation sources must be operated off of their most efficient operating point.

Future trends

Geographical usage beyond California. The wind power stations installed in California generated about one percent of that state's total electrical energy needs during 1989. Two factors will increase the impact of wind energy generation in California. First, the performance of the existing plant will increase through continuing performance and reliability improvements. Second, the currently-installed capacity conservatively represents development of less than half of the state's wind resource potential.

In other parts of the US, studies published by the Solar Energy Research Institute (SERI) and by the Electric Power Research Institute (EPRI) indicate a much larger total potential for the generation of electricity by wind systems. Regions other than California include the Great Plains, the Atlantic seaboard, the Great Lakes coastal regions, the Appalachian mountains, the Aleutian islands and Hawaii.

Technology trends. The principal technology improvements will be associated with increases in wind turbine size, improved knowledge of structural materials and structural responses, the incorporation of improved control hardware and algorithms, utilization of power-conversion electronics, and the development and integration of short-term energy storage systems.

The power rating of wind turbines used thus far in the California installations, on average, have doubled from about 50 to 100 kW. For wind farm applications, economic optimization studies have indicated that the optimum size lies in the range 200 to 600 kW. This corresponds roughly to the rotor diameter range 20 to 40 meters.

Advances in airfoil performance and materials used for the wind turbine blades will allow the much wider geographic utilization of wind turbines. Changes in the electrical configuration of wind turbine generators, made possible by advances in power electronics and digital control, will further enhance the energy production performance of wind turbine power generation systems and make them even more competitive with fossil-fueled and nuclear power stations. Wind turbines will be self-controlling machines, able to adapt to changing wind and load conditions to a much greater extent than is currently implemented.

A major improvement in the wind turbine system architecture will be the incorporation of power electronics between the wind turbine generator and the load (the utility grid). As a wind system element, power electronics will bring several major benefits. It will allow the

wind turbine rotor to be more efficient in converting power in the wind to delivered electrical power. It will provide a new control dimension which should permit lighter-weight structural elements, thus reducing the capital cost. Finally, power electronics will completely eliminate the requirement for reactive power from conventional sources. The incorporation of power electronics will be a major factor in allowing the increased usage of wind systems with conventional generation sources.

As discussed above, the principal characteristic which limits the use of wind systems without any support from conventional power sources is the time-variability of the real power. Research in and the development of cost-effective energy storage and conversion systems will smooth this variability.

Public policy initiatives

The current era may be characterized as one of low energy prices coupled with uncertainty as to when (or whether) energy prices will rise. Practically all financial incentives for the further private sector advancement of renewable energy technology have been allowed to expire. These circumstances make it difficult to attract the investment of private-sector capital for further improvements and applications of the technology. Similarly, federal research budgets have been reduced drastically.

At the same time, there is increasing concern and knowledge about the effects of conventional power sources on our environment. And a case can be made that energy costs will increase significantly,

whether as a result of geopolitical factors, simple depletion or environmental concerns and the attendant costs.

These factors, together with the general perception that there is no urgent need for renewable sources of energy, represent a unique window of opportunity. This is an opportunity of such importance that public policy can legitimately be employed to shape the future and assist in realizing the benefits offered by these energy generation systems.

Public policy initiatives to further the technical development, economics and application of wind-driven power systems (and all renewable power systems) include:

- tax incentives based upon the energy delivered;
- recognition in energy pricing of both the direct and the indirect costs of energy generation by the various sources;
- provisions in power purchase contracts offering some level of predictability for debt service of construction financing;
- majority utility ownership of renewable power systems;
- access to long-distance power transmission (wheeling) by independent power producers as well as utilities;
- incentives for the export of renewable power equipment and services.

Such policy initiatives would attract private sector capital to further the needed technical development and facilitate additional renewable energy generation facilities. This would mitigate further environmental damage, and permit US manufacturers to establish and maintain a pre-eminent export position in this capital-intensive, environmentally-important power generation technology.

Energy Storage

John G. Ingersoll

The importance of energy storage

Energy is useful only if it is available when needed and then if it is in a usable form. Keeping energy available until it is needed and in a usable form constitutes storage. Some forms of energy by virtue of their physical nature lend themselves more readily to storage than others. Two extreme examples are oil and electricity. The former can be stored in a simple and inexpensive manner in a tank or container after it is extracted from the ground. The latter requires rather sophisticated and invariably expensive means of storage such as electrochemical batteries. The problem arising from the difficulty of storage for some forms of energy may be further compounded by variability in demand and supply.

Improving efficiency

Energy storage in general results in an efficient utilization of energy resources. Moreover, energy storage almost guarantees that certain desirable but presently uneconomic energy sources and end uses become more competitive. Three examples illustrate these points: utility load leveling, renewable energy resource use and alternative transportation means.

One of the major problems facing the electric utility industry is matching supply with demand. Traditionally, utilities have set up a three-tiered generation scheme so as to produce electricity with the best efficiency and adequate reliability. Typically 40-50% of the load (base load) is supplied by large coal or nuclear units of the highest efficiency operating most of the year. Another 30-40% of the load (the intermediate or cycling load) is met by the utility's less modern and less efficient coal, oil and gas units as well as hydroelectric units and possibly gas turbines. Brief peak loads are met by still older fossil-fuel units and by gas- and oil-fired turbines and diesel generators. Availability of proper storage to accumulate the electricity output during periods of low demand (nights, weekends) for periods of high demand can in essence eliminate cycling and peaking units altogether, while base load plants are operating at a constant load for maximum efficiency and minimum outage time.

Renewable energy resources can be effectively utilized if the time of their occurrence can match the demand side. Because such a coincidence of supply and demand is very unlikely, particularly over short periods of time such as a day, storage becomes almost imperative. One of the most frequently encountered renewable resources, hydro power lends itself to a relatively easy solution as water can be stored behind a dam. On the other hand, solar and wind energy have to be stored in the form of heat, electricity or a chemical compound (e.g., hydrogen) to command a higher value in the energy market. For example, the economic success of the Luz solar thermal-electric power plants in the Mojave Desert in California (285 MW in operation and 350 in planning) is due to the availability of thermal storage so that the electricity can be generated to meet more closely the demand. It is also interesting to note that even though the utility grids in the U.S., because of their vast interconnections, can provide an initial storage for solar and wind electricity of up to an estimated 20% total penetration of the generation system, utilities refuse to offer capacity credits for solar- and wind-derived electricity for lack of storage at the generation site.

In the transportation sector tremendous energy savings can be realized if, for instance, the internal combustion engine is replaced by an electric motor. This requires, however, the replacement of the gasoline tank having an energy density of about 13 kWh/kg (9.4 kWh/l) with, say, electrochemical batteries the maximum energy density of which may range from 40 Wh/kg (80 Wh/l) for commercially available lead-acid to possibly 200 Wh/kg (100 Wh/l) for sodium-sulfur ones.

Energy storage systems are normally classified into five categories depending on the form and origin of the energy stored: mechanical, electrical, thermal, chemical, and biological storage.

Mechanical and electrical storage

Mechanical storage comprises pumped hydrostorage, compressed air and flywheels. Pumped hydrostorage involves fairly large systems
The author is a physicist, residing at 21315 Lighthill Drive, Topanga, CA 90290.

on the order of several hundred up to a few thousand MW. Because of the remote location of appropriate reservoirs from urban centers and the potential environmental implications of permanently flooding large areas, the likelihood of further significant pumped hydrostorage development in this country is very small.

Compressed air systems can vary in size from tens of MW to several hundred MW. They represent a new technology in its initial phase of commercialization (a 290 MW plant near Bremen, Germany since 1979 and a 60 MW plant in Alabama, to be completed in 1990). Although compressed air systems are not yet as efficient as hydrostorage (50% versus 70%), they have more than an order of magnitude higher specific energy density (110 Wh/kg and 8 Wh/l at 20 atm) and an inherent versatility of location compared to the latter. Efficiencies approaching 70% can be attained by improving the design of recuperators that can use the heat extracted during compression to reheat the air during expansion.

The advent of new lightweight materials with high tensile strength, such as carbon fiber, kevlar, and fused silica to mention a few, has significantly enhanced the chances of flywheels becoming practical storage systems. Specific energy densities on the order of 50 Wh/kg (60 Wh/l) are already available, albeit for specific applications because of the cost of composites (the Canadian Coast Guard is replacing the present lead-acid battery storage of photovoltaic-powered remote light stations with standardized 8.5 kWh at 23,000 rpm s-glass, carbon fiber, aluminum composite flywheels). An order of magnitude higher densities are possible with the full utilization of the new materials. Thus, composite flywheels making use of several layers of different materials to optimize energy density are compact, have efficiencies in excess of 90%, a life expectancy over 20 years and are well suited for load leveling and renewable storage of residential and small commercial buildings as well as for increasing the efficiency and/or powering of electric vehicles.

Electrical storage includes electrochemical batteries and magnetic superconducting coils. The last decade has seen the commercialization of advanced lead-acid batteries employing the so-called starved electrolyte concept, which makes use of a highly porous separator to keep the electrolyte immobilized. The need to add water is eliminated. The electrode grids are also made of a lead-calcium alloy to further enhance the life expectancy of the battery. Specific energy densities on the order of 35 to 45 Wh/kg are already available with an efficiency of 80% and over 1500 discharge cycles at 80% depth of discharge. Of all the other large energy storage electrochemical batteries, the one nearing commercialization is the sodium-sulfur battery. It can attain a 180 to 200 Wh/kg specific energy density and an 80-85% efficiency. The molten sodium and sulfur electrodes insure a very long life, although the solid beta-alumina electrolyte limits this life at present to 1000-1500 cycles. Electrochemical batteries can offer storage ranging from one kW up to several MW and as such are ideally suited for: load leveling for utilities (the largest systems in the world are a 17 MW in Berlin, Germany since 1987 and a 10 MW at Chino, California since 1988, both lead-acid of the standard open cell type), commercial and residential buildings; renewable energy storage at the residential level (thousands of photovoltaic-powered houses exist in the U.S. and around the world); and powering electric vehicles (the GM Impact unveiled in 1990 has a 13.6 kWh storage in 32 advanced lead-acid batteries with a range of 124 miles).

Electricity can be stored with very high efficiency in superconducting coils in the form of a magnetic field. This development is in its infancy, but the potential is great as it offers a direct and mostly superior substitute for pumped hydrostorage. Although the specific energy density of this system is comparable to that of pumped hydrostorage, its efficiency is about 95% (2% refrigeration losses and 3% AC/DC conversion losses), and it can respond literally in a fraction of a second to supply and demand changes. It is envisioned that standard utility systems will have a size of 1000 MW with 5000 MWh capacity, a 5 h charge of discharge time and a circular coil of 1000 m in diameter.

Thermal storage

Thermal storage comprises the traditional sensible and latent heat storage as well as the more novel thermochemical storage. Thermal storage appears to be of paramount importance in the development of solar thermal technologies both at the utility level as well as the residential and commercial building levels. It can be also used as for load leveling in certain situations. Sensible heat storage can employ water (1.2 Wh/l°C), rocks (0.6 Wh/l°C), and other materials. For example, a specially formulated oil is used in the Luz solar thermal-electric plants at an operating temperature of 250 °C-350 °C. Iron, which has almost the same heat capacity as water, can operate at high temperatures unlike water and can transport heat much more effectively than rocks.

Of the various latent heat storage materials at ambient temperatures, calcium chloride hexahydrate is commercially available mostly for thermal storage in buildings and comes prepackaged in a number of configurations, including rods, translucent pods and steel cans. This particular material in a proprietary formulation to minimize phase separation has a phase change temperature of 27 °C, a thermal storage capacity of 48 Wh/kg (82 Wh/l), and a life expectancy of several thousand cycles. On the other hand, several high temperature latent heat chemical compounds are available. Besides storing heat, cold storage is becoming nowadays even more important. Using off-peak electricity, one can freeze (93 Wh/kg) or possibly chill water, which is then used for air conditioning, refrigeration or other related applications during on-peak electricity demand periods. Several companies are already manufacturing standardized water containers that can be used to store certain amount of cold. The typical efficiency of storing and recovering sensible and latent heat may be on the order of 80 to 90% depending on system design.

Thermochemical storage typically entails the storage of solar heat as chemical energy in materials produced by the thermal dissociation of certain compounds. The recombination of the generated chemicals will release heat at a desirable rate. Thermochemical systems operate at high temperatures and are limited to specific materials. Two proposed and studied, but never built and tested, systems involve the dissociation of ammonia (915 Wh/kg) and sulfur trioxide (336 Wh/kg). An estimated heat storage efficiency of 70% is typically quoted for thermochemical processes.

Chemical and biological storage

Energy can be held in the chemical bonds of many compounds and released by exothermic reactions. Combustion is the most notable such reaction. Chemical energy storage is very practical for several uses, the most prominent of which is transportation, because of its high specific energy density. Two of the most important chemical storage compounds are methanol and hydrogen.

Methanol has attained preeminence because it is the feedstock material of several chemicals and most recently has been proposed as a substitute for gasoline in internal combustion engines. Methanol is made from the catalytic reaction of hydrogen and carbon monoxide both of which can be obtained readily from either coal or natural gas. Methanol can also be obtained from biomass but with considerable more complexity. The major advantage of methanol as fuel is its presumed reduction in the generation of ozone and emissions of hydrocarbons and carbon monoxide, while it appears to generate formaldehyde (which can be reduced through proper on-board catalysts). Production of methanol from coal increases the amount of carbon dioxide in the atmosphere compared to the combustion of gasoline of equal energy content, while production of it from natural gas may result in a small reduction of carbon dioxide. Methanol from biomass eliminates net greenhouse gas emissions but cannot be generated in adequate quantities to replace all petroleum-derived fuels in the U.S.

The low vapor pressure of methanol requires a 85-15% methanol-gasoline mixture for cold starts. It has been estimated that this small addition of gasoline results in only half as much reduction in ozone as

that from the use of pure methanol. Hence, the impact of methanol in reducing the greenhouse effect and air pollution appears to be very small, if any at all. We may also note that there is a widespread perception, which may not be entirely correct, that methanol can easily replace gasoline with relatively small modifications in the present fuel distribution system and vehicles. It should be also noted that methanol has only half the specific energy density of gasoline (6.4 kWh/kg and 5kWh/l).

The idea of utilizing hydrogen as a universal fuel as well as an energy storage medium is not a new one. The concept of the so-called hydrogen economy has been around for two decades now. In this scenario hydrogen becomes the foremost energy carrier even more so than electricity. Although hydrogen can be generated from coal and natural gas, its true usefulness comes from being generated by the decomposition of water with the aid of renewable energy resources. The best known way of decomposing water is electrolysis. Thermochemical cycles offer another possible avenue of hydrogen generation from water, but none has ever been tried on a commercial scale. Hydrogen is the ideal fuel for any combustion process for it produces virtually no pollutants with the possible exception of nitrogen oxides in internal combustion engines (which can be nonetheless reduced to well below the emissions from a gasoline powered engine). The catalytic combustion of hydrogen, for example, in household uses totally eliminates nitrogen oxides as well. Hydrogen can be transported and distributed by pipeline like natural gas (a hydrogen pipeline has been operating in the Ruhr area of Germany since the 1930's).

Hydrogen's use as an automotive fuel presents some space problems because of its low density. Although the specific energy density of hydrogen is 38.9 kWh/kg, it is reduced to 0.4 kWh/kg (0.8 kWh/l), 1.1 kWh/kg (0.55 kWh/l) and 6-7 kWh/kg (0.95 kWh/l), respectively, if stored on-board the vehicle in a metal hydride, as pressurized gas at 200 atm, and as liquid in a proper cryogenic dewar. Prototype cars powered by hydrogen were unveiled in 1989 by Mercedes-Benz using a metal hydride storage with a 70 miles range and by BMW using a liquid storage with a 135 miles range. Another hydrogen storage possibility for automotive applications is ammonia, in which case the energy density per volume is comparable to that of gasoline. However, a temperature of 700-800 °C is required to decompose ammonia in order to obtain the hydrogen component for combustion.

The availability of hydrogen as an automotive fuel makes feasible the replacement of the internal combustion engine by fuel cells. In this case the fuel cells generate electricity to power electric motors for a far more efficient utilization of energy compared to the internal combustion engine. We may also point out the hydrogen from the reformation of natural gas, even though a temporary solution, can

eliminate local pollution problems without worsening the greenhouse effect any more than directly burning the natural gas used in the generation of hydrogen. If anything, hydrogen from natural gas would lessen the greenhouse effect because the fuel efficiency of a hydrogen-powered internal combustion engine appears to be as much as 40% higher compared to gasoline due to the gaseous nature of hydrogen and its high speed of diffusion in the air mixture.

Biological storage is identical to chemical storage in principle, the only difference being that the chemical compounds are produced naturally by photosynthesis. Nature generates a multitude of organic compounds starting with water, carbon dioxide and solar radiation. However, the conversion of solar radiation to chemical energy proceeds at a very small efficiency. It is a matter of simple arithmetic to realize that at a 1% conversion efficiency, it is practically impossible to meet the energy needs of the U.S. from biological sources. However, biological sources can supply most or all the needs of selected fuel usage such as in agriculture. Moreover, biological sources can supply all our societal needs for the chemicals currently generated from petroleum. For example, a mixture of 40% soybean oil (10.8 kWh/kg, 10 kWh/l) and 60% ethanol (8.3 kWh/kg, 8.9 kWh/l), from sugar fermentation, can be used interchangeably with diesel oil in trucks and tractors. The cost of this mixture is presently \$1.60 per gallon vs. \$1 per gallon for diesel fuel. As another example, we can mention the use of starch either in a mixture with polyethylene or even in pure form to produce varying grades of biodegradable plastics. Again the cost of such biodegradable plastics may be two to three times the cost of the petroleum-derived products at the present time.

Policy implications

A natural question to ask at this point is why energy storage, important as it appears to be, has not yet been implemented in a large scale. The reason is obviously not the lack of technology. For even though technical questions in several areas need to be answered, there exists plenty of practical technology waiting for implementation. It can be argued then that the major roadblock is unfavorable economics. However, one can easily find situations, such as utility load leveling, where storage is more economical than present policies. But even if energy storage technologies are presently more expensive or less convenient than the business-as-usual alternatives, there is evidence indicating that the public may support the necessary changes in the interest of protecting the environment. Thus, for example, people will be willing to fill their car tanks twice as frequently if the reward is a cleaner environment. This implies, however, that clear messages have to be sent to the public from the government and other policy-making entities saying that such changes are needed.

NEWS

Forum Elections

We'll have to wait until the July issue to print the results of the recent Forum election. We usually run the results in April, but this year our new election procedure, directly mailing the ballots rather than printing them in the January *Physics and Society*, was embarrassingly successful. It produced many more responses than usual, perhaps ten times as many. It's a major effort to open the ballots and count them, and the count won't be finished until after this issue goes to press. Sorry

1990 Szilard and Forum Awards

Both awards will be presented at the 1990 APS spring meeting, 16-19 April in Washington, DC.

1990 Leo Szilard Award for physics in the public interest: To Theodore A. Postol of the Massachusetts Institute of Technology:

"For his incisive technical analysis of national security issues that has been vital for informing the public policy debate, especially with regard to basing modes for ballistic missiles, survivability of submarines, effects of nuclear war, effectiveness of tactical ballistic missiles, and implications of accidental launch protection systems."

1990 Forum Award for promoting public understanding of the relation of physics to society. To Richard Wilson of Harvard University: "For his outstanding research and promotion of public understanding on a broad spectrum of issues dealing with physics, the environment, and public health, including his work in reactor safety, estimation of hazards posed by environmental pollution, and pioneering use of comparative risk analysis."

Newly Elected Forum-Sponsored Fellows of the APS

Caroline Littlejohn Herzenberg: "For leadership and advocacy

with respect to women's participation in physics, and for contributions toward assessment of issues relating to space weaponry, and for research accomplishments in Mossbauer spectrometry."

Allan R. Hoffman: "For his many and creative contributions to analyzing and facilitating legislation and National Research Council studies on energy, science advice, and science and public policy."

Henry C. Kelly: "For his outstanding contributions to arms control, solar energy, and energy and economic policy."

Richard A. Meserve: "For his contributions at the interface of physics and society, especially for his report on safety problems of nuclear reactors at government laboratories."

Rustum Roy: "As director of the Penn State Science Technology and Society Program, and in many other ways, he has considerably improved our understanding of the interaction between science, technology, and society."

Carl Edward Sagan: "For his sustained and exceptional contributions to the public understanding of science and societal impacts of technology."

Forum Sessions at the Anaheim Meeting

One Forum session was presented at the Anaheim meeting, held 12-16 March 1990:

International Safeguards on Pu/HEU. David Hafemeister, California Polytechnical State University, presiding.

- "Restricting production of fissionable materials: an historical overview," John M. Taylor, Sandia National Laboratory.
- "Realities on verifying the absence of HEU in gas centrifuge plants," David W. Swindle, Oak Ridge National Laboratories.
- "International safeguards for reprocessing can be effective," James E. Lovett, Lovett Associates.
- "Limiting and reducing inventories of fissionable material," Charles Hebel, Xerox Corporation.

Forum Sessions at the Washington DC Meeting

The spring meeting, being held in Washington DC during 16-19 April this year, is traditionally the big meeting of the year for the Forum. In Washington, we'll have the Forum Awards and lectures, three invited paper sessions, a group of physics-and-society contributed papers, and our annual business session. We hope that you will attend these sessions, and that you will try to attend this meeting this year and every year.

Forum Awards Lectures. The 1990 Leo Szilard Award for physics in the public interest will be awarded to Theodore A. Postol of Massachusetts Institute of Technology, and the 1990 Forum Award for promoting public understanding of the relation of physics to society will be awarded to Richard Wilson of Harvard University. Recipients will give a talk following each award ceremony. Their citations are given above.

Health Effects of Non-Ionizing Radiation. Lynn Jelinski, presiding.

- "Interaction of extremely low-frequency electromagnetic fields with humans," Thomas S. Tenforde, Battelle Pacific Northwest.
- "Substrates of electromagnetic field interactions with biomolecular systems," W. Ross Adey, Veterans Administration Medical Center, Loma Linda.
- "60 Hz fields: problems in risk assessment and policy response," M. Granger Morgan, Carnegie Mellon University.
- "Non-ionizing radiation activities and issues," Joe A. Elder, U.S. Environmental Protection Agency.

Science and Mathematics Pre-College Education: What Can We Do? James Rutherford, AAAS, presiding.

- "Project 2061: possible impacts on science education," Margaret

Macvicar, MIT.

- "Models for scientist involvement in pre-college education," William Aldrich, National Science Teachers Association.
- "Science education: a high-school educator's view," Clara Tolbert, Vice Principal, Central High School, Philadelphia.
- "AIP activities in science education," Brian Schwarz, AIP.

Missile Technologies and Nuclear Arms Control. Frank von Hippel, presiding.

- "Arms control and breakout from nuclear arms treaties," Michael I. Sobel, Brooklyn College.
- "A flight-test ban and new reentry vehicle technologies," Lisbeth Gronlund, Program for Defense and Arms Control Studies, MIT.
- "Depressed trajectories, short time-of-flight, low-burnout and fast-burn boosters," Bob Dietz, retired engineer, Lockheed Missile Division.
- "Deterrence through a comprehensive ballistic missile flight-test ban," Robert Sherman, defense specialist for Congressmen Les AuCoin and Tom Downey.

Promote Science and Society Awareness! Inform Others About the Forum

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Urge others to join the Forum. *Physics and Society* is sent free to all Forum members, and Forum membership is free to APS members. To join, APS members need only request Forum membership on the annual APS membership renewal notice, by listing "Forum" on the front side of the notice as described under "renewal instructions." Alternatively, APS members can join the Forum by filling out the statement of intent, below, and mailing it either to the editor or directly to the APS.

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COMMENT

Strategic Instability is a Bad Buy

Strategic nuclear weapons issues seem almost *passe* in these days of elections in Eastern Europe, arms control breakthroughs, withering hawk and doves, and *New York Times* announcements of the end of the cold war. But unfortunately, nuclear arsenals still threaten the globe, new first-strike nuclear weapons still threaten superpower stability, and a new \$295 billion Defense budget still threatens our wallets. So continued analysis is not yet out of line, in fact may be especially in line now when things are changing so rapidly that anything seems possible.

This essay's thesis is that the United States can actually buy more military security by spending less money on several strategic weapons programs, and that this is true even when "security" is defined in the narrow, purely military, cold war sense. Looking only at the strategic part (12%) of the defense budget, we could save some \$13 billion per year by canceling or reducing several programs that are not only unnecessary but are in fact harmful to national security.

Nuclear weapons, especially strategic ones, are fundamentally different from other weapons. Although most people, and even most defense analysts, give lip service to this notion, defense budgets seldom embody it. Military security, understood in the conventional sense of preventing or defeating armed attack on the nation or on its interests, is generally increased by possession of greater numbers of weapons. So arguments over non-nuclear military spending are generally over priorities: is it better to buy this weapon system, or to put the money someplace else? Nuclear weapons are different. Their purpose is to deter war, not to fight one. In a sense, they are not military weapons at all, for their actual use would defeat their purpose. So more may not be better. Sometimes more is worse.

To think about deterrence, we must ask how nuclear war could occur. Even under the most malign assumptions about Soviet (or U.S.) motives, nobody expects nuclear attack to occur on purpose, i.e. "out of the blue," like Pearl Harbor: neither side would risk it. Scenarios involving accidents and mad generals are a little more plausible. But most plausible by far is the pre-emptive nuclear strike in the midst of a crisis, out of fear of loss of control and of attack (stimulated by the same fears) by the other side. Any rational deterrence policy must be directed at preventing this scenario.

A pre-emptive strike would aim mainly at the other side's strategic nuclear weapons. So superpower "A" would be more likely to pre-empt in a crisis if either "B's" nuclear weapons are vulnerable to attack by A (because then A might reduce its own damage or even "win the war" by attacking B), or if A's weapons are vulnerable to B (because then an attack by B seems plausible to A—the "use them or lose them" syndrome).

It follows that, from a purely military point of view, strategic nuclear weapons should be invulnerable and should not threaten the weapons of the other superpower. Weapons that don't satisfy these criteria might be worse than useless, for they might encourage the crisis pre-emption that nuclear weapons should be primarily designed to discourage.

And it would be ridiculous, wouldn't it, to spend money on weapons that are worse than useless?

There are at least four big-bucks programs that our country would be militarily better off without even if they were free, because the weapons are either vulnerable, or they make Soviet weapons vulnerable:

- *Rail-based MX*. Its vulnerability, combined with its threatening lethality against Soviet silos, make this the world's most destabilizing

weapon. Moving our 50 MXs (500 warheads) from their present silos to their planned rail garrisons will make them more, not less, vulnerable in the only scenario that matters: an escalating crisis in which the U.S. does not have or does not take the 4 hour lead time needed to disperse the MXs. With a 4 hour lead time, we can mobilize plenty of additional deterrent power without the MX. Cancellation would save over \$2 billion per year for several years. The best thing to do with our present MXs is trade them away, e.g. for Soviet SS-24s or SS-18s (but not for the ground-mobile SS-25s, which are stabilizing).

- *SDI testing and deployment plans*. Space-based defense cannot prevent total destruction in a determined Soviet attack. SDI would do us more harm than good by increasing Soviet perceptions of a U.S. first-strike threat, because even a partially effective SDI might be of real benefit in defeating a weakened Soviet retaliatory strike. Thus SDI, to the extent that it works, will be destabilizing. Cutting it back to pure research, as it was before then-President Reagan's "Star Wars" speech, would save some \$3 billion per year.

- *Trident II submarine-launched ballistic missile*. Although the nearly-invulnerable SLBMs are usually regarded as stabilizing, Trident II is different. Because it can destroy Soviet silos, it is destabilizing. We have plenty of stable SLBMs now, and have no need for the Trident II. Cancellation would save \$2 billion per year.

- *B-2 bomber*. We have plenty of bombers. The B-2 adds no deterrent value to our existing B-52 and B-1 bomber forces. The purely deterrent mission is performed better (because more surely) with cruise missiles launched from outside the Soviet Union than with B-2s overflying the Soviet Union. There is only one task the B-2 can perform that existing bombers cannot: finding and destroying Soviet mobile missiles (although inefficiently). This task is destabilizing and thus harmful to U.S. security. Cancellation of this expensive program would save us over \$6 billion per year.

Cold war fears have kept these programs alive for years, even decades (nearly 20 years for MX). This is an auspicious year to finally defeat them, because of U.S. budget pressures and because the Gorbachev era makes a less paranoid perspective possible.

You might have noticed that the ground-mobile Midgetman missile is one large strategic program that is not on my list. Midgetman falls into a different category, because its deployment would have a stabilizing effect on our currently unstable ICBM force. This is true even though the Midgetman has the unfortunate ability to destroy Soviet missile silos with high probability. Current U.S. ICBMs have this first-strike (the approved euphemism is "counterforce") ability, but they are also vulnerable. Midgetman, deployed in the "random mobile" configuration over large tracts of land in the southwest, would be essentially invulnerable. The only question about Midgetman is whether its advantages are worth the money. If we decide not to buy Midgetman or some other invulnerable ICBM scheme (there is at least one other, known as "multiple silos" or "carry hard"), then we should dismantle our ICBMs and go to a "diad" of bombers and submarines.

Beyond the increased military security, we obviously increase overall national security by saving money on these harmful big-budget programs. For a rough estimate of this effect, let's imagine dividing the saved \$13 billion per year among the 50 states. Then each state gets \$260 million per year. For comparison, the Governor of my own state of Arkansas recently proposed an excellent and comprehensive new education package, but the legislature defeated it on cost grounds. The cost of this supposedly exorbitant program was \$200 million per year.

Art Hobson