Palmer of Imperial College, London, report that about 43 million years ago, when the world was perhaps 5°C warmer than today, carbon dioxide levels were not dramatically higher than they are now. An independent study by paleoceanographer Mark Pagani of the University of California, Santa Cruz, and his colleagues in this month's *Paleoceanography* comes to a similar conclusion for a warm spell about 15 million years ago. Even when climate did shift, Pagani's team says, carbon dioxide levels stayed fairly constant.

The new studies suggest that "we may have to think harder about what's driving the [climate] system on these long time scales," says paleoclimatologist Thomas Crowley of Texas A&M University in College Station. "It could be the whole carbon dioxide paradigm is crumbling," at least when it comes to explaining very long-term climate change. Carbon dioxide is still a powerful driver of climate, Crowley and others say—powerful enough, researchers think, to warm the world in the coming century—but over millions of years, other factors such as changing ocean circulation may have warmed or chilled the planet.

Lacking any way to sample air directly from tens of millions of years ago, researchers often seek clues to past carbon dioxide levels in ancient marine sediments. One technique uses the carbon isotope composition of the organic matter from tiny algae called phytoplankton, which like all plants tend to incorporate the lighter isotope of carbon, carbon-12, over carbon-13. The phytoplankton can afford to incorporate more light carbon when there is plenty of carbon dioxide in the water—and therefore in the air. Such analyses have tended to support the carbon dioxide–climate link, putting carbon dioxide levels 65 million years ago and for many millions of years thereafter as high as five to six times today's values.

However, other factors can also bias the carbon isotope ratio, including the species of plankton, their shape and growth rate, and contamination by organic matter from land. So Pagani and his colleagues Michael Arthur and Katherine Freeman at Pennsylvania State University, University Park, refined the technique. They focused on a single type of organic molecule—long-chain ketones called alkenones—that are made exclusively by a type of phytoplankton called coccolithophorids. These plankton lived in nutrient-poor waters and presumably grew at low and constant rates.

With this method, Pagani found that 17 million years ago, when much of the ocean was up to 6°C warmer than today, carbon dioxide was actually lower than 270 parts per million (ppm), its value just before the industrial buildup began. And when the ocean abruptly chilled and ice began piling up on Antarctica 14.5 million years ago, carbon dioxide rose slightly rather than falling. Between 25 million and 10 million years ago—when climate was generally warmer than today—atmospheric carbon dioxide varied between 260 and 190 ppm.

Pearson and Palmer found a similar decoupling of carbon dioxide and temperature when they monitored ancient carbon dioxide levels using a different set of isotopes: isotopes of boron in the skeletons of plankton called foraminifera. To build their skeletons, forams take up carbonate ions from seawater, but they sometimes incorporate boron instead by mistake. The isotope composition of that interloper boron depends on the relative proportions of borate and boric acid in seawater, which depends in turn on pH. And the ocean's pH depends, among other things, on the amount of carbon dioxide dissolved in the seawater as carbonic acid.

When Pearson and Palmer applied the boron technique to 43-million-year-old marine sediments from the tropical Pacific—a time of such warmth that the waters around Antarctica were perhaps 16°C warmer than now—they found that carbon dioxide levels were somewhere between 180 ppm and 550 ppm, with the most likely value being 385 ppm—well below the earlier reports of six times the present level. Either the climate system is extraordinarily sensitive to small changes in carbon dioxide, Pearson and Palmer conclude, or something other than carbon dioxide drove the 50-million-year cooling.

Taken together, the two studies suggest that "we need to reconsider the prevailing dogma," says paleoceanographer Edward Boyle of the Massachusetts Institute of Technology. No one is challenging carbon dioxide's status as a potent agent of climate change; there's little doubt, for example, that carbon dioxide rose and fell in step with climate over the 100,000-year cycle of recent ice ages. But researchers will be looking at other factors to help explain the long-term chill of the past 50 million years.

The leading alternative is a reorganization of the ocean currents that carry heat to high latitudes. When the ocean was cooling 15 million years ago, shifting continents were probably opening the way for the circumpolar Antarctic current to develop, isolating the Antarctic from tropical heat and tending to push the world into a colder climate, notes Pagani. Other climate-altering circulation shifts might have come when the eastern end of the now-vanished Tethys Sea between Asia and Africa closed around 15 million years ago and when the rise of the Isthmus of Panama separated the Pacific and Atlantic oceans 2 million to 4 million years ago—all times of cooling.

Of course, it's also possible that the methods behind these two studies are in error, as

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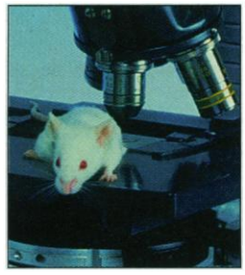
ScienceScope

Anti–Mouse Antibodies Groups that want biomedical researchers to stop harvesting antibodies from mice are organizing a scientific panel to press their case.

Every year, scientists kill about a million mice to get monoclonal antibodies, used for everything from analyzing tissue samples to attacking cancer. In April, a National Academy of Sciences (NAS) committee concluded that test tube alternatives were available for producing most antibodies (*Science*, 9 April, p. 230). But the panel, citing cost and other concerns, said it was too soon for the National Institutes of Health (NIH) to follow four European nations in restricting the mouse, or "ascites," method.



Proponents of such restrictions, notably the Alternatives Research and Development Foundation of Eden Prairie, Minnesota, hope to combat what ARDF head John McCardle calls a "heavily biased" NAS report by assembling their own expert panel. The panel—to meet in August in Bologna, Italy—will also draft a guide for labs interested in alternatives.

Meanwhile, the groups have petitioned NIH to cut back on ascites production. They say a suit is possible if they are unhappy with NIH's response, expected later this year.

Off the Table Georgetown University has officially abandoned a cost-saving plan that would have cut medical faculty salaries after 19 professors went to court to kill it.

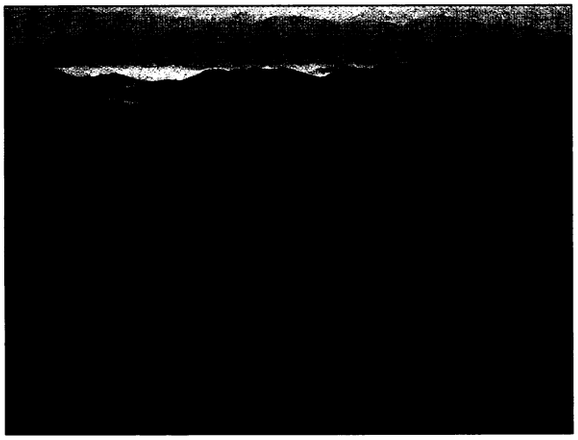
As part of a pretrial settlement, the university on 27 May agreed to send a letter to all medical faculty pronouncing the policy "null and void." The plan, which would have required researchers to raise 70% of their salaries through grants, was shot down by a campus grievance committee last fall (*Science*, 11 December 1998, p. 1967). The administration nonetheless implemented it, then rescinded it in February after faculty members filed suit claiming the university was violating its own procedures as well as academic freedom.

The settlement allows the faculty "to bypass the grievance process and go straight to court" if there is any sort of "reincarnation" of the plan, says pharmacology professor Robert Glazer. The university notes that it is still "free to adopt a[nother] compensation policy in the future."

ECOLOGY

Great Smokies Species Census Under Way

For most hikers or picnickers, flies are a minor nuisance dealt with by a firm swat. For Brian Wiegmann, however, they bring the kind of delight only a dipterist can feel. When a slender black fly with orange spots alighted on Wiegmann's knee last month in Great Smoky Mountains National Park, a fellow fly hunter knew right away they were looking at a flower-pollinating species never seen before. By the end of the Memorial Day weekend, Wiegmann and several colleagues had collected at least five new species. "It was pretty exciting," says Wiegmann, an entomologist at North Carolina State University in Raleigh.



They're out there somewhere. Scientists plan to catalog every species in Great Smoky Mountains National Park.

This was no casual fly safari: Wiegmann and gang were taking part in the kickoff of the All Taxa Biodiversity Inventory (ATBI). Led by the National Park Service and a nonprofit called Discover Life in America, the ambitious project, now in a 2-year pilot phase to hash out methods, is inviting scientists to tally every species that calls the park home. It's a tremendous undertaking, considering that scientists so far have identified only 9800 of an estimated 100,000 species (excluding bacteria and viruses) in the 225,000-hectare park, which straddles the border of Tennessee and North Carolina.

Besides being a taxonomist's dream, the project aims to shed light on why some regions have a richer array of life-forms than others and how quickly species are going extinct. "It would be nice to have a chunk [of land] where we know everything that occurs," says taxonomy group leader Don Wilson, a mammalogist at the Smithsonian Institution. However, accruing such knowledge carries a hefty price tag: Adding 90,000-odd branches to the tree of life could take up to 15 years and $100 million, according to ATBI organizer John Pickering, an entomologist at the University of Georgia, Athens. (Not everyone thinks the cost will be that high.) "There's lots of excitement in the scientific community, but not lots of money," says Mike Sharkey, an insect systematist at the University of Kentucky, Lexington, and ATBI participant. Sharkey and others admit they don't know if they can raise that kind of money for a species census.

The original plan, conceived 6 years ago by University of Pennsylvania ecologist Daniel Janzen, was to carry out an ATBI in a swath of rainforest in Guanacaste, Costa Rica. The idea resonated with academics, thanks in part to enthusiasm sparked by INbio—a novel institute, run by the Costa Rican government with support from the pharmaceutical giant Merck, that prospects in the rainforest for candidate drugs. But this incarnation of the ATBI, expected to cost $90 million, fell apart after Costa Rican officials opted for a limited survey (*Science*, 9 May 1997, p. 893).

Bowed but not beaten, ATBI adherents revived the idea a couple of years ago, settling on the Great Smokies park as the venue because it's one of the most species-rich temperate areas in the world, and it's much easier and cheaper for U.S. scientists to reach than Central America. Also, in contrast to the cool reception researchers encounter in most parks—where getting a permit to collect even a single species can be an uphill battle—Smokies officials welcomed the opportunity to have waves of scientists bearing down on them. "We have a management team that thinks science is important," says park biologist Keith Langdon, an ATBI organizer. The park, he says, has pledged to open up to ATBI researchers a $3 million lab it hopes to build in 2001.

Project scientists are still working out the mechanics of their whole-earth survey. For instance, Langdon's staff has laid out 20 1-hectare plots to help scientists sample the park's various habitats. The project has a Web site logging bugs, salamanders, and other verified park denizens; it will eventually include data on each species' range, behavior, and population dynamics (www.discoverlife.org).

Impressive, maybe, but will the taxonomy community at large get fired up over a species quest in Tennessee? "The Smokies is not as sexy a place" as Costa Rica, admits Wilson, who isn't counting on seeing any new charismatic species, like mammals or birds. "From the standpoint of the scientific community, there's maybe less hoorah." Nev-

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ScienceScope

One More? Radiologists and bioengineers have joined forces to lobby for a new "home" at the National Institutes of Health (NIH). The goal: an Institute of Biomedical Imaging and Engineering.

Math- and physics-based research cannot truly prosper in biomedicine until NIH dedicates an institute to them, says Ed Nagy, executive director of the Academy of Radiology Research. Representing a score of societies, the group has teamed up with the American Institute for Medical and Biological Engineering to push companion bills introduced last month by Representative Richard Burr (R–NC) and Senate Majority Leader Trent Lott (R–MS).

NIH officials strongly oppose the idea, saying it would be disruptive to "pull out" imaging experts and engineers from various NIH labs and stash them in a single institute. Although NIH director Harold Varmus and others have been supportive of the fields, Nagy says, a permanent home would ensure that "we don't have to depend on" the good will of individuals. The bills face an uphill road.

Stern Words One week after chiding particle physicists for being wedded to outdated technology (*Science*, 4 June, p. 1597), NASA Administrator Daniel Goldin has accused astronomers of lacking vision. But some think it's a cheap shot.

Speaking at an American Astronomical Society meeting in Chicago on 3 June, Goldin mocked astronomers who are enamored with the status quo, including the Hubble Space Telescope. He said facetiously that the agency could install the telescope in the National Air and Space Museum in Washington, D.C., and allocate "hug time" for astronomers unwilling to embrace newer technologies. He also complained that astronomers were ignoring such ideas as robotic explorers that can learn using neural networks and "genetic algorithms."

But some members of the audience think Goldin is confusing timidity with a healthy skepticism. Neural and genetic programs are not mature enough to be used on space missions, said one astronomer. And when Goldin shot back that "ignorance is not a place to be," another scientist stood up "in defense of 'ignorance' "—meaning current knowledge and expertise. No word yet on Goldin's next target.

Contributors: David Malakoff, Constance Holden, Eliot Marshall, James Glanz