tial, higher temperatures might allow them to complete two life cycles in one crop growing season, "meaning some crops will get hammered twice."

Sex ratios among reptiles may become distorted. At high temperatures, lizards and alligators produce mostly males, while turtles produce mostly females. "We could end up with a total absence of one sex, or incredible skews in the sex ratio," noted Rubenstein.

The indirect effects of climate change are harder to get a handle on but may be just as powerful. Changes in temperature and wind could disrupt communication among social insects that depend on pheromones.

Changes in habitat, whatever form they take, will alter the social structure of animals, said Rubenstein. And changes in social structure, in turn, can have pronounced consequences for behavior and genetics.

For example, during the rainy season when vegetation is ample, female elephants tend to aggregate on the plains in large herds, allowing one bull to dominate and sire many offspring. Younger, lower ranking bulls usually copulate in the dry weather, when the females break into smaller groups and return to the swamps. If the greenhouse brings drier weather and the elephant population is fragmented, then the dominant bull may lose his monopoly on copulation, bringing greater variety, and perhaps inferior traits, to the gene pool.

One thing seems all too clear: changing climate will spell boom days for parasites and pathogens, predicted Andrew Dobson of the University of Rochester. "Parasites are good at solving problems, and because they reproduce so quickly, they always win."

*Haemonchus contortus*, a nematode that causes an economically important disease in sheep, should do quite well under greenhouse conditions, said Dobson. Although the worm's survival time decreases at higher temperatures, its development time rapidly increases; thus, it remains infective over a wide temperature span. As a result, the pathogen may be able to increase its range at a time when resistance to drugs is spreading.

For the tsetse fly, which carries the trypanosomiasis that causes sleeping sickness, things may take an unexpected turn. If the temperature rises 2°C, as one of the climate models predicts, the tsetse fly might disappear from the middle belt of Africa, where it is now endemic, and move further south. From a conservation perspective, that could be devastating in that the presence of sleeping sickness keeps out humans and their domesticated animals. As the tsetse fly moves south, much of the land that is now a de facto wildlife reserve would be open for human exploitation.

The bottom line, said Dobson, is that some parasites and pathogens will do really well. Although some rare species may go extinct, "some now-obscure parasites will probably make a name for themselves." What it may mean, he warned, is that many of the infectious diseases that now occur only in the tropics, will, with increased warming, spread to the temperate zone.

What does all this mean for conservation? The overriding task, it was generally agreed, is to slow the rate of climate change. But even if all the greenhouse gases were somehow turned off tomorrow, a 1° to 2°C warming is already in the pipeline. And, Peters noted, temperature swings of 1°C or less have brought documented shifts in ranges.

Mitigation strategies might include setting up corridors between protected areas that will allow species to migrate, especially north-south corridors, and designing new reserves with climate change in mind, which might mean ensuring that they contain adequate water and a varied topography, as it is easier for a species to go up a mountain than to trek hundreds of kilometers north. More monitoring and more intensive management of wildlands seem certain.

"Those of us who are into 'the natural' are not going to like what we will have to do, which is damage control to minimize the amount of loss," added Jerry Franklin of the University of Washington. "We will have to become ecological engineers, managing natural areas."

It was Russell Graham, however, who called into question the premise on which much of conservation has been based. The fact that plants and animals respond individually to climate change, as the fossil record shows, rather than collectively as communities, raises fundamental questions about just what conservationists should try to protect: community patterns or biodiversity in general. Most conservation efforts to date have focused on the former, an approach Graham considers misguided.

"Communities are not static entities. They have been changing in the past and we can assume they will change in the future," said Graham. "The question is, can we accommodate change and allow new communities to form naturally, by providing migration corridors, or do we take a more controversial course and manufacture new communities ourselves?"

Graham is the first to admit that manufacturing new communities could cause all kinds of havoc. "I would prefer corridors to let things happen naturally, but if we can't do that, the alternative might be to transplant species. We hedge our bets if we distribute species over a broad area. Those species that are geographically confined are more likely to go extinct."

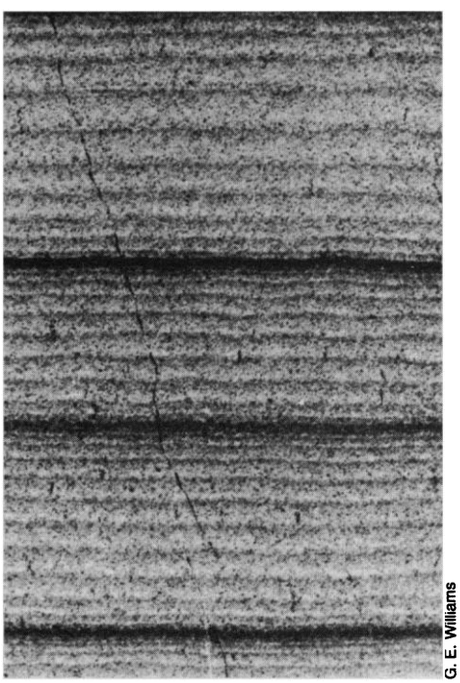
■ LESLIE ROBERTS

# A Sun-Weather Connection Broken

It seemed too good to be true, and it was. Until last year, the most promising evidence of a link between varying solar activity and Earth's weather seemed to be recorded in 680-million-year-old sediments from Australia. The discoverer of this ancient sun-weather link, George Williams of the Broken Hill Proprietary Company Limited in Victoria and his subsequent collaborators, assumed that the thin laminations in the rock were annual sediment deposits whose rhythmically varying thicknesses reflect the ancient solar cycle.

Williams has changed his mind, in light of the discovery of additional laminated sediments at other Australian sites. He says the more reasonable interpretation now is that the rock recorded lunar tides rather than solar cycles.

The solar cycle interpretation seemed likely, if not inevitable, in 1980 when Williams first wrote up his results. Cycles containing about 11, 22, and 90 laminations were evident in the layered Precambrian rock, just as cycles containing the same number of



G. E. Williams

**Now tidal signals.**

years are obvious in the activity of the sun. And lamination thickness and sunspot number seemed to behave similarly over time as well. Each lamination could have formed as a surge of sediment-laden melt water from nearby glaciers fanned out over the bottom of a deep lake. The thicker the lamination, the more melt water and the warmer the summer. The only fly in the ointment was the extreme sensitivity of climate to solar influence that would have been required to produce such regular climate variations. Earth's climate certainly does not work that way today.

Williams' thinking began to shift recently when he found new, far thicker sedimentary cycles near Adelaide. These contain 14 or 15 laminations per cycle, just the number of daily tidal ebbs and flows in the fortnightly lunar tidal cycle. The overall pattern of these cycles also closely resembled the tidally controlled growth patterns of modern clams. Then Williams learned of recent work that showed how fine sediment can be carried into offshore deep water by jetting currents of the ebb tide. That clinched his turnaround.

Working from the tidal interpretation of the laminations, Williams finds that 650 million years ago the moon revolved around Earth faster—13.1 ± 0.5 rather than 12 times in a year, the day was shorter—Earth's year had 400 ± 20 days rather than 365 days, and the moon was closer—the Earth-moon distance was 96.9 ± 1.7% of its present value. That is consistent with at least one theory of why the moon's present rapid drift away from Earth due to tidal drag does not imply similarly high rates in the distant past and an uncomfortably close encounter between the two bodies only a few billion years ago (*Science*, 16 September 1983, p. 1166).

Alerted by Williams that the laminations were most likely tidally induced, Charles Sonett and his colleagues at the University of Arizona have made similar calculations. Sonett had collaborated with Williams on the implications of the laminated sediments for the history of the sun.

The field of sun-weather relations may have lost a seemingly strong piece of support, but the study of the history of the Earth-moon system appears to have gained a new kind of record. Would that every abandoned sun-weather relation was so productive. ■ RICHARD A. KERR


ADDITIONAL READING

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# Psychiatrists Psych Out the Future

*With new techniques racing ahead and treatment capabilities lagging behind, psychiatrists face a 21st century full of challenges*

"WHEN I BEGAN AS A MEDICAL STUDENT, psychiatry was brainless," says Leon Eisenberg of Harvard Medical School. "The brain was not the object of study; it was seen as being in the head for ballast. That view has changed. But now psychiatry is getting mindless."

Eisenberg's comments echo a recurrent theme of a recent meeting on the "Next Steps That Will Revolutionize Psychiatry in the 21st Century"*—namely, that a major challenge will be to integrate the concepts of mind and brain. Participants agreed that psychiatrists need to combine the ever-increasing mass of information about the biological aspects of brain function and mental illness with the social, cultural, and psychological factors that also influence human behavior.

**Leon Eisenberg.** *"Our society is so unwilling to commit resources . . . that few integrated treatment programs exist."*

Another point of consensus was that 21st-century psychiatrists will have very sophisticated information and technology at their disposal. They will peer routinely into the living human brain using imaging techniques, and may be able to identify structural or functional defects in specific brain regions. In addition, they may be able to prescribe drugs that are designed to correct particular biochemical defects—to alter the actions of the neurotransmitter serotonin, for example—and thereby treat certain mental illnesses such as depression more rapidly and without adverse side effects.

Psychiatrists in the next century may also be able to tell if someone carries a genetic predisposition for certain mental illnesses such as manic depression or schizophrenia (see p. 1009). With this knowledge they could counsel the person and the family on ways to avoid stresses that might precipitate the illness and might also be able to estimate the person's chances of having a child that carries the same inherited tendency.

As is the case today, some of the dominant forces likely to shape psychiatry in the 21st century will come from outside the field. The so-called biological revolution of the 1960s and 1970s that reshaped the diagnosis and treatment of many mental disorders now includes basic research in three areas—neurobiology, genetics, and immunology. The influence of these disciplines on psychiatry is likely to grow. "The hope is to use this new knowledge to help psychiatric patients," Alfred Freedman of New York Medical College in Valhalla told *Science*.

For example, in his presentation at the meeting, Gerald Edelman of Rockefeller University in New York initiated a major theme of the meeting—namely, that psychiatrists should take an integrated or "biopsychosocial" approach to the diagnosis and treatment of mental disorders. Edelman, a basic research scientist who won a Nobel Prize in 1972 for his work on the structure of antibody molecules, has more recently turned his attention to neurobiology. He acknowledges that although researchers are learning more and more about brain development and function, this knowledge alone will not solve problems of human behavior. The links between brain function and the more elusive entity of the mind are still far from clear, he says.

Nevertheless, the way the brain works inevitably affects the way an individual behaves. Edelman emphasizes variation within

*The meeting, held 7 to 10 October in New York City, was sponsored by the Department of Psychiatry and Behavioral Sciences of the New York Medical College.