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

C. P. Sonett, S. A. Finney, C. R. Williams, "The lunar orbit in the late Precambrian and the Elatina sandstone laminae," *Nature* **335**, 806 (1988).

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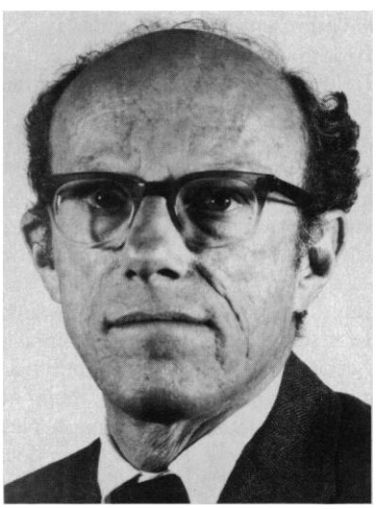
Psychiatrists Psych Out the Future

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.

an individual organism and among members of the same species. Within the same individual, he says, brain circuits change during embryonic development as a result of genetically programmed information and extragenetic factors. These include cell-cell interactions, the effects of neurotransmitters or hormones, and the interactions an organism has with the external environment throughout its entire lifespan.

During brain maturation, certain neuronal connections within circuits are strengthened and others are weakened. Edelman likens the process to a Darwinian kind of evolution. Brain variation within the species is not only preserved, he believes, it is required for survival in a complex environment. "That means that there is an obligate generator of diversity," he says, implying that normal mechanisms within the nervous system operate to produce the variability.

The 21st century will also see an increasing role in psychiatry for a second area of basic research—molecular genetics. "For many years, genetics was in disrepute in psychiatry because you couldn't do anything about it," says Seymour Kety of the National Institutes of Mental Health (NIMH). That has changed and now psychiatrists agree that many mental illnesses, including manic depression, schizophrenia, and perhaps anxiety disorders, may have a hereditary component. "But the genetic patterns in these disorders are not likely to be clear-cut," Kety cautions.

For example, unlike Huntington's chorea, a neurodegenerative disorder that includes progressive dementia and appears to be caused by a single dominant gene, an illness such as schizophrenia probably has more than one genetic component. Another complication is that when a gene locus for a particular mental illness is identified in one group of people, it may not hold true for another group. Manic depression, for instance, is linked to a gene on chromosome 11 in certain American Amish populations, but non-Amish American families and those in Iceland with the disorder do not show the same chromosome 11 locus.

Another hallmark of psychiatry in the next century will be that biological changes in the entire body, not just the brain, affect behavior. Understanding these interactions may lead researchers to develop drugs that are designed to correct specific metabolic imbalances, says Jay Weiss of Duke University Medical Center in Durham, North Carolina. He points to immunology as a third area of basic research that is having a significant impact on psychiatry.

For example, a strong, chronic stress to an animal not only affects its behavior, it can also depress immune system function. Under stressful conditions, T lymphocytes, which orchestrate many immune responses, decrease their production of interleukin-2, a growth factor for the cells. Also, spleen and blood lymphocytes lose their response to chemicals that normally induce them to proliferate. In contrast, a mild stress may increase immune system function transiently, says Weiss.

Christopher Johnson

Seymour Kety. *"The genetic patterns in these disorders [schizophrenia or manic depression] are not likely to be clear-cut."*

How do such cellular changes affect a person's mental health? The links are not yet known, but many investigators, including Marvin Stein of Mount Sinai School of Medicine in New York, believe they exist. "If the brain does modulate immunity, then psychosocial phenomena can influence immunological processes," he says. For example, a 1981 epidemiological study by K. J. Helsing of the Johns Hopkins School of Public Health in Baltimore, showed that bereavement following the death of a spouse is sometimes associated with increased mortality. A man whose wife has died may be more likely to die earlier than his age-matched counterparts whose spouses are still alive. Interestingly, among women, the loss of a spouse has absolutely no effect on life expectancy.

In a 1983 report, Stein and his colleagues connected early death after the stress of bereavement with abnormal lymphocyte function. "I think that we have evidence of bereavement being associated with alterations in lymphocyte function but we do not have evidence that these changes are associated with increased mortality," he says.

Another focus of the meeting was on technological advances for studying brain structure and function. Nuclear magnetic resonance imaging or MRI has virtually replaced the computerized tomography (CT) scan for visualizing the living human brain, notes Daniel Weinberger of NIMH. "We are trying to develop a diagnostic index that would allow us to pick out psychiatry patients who have brain abnormalities with 90 to 95% accuracy," he says.

Whereas MRI allows a researcher to detect structural abnormalities in the brain, single photon emission computed tomography, or SPECT, may become the technique of the future for identifying abnormal brain function. Unlike its predecessor, positron emission tomography (PET), SPECT is relatively inexpensive and does not require a cyclotron. With SPECT, a researcher can evaluate metabolic activity or measure patterns of neurotransmitter binding in different parts of the brain. For instance, Weinberger has preliminary data suggesting that Alzheimer's patients show abnormally low levels of binding to the muscarinic acetylcholine receptor in certain brain regions. If these results are supported by further work, SPECT scanning may become useful as a diagnostic tool in Alzheimer's.

The roots of these advances exist today and no one doubts that they will continue to develop in the next century. In the absence of stronger public support for comprehensive programs to diagnose and treat mental illness, however, this scientific progress will stand in stark contrast to pressing social and public health problems in psychiatry. "Our society is so unwilling to commit resources for the care of the chronically mentally ill that few integrated treatment programs exist," says Eisenberg.

Today, fewer than 20% of people who have a diagnosable mental illness receive psychiatric treatment, according to a recent regional survey by NIMH. Psychiatrists hope to correct this situation through improved awareness, diagnosis, and access to treatment—particularly for ever-increasing numbers of elderly and poor patients. But if only 4% of medical students continue to specialize in psychiatry, the number of psychiatrists is unlikely to keep pace with demand.

The obvious benefits of high technology for rapid diagnosis and drugs for specific illnesses notwithstanding, some foresee a struggle to keep the humanity in psychiatry. In an age of specialization, psychiatrists remind one another to maintain a broad, humanistic perspective and to integrate the basic, natural, and behavioral sciences in the clinical practice of psychiatry. And, as patient evaluation and treatment will inevitably cost more, medical care institutions will seek to decrease costs.

■ DEBORAH M. BARNES