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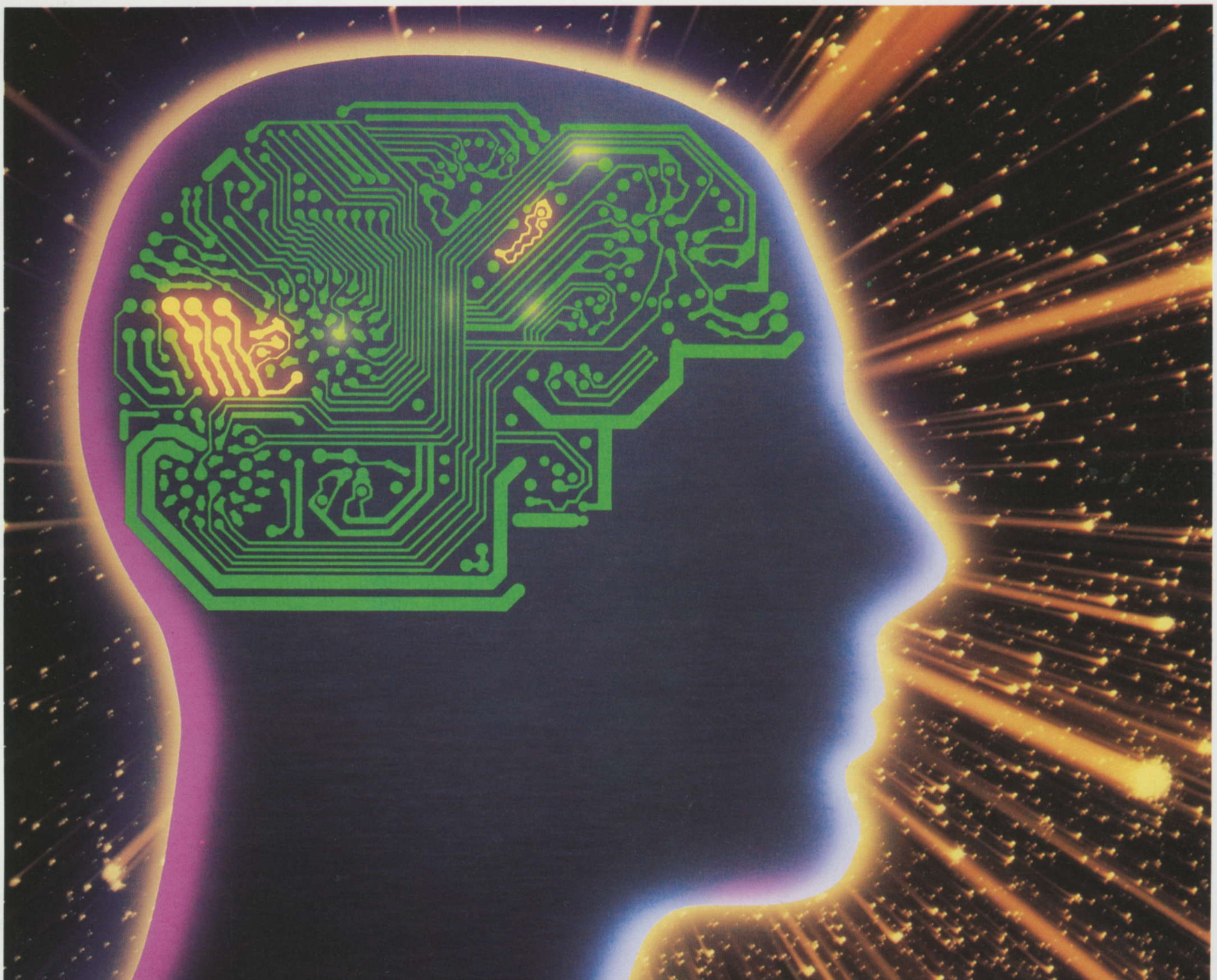


NATIONAL ACADEMY OF SCIENCES NATIONAL ACADEMY OF ENGINEERING INSTITUTE OF MEDICINE

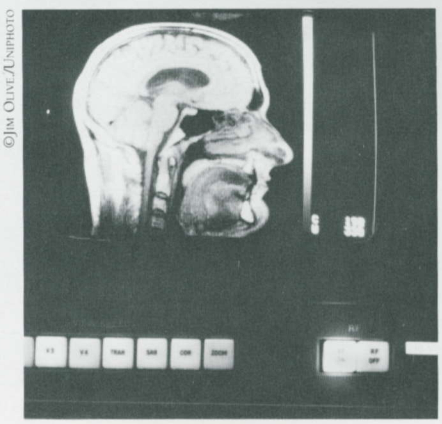
3-D Computerized Maps Would Speed Brain Research

"Because of its ability to manage and process enormous quantities of information in a reliable, mechanical way, the computer, as a scientific research tool, has already revealed a new universe. This universe was previously inaccessible, not because it was so small or so far away but because it was so complex that no human mind could disentangle it."

— Heinz Pagels, *Dreams of Reason*

The explosive growth in brain research in recent years has pushed neuroscience onto the threshold of discovering the causes of mental illnesses, the underpinnings of human emotion and thought, and the mechanisms governing behavior, among other things. But researchers trying to unlock the mysteries of the mind often find themselves entangled in a thicket of information.

To help these investigators achieve better visualization of current knowledge about the brain, an Institute of Medicine committee has recommended that computer technology be harnessed to put the various pieces of neuroscience information together into a comprehensive three-dimensional map of the brain and its functions.



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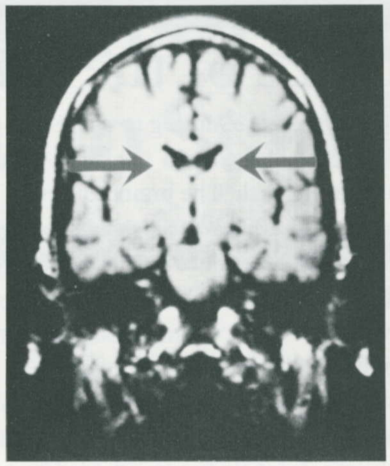
Likening brain researchers to surveyors, the committee noted that "a single surveyor who charts a field cannot hope to map a continent without a coordinated plan involving other mappers." The Brain Mapping Initiative, which the committee proposes in its recently published report, would pull together several computer databases and computer graphic systems so that brain researchers can easily see how their findings fit into "the big picture."

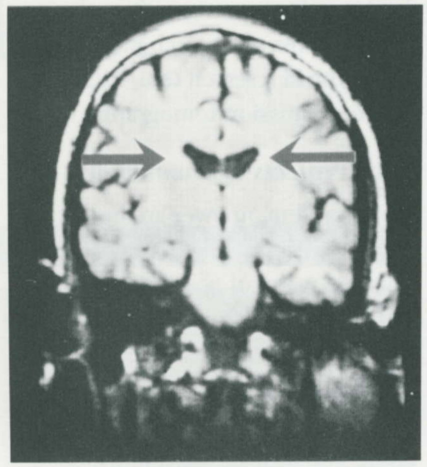
With such a computer system, the following scenario might unfold in the future: An investigator uses magnetic resonance imaging to generate pictures of the overall brain structure of a patient with a certain brain disease. When the investigator uses the computer to superimpose these brain scans onto those of normal individuals that the computer has on file, the investigator discovers that one portion of the brain is strikingly smaller in patients with this disease.

The researcher then plugs into a map that highlights the types of brain cells found in the abnormal area. Venturing into a different database, he or she uses the computer to discover which of the more than 100 possible chemical signals (neurotransmitters) these cell types use.

Mapping the Brain and Its Functions. Committee on a National Neural Circuitry Database, Division of Health Sciences Policy, Institute of Medicine; (1991, 180 pp.; ISBN 0-309-04497-9; available from National Academy Press, $24.95 plus $3.00 shipping).

National Institute of Mental Health





Magnetic resonance images of the brains of 44-year-old identical twins show enlarged cerebral ventricles of the schizophrenic twin (right).

Zooming in further, the researcher uses the computer to scan for information on the known functions of those neurotransmitters and whether abnormal concentrations of any of them are tied to the behavioral problems observed in the patient. The data the computer reveals make the investigator suspicious of a particular neurotransmitter we shall call in this fictitious case "Substance X." The investigator then uses the computer to see if the structure of Substance X matches that of any of the proteins generated by the genes particularly prevalent among patients with the disease under investigation. A close but not identical match might indicate that a defective form of Substance X fosters that disease.

With such a remarkable ability to travel quickly from the small- to the large-scale landscape of the brain, neuroscientists will be better equipped to see patterns that may clue them in to the causes of mental illnesses, addictive disorders, and other neurological abnormalities.

The computerized display of information in map form as opposed to data tables, in addition, should further aid researchers trying to navigate the brain. Studies show that the human eye more readily recognizes patterns in a picture than in a display of numbers, the committee noted. In other words, one picture says more than a thousand numbers. A three-dimensional brain map, consequently, should allow researchers to "see the unseen" and "capture the discoverable architecture of the brain," the committee wrote.

The computer system won't be able to generate a picture of all of the information in its databases. But what can't be graphically presented will be keyed into the overall map of brain anatomy so that an investigator could see what is known about a specific area of the brain by merely directing the computer to that spot on the brain map.

Communications Network

"In science, the communication of data and ideas is as important to the growth of knowledge as the data themselves," the committee observed. A key component of the computer system the committee proposes, consequently, will be an electronic network that allows neuroscientists from all over the world to communicate their research methods, ideas, or findings to each other in a matter of minutes.

This network should speed up the pace of brain research because currently it takes several months before investigators' methods and findings are delivered to each other via conventional scientific publications.

The computer system also could include directories of neuroscientists who are involved in specific areas of research, as well as smaller specialized databases for investigators exploring the same area of research or using the same type of research tool, such as positron emission tomography.

Pilot Projects Recommended

Money and manpower are needed to move the proposed computer system from the realm of possibility to the realm of reality. Current computer technology can furnish most of the hardware and software needed to bring the system to life. A pioneering group of neuroscientists and computer scientists will have to work together, however, to develop a means for standardizing the many types of data generated by researchers and for translating the data into a form that can be easily accessed by others via a computer network.

To move toward the objective of an integrated set of databases, the committee recommended the establishment of pilot projects or consortia to address these issues and develop the long-range planning for the second phase of the initiative. In this phase, mapping the anatomy, chemistry, and functions of the brains of humans, monkeys, and rats would be a primary undertaking. Monkey and rat brains will be included because much neuroscience research is done on the brains of these animals, which model the human brain. The IOM committee urged the Brain Mapping Initiative to maintain close ties with ongoing gene mapping and protein sequencing efforts, including the Human Genone Project.

Projected Funding

The committee projected that the Brain Mapping Initiative could begin with a budget of about $10 million annually — less than one percent of the entire U.S. neuroscience research budget. Funding could come from such federal sources as the National Institutes of Health, the National Science Foundation and the Alcohol, Drug Abuse, and Mental Health Administration.

But in these lean times, brain researchers have to scramble for scarce funds just to keep generating data, let alone to see those data entered into a computer system such as the one proposed. Recognizing this, the committee wrote: "[A] Brain Mapping Initiative, by enhancing the process of discovery and the communication of new insights in neuroscience, can help to maximize the benefits gained from the present investment of national resources."

Noting the enormous financial and emotional toll of brain disorders, the committee added, "It is now time to fit the millions of pieces of the puzzle into place and bring neuroscience to a point at which it can begin to alter the course of many diseases and disabilities."

— *Margie Patlak*

The author is a free-lance science writer in Philadelphia.

Maze of the Mind

Researchers attempting to chart the landscape of the brain are faced with a daunting task. The brain houses more than 100 billion nerve cells (neurons) that come in at least 100 different varieties. To communicate with each other, a typical neuron puts out about 1,000 thread-like structures that connect it to other neurons. One hundred different chemical signals can be released in this web at a rate of 1,000 a second.

"The challenge [of brain mapping] is to assemble a multimillion-piece, three-dimensional puzzle," wrote the Institute of Medicine Committee on a National Neural Circuitry Database. "In addition, the puzzle that represents the brain must depict more than simply a structure. It must integrate structure with function, function with chemistry, and chemistry with genetic mechanisms."

— *M.P.*