taking a cup of tea, an infusion of the moss *Sphagnum antivirans*. This moss, discovered just before the felling of the last stand of the world's rain forest, is a potent source of small molecules that block viral adhesion to epithelial cells. The only side effect of this natural drug is that it produces a mild euphoria. The rain forests of the world will have been saved, in order to provide sufficient quantities of tea for those of us fed up with the autumnal ritual of suffering brought about by the new school year.

Peter N. Goodfellow
Department of Genetics
University of Cambridge

THE AMERICAN PUBLIC WILL BE TOLD BY the popular press that bacterial products help the immune response to infections such as the common cold. Consequently, health clubs will set up programs to put "muscle into lymphocytes," in which yuppie individuals in leotards swallow capsules containing Gram-positive bacterial cell walls mixed with bee pollen.

Philippa Marrack
Howard Hughes Medical Institute
Denver, Colorado

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DAMAGE TO THE BRAIN OR SPINAL CORD, caused by acute insults such as stroke or trauma, or neurodegenerative diseases such as Alzheimer's disease or amyotrophic lateral sclerosis, can destroy the quality of life, or life itself. The first neuroprotective treatments, capable of slowing or limiting neuronal loss, have now entered clinical practice—methylprednisolone for spinal cord trauma, deprenyl for Parkinson's disease. Presumptive identification of the mechanisms responsible for neurodegeneration in certain diseases, including overactivation of neurotransmitter signaling systems or inappropriate triggering of genetically programmed apoptosis, has led to the development of therapeutic countermeasures, many of which should move to clinical trials over the next 5 to 10 years.

Understanding the principles governing axonal outgrowth and correct synaptic connectivity during ontogeny, together with appreciation of the specific hurdles posed by tissue responses to injury, should lead to practical methods for promoting human nervous system regeneration. Approaches to replacing lost tissue with transplanted cells derived from fetal brains, or cell lines transfected with useful genes, also have considerable momentum in the animal laboratory.

Disability resulting from the selective disruption of major central or peripheral nerve pathways will find remedy in "silicon shunts." Microdetectors placed proximal to a lesion in nerve stumps, sensory organs, or higher order cortical centers could guide electrical effector arrays placed downstream in brain or muscle targets.

Dennis W. Choi
Department of Neurology
Washington University School of Medicine

OUR UNDERSTANDING OF BRAIN FUNCTIONS will be steadily advanced, but it is difficult to predict whether we will have any big discoveries during the coming decade. Instead, we may be able to enjoy big developments in diagnostic technology and therapeutic treatments in brain disorders on the basis of our understanding of molecules (receptors and secretory vesicular molecules) essential for brain functions.

Shigetada Nakanishi
Institute for Immunology
Kyoto University

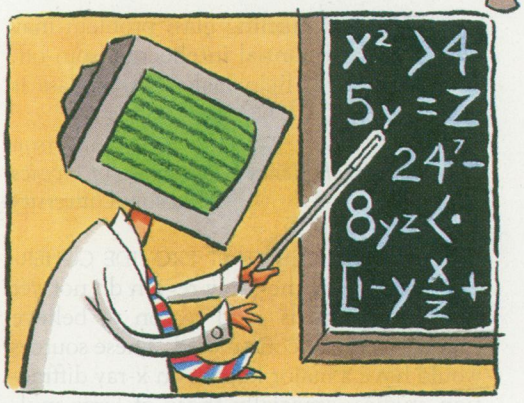
WITHIN THE NEXT SEVERAL YEARS, THE etiology and pathogenesis of many common diseases of the nervous system including degenerative diseases will be established with greater or less degrees of certainty. Knowledge about the etiology of diseases like Alzheimer's dementia, schizophrenia, and manic-depressive states will be reflected in improved management, but curative therapy for many of them will elude scientists for at least two more decades.

Helen M. Ranney
Alliance Pharmaceutical Corporation
San Diego, California

EACH STUDENT HAS SPECIFIC STRENGTHS and weaknesses, and effective education will respect such individual differences. Recent advances in human brain imaging allow researchers to characterize which parts of the brain are activated during specific types of processing. It is now possible to design tasks that selectively activate different areas of the brain, including those that play a key role in different types of cognitive strategies—for example, visual-spatial, analogical, and deductive. These tasks can then be administered and scored by a computer, allowing it to assess an individual's "information processing profile." The computer could then "tune" its presentation style to take advantage of the student's effective processing and avoid taxing his or her cognitive weaknesses.

It should soon be possible to diagnose which cognitive functions have been destroyed by stroke or other kinds of brain damage, and design rehabilitation programs that selectively encourage growth and reorganization of intact tissue.

The means by which central nervous system activity affects the body (via the endocrine, immune, and autonomic systems) are now coming to be understood. In due



course we will understand the mechanisms that underlie placebo effects (which are often very large). We will understand not only the mechanisms that promote healing, but also the psychological factors that engage these mechanisms. The technology that emerges will replace some drug therapies and will produce a healthier population while reducing health costs.

Some forms of psychotherapy have been shown to change brain metabolism. Measures of such effects could be used to determine the most effective form of therapy for a given individual. Indeed, therapies may be developed that make use of "hill climbing" techniques, with brain scanning results being used to direct the course of therapy.

Recent advances in brain imaging (for example, functional magnetic resonance and magnetoencephalography) and local brain stimulation (via focused magnetic fields) could open a whole new era of "virtual reality." Such a development would be useful not only for remote control of mechanical devices (using on-line brain imaging to provide instructions to computers), but also for communication, psychotherapy, and entertainment. However, given the subtlety and complexity of the neural code and the possibility of great individual differences in the coding of high-level cognitive processes, such rich sensory-motor direct interface is probably unattainable. Nevertheless, even modest progress would be useful for people with impaired sensory organs or motor control.

Stephen M. Kosslyn
Department of Psychology
Harvard University

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THE DEEPEST AND MOST INTERESTING UNsolved problem in solid state theory is probably the theory of the nature of glass and the glass transition. This could be the next breakthrough in the coming decade. The solution of the problem of spin glass in the late 1970s had broad implications in unexpected fields like neural networks, computer algorithms, evolution, and computational complexity. The solution of the more

important and puzzling glass problem may also have a substantial intellectual spin-off. Whether it will help make better glass is questionable.

P. W. Anderson
Joseph Henry Laboratories of Physics
Princeton University

PHOTON SOURCES THAT PROVIDE COHERENT radiation in the x-ray region do not yet exist, but there is good reason to believe that they can be constructed. These sources would have a major impact on x-ray diffraction studies, especially those of large molecules such as proteins. Effectively such sources would obviate the phase problem and should make structure determination significantly easier and faster.

John I. Brauman
Department of Chemistry
Stanford University

THE PROTEIN "SEQUENCE-STRUCTURE" problem will be solved based on homology comparisons to known structures (but the solution of the ab initio folding problem will not be). New approaches will be developed for bioremediation and environmental cleanup. Novel metabolic pathways will be identified to carry out the biosynthesis of various compounds. Biomaterials with novel mechanical and catalytic properties will be discovered, such as biomineral, spider silk, and hyperthermostable proteins. There will be a computational solution of the crystallographic phase problem for macromolecules and substantial progress in determining the structures of single molecules by various scanning probe microscopies.

Douglas C. Rees
Division of Chemistry and Chemical Engineering
California Institute of Technology

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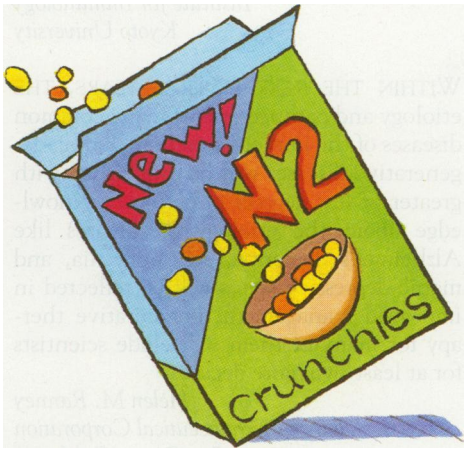
THE COMMERCIAL EXTINCTION OF MANY species of fish in previously rich fishing areas, such as the Grand Banks of the North Atlantic, has placed enormous pressure on aquaculture as a source of food. The maximum sustainable catch has been estimated at approximately 100 million metric tons, whereas demand for fish and fish products predicted for early in the next century is in the range of 135 to 165 million metric tons. Major advances in hormonal regulation of spawning and egg production should allow most commercially important species to be raised in closed systems. A major breakthrough will be the development of tissue culture procedures for maximum production of fish protein in a controlled, pathogen-free system.

Rita R. Colwell
Maryland Biotechnology Institute
University of Maryland

IF WHEAT, CORN, OR RICE COULD OBTAIN a substantial amount of nitrogen (N) through biological reduction of N_2, the economic and environmental benefits would be enormous. Because of the extreme biochemical complexity of nitrogenase, it is unlikely that an N_2-fixing cereal will result from transforming bacterial nitrogen fixation genes into the plant. However, bacteria that normally fix N_2 might be selected to produce excess N as they grow on cereal roots. This would involve identifying potential strains and optimizing both bacterium and plant genomes to generate an effective association.

Winston J. Brill
R&D Innovator
Madison, Wisconsin



CONTROLLING THE RATE OF RIPENING OF fruits and vegetables is a target of much activity. Technical and regulatory success in this arena led to the 1994 market introduction of a tomato with extended shelf life. Many related products are now being planned, from bananas to papaya. New sources of income will be possible when post-harvest stability of tropical crops is improved, thus increasing the amount and diversity available for export. With the reduction of post-harvest losses due to spoilage, the increased delivery may represent the margin needed to allow poor countries to become self-sufficient in food production.

Charles J. Arntzen
Institute of Biosciences and Technology
Texas A&M University

PLANT MOLECULAR AND CELLULAR BIOLOGY and related biotechnologies, when combined with traditional breeding, will contribute significantly to the development of agriculture in the next decades. Isolated genes, independent of their evolutionary origin, can be reconstructed, introduced into the genome of most if not all crops, and expressed in a regulated manner in various organs of transgenic plants. It already is, or will be, possible to target gene products to specific subcellular compartments, such as plastids, vacuoles, and membranes. Research based on molecular genetics should be able to identify genes that confer increased resistance to both biotic (for example, fungal, bacterial, and viral diseases; attack by insects; and competition by weeds) and abiotic (climatic) stresses. Judicious introduction of other types of genes will enable plants to synthesize useful lipids, carbohydrates, and biodegradable plastics, or even pharmaceutical products. Detailed chromosomal maps will enable plant breeders to accelerate as well as refine their programs.

Rapid reactions in plants to environmental signals can result from rapid changes in the activity of some cellular proteins or from differential RNA stability. Understanding the underlying biochemical mechanisms could lead to the breeding of crops with yields less affected by changing environmental influences. Knowledge of the mechanisms that control cytoplasmic streaming and modifications of the structure and properties of the cytoskeleton in response to various endogenous or environmental signals could also contribute to the improvement of plants. Elucidation of the biochemistry and the genes underlying the synthesis of lignin in trees, as well as the structural role played by these polymers, should help to produce trees with properties that allow a cleaner and more economical production of paper.

We will understand and be able to make use of the phenomenon of totipotency—that is, the ability of some plant tissues to regenerate whole, fertile plants from differentiated somatic cells. However, it is unlikely that the signal transduction mechanisms that control plant growth will turn out to be fundamentally different from those in yeast and animal cells. Totipotency, therefore, might be the result of the action of the same signals throughout the whole process of plant development.

Jeff Schell
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Köln, Germany

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UNDERSTANDING THE MECHANISM OF PRE–messenger RNA (mRNA) splicing will require a detailed picture of secondary and tertiary interactions among chemically reactive groups within the spliceosome. The recent crystallization of the ribosome has fueled speculation that other complex ribonucleoprotein structures could be subjected to analysis at the atomic level. The crystallization of the spliceosome and the solving of its structure would provide invaluable information concerning the catalytic mechanisms whereby nuclear pre-