StonyBrook Review

2001

Let's Look Ahead to...

The year 2001 is only 30 years away. The 21st century promises to bring many changes and surprises, problems and improvements. Some dramatic glimpses of the future are revealed here in the first of a future-oriented series of faculty-written articles to appear in consecutive issues of the Review.

Computer graphics by Joshua K. Kopp, Brookhaven National Laboratory

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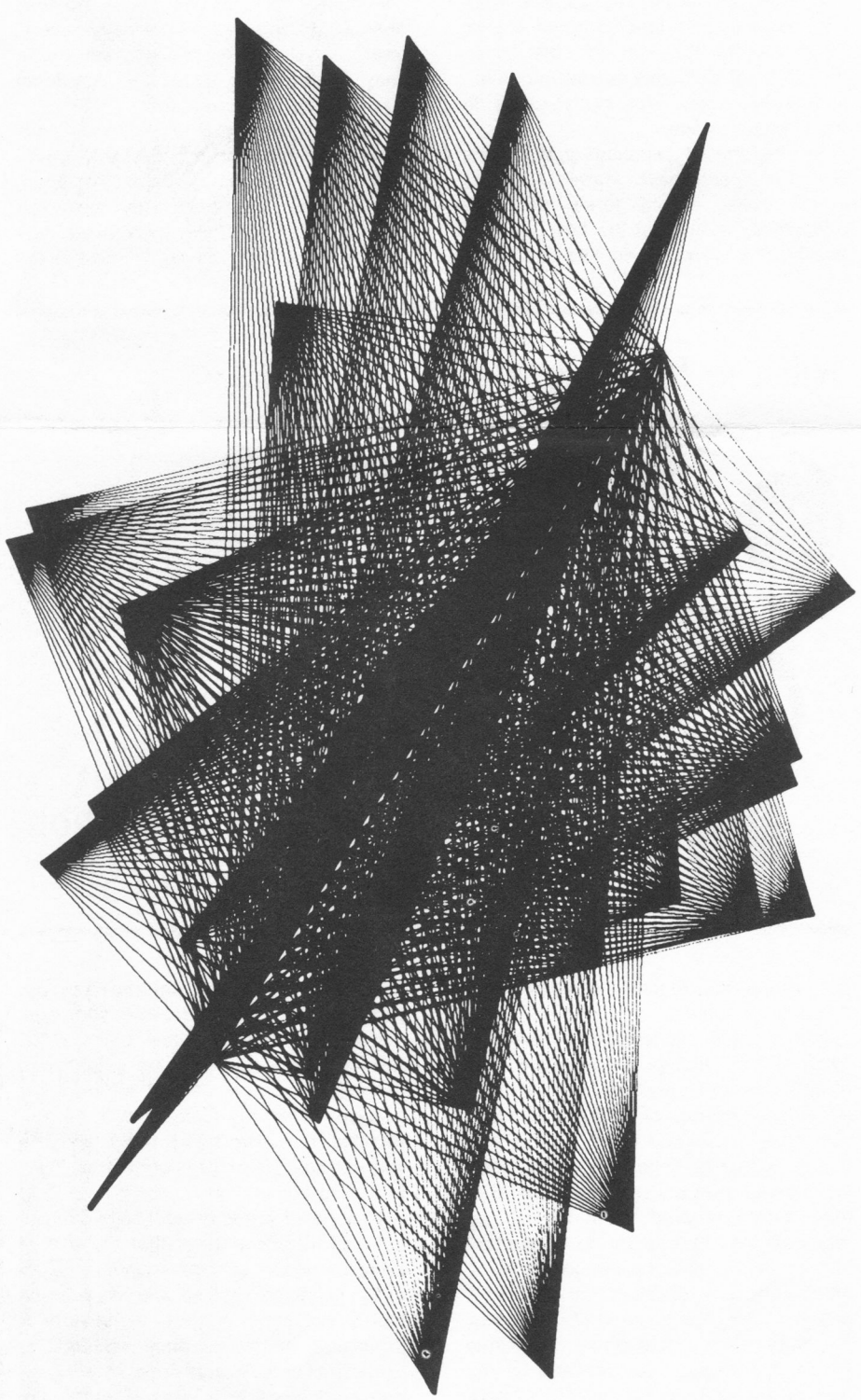


MAN IN 2001

by Dr. Bentley Glass
Distinguished Professor of Biological Sciences and Academic Vice President

Dr. Glass, who retires this year from his position as Stony Brook's academic vice president, is an internationally known geneticist. He has recently completed simultaneous terms as national president of Phi Beta Kappa and the American Association for the Advancement of Science. This article is a condensation of two of his professional addresses.

At the end of each year, and even more customarily at the close of every decade, we are wont to look forward in the hope of forecasting as well as possible what the next year, the next decade, or even the next century may hold for us. What, for example, will biology have achieved by the year 2001? What will man be? It is rash indeed to guess, but one can perhaps see a few present trends whereby our control over life will be extended.

But before speculating, let's first consider for a moment whether there are finite limits to man's scientific exploration, or whether endless horizons stretch before us. In the spectrum of belief about the future of science, there are two extremes. One is the view of limitlessly expanding knowledge, of infinite extent; the other, the view that scientific knowledge, like our universe, must be finite, and that the most significant laws of nature will soon have been discovered.

The second view seems to me the more likely. In genetics, the last two decades have added a greater knowledge of the chemical basis of heredity and its mechanisms than in all the years before. The great conceptions, the fundamental mechanisms, the basic laws are now known. For all time to come, these have been discovered, here and now, in our own lifetime. Like Newton's laws of motion, like the Copernican solar system, like the origin of species, or like relativity and quantum mechanics, they are now the known, not the unknown — and by just so much is the extent of unknown nature diminished.

True, we may be like little boys on the shores of a vast ocean, tossing pebbles into the waves. What remains to be learned may indeed dwarf imagination. Nevertheless, the universe itself is closed and finite, or at least bounded to our knowledge by the radius of the lightyears since its beginning, about ten billion years ago; and our telescopes have now plumbed space almost to those limits of the observable. Their growing knowledge of the universe has led scientists to believe more and more firmly that the laws of nature have universal applicability. Matter is composed of the same particles and elements everywhere. Radiant energy moves with the same speed and has the same characteristics everywhere. Local differences are explicable in terms of local conditions and past history.

The uniformity of nature and the general applicability of natural laws set limits to knowledge. If there are just 100, or 105, or 110 ways in which atoms may form, then when one has identified the full range of properties of these, singly and in combination, chemical knowledge will be complete. There is a finite number of species of plants and of animals — even of insects — upon the earth. We are as yet far from knowing all about the genetics, structure and physiology, or behavior

> Has man discovered about all there is to know?

of even a single one of them. Nevertheless, a total knowledge of all life forms is only about two million times the potential knowledge about any one of them. Moreover, the universality of the genetic code, the common character of proteins in different species, the generality of cellular structure and cel-

lular reproduction, the basic similarity of energy metabolism in all species and of photosynthesis in green plants and bacteria, and the universal evolution of living forms through mutation and natural selection — all lead inescapably to a conclusion that, although diversity may be great, the laws of life, based on similarities, are finite in number and comprehensible to us in the main even now. We are like the explorers of a great continent who have penetrated to its margins in most points of the compass and have mapped the major mountain chains and rivers. There are still innumerable details to fill in, but the endless horizons no longer exist.

By whatever parameters one may select, the accumulation of knowledge in the past century and a half has been accelerating exponentially, with a doubling time of 12 to 15 years. The number of scientific periodicals, the number of scientists publishing or working, and the number of scientific papers have been doubling almost every ten years. Moreover, the amount of extant scientific information is currently increasing at a rate related to the absolute number of scientists, technologists, and laboratory workers in the population. In the United States this rate cannot long be maintained, since it is much faster than the rate of population growth for the country and already constitutes about 20% of the entire professional labor force.

In fact, no rate of scientific development equal to that of the past half century can be sustained for long. As Gunther Stent has written, "If one examines one by one the parameters conceivably relevant to estimating the rate of progress, such as world population and energy consumption, per capita income, or speed of travel, one must conclude that none of them is likely ever to exceed some definite bound." The farther we have advanced on the accelerating curve, the closer we inevitably come to the time when limiting factors will curb the growth and bring it into some degree of stasis, or equilibrium, or possibly decline.

Progress cannot continue indefinitely. Indeed, so awesome is already the accelerating rate of our scientific and technological advance that simple extrapolation of the exponential curves shows unmistakably that we have at most a generation or two before progress must cease, whether because the world's population becomes insufferably dense, or because we exhaust the possible sources of physical energy or deplete some irreplaceable resource, or because, most likely of all, we pollute our environment to toxic, irremediable limits.

Certainly grave problems lie ahead, but so do some amazing technological developments and scientific achievements. We may gain some comprehension of the speed with which we are approaching the end of progress by considering what we can expect to have mastered by the turn of the century.

We will surely, before the next 30 years have passed, have solved the problems of photosynthesis and have learned how to assure mankind of an inexhaustible supply of food. First, probably, will come methods of farming the seas and culturing in large vats algae and yeasts, more palatable than strains available today. By the year 2001, knowledge of the constitution of the enzymes required in each of the photosynthetic steps and the control of the flow of energy from the sun should finally reach the point where we can create sugar from pure water and carbon dioxide.

Infectious diseases will very likely have been banished completely by the year 2001, along with hunger. The artificial production of immunoglobulins, conferring specific immunities or preventing infections from resulting in serious illness or death, will take their places beside present vaccines, antibiotics and drugs. Constant vigilance will still be needed to cope with the sudden appearance of new forms of infectious agents by mutation. The doctor's pharmocopeia will utilize combinations of drugs and cyclic replacement of antibiotics to combat these difficulties. The viruses and hereditary susceptibilities involved in various malignant disorders will be far better known than today, and for some of the viruses vaccines as effective as the antipoliomyelitis vaccine may have been developed. Much more, too, will be known about the prevention of premature death from coronary disease, arteriosclerosis and high blood pressure.

The entire age structure of our population will change radically, as the average prospective life of each babe born today creeps upward toward 75 years. The science of medicine will increasingly concentrate on the disorders of senescence and old age. Whereas now many persons over 80 years of age are reduced to an almost vegetable-like existence, we may expect that discoveries will be made that will permit many or most persons to enjoy to 90 years or a full century of life the remarkable vigor of mind as well as body that now characterizes an Artur Rubinstein or a Pablo Casals.

Surgery is making great strides in the replacement of diseased or defective parts. Studies in immunogenetics and radiation biology may well make it possible within the next decades to overcome the normal resistance to successful transplants of organs between persons who do *not* carry identical sets of genes. The first big successes should most likely permit transplants between close relatives who do not differ in a great many genes. Healthy organs from individuals who have died, especially those who die by accident, will be banked and treated to reduce the immunogenetic reaction of the host against the donated organ, or vice versa. Artificial organs, such as hearts, kidneys, and blood vessels, which can be safely used to replace the worn-out or diseased originals, will be further developed. The old man or woman of tomorrow may live on in better health for several decades with artificial parts.

Surgery, specifically the replacement of defective organs, will extend to the prenatal life; indeed, this is already a rapidly developing art. The embryo has a remarkable capacity to regenerate lost parts, a capacity which is lost as the fetus grows older. Also, the immunogenetic reactions are weak or absent at first and mostly develop late in fetal life or even after birth. It will be possible to immunize the fetus or the newborn infant so successful transplants from any donor can be made without fear of rejection. Genetic surgery, the transformation of defective genes into functional ones, may also be possible in the prenatal stage.

By the end of the century biologists will, I suspect, have learned how to create some simple forms of living organisms, perhaps at the level of complexity of a virus. To do that is not too far beyond the recently achieved synthesis of a gene.

It should also be feasible, by the year 2001, to bank human reproductive cells of both sexes in frozen state, as we now do with the sperms of domestic animals, especially sheep and cattle. In this way the reproductive cells of selected individuals might be utilized even long after their deaths to produce in the laboratory embryos that might be implanted in the womb of a foster-mother, or even, after sufficient development of technique, to be grown in bottle cultures. The latter "brave new world" technique I do not expect to see realized by the turn of the century. On the other hand, I do expect that techniques will be developed for the cultivation in the laboratory of portions of human ovary and testis permitting successful continuous production of mature ova or sperms.

By studying the development of the human embryo and fetus under continuous observation and under various conditions, medical scientists will learn what factors produce particular kinds of abnormalities and how these may be corrected or avoided. Sex determination of the embryos is possible before implantation; and embryos with abnormal chromosome constitutions can be discarded. The development of the implanted fetus within the mother and its normal delivery at full term will engender the maternal and paternal feelings of the "parents" far more fully than adoption of a child already several years old. Most couples who are sterile may in this way have the significant experiences of parenthood.

By preserving the reproductive cells obtained from young persons under conditions which minimize mutation, those same individuals may have offspring at a relatively advanced age without incurring the higher probability of adverse gene and chromosome defects that normally increases with age.

It seems very likely that before 2001 A.D. genetic clinics will be established in which as many as 100 different recessive hereditary defects will be detectable in the carriers, who may be warned against or prohibited from having offspring.

In spite of personal and religious objections, it seems clear that the use of present means of contraception, especially of steroid "pills" and intrauterine loops, will soon become worldwide. A promising recent advance appears to be that of inserting a dose of progesterone enclosed in a capsule under the

Will the future bring

disease-free life
prenatal surgery
appetizing algae
genetic manipulation
longer life spans
test tube babies
compulsory contraception
government-issued LSD

skin of the female. Under these conditions, microdoses would seep into the circulation and prevent conception even without modifying the usual female cycle. The capsule can be easily and painlessly put in place and may be removed at any time. The method works in mice. It is being tested in humans. Modern methods of contraception, it seems clear, will if adopted be the quickest and surest means of securing control over the explosive population increase, and seem infinitely superior to widespread use of legal abortion.

We might even go so far as to predict that by the year 2001 many countries will have reached such a population density in relation to their food supply that no further increase can be tolerated. A marriage certificate might then bear two coupons entitling the couple to produce two children, no more. Restrictive tax measures, such as an income tax graduated more heavily as the number of children increases, or even temporary sterilization by court order, might be utilized by countries under desperation. In a world where each pair must be limited, on the average, to two offspring and no more, the right that must become paramount is not the right to procreate, but rather the right of every child to be born with a sound physical and mental constitution, based on a sound genotype. No parents will in that future time have a right to burden society with a malformed or a mentally incompetent child.

The control of human behavior by artificial means will have become by the year 2001 a frightening possibility. Government — "big brother" — might use tranquilizers, or hallucinogens like LSD, to keep the population from becoming unruly or over-independent. More and more subtle forms of conditioning will lead people to react in predictable ways desired by government or by commercial interests, without people quite knowing how they are hoodwinked. The added possibilities of controlled reproduction make these psychological methods of control over learning and behavior even more drastic.

I thus predict a future in which many cherished values of our society and many ethical standards may be questioned or superseded. It is not sufficient to have a few scientists raise such issues. Only a prolonged and profound attention by many of the wisest men of our time, men of philosophy and religion, students of society and of government, and representatives of the common interests of men throughout the world, together with school administrators and scientists, may achieve a wise and sober solution of the crisis evoked in our world by scientific discoveries and their applications. Every citizen, every man in the street, must learn what science truly is and what risks and quandaries, as well as what magnificent gifts, the powers that grow out of scientific discovery engender. □

Free Lecture Series Explores Many Aspects Of Yesterday, Tomorrow

From Aztec art to the predetermination of fetal sex by the latest techniques of genetics is a quantum leap in the history of man. Within these bounds stretch a variety of human accomplishments, failures and insights which form the subject matter of this spring's offerings in the University Lecture Series.

The Lecture Series is composed of eight weekly seminars offered by the Center for Continuing Education. The first hour of each session — a lecture by a distinguished faculty member — is open to the general public without registration or charge. The remaining two hours of each seminar are open only to students enrolled in Continuing Education, which offers a Master of Arts in Liberal Studies.

Each of the lecture/seminar courses averages seven classes from February through May in one of these areas of study: science and the future of man, Shakespeare, the intellectual effects of Darwin's concept of natural selection, science and literature, Latin American culture, political themes in four major novels, contemporary theology, and the philosophical dimensions of American experience.

Problems facing mankind, such as air and water pollution, nuclear radiation, and the prospects and problems involved in genetic manipulation of inheritable human characteristics are among the topics to be covered in "Science and the Future of Man," the series by Dr. Bentley Glass, Stony Brook's Academic Vice President and Distinguished Professor of Biological Sciences.

In the past, Dr. Glass has speculated on human problems arising from developments in the biological sciences. These include decisions that will have to be made about such ideas as mating frozen sperm and ova in the laboratory, sex determination of fetuses, donor selection and control, and other problems which will confront man as he masters the secrets of life.

The plays of Shakespeare as interpretations of the human experience, including man's motivation and behavior, will be the subject of lectures by Dr. Herbert Weisinger, Dean of the Graduate School. Plays to be examined include *Cymbaline, Measure for Measure, Pericles, The Tempest,* and *A Winter's Tale.*

"Science and Literature" is a course designed to investigate the interactions of these two areas of scholarship. Conducted by Dr. Elizabeth Garber of the Physics Department, this series will consider, among other views, C.P. Snow's concept of the "two cultures" of the scientist and the humanist.

Dr. Thomas J.J. Altizer, whose work at Emory University gained national attention in the "God is Dead" debate a few years ago, continues his course on "Fundamentals of Religion," focusing on the meaning of religion in today's world. In the spring series, Professor Altizer will discuss the writings of representative modern theologians including Martin Buber, Karl Barth, Paul Tillich, Teilhard de Chardin and others.

The work of Charles Darwin involving the concept of natural selection, and the effects of this discovery on the intellectual community in Europe and America during the latter half of the 19th century will be discussed by Dr. Peter Bretsky of the Department of Earth and Space Sciences. His course, "Darwinism: An Intellectual Revolution," is a new addition to the University Lecture Series this year.

A specially arranged program of visual aids will highlight Professor of Art Leopoldo Castedo's offering, "Latin American Cultural Development," which will be illustrated with some of the thousands of slides and photographs taken by him during his 14,000-mile journey throughout Latin America last summer. His lectures will cover contemporary ways and styles of living in Latin America within a retrospective historical analysis, starting with modern times and ending with pre-Columbian civilizations.

A discussion of political themes in the works of four major novelists provides the focal point of "Literature of the 20th Century: Politics and the Novel," a series of lectures by Dr. Paul Dolan, Chairman of the English Department. Novels to be studied in this series are Feodor Dostoevski's *The Possessed,* Henry James' *Princess Cassamassima,* Joseph Conrad's *Nostromo* and Thomas Mann's *Dr. Faustus.*

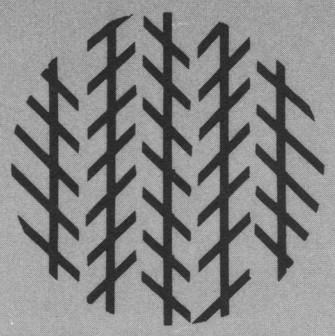
An interdisciplinary analysis of selected themes, such as the meaning of history, the themes of time, nature, and the conflict between doctrine and experience form the core of lectures by Dr. John J. McDermott, visiting professor of English, in his lecture series, "Philosophical Dimensions of American Experience."

University Lectures are given in the late afternoons and early evenings. For additional information, including dates, times and locations of each lecture, call (516) 246-5936. □

University's Impact On Schools Outlined

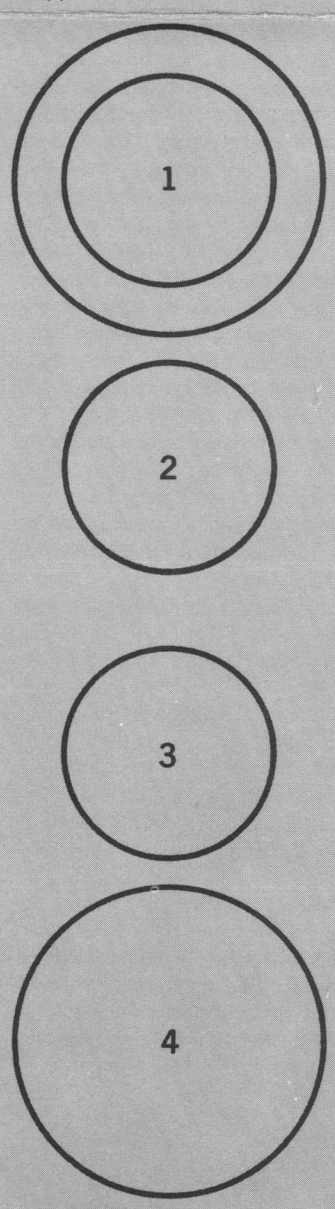
Perhaps the most effective town/gown relationships in any university community are those between the campus and the local schools. In a discussion of the University's impact on the Three Village School District at a recent meeting of the Association for Community-University Cooperation, Dr. Francis Roberts, District Superintendent, quickly listed about a dozen such relationships between Stony Brook and area schools:

- A science project for the elementary schools, jointly planned and executed by the University and the schools.
- Musical programs presented in the School District by groups and individuals from the University.
- Cooperation and sharing of facilities in the Marine Sciences, "very much to the benefit of the schools."
- "A steady sharing" of physical education facilities, including the University's track, gym and swimming pool, especially prior to the completion of the District's new secondary schools.
- A dramatic arts program at the North Country School sponsored by the University's Theatre Arts Department, a program Dr. Roberts described as "an example of the quiet relationships that don't receive headlines but are very beneficial."
- University-School District cooperation in student teacher programs. (About 40 student teachers from the University are presently assigned to the District.)
- "A very healthy kind of diversity" in school enrollment, through children from University families coming to the area from throughout the country and abroad.
- The University library's provision of "a much deeper, much broader range of materials than could ever be supported by the school district taxpayers, materials which have been of benefit to students and especially to the district's teachers."
- General participation of University faculty and staff members in school affairs. "There has never been any reluctance on the part of University people to work with the schools," Dr. Roberts said, noting as an example, "the very significant kind of human relationships" that can be seen in the District's Science Fair. Senior faculty from the University serve as judges for the fair. "There's just no way to describe the effect on a seventh grade scientist when he knows that Dr. Yang (the University's Nobel Laureate physicist) is looking at *his* work." Readily available guest lecturers from the University and personnel from areas such as the University's Health Sciences Center who have provided career counseling were other examples of such cooperation cited by Dr. Roberts.
- The availability of University-level courses on campus for high school students. This, Dr. Roberts said, provides "both a tax saving to the community and a stimulus to students to go on with their education."
- Special therapeutic programs such as the psychological counseling clinic for local students and parents conducted by the University's Psychology Department.
- Continuing education courses for teachers.
- An aid to teacher recruitment in the local schools. The University's presence in the area is "quite a stimulus," Dr. Roberts said, for the School District's efforts to attract fine teachers. □



ABOVE Failing to see the five long lines as parallel is only one of several errors your visual system will make if you try to perceive this figure. When Frederich Zollner first discovered this effect in 1860, he also noticed that the illusion is stronger if you tip your head 45° or rotate the page. Both these effects find a common explanation in a theory of visual system interaction proposed by graduate student Jerry Nelson.

BELOW Circles 1, 2 and 3 are the same size, but when a circle is drawn around 1, it appears larger than the others. Also, if you look steadily at larger circle 4 for 15 seconds or so and then look at 3, 3 will appear smaller than it is. This "figural aftereffect" was discovered in 1944 by Drs. Kohler and Wallach. Mr. Nelson has suggested that the same neural mechanisms in the brain cause both the illusion and the aftereffect, even though they are opposite.



Optical Illusions May Provide Key To Secrets of Perception

Some things just aren't what they seem. But why?

For thousands of years, man has been amused and bemused by optical illusions. And in the past century or so, these mind-baffling puzzles have stubbornly challenged scientists seeking a physiological explanation of their effects.

Now, pursuant to research begun in the 1960's, science is on the verge of fully explaining optical illusions. Even more important, according to a Stony Brook psychology graduate student who has already become an acknowledged world expert in the field, the key to optical illusions may also unlock the secrets of ordinary perception.

The student, Jeremiah Nelson, is advancing a minority view by positing a close relationship between ordinary perception and perception of illusions. But he has earned the attention of electrophysiologists and psychologists in the field, and in late January he visited Cambridge University, where he had been invited to deliver a lecture at a world symposium on visual perception sponsored by the Brain Research Association. After the symposium, Mr. Nelson visited Braunschweig University, near Hanover, where he had been invited to meet with the eminent German psychologist Heiner Erke.

Mr. Nelson's new, physiological approach flatly rejects the idea that optical illusions are caused by properties in external shapes or patterns. Rather, he says, they arise from the fact that brain cells, which respond differently to different shapes, are interacting with each other. This cell interaction, when shapes are in certain patterns, causes misperceptions or illusions.

"As a psychologist," Mr. Nelson says, "I'm a little embarrassed that we still have no explanation of perception."

Mr. Nelson became interested in the physiological basis of visual perception as an offshoot of his doctoral work with Dr. Marvin Levine, professor of psychology, on "Perceptual Influences in Human Problem-Solving." That interest became a hobby and the hobby a preoccupation. Now, though he is finishing his Ph.D. work, Mr. Nelson has become enthralled by his hobby — having read and synthesized some 2000 scholarly articles on the subject — and plans to pursue it full-time when his doctoral studies are completed.

Professor Harry Kalish, Chairman of Stony Brook's Psychology Department, said it was "certainly unusual" for a graduate student to be invited to address an international colloquium. "It's really an outstanding achievement," he added, "since the work has been done so much on his own."

Mr. Nelson says a major advance in his field occurred in the early 1960's, when Harvard scientists managed to implant a fine-tipped needle into a brain cell of an anesthetized cat. An electrical hookup, much like a good hi-fi amplifier, then allowed the scientists to measure the frequency of electrical pulses emitted by the cell when various shapes were projected on a wall before the cat's eyes. This laboratory breakthrough allowed the isolation and observation of living brain cells involved in the act of perception.

These scientists consequently learned that there are some cells which respond best to a specific shape, for instance to a straight line in a certain position. The shape elicits frequent pulses from that kind of cell, which has been dubbed a "line orientation detector." But no cell has ever been found that responds best — that is, with frequent pulses — to a triangle or other complete figure.

The great challenge and goal of the research, Mr. Nelson says, is understanding how human beings perceive things as well as they do despite this cellular handicap.

"We've long known," Mr. Nelson says, "that the eye lens projects an image onto the retina, which is connected to the back of the head. In the 1960's, we began to discover details. For example, it was found that some brain cells are geared to respond to specific visual details. Now people are trying to figure out how to put the research data together to understand perception."

He believes the explanation lies somewhere in the process of "lateral interaction," by which one cell tuned to detect one kind of figure is able to suppress or inhibit the activity of neighboring cells. But, he says, the formulation of a complete theory is yet to come.

"The next decade should be quite exciting," he said. "What's at stake is nothing less than learning how we perceive objects even though we apparently come from the factory without being prewired to detect anything more complicated than one or two straight lines." — Sam Segal □

SPRING CONCERT SERIES

Famed Composer, Cellist — Even Mixed Media

Concerts by a Pulitzer Prize-winning composer, a group of multi-media performers and a world famous cellist are among the programs scheduled in the Spring Concert Series at Stony Brook.

The three-month-long series is sponsored by the Music Department. Admission is $2.50 for the general public, $1.50 for University faculty and staff. Performances begin at 8:30 p.m. in the Union Theater.

February 26 — Charles Wuorinen, a recent recipient of the Pulitzer Prize for music, will perform in a concert of contemporary music, including some of his own work.

March 6 — A chamber music concert, organized by Ronald Roseman, oboist and member of the University music faculty, will feature several Stony Brook artists-in-residence.

March 13 — The Lenox String Quartet, an internationally known group currently in residence at the State University at Binghamton, will perform.

March 21 — Creative Associates, a multi-media group from Buffalo, will present an avant-garde concert featuring electronic music.

April 26 — Ralph Froelich, a member of the New York Woodwind Quartet, will play the French horn and Gilbert Kalish, a member of the Contemporary Chamber Ensemble, will play the piano in a concert featuring works by Beethoven, Saint-Saens, Cowell and Muller. Both musicians are Stony Brook performing-artists-in-residence.

May 7 — Bernard Greenhouse, world-renowned cellist and member of the Beaux Arts Trio, will perform an all-Beethoven concert featuring the G-Minor Sonata, Variations on a Handel Theme, C Major Sonata and A Major Sonata. Mr. Greenhouse is also a performing-artist-in-residence at Stony Brook.

Further information on all concerts is available through the Music Department, 246-5671. □

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