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28. The Science Policy Research Unit at the University of Sussex is embarking on a long-term study (Project SAPPHO) which aims to identify, quantify, and record the circumstances surrounding a large number of successful *and* unsuccessful research projects, inventions, and innovations in various countries, and to deduce patterns which will be useful for predictive as well as descriptive purposes. Information will be fed into a computerized data bank—for example, information from biographical profiles of individual scientists and managers, or from case studies of individual inventions and innovations, whenever this material is met with in the other projects inside the unit or is specially gathered to provide a broad base for pattern finding. We shall try to develop procedures to establish the existence of "best" descriptive patterns of the data, or of subsets of the data, and sampling procedures will then be used to find "sibling" or control data elsewhere in the data bank, so that the observed descriptive pattern can be gauged logically as a predictive pattern. To be effective, SAPPHO will need a large volume of data. For this reason we would welcome case studies of discoveries, inventions, and innovations from scientists and engineers in any country, including material on unsuccessful projects (which is rarely published). We would also welcome comments and views on the most significant features of the research-innovation process. We shall try to link biographically oriented data on scientists, inventors, and entrepreneurs with information which is "event-oriented." The traditional compartmentalization of fields of knowledge is inadequate for this kind of study, and for this reason we have deliberately brought together both natural and social scientists to work on these problems.
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Nobel Prize: Three Named for Medicine, Physiology Award

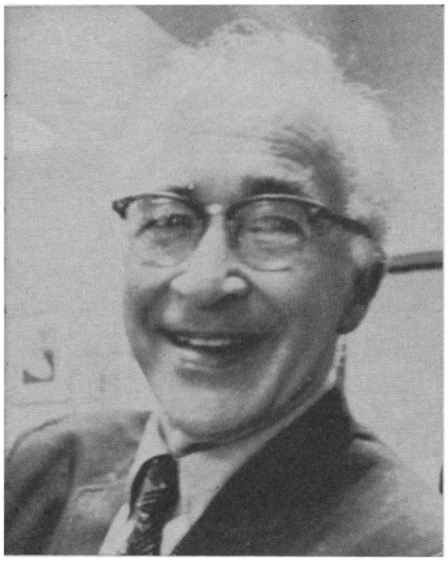
Three scientists, George Wald, Ragnar Granit, and Haldan Keffer Hartline, were named last week to share the 1967 Nobel prize in medicine or physiology. Wald is professor of biology at Harvard University. Granit is retired director of the Neurophysiological Institute of the Royal Medical School in Stockholm; at present he is serving as a visiting professor at St. Catherine's College in Oxford. Hartline is professor of biophysics at Rockefeller University. The following are appreciations and descriptions of Wald's work by John E. Dowling and of Granit's and Hartline's work by Floyd Ratliff.

George Wald

Nobel prizes have generally been awarded either for a single great contribution or for sustained contributions over a period of many years. In the work that brought the award this year to George Wald, both criteria are met. Wald's greatest contribution, of course, was the discovery of the role that vitamin A plays in vision, as precursor to retinene (vitamin A aldehyde), the chromophore of all the known visual pigments. Wald's discovery provided one of the first identifications of the biochemical function of a vitamin, and today this is still the only specific biochemical function known for a fat-soluble vitamin.

Beyond this important discovery, Wald has made innumerable contributions to our knowledge of the biochemistry of vision. This work includes extensive studies on the chemistry of the rod pigment, rhodopsin; the extraction and characterization of the first known cone pigment, iodopsin; and the discovery and tracing in nature of visual pigments synthesized with vitamin A_2, the porphyropsins. Wald and his collaborators discovered the role of *cis-trans* isomerization in the visual process, demonstrating for the first time that such molecular transformations play a role in biology. In addition he and his co-workers have provided important information on vitamin A deficiency, visual adaptation, color vision, and the cone pigments in primates. No one has contributed more to our understanding of the visual pigments and their relation to vision than George Wald.

Wald was born in 1906 in New York City and grew up there. He was graduated from Washington Square College in 1927, and from there he moved to Columbia, where he received his Ph.D. in 1932. At Columbia he was a student of Selig Hecht, who introduced him to visual physiology, where Wald's principal interests have resided for the past 40 years. Wald was profoundly influenced by Hecht and, when accepting the Proctor medal in 1955, spoke of him thus: "Hecht was a great teacher and physiologist. Also he was one of those rare persons who sets a standard both at work and at leisure. I was fortunate in having his instruction and later his friendship. I saw too little of him after leaving his laboratory but I felt his presence always. What I did or said or wrote was in a sense always addressed to him."



George Wald

From 1932 to 1934 Wald was a National Research Council Fellow in Biology. In his first year of that fellowship, while in the laboratory of Otto Warburg in Berlin-Dahlem, he first discovered vitamin A in the retina. Shortly thereafter, Wald moved to Paul Karrer's laboratory in Zürich to complete and confirm his discovery. He spent the second year of the fellowship at the University of Chicago. In 1934 Wald assumed his first academic position, as tutor in biochemical sciences at Harvard. He has remained at Harvard for all of his academic career, attaining the rank of full professor in 1948. Wald has received many honors over the years, including the Eli Lilly award of the American Chemical Society in 1939, the Lasker award of the American Public Health Association in 1953, the Proctor medal of the Association for Research in Ophthalmology in 1955, the Rumford medal in 1959, and the Frederic Ives medal of the Optical Society of America in 1966.

Although Wald's research has centered almost exclusively on the visual pigments and related aspects of vision, he has long been concerned with broad biological and biochemical problems. His studies on the distribution of vitamin A_1 and vitamin A_2 in nature led him into the field of biochemical evolution, and he has written superb and provocative articles with such varied titles as "The Significance of Vertebrate Metamorphosis," "Life in the Second and Third Periods; or why phosphorus and sulfur for high energy bonds," and "The Origin of Optical Activity." His popular and highly entertaining lecture "The Origin of Life" is world-famous, and recently he has added a sequel, "The Origin of Death."

Wald has also long been concerned with the impact of modern biochemistry on biology. His biochemistry course at Harvard was famous for lucid lectures that emphasized the biological aspects of biochemistry. In more recent years, Wald has felt strongly that the great contribution biochemistry has made to biology has been to show the basic similarity of organisms on the molecular level, and that this is what should be emphasized in biology, rather than the differences between organisms, as in the more traditional approach. To implement these ideas, Wald began (in 1960) a new introductory course in biology at Harvard which incorporated this view and more. The course begins with a discussion of elementary particles, shows how atoms and molecules are put together, and introduces "biology" with a discussion of the basic metabolic processes—fermentation, respiration, and photosynthesis—that are fundamental in nature. The course has been received with enormous enthusiasm, and those of us who have assisted with it believe there is no other way to approach biology.

Wald has long been an enthusiastic art collector. Rembrandt etchings, for example, are a great joy to him, and he has many superb ones that he will show to visitors with utmost pleasure, magnifying glass in hand. Also, he has found primitive art, particularly pre-Columbian pottery, a source of fascination—to the point of participating in archeological expeditions in Mexico. Wald is married to his co-worker Ruth Hubbard, who is a brilliant and distinguished investigator in her own right. They have two children, Elijah and Deborah. Wald also has two sons, Michael and David, by a former marriage.

In any discussion of his research career or accomplishments, Wald would insist that mention be made of his other long-time co-worker, Paul Brown. Brown has been with Wald for almost 20 years—first assisting, then participating as a full-fledged collaborator, more recently striking out on his own in new directions. Wald and his co-workers, Hubbard and Brown, form the nucleus of a laboratory that has been extraordinarily fruitful as the world's foremost center of visual-pigment biochemistry.

In sharing this year's Nobel prize with Hartline and Granit, Wald completes a triumvirate that has led and guided visual research for over 30 years. Those of us in visual research particularly owe them a great debt, and we are exceedingly pleased that they have been so honored.

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Ragnar Granit

If it shall be demanded, then, when a man begins to have any ideas? I think the true answer is, when he first has any sensation. For since there appear not to be any ideas in the mind before the senses have conveyed any in, I conceive that ideas in the understanding are coeval with sensation. . . .

These words from John Locke's "Essay Concerning Human Understanding" preface Ragnar Granit's Silliman Lectures on sensory processes. They are equally fitting as an introduction to this brief account of his scientific life and work, for, stated succinctly, the aim of much of the research that he has carried out over the past 40 years was to reach an understanding of how the senses "convey" information. In this he has succeeded admirably. His researches on the physiology of vision have elucidated broad principles of neural action and interaction that govern how the retina processes and encodes information about form, motion, and color, and how the optic

Ragnar Granit

nerve then transmits that information to the higher visual centers in the brain. For these contributions, he has just been awarded the Nobel prize.

Granit was born in 1900 in Finland, and was graduated from the Swedish Normallyceum, Helsinki, in 1919. He received the Mag. Phil. degree from Helsinki University in 1922, and the Doctor of Medicine degree, also from Helsinki, in 1927. From 1929 to 1931 he was a Fellow in Medical Physics at the Johnson Foundation, University of Pennsylvania. It was there that he first met Haldan Keffer Hartline, and also Clarence H. Graham, a psychologist who collaborated with him and with Hartline in some of their early research. It was also during this stay in the United States that he met George Wald, at that time a student of Selig Hechts at Columbia. In 1932, and again in 1938, he studied neurophysiology under Sir Charles Sherrington at Oxford.

From 1945 until his recent retirement, Granit was Director of the Neurophysiological Institute at the Karolinska Institute of the Royal Medical School in Stockholm. His first major appointment was that of professor of physiology at Helsinki University in 1937. Three years later he was invited to the Institute for Neurophysiology at the Karolinska. In 1956 he was appointed Visiting Professor at the Rockefeller University in New York. Still active in retirement, he is at present serving as a visiting professor of neurophysiology at St. Catherine's College in Oxford.

Granit's many prizes and awards for his work in neurophysiology include the K.K.K. Lundsgårds gold medal, the Jubilee prize of the Swedish Society of Physicians, the Donders medal (Utrecht), the Anders Retzius gold medal (Stockholm), the Anders Jahre medical prize (Olso University), and the Saint Vincent prize of the Accademia di Medicina, Torino. In addition, he has received numerous honorary degrees.

The several academies and learned societies to which he belongs include the Royal Swedish and Royal Danish academies of science; Societas Scientiarum Fennica; the American Philosophical Society; Sociétè Philomatique, Paris; the Academy of Science in Bologna; the Accademia di Medicina, Torino; the Royal Society (London), of which he is a Foreign Member; and a number of societies for biology, opthalmology, and neurology.

Ragnar Granit married Baroness Daisy Brunn in 1929. They have one son, Michael, who is an architect in Stockholm. Granit was the first fellow appointed to the faculty of the Johnson Foundation in Philadelphia. Detlev W. Bronk (then head of the Foundation), reports that, in order that Granit's intended wife might accompany him to the United States, she and Granit advanced the date of their marriage by a year. An enthusiastic and expert yachtsman, Granit has spent much of his spare time sailing on the Baltic.

Following some psychophysical studies on human vision, Granit undertook the analysis of the retinal action potential of the vertebrate eye—discovered by Holmgren in 1865. The complex time course of this electrical response to illumination Granit ascribed to three underlying processes, of which the two principal ones are antagonistically excitatory and inhibitory. This analysis was, and still is, significant because it furnishes the experimental foundations supporting the concept (which Granit himself did so much to advance) that visual responses are "molded" by the interplay of excitation and inhibition. His scheme, devised to represent the three interacting processes, forms the basis for most of the interpretations of the vertebrate electroretinogram today.

The retinal action potential furnishes a valuable objective sign of retinal action, and has become increasingly useful, especially in the hands of experimental psychologists and visual physiologists, who in recent years have used it as an objective electrophysiological parallel to behavioral measures of visual processes. In the clinic, Granit's analysis has served as a basis for interpretations of the differences between normal and pathological responses.

The contributions of the receptors to the retinal action potential absorbed much of Granit's interest; his early contributions toward understanding the link between receptor excitation and the generation of nervous action retain their validity today, a validity that is heightened by the better understanding we now have of cellular processes of excitation. Granit's term, *generator potential,* gave succinct expression to ideas then current in the early phases of retinal electrophysiology. These ideas are now widespread, and the term is now used universally in sensory physiology.

Closely connected with the problem of receptor excitation are the familiar large changes in sensitivity comprising light and dark adaptation. The prevailing view in the 1930's (exemplified by that of Selig Hecht, who was the first to give precise quantitative physical and physiochemical form to the theory of adaptation) was that these changes were the expression of the bleaching and regeneration of the visual pigment of the receptor. Largely on the basis of electrophysiological evidence, however, Granit and his co-workers and others —notably R. Lythgoe—contended that neural factors must play a role in adaptation. Although then controversial, this interpretation complemented rather than contradicted the photochemical view. Today, the conclusion that some factors other than bleaching and regeneration are involved is no longer at issue, but the nature and extent of both the photochemical and the neural contributions to adaptation have yet to be fully determined.

Some of Granit's most important discoveries concern the activity of individual optic nerve fibers of the mammalian retina. Granit and his colleagues were among the first to develop the use of the microelectrode in neurophysiology. With it they were able to restrict the recording to one or, at most, a few retinal ganglion cells. It is from such records that interaction in the retinal pathways, with the interplay of antagonistic excitatory and inhibitory influences, is most strikingly revealed as the mechanism that shapes patterns of neural activity.

Granit undertook his microelectrode studies with a view to analyzing mechanisms of color vision. He and his colleagues showed that some elements ("dominators") have broad spectral sensitivity but that some elements ("modulators") show, either directly or after chromatic adaptation, narrow-band spectral response curves. These latter elements fall, moreover, into three main groups within the spectrum, in general accordance with the Young-Helmholtz theory of color vision. Thus, Granit's studies of retinal ganglion cells provided the first direct evidence of the specialized unitary spectral sensitivity that underlies color vision. At the level of the receptors, specificity of spectral sensitivity is now being firmly established in a number of laboratories throughout the world. This increased understanding is based both on the more direct and more localized electrophysiological observations which are now possible and on greatly refined methods of studying the visual pigments *in situ.*

Granit has truly pioneered broadly in visual physiology; his contributions have grown in basic significance in recent years. In his research on the retina he has made more explicit many of the ideas about the intergrative action of the central nervous system that were only in their early formative stages at the time of his studies in Sherrington's laboratory. Indeed, the one thread that runs through all of Granit's studies is his aim to determine exactly and state explicitly the role of the interplay of excitatory and inhibitory influences in molding patterns of nervous activity, both in the retina and in the central nervous system.

In his admirable work of more recent years he has returned to the study of the spinal cord and the problem of motor control. These researches, and his recently published scholarly biography of Sherrington—which is not only an appraisal of the man but also a comprehensive study of the origin and development of modern neurophysiology—are not within the scope of this discussion, but they are pertinent to the extent that they show the great breadth of his interests and the generality of the insights he has given us from his retinal studies. The mechanisms of neural interaction with which he has dealt so successfully in vision are indeed founded on principles that have broad validity in all fields of neurophysiology.

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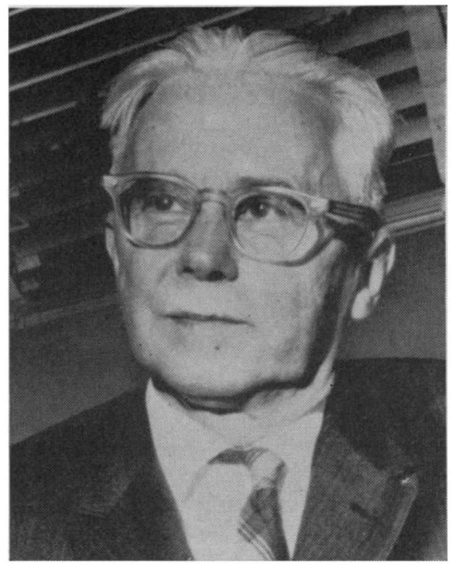
Haldan Keffer Hartline

By the methods of comparative physiology, or of experimental biology, by the choice of a suitable organ, tissue or process, in some animal far removed in evolution, we may often throw light upon some function or process in the higher animals, or in man.

This prophetic remark by the noted biophysicist A. V. Hill, in 1929, is an almost perfect characterization of the four decades of research on vision by Haldan Keffer Hartline, which began at about that same time and for which he has just been awarded the Nobel prize.

Since 1953, Hartline has been professor of biophysics at the Rockefeller University. He received his M.D. at the Johns Hopkins Medical School in 1927,


Haldan Keffer Hartline

remained there for 2 years as a National Research Council fellow and then undertook the study of physics as a Johnson Research Scholar at Leipzig and Munich. Subsequently, he joined the Johnson Foundation for Medical Physics at the University of Pennsylvania, beginning a long and fruitful association with D. W. Bronk. It was there that he first met Ragnar Granit and also became associated with Clarence H. Graham. At about the same time, Hartline became acquainted with George Wald during a summer at the Marine Biological Laboratory at Woods Hole.

Hartline remained at The Johnson Foundation (except for 1 year at the Cornell University Medical College in New York) and then in 1949 moved to the Johns Hopkins University as professor of biophysics, and finally, in 1953, to the Rockefeller Institute. Hartline is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, and the American Philosophical Society, and a Foreign Member of the Royal Society. His honors and awards include the Howell award, the Warren medal, the Michelson award, and an honorary Sc.D. from Lafayette College, where he did his undergraduate work.

Haldan Keffer Hartline (known by his friends and colleagues as Keffer) was born in 1903 at Bloomsburg, Pennsylvania, the son of a biologist at Bloomsburg State College. He married Elizabeth Kraus in 1936. Their three sons, Daniel Keffer, Peter Haldan, and Frederick Flanders, are all doing graduate work now in biology.

Hartline loves the out-of-doors. When younger, he enjoyed mountain climbing in the Wyoming Rockies and piloting his own open cockpit plane about the country. He has also engaged in the supposedly less dangerous sport of sailing, with Bronk near their summer homes at Mt. Desert, Maine, and, on occasion, with Ragnar Granit in the Baltic.

Hartline is a rather shy and unassuming man who guides the efforts of his co-workers and students with a gentle hand. His laboratory, once described as "a slightly disorganized but extremely fertile chaos," contains antique but perfectly functioning devices of his own design along with the latest electronic instruments—all interconnected, within rooms and between rooms, by a tangle of wires and cables. His early technique of dissecting the optic nerve by hand is still in use—but he does not make a fetish of old ways; he is one of the few scientists of his generation who write their own computer programs.

Hartline's research in vision began in 1923—at the age of 20—while he was still an undergraduate at Lafayette. This research (a study on phototropic reactions of land isopods) came to the attention of Jacques Loeb and Selig Hecht; their early interest in his work, and their ideas on the rigorous application of quantitative physical and chemical methods to the study of biology had a significant and lasting influence on Hartline's career.

Using an Einthoven string galvanometer, Hartline began his electrophysiological research with an investigation of the retinal action potentials in living animals. His method for recording from the intact human eye showed the feasibility of studying simultaneously the electrical events in the eye and the visual responses of the human subject and, thus, of determining the relations between them. From this early work and that of other pioneers in the field, including Granit, modern experimental and clinical electroretinography has developed.

The first records of activity of the optic nerve were obtained in 1927 by Adrian and Matthews. In their early work (on the eye of the eel), they were able to record only the massive discharge of the whole nerve trunk. However, Adrian and his co-workers, Bronk and Zotterman, were able to record the activity of single nerve fibers in other parts of the nervous system. Inspired by their successes, Hartline and Graham undertook similar studies

NEWS IN BRIEF

• **MARIJUANA AND ALCOHOL:** A statement by James L. Goddard, commissioner of the Food and Drug Administration, in which he equated the perils of marijuana and alcohol has resulted in a barrage of criticism and several demands for his resignation. Goddard, speaking at a press conference at the University of Minnesota on 18 October, said "whether or not marijuana is a more dangerous drug than alcohol is debatable—I don't happen to think it is." He added that he favored removal of all penalities for simple possession of marijuana, but not the complete legalization of the drug. He stated more research is needed on the chronic use of marijuana. The day following Goddard's remarks, Congressman Dan Kuykendall (R–Tenn.) called for Goddard's resignation, as did Robert W. Baird, director of a Harlem narcotics clinic. Kuykendall told the House that Goddard "should be prevented from using the prestige of a high federal office to encourage delinquency and the smoking of pot by others outside his family." While critics were assailing him, Goddard issued a statement of clarification in which he said, "The statement that marijuana may not be more hazardous than alcohol can be misleading to those who are not familiar with the hazards of alcohol. It is estimated that there are 11,000 deaths from alcohol each year—and most experts regard that as a conservative figure."

• **JOINT ENVIRONMENTAL INSTITUTE:** The Environmental Science Services Administration and the University of Colorado have formed a cooperative institute in the environmental sciences. The new institute is under the direction of a steering committee headed by George Benton, director of ESSA's Institutes for Environmental Research.

• **CELL SCIENCE CENTER:** Plans for the construction of a $1.8-million Cell Science Center at Lake Placid, N.Y., have been announced by the Tissue Culture Association. After completion in mid-1969, the facility will be the permanent center for the association's summer course in cell culture as well as for training activities, conferences, and seminars. A full-time staff of about 14 persons, including a director and two professional associates, is planned. Space in the laboratory will be available most of the year for visiting scientists. The center will be built on a 32-acre site donated by Mrs. W. Alton Jones, widow of W. Alton Jones, former chairman of the board of the Cities Services Company. Construction funds are being provided by a grant from the W. Alton Jones Foundation.

• **PEACE CORPS PHYSICIANS:** Because the new draft law no longer allows military deferments for Peace Corps physicians, the corps has started an intensive nationwide campaign for doctors to care for its overseas volunteers. Physicians previously were assigned to the corps by the U.S. Public Health Service (PHS). They could fulfill their 2-year military obligation with either the corps or PHS. "In the past, we had up to 400 doctors who were completing their internships who asked for this appointment," said Stanley C. Scheyer, director of the Peace Corps' Office of Medical Programs. "We've had over 400 inquires this year but now that the draft exemption is gone, we've been receiving letters from applicants saying they can't take two years out of their lives to serve in the Peace Corps and then another two years for military service."

• **UNIVERSITY BANKRUPTCY:** The nation's colleges and universities have failed to make their need for public funds known and as a consequence face "imminent bankruptcy." McGeorge Bundy, president of the Ford Foundation, made the remarks on 13 October during the American Council of Education's annual meeting in Washington, D.C. He asserted, "We have no choice but to seek a drastic increase in the levels of public support for both private and public institutions." He attributed the plight of the institutions to an absence of clearly stated facts and figures about the financial crisis and to the esteem in which universities have been held during a 20-year period of expansion. "We come before the country to plead financial emergency at a time when our public standing has never been higher," he stated. "It is, at least in one way, an unhappy accident of timing."

on the optic nerve of the horseshoe "crab" *Limulus*. The compound eye of this venerable animal, with its large photoreceptors and long optic nerve, was ideally suited for the study, and, in 1932, they were able to record—for the first time—the activity of single optic nerve fibers.

Their research showed that all impulses transmitted by an optic nerve fiber are essentially identical, and that information about the intensity of the light incident on the photoreceptor is coded in terms of *frequency* of the discharge of impulses, rather than in terms of the shape or amplitude of the impulses themselves. (Such "all-or-none" character is typical of the propagated impulses in all single nerve fibers.)

This technique also provided a method for studying the physical and chemical events in the photoreceptor that give rise to the nerve impulses. For example, in 1935 Graham and Hartline used it to determine the spectral sensitivity of the *Limulus* photoreceptor. The results obtained with this method and those obtained recently by Hubbard and Wald, who extracted the photopigment from the eye of *Limulus* and determined its spectral absorption by direct methods, agreed almost point for point.

These and numerous other experiments on the eye of *Limulus* had many implications for the study of human vision, which psychologists were quick to recognize, and on which they based parallel psychophysical experiments. They also "adopted" Hartline himself when they awarded him the Warren medal for his studies on light and dark adaptation, for the medal carries with it honorary membership in the Society of Experimental Psychologists.

Early extracellular records of retinal activity gave tantalizing glimpses of the "generator potential." But it was not until improved microelectrode and vacuum tube amplification techniques became available and were applied to this problem by Hartline and his associates at Johns Hopkins University—about 1950—that clear-cut records of the intracellular electrical activity could be obtained.

These techniques enabled them to study the photoreceptor as a biological transducer, relating nerve impulses to generator potential and generator potential to the light incident on the photoreceptor. Exactly how the photochemical events in the receptor give rise to the generator potential and it, in turn, to impulses remains one of the major problems in visual physiology—a problem still under intensive study in Hartline's laboratory and in many others.

One of Hartline's most significant contributions was his study, begun in the late 1930's, of the retinas of cold-blooded vertebrates. With an exquisite technique of microdissection, Hartline was able—this also for the first time—to isolate single optic nerve fibers of the vertebrate retina and record their activity. He found that the response of the whole nerve, observed a decade earlier by Adrian and Matthews, resulted from the summated activity of fibers whose individual responses differed markedly. Some discharged steadily in response to steady illumination, some in response to the onset and cessation, others only to the cessation, of illumination. Exquisite sensitivity to moving patterns of light and shade characterized many of these fibers. This demonstration that the processing of visual information begins in the retina with the specialized activity of diverse types of ganglion cells was fundamental.

Equally important for the modern theory of vision was Hartline's research on the "receptive fields" of optic nerve fibers (the term borrowed from Sherrington's analyses of reflex activity). He mapped these fields in detail, showing that a retinal ganglion cell can receive excitatory and inhibitory influences over many convergent pathways from many photoreceptors. The optic nerve fiber arising from the retinal ganglion cell is simply the final common pathway. As Hartline remarked in his Harvey Lecture (1942), "The study of these retinal neurons has emphasized the necessity for considering patterns of activity in the nervous system. Individual nerve cells never act independently; it is the integrated action of all the units of the visual system that give rise to vision."

The past decade or so of Hartline's research has been devoted mainly to this very problem. He found, in 1949, that even in the primitive eye of *Limulus* there is an interplay of excitation and inhibition. It was later found that this interaction molds the spatial and temporal patterns of activity so that information about certain significant features of the retinal image tend to be emphasized. For example, strongly illuminated receptors inhibit the activity of receptors in adjacent dimly illuminated regions more than the latter inhibit the activity in the former; thus border contrast is enhanced. The compound eye of *Limulus* has provided an especially favorable reputation for the analysis of the functional properties that arise from inhibitory interaction in a neural network. In recent years, these integrative interactions have been analyzed in detail by Hartline and his associates and expressed in quantitative forms.

These basic processes of integrative action observed in the eye of the ancient horseshoe "crab," although "far removed in evolution," are surprisingly like those in higher animals and man.

The study of vision is just as vital and organic a process as is vision itself, and Wald, Granit, and Hartline have always recognized the interdependence of their separate contributions and those of other workers as well.

They have also always been generous in sharing the credit for advances in the field with their many colleagues, co-workers, and students, who could not be mentioned in these brief notes.

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Federal Economizing: House Votes To Take It Out of R&D

The scene was the House of Representatives. At issue was no less an item than authority for the U.S. Government to continue to pay the bills of dozens of agencies whose appropriations were late in clearing Congress—among them NASA, the Department of Labor, the State Department, the Department of Health, Education, and Welfare, NSF, the foreign aid agency, and the Commerce Department. It was 3 October, and if approval did not come out of Congress by 23 October, there would be no choice but for the Treasury Department to turn off the check-writing machines for the above-cited agencies as well as a good many others.

And there, holding the floor, was Representative Wayne Hays (D–Ohio), telling his colleagues about his farm in Belmont, Ohio. "We have a policy there," he explained, "that we only save about two of the best bull calves for breeding purposes, and the rest of them are made steers and eventually wind up in the butcher shop. And while I was riding around thinking about this, it occurred to me that . . . if I were President of the United States I could not think of a better present that I would like the Congress to give me than a $5-billion goldplated castration knife—and do not think I would not know where to cut."

On that day, the House apparently visualized the implications of following Hays's metaphor to its conclusion, for when the vote came (on a procedural issue) it was 213 to 205 against so equipping Lyndon Johnson to cut $5 billion. But that was on 3 October, and, since then, the lower chamber of the U.S. Congress has put on a series of performances that, though assuring the financing of the affected agencies at least until mid-November, provide little ground for certainty as to what the U.S. Government will be financially able to support in the coming year. This uncertainty applies right across the board, with the exception of the Vietnam war, which has a blank check. But, as it turns out, the uncertainty is thickest in the area of research and development, which, among all areas of federally supported endeavor, was singled out as especially ripe for vigorous chopping.