NATIONAL ACADEMY OF SCIENCES

RALPH WALDO GERARD

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A Biographical Memoir by

SEYMOUR S. KETY

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RW Gerard

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DURING THE MIDDLE DECADES of the twentieth century, study of the nervous system became a major component of biological research, growing from a strong base in morphology and physiology to involve all of the biological and behavioral sciences. It was not by chance that this development coincided with the time and span of Ralph Gerard's scientific career, for he was one of a small number of intellectual leaders who brought it about.

Born in Harvey, Illinois at the beginning of this century, Ralph Gerard was blessed with an uncommon intellectual endowment, a heritage that has traditionally held scholarship and ethics in high regard, and a remarkable father who nurtured his scientific curiosity. His father, Maurice Gerard, who had come to America from Central Europe after receiving a degree in engineering in Britain, was a self-employed consultant to industry. He named his son after Emerson, whom he admired, and saw for him the career in pure science that he had been unable to pursue. From his father, Ralph Gerard also gained an appreciation of mathematics and of chess, showing particular aptitude for the latter, so that in his teens he beat the American champion and the world champion at different times when they were playing simultaneous matches in Chicago.

He completed the four-year course at Chicago's Hyde Park High School in two years, by passing examinations in subjects he already knew or had taught himself outside of class.

He entered the University of Chicago at the age of fifteen, where he took at least one course in every one of the sciences offered and in most of the other disciplines besides. In this way, the natural genius and irrepressible interest that had been stimulated and reinforced by his father was broadened, undoubtedly contributing to his comprehension of many fields as a scientist and his unique ability to compound and integrate that knowledge with ever-widening scope. He was strongly influenced by Julius Stieglitz in chemistry, and by Anton Carlson and Ralph Lillie in physiology and neurophysiology. He received his doctorate in physiology in 1921. Shortly thereafter, he married Margaret Wilson, who had just completed her doctorate in neuroanatomy, and together they finished their medical training at the Rush Medical College in 1925. Margaret Wilson Gerard went on to train in pediatrics and psychiatry and to become an outstanding scholar and practitioner of child psychiatry until her death in 1954.

Ralph Gerard took an internship at the Los Angeles General Hospital, at the end of which he was faced with what he felt was the major career decision of his life. He was offered a much-coveted residency in medicine at the same time that he was awarded a National Research Council fellowship in neurophysiology and neurochemistry. He accepted the research fellowship. In an interesting revelation of his restive nature and lack of complacency, he recalled that decision at times with some misgiving, even after achieving worldwide acclaim as a neurophysiologist.

The research fellowship launched him most propitiously on his career in neuroscience. With A. V. Hill and Otto Meyerhoff, two giants in biophysics and biochemistry, respectively, he carried out pioneering research leading to the recognition that the conduction of the nerve impulse depended on biochemical processes along the nerve. When he returned to the University of Chicago in 1928, he was faced with another major decision. An offer by Carlson of an appointment in physiology was more than matched by Dallas Phemister, who was in the process of establishing the Department of Surgery in the new Medical School there. Again he chose physiology and remained in that department for twenty-five years. His laboratory there, which encompassed all of the promising neurobiological disciplines, trained a large number of graduate students and postdoctoral fellows, several of whom were later to become leaders in neuroscience.

In 1952 Gerard was asked to develop and direct the research laboratories of the Neuropsychiatric Institute of the University of Illinois, and he spent the next two years organizing a multidisciplinary research program that brought neurology and psychiatry more closely together, as well as the fundamental disciplines that sustain them both.

After the death of Dr. Margaret Gerard, he accepted an invitation from Ralph Tyler to join the first group of distinguished fellows of the Center for Advanced Study in the Behavioral Sciences, which had been established adjacent to the campus of Stanford University.

During the preceding sixteen years, while he was engaged in some of his most significant contributions to neurophysiology, he found time to contemplate and address philosophical and social problems that lay beyond neuroscience. He published "The Role of Pure Science" in 1938, "Organism, Society and Science" in 1940, "A Biological Basis for Ethics" and

"Higher Levels of Integration" in 1942, "Extrapolation from the Biological to the Social" in 1945 and, in 1946, "The Biological Basis of Imagination."

At the Center in Palo Alto, Ralph Gerard's interest in the behavioral and social sciences expanded further in what must have been exciting interactions with Anatol Rapoport, Clyde Kluckhohn, Franz Alexander, Paul Lazarsfeld, and Alex Bavelas, from which emerged "Biological and Cultural Evolution" in 1956 and, in 1957, "Problems in the Institutionalization of Higher Education."

In January 1955 he married Leona Bachrach Chalkley, whom he had known since high school when they were captains of opposing debating teams. "Frosty," as he preferred to call her, in addition to being a skilled debater, is an accomplished writer and poet. In the course of the fellowship year at the Center, another salutary event occurred when James Miller invited Gerard to join him and Anatol Rapoport in founding the Mental Health Research Institute at the University of Michigan, and Ralph Gerard spent many hours discussing with Anatol Rapoport the possibility of creating a new and broader consortium of sciences dedicated to the study of behavior. Convinced of the sincerity and commitment of the Commonwealth and University of Michigan to this important concept, he accepted this opportunity and spent more hours with Miller, planning the philosophy and scope of the new research institute.

Ralph and Frosty spent the next nine years at Ann Arbor, where he was professor of neurophysiology and director of the Institute's laboratories. During that time the Mental Health Research Institute grew from imaginatively conceived plans to one of the outstanding behavioral and psychiatric research centers in the nation, with a scope that embraced fundamental neurochemical and physiological research, the behavioral sciences, and information processing. He devoted the bulk of his research efforts during that time to organizing and leading a multifaceted study of schizophrenia, the most important of the mental illnesses in terms of loss of fulfillment to the individual and family and cost to society.

At the age of sixty-four, when some might have thought of retiring, Ralph Gerard instead accepted a new and broader challenge, moving to the new Irvine campus of the University of California as professor of biological sciences and dean of the Graduate Division. This enabled him to revive the imaginative interest in teaching and educational philosophy that earlier had made him one of the most stimulating contributors to the new concepts of undergraduate education introduced by Robert Hutchins shortly after Ralph Gerard's appointment to the University of Chicago. At Irvine he continued his nurture of neuroscience, participating in the establishment of the important Department of Psychobiology. Most of his energies and wisdom, however, were devoted to the wider fields of education, science, society, and the social aspects of medicine.

At the age of seventy he retired to throw himself fully into civic affairs. At the same time his wife and his colleagues became concerned over some changes in his personality and some slowing of his intellectual functions. An intracerebral tumor was discovered, but even for this ominous situation, his remarkable brain found a salutary resolution. The tumor turned out to be a benign meningioma, which was removed successfully and with complete recovery. Frosty has related a remarkable incident at that time that describes his indomitable spirit: "Service for a year on the Orange County Grand Jury meant so much to him that two days following the neurosurgical operation, and while he still remained in the hospital's intensive care unit, he insisted on dictating to me a letter to the Grand Jurors. He wrote them about his feelings when tests had revealed the existence of a massive tumor. If further tests had suggested that the mass was malignant, he would have refused to undergo surgery and merely awaited the end. Instead, a benign tumor was indicated, he had taken his chances, and won. He wanted them to know that he was eager to rejoin them and to carry his share of the load. Two months later he was among them." For the next three-and-one-half years Ralph Gerard remained active; he died of coronary insufficiency in 1974.

Ralph Gerard was elected to the National Academy of Sciences and to the American Academy of Arts and Sciences in 1955. He was the recipient of numerous honors and awards. Honorary degrees were bestowed upon him by the Universities of Maryland, Leiden, and St. Andrews, and by Brown University and McGill University. He was awarded the Medal of Charles University and the Order of the White Lion in Prague in 1946, the Stanley Dean Award in 1964, the Alumni Medal of the University of Chicago in 1967, and the Extraordinarius Award of the University of California at Irvine, posthumously. He was a Distinguished Fellow of the American Psychiatric Association and an Honorary Fellow of the Royal Society of Edinburgh. A long list of honorary lectureships in this country and abroad attests to his international esteem and his brilliance as a speaker. He was a consultant to numerous research arms of the federal government, including the Office of Naval Research, the National Institute of Mental Health, and the National Science Foundation, and an advisor to numerous private foundations.

Ralph Gerard was so extraordinary a man that he became a legend during his lifetime. His intellectual power was his outstanding characteristic, expressed early on by scholastic precocity, in mid-career by creative insights and the careful execution of crucial experiments, and at the end of his career in encyclopedic erudition and wisdom. His knowledge of the scientific literature, perceptiveness, and ability to synthesize observations in a great variety of disciplines, coupled with an almost poetic fluency in articulating and crystallizing issues, made him highly regarded as a teacher and as a summarizer of scientific conferences, in which he was undoubtedly one of the world's leaders for several decades. He also possessed a remarkable sense of humor and a comparable fund of anecdotes, which were always to the point. Among his physical characteristics, more striking than his portly figure and bald pate, were his eyes, which have been described as "bright and restless—the visible edge of a keen and probing mind . . . eyes that showed by their sparkle not only the excitement of discovery, but also a reflection of profound awe before the intricacy and complexity of the natural order."* These attributes will remain in the memories of his students and colleagues and all who knew him, but his most enduring legacy will be in his contributions to science, and particularly to neuroscience. During the twenty-five years that he devoted to laboratory research, he was responsible for a remarkable number of pioneering insights and discoveries that opened up areas of neurobiological research that are far from exhausted today.

Ralph Gerard aptly described the motivation and significance of his scientific career as a commitment to "the minute experiment and the large picture."† His contributions fulfilled that commitment generously, for they demonstrate his remarkable ability to design and conduct rigorous research that crucially examines a specific hypothesis. They also epitomize his vision, imagination, and courage to perceive the implications of the experimental results to the broad picture

*The Reverend Edward P. Allen, remarks on the occasion of a memorial convocation, University of California at Irvine, 7 March 1974.

†R. W. Gerard, "The Minute Experiment and the Large Picture," in *The Neurosciences: Paths of Discovery*, ed. F. G. Worden, J. Swazey, and G. Adelman (Cambridge, Mass.: MIT Press, 1975), pp. 456–74.

that would eventually emerge. He was both an architect of neuroscience and a stone carver.

He attributed his enduring interest in the nervous system to a brief encounter with Anton Carlson, his professor of physiology, while a student at the University of Chicago. Gerard successfully defended his unwillingness, on logical grounds, to draw the accepted conclusion from a laboratory experiment that had for years been used to demonstrate the nonfatigability of nerve. Carlson appreciated the wisdom in what a lesser man might have seen as brashness, took a continuing interest in young Gerard, and, several years later, recommended him for the National Research Fellowship he was awarded in 1925.

That fellowship permitted him to participate in A. V. Hill's classical demonstration of heat production by nerve and to make his first major discovery in the delayed heat production that follows a period of stimulation. Gerard described those observations at Hill's suggestion at the International Physiological Congress in Stockholm in 1926 and in his paper on "The Two Phases of Heat Production of Nerve" in 1927. He had found that of the total quantity of heat attributable to a period of stimulation, only 11 percent was released during the stimulation, the much larger moiety being liberated over a period as long as ten minutes immediately following the stimulation.

Although the heat generated in muscular contraction had been demonstrated and measured for a long time, the much smaller amounts associated with nerve conduction had remained elusive. Hill, thirty-three years after this successful demonstration, recounted his many previous unsuccessful attempts and those of others going back to Helmholz's first attempt in 1848, explaining its importance:

> Why did people go on trying to measure the heat production of nerve, in spite of repeated failure? Chiefly, I suppose, in order to settle the

question of whether the nerve impulse is the sort of physical wave in which the whole of the energy for transmission is impressed on the system at the start. . . . If it could be shown that heat really was produced all along the nerve during transmission, then the purely physical theory of conduction would be untenable. A distributed relay system would be required, with energy derived presumably from chemical change.*

During the second year of his fellowship, Gerard moved to the laboratory of Otto Meyerhoff in Berlin in order to examine some of the chemical processes involved in axonal transmission and the differences he surmised would exist during stimulation and recovery. With the use of specially prepared chambers of small size, he was able to measure the oxygen consumed and the carbon dioxide released by a segment of nerve at rest and during stimulation. He found that whereas the resting oxygen consumption of nerve and muscle were equal, the increase during stimulation in muscle was 8,000 times greater than that achieved in nerve. In addition, he measured the temperature coefficient of the oxygen metabolism in nerve and its respiratory quotient at rest and during stimulation, and found evidence for the development of an oxygen debt in nerve during anoxic stimulation.

The increased oxygen consumption of stimulated nerve was soon challenged as an artifact resulting from unphysiological stimulation rather than the physiological activity that resulted. F. O. Schmitt was able to counter that criticism by demonstrating that the oxygen consumption was correlated with the number of transmitted impulses rather than the amount or intensity of the stimulation. Then, in the summer of 1933, Gerard and H. K. Hartline established that physiological transmission alone accounted for the increased oxygen consumption:

Hartline and I agreed to test this out on the *Limulus* optic nerve,

*A. V. Hill, "The Heat Production of Muscle and Nerve, 1848–1914," *Annual Review of Physiology*, 21 (1959):1–18.

isolated along with the attached eye. The first attempt, using small Warburg vessels, was clearly far below the required sensitivity; but the problem was solved that same night by threading the optic nerve into a capillary through a Vaseline seal, the eye being outside and the far end being closed with a measuring drop. Two such capillaries in a large closed test tube in a thermostat were arranged so that light could be shined on the eye of either nerve, and each one thus constituted a control for the other. The movement of the index drop was followed with an ocular micrometer minute by minute. The oxygen consumption when "natural" nerve impulses were carried was established, and a valuable microrespirometer became available. Since our time commitments were such that we had less than a week to work together, experiments were continued day and night and neither of us was out of his clothes for the entire period.*

With H. M. Serota he looked for a similar coupling of metabolism to functional activity within the mammalian brain, where, unfortunately, the elegant technique he had used on the optic nerve was inapplicable. Using temperature, the only approach available to them, but which they could measure accurately, they inserted five thermocouples into particular structures by means of a stereotaxic instrument. They recognized that a change in temperature accompanying functional activity at a point within the brain could be the result either of altered metabolism or altered perfusion. They also reasoned that where the temperature of the blood and brain was the same, a sudden increase in temperature was likely to indicate the liberation of metabolic heat. Recording temperature changes and electrical activity, they were able to demonstrate an increase in both in the optic radiations, the lateral geniculate, and the visual cortex upon illumination of the eye. It was not until forty years later that Louis Sokoloff succeeded in conclusively demonstrating the highly localized increased metabolism that accompanies functional activity in the visual system.

* R. W. Gerard, "The Minute Experiment."

In 1931 Gerard carried out an imaginative series of experiments with D. D. Cook on the phenomenon of axonal degeneration. They reasoned that a nerve degenerates beyond a cut either because that portion is no longer stimulated, or because an important nutrient flow of chemical substances down the fiber is stopped. They tested the first possibility by chronically stimulating a cut sciatic nerve with buried electrodes and observed that the nerve lost its function even more rapidly when stimulated than when at rest. They concluded: "Degeneration of a nerve process isolated from its cell body might be due to lack of impulses conducted by it or of necessary substances spreading along it. The evidence (here) considered favors the second possibility."* This was perhaps the first suggestion, supported by experimental evidence, for the important process of axonal flow, which Paul Weiss was able to demonstrate thirteen years later. In 1951, employing isotopically labelled phosphorous, Ralph Gerard and four collaborators made the first measurements of the flow of a chemical substance, phosphoprotein, down nerve trunks, which occurred at a rate of 3 millimeters per day.

In 1940, with Oscar Sugar, Gerard tackled the controversial subject of regeneration in the transected mammalian spinal cord. Using immature animals, impeccable surgical techniques, and following a suggestion of Cajal by implanting pieces of peripheral nerve to serve as a scaffold on which the sprouts might climb, they provided the first demonstration that functional as well as structural regeneration could take place. Because of the prevailing belief that regeneration was impossible in the mammalian spinal cord, the report received scant attention. In summarizing a conference on the subject thirty years later, Gerard was able to take some satisfaction

* R. W. Gerard and D. D. Cook, "The Effect of Stimulation on the Degeneration of a Severed Peripheral Nerve," *American Journal of Physiology,* 97 (1931):412–25.

from the new evidence presented, commenting that "Today the question is rather 'how,' not 'if.'"* Expressing a note of optimism, he congratulated William Windle for having kept the spark alive.

In 1933, 1934, and more completely in 1936, Gerard published, with Wade Marshall and Leon Saul, the results of research that opened a new chapter in neurophysiology and made possible the systematic mapping of the mammalian brain by Clinton Woolsey, and of the human brain by Wilder Penfield. Recognizing the power of recently developed tools—the oscilloscope, powerful amplifiers, and sterotaxic instruments for precise localization—they proceeded to explore the cat brain for spontaneous activity in its various regions. Using what they called "evoked potentials," they were able to trace the pathways by which particular sensory stimuli proceeded to the cortex and to follow their ramifications and ripples into quite unexpected regions. With the cooperation of two neurosurgeons, it was possible to demonstrate evoked cortical potentials at the operating table—the first demonstration of what was to become a powerful clinical tool for the diagnosis and further understanding of disturbed cerebral function.

With Benjamin Libet in 1939 and 1941, Gerard published the first experimental observations of steady potentials in the brain and their potential relationship to excitability patterns and the form of brain waves. They also demonstrated that spread of neuronal activity need not necessarily be mediated by the usual synaptic transmission. Caffeine-induced epileptiform waves were shown to travel across a complete transection of the frog brain. It became apparent that extracellular fields of electric current flow could provide a significant mode of neuronal interaction and synchronization. Addi-

*R. W. Gerard, "Summary of the Paraplegia Conference, Palm Beach, Florida, May 1–3, 1972," R. W. Gerard Collection, University of California at Irvine.

tional studies on isolated frog brain and fragments thereof showed that spontaneous rhythmicity in brain tissue could be a function of localized neuron groups and their immediate ionic environments. As a result of these and his earlier observations, Gerard developed the now generally accepted concept that the electroencephalogram represents the summation of envelopes of slow potentials rather than neuronal spikes.

Although these remarkable contributions were made with the existing Adrian-Bronk concentric electrodes or with other macroelectrodes, Gerard was convinced that a true microelectrode could be developed that might record the physiological activity of individual neurons in the brain. When Judith Graham joined his laboratory as a graduate student a few years later, she began work on that goal by pulling fine glass capillaries. Gerard traced the idea behind this to what was probably his first research project, imaginatively inspired and ingeniously executed while he was an undergraduate at Chicago. From George Bartelmez, the professor of histology, he learned about myofibrils and the continuing controversy over whether they were real or fixation artifacts. He suggested to the professor "that if a quartz needle was moved steadily across a living muscle fiber, the tip would move smoothly if the protoplasm was homogeneous but in a sort of cogwheel fashion if viscous fibrils were embedded in fluid sarcoplasm, and this could be followed by reflecting a beam of light from a mirror attached to the needle."* Bartelmez was enthusiastic and presented Gerard with the original micromanipulator that had been developed in the department by Kite. "It was a museum piece but it still worked and I had a lot of fun learning micromanipulation and that protoplasm was a more complex thing than I

* R. W. Gerard, "Informal Talk by an Old-timer" (lecture of 30 March 1972), R. W. Gerard Collection, University of California at Irvine.

thought." He did not solve that problem but the experience was invaluable later on to him and to neurophysiology.

Judith Graham was able to draw capillaries down to a diameter of several micra, fill them with a conducting potassium chloride solution, insert them into individual muscle cells, and record the intracellular potential. In their publication of the findings in 1946, Graham reported an average membrane potential of 62 mV but with a large range (41–80 mV). They felt that the variation was due largely to the injury of insertion, since the finest electrodes gave smooth penetration under the microscope and also the highest readings.

Gilbert Ling, who was also a graduate student in the laboratory at that time, began to work on the problem and after two years found that it was possible to make finer micropipettes, considerably less than one micron at their tip and with a taper gentle enough that the tip would not break off. These could be inserted into a muscle cell without any indication of injury. Using these, Ling and Gerard were able to report in 1949 a membrane potential (78 ± 5 mV) consistently at the high range that was previously obtained. Alan Hodgkin, attending a meeting of the American Physiological Society, was much impressed by these microelectrodes, came to observe their manufacture and application, and asked permission to take one back to Cambridge. There he modified it by increasing the concentration of electrolyte and adding a cathode follower, which made it capable of recording the rapid changes in potential that accompany action spikes in single cells. John Eccles applied the microelectrode to studies of activity of individual units within the spinal cord and brain and Andrew Huxley used it in muscle cells.

It would be difficult to exaggerate the important role that the capillary microelectrode has played in neurophysiology in the thirty years since its development. It made possible the neurophysiological research for which several Nobel Prizes have been awarded, and many of the most exciting advances that have occurred in the past two decades regarding neuronal activity in sleep, sensory processing, voluntary muscular movements, and attention—to name just a few—could not have occurred at the time without it.

Ralph Gerard indicated more than once that he did not consider the development of the microelectrode to be his most important contribution. This may have been because of its technical rather than its conceptual nature. It was the quality of imaginative and prescient conceptualizations, such as those that underlay his research on memory, of which he was most proud.

In his Gregory Lecturé on "Physiology and Psychiatry" in 1948, Gerard proposed a concept of memory that was to become the basis of his experimental work in the field and that, today, remains the most plausible and heuristic model that we have:

> All is not over when an impulse flashes across a synapse and on to its destination. It leaves behind ripples in the state of the system. The fate of a later impulse can thus be at least a little influenced by the past history of the neurons involved. . . . Reverberant circuits, in principle, could last indefinitely, but in practice their duration is doubtful. . . . Perhaps there is a short-lasting active memory, depending on circuits, and a more enduring static one.*

In a later series of ingenious experiments, it was possible to show that by interrupting or confounding the electrical activity of the brain by induced hibernation or electroshock, recently acquired memories would be erased while those that had been formed an hour or more before would persist. He surmised that in a brief critical period following a learning experience, the memory was transformed from a dynamic

*R. W. Gerard, "Physiology and Psychiatry," *American Journal of Psychiatry,* 106 (1949):161–73.

representation in electrical activity through some chemical process to a more permanent molecular, physiological, or morphological state. In 1963, with T. J. Chamberlain and P. Halick, he tested this concept in an experiment that had all of the elegance and simplicity of Claude Bernard's demonstration of the site of action of curare. They found that the postural asymmetry produced by a unilateral cerebellar lesion induced in less than one hour a persistent asymmetry in function at the level of the lower motor neuron. In further experiments with G. H. Rothschild, evidence was adduced that this process could be facilitated by an agent that stimulated RNA synthesis and was retarded by drugs that inhibited that process. There have been thousands of experiments carried out since that time with more sophisticated physiological and biochemical techniques and the general thrust of all of the research has been to support the idea that short-term memory is consolidated in long-term memory by means of chemical processes, and that in that process RNA and protein synthesis may play essential roles.

Gerard was also proud of his contributions to psychiatry in recognition of which he was made a distinguished fellow of the American Psychiatric Association. His contributions here were not at the level of the minute experiment but of the large picture. Indeed, he played an important role in fostering the development in psychiatry of critical and judicious scientific approaches. In the Gregory Lecture, he commented on the continuing controversy regarding the genesis of psychoses:

> The constitutionalists and the organicists and the environmentalists and the mentalists too often are quarreling with each other as to which of them has *the* cause. Now, it is obviously useful to find out that schizophrenics have abnormal capillaries in their fingers, that they had abnormal experiences in their childhood, and that they have abnormal individuals as parents or sibs; but one does not exclude the others and no one of them

can possibly be the whole story. . . . It is never sensible to ask the question "Does heredity or environment determine some characteristic?" It always takes both . . . and the meaningful question which is mostly not asked is a quantitative one.*

In his Academic Lecture at a convocation of the American Psychiatric Association (1955), he developed further the theme of etiologic and typologic diversity in mental illness:

> Many different etiologies may initiate the same train of pathogenic events; many different pathogenic sequences may produce a single pathology; and many different pathologies may still lead to a single symptom. . . . Can it be doubted that mental disease also presents symptoms and even syndromes which may subsume multiple nosologic entities and which are almost certainly based on multiple chains of abnormalities? †

Gerard prepared that lecture just before moving to the Mental Health Research Institute at the University of Michigan. During the eight years he spent there, he organized and directed a large multidisciplinary program that was to examine his concept of the heterogeneity of schizophrenia. On the basis of a small number of objective psychological, physiological, and biochemical measurements, it was found that seven typologies could be distinguished and characterized as well by clinical and behavioral observations.

Ralph Gerard's recognition of the importance of both genetic and environmental components in mental illness and the heterogeneity of the classical syndromes is by this time well established and has become part of the mainstream of modern psychiatry, where it has led to a more open-minded and less doctrinaire examination of plausible hypotheses that are not mutually exclusive.

It has been possible in the foregoing account to delineate

* *Ibid.*

† R. W. Gerard, "The Academic Lecture: The Biological Roots of Psychiatry," *American Journal of Psychiatry,* 112 (1955):81–90.

some of the peaks of Ralph Gerard's scientific work. There were other peaks as well, and all rose from a high plateau of phenomenal productivity extending over fifty years and more than 500 publications. By far the major portion of his dedication was to neuroscience, which he insisted was a single discipline. In a deep sense, the appreciation and command of biophysics, biochemistry, physiology, psychology, and psychiatry that his own career exemplified offered a clear validation of that thesis. He played an important role in establishing the Society for Neuroscience and at its founding meeting in 1969 he was elected honorary president by unanimous acclaim.

His large picture, however, was even larger than neuroscience. It embraced all of science and human imagination as well, which he once described as the culminating efflorescence of the process of evolution up to the present time. He was a strong exponent of the implications and responsibility of science to society, but a courageous mentor as well of the reciprocal responsibility of society to scientific freedom and growth. In 1952, in an important paper entitled "The Organization of Science," he wrote:

> It bears repetition . . . that the increase in organization is an inexorable trend in evolution; our problem is to fight the diseases and enhance the uses of interrelatedness. The great danger is authoritarianism and conformity. This can blight at any level from the petty bookkeeping practices of too many governmental agencies to the national murder of the free pursuit of truth. The Lysenko story in Russia and the earlier distortions under Hitler deserve the most careful attention by scientists. Although these represent excesses under totalitarian police states, the anlages of similar attitudes are clearly present in our country.*

Ten years earlier, he saw the relationship of science to society in a remarkable perspective which is even more pertinent today:

***Annual Review of Physiology*, 14 (1952):1–12.

These are the New Frontiers of mankind in the illimitable domain of the mind which science penetrates and scholarship consolidates. Change is often uncomfortable but it is exhilarating. Societies like animals must evolve or retrogress. Science, created by the social organism to sensitize itself to a fuller environment, is stirring and shaking the body politic with the birth pangs of the new. Men may suffer on the way—probably a caterpillar does not metamorphose painlessly into a butterfly—and the direction of travel is still obscure. But mankind is on the march somewhere, not vegetating into decadence. Science has brought and will bring men both weal and woe, mostly weal; and it is not destroying and will not destroy, rather it is enhancing those values of human society which we call civilization.*

That understanding and appreciation of science and its salutary role in social evolution was Ralph Gerard's enduring credo.

He died on February 17, 1974, survived by his son James and his wife Leona Bachrach ("Frosty") Gerard. A dedicated, creative, and compassionate person in her own right, she had made the two decades they spent together a happy and mutually enriching experience.

Many of his colleagues and former students have tried to put into words the unique qualities of Ralph Waldo Gerard. Perhaps Lord Adrian, who was his onetime mentor and longtime friend, stated it best: "There were few physiologists or philosophers with his understanding both of experimental techniques and of human aspirations."†

I AM GREATLY INDEBTED to Leona Bachrach Gerard, who shared with me her personal reminiscences, biographical memorabilia, and letters; to Benjamin Libet and Richard Thompson for notes on Gerard's scientific contributions; to Roger B. Berry of the Irvine University Library for complete bibliographies; and to Roxanne-Louise Nilan, who compiled the Gerard Microfiche Collection, for access to unpublished documents.

* R. W. Gerard, "Science at the Celebration," *University of Chicago Magazine*, 34 (1941):12–14.

† Lord Adrian to Leona Gerard, 10 March 1974.

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