

NATIONAL ACADEMY OF SCIENCES

CHANDLER McCUSKEY BROOKS  
1905—1989

---

*A Biographical Memoir by*  
KIYOMI KOIZUMI AND MARIO VASSALLE

*Any opinions expressed in this memoir are those of the authors  
and do not necessarily reflect the views of the  
National Academy of Sciences.*

*Biographical Memoir*

COPYRIGHT 2008  
NATIONAL ACADEMY OF SCIENCES  
WASHINGTON, D.C.



*Chandler Mc P. Brooks*

# CHANDLER McCUSKEY BROOKS

*December 18, 1905–November 29, 1989*

BY KIYOMI KOIZUMI AND MARIO VASSALLE

CHANDLER McC. BROOKS (elected to the National Academy of Sciences in 1975) was born in West Virginia on December 18, 1905, the son of a Presbyterian minister. His family was respected and loved by the people of the various communities in the area. This environment influenced Chandler very much in his early years, shaping the foundations of his philosophical approach to life, his sense of obligation, and his long-term aims.

When he was 12 years old, his family moved from West Virginia to Massachusetts. He was emotionally tested as an adolescent by the death of his mother, an event that drew him closer to his father. According to his own account, the schools he attended in the poor districts of Massachusetts gave him little education throughout his high school period. For his college education he turned to the Midwest, where he attended Oberlin College in Ohio.

The rough experience of precollege school was not entirely negative. Brooks wrote:

My experience with barbaric young people and an antagonistic community in my youth may have enabled me to be tough too and survive in Brooklyn for over a third of a century and administer my institution during the dark

days of the late 60's when faculties and students were in destructive revolt against the system and destroyed many presidents and deans. My parents and their beliefs typify what is essential to our culture and the preserving of man's greatest attainments.

Although Brooks considered entering the ministry, he liked athletics and science at college, majoring in zoology and taking courses in the classics, English literature, and history. His performance earned him Phi Beta Kappa membership. He was also a marathon runner during his college years, winning prizes and varsity letters.

Upon his graduation, Brooks was helped by an Oberlin professor in obtaining a fellowship in the Biology Department at Princeton University. It is of interest that he not only wished to study science but also philosophy and theology at the seminary in Princeton. Brooks's reason for this was that he saw the limitations of a single approach. He felt that scientists were too narrowly focused and philosophically naïve, while the ministry was unaware of scientific foundations and of what should be its broader obligations. Not surprisingly, that plan did not materialize due to opposition by both schools. He wrote, "I was unhappy at Princeton and did poorly until I met Dr. Philip Bard and became a physiologist." In spite of all that, Brooks completed his Ph.D. in biology at Princeton in only three years, in 1931.

Brooks followed Bard from Princeton to Harvard University, where Brooks was a fellow in the laboratory of Walter B. Cannon for two years. There he began his experimental studies on the neural control of the endocrine system, a research field still unknown to most scientists in those days. He went to Johns Hopkins University in 1933 when Bard moved there to become the chairman of the Department of Physiology.

At Johns Hopkins he worked and taught as instructor first, then as associate professor in 1941. In those years

Brooks's research spanned from the central control of the motor and autonomic nervous systems to the neural control of endocrine glands through the hypothalamus. These were very productive years for him, for he made many important contributions in all of those fields.

In 1946, as a Guggenheim fellow, Brooks went to Dunedin, New Zealand, to work with Professor John Eccles, who later became Sir John and a 1963 Nobel Laureate. Brooks later told us that at this point in his research on the central nervous system control of the endocrine system he needed more knowledge and experimental skills either in endocrine physiology or in neurophysiology. He wished to work with either Professor Bernardo A. Houssay in Argentina, the famous endocrinologist and a 1947 Nobel Laureate, or with Professor John C. Eccles, who was a leading neurophysiologist on the central nervous system. Professor Houssay advised Brooks not to come to Argentina, as Houssay was in trouble with the political regime in his country.

Following a 40-day trip by ship from New York to New Zealand, Brooks and his wife, Nelle, settled in Dunedin for two years. In Professor Eccles's laboratory Brooks wished to learn how to record the electrical impulses from neuroendocrine cells in the hypothalamus in order to understand how the nervous system controls the endocrine function through the pituitary. Brooks later told us that Professor Eccles immediately rejected the idea, saying, "Brooks, one cannot record electrical impulses from such cells; they are gland cells and not neurons; you better work with me on the spinal cord." So he did, and their work resulted in many significant papers published in the *Journal of Neurophysiology*. (The actual recording of electrical impulses from those hypothalamic neuroendocrine cells was accomplished in Brooks's own laboratory in the early 1960s.)

In 1948 Brooks was invited to become professor and chairman of the Department of Physiology and Pharmacology at the Long Island College Hospital School of Medicine, in Brooklyn, New York. In 1950 the school of medicine became the State University of New York Downstate Medical Center. Getting an “almost non-existent” department, Brooks, with his unique energy, talent, discipline, and vision, began to create and organize the new unit, hiring young faculty members to carry out research and teach medical students. He had the foresight to establish a visiting professor system, so that he could bring outstanding senior scientists to help establish the research activity by younger faculty in the department. He decided that the department would concentrate in at least two fields of research: neurophysiology and cardiac physiology.

The first visiting professor was Oscar Orias, who came from Argentina in 1949. Brooks knew Professor Orias, an expert in cardiac physiology, from Cannon’s laboratory at Harvard. Employing the open-heart preparation in dogs, Orias, Brooks, and associates began studies on cardiac excitability with help from an expert engineer recruited from Professor Eccles’s laboratory in New Zealand. This very first accomplishment led to international recognition of the department and to the publication in 1955 of the now classic, widely cited book *The Excitability of the Heart*. Around the same period Brooks and his associates began their pioneer work on intracellular recordings from heart cells, a brand-new field in cardiac research at that time.

In the field of neurophysiology, with the help of visiting professor M. G. F. Fuortes from Italy in 1950, the Brooks laboratory began electrophysiological work on the spinal cord in cats. These early accomplishments led to an invitation to contribute a review article “Excitation, Conduction

and Synaptic Transmission in the Nervous System” to the *Annual Review of Physiology* in 1952.

In 1956 Brooks made the decision to separate the Physiology and Pharmacology Departments. He continued as chairman of the Physiology Department and recruited Robert F. Furchgott to chair the new Department of Pharmacology. Professor Furchgott received the Nobel Prize in Physiology and Medicine in 1998.

Brooks’s research activity later expanded (in addition to cardiac physiology) to the autonomic nervous system and the neuroendocrine system. In regard to “the most important discoveries” in his long career as a physiologist, Brooks wrote:

It is somewhat difficult for me to identify my most important discoveries. I have always been a generalist and I have done work which I consider to have been significant in at least four fields as well as in history and philosophy of science. If I can lay claim to any uniqueness in accomplishment it is based on the number of important contributions to numerous fields rather than on one or two major discoveries.

His major accomplishments in four fields (autonomic nervous system, neurophysiology, neuroendocrinology, and cardiac physiology) are summarized below:

#### THE AUTONOMIC NERVOUS SYSTEM

His interest in the autonomic nervous system arose from his association first with Professor Walter B. Cannon at Harvard Medical School. (Brooks later held the symposium to commemorate Professor Cannon’s accomplishments, with Cannon’s former pupils and Cannon’s son as speakers. The presentations were published in 1975 in the book *Life and Contributions of Walter Bradford Cannon*). His major discoveries are: (1) studies of the somato-autonomic reflex (i.e., how the afferent impulses from the skin and muscle evoke electrical discharges in pre- and postganglionic fibers (autonomic ef-

ferents), causing various organ responses; (2) involvement of the autonomic nervous system in certain endocrine functions, namely, the adrenals and the pineal glands controlling the circadian rhythms; (3) autonomic control of the heart, particularly by direct recordings from the cardiac vagal and sympathetic nerves in various conditions, and their reciprocal and nonreciprocal actions on the heart; (4) interactions between the heart and hypothalamic neuroendocrine system that control the water balance in the body; and (5) development of the idea that the autonomic nervous system is the great integrator of body functions in that it participates in all functional activities and affects all body tissues and organs. Brooks greatly influenced this field by employing electrophysiological techniques in studying the autonomic reactions. This had been somewhat neglected during the 1950s and 1960s, since most autonomic work then was done only through the recording of effector organ responses.

#### NEUROPHYSIOLOGY

(1) His discovery in the 1930s that destruction of the hypothalamic ventromedian nuclei produced obesity in rats and monkeys opened the field for later intensive research. (2) The discovery of cortical locus of control of hopping and placing reactions raised the question of cortical localization and plasticity. (3) Studies of central inhibition and the role of Golgi II cells in the spinal cord carried out with J. C. Eccles have become a classic in the understanding of inhibitory processes in the nervous system. (4) In his electrophysiological studies on the spinal cord and midbrain, Brooks and his associates made a number of discoveries early that were developed later by others (e.g. studies on origins of the dorsal root reflex, evidence of presynaptic inhibition, effects of cold on the central nervous system and their mechanism [namely, changes in the accommodation process in single



motor neurons], long-lasting facilitatory influences exerted by the reticular formation on spinal neurons). This last observation has developed into the popular “LTP (the long-lasting tetanic potentiation),” forming the basis of learning.

#### NEUROENDOCRINOLOGY

Brooks was among the first neuroendocrinologists, having been chosen as 1 of 21 in the world to be listed in the first volume of *Pioneers in Neuroendocrinology* in 1975. According to Brooks, he entered the field “because the hypothalamus was involved in control of the autonomic system and its functions.” His accomplishments include (1) before the discovery of relationships between the hypothalamus and the anterior pituitary (hypothalamo-adenohypophysial system), he cut the pituitary stalk or made hypothalamic lesions to locate the pathways for various phenomena (e.g., ovulation, pseudopregnancy, and diabetes insipidus). He claimed that he may have been the first to produce diabetes insipidus in monkeys. His early work suggested the presence of “releasing factors” but their existence was not demonstrated by him. Later accomplishments are (2) in the early 1960s he and his associates recorded electrical activities from neurosecretory cells in the supraoptic and paraventricular nuclei in the hypothalamus. This pioneering technique spread widely in the succeeding years to England and elsewhere. With this technique they were able to show that “natural” stimuli, such as distention of uterus and vagina and gentle tactile stimuli to the mammary glands in pregnant animals, released oxytocin. It was also shown that hypertonic stimuli to these neurons produced and released vasopressin into the vascular system. (3) The first intracellular recordings from the hypothalamic neurosecretory cells in dogs, cats, and rats were made as well as studies of many factors influencing activities of these neurosecretory cells and the release of

hormones leading to changes in various body functions. (4) Recordings from pineal gland cells showed that these cells respond to light through the sympathetic nerves innervating the pineal. As for many other studies that Brooks and his associates initiated, their early findings often stimulated many other investigators, resulting in greatly expanded work in the field of neuroendocrinology in later years.

#### CARDIAC PHYSIOLOGY

As mentioned before, Brooks began research in this field with Oscar Orias, the first visiting professor in Brooks's newly created department. The combined expertise of Orias in cardiac physiology and that of Brooks in neurophysiology led to the work on cardiac excitability. (1) The first discovery was the period of cardiac vulnerability and its relation to arrhythmias. The work led to publication of *The Excitability of the Heart* in 1955. (2) These studies led to the development of the principles for the use of acute and chronically implanted pacemakers. The first chronic pacemaker was implanted in a dog, showing the heart could be driven artificially. This feat was done in the early 1950s, long before the beginning of development of the artificial pacemaker. (3) Brooks's group was at the forefront of intracellular recordings in cardiac muscle cells and Purkinje and sinoatrial node pacemaker cells, with the first publication appearing in 1952. This developed into many discoveries, including the role of calcium ions in the action potentials of the sinoatrial node dominant pacemakers. (4) They also conducted some of the earliest studies of the intrinsic and extrinsic factors affecting the discharge of sinoatrial node pacemaker cells, including fast drive, and intracellular recordings of isolated pacemaker cells.

Brooks's publication list covers all those fields. He is the author of 4 books, editor of 7 books, contributor of 26

chapters, and author of over 200 reviews and original papers in scientific journals, spanning the period from 1929 to 1989, not including numerous abstracts. His contribution to physiology also includes the founding of the *Journal of the Autonomic Nervous System* (by Elsevier) in 1978, when no such journal existed in English (the only one then was in Japanese). He was editor in chief of that journal for seven years. The journal has been continued to the present as the *Journal of Autonomic Neuroscience*, resulting in the formation of the International Society of Autonomic Neuroscience.

In addition to being a very successful physiologist, Brooks was a creative and skillful organizer in promoting teaching and research in the medical school. As chairman of the Department of Physiology he encouraged and nurtured young faculty members in his own department, but he also invited numerous visiting fellows and scholars from all over the world. This was particularly significant in 1950s, when he could invite many Asian physiologists, giving them an opportunity to do research in the United States. On returning to their own countries they could make big contributions to the promotion of research there. Brooks's help to science and scientists in war-devastated Japan after the World War II was recognized when the Order of the Rising Sun (3rd Class) medal was given to him by the emperor of Japan in 1979. He also received many medals and honors from Korea and Taiwan.

Brooks's contributions to medical education are also noteworthy. He was a founder and the first dean of the graduate school at The State University of New York Downstate Medical Center, a founder of the State University of New York Press, and for one year the acting president and acting dean of the medical school. He also promoted basic research, organizing the Sigma Xi chapter at SUNY Downstate Medical Center, and numerous lectures and symposia

for all faculty and student bodies. In addition, Brooks was sought after by the State University of New York to serve on numerous committees concerned with health education and university-wide affairs.

One of his notable contributions to the medical school was establishing the Visiting Scholar Program during the 1960s and 1970s to foster the cultural interests of the faculty and medical students. There were many distinguished speakers, such as Arnold Toynbee, Archibald MacLeish, Marianne Moore, W. H. Auden, Edwin Reischauer, Aaron Copland, Harold Clurman, William Stockhausen, a rabbinical scholar, and a Jesuit theologian, who not only gave lectures but also spent two full days on our campus meeting with students and faculty at breakfast, lunch, and dinner.

After his retirement as chairman of the Department of Physiology in 1972, he continued to be active in research at the school as a distinguished professor. He also turned his talents to philanthropy, as a trustee and chairman of the grants committee of the International Foundation. With his interest in helping worthy projects (matched by his meticulous attitude and conscientious thoroughness), he spent hours of his busy days scrutinizing health applications and meeting people in faraway places in order to find out how funded plans were doing. His idea was to help projects that needed start-up funds that would continue to develop into a successful operation. His work continued to his untimely death in 1989.

In 1986 Brooks added a new field of interest to his long career as a scientist, educator, and philanthropist: He became a fellow of the Center for Theological Inquiry in Princeton. At this late stage of his life and four years after the death of Nelle, his wife of 50 years, he turned his inquiry and learning toward more fundamental questions of life and of man.

We wish now to cite some words of his colleagues expressed in the book *Chandler McCuskey Brooks, The Scientist and the Man* published in 1990 on the occasion of a memorial ceremony for Brooks.

[Brooks made] many contributions to this institution, to the science of physiology, and in a real sense to the world at large ... over a period spanning more than 40 years at this institution he profoundly affected the intellectual spirit at this institution through his many interactions with students, faculty and visiting scientists.

If I must identify one thing as most important, I select Dr. Brooks' dedication to the instruction of students ... It was his firm conviction that if something is worth teaching, you'd better learn how to teach it well and do just that.

In his youth, Chandler was a long distance runner and so he was throughout his life. Of the long distance runner, he had the physical endurance, the discipline, the strength of character and a determination to win ... The level at which he operated was set by his determination to pursue excellence and he worked at that with great tenacity throughout his life ... [He] considered the Department of Physiology as a larger family and, by treating people accordingly, fostered respect, loyalty, and devotion. He knew the value of moderation and thoughtfulness in smoothing the inevitable contrasts that must arise in any community of individuals ... He saw to it that no one should fail and he accomplished that not by lowering standards but by providing help or adjusting the goals to individual capacities. He felt that as scientists we have an obligation to train and educate young people who come to us from near and afar and to help them in their careers when they return home. ... In all his endeavors, he worked very hard because he realized that the attainment of quality performance requires not only worthwhile aims but also a careful attention of details. And this takes time, effort and organization. ... In spite of his many duties, he always sought any initiative that would constitute development and growth, from the Visiting Scholar to the Visiting Professor Programs. He left an imprint in those who worked with him by setting an example of industry, tenacity, perceptive intelligence, and fairness in human relationships, integrity of character and trust. ... Busy as he was, he showed his inner gentleness on innumerable occasions as when he wrote

stories and drew cartoons for the little son of one of his associates. ... As a result of his life-long labors, he established himself as a most prominent scientist, widely known internationally as testified by the numerous honors that he received during his long and productive career.

[Brooks] treated each of us in the Department with respect and trust. He was fair to everyone, and we in turn had tremendous respect and deep affection for him. Though definitely a “minority” member in the school, from the beginning I never felt discriminated against as a woman or Asian in his Department. This was unusual if one remembers that in the early fifties it was rather difficult for Asians to find a decent apartment even in Brooklyn ... Chandler’s kindness and willingness to help others often gave him an extra burden in his very busy life, but he was always willing and never complained. Not only did he take time to go to the airport to meet foreign visitors in person, but he and his wife took them to their home, found an apartment and helped them to settle. The basement of his house in Brooklyn was always full of baby cribs, folding beds and other pieces of furniture. When one family came, out went the furniture; when they left the US the furniture went back to the basement ... Chandler had a remarkable ability to create and organize many important projects; he not only had a very clear idea about them from the beginning, but also planned them in great detail. Many of his accomplishments, such as the initiation of the Graduate Education Program and the famous Visiting Scholar Program at Downstate, his establishment of the State University Press, his help in publishing *Japanese Physiology, Past and Present*, which was distributed to all International Union of Physiological Sciences participants at the Tokyo Congress in 1965 in order to introduce Japanese physiology to the world, his founding of the *Journal of the Autonomic Nervous System*, his active role in organizing several very significant symposia and many more activities, reflected his dreams, his intellectual perception and his determination to accomplish something he felt worthwhile and important.

In all the scientific work in Brooklyn, Chandler had the collaboration of younger scientists who had come from various parts of the world to work and study in Brooklyn. At one time, there were 15 Department chairmen in Japan who had studied in Brooklyn; in South Korea there were 11 Downstate people. There are people everywhere who have been touched by Chandler Brooks: in Scotland, England, New Zealand, Australia, Taiwan, India, Japan, Korea, Hungary, Italy, France, Switzerland, Finland, the Soviet Union,

Bulgaria, Argentina, Chile, Mexico. With many of these visiting scholars, especially those who did not write English well, Chandler spent hours and hours helping them to improve their drafts and seeing the manuscripts through to publication.

In spite of all his own accomplishments, Chandler Brooks was a simple man. He did not put on airs, or strut about over his achievements. He recognized talent in others, and was generous in praise and support. ... What made Chandler Brooks the way he was? The answer is not that difficult. His spiritual upbringing and his faith in God helped him hold a steadfast course in his life. The whole purpose of his life was service: service to science, service to society and service to mankind.

When asked why he brought non-doctors to a medical school [under the visiting scholar program], Dr. Brooks declared: "The physician must eventually confront and communicate with people as they are. The more he knows of man and his social state, his cultures and the basis of his mores, the better." I might add that he belonged to the Medieval Club of New York for some time. ... Chandler's concept of medicine and medical education was unusually broad and deep and based on his desire to seek and understand the nature and predicament of man and ultimately the nature of God. It is for these reasons, I believe, that he spent countless hours in his later years as chairman of the Grants Committee of the International Foundation and decided in 1986 to become a fellow of the Center of Theological Inquiry in Princeton. ... As a fellow Dr. Brooks' main concern was to learn more about the nature of the soul and immortality. ... He was keenly aware that having spent the major part of his active life in medical research, he had no time left to read and digest the subtle and complex teachings of past theological and philosophical masters on basic issues of life. It seemed to him, and he was saddened by the fact, that not many contemporary students of theology were interested in the topics which occupied his mind. And yet, he questioned, sought answers and continued to learn.

As mentioned above, in the later years of his life Brooks became much interested in pursuing the fundamental questions in one's life, such as: what is man, what is man's soul. He wrote to his own minister: "Yes, faith, hope and love abide. But an even greater word is courage. Courage is what

counts—the courage to move out into the wilderness of inquiry, the courage to move through the darkness to the light.”

#### IN CONCLUSION

The above presentation of the life and work of Chandler McCuskey Brooks makes it clear that he was an exceptional man. What made him so exceptional? The underlying foundations of character can perhaps be traced to his family background. His father was a minister and when Chandler was young he wanted to become a minister himself. How important and long-lasting this interest was is shown by the fact that when he retired from Physiology he went to the Center for Theological Inquiry to pursue inquiries about spiritual matters. To the embarrassment of some of the theologians, he asked pointed questions about the nature of the soul. The inquiry in general reveals the scientist and the specific inquiry reveals his desire to understand matters that rise above the human clay. Of course, he did not get a definite answer, but pursuing those questions already gives a measure of the broad interests of his mind. In this connection it is of interest that there was a period of time in his life when he wrote to his father about different matters (including botany) *every day*.

This background, in which religious aspirations are imbedded in one's soul and not merely within the precinct of a church, may account for one of his major characteristics: integrity. That is to say: honesty based on principles, and therefore not easily transgressed. He was a man you could entirely trust.

Another of his outstanding characteristics (perhaps linked to the previous one) was self-discipline. His discipline allowed him to overcome many difficulties and obstacles, for it is at the school of discipline that he formed his charac-



ter. Add to this a keen intellect, a sense of duty, foresight, perceptivity, and hard work and there is the substratum on which the rest of his qualities prospered.

The rest included a healthy ambition that was never pursued in itself, but it was almost viewed as a duty toward the development of his capabilities. And there was the genuine interest of a true scientist in the discovery of the marvels of nature—a passion and a wonder for understanding the works of the Creator and a deep appreciation of the exhilaration of discovery.

That was certainly enough to fill the life and aspirations of anyone, but not of Chandler. Even in science he refused the limitations of a too narrow approach. He was a physiologist of the body, not of a cell, an enzyme, or a molecule. He was a true physiologist who wanted to understand the secret mechanisms of the extraordinary human machine. At a meeting, speaking on the manipulations of certain experimental approaches, he remarked, “They are studying what the cell can do, not what the cell does.” And that perhaps is the very source of many disagreements. And, if one does not watch out, sometimes one risks wanting to teach nature.

As one would expect, he took his administrative duties with a deep sense of responsibility and worked hard at them. He did not hesitate to serve for one year at the same time as chairman of the department, dean of the graduate school, acting president of the center, and acting dean of the medical school. And in the evening he had a timer that would switch off the lights at midnight so that he and one of us (K.K.) had to stop the writing of scientific papers. But his versatility was shown also by his understanding of human nature, the psychology of human relationships—a necessary requirement for anyone dealing with and leading a community of people. He was hard working and disciplined, but certainly neither rigid nor unperceptive.

Was he then without faults and limitations? Certainly not. But what is extraordinary is that he could accomplish so much by mastering the qualities of his merit. While he shared with everybody else the limitations of our human nature, not many others shared the qualities that he cultivated and practiced. But what really distinguished him was that in everything he did, he sought excellence. This was his secret, which he pursued no matter what it cost.

One might conclude with the following quote from *Chandler McCuskey Brooks, The Scientist and the Man*:

The force of example resides only in the receptivity of a willing and eager mind. However, the example itself must be made available not only to those who knew Chandler but to all who are interested in better understanding themselves through the mirror provided by the life and humanity of others.

## SELECTED BIBLIOGRAPHY

1931

With P. Bard. Localized cortical control of some postural reactions in the cat and rat together with evidence that small cortical remnants may function normally. *Proc. Assoc. Res. Nerv. Ment. Dis.* 13:107-157.

1940

Relation of the hypothalamus to gonadotropic functions of the hypophysis. *Proc. Assoc. Res. Nerv. Ment. Dis.* 20: 525-550.

1946

The relative importance of changes in activity in the development of experimentally produced obesity in the cat. *Am. J. Physiol.* 147:708-716.

1947

With J. C. Eccles. An electrical hypothesis of central inhibition. *Nature* 159:760-771.

1948

With J. C. Eccles and J. L. Malcolm. Synaptic potentials of inhibited motoneurons. *J. Neurophysiol.* 11:417-430.

1950

With O. Orias, E. E. Suckling, J. L. Gilbert, and A. A. Siebens. Excitability of the mammalian ventricle throughout the cardiac cycle. *Am. J. Physiol.* 163:272-282.

1951

With B. F. Hoffman, E. F. Gorin, F. S. Wax, and A. A. Siebens. Vulnerability of fibrillation and the ventricular-excitability curve. *Am. J. Physiol.* 167:88-94.

1952

With M. G. F. Fuortes. Excitation, conduction and synaptic transmission in the nervous system. *Annu. Rev. Physiol.* 14:363-390.

1955

With B. F. Hoffman, E. E. Suckling, and Oscar Orias. *The Excitability of the Heart*. New York: Grune and Stratton

1956

With K. Koizumi. Origin of dorsal root reflex. *J. Neurophysiol.* 19:61-74.

With P. F. Cranefield, B. F. Hoffman, and A. A. Siebens. Anodal effects during the refractory period of cardiac muscle. *J. Cell. Comp. Physiol.* 48:237-241.

1958

With I. Suda and K. Koizumi. Reticular formation influences on neurons of spinal reflex pathway. *J. Neurophysiol.* 21:113-123.

1959

With K. Koizumi and J. Ushiyama. Hypothermia and reaction patterns of the nervous system. *Ann. N. Y. Acad. Sci.* 80:449-456.

With A. A. Siebens, B. F. Hoffman, and P. F. Cranefield. Regulation of contractile force during ventricular arrhythmias. *Am. J. Physiol.* 197:971-977.

1960

With K. Koizumi and J. Ushiyama. Effect of hypothermia on excitability of spinal neurons. *J. Neurophysiol.* 23:421-431.

1962

With J. Ushiyama. Intracellular stimulation and recording from single cardiac cells. *Am. J. Cardiol.* 10:688-694.

1964

With K. Koizumi and T. Ishikawa. Control of activity of neurons in the supraoptic nucleus. *J. Neurophysiol.* 27:878-892.

1966

With T. Ishikawa, K. Koizumi, and H.-H. Lu. Activity of neurons in the paraventricular nucleus of the hypothalamus and its control. *J. Physiol.* 182:217-231.

With T. Ishikawa and K. Koizumi. Electrical activity recorded from the pituitary stalk of the cat. *Am. J. Physiol.* 210:427-431.

With J. Ushiyama and K. Koizumi. Accommodative reactions of neuronal elements in the spinal cord. *J. Neurophysiol.* 29:1028-1045.

With H.-H. Lu, G. Lange, R. Mangi, R. B. Shaw, and K. Geoly. Effects of localized stretch of the sinoatrial node region of the dog heart. *Am. J. Physiol.* 211:1197-1202.

1972

With K. Koizumi. The integration of autonomic system reactions: A discussion of autonomic reflexes, their control and their association with somatic reactions. *Ergeb. Physiol.* 67:1-68.

With H.-H. Lu. *The Sinoatrial Pacemaker of the Heart*. Ft. Lauderdale: Charles C. Thomas.

1974

With J. Krellenstein, B. Pliam, and M. Vassalle. On the mechanism of idioventricular pacemaker suppression by fast drive. *Circ. Res.* 35:923-934.

1976

With H. Nishino and K. Koizumi. The role of suprachiasmatic nuclei of the hypothalamus in the production of circadian rhythm. *Brain Res.* 112:45-59.

1982

With K. Koizumi, N. Terui, and M. Kollai. Functional significance of coactivation of vagal and sympathetic cardiac nerves. *Proc. Natl. Acad. Sci. U. S. A.* 79:2116-2120.