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CARL JOHN WIGGERS

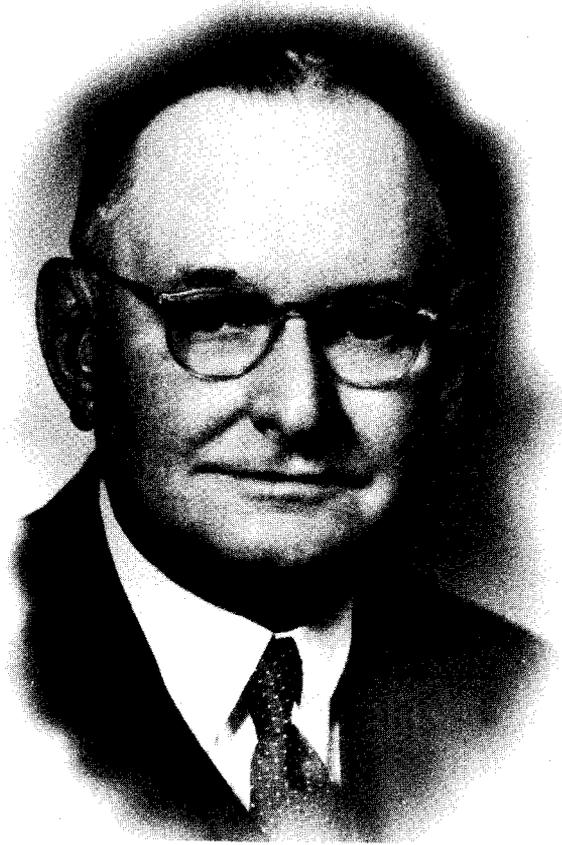
1883—1963

A Biographical Memoir by
EUGENE M. LANDIS

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Biographical Memoir

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Carl J. Wiggins

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May 28, 1883–April 29, 1963

BY EUGENE M. LANDIS

WHENEVER HISTORIANS of science deal with the development of physiology and medicine in the United States, they give special significance to the period 1900–1950. At the turn of the century, physiology was beginning its growth in this country as a science in its own right and as a discipline useful to medicine and surgery. The life and contributions of Carl John Wiggers coincide almost precisely with this period. In 1901 he entered medical school with the customary aim of becoming a physician. Almost at once he attracted the attention of his professors in the preclinical sciences. Stimulated and encouraged by them, he became interested in physiological research and enhanced that interest by advanced study abroad. Upon his return to the United States, he became a member of a small but important group of leaders who developed highly individual and productive research laboratories in several medical schools and in several specialties of physiology.

Carl Wiggers's chief location was the medical school of Western Reserve University for thirty-five years (1918–1953), and his lifelong interest was cardiovascular physiology. Two generations of physiologists and clinicians were stimulated to follow research careers because of his influence as teacher, preceptor in research, lecturer, author, and editor. He was prominent among those who formulated the physiological principles

that underlie many of the recent, often spectacular, advances in the diagnosis and treatment of cardiovascular diseases. He was elected a member of the National Academy of Sciences in 1951.

Carl John Wiggers was born in Davenport, Iowa, on May 28, 1883. He was the first of two children; a younger sister died in childhood. His father, Jürgen Wiggers, accompanied by a brother, John, had left the limited prospects of a small family farm in the duchy of Holstein to seek opportunity in this country. To pay their passage across the Atlantic, they served as sailors and in 1876 arrived in New York as immigrants. Jürgen, during a period of orientation, worked his way west as far as Colorado through temporary farm jobs and even some unsuccessful prospecting for gold. He subsequently returned eastward to Scott County, Iowa, and settled in Davenport. There, in 1882, he met and married Anna Margaretha Kundel, whose family had also emigrated from Holstein. Eventually, Jürgen Wiggers became manager of a social club called Lahrmann's Halle, which resembled the celebrated *Ratskellern* of Germany and was a favorite rendezvous of professional and business men in the downtown area of Davenport. In his autobiography Carl Wiggers describes how his father, while still in Holstein, had aspired to an education in law or even medicine. For the father these ambitions could not be fulfilled; but the son received parental encouragement for education toward a profession, in addition to the usual German domestic traditions and thrift.

Carl Wiggers attended elementary and high schools in Davenport. Before he went to high school, his parents required that he have in mind aims for a specific vocation or profession. To keep within the family's limited resources, he chose pharmacy. In high school his teachers of chemistry, physics, and zoology provided special stimulation to young Wiggers; and he, an eager student, proved especially interesting to them. They took

"every opportunity to discuss his future aspirations and tactfully awakened the idea" that he should aim for medicine rather than pharmacy. In a carefully reasoned comparison between the newer Johns Hopkins medical school (college degree required) and the slightly older medical school of the University of Michigan (high school diploma then still sufficient), Wiggers chose the latter. In his choice he noted that he really couldn't afford four years of college, that the organization and curricula of the two schools seemed similar, and, more significantly, that Johns Hopkins, in developing its own medical faculty, had, in fact, chosen three of its professors from Michigan's faculty.

Early in medical school at Ann Arbor, Wiggers must have shown again some qualities that attracted the immediate interest of his first professors. His initial intentions to prepare for public health work, or for practice in obstetrics and pediatrics, gave way to curiosity concerning physiology and research. He ascribed this change, first, to an "experiment in education" by Professor Warren P. Lombard, which involved a "research problem" assigned to students in the final weeks of their course in physiology. Second, this was followed by Professor Arthur A. Cushny's emphasis on the physiological actions of drugs. And, third, Lombard offered Wiggers a paid student assistantship in physiology that continued until he received his M.D. in 1906. He was then promoted to an instructorship in physiology, which he held from 1907 to 1911.

His publications began while he was a medical student. In 1905 he described the action of adrenalin on the cerebral blood vessels and demonstrated his findings at the American Physiological Society meeting in Ann Arbor that same year. At this meeting he also heard reports and observed demonstrations by well-known investigators such as Macleod, Brodie, Erlanger, and Y. Henderson. By his own account the stimulation from informal conversations with these and other physiologists firmly established his interest in physiology as a career. In the thirteen

papers that Wiggers published from 1905 to 1911, he described the responses of cerebral, coronary, and pulmonary blood vessels to electrical or chemical stimulation; presented an improved apparatus for measuring blood flow; and reported studies on hemorrhage with particular emphasis on the ineffectiveness, or even harmfulness, of adrenalin injections. As a group, these papers present a general preview of areas and topics that Wiggers continued to study in greater depth for forty years. His chief lifelong interest, cardiac physiology, became obvious several years later.

In 1907 Carl Wiggers married Minerva E. Berry, a junior medical student and thus, as he worded it, "two careers—one scientific, the other domestic—were launched almost simultaneously," and their "coexistence proved facilitatory and salutary." This was verified many times over by his wife's assistance as part-time secretary and by her understanding companionship and help during long hours of research and writing. They had two sons, both of whom became eminent. One, Harold, became himself a Professor of Physiology and later, in 1953, Dean of Medicine at Albany Medical College. The other, Raymond, entered the field of industrial advertising and became an award winner in that area. In later years a lifelong habit of hospitality and personal interest enlarged the social boundaries of the Wiggers family and home to include research fellows, junior staff members, colleagues, and visitors from other laboratories and countries. It is significant that in 1952 the affection of this larger family was expressed by their establishing at Western Reserve University a joint honor entitled "The Minerva and Carl Wiggers Annual Prize in Physiology."

In 1907, during his first year as an Instructor, Wiggers was given the responsibility for a didactic and demonstration course in physiology for dental students, who had become seriously discontented with Professor Lombard's offerings. In this first course, he revealed his conviction that, if subject matter was

chosen wisely, basic courses could be made not only valuable to students but also interesting. In describing the results of this first responsibility for teaching, he made the modest and gently humorous appraisal that "the attitude of dental students toward physiology was changed; it no longer was regarded as an ordeal but as a satisfaction, if not exactly a pleasure." The course led to the publication in 1914 of his first book, *A Brief Text of Physiology*.

An important career decision was made by Wiggers early in his instructorship. To supplement their low salaries, members of basic science departments were allowed, and even encouraged, to engage in limited practice of medicine. A brief test of such part-time clinical work led him to conclude that it was hindering, not helping, his academic career, and reinforced his decision to make physiology his sole activity. In 1910 Professor Lombard took a sabbatical year to study abroad, and Wiggers became acting head of the department. He mentioned later that it was helpful to learn at an early age the nature of administrative work. At this time, with the advice of A. W. Hewlett, the new Professor of Medicine, he used some hours in the basic physiology course to demonstrate to first-year students how physiologic information could be applied to clinical problems and help interpret the signs and symptoms of disease in patients.

During this period Wiggers found that his studies were being limited by the unreliability of the pressure recorders then available to physiologists. Professor Hewlett told him of the optical recording methods devised by Professor Otto Frank in Munich, and Wiggers promptly arranged, through Lombard, then in Europe, for a year of study abroad. But this had to be postponed to 1912 and abbreviated to a spring and summer because, on the recommendation of W. H. Howell of Johns Hopkins, Graham Lusk invited him to come to Cornell Medical School in New York as Instructor of Physiology. It was agreed, however, that after a few months at Cornell, he would have a

leave of absence for study with Professor Frank at the Physiological Institute of Ludwig-Maximilian University. Arriving there in May 1912, Wiggers found that, as a representative of Lusk's group, he was granted exceptional privileges in observing the optical equipment and methods that the usually reserved, even secretive, Otto Frank was developing in his laboratory for measuring rapidly and accurately not only blood pressures, but also pulse contours and rates of blood flow. By some additional visits elsewhere, Wiggers also gained a "traveller's acquaintance with other laboratories in Europe."

When Wiggers returned to New York in the summer of 1912, his research interests were not limited to physiology, but continued to include cardiovascular disease also. To learn more about the latter, he devoted one morning each week to attending ward rounds in Bellevue Hospital. He kept improving the reflecting mirror manometer of Otto Frank and devised a mobile unit that brought his equipment into use at the bedside. He was promoted to Assistant Professor of Physiology in 1913. His research from 1912 to 1918 dealt with many areas of cardiovascular function but began to deal increasingly with an analysis of cardiac function, normal and abnormal. Early in this period he published the first optically recorded pressure pulses in the pulmonary arteries of dogs through cannulas inserted directly. These records, together with Otto Frank's studies of the central arterial pulse in the aorta, permitted comparisons of pressure levels in the lesser and greater arterial circulations. In 1917 he compared the timing of pressure changes in the heart chambers with the contractions of heart muscle and with the electrocardiogram. He was thus in a position to amplify the findings of Thomas Lewis (later Sir) in London, who was challenging Einthoven's view that the electrical and mechanical events of cardiac contraction were simultaneous. These observations indicated that electrical events preceded the contraction of heart muscle and were a measure of the progressive conduction

of the excitation process throughout the heart. With clinical co-workers in Bellevue Hospital, he studied atrial fibrillation, analyzed the supraclavicular venous pulse in man, and began registering heart sounds. Even at this early stage he was convinced that physiologists should at intervals describe in review form the status of ongoing research in order to keep clinicians well informed. His second book, *Modern Aspects of the Circulation in Health and Disease*, published in 1915, was such a progress report. It was a monograph that described, with examples, the usefulness of newer methods in the clinical diagnosis and treatment of cardiovascular diseases as seen in hospital practice. He was always a vigorous supporter of the view that advances in medicine and surgery must be based upon an investigative and basically physiologic approach to disease.

In 1917-1918 the entry of the United States into World War I presented a new series of cardiovascular problems, ranging from cardiac-fitness examinations in draftees, through neurocirculatory asthenia or "soldier's heart" in stressed individuals, to the physiologic principles underlying the diagnosis and treatment of hemorrhage and shock in the severely wounded. In 1918 Wiggers served on a medical appeal board and used his experience with electrocardiography to help adjudicate in cases of draftees when physical fitness was disputed. At this time, too, he became a member of a National Research Council Committee on Shock. Sir Thomas Lewis invited him to come abroad to share in a study of neurocirculatory asthenia, but he had to decline, chiefly because Graham Lusk was on leave for war research abroad, and again he was acting chairman of a department. However, as a "Contract Surgeon" in U.S. Army General Hospital #9, he spent a short time during the summer of 1918 in a research laboratory, headed by Professor Francis W. Peabody from Harvard, for the purpose of studying cardiac disabilities in draftees and soldiers.

With all this in progress, and during a meeting of the Com-

mittee on Shock in Baltimore, Torald Sollman, Professor of Pharmacology at Western Reserve Medical School, told Wiggers that J. J. R. Macleod, then Professor of Physiology at Western Reserve, had decided to accept a position with the University of Toronto, and then urged him to consider accepting the vacant professorship beginning with the autumn term of 1918. Wiggers accepted, but only after making sure that he could arrange matters at Cornell so that Graham Lusk would be inconvenienced as little as possible by his leaving.

Thus in 1918, and at age thirty-five, Wiggers began to establish in Cleveland his own center of cardiovascular research, first in a small loft of the older medical building, and then from 1924 onward, in a separate floor of a new medical building in which the physiology department had more space and facilities as planned by Wiggers himself. The problems of new equipment, staff, courses for students, and budgetary matters were burdensome at times but did not perceptibly interrupt his research and publications. During the thirty-five years from 1918 to 1953, almost every part, and almost every physiological function, of the heart and blood vessels were the direct or indirect topics of some study by Carl Wiggers or by his many graduate students and co-workers. Approximately 400 papers were published from the laboratories that Wiggers established and supervised. In matters of authorship and credit, he was again characteristically generous. In over half of these papers, his colleagues and students were granted sole authorship. Wiggers believed firmly that beginning investigators deserved sole authorship of papers dealing with their work, even though the head of a laboratory may have given essential assistance in ideas, advice, and editing. Wiggers also published a total of seven books in editions ranging from one to five.

To do justice to the content of all these papers and books is impossible in any brief memoir. It is fortunate that Wiggers wrote in 1958 an autobiography entitled *Reminiscences and*

Adventures in Circulation Research. That book provides a detailed, chronological account of the questions that prompted his research, his development of suitable equipment, and his experiments and results. Descriptions of successes are balanced by frank discussion of failures, oversights, and those second thoughts that increasing experience and new facts produced. In this brief memoir it is more appropriate to describe a few of the main lineages of ideas that determined the major pathways and methods used by Wiggers in his researches.

One of the earliest of these lineages dealt with analyzing the interrelations of electrocardiographic, excitatory, contractile, and hemodynamic events during the cardiac cycle. This was not easy, because in the early 1900s it was necessary to import almost all research equipment of any intricacy from instrument makers abroad, and at great expense. When Wiggers began working in Cleveland, conditions were improving, but it was still necessary for him to establish a departmental workshop to produce his own improved optical manometers for recording pressures or sound, as well as cardiometers and flowmeters for volume measurements. Moreover, each of these devices had in the past been used separately by individual investigators and usually for limited and special problems. Most difficult of all was the task of obtaining the best possible string galvanometers for electrocardiography, but this, too, was accomplished. In viewing the future of cardiac research, Wiggers saw that:

“ . . . by aligning such a galvanometer with optical recorders for pressure, muscular contraction and heart sounds, the interrelations of electric and contractile events in the heart could be determined more accurately than before. This problem was—and remains—one of cardiologic as well as scientific interest, for it is basic to the usefulness of electrocardiographic interpretation of impulse conduction.”

Each of the new instruments presented technical problems, and combining several devices produced a really formidable

challenge. Nevertheless, Wiggers collected the data necessary to produce a graphic summary that correlated the dynamic, mechanical, acoustic, and electrocardiographic events during the normal cardiac cycle, lasting approximately 0.9 seconds. As a chart this summary became a standard textbook figure and was reprinted in reviews and books dealing with physiology, electrocardiography, and cardiology in general. It is still used as a diagram upon which new data, such as single-cell membrane action potentials, can easily be added.

In 1921 Wiggers wished to measure more accurately the effects on the cardiac cycle of changing venous return, as in muscular exercise, and of aortic pressure, as in hypertension. It was necessary to subdivide ventricular systole and diastole into smaller and more precise units. Eventually eight phases were identified: isometric contraction, maximal ejection, reduced ejection, protodiastole, isometric relaxation, rapid inflow, diastasis, and atrial systole. The beginning and end of each phase was defined precisely by relevant simultaneous changes of blood pressure levels in the left ventricle, aorta, or atrium; by small, more detailed changes in the configuration of the pressure pulses; and by heart sounds. Also, for each phase, the normal range of duration was measured. This subdivision of the cardiac cycle was also widely used in physiology and cardiology. Moreover, from these studies developed a second lineage of problems, ideas, and research.

During experiments on the exposed heart, Wiggers had been impressed with its great resistance to drastic manipulations and even injury. "However, it happened far too often that the thrust of a cannula or stylus through the ventricular walls was followed by irreversible fibrillation whose occurrence could not be related to the region involved, the nutrition or dynamic state of the ventricles, or to the age of the animal. The hazard of terminating an experiment by fibrillation was materially increased when strong shocks were applied during systole. . . ."

He tried many expedients to diminish the incidence of ventricular fibrillation but results were discouraging.

In the 1920s, as electrical appliances in home and industry became more numerous, so had also the deaths of users by accidental electrocution from faulty wiring. After a "Conference on Electric Shock" in 1929, Professor W. H. Howell of Johns Hopkins asked Carl Wiggers to join efforts with Donald R. Hooker in exploring possible ways of restoring normal rhythm to hearts in which fibrillation had been produced by electric currents. Wiggers accepted, but with the cautious feeling that the most he "could hope for was some discovery that might reduce the mortality rate of experimental animals."

His first approach was a screening study to explore chemical methods of restoring normal cardiac rhythm. Although intraventricular injections of potassium chloride often made the fibrillating heart quiescent and calcium salts sometimes restored a normal heartbeat, these effects were not consistent enough to be satisfactory, even in experimental animals. After deciding that not enough was known about the genesis of ventricular fibrillation, Wiggers and his group in 1930 used coordinated cinematographic and electrocardiographic methods to study the earliest stages of the arrhythmia, which then emerged as an evolving process that progressed irregularly through four fairly characteristic, but often overlapping, stages. These might take a few to many minutes to develop fully from the first undulating contractions to the fourth, and longest, atonic stage, lasting from twenty to sixty minutes. Because this final atony did not develop when the ventricles were perfused artificially with oxygenated blood, Wiggers suggested that the final lethal flaccidity of unperfused, fibrillating hearts could "probably be referred to failure to reconstitute energy yielding material during the progressing anoxia."

In 1932 Kouwenhoven, Hooker, and Langworthy, while studying the distribution of electric current in the bodies of dogs,

tested and confirmed an almost forgotten statement published in 1899 by Prevost and Battelli to the effect that if ventricular fibrillation occurred it could be terminated by applying a strong electric current to the heart. Wiggers had accumulated methods and experience that placed him in an ideal position to provide speedy, additional confirmation of the beneficial effects of countershock, though he found it effective only when applied within two or three minutes after induction of fibrillation. In the meantime, H. B. Williams and associates had also confirmed observations by Wiggers that electric shocks during the "vulnerable period of the heart cycle" induced fibrillation and that immediate application of strong currents to the chest wall could stop that fibrillation. As Wiggers expressed it, the problem became one of "extending the period during which countershock could be effective after development of fibrillation."

Success in doing this was "not a matter of chance; it resulted from a logical application of observations from contemporaneous experiments. . . ." These pointed to the conclusion "that the fibrillating ventricles lose their power of effective contraction after 2 or 3 minutes, because they are deprived of oxygenated blood. The remedy apparently needed was a supply of oxygen for the myocardium *before* application of countershock." In 1936 Wiggers suggested that gentle manual rhythmic compression of the ventricles be started as quickly as possible to raise arterial blood pressure and to restore blood flow through the coronary vessels in the heart muscle. When this maneuver was continued until vigorous fibrillary movements were re-established, then countershock usually restored coordinated ventricular contractions. In addition, however, dogs with larger hearts often required "serial defibrillation," i.e., administration of three to five brief shocks at intervals of two seconds to reach the deeper lying parts of the ventricular wall. By 1940 he could demonstrate by means of these innovations that a dog could survive if its heart were fibrillated and defibrillated reversibly at will many times in succession. Over a decade elapsed,

however, before these principles were utilized clinically in the emergency treatment of ventricular fibrillation in patients. During this time he and his co-workers continued to study in the laboratory many related topics, including quantitative fibrillation thresholds, fibrillation following induced coronary occlusion, effects of type of current and voltage, and actions of drugs. Collectively, these research reports form an essential part of the physiologic foundation that supports modern cardiac resuscitation and defibrillation, cardiac monitoring, and pacemakers, as well as the feasibility and relative safety of "elective cardiac arrest" in open-heart surgery.

In still another lineage of interlocking experiments, Wiggers and his students dealt with the hemodynamics and control of blood flow through the heart and past its valves, through a distensible aorta, and through a branching system of peripheral vessels, including especially the coronary arteries in the heart muscle itself. The number and ramifications of these experiments defy any brief summary. They included studies on the energetics and biophysics of the heart as a pump, wave forms in the aorta and its branches, and peripheral resistance to blood flow through arteries and arterioles. His interest in abnormalities such as valvular lesions, arteriosclerosis, and hemorrhage can be traced back to his instructor days at Michigan, and especially to his hours on the wards of Bellevue Hospital, in New York. His experiments were sometimes analytic—e.g., central and peripheral pulse wave forms, factors determining coronary blood flow, accuracy of blood pressure measurement in animals and man—and sometimes integrative—e.g., his classification of stages in severe hemorrhage and ensuing shock. The wider implications of these integrations are found in his seven books: *Modern Aspects of the Circulation in Health and Disease* (two editions, 1915 and 1923), *Pressure Pulses in the Cardiovascular System* (1928), *Principles and Practice of Electrocardiography* (1929), *Physiology in Health and Disease* (five editions, 1934 to 1949), *Physiology of Shock* (1950), *Circulatory Dynam-*

ics: *Physiologic Studies* (1952), and *Reminiscences and Adventures in Circulation Research* (1958).

In whatever he did Carl Wiggers was always ready to describe clearly and unequivocally his basic principles and convictions. For instance, he emphasized repeatedly that an ideal department of physiology in a medical school had three main functions: first, to offer medical students the broadest possible education in physiology and its importance for medicine; second, to contribute actively and regularly to physiological knowledge by research; and, third, to educate and train experimenters and teachers for both physiology and medicine.

In the course of accomplishing the first two objectives, as already summarized above, Wiggers provided an exceptionally good environment for the third. In his thirty-five years at Western Reserve, his department provided direct research experience for almost 200 individuals. By 1953 his alumni included a score of professors of physiology or heads of closely affiliated research laboratories. Among these were research centers, almost as eminent as the parent one, in special topics such as coronary blood flow, membrane action potentials in cardiac muscle, peripheral resistance to regional blood flow, clinical electrocardiography, hemorrhage, and shock. Visiting students came from foreign countries and returned to important positions in physiology or medicine abroad. One of them, Corneille Heymans, from Belgium, received a Nobel Prize in 1930. By conservative estimate almost a hundred young physicians and surgeons held fellowships that gave them direct experience with the principles of physiological research. In most instances this advanced work was related informally to research in progress, but in 1949 Wiggers felt that new conditions made a new training procedure appropriate.

In 1945, the end of World War II began a period of expanded support for research. In addition, by 1947, clinical interest in catheterization technics for early diagnosis and

treatment of congenital cardiac defects and coronary artery disease was growing faster than the supply of clinical investigators. To meet this need Wiggers proposed a more formal "apprenticeship" program in cardiovascular research and writing. Under the joint sponsorship of the American Heart Association and the U.S. Public Health Service, and with the facilities in his laboratories, he and his staff graduated about twenty "U.S.P.H.S. Training Course Fellows" during the three years from 1949 to 1952. These graduates brought to a number of new clinical cardiology centers the skills and judgment of experienced investigators.

In developing this apprenticeship program, Wiggers emphasized still another of his basic principles, namely that any research effort is not complete until the results are carefully written, thoroughly edited, and promptly published in a form that is both clear and useful to others. With characteristic humor he describes in his reminiscences how the critiques of his own first papers in 1905 by Professor W. P. Lombard seemed devastating temporarily and then helpful eventually. In 1925 Wiggers shared in founding the *American Heart Journal*, was a member of the original Advisory Editorial Board, and remained a member until 1937. In 1952 he was only a year away from retirement and accepted still another editorial challenge. The American Heart Association had adopted a policy of increasing support for basic research and found it timely to publish a new journal that could emphasize a multidisciplinary approach to fundamental studies of the cardiovascular system. Wiggers was asked to organize and edit this new journal, *Circulation Research*, with the first issue scheduled for 1953. He turned over the administration of the Department of Physiology in 1952 to a newly appointed successor, Dr. George Sayers. He then accepted an appointment as Honorary Professor of Physiology with the Frank E. Bunts Educational Institute of Cleveland and organized an editorial office in space provided by the Cleveland

Clinic. As the first editor of *Circulation Research* from 1953 to 1958, he brought the new journal rapidly into a leading position worldwide for reporting the results of basic research on heart and blood vessels. His editorials were widely quoted, and authors accepted with gratitude the conscientious reviews and criticisms that their papers received from him and his carefully chosen editorial board members.

Among his duties as a physiologist, Wiggers also included travel to learn firsthand of outstanding work elsewhere, combined with lecturing to review for others recent advances in ongoing research. During his thirty-five years in Cleveland, he made several trips abroad to attend and address congresses and symposia, with visits to laboratories added. In 1939 he was invited to lecture in Argentina and elsewhere in South America. For this he prepared by learning Spanish. Other invitations to give honorary lectures took him to Germany, Holland, England, and from coast to coast in the United States. Because Wiggers had many interests in both physiology and medicine, his memberships in scientific societies included a number in each category, with service as officer in many. His earliest and longest loyalty went to the American Physiological Society, where, in annual meetings for fifty years, he was a dependable source of lively discussion and admonitions to young and old investigators, delivered over his ever-present cigar and with a friendly humor to temper any incisive criticism. He served the Society as Secretary, Treasurer, and in 1949 as President. His other memberships ranged from the American Society of Pharmacology and Experimental Therapeutics to the American College of Physicians, American Medical Association, American Heart Association (Vice-President, 1947), and numerous cardiology groups, ranging from a local Cleveland area heart society (President, 1955–1956) to the Inter-American Cardiological Society (President, 1956).

Honors came to Carl Wiggers in abundance both in early

life and later, both at home and abroad. The gratitude and homage of his many students and co-workers led to frequent "Anniversary Dinners" in his honor. These included annual gatherings during meetings of the American Physiological Society and special testimonial dinners in Cleveland celebrating his twentieth and twenty-fifth years there and his emeritus year, when his portrait was presented to Western Reserve Medical School. The Circulation Group of the American Physiological Society grants annually to an outstanding physiologist its "Carl J. Wiggers Award and Lectureship." In 1951 an issue of the journal *Circulation* was dedicated to him. In 1958 a group of his former pupils volunteered research papers that made up an entire number of *Circulation Research* to commemorate two events: first, the "retirement of Carl J. Wiggers after his five years of devoted service as its first editor," and second, "the seventy-fifth birthday of this man, one of the surviving giants of the legendary age of American physiology."

Wiggers received honorary doctorates from his alma mater, the University of Michigan (1951); the Royal Ludwig-Maximilian University of Munich, Germany (1952); Free University of Brussels, Belgium (1956); and Ohio State University (1958). Honorary memberships in academies, professional societies, and university faculties began at home with the Cleveland Academy of Medicine and included honors from many others in the United States, England, Mexico, and several countries in South America. From the American Heart Association he received the Gold Heart Award (1952) and the Albert Lasker Award (1955). In both he was named "Dean of Cardiovascular Physiologists." *Die Deutsche Gesellschaft für Kreislaufforschung* awarded him their Carl Ludwig Medal (1954) and the Royal Academy of Medicine in Belgium awarded him their gold medal (1956).

Carl John Wiggers died suddenly at his home in Cleveland on April 29, 1963, one month short of his eightieth year. His death meant the loss of still another of that small group of

brilliant leaders in research who initiated and shaped the rapid growth of physiology in the United States during the first half of this century. Not lost at all, but persisting unchanged, is the lasting heritage of his example, bestowed on everyone who had the privilege of associating with him. To quote from only one of many paragraphs of eulogy and gratitude: "Author, pioneer research worker in cardiovascular physiology, his monument is the host of great students sent into the world imbued with his own philosophy and the values of precision, promptness, hard work and thoroughness. All over the world his work will continue in many other leading physiologists and physicians."

I WISH to express my special gratitude to Dr. Robert M. Berne for providing the following bibliography prepared from departmental records at Western Reserve University.

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KEY TO ABBREVIATIONS

- Alumni Bull. Sch. Med. Affil. Hosp. = Alumni Bulletin of the School of
Medicine and Affiliated Hospitals, Western Reserve University
- Am. Heart J. = American Heart Journal
- Am. J. Med. Sci. = American Journal of Medical Sciences
- Am. J. Physiol. = American Journal of Physiology
- Ann. Intern. Med. = Annals of Internal Medicine
- Annu. Rev. Physiol. = Annual Review of Physiology
- Arch. Intern. Med. = Archives of Internal Medicine
- Circ. Res. = Circulation Research
- Exp. Med. Surg. = Experimental Medicine and Surgery
- Fed. Proc. Am. Soc. Exp. Biol. = Federation Proceedings of the American
Society for Experimental Biology
- J. Am. Med. Assoc. = Journal of the American Medical Association
- J. Exp. Med. = Journal of Experimental Medicine
- J. Lab. Clin. Med. = Journal of Laboratory and Clinical Medicine
- J. Pharmacol. Exp. Ther. = Journal of Pharmacology and Experimental
Therapeutics
- Physiol. Rev. = Physiological Reviews
- Proc. Soc. Exp. Biol. Med. = Proceedings of the Society for Experimental
Biology and Medicine
- West. Reserve Univ. Sch. Med. Clin. Bull. = Western Reserve University
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