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# MAURICE BOLKS VISSCHER

*1901—1983*

*A Biographical Memoir by*
HORACE W. DAVENPORT

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*August 25, 1901–May 1, 1983*

BY HORACE W. DAVENPORT

MAURICE VISSCHER WAS a physiologist who made two important contributions to his science. His own early opinion was that the more important was his demonstration that heart muscle becomes less efficient as it fails and that cardiotonic drugs tend to restore its efficiency. Later he concluded that his pioneer use of isotopes to define and measure the absorption of electrolytes by the small intestine was more important. Knowledgeable physiologists, including some of his own students, agreed with Visscher's revised judgment.

Maurice Bolks Visscher was born on August 25, 1901, in Holland, Michigan, the fourth of six children of Dutch Calvinists whose own parents had been members of a large group that had migrated to western Michigan in the 1840s to escape religious and economic oppression. Those immigrants had established churches, schools, and colleges before they finished building their own homes. Maurice Visscher attended high school and Hope College in his home town, and he thought himself fortunate in having stimulating biology teachers in both high school and college. His teacher at Hope College made Visscher a teaching assistant and charged him to do a research project, studying pollution of local streams and a lake caused by the town's discharge of raw sewage. His father became incapacitated while Visscher was in high school, with the result that the boy had the responsibility of running the family's two farms. He resented the loss of time he could devote to his studies, but he thought the experience taught him the importance of hard work and the necessity to budget his time if he were to succeed as a student while helping his family.

When Visscher was about to graduate from Hope College in 1922, he was encouraged by his biology teacher and inspired by the example of a physician uncle to apply for a scholarship to study medicine or a preclinical science. One application went to the University of Minnesota, where Elias Potter Lyon was both dean of the medical school and head of the Department of Physiology. Lyon, who himself had graduated from a small Michigan college, was on the lookout for similar applicants, and he gave Visscher a teaching assistantship in physiology so that Visscher could work for the Ph.D. and M.D. at the same time. Visscher earned his Ph.D. in three years, presenting a thesis on the transport and storage of carbohydrate in the animal body on May 9, 1925. Minnesota's flexible medical curriculum allowed Visscher to pick up clinical experience on a catch-as-catch-can basis, so that he received his Minnesota M.D. in 1931 while he was head of the Department of Physiology and Pharmacology at the University of Southern California. Visscher later lamented that the rigidity imposed on medical studies by "curriculum reform" prevented many others from following his example.

Visscher received a National Research Council fellowship for two years in 1925, and he spent the first year working with Ernest Henry Starling at University College London and the second year in the Department of Physiology at the University of Chicago. Immediately afterward he was appointed associate professor and head of the Department of Physiology at the University of Tennessee. He moved to the University of Southern California in 1929, and from there he migrated in 1931 to the University of Illinois College of Medicine in Chicago, where he was head of the Department of Physiology. Lyon retired from physiology at Minnesota in 1936, and Visscher was brought back to Minneapolis to head the Department of Physiology. He became successively Distinguished Service Professor and Regents' Professor. When he became emeritus in 1970, he moved to another laboratory to continue his physiological research until just before he died of cancer on May 1, 1983.

When Maurice Visscher arrived in Starling's laboratory at University College London in the autumn of 1925, Starling had returned to the study of the behavior of the heart–lung preparation of a dog he had developed in 1912. In a heart–lung preparation, blood flows in a closed circuit from a reservoir into the right heart. From the right ventricle blood is ejected into the pulmonary artery and then into the lungs, where it is aerated by mechanical ventilation. Blood flows from the lungs through the pulmonary vein into the left heart, and upon being ejected by contraction of the left ventricle into the aorta, it passes through an adjustable resistance, then through a device by which the rate of flow of the blood is measured, and then into the reservoir, from which it returns to the right heart. The heart's rate of contraction is raised or lowered by warming or cooling the sino-atrial node, and the pressure by which it is filled is adjusted by raising or lowering the reservoir. The pressure against which the left ventricle works on each stroke is measured by a manometer, and the pressure is varied by adjustment of the resistance through which the blood then flows. The output of the ventricle on each contraction is calculated by dividing the rate of blood flow by the heart rate, and consequently the static work done by the ventricle by raising the pressure of the blood is calculated. Using this preparation, Starling had found what he said was the Law of the Heart: that "the mechanical energy set free on passage from the resting to the contracted state depends on the area of chemically active surfaces, i.e., on the length of the muscle fibres which in turn is determined by the volume of blood in the ventricle during diastole."

Starling and Visscher modified the heart–lung preparation by inserting a spirometer into the circuit ventilating the lungs, and by that means they could measure the rate of oxygen consumption by the preparation and could calculate the average oxygen consumption of the heart at each contraction. The calculation was not entirely correct, for the lungs as well as the heart consumed oxygen. Starling and Visscher thought the lung metabolism was probably constant and that in the face of the large changes in oxygen consumption by the heart, the lung oxygen consumption introduced little error. Likewise, the calculation of work done was not entirely correct. Starling and Visscher did not at that time measure pulmonary artery pressure or coronary blood flow. They also neglected kinetic work done in accelerating the blood. Nevertheless, they could obtain a reasonable estimate of the energy liberated by the oxygen consumed in relation to the work done. At this distance in time it is impossible to tell how much Starling and how much Visscher contributed to performing the experiments and drawing conclusions. Starling's own heart was beginning to fail, but Visscher wrote later "that [Starling] . . . was experiencing recurrence [of his disability], but he refrained from talking much about it and instead went right ahead with his research and writing program."[1]

Starling and Visscher found that in a sound heart whose output was maintained constant, the rate of oxygen consumption was directly proportional to the aortic pressure and therefore to the work done. When Starling and Visscher varied both the cardiac output and the aortic pressure, the rate of oxygen consumption was directly proportional to the diastolic volume and therefore to the diastolic length of the ventricle's muscle fibers. In a failing heart there was only a random relation between diastolic volume and work done, but here again there was a linear relation between the rate of oxygen consumption and diastolic ventricular volume. Starling and Visscher wrote:

> Under all conditions we have studied, the oxygen consumption of the isolated heart, maintained under constant chemical and temperature conditions, is determined by the diastolic volume, and therefore by the initial length of its muscle fibres. This rule applies whatever the physiological condition of the heart. During the whole of an experiment the oxygen consumption at a given diastolic volume is always the same, whatever the work the heart is performing at this volume.[2]

Visscher often restated the conclusion: the energy derived from oxidative metabolism is directly proportional to the diastolic volume of the heart, and the efficiency of the use of that energy decreases as the heart fails.

In Chicago Visscher refined the heart–lung preparation, and in particular he improved the accuracy of measurement of oxygen consumption. He added calculation of kinetic work to his estimate of work done by the left ventricle, and he arbitrarily substracted 20 per cent from the oxygen consumed to correct for its use by the lungs. When he used the value of 5 calories liberated per cubic centimeter of oxygen consumed, he found the efficiency of a sound heart to be about 6 per cent and that of a failing heart to be about 3 per cent. Such a calculation is critically dependent upon the assumed energy equivalent of oxygen, for if carbohydrate is burned the value is near 4 and if fat is burned the value is near 9. In Starling's laboratory Visscher had found that insulin "free of an adrenalin-like impurity" provoked an increase in oxygen consumption; when he was in Tennessee he found that the glycogen content of a dog's heart did not fall in an experiment lasting as long as six hours and that the amount of glucose taken from the blood could not account for more than 6 per cent of the heart's metabolism. In California Visscher enlisted the help of Richard Barnes and Eaton McKay, two experts on fat metabolism, and together they determined that oxidation of β-hydroxybutyric acid could account for between 22 and 82 per cent of the heart's oxygen consumption. The lungs alone used 80 per cent of their oxygen consumption to oxidize the ketone body.

While he was still in Chicago, Visscher had found in a few experiments that adding a digitalis glucoside increased both the heart's oxygen consumption and efficiency at constant diastolic volume. Soon after he arrived in Minnesota, Visscher had Gordon K. Moe as a graduate student and collaborator, and together they made a systematic study of the effects of digitalis preparations on the heart–lung preparation. First they found that a dose of digitalis insufficient to evoke irregularities of rhythm prevented or delayed failure. When Moe and Visscher allowed a heart to fail, they saw in one experiment that over fifty minutes the heart's efficiency dropped from 6.76 per cent to 3.88 percent. A dose of 2 milligrams of a digitalis glucoside restored efficiency to 4.91 per cent, and an additional 0.5 milligram raised it to 7.00 per cent.

During his tenure as head of the Department of Physiology at the University of Illinois College of Medicine in Chicago in 1931–36, Visscher substituted a study of absorption from the intestine for much but not all of his work on the heart. There is a story that Visscher became interested in absorption when a physician asked him whether perfusion of the intestine might be used as a means of dialysis in patients with kidney failure. That story may be true, but the most important factor in Visscher's study of absorption was that at Illinois he had the collaboration of Raymond C. Ingraham, who had just earned his Ph.D. in chemical engineering at Cornell. Papers by Ingraham and Visscher contain first- and second-order differential equations. Such mathematical formulation had not appeared before in Visscher's work, nor did it appear after his collaboration was broken by Visscher's return to Minnesota in 1936.

When Visscher began to study intestinal absorption, the topic was dominated by investigators attempting to replace what they conceived to be Rudolf Heidenhain's vitalism by strictly physical and chemical concepts. In the 1880s and 1890s Heidenhain had demonstrated that intestinal absorption cannot be attributed to osmotic and diffusive forces alone. Homologous serum, he showed, is absorbed by a tied-off loop of intestine of an anesthetized dog, although the serum has almost the same composition as the plasma into which it is absorbed. Even serum concentrated twice by evaporation in vacuo is absorbed. Likewise, chloride is absorbed against a concentration gradient, and its absorption is abolished by 0.04 per cent sodium fluoride. Heidenhain concluded that in addition to diffusion and osmosis, absorption is effected by a driving force, Treibkraft, residing in the cells of the intestinal epithelium.

Although Heidenhain repeatedly and vigorously asserted that by Treibkraft he did not mean "anything more . . . than [that] the chemical and physical events occurring within the cells produce demonstrable alteration within the cells or their surroundings,"[3] he was accused of vitalism by those who did not read his papers carefully. Physiologists in the first third of the twentieth century reacted against imputed vitalism by invoking the many anomalies of diffusion and osmosis through artificial membranes uncovered by physical chemists like Jacques Loeb. One physiologist reviewing intestinal absorption in 1921 wrote that "factors other than osmotic may be active in modifying [absorption]. . . . All the evidence points to their physico-chemical nature, and much useful research may still be expended before we need to seek refuge in that resort, 'vital cell activity.'"[4] Visscher, working first with Ingraham at Illinois and a few years later at Minnesota, laid the foundation upon which many others erected the elaborate structure called "active transport." For some reason, the term "active transport" introduced by Visscher seemed more mechanistic than "Treibkraft."

Visscher improved on Heidenhain's experiment by demonstrating absorption of autologous rather than homologous serum, and he and Ingraham analyzed luminal fluid and plasma for cations as well as for anions.

Sulfate ions are poorly absorbed by the intestine, and when Igraham and Visscher placed a mixture of half-isotonic sodium sulfate and half-isotonic sodium chloride in a loop of terminal ileum of an anesthetized dog's intestine, they found that in 1.5 hours the chloride concentration fell to less than 0.5 per cent of that in the dog's plasma. Bicarbonate concentration in the luminal fluid rose from zero to a concentration above that in plasma. Magnesium ions are also slowly absorbed, and when Ingraham and Visscher placed a mixture of magnesium chloride and sodium chloride in a similar loop, they saw that the sodium concentration fell to 5 mN, far below plasma concentration. When they divided the small intestine into four segments and repeated the sodium sulfate experiment, Ingraham and Visscher found that very little difference in chloride concentration was established in the jejunum. Chloride was more completely absorbed in descending segments. Because absorption of both chloride and sodium was abolished by metabolic inhibitors, Visscher concluded that their absorption is effected by active transport. Thus, Visscher's early experiments established that both anions and cations can be absorbed against a diffusion gradient and that there is a lengthwise gradient of absorption and secretion in the small intestine.

The Physics Department of the University of Minnesota had constructed a Van de Graaf apparatus before Visscher arrived in 1936, and Visscher could use short-lived $^{24}Na^+$ and $^{38}Cl^-$ produced in the machine. He used a homemade counter to measure radioactivity and a simple density method to measure $D_2O$. Later A. O. C. Nier, the head of the Physics Department, provided Visscher with a mass spectrometer. Because his work was done before methods of handling isotope data were generally agreed upon, Visscher had to invent his own method of using his data, and consequently his two papers published in the June and November 1944 issues of the *American Journal of Physiology* are hard to understand. Visscher had wrestled with his data for years before submitting the papers, and editors reluctant to accept papers with mathematical expressions caused additional delay in publication.

Visscher established good working relations with Owen Wangensteen, head of Minnesota's Department of Surgery, and young surgeons in training worked in Visscher's department, bringing with them their surgical skills.[5] Visscher, who had been trained in an era when no physiologist was happy unless he was up to his elbows in a 60-kilogram anesthetized dog, could begin to use dogs with chronically prepared Thiry-Vella loops of the small intestine or gastric pouches. He soon found that absorption is more rapid in a loop of an unanesthetized dog than it is in the corresponding loop of an acutely operated anesthetized dog, probably because of substantial sympathetic nervous activity in the latter.

When Visscher repeated on an ileal loop of an anesthetized dog his experiment of filling the loop with a mixture of half-isotonic sodium sulfate and half-isotonic sodium chloride, he added radioactive chloride as well as $D_2O$. Net chloride absorption, he found, was the difference between chloride being absorbed from the lumen and chloride being delivered to the lumen from the blood. Thus he established that net flux across the intestinal wall is the result of unidirectional fluxes in each direction. From the $D_2O$ data Visscher calculated that the concentration of chloride in fluid leaving the gut was half that in fluid entering the gut. Furthermore, when he measured the effect of osmotic pressure of luminal fluid upon absorption by putting 53 mN NaCl, 160 mN NaCl, or 480 mN NaCl in loops, he found that the rate of chloride moving from lumen to blood increased with luminal concentration of chloride but the rate at which chloride moved from blood to lumen was unaffected by the osmotic pressure of the fluid into which it moved. When luminal osmotic pressure was low, there was a net flow of water from lumen to blood, and when luminal osmotic pressure was high, the net flow was from blood to lumen. Using his $D_2O$ data, Visscher calculated that unidirectional flux of water from blood to lumen was essentially independent of luminal osmotic pressure, whereas flux from lumen to blood was high when luminal osmotic pressure was low and low when luminal osmotic pressure was high. The difference between the two fluxes accounts for whether net flow was in one direction or the other.

Visscher used chronically prepared Thiry-Vella loops of the duodenum, jejunum, ileum, and colon for his work with radioactive sodium. When he put labeled isotonic sodium solution in each loop, he found that the concentration of sodium in the lumen remained nearly constant in the lumen of the duodenum but that its specific activity decreased rapidly. The specific activity of sodium decreased less rapidly in the lumen of the jejunum than in the duodenum, and it decreased still less rapidly in the ileum and only very slowly in the colon. In corresponding experiments in which Visscher injected radioactive sodium into the dog's blood, he saw the specific activity of isotonic sodium solutions in the lumen rise rapidly in the duodenum, less rapidly in the jejunum, still less rapidly in the ileum, and only slowly in the colon. This observation established that there is a substantial two-way traffic of sodium between blood and lumen of the small intestine and colon and that there is a gradient of decreasing traffic from duodenum to colon. Visscher had demonstrated how the intestine handles electrolytes. Chyme is brought to isotonicity and neutrality in the duodenum and upper jejunum by a brisk flow of electrolytes in both directions across the intestinal mucosa. In the ileum there is net absorption of sodium, chloride, and water, with secretion of bicarbonate replacing chloride in the lumen. The colon performs the essential function of maintaining the volume of extracellular fluid by net absorption of the sodium that escapes absorption in the ileum.

After the Second World War, many persons newly arrived in physiology and biophysics greatly elaborated on the study of intestinal absorption by means of isotopes, and they developed perfusion methods permitting study of absorption by the human intestine. In the great flood of enthusiasm for this work, only a few remembered that Maurice Visscher deserved credit for starting it all.

At Minnesota, Maurice Visscher built a large Department of Physiology that under his leadership trained thirty-six Ph.D. students and provided research experience for more than fifty residents in training from clinical departments. Many of these students became distinguished physiologists or physiologically oriented clinical professors. In addition, Visscher's Department of Physiology contained the Division of Physiological Chemistry until it became an independent department in 1946. A Division of Cancer Biology was made a part of the Department of Physiology in 1942, when John J. Bittner, who had described the milk factor in mammary carcinogenesis, came to Minnesota from the Jackson Memorial Laboratory in Bar Harbor, Maine. Ancel Keys's Laboratory of Physiological Hygiene was housed in Visscher's department until 1946. Consequently, Visscher could assign his numerous graduate students to one or another of those programs as well as to his own multiple research programs in cardiac, gastrointestinal, and respiratory function. As a result, Visscher's name is on some 200 research papers published from Minnesota. His name is first in order on only the most important papers, and it is usually last on the others. One of his best students said Visscher put his own name last in order to give his students advantage in acquiring reputation and perhaps also in conformity with the English practice of listing names in alphabetical order, as exemplified by the Starling-Visscher paper. Now it is impossible to discover the magnitude and nature of Visscher's own contribution to papers on cancer, nutrition, aging, circadian rhythms, arterio-venous fistulas, acid–base balance in hyperventilation, edema of the lungs, kidney function, endotoxin shock, hypertension, and the rest that have a student's name first. When queried on this point, one of Visscher's students, a man who was with Visscher at Minnesota almost from the first and who had a long and brilliant career of his own, wrote: "I would be surprised if Maurice did not make a significant contribution at least to design and interpretation of any investigation in which he was involved."

Maurice Visscher's most remarkable administrative accomplishment at Minnesota was to foster close relations between his Department of Physiology and the Department of Surgery, an accomplishment all the more remarkable when one remembers that in most medical schools in the United States physiologists and surgeons scarcely know each other by sight. This relationship was promoted by three factors. The first was that the University of Minnesota had a Graduate School of Medicine that encouraged research and research training in all clinical departments, with the result that a large number of physicians and surgeons spent a year or two in basic science laboratories during their residency training, earning a master's or a doctor of philosophy degree. The second is the enthusiasm of Owen H. Wangensteen, head of the Department of Surgery from 1930, for physiological research. Wangensteen, who had himself earned a Ph.D. in 1925, believed that basic research has immediate application in treatment of patients before, during, and after surgical intervention, and his own research earned him election to the National Academy of Sciences in 1966. Wangensteen maintained surgical research laboratories, and he supported them by gently extracting donations from rich patients. As a result of his example and precept, 115 surgical fellows earned the Ph.D. degree, and Wangensteen himself was the major advisor of 69. The third was Visscher's urge to apply physiology to the solution of clinical problems. He had learned during his own clinical training that problems in patient care might be solved by application of basic science knowledge, and he encouraged his graduate students to earn an M.D. as he had done so that they could appreciate the potential applications of physiology to medical practice.

Cooperation between the two departments paid off handsomely. Wangensteen said that open heart surgery performed by the surgical staff could not have been done without the physiological background the surgeons had acquired, but there were many less spectacular benefits. For example, continuous monitoring of oxygen, carbon dioxide, and anesthetic gases day to day in the operating room made possible by the use of physiological equipment resulted in greatly improved condition of surgical patients in the recovery room.

Maurice Visscher abandoned the Calvinistic faith of his Dutch forefathers, and he stopped believing in an authoritarian underpinning of ethics provided by revealed religion. "Science and technology," he wrote, "contribute to rejection of values of yesterday."[6] When Visscher looked for a scientific and universally applicable ethical principle, he turned to the Unitarian Church, of which he became a trustee, and he adopted the Unitarian "effort to make the world better for all human beings." For him, improvement in the human condition is the desired good. Nevertheless, Visscher wrote that the rigidity of Calvinist doctrine promoted in him a sense of urgency so that he doubted whether he would have been as active in promoting humanistic values if he had been raised in a Unitarian family.

As a scientist, Visscher believed that the ethical imperative is "complete truthfulness, fearlessness in defending unfettered scientific inquiry and the necessity to communicate one's findings to the world." He thought that the growth of scientific knowledge occurring in his lifetime brought severe problems in scientist-to-scientist communication, and he helped to solve some problems by improving the effectiveness of abstracting and indexing and by supporting publication of reviews and critical compendiums. He became president of the board of directors of *Biological Abstracts*, and largely through his efforts *Biological Abstracts* was rescued from financial difficulties to become once more an important member of the information retrieval system. As a member of the board of *Annual Reviews*, he promoted a program of annual publication of critical review volumes not only in physiology but in thirteen other major areas of science. After Visscher finished his term as president of the American Physiological Society, he became a member and then chairman of the Society's board of publication trustees. As the result of the success of *Physiological Reviews* published by the board, a substantial surplus had been accumulated and wisely invested. Visscher persuaded the board and then the council of the Society to use the surplus to publish a series entitled *Handbooks of Physiology* to replace the German *Handbücher*, whose publication had been terminated by the war. Visscher served as chairman of the *Handbook* editorial committee for ten years, and he recruited editors and authors for authoritative surveys of each field of physiology. The multivolume *Handbooks* were an enormous success from the first, and the long row of blue-bound *Handbooks* are on the shelves of all university and medical school libraries as well as in the offices of progressive college teachers who want to keep up with the progress of physiology.

Maurice Visscher believed the antivivisection movement was a major threat to unfettered scientific inquiry, and for forty years he was an active and effective opponent of restrictive antivivisection legislation in the United States. As a board member and then vice-president and president of the National Society for Medical Research, the medical scientists' organization for combatting antivivisection, Visscher was tireless in attacking what he called "little old ladies of both sexes" who put their sentimental version of animal welfare before human welfare. In particular, Visscher lobbied in Minnesota and Washington against restrictive legislation, and in doing so he turned the ethical argument of antivivisectionists around, saying that man at the pinnacle of evolution of animals on earth has a moral obligation to use animals in humanely executed experiments to solve human problems.

Maurice Visscher fervently believed that he had a duty as a citizen as well as a scientist, and it would probably be easier to list good causes, if any could be found, other than those into which he threw himself with irresistible energy. Many were related to his professional work. He was an officer of the American Physiological Society, the Society for Experimental Biology and Medicine, the American Heart Association, the American Cancer Society, the Minnesota Polio Research Commission, the International Organization of Medical Sciences, and the International Union of Physiological Sciences. In 1938 he helped to organize the Minnesota Medical Foundation, an early health maintenance organization, against the formidable opposition of organized medicine. He was an officer of the American Association of Scientific Workers, of the American Association of University Professors, and of the Special Committee on the Civil Liberties of Scientists of the American Association for the Advancement of Science. For ten years Visscher ran the Prospect Park Consumers' Co-op out of the basement of his home. He worked for Hubert Humphrey in Humphrey's first campaign for mayor of Minneapolis, but he later broke with Humphrey over his support of the Vietnam War. Visscher was a member of the Unitarian Service Committee and of the United Nations Relief and Rehabilitation Medical Mission to Italy in 1945–46, and he went on a medical teaching mission to Austria for the World

Health Organization in 1947. At the time of atmospheric testing of atomic bombs, Visscher demonstrated pollution of food in Minnesota by radioactive fallout, and he became a member of Minnesota's Governor's Commission on Atomic Energy Development Problems and of the National Committee for a Sane Nuclear Policy.

As the inevitable consequence of some of these activities, Visscher was suspected of disloyalty during the period that followed President Truman's Loyalty and Security Executive Order of February 15, 1947. His telephone was tapped, and he was subjected to harrassment by the Loyalty Board of the Federal Security Agency. He received official notice on February 15, 1949, "that no reasonable grounds exist for belief that you are disloyal to the Government of United States." Thereafter Visscher refused to accept any appointment that would involve loyalty clearance. That, he believed, gave him greater freedom of action.

Maurice Visscher was a member of many senior committees of his medical school and university, and he expressed his views on medical school and university governance with his characteristic devotion to high principles and his disregard for any unfavorable consequences to himself. He even broke with his old friend Owen Wangensteen over a question of university policy. His dean wrote that "Dr. Visscher is an energetic and compulsive man about his own plans, projects and ideas. He rarely gives any evidence of self-doubt about his position in discussion of these or hesitancy in their promotion. The result is that he can be more than a little vexing at times."[7] Those who dealt with Maurice Visscher on other fields of action sometimes agreed with the dean.

Maurice Visscher was elected to the National Academy of Sciences in 1956. He was also a Fellow of the American Academy of Arts and Sciences and a member of the American Philosophical Society. He married Gertrude Pieters on August 12, 1925. She and two daughters and two sons survived him.

I AM GRATEFUL TO Nathan Lifson, Gordon K. Moe, Clara M. Szego, and Leonard G. Wilson for providing me with documents concerning Maurice B. Visscher, for making comments on his personality and career, and for answering questions about him.

## NOTES

1. Quoted by C. B. Chapman, "Ernest Henry Starling: The Clinician's Physiologist," *Annals of Internal Medicine* 57(Suppl. 2)(1962):42.

2. E. H. Starling and M. B. Visscher, "The Regulation of the Energy Output of the Heart," *Journal of Physiology* (London) 62(1927):243–61, p. 260.

3. R. Heidenhain, "Beiträge zur Histologie und Physiologie der Darmschleimhaut," *Pflugers Archiv* 43(Suppl.)(1888):63.

4. S. Goldschmidt, "Absorption from the Intestine," *Physiology Review* 1(1921):421–53, p. 449.

5. Visscher's admiration for Wangensteen and something of the collaboration between Visscher and Wangensteen in research and research training are described in Visscher's biographical memoir of Wangensteen.

6. Ethical principles and quotations attributed to Maurice Visscher are taken from his writings on ethics listed in the bibliography. I have occasionally paraphrased him. I am grateful to Dr. Kenneth W. Phifer of the Ann Arbor Unitarian-Universalist Church for advice on Unitarian ethics.

7. J. A. Myers, *Masters of Medicine* (St. Louis: Warren H. Green, 1968): 394–95.

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