

Biog

a history of medicine in pictures

by George A. Bender

painting by Robert A. Thom

Helmholtz: Physicist-Physician

HERMANN LUDWIG FERDINAND VON HELMHOLTZ as a youth did not want to be a physician: he wanted rather to be a physicist, or a mathematician. Later in life he became a scientific investigator who made outstanding contributions in each of these fields. Of him, Sigerist wrote: "It was a rare stroke of luck for medical science that a man with such eminent physical and mathematical gifts should be forced by circumstances to devote a considerable part of his life to medical science."

Medical men may remember Helmholtz best for his inventions: the ophthalmoscope and the ophthalmometer. However, his original research, both in physical optics and in color sensation, was much more extensive; and of almost equal importance to medicine were his studies of acoustics and of the mechanism of the middle ear. The scope of Helmholtz' interests and of his original work is amazing: in addition to the sciences of medicine, optics, and acoustics, the great German scientist made important contributions to knowledge in psychology, chemistry, physiology, physics, mechanics, hydrodynamics, electricity, color, meteorology, and mathematics. Hall comments that "It is doubtful if the world has ever produced a man who combined greater breadth of knowledge and greater depth of wisdom, with keenness of vision, persistency and patience of pursuit, and modesty of claim."



ROBERT THOM

Hermann Helmholtz was born August 31, 1821, at Potsdam, near Berlin. He was the son of Ferdinand Helmholtz, teacher in the Gymnasium (high school) and a man of high culture and intelligence. The mother was a daughter of a Hanoverian artillery officer named Penne—a lineal descendant of William Penn, the great Quaker who came to North America and founded Pennsylvania. A grandmother was of French origin. Helmholtz thus had German, English, and French blood in his veins. One of four children in a family of modest means, he was sickly as a child and had poor health throughout a long life. Confined to his room by illness for long periods, the boy sought amusement through activity of mind. He read widely and whiled away time with a set of blocks, from which early he gained concepts of geometry. He grew to love nature and enjoyed hikes in the country, gaining from them an appreciation for natural laws. His early interest in physics was revealed in his construction while in high school of optical apparatus, using odd lenses; in his surreptitious application of optical principles; and in his drawing diagrams, while attending lectures, illustrating passage of light through telescopes. He developed his mathematical talents without the aid of special instruction.

Young Helmholtz wanted to devote his life to the study of physics but the limited means of his father dictated otherwise. Surgeon-General Mursinna, a relative, advised the boy to study medicine, and in 1838 arranged for his admission to the Royal Medico-Chirurgical Friedrich-Wilhelms-Institute in Berlin—an appointment given freely to youths on condition that afterward they become surgeons in the Prussian army.

During his years in medical school, Helmholtz came under the influence of Johannes Müller, one of the Institute's great teachers, a circumstance which led to his association with DuBois Reymond, Brücke, Gustav Magnus, Kirchhoff, Virchow, and others who later joined with him in founding the Berlin Physiological Society.

During his student years, Helmholtz suffered an attack of typhoid fever and was treated at no cost to him at Charité Hospital. With money saved from his stipend during this period, he purchased a compound microscope, an instrument rarely possessed by students in those days. In 1842, Helmholtz, at the age of 21, presented his doctoral thesis, *On the Structure of the Nervous System of the Invertebrates*, in which he contributed basic knowledge: proof that nerve fibers are branches of nerve cells, a fact theretofore unknown.

For more than 50 years thereafter, from this time (1842) on to 1894, when Helmholtz reached the age of 73, papers flowed from his pen in almost uninterrupted succession. By the end of his career, he had published 217 papers and books.

Serving for six years, after graduation in 1842, as a medical officer in the Prussian army, Helmholtz continued research in his spare time. Among subjects he investigated were fermentation (in which he preceded Pasteur), and production of heat in contracting muscle. In 1847, at the age of 26, he published in pamphlet form what perhaps was his greatest scientific accomplishment: postulation and proof of the law of conservation of energy. Though now axiomatic, Helmholtz' theses...that energy is indestructible and that energy may be transformed but is never lost or destroyed...represented the first clear and

the picture Among great contributions to medicine in the nineteenth century was the ophthalmoscope, instrument used for inspection of the interior of the eye, invented in 1850 by Hermann Ludwig Ferdinand von Helmholtz (1821-1894). Professor of Physiology at Königsberg. Physician by training and teacher by profession, Helmholtz became Germany's foremost physicist, succeeding to the Chair of Physics at the University of Berlin. His contributions to medicine's knowledge of acoustics nearly equaled those to physiologic optics. His discoveries in physics advanced knowledge in a dozen scientific fields, earned him ennoblement, and brought him world-wide recognition during his lifetime.

unmistakable presentation of an idea, applicable to medicine as well as to mechanics, that had been only hinted at by earlier scientific workers.

In 1848, Helmholtz was allowed to leave the army so that he might become Professor of Anatomy at the Academy of Art in Berlin. In 1849, he became Professor of Physiology in Königsberg. Continuing research there, Helmholtz measured the velocity of the nerve impulse—believed by his teacher, Johannes Müller, to be technically impossible. At this time, too, he began intensive study of the physiology of the senses.

In the course of studies relating to physiologic optics, in 1850, Helmholtz invented the ophthalmoscope. He once wrote how the discovery came about: "I was endeavoring to explain to my pupils the emission of reflected light from the eye, a discovery made by Brücke, who would have invented the ophthalmoscope had he only asked himself how an optical image is formed by the light returning from the eye. In his research it was not necessary to ask it, but had he asked it, he was just the man to answer it as quickly as I did, and to invent the instrument. I turned the problem over and over to ascertain the simplest way in which I could demonstrate the phenomenon to my students. It was also a reminiscence of my days of medical study, that ophthalmologists had great trouble in dealing with certain cases of eye disease, then known as black cataract. The first model was constructed of pasteboard, lenses and cover glasses used in the microscopic work. It was at first so difficult to use, that I doubt if I should have persevered unless I had felt that it must succeed; but in eight days I had the great joy of being the first who saw before him a living human retina."

The ophthalmoscope consists essentially of a converging or concave mirror for concentrating light through the patient's pupil thus illuminating the retina and other parts of the eye. The eye of the observer is behind a small hole in the center of the mirror. In front of this opening is a magnifying lens or combina-

tion of lenses. Invention of this instrument opened a new era, not only for ophthalmologists, but for other practitioners of medicine, as well. Ophthalmoscopic examination of the retina, which may be regarded as an outlying portion of the brain, gives information of value, not only in diagnosis of diseases of the eye, but also in assessing pathologic states in other parts of the body.

Helmholtz' interest in physiologic optics began with the ophthalmoscope and did not end until he felt he had completely mastered the whole field. Next problem to attract his attention embraced optical constants in the eye. In order to determine the curvature of refractive surfaces, Helmholtz developed the ophthalmometer, by means of which refractive powers and visual defects of the individual eye might be measured. This work he continued until he could lay down rules for guidance of practicing ophthalmologists in use of the instrument in solution of problems of ocular accommodation, and in measurement necessary for preparation of lenses for correction of visual defects.

Helmholtz next turned to problems of color sensation, which he explored intensively, including causes of color blindness. This work on optics, begun in Königsberg, was continued in Bonn, and in Heidelberg, culminating in 1867 with publication of his classic work, *Handbook of Physiologic Optics*.

In 1856, Helmholtz, then 36 years of age, accepted the Chair of Anatomy and Physiology at the University of Bonn; three years later, in 1859, he became Professor of Physiology at Heidelberg, where he remained until 1871.

Paralleling his work on optics, and of almost equal importance to medicine, was Helmholtz' work on physiologic acoustics. Begun in Königsberg, the greater part of these studies was carried out in Bonn. Before Helmholtz' research, knowledge of acoustics was rudimentary and largely empiric. He combined his advanced knowledge of physics with experimental physiology and went on, not only to define physical principles underlying transmission of sound, but followed its course

Acknowledgment of helpful assistance in historical research basic to preparation and completion of the text and of the picture, Helmholtz: Physicist and Physician, is extended to Erwin H. Ackerknecht, M.D., Professor and Director of the Institute of the History of Medicine and Biology, University of Zurich, Switzerland; to Professor Robert Herrlinger, M.D., Ph.D., Director of the Institute of the History of Medicine, and to William Munich, M.D., University of Würzburg, Germany; to Professor Johannes Steudel, M.D., Director, Institute of the History of Medicine, University of Bonn, Germany; to Rudolph Sachtleben, Ph.D., Keeper of the Chemistry Department, Deutsches Museum, Munich, Germany; to Ludwig Kraft, Oberamtmann, Münchner Stadtmuseum, Munich, Germany; to Professor Gernot Rath, M.D., Chairman of the Department of the History of Medicine, University of Wisconsin Medical School, Madison, Wisconsin; to Henry A. Dunlap, M.D., Ophthalmologist, Jennings Hospital, Detroit, Michigan; to W. R. Jeeves, Vice President and Director of Overseas Operations, to Carl Johnson, Vice President, Advertising and Public Relations, and to J. P. Gray, M.D., Director of Special Medical Services, Parke, Davis & Company, Detroit, Michigan.

Printed in U.S.A.

Text and illustration copyright 1961 by Parke, Davis & Company.

through the middle ear to the brain. He accurately described, in detail, the anatomy of the middle ear, and the function of each tissue therein. Results of these studies were outlined in his book, *Sensations of Tone as the Physiological Basis of Music*, published in Heidelberg in 1863. These developments had been preceded by a number of papers over the years, including: *Vowel Tones*; *The Physical Basis of Harmony and Dissonance*; *The Theory of Organ Pipes*; *Musical Temperature*; and *Motions of the Strings of a Violin*. His monograph on anatomy of bones of the middle ear appeared in 1869.

After 1867, Helmholtz' work and publications were predominantly in the field of physics and mathematics, although his contributions relating to cerebral functions were of fundamental value to the field of psychology. In 1871, Helmholtz, logically, was invited to return to Berlin to take over the Chair of Physics at the University of Berlin, to succeed the great Magnus. In this position he was accorded recognition as the foremost physicist in Germany. During the next eleven years he contributed a total of 60 scientific papers on various subjects.

In 1888, Helmholtz became the first director of the Imperial Institute for Physics and Technology, at Charlottenburg, near Berlin. In addition to these new duties, he maintained his Chair at the University until his death. In his later years, instead of declining, Helmholtz seemed to increase in mental power. More and more, he devoted himself to establishment of fundamental principles related to dynamics, hydrodynamics, thermodynamics, electrodynamics, and other complex physical problems. He continued his popular science lectures, begun in Königsberg.

Despite his heavy program of scientific research, Helmholtz was a lover of art in all its forms: he was an accomplished musician; and, for recreation, he loved a climb in the mountains or a walk in a meadow. Some of the answers to his most puzzling problems, he related, came to him during his visits to nature. During his lifetime he was twice married. Two children were born to each union. His home life has been described as quiet, cultural, and pleasant.

Emperor Wilhelm I ennobled Helmholtz and often received him in the imperial domestic circle. Helmholtz' seventieth birthday anniversary was celebrated as a national event,

for which a gold medal was struck in his honor. The Kings of Sweden and of Italy, the Grand Duke of Baden, and the President of the French Republic each conferred special honors upon him.

Despite age, Helmholtz continued to be active: in 1892, he attended meetings of the British Association for the Advancement of Science, in Edinburgh, Scotland; and in 1893, the International Exposition in Chicago, after which he toured the United States and Canada. On his homeward journey, he fell on shipboard and suffered concussion of the brain. From this injury he only partially recovered, and in July, 1894, he suffered a stroke. Death took the great physicist and physician, September 8, 1894, just eight days after his seventy-third birthday anniversary.

Helmholtz... teacher, experimenter, physician, and physicist... left the world a great heritage of scientific advancement. There was an intimate relationship between his functions as professor and as original investigator: he investigated because he wanted to speak of matters with knowledge gained firsthand. Again and again he took up problems that he might master them himself, so that he might make clear explanations to his pupils. Students profited... and so did the entire world... for the work of the kindly, reserved professor was spread 'round the globe among practitioners of medicine and among those active in several other fields in science.

REFERENCES

- Ackerknecht, E. H., unpublished monograph.
- Ackerknecht, E. H., *A Short History of Medicine*. New York, Ronald Press Co., 1955.
- Arrington, George E., Jr., *A History of Ophthalmology*, New York, MD Publications, 1959.
- Friedenwald, H., *The History of the Invention and of the Development of the Ophthalmoscope*. The Journal of the American Medical Association, Vol. 38, No. 9, March 1, 1902.
- Goodspeed, A. W., *Contributions of Helmholtz to Physical Science*. The Journal of the American Medical Association, Vol. 38, No. 9, March 1, 1902.
- Hall, W. S., *The Contributions of Helmholtz to Physiology and Psychology*. The Journal of the American Medical Association, Vol. 38, No. 9, March 1, 1902.
- Knapp, H., *A Few Personal Recollections of Helmholtz*. The Journal of the American Medical Association, Vol. 38, No. 9, March 1, 1902.
- Koenigsberger, L., *Hermann von Helmholtz*, 3 Vols. Braunschweig, 1902.
- McKendrick, J. G., *Hermann Ludwig Ferdinand von Helmholtz*. London, T. Fisher Unwin, 1899.
- Randall, B. A., *The Debt of Otology to Helmholtz*. The Journal of the American Medical Association, Vol. 38, No. 9, March 1, 1902.
- Sigerist, H. E., *The Great Doctors*. New York, Norton & Co., 1933.
- Wood, C. A., *Hermann von Helmholtz, The Inventor of the Ophthalmoscope*. The Journal of the American Medical Association, Vol. 38, No. 9, March 1, 1902.