Singapore Med J 2006; 47(5) : 359

Medicine in Stamps
Hermann von Helmholtz (1821-1894): inventor of the ophthalmoscope

Tan SY, MD, JD, and Shigaki D, MS*
Professor of Medicine and
Adjunct Professor of Law, University of Hawaii
** 4th year medical student at John A. Burns School of Medicine, University of Hawaii*

"In the whole history of medicine there is no more beautiful episode than the invention of the ophthalmoscope, and physiology has few greater triumphs." – Edward Loring, American ophthalmologist, 1892

Until the middle of the 19th century, ophthalmology was literally in the dark. Clinicians were wholly dependent on symptoms and autopsy findings because they could not properly examine the eye. Earlier attempts by luminaries such as Purkinje, Babbage, Cummings and Brucke at designing an instrument capable of visualising the inner eye had failed. In 1850, Hermann von Helmholtz, a quiet and reserved physiology professor, succeeded in building a workable ophthalmoscope, which gave him *"the great joy of being the first to see a living human retina."* Remarkably, his revolutionary invention took all of eight days.

Physician, Physiologist and Physicist: Hermann Helmholtz (the title "von" was later bestowed by the Kaiser Wilhelm I in 1882) was born on August 31, 1821 in Potsdam, Prussia. He excelled in geometry and physics, and in his early teens, constructed various optical instruments using equations from old textbooks and lenses from cast-off spectacles. Helmholtz never wanted to become a doctor. His dream was to pursue a career in physics, but his family could not afford it. Becoming a doctor was a compromise, as he could get a free education at the Royal Fredrich-Whilhelm Institute for Medicine and Surgery in Berlin, a military medical school, and still have a career that is somewhat related to the sciences. In Berlin, he studied under the influential physiologist, Johannes Müller, discoverer of the Müllerian ducts, who taught him to emphasise experimentation over simple observations.

Helmholtz's first year after graduation was as a house-surgeon at the Charité Hospital, but he was put off by the incurable illnesses of his patients and the long work hours. His next job was as an army surgeon at Potsdam, where he was able to conduct experiments during his free time. After completing his military obligations, he joined the medical faculty at Königsberg, and devoted his energies solely to research.

The idea of examining the inner eye occurred to scientists, including Helmholtz's mentor, Müller, when they noticed that certain animal eyes would glow in the night. In the 1840s, William Cummings, an English physician, and Ernst Brucke, Helmholtz's good friend, separately noticed that the human eye also glowed when a bright light was directed to it in a dark room. They both attempted to peer into the eye but were unsuccessful because glare was reflected from the directed illumination (the fundus red reflex).

In 1850, Helmholtz was preparing a lecture on optics for his physiology students, when he asked himself why the pupil of an uninjured eye was always black. He determined that it was due to the refractive media of the inner eye, and then realised that reflected light returned along the same path as the illumination source. That explained why Cummings and Brucke could not see directly into the pupil. Helmholtz constructed an instrument that would allow him to reflect light into the eye without accompanying glare, but still provided enough illumination to view the retina. Although his instrument could not easily correct for lens refractive errors, it incorporated three essential features: (1) a source of light, (2) a reflective surface to direct light into the eye, and (3) a mechanism to focus the image on the fundus.

Helmholtz called his instrument *Augenspiegel* (eye mirror), and instantly knew that *"... all the alterations of the vitreous body and of the retina,*

which until now have been found in cadavers, will also be recognizable in the living eye, a possibility which appears to give promise of the greatest advances in the hitherto underdeveloped pathology of these structures." Years later, he would write that *"The ophthalmoscope became the most popular of my scientific achievements, but I have already pointed out to the oculists that good fortune had more to do with it than merit. I had to explain the theory of the emission of reflected light from the eye as discovered by Brucke to my students. Brucke himself was but a hair's breadth off the discovery of the ophthalmoscope. He had only neglected to ask himself what optical image was formed by the rays reflected from the luminous eye."*

More than one physician was puzzled by the mechanics of the instrument, and others were afraid that the light from the instrument could damage diseased eyes. One physician even asserted that *"only those with poor eyesight needed the assistance of such instrument."* But his invention thrilled Albrecht von Graefe, the most famous 19th century eye surgeon, who exclaimed that *"Helmholtz has unveiled a new world to us."* The ophthalmoscope allowed von Graefe to use iridectomy as treatment for glaucoma. In 1858, at the Heidelberg Ophthalmological Congress, von Graefe personally presented Helmholtz with a prize inscribed with these words: *"To the creator of a new science, to the benefactor of mankind, in thankful remembrance of the invention of the ophthalmoscope."*

After inventing the *Augenspiegel*, Helmholtz was given chairs both in anatomy and physiology at the University of Bonn. In 1871, he became the new chair of physics at the University of Berlin, a position he held for the rest of his life.

Other Contributions: Helmholtz's interests in the arts, biology and physical sciences, along with his unique ability to apply knowledge in one field to help explain phenomena in another, resulted in several important discoveries. In the field of optics, he is known for the Young-Helmholtz theory of colour, his theory on accommodation, and his three-volume work, *"Handbook of Physiological Optics."* He also made important contributions in energy research, worked on electric circuits and electrodynamics, and inspired many students, including Heinrich Hertz, who discovered "Hertzian waves", the basis of modern day wireless transmission.

Helmholtz was as passionate about science as he was the arts, including literature and theatre. He loved music and enjoyed playing the piano, which later influenced his studies in acoustics. His published work, *"The Sensation of Tone as a Physiological Basis of the Theory of Music,"* was read widely by physicists, physiologists and musicians. Indeed, it is said that Steinway, the famous German maker of quality pianos, experimented with some of Helmholtz's suggestions on the latter's family grand piano.

A Tragic Life, a Fateful Fall: Helmholtz's personal life was not a happy one. In 1849, he married Olga von Velten, who developed an unspecified debilitating illness a few years into their marriage. On June 4, 1858, Helmholtz's father, with whom he had an affectionate relationship, sustained a severe stroke and died before Helmholtz could reach him. Six months later, his wife Olga died. Two years after her death, he married a much younger Anna von Mohl, a cosmopolitan woman, but lost their two sons, Robert and Friedrich, when they were both quite young. Later, he was to lose his daughter Kathé, who died shortly after giving birth in 1877.

In 1893, Helmholtz made a fateful journey to the World's Fair in Chicago. This was his first and only visit to the United States and he was awe-stricken by the splendour of Niagara Falls. During his last stop in Boston, he fell down a steep stairway. Helmholtz already suffered from chronic migraine and fainting spells, and the fall resulted in a concussion and double vision. It took him twice as long to do his work and soon thereafter, he was unable to walk. His doctors determined that the paralysis was due to a slowly enlarging cerebral haemorrhage. His mental status fluctuated, and during semi-lucid times, he fantasised about Niagara Falls, repeatedly asking to look at pictures of this majestic natural wonder. In September 1894, Helmholtz died from complications of cerebral haemorrhage.

BIBLIOGRAPHY

1. Applebaum EL. Hermann von Helmholtz: A giant of science who cast his shadow on otolaryngology. Laryngoscope 2001; 111:937-9.
2. Blodi FC. The origin of the ophthalmoscope. Ophthalmology 1986; 93:1125.
3. Garrison FH. An Introduction to the History of Medicine. 4th ed. Philadelphia: WB Saunders, 1929.
4. Keeler CR. The ophthalmoscope in the lifetime of Hermann von Helmholtz. Arch Ophthalmol 2002; 120:194-201.
5. Koenigsberger L. Hermann von Helmholtz. Translated by Welby FA. New York: Dover Press, 1965.
6. Law FW. The origin of the ophthalmoscope. Ophthalmology 1986; 93:140-1.
7. Porter R. The Greatest Benefit to Mankind: A Medical History of Humanity. New York: WW Norton, 1997.
8. Ravin JG. Sesquicentennial of the ophthalmoscope. Arch Ophthalmol 1999; 117:1634-8.
9. Tuchmann A. Helmholtz and the German medical community. In: Cahan D, ed. Hermann von Helmholtz and the Foundations of Nineteenth-Century Science. Berkley: University of California Press, 1993.
10. Wade NJ. Hermann von Helmholtz. Perception 1994; 23:981-9.