Historical vignette

François Magendie (1783–1855) and his contributions to the foundations of neuroscience and neurosurgery

R. SHANE TUBBS, M.S., PA.-C., PH.D.,1,2 MARIOS LOUKAS, M.D., PH.D.,3,4 MOHAMMADALI M. SHOJA, M.D.,5 GHAFFAR SHOKOUIHI, M.D.,6 AND W. JERRY OAKES, M.D.1

1Section of Pediatric Neurosurgery, Children’s Hospital, and 2Department of Cell Biology, University of Alabama at Birmingham, Alabama; 3Department of Anatomical Sciences, St. George’s University School of Medicine, Grenada, West Indies; 4Department of Education and Development, Harvard Medical School, Boston, Massachusetts; 5Lung Disease and Research Institute and 6Department of Anatomy and Neurosurgery, Tabriz University of Medical Sciences, Tabriz, Iran

François Magendie lived during a tumultuous period in French history. Although this early medical pioneer made significant contributions to the fields of neuroanatomy, physiology, and pharmacology, little information is found in the non-French literature regarding this significant person in history. Based on this review, one could also consider this trained surgeon as an early pioneer of neurosurgery. For example, he is known to have used Galvanic current to treat various neuralgias, described a technique for extracting cerebrospinal fluid and quantitated and described its characteristics in normal and pathological specimens, and elucidated the functions of the cranial nerves using vivisection. Additionally, he accurately described the functions of the dorsal and ventral rootlets using vivisection, and realized that the exposed meninges were susceptible to painful stimuli. Our current knowledge is based on the early contributions of scientists such as François Magendie. (DOI: 10.3171/JNS/2008/108/5/1038)

KEY WORDS  •  François Magendie  •  neuroanatomy  •  vivisection

I began to regard it as probable that the posterior roots of the spinal nerves might very well have different functions from the anterior roots, and that they were more particularly destined for sensibility.

François Magendie7

Early Years

The Frenchman François Magendie (Fig. 1) was born in Bordeaux on October 6, 1783, and died on his birthday in 1855.4 This early scientist was considered a pioneer in experimental physiology. Magendie lived through tumultuous times, such as the occupation of Paris, the Hundred Days, and Waterloo. The son of a surgeon, Magendie also became a well-trained surgeon. Magendie was the son of Antoine Magendie and Marie Nicole de Perey. He had a younger brother, Jean-Jacques, whose name reflects his parents’ admiration of Jean-Jacques Rousseau (1712–1778). The two Magendie children were raised based on Rousseau’s teachings, which entailed fostering a child’s personal independence. Thus, Magendie at the age of 10 had never attended school and was unable to read or write. Encouraged by the French Revolution, Magendie’s family migrated to Paris in 1791 when Magendie was a child. In Paris, his father became more politically active and focused less on his surgical practice.2 His mother died in 1792.

At age 16, and too young to be admitted to the École de Santé, Magendie became an apprentice at the Hôtel-Dieu, where the surgeon Baron Alexis de Boyer (1757–1833), a friend of his father’s, accepted him as a student and put him to work preparing anatomical dissections.

Medical Training and Appointments

In 1803, Magendie was accepted as a medical student at the Hôpital Saint-Louis. In 1807, he officially became an assistant instructor in anatomy at the École de Médecine and taught courses in anatomy and physiology. He received his medical degree in Paris on March 24, 1808. This was a time of chaos for the practice of medicine in France. For example, in 1801, Napoleon created a law stating that no physician could practice medicine without a diploma from a medical school. Even Boyer, Napoleon’s personal surgeon, and the acclaimed Guillaume Dupuytren (1777–1835) had to pass new examinations.2,3

After his thesis, Magendie’s first publication was an article that appeared in the Bulletin des Sciences Médicales,
François Magendie

which was published by the Société Médicale d’Émulation, glorifying the memory of Marie François Xavier Bichat (1771–1802). In 1811, Magendie was appointed anatomy demonstrator at the Faculté de Médecine in Paris, and for 3 years he taught anatomy, physiology, and surgery. He was known as a skilled surgeon during operations he performed at the École Pratique. Magendie’s rude behavior is said to have resulted in a conflict with a professor of anatomy, François Chaussier (1746–1828). Additionally, it is said that the famous professor of surgery, Guillaume Dupuytren, saw Magendie as a dangerous rival and attempted to obstruct him on multiple fronts at the Faculté de Médecine.

In 1813, Magendie resigned from his position as an instructor of anatomy and began to practice as a private physician, and also began teaching private classes in physiology. In 1818 and after intense competition, he was appointed to the Bureau Central des Hôpitaux Parisiens, and in 1826 became Médecin adjoint at the Salpêtrière. In 1821, he founded the Journal de Physiologie Expérimentale. In 1831, he replaced Joseph Claude Anthelme Récamier (1774–1828) as the chair of medicine at the Collège de France. The reason behind Magendie’s shift from surgeon to experimenter has been debated. One theory is that political pressure from Dupuytren resulted in Magendie attempting to establish himself in a field in which competition was not as great as it was in surgery.

Experimental and Neuroanatomical Contributions

Experimentally, Magendie made multiple physiological and pharmacological discoveries. He disputed the function of the epiglottis during deglutition as necessary for preventing food from entering the trachea and demonstrated in animals that this belief was untrue. He demonstrated that pulmonary inflammation was less severe if the vagi were transected, and made a positive contribution to the study of infection when he demonstrated that the saliva of rabid dogs contained the contagious component.

His first physiological experiments concerned the mechanisms of swallowing and vomiting, proving the passive role of the stomach in vomiting. He also demonstrated the hemodynamic importance of elastin in the arteries and provided proof for the role of the liver in detoxification of the blood. Magendie introduced into medical practice a series of recently discovered alkaloids: strychnine, morphia, brucine, codeine, quinine, and veratrine. With consultation from Jean Louis Marie Poiseuille (1799–1869), he noted that blood pressure rises on expiration. In 1817, in collaboration with Pierre Joseph Pelletier (1788–1842), Magendie discovered emetine, the active ingredient of ipecac. Magendie did not hesitate to test all the substances on himself that he found harmless in his animal experiments.

Neuroanatomically, Magendie made important observations of the retina. He showed that the thalamus and cerebral peduncles were concerned with movement and that sectioning of the brain in these areas lead to hypertonicity. He was the first to produce deacrebrate rigidity with accuracy and also studied elementary reflex arcs. Magendie observed that puppies could still detect vapors such as tobacco smoke and ammonia after transaction of their olfactory nerves and concluded that the trigeminal nerve must be involved in conveying such stimuli. Moreover, he ascribed almost all sensory functions of the head to the trigeminal nerve and refuted historical ascriptions of sight to this cranial nerve (Figs. 2 and 3). Magendie also demonstrated that transaction of the anterior one-half of a cerebellar peduncle resulted in rotational movements of the experimented animal.

Major Scientific Contributions

It has been said that Magendie’s most important contribution to science was also his most disputed contribution. A contemporary of British anatomist Sir Charles Bell, Magendie conducted a number of experiments on the nervous system, in particular verifying the differences between sensory and motor nerves in the spinal cord. This discovery has been likened to the importance of William Harvey’s (1578–1657) description of the circulation of the blood. Moreover, this discovery was essential to Marshall Hall’s (1790–1857) discovery of the spinal reflexes. Many British claimed that Bell published his discoveries first and that Magendie purloined his findings. This intense dispute over the rightful discoverer resulted in Magendie’s claims.

In sum, Charles Bell had had, before me, but unknown to me, the idea of separately cutting the spinal roots; he likewise discovered that the anterior influences muscular contractility more than the posterior does. This is a question of priority in which I have, from the beginning, honored him. Now, as for having established that these roots have distinct properties, distinct functions, that the anterior ones control movement, and the posterior ones sensation, this discovery belongs to me.

Why must this scientist (Bell) spoil his work and injure
himself by not rendering to his rivals the justice due them? Why must he cling to that barbarous patriotism which rejects everything that does not come from his own country? Why does he persist in his pretensions to discoveries which he has not made?"

Olmsted concluded that the designation “Bell-Magendie law” represented a compromise between the points of view of the older anatomist (Bell) who arrived at function by way of observation and inference and the physiologically-minded scientist (Magendie) who insisted on experimental verification. Magendie also found that electrical stimulation of the dorsal roots in the lumbar region resulted in variations in blood pressure.

Magendie became infamous for his live public vivisections. In fact, a landmark bill banning animal cruelty in Britain described Magendie’s public dissection of a dog, in which the animal was nailed down ear and paw, half the nerves of its face dissected, and left overnight for further dissection the following day. During a trip to England in 1824 and as a guest of William Hyde Wollaston (1766–1828), Magendie publically demonstrated his method of vivisection of other cranial nerves in canines. Such experiments were rebuked in Britain for their brutality but proved important in determining multiple functions of such nerves as the optic, facial, and vestibulocochlear. For example, he was the first to ascribe a sensory function to the facial nerve because sectioning of this structure resulting in the crying out of experimented animals.

From 1824 to 1828, Magendie made many important discoveries regarding CSF. In fact, only 3 years after the death of the Italian savant Domenico Cotugno (1736–1822) who discovered CSF, Magendie documented his observations of this fluid and debated whether or not it was derived from the serum or was a fluid sui generis. In 1828, he presented these findings regarding the brain, titled “Mémoire Physiologique sur le Cerveau,” at the Academy of Sciences in Paris. At this meeting he documented his findings that demonstrated the egress of CSF from the fourth ventricle into the subarachnoid space at the “tip of the cerebellum.”

Fig. 2. Drawing of the brain and spinal cord with associated nerves from Magendie’s An elementary treatise on human physiology, on the basis of the précis elementaire de physiologie. Courtesy of the Reynolds Historical Library, The University of Alabama at Birmingham.

Fig. 3. Neuroanatomical drawing from Magendie’s An elementary treatise on human physiology, on the basis of the précis elementaire de physiologie. Courtesy of the Reynolds Historical Library, The University of Alabama at Birmingham.
of the calamus scriptorius of the medulla” (foramen of Magendie). Prior to Magendie’s description of the median fourth ventricular outlet, it had been recognized that there was some form of communication between the fluid contents of the cerebral ventricles and the subarachnoid spaces and cisternae. Interestingly, Magendie compared this pathway of CSF to a tunnel under the Thames and thought that the pineal gland was a “plug destined to open and shut the aqueduct.” He thought this a more practical function than the “seat of the soul” which Descartes had attributed to it. Regarding CSF flow from the fourth ventricle into the subarachnoid space, Magendie contradicted Bichat’s law, which stated that fluid secreted by a hollow organ is always secreted toward the interior of the organ and not toward its exterior. When Friedrich Tiedemann (1781–1861), a famous German physiologist, visited Paris he spoke with Magendie regarding such contradictions. Magendie vivisected an animal to demonstrate his findings to Tiedemann who then returned to Germany to push for the acceptance of this new idea.

Clinically and in the area of neurology, Magendie described a 34-year-old female with gigantism and attributed this condition to a pituitary disturbance, and reported a child with congenital absence of the cerebellum. Magendie was approached by a Polish officer who had been knocked unconscious in a battle with the Russians. Once revived, he had lost his sense of hearing and taste. After consulting physicians in Vienna and Trieste, this patient allowed Magendie to apply electrical current to his chorda tympani nerve via the external auditory meatus, which resulted in a return of his sense of taste. Magendie is said to have also restored this man’s hearing and that the first sound that the man heard following treatment was the beat of the drums at sunset in the Luxembourg Gardens. Magendie also had some success in dealing with various neuralgias by using Galvanic current and is reported to have amazingly restored the sight to a blind man using this method. He also described a technique for extracting CSF without injuring underlying neural tissue by piercing the posterior atlanto-occipital membrane (puncture of the cisterna magna). In a memoir read at the Royal Academy of Sciences in 1824, Magendie overturned the historic concept that CSF was a pathological product. He also determined the composition of this fluid in both normal and pathological conditions. Magendie stated that the CSF took on a yellow color in jaundice, a reddish color in scurvy, and a marked increase in protein in cholera.

Magendie married the wealthy widow Henriette Bastienne de Puisaye in 1830 and acquired an estate in Sannois, Seine-et-Oise. He left the Hôtel-Dieu in 1845 and Claude Bernard (1813–1878) substituted for him in his absence at the Collège de France (1847). Bernard was Magendie’s student from 1841 to 1843.

The French novelist Honoré de Balzac (1799–1850) wrote that Magendie (Fig. 4) was a distinguished intellect, but skeptical and contemptuous, and that he believed only in the scalpel. He also reported that his temper made him unpopular. Magendie’s students are said to have considered him impulsive and brusque of manner. Magendie said of himself:

Every one is fond of comparing himself to something great and grandiose; as Louis XIV likened himself to the sun, and others have had like similes. I am more humble. I compare myself to a mere ragpicker: with my spiked stick in my hand and my basket on my back, I traverse the field of science and I gather what I find. Medicine is a science in the making.

Conclusions
François Magendie made epoch-making contributions to experimental physiology, pharmacology, anatomy, and pathology. His name lives on today in the eponyms Bell-Magendie law, Magendie’s foramen (median aperture of the fourth ventricle), Magendie’s space (subarachnoid space), and Magendie’s sign (or Magendie-Hertwig syndrome, a downward and inward rotation of the eye due to a lesion in the cerebellum; Karl Heinrich Hertwig [1798–1881]). With such discoveries, Magendie made important contributions to the foundations of neurology and neurosurgery.

References
7. Magendie F: An Elementary Compendium of Physiology; for the Use of Students. E. Milligan, trans. Philadelphia: James Webster, 1824

Accepted August 16, 2007.

Address correspondence to: R. Shane Tubbs, Ph.D., Pediatric Neurosurgery, Children’s Hospital, 1600 7th Avenue South, ACC 400, Birmingham, Alabama 35233. email: rstubbs@uab.edu.