

History of neurology: Charles Bell and François Magendie - British versus French fights in the age of Napoleon and the discovery of the Bell-Magendie Law

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A live recording of this lecture can be viewed here:
[RRNMF – Charles Bell & Francois Magendie](#)

This History of Neurology segment is about Charles Bell and François Magendie. I have subtitled this talk “British versus French Fights in the Age of Napoleon and the Discovery of the Bell-Magendie Law”.

Charles Bell, who was eventually knighted as Sir Charles Bell, was born in Edinburgh.¹ He attended medical school in Edinburgh, where one of his mentors was Alexander Monro of the famed Monro dynasty. Bell was also a very talented artist, and many members of his family shared this artistic talent. While he was in medical school, he wrote *Systems of Dissection* to help medical students understand anatomy.² He then published this as a book in 1798 and it became very popular.

In 1804, Bell left Edinburgh for London. He was part of a diaspora of highly talented Scottish physicians and anatomists who relocated to London, where his career ultimately developed. Bell served as a physician during the British–French wars, caring for wounded soldiers. He was present at the Battle of Waterloo in 1815 where the Duke of Wellington, the commander of all the Allied forces, finally defeated the Napoleonic forces. Bell served as a battlefield surgeon dealing with many gruesome war injuries. He noted this made him a better surgeon in his civilian practice, as our modern military physicians often report.

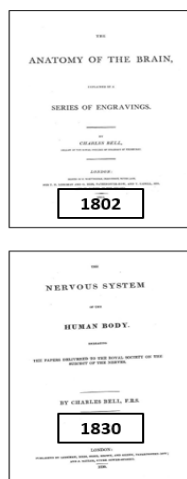
Figure 1

Sir Charles Bell (1774 – 1842)



- B. Edinburgh
- Mentor: Alexander Munro
- Was an Artist
 - In Med School published & illustrated *Systems of Dissection* (1798)
- Left Edinburgh late 1700's / early 1800's for London
- London; age 30; surgical practice & private anatomy school
- Most prominent of many Scottish surgeon/anatomists
- Cared for soldiers in Brit/French war
 - Was at Waterloo 1815!

Figure 2



Sir Charles Bell Books

- Wrote nervous system sections in brother John Bell's *Anatomy of the Human Body* – 1797
- *Systems of Dissection* – 1798
- *The Anatomy of the Brain, Explained by a Series of Engravings* – 1802
- *A Series of Engravings Explaining the Course of the Nerves* - 1803
- *Essays on the Anatomy of Expression in Painting* – 1806 (for artists)
- *Idea of a New Anatomy of the Brain: Submitted For The Observation of His Friends* – 1811
- *On the Nerves of the Face* - 1829
- *The Nervous System of the Human Body: Embracing the papers delivered to the Royal Society on the subject of the Nerves (with) Appendix, Cases & Letters on the Functions of the Nerves* – 1830

We know Charles Bell through his many publications, especially his books, and many of these have been recently reprinted (Figure 2). He first wrote on nervous anatomy in his brother John Bell's book, *Anatomy of the Human Body*, when he still lived in Scotland.³ Bell had incredible artistic and drawing skills and he created all of his figures himself. After moving to London, he began publishing important neuroanatomy manuscripts and books. *The Anatomy of the Brain, Explained by a Series of Engravings*, published in 1802, was followed by *A Series of Engravings Explaining the Course of the Nerves*, in 1803.^{4,5} The brain anatomy book contains exquisite color engravings of the brain (Figure 3). After he drew the detailed and beautiful images, they would be sent to an engraver, and the engraver would then send them to a publisher. Often the names of the artist (Dr. Bell), the engraver, and the publishing are all listed at the bottom of a figure. One illustration shows a human head with the brain exposed, resting thoughtfully on a hand. These are reminiscent of the naturalistic poses Andreas Vesalius often used in his landmark anatomy book in 1543 (Figure 4).⁶

Bell created his own drawings and then passed these on to an engraver. Vesalius, on the other hand, worked with a workshop of artists led by the famous Venetian artist Titian (Tiziano Vecellio). At the time of Vesalius, the prints of the drawings were made through the woodcut process. In other words, the drawings were given to a woodcut engraver who reproduced the image in a wood block. Ink was placed on the woodcut and paper was applied to transfer the image. At the time of Charles Bell, prints were made by engravings in copper and ink was applied to the copper which was then transferred to paper.

In the 1803 book on *The Course of the Nerves*, in the preface Bell stated his “ambition” was “to dedicate the first years of his profession to the investigation of the strict anatomy of the human body; and to supply the imperfections of the introductory schoolbooks”. Also in the preface, he stated the “views are given with simplicity, so as to facilitate an intricate study, and to enable the student to prosecute this department of Anatomy with encreasing interest and to greater minutness”. Therefore once again, his goal was to teach

Figure 3

Charles Bell *Anatomy of the Brain* - 1802

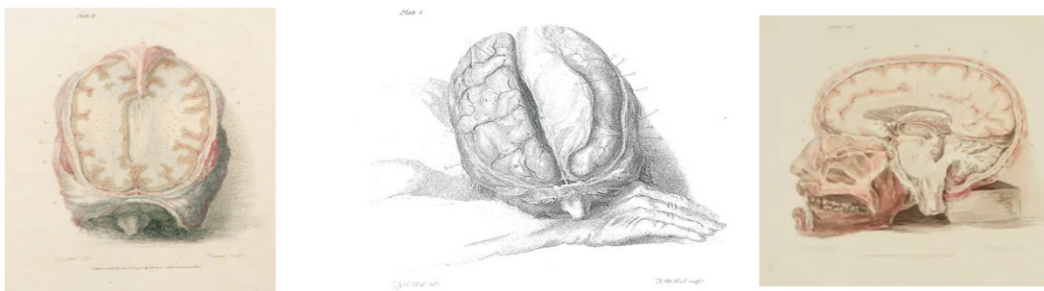


Figure 4

Images from Andreas Vesalius' 1543 Book *De Humani Corporis Fabrica Libri Septem*



Figure 5

Charles Bell
Anatomy of Expression - 1806
 ESSAYS

ANATOMY OF EXPRESSION

OF
 PAINTING.

BY CHARLES BELL.

— KEMER, SCOTCH, & SON

ST. PAUL, WEST-CHURCH, FURNISHING, BOOKS, AND STATIONERY.

NO. 1, WEST-CHURCH.

LONDON:

PRINTED FOR LONGMAN, REES, ORME, AND GREEN, PATERNOSTER-ROW.

1806.



Figure 6

Charles Bell
Anatomy of Expression - 1806

2. OF BODILY PAIN, ANGUISH, AND DEATH.



anatomy to medical students. Charles Bell was a teacher, in addition to being a physician and artist.

In 1806, he published *Essays on the Anatomy of Expression in Painting* (Figures 5 & 6).⁷ This book was written specifically for artists so they could understand facial expression. This book included not only drawings of human facial expression but also expressions in animals. As a result, his work became well known in the art community, and he gained access to London's social and artistic circles, which he greatly enjoyed. He received a steady income from both the *Systems of Dissection* and *Anatomy of Expression* books that sustained him until his London practice matured.

Bell wrote a small volume called *Idea of a New Anatomy of the Brain* in 1811 (Figure 7).⁸ This work was written primarily for his friends, and only about one hundred copies were produced. The early ideas he noted in this brief 36-page book became very important in the later debates with Francois Magendie on who first developed the concept of what would later be called the Bell-Magendie law.

Beginning in 1821, he read a series of papers that were later published in the *Philosophical Transactions* of the Royal Society of London.⁹⁻¹² In the 1821 paper, he described experiments that led him to the conclusion that cranial nerve VII sent nerves to the muscles of the face and cranial nerve V contained nerves that brought sensory information

to the brain. This was a new concept that had not been published before this time. It showed that some nerves were predominantly motor and other nerves were predominantly sensory. In 1824, these papers were published in book format.¹³ In 1829, he published in the *Philosophical Transactions* the paper *On the Nerves of the Face*, which he had previously read at the Royal Society.¹⁴ In this publication, he gave detailed descriptions of the course of the seventh cranial nerve. In 1830, he wrote a much larger and more comprehensive book titled *Nervous System of the Human Body* (Figure 8), again featuring many detailed and elegant illustrations which included his now classic figure and description of the nerves of the face.¹⁵ This book was his magnum opus. The title page stated the book was "embracing the papers delivered to the Royal Society on the subject of the nerves" presumably over many years. The 1830 publication contained an "appendix, containing cases and letters of consultation on nervous diseases, submitted to the author since the publication of his papers *On the Functions of the Nerves*, in the transaction of the Royal Society, and illustrative of the facts announced in the preceding pages". In the appendix, he then described case reports of 89 patients on whom he had been consulted. A number of these cases described injuries to the face producing facial paralysis. Other cases in which there were no obvious cause for the facial paralysis were described. We now call

these cases of facial paralysis “Bell’s palsy”. He also described cases producing paralysis of the lower extremities. These books made Bell famous throughout the world of medicine. At the same time, he maintained a very busy medical practice and he became wealthy.

As seen in Figure 8, Bell produced detailed illustrations of peripheral nerves, including drawings of the brachial plexus and a striking diagram showing all the spinal roots and cranial nerves emerging from the brainstem and spinal cord.

Scientifically, Bell made numerous important contributions (Figure 9). As noted above, he demonstrated that cranial nerve V is primarily sensory to the face. He showed that cranial nerve VII is motor to the muscles of facial expression and described facial palsy due to damage

of cranial nerve VII from a variety of causes, including gunshot wounds, syphilis, goring by an ox, and cases in which no cause could be identified. He described the long thoracic nerve which arose from cervical roots 5, 6, and 7 and innervated the serratus anterior muscle. This is now referred to as “the long thoracic nerve of Bell”. He also described what is known as Bell’s phenomenon or the palpebral-oculogyric reflex, in which the eyeballs rotate upward during voluntary eye closure. Neurologists use this sign routinely in medical practice to determine if a patient is giving full voluntary effort to squeeze their eye shut. When the examiner tries to pry the lids apart, if the pupils are still looking straight ahead, then the patient is not giving full effort.

Figure 7

Charles Bell

Idea of A New Anatomy of the Brain - 1811

- "On laying bare the roots of the fpinal nerves, I found that I could cut acrofs the pofterior fafciculus of nerves, which took its origin from the pofterior portion of the fpinal marrow without convulfing the mufcles of the back ; but that on touching the anterior fafciculus with the point of the knife, the mufcles of die back were immediately convulfed."

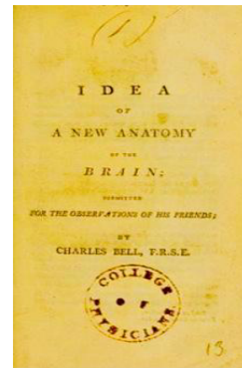


Figure 8

Charles Bell

Nervous System of the Human Body – 1830

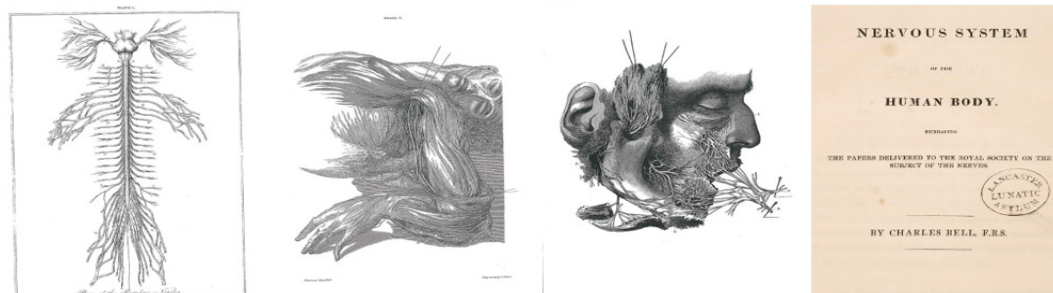


Figure 9

Charles Bell (1774 – 1842)

Scientific Innovations

- Demonstrated CN5 was sensory to the face & motor to mastication
- Demonstrated CN7 was motor to muscles of expression
- Facial palsy was to damage of CN7 due to a variety of causes:
 - Gunshot
 - Syphilis
 - Goring by ox
 - Unknown cause – Bell's Palsy
- Long Thoracic Nerve of Bell
- Bell's Phenomenon: Palpebral – Oculogyric Reflex
- Bell-Magendie Law

Figure 10

François Magendie (1793 – 1855)

Founder of French Experimental Medicine

- B. Bordeaux; family moved to Paris during revolution/political
- Med School 1799: Hotel Dieu/Charite
- Mentors: Dupuytren, Bichat
- Practicing hospital physician whole life
- 1803 – lecturer in anatomy
- 1816 – began experimental physiology in animals
 - Book: *Précis elementary de physiologies*
- 1822 – focused research on nervous system
- 1828 – Prof Physiology & General Pathology; College of France
- Experiments dividing various cerebellar connection & also removing cerebral hemispheres
- Described aperture medialis ventriculi quarti: now called Foramen of Magendie

This brings us to the Bell–Magendie law.

Before discussing the law itself, who was François Magendie (Figure 10)? Magendie is considered the founder of French experimental medicine, predating Claude Bernard. He was born in Bordeaux but moved to Paris because his father was very active in the French Revolution. He attended medical school in Paris, where his mentors included Dupuytren and Bichat.

Magendie practiced as a hospital physician throughout his life, but he was also a lecturer in anatomy. He established his own anatomy school and became deeply involved in experimental physiology. In 1816, he published a book describing a wide variety of animal experiments, which became very well-known called *Précis élémentaire de physiologie*.¹⁶ Beginning in 1822, he focused his research on the nervous system and was eventually appointed professor.

Magendie conducted numerous experiments on the central nervous system, including dividing different cerebellar connections and observing the resulting effects in animals. He removed one or both cerebral hemispheres in experimental studies and described the aperture of the median ventricle,

now known as the foramen of Magendie.

Regarding the Bell–Magendie law, the key questions are: who was first, and what exactly was discovered? In 1822, Magendie published a paper in a French journal in which he divided the anterior and posterior spinal roots in dogs.¹⁷ These were elegant and precise experiments. When he stimulated the posterior roots, he elicited pain. When he stimulated the anterior roots, he elicited movement. In doing so, he demonstrated that spinal nerves have two divisions: sensory information enters the spinal cord through the posterior roots, and motor information exits through the anterior roots. This became known as the Bell–Magendie law.

After this paper was published, Bell claimed that he had already described this phenomenon in his 1811 book, which had been written for a small circle of about one hundred friends (Figure 11).^{8,18} In that book, Bell stated that he could cut across the posterior fascicles of nerves originating from the posterior portion of the spinal marrow without causing muscle convulsions, but that touching the anterior fascicles with the point of a knife immediately caused the muscles to convulse. Bell believed this demonstrated that he had

Figure 11

Bell-Magendie Law Who Was First?

- Long debate over years:
 - 1822 – Magendie divided anterior and posterior spinal roots in dogs:
 - Stimulate posterior roots – pain
 - Stimulate anterior roots – movement
 - Proof spinal nerves had 2 divisions
 - Sensory information enters via posterior roots
 - Motor information exits via anterior roots
 - Pub: *J Physiol exper path* 1822;2:276-366
 - 1824 – Bell then said he 1st discovered this in 1811 book written for “friends” (100 copies)
 - *“I found that I could cut across the posterior fascicles of nerves, which took its origin from the posterior portion of the spinal marrow without convulsing the muscles of the back; but that on touching the anterior fascicles with the point of the knife, the muscles of the back were immediately convulsed.”*

Republished findings in 1824

discovered the principle first, though not in the level of detail provided by Magendie.

As a result, a scientific dispute ensued and lasted for many years. In both his 1824 book and in the preface to the 1830 book *The Nervous System of the Human Body*, Bell relitigated the argument and republished long quotations from his 1811 manuscript. He also tried to explain why he had not published these findings earlier in the transactions of the Royal Society. In addition, in a footnote to the preface, he claimed that some of his students had performed detailed laboratory experiments in 1821 that had been published. He also stated that in July of 1821, he himself read his first paper regarding a quote “new arrangement” of the nerves that contained many of these concepts.⁹ Therefore, he was not going to relinquish his claim that he was first. Bell and Magendie also argued over other neuroanatomical issues. While Napoleon was battling Horatio Nelson and the British on the battlefield, Dr. Bell and Dr. Magendie were fighting their own battles in the scientific press. However, he was not always arguing with Magendie. In the 1830 book, he took a more conciliatory approach and frequently mentioned other neuroanatomical contributions of Magendie that he agreed with.

Both Bell and Magendie are now considered giants in the early development of experimental neurophysiology and clinical neurology.

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