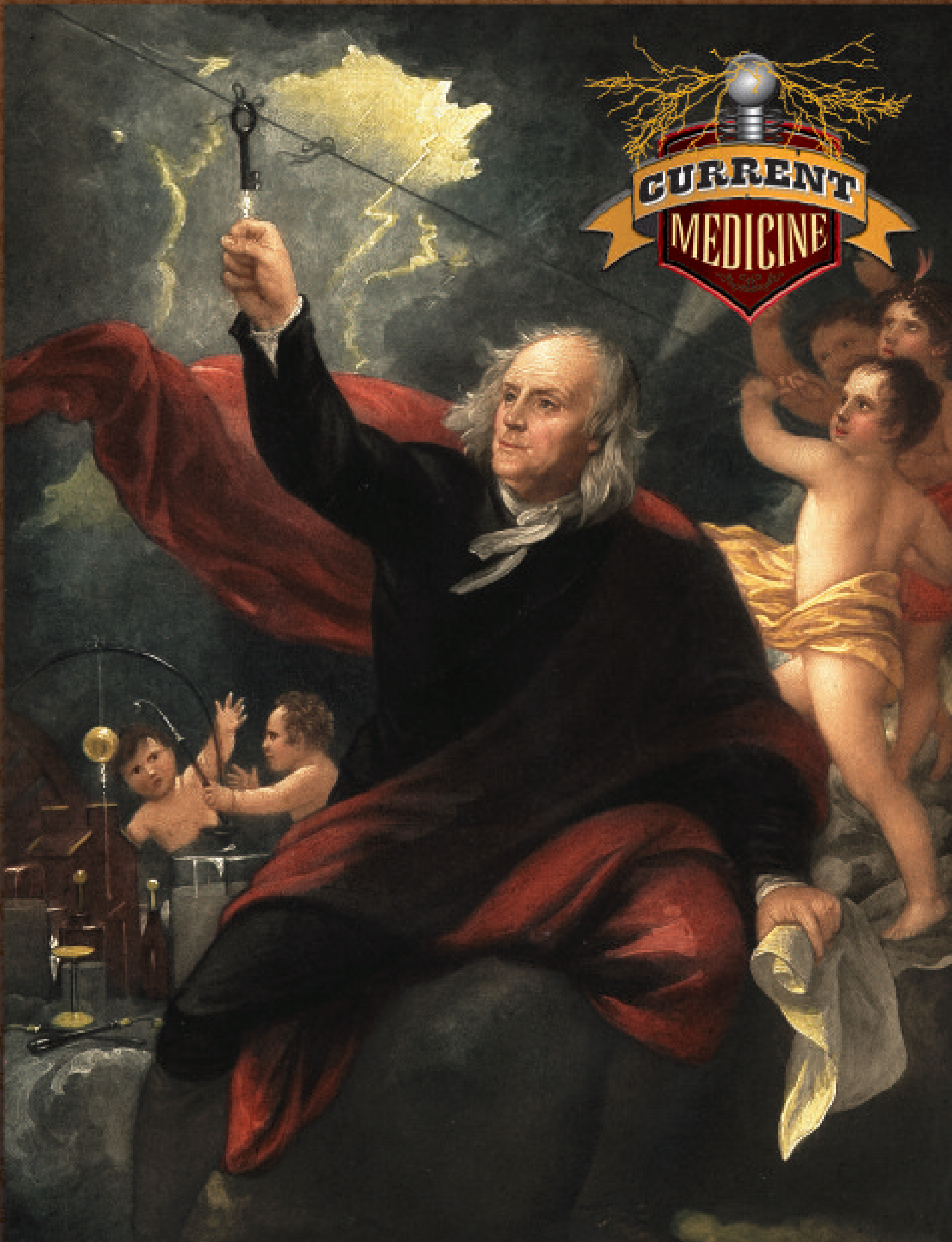
CURRENT
MEDICINE

the
William P. Didusch
CENTER FOR *Urologic History*

May 2010

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With
The William P. Didusch Center for Urologic History
of the American Urological Association
Rainer M. Engel, MD, Curator

Top | *Nikola Tesla (1856 – 1943) was a Serbian physicist and electrical engineer who could also visualize his inventions with extreme precision and did so well before beginning to construct them. Some of his best known inventions are the A.C. induction motor, the radio, wireless communications, wireless transmission of electrical energy, the remote control, Tesla's turbines and vertical take-off aircraft. He came to the United States to work for Thomas Edison, redesigning motors and generators, which led to Tesla's development of the alternating current system of electric generators. Tesla's A.C. induction motor is widely credited with starting the Industrial Revolution.*

Bottom | *Dispensing of electricity. Oil painting by Edmund Bristow, 1824.*

CURRENT MEDICINE

Critical *to a myriad of innovations in modern medical understanding and practice, the discovery of electricity and the means to harness its forces has profoundly impacted the progress of medical science for more than two centuries. From Luigi Galvani's first observations of bio-electricity to telemedicine and the insights provided by the latest medical imaging technologies, our ever-growing understanding of electricity and electro-magnetism has continued to bring revolutionary advances to the science of medicine.*

From the magnetic fields of our cosmos to the impulses that power our bodies at the cellular level, electricity is present throughout our universe. Although studied since antiquity, significant advances in the science of electricity would not take place until the 17th and 18th centuries. The ensuing developments in the production, availability and practical application of electricity, including its dramatic impact on communications, would drive a flood of medical innovations – along with some fascinating quackery – which persists through the present day.

The Earliest Observers

Ancient Egypt was the earliest civilization to formally observe electrical phenomena. Egyptian texts from 2,750 B.C. refer to the 'Thunderer of the Nile' and describe the shocks of electric fish. Within 1,000 years Greek, Roman and Arabic physicians would also observe the unique characteristics of the fish. Arabs indentified lightning and electricity and coined the term *raad*, for electric ray, sometime in the first millennium B.C.

Thales of Miletus (640 B.C. – 546 B.C.) is regarded as the first to observe a key force of electricity: attraction. Thales observed attraction in his studies of amber and lodestone, a natural magnet. Amber, when rubbed, attracted small bits of straw, wool and other light materials, leading Thales to postulate that these attractive items were alive based on the premise that only living things can give movement to inanimate objects. What Thales had discovered was not that the materials possessed life; rather, he was witnessing two natural powers – magnetism and static electricity – phenomena that would not be studied in great detail until two millennia later. The Greek word for amber, "elektron," is the origin of the word "electricity".

Author and naturalist **Pliny the Elder** (23 A.D. – 79 A.D.) and **Scribonius Largus** (1st c. A.D.), court physician to Roman emperor Claudius, wrote about the "numbing effect" of electrical shocks from certain catfish and torpedo rays. In *Compositiones Medicae* (circa 47 A.D.), Largus prescribes the application of the fishes' shock to treat pain in gout and headache patients. The treatment's effectiveness is unknown, but these cases may represent the first recorded intersection of electricity and medicine.

English court physician **William Gilbert** (1544-1603) explored both magnetism and electricity and, unlike others of the time, argued that they were separate forces. Like Thales before him, Gilbert studied the properties of lodestone as well as the attractive nature of rubbed amber. Unlike his ancient counterpart, however, Gilbert postulated that the properties of lodestone were different than those exhibited by rubbed amber. He coined the term "electricus" to describe the effect. Gilbert also studied the concept that the Earth is a magnet and asserted in his "attraction theory" that

The Baghdad Batteries and Moche Electroplating

In 1938, working outside present-day Baghdad, German archaeologist Wilhelm Konig discovered curious clay jars. Measuring about five inches long, the pots contained a copper cylinder, an iron rod and an asphalt stopper. Tests showed that the containers had held an acidic substance, perhaps wine or vinegar. Controversy still surrounds the find, yet archaeologists generally agree that the jars date from around 200 B.C., are of Parthian origin and are very likely to be batteries. Replicas of the jars, when filled with an electrolyte, produced nearly two volts– voltage similar to a modern AA battery. While none can say for certain, researchers have suggested a variety of possible uses, including "magical" ceremonies, medicine or electroplating.

No electroplated artifacts have been found from the Parthian period in the Middle East; however, artisans of the Moche civilization of northern Peru (100 B.C. – 800 A.D.) seem to have discovered just such a metallurgical process. Studies of gilt copper Moche burial artifacts discovered in 1969 have shown that the items had been plated using an electro-chemical replacement process. Just how much the Moche artisans understood electricity remains unknown, but the discovery puts Moche electroplating at least a millennium a ahead of the first European application of the process: in 1805 Italian chemist Luigi G. Brugnatelli began the modern era of electroplating using his colleague Alessandro Volta's 1800 invention: the voltaic pile, or battery.

Top right | *The first electrical machine invented by Otto von Guericke.*

Center | *Portrait of The Honourable Robert Boyle (1627 – 1691), Irish natural philosopher*

Bottom Left | *Thales of Miletus*

Bottom Right | *Stephen Gray's experiment of electrifying a boy by means of an excited glass rod.*

magnetism pulls objects to the Earth. This theory refuted Aristotle's long-held belief that all matter was animate and that objects fell because they were seeking their natural place in the world.

In order to fully explore the nature of electricity, scientists first needed a means by which it could be generated in quantities sufficient for experimentation. In 1660, **Otto von Guericke** (1602-1686), a German physicist, invented the first machine to harness static electricity – a generator consisting of a shaft topped with a ball of sulphur that could be rotated by hand to produce electricity through friction. Guericke would go on to build "bigger and better" generators, including a machine that incorporated a glass globe in its design. The globe would collect a charge while the machine was running and, once disconnected, would act as a battery of sorts for experiments. Through his studies, Guericke also demonstrated the concepts of conduction and repulsion, showing that electricity could be conducted through a moist thread and that similar materials (with like charges) repel each other. In 1675, the Irish natural philosopher and inventor **Robert Boyle** (1627-1691) would use one of Otto von Guericke's earlier inventions, the vacuum pump, to discover that electric forces could travel through a vacuum and to observe properties of electrical attraction and repulsion.

As the Middle Ages gave way to the Age of Enlightenment, scientific curiosity surrounding magnetism and static electricity prompted a number of notable scientists to further observe and experiment with the phenomena, expanding their knowledge and exploring potential uses of electricity.

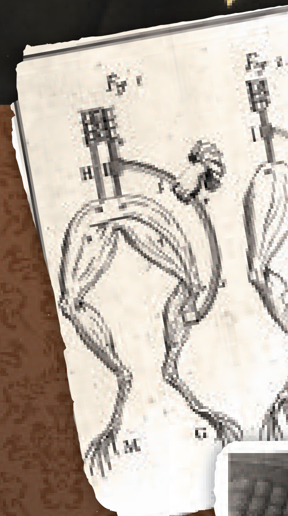
Critical to the understanding of electricity's behavior were the concepts of insulators and conductors, first observed and demonstrated by **Stephen Gray** (1666-1736) of England in 1729. Gray, a contemporary of Sir Isaac Newton, was conducting static electricity experiments using a glass tube as a friction generator when he noticed that the cork at the end of the tube demonstrated attractive properties. Testing his theory that the cork was conducting electricity, Gray inserted a stick into the center of the cork and saw that the charge was evident at the end of the stick. After demonstrating the effect with sticks of greater length, he began experimenting with threads connected to an ivory ball. He found that the fibers carried the charge of the electrified tube to the ball, where it showed slight attractive properties. Gray's conduction experiments ultimately reached a distance of 800 feet. From these experiments came the understanding that the threads should be insulated from the ground, lest they lose their charge. In 1732, French chemist **Charles Francois du Fay** (1697-1739) visited Gray, saw the experiment and returned to France where he proposed his "two-fluid" theory of electricity. After noticing that certain materials repelled each other and that others attracted, du Fay asserted that there were two types of electricity – resinous and vitreous. Du Fay proposed that resinous electricity was found in objects such as paper, and vitreous electricity was found in objects such as glass. Subsequent experimenters would later propose that these objects did not contain unique types of electricity; rather, that electricity had two different states.

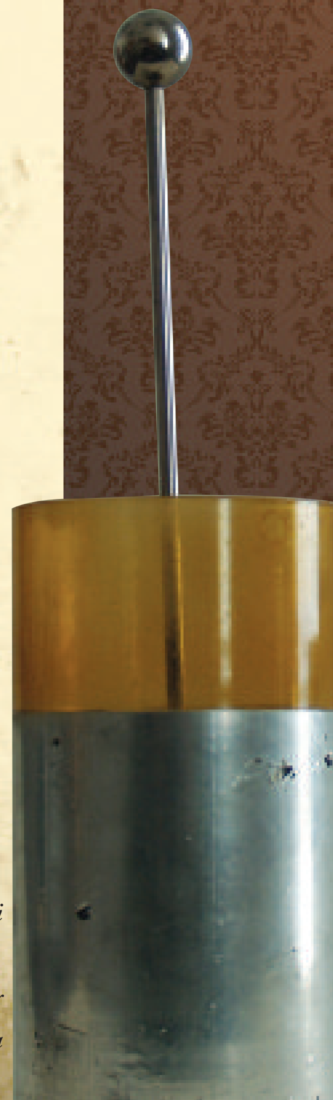
Gathering Energy

In 1754, Dutch physicist **Pieter van Musschenbroek** (1692-1761) and German clergyman and scientist **Ewald Georg von Kleist** (1700-1748), working independently, showed that it was possible to accumulate the charges generated by an electrostatic machine in a compact space. This early capacitor would ultimately be dubbed the Leyden jar (after Musschenbroek's hometown of Leyden in the Netherlands). Prior to the jar's invention, researchers had to use insulated conductors with large dimensions to store electrical charges. The improved device was a glass jar, lined with foil and partially filled with water. A rod electrode projected through a cork in the mouth of the jar and into the water. An electrostatic generator applied charge to the foil, causing positive and negative charges to accumulate. The accumulated charge could be dispersed through the rod when touched by a conducting material; it is said that both Musschenbroek and von Kleist received strong shocks after inadvertently touching the rod. A year later, English physician **William Watson** would go on to create an advanced version of the Leyden jar, lining the inside and covering the outside with foil to improve its capacity to hold electrical charges. At the time it was still believed that the charge in the Leyden jar was held by the water inside, not the jar itself.

American inventor **Benjamin Franklin** (1706-1790) – already having an avid interest in electricity after being given an electric tube by British scientist Peter Collinson in 1747 – was fascinated by the Leyden jar, and conducted his own experiments on what he termed "Musschenbroek's wonderful bottle." These experiments prompted Franklin to further explore the phenomenon of electricity using the device, ultimately postulating that the jar itself held the charge (not the water) and that electrical discharge was a means by which charges could equalize between materials.

Franklin also hypothesized that electricity was a natural, fluid force and that lightning was the result of electrostatic charges coming together into a single current. In 1752, using a kite, a metal key and a Leyden jar attached to the key by a thin wire, Franklin proved his theory. He flew the kite in the early stages of a storm (before lightning moved in) and saw that the Leyden jar and key had collected an electrostatic charge—a phenomenon that was unmistakable because several strings tied to the end of the cord that held the kite had moved to avoid each other's charge. Franklin touched the key and received a small shock. The Leyden jar continued to carry a charge. The stored charge cemented his hypothesis and paved the way for Franklin's invention of lightning rods. While these key researchers in England and America were exploring the means by which electricity could be generated and accumulated, one of the most important debates in the history of science was taking place in Italy between **Luigi Galvani** (1737-1798) and **Allessandro Giuseppe Antonio Anastasio Volta** (1745-1827).





Top Left | *View of Franklin , depicting the kite and key experiment.*

Top Right | *Luigi Galvani*

Center | *Galvani's experiments on the sciatic nerves of frogs.*

Bottom Left | *Leyden Jar*

Bottom Right | *Count Alessandro Giuseppe Antonio Anastasio Volta*

In 1771, Galvani, an Italian physician and physicist, working on a table where he had been conducting static electricity experiments, began the dissection of a frog. When Galvani's metal scalpel inadvertently touched the metal pin holding a frog's leg to the dissection surface , the frog's muscles twitched, leading Galvani to postulate that the frogs' legs contained a sort of "animal electric fluid." Galvani continued to explore the phenomenon, applying charges contained in a Leyden jar or from a rotating static electricity generator, ultimately coming to the conclusion that this "animal electric fluid" came from the brain and was activated by the electric charges.

Volta, a friend and colleague of Galvani, was inspired by the concept, telling the Royal Society in London that it was "one of the most beautiful and most surprising discoveries," and asserting that it had the potential to become the foundation from which other discoveries could be made. Volta strongly disagreed with Galvani's theory of bioelectricity, instead holding strong to his theory that electricity was a physical – not biological – phenomenon, and would go on to show that the spark-induced movement came not from the "fluid" within the animal, but from electricity moving between the scalpel and the metal pin (with the animal's tissue serving as a conductor). His experiments involved the pairing of metals to create electric charges; by stacking disks of two alternating metals interposed with moist, porous materials (such as felt or paper), he built the direct ancestor of the modern battery.

The popularity of the "Voltaic Pile" is said to have surpassed that of the Leyden jar, igniting inspiration in those who dreamt of a new source of power and energy. Napoleon even traveled to Pavia to view Volta's discovery.

Original Voltaic pile.
Probably made and used by Volta himself.
This pile was shown at the exhibition at Como, Italy in 1899, commemorating the work of Galvani and Volta.

In the early 19th century, **Sir Humphry Davy,** English inventor and chemist, having already improved upon the Voltaic pile, explored the concept of using an electric power source to generate light. In 1809, he invented the first electric light, attaching wires and charcoal strips to a battery to create an electrical arc. Working as an assistant to Davy at the time, Michael Faraday would later expand upon Davy's work and conduct some of the most important experiments of the 19th century.

As the early 19th century progressed, scientists began to more fully understand the relationship between magnetism and electricity. During a lecture April 21, 1820, **Hans Christian Oersted** (1777-1851) noticed that a compass needle's movement was influenced by an electric battery; when the battery's current was turned on and off, the needle deflected from magnetic north. Oersted came to believe that magnetic effects radiated from all sides of a charged wire – and that electricity could generate magnetic fields. He later published his findings, inspiring additional research and moving the scientific community toward a unified concept of energy.

On September 11, 1820, Oersted's finding would reach **André-Marie Ampère** (1775 –1836), a French physicist and mathematician. One week later, on September 18, Ampère presented a paper on the subject of what he called "electrodynamics" before the Académie des Sciences. This exposition and subsequent experiments would form the new field of electromagnetism. Having greatly expanded upon the science behind observed electromagnetic effects, Ampère's mathematical theories would also predict new phenomena, such as the magnetic effect of charged helical coils, and suggest what many regard as a precursor of the electron-shell model – his proposition that molecules are surrounded by a perpetual electric current. The International System of Units measurement of electric current, the ampere or 'amp', is named after him in acknowledgment of his contributions to the science.

In 1821, a year after Oersted's discovery that electricity could generate magnetic fields and the beginning of Ampere's investigations, **Michael Faraday** (1791-1867), a self-educated physicist who had assisted Davy in England, proved that the converse also held true: magnetic fields could generate electricity. He is best known for his law of induction, which states that a magnetic field changing in time creates a proportional electromotive force. This concept laid the foundation for electric motor technology, and cemented Faraday's status as one of the most influential scientists of his time.

Michael Faraday

Though coming from a poor family on the outskirts of London and having little formal education, Michael Faraday is considered by many to be one of history's most important scientists. Apprenticing himself to a book-binder at age 14, Faraday developed an intense love for books – science books in particular. By age 20, not long after completing his trade apprenticeship, Faraday was taken on by Sir Humphry Davy as a secretary. The following year, Davy would appoint Faraday as Chemical Assistant at the Royal Institution. Though Faraday would suffer from persistent class discrimination throughout his early life, his devotion – along with the help of a few insightful sponsors – would lead him, through constant experimentation, to momentous scientific discoveries in chemistry, electricity and magnetism. He would be elected to the Royal Institution of Great Britain in 1824; and appointed to a Fullerian professorship in chemistry for life.

"Nothing is too wonderful to be true if it be consistent with the laws of nature, and in such things as these, experiment is the best test of such consistency." – Michael Faraday

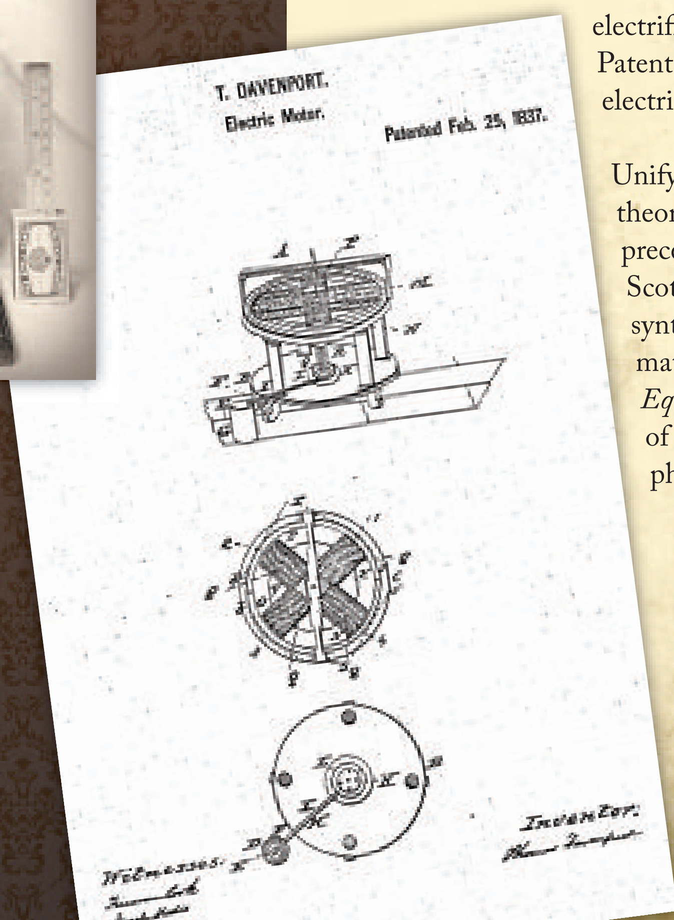
Top Left | *Portrait of Michael Faraday*
Top Right | *André-Marie Ampére*
Center | *Magnetic sparking coil made and used by Faraday, side view.*
Bottom Right | *Patent for electric motor by Thomas Davenport*

In 1832, Faraday, building upon Davy's earlier experiments with electrolysis, would produce his *1st law of electrolysis,* a process now widely used to separate elements and materials in chemistry and manufacturing. By 1839, Faraday had completed a set of experiments investigating the fundamental nature of electricity. He concluded, contrary to the dominant scientific opinions of the time, that electricity was a single force and that the various phenomena it produced were a result of variations in current and voltage.

In 1845, Faraday made what would, perhaps, be his most important discovery. He had discovered that the polarization of light could be influenced by the application of magnetic forces. The magnetic effect on light is now known as the *Faraday Effect* and would perpetually inspire physicists - including Albert Einstein, who venerated Faraday alongside Sir Isaac Newton and James Clerk Maxwell. The consequence of Faraday's discovery – the effective unification of electricity, magnetism and light as components of a single natural force – defies overstatement.

Oersted's discovery also inspired British scientist **William Sturgeon** (1783-1850) who in 1824 built the first electromagnet which, upon further refinement, earned him the silver medal of the Royal Society of Arts in 1825. Sturgeon established the journal *Annals of Electricity,* founded the Electrical Society of London, developed a galvanometer to detect and measure current, built one of the first practical electric motors, expanded Volta's cell concept to create a longer-lasting battery and invented the commutator – a key part of today's electric motor.

Combining Volta's and Sturgeon's inspired inventions, the American inventor **Thomas Davenport** (1802-1851) developed a battery-powered electric motor, as early as 1834. Using the motor to power a model car on a short section of track, his invention led to the electrification of street cars. Davenport received U.S. Patent No. 132, the first American patent for an electric machine, in 1837.



Unifying the observational, experimental and theoretical work in electricity and magnetism that preceded him, **James Clerk Maxwell** (1831-1879), Scottish physicist and mathematician, would synthesize classical electromagnetic theory. His mathematical work on the subject – *Maxwell's Equations* – would formally establish the unity of electricity, magnetism and light in a single phenomenon: the electromagnetic field.

Art Imitating Life

By the end of the 18th century, scientists, intellectuals and the general public were fascinated by the mysterious power of electrical current and its prospects for the future. Galvani's theory that animal tissues were infused with electric fluid had sparked others – including friend and colleague Volta – to explore the ways by which electricity interacts with life. The radical new technology was believed to have the ability to transform society by powering industry, curing disease and even resurrecting the dead. Many were testing Galvani's theory, including **Professor Giovanni Aldini**, Galvani's nephew. It was Aldini who conducted a notorious demonstration on January 17, 1803, in which he applied electricity to the fresh corpse of a murderer, Thomas Forster. He reported that immediately after the current was applied, "the jaw began to quiver, the adjoining muscles were horribly contorted, and the left eye actually opened."

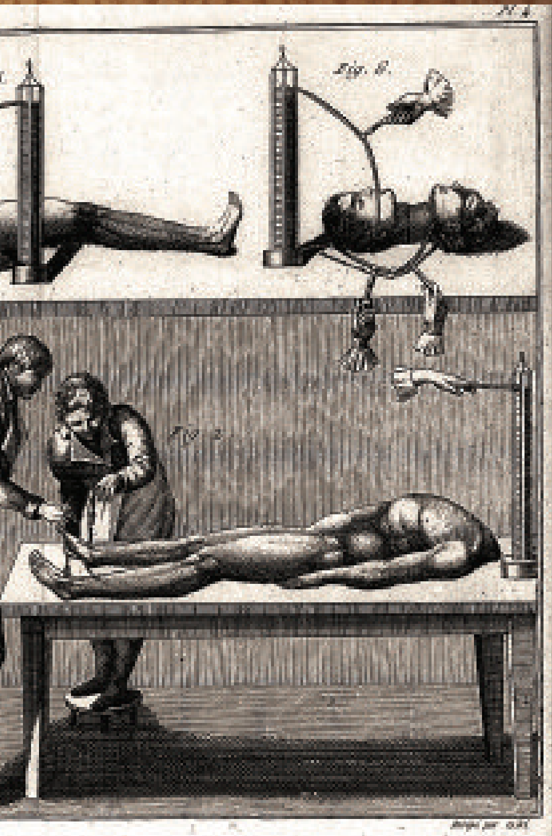
Novelist **Mary Shelley** (1797-1851) lived and wrote amidst this backdrop of scientific discovery, new electrical advances and an obsession with bringing the dead back to life. During the summer of 1816, she went to visit Lord Byron, who was living in the Villa Diodata on Lake Geneva. During the gathering, Lord Byron and Mary's husband, Percy Bysshe Shelley, took part in discussions involving the boundary between the living and the dead and the scientific search for the principle of life. One night, when the Shelleys and other guests were trapped indoors during a thunderstorm, Byron challenged his guests to write a ghost story: Mary's story became *Frankenstein*. Mary's book, which confronts many of the fascinating questions regarding electricity that occupied the scientific minds of the day, is the tale of Dr. Victor Frankenstein and his creature, composed of dead flesh and brought to life by electricity. It went on to become a huge success when published in 1818.

"*Many and long were the conversations between Lord Byron and (Percy) Shelley, to which I was a devout but nearly silent listener. During one of these, various philosophical doctrines were discussed, and among others the nature of the principle of life, and whether there was any probability of its ever being discovered and communicated,*" Mary wrote in the preface to the 1831 edition. "*They talked of the experiments of Dr. [Erasmus] Darwin, (I speak not of what the Doctor really did, or said that he did, but, as more to my purpose, of what was then spoken of as having been done by him) who preserved a piece of vermicelli in a glass case, till by some extraordinary means it began to move with voluntary motion. Not thus, after all, would life be given. Perhaps a corpse would be re-animated; galvanism had given token of such things: perhaps the component parts of a creature might be manufactured, brought together, and endued with vital warmth.*"

Top Left | *Galvanism experiments. From: Essai theoretique experimental sur le Galvanisme*

Center | *Portrait of Mary Shelley, 1840*

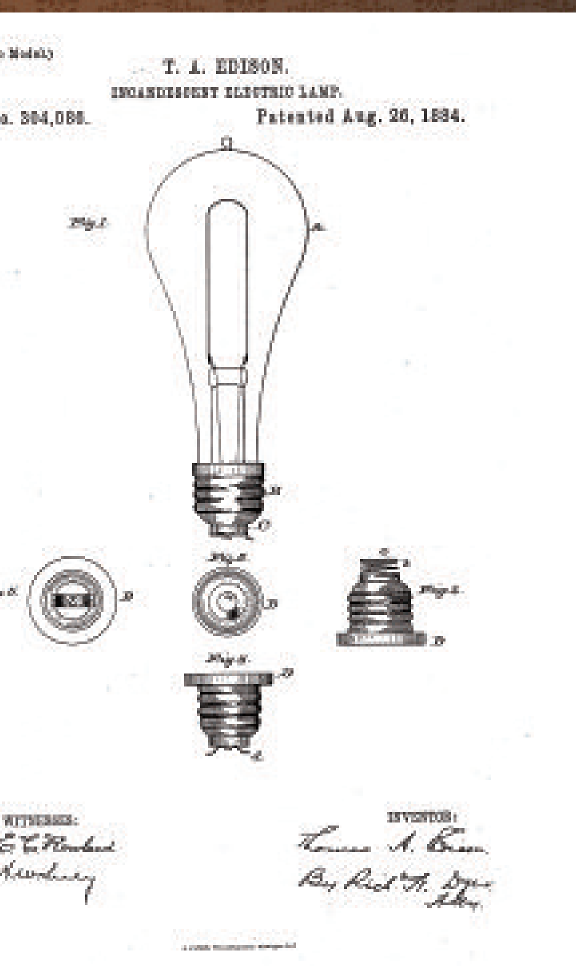
Bottom Right | *Patent for "incandescent electric lamp", 1884, T.A. Edison*



Shelley's literary work is a product of the societal clash between the fervor of romanticism and the Enlightenment philosophy of scientific rationality of the time. Though she engages with themes that were popular during the late 18th and early 19th centuries, her warning about the desire to harness the powerful forces of nature and to play with the delicate balance between life and death still resonates today. *Frankenstein* has stood the test of time, serving as a reminder of what humans can achieve through scientific discovery and the vital role electricity plays in the workings of the human body. *Frankenstein* also reminds us of the human quest to prolong life and of the tragedies that sometimes occur during this quest.

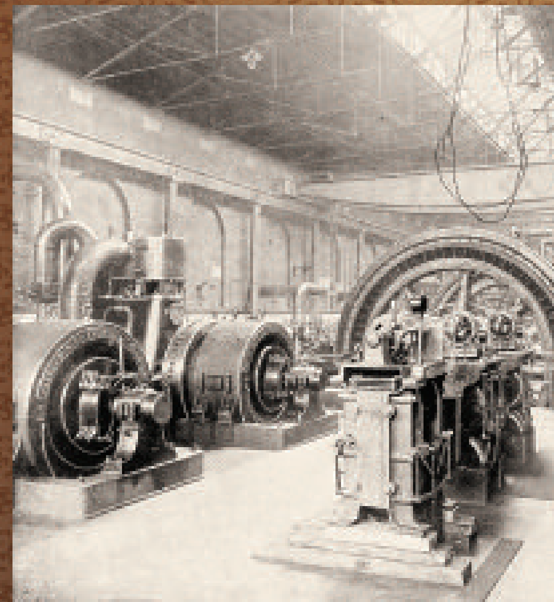
Bringing Power to the People

As inventors such as Sturgeon and Davenport applied Faraday's electromagnetic discoveries to the motor, numerous others worked to develop a more practical, cost-effective electric light source. English chemist and physicist **Joseph Wilson Swan** (1828-1914) and the American inventor **Thomas Alva Edison** (1847-1931) would go on to win the race for a functional electric light, with Swan winning the first English patent for the incandescent light bulb in 1878 and Edison ultimately inventing the first commercially practical incandescent light bulb and the means by which it could be used by the masses.



The same year that Swan won his patent, Edison started the Edison Electric Light Company in New York City, taking the features of earlier light bulb designs and setting his company's workers to the task of creating longer-lasting bulbs. By 1879, he had produced a new concept: a high resistance lamp in a very high vacuum, which would burn for hundreds of hours (early prototypes lasted fewer than 20 hours). In 1880, Edison received a patent for the first design for electricity distribution. Swan established the Swan Electric Light Company in 1881 in England. In 1882, Edison's new company, the Edison Illuminating Company, provided 110 volts direct current (DC) to 59 customers in lower Manhattan, allowing homes in the area to make use of Edison's light bulb. Electric power in homes was here to stay. In 1883, Edison and Swan would merge their companies to establish the Edison & Swan United Electric Light Company.

War of the Currents: AC vs. DC

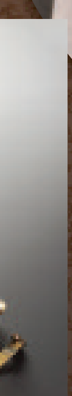


In 1882, **Nikola Tesla** (1856-1943), an engineer at the Continental Edison Company in Paris, developed the first induction motor, where power is supplied by a rotor (electromagnetic induction) in an alternating current (AC). Tesla came to the United States from Europe in 1883 to improve Edison's DC-powered machines. Following a falling-out supposedly arising from Edison's failure to pay Tesla promised funds, he severed ties with Edison and began to focus his work on his own experiments with AC power, becoming Edison's greatest rival. In 1889, Tesla's work gained the attention of **George Westinghouse, Jr.** (1846-1914), an inventor known for developing the railway air brake, who began dabbling in electrical power distribution around the turn of the century. Westinghouse, a notable industrialist, saw great promise in Tesla's work on alternating current, purchased his AC motor patents and hired him to apply the technology in Westinghouse's own power system. The "War of Currents" had begun.

Edison's system delivered direct current to customers; however, it could only be effectively delivered in a single voltage over a distance of approximately one and a half miles, making it economical only for those living within a close proximity to a generating station. Tesla's alternating current could be sent from the power plant at high voltages over thinner and cheaper wires and then stepped down by a transformer at the destination for distribution to users. A vast public relations war was waged between the two power-houses, and, after a long battle of public opinion, the more practical AC distribution system – and Tesla – won out.

Electricity was now harnessed and economically distributed to customers to power practical, life-changing machines. The field of medicine was one of many that would soon take the advances and apply them to create devices and instruments we use to save lives every day.

Top Left | *An electric power generating station of 1904.*
Top Right | *George Westinghouse, Jr.*
Center | *Images showing a male having his face stimulated by electricity in an experiment on the electro-physiological expression of passions.*
Center Right | *Duchenne demonstrating the use of electrotherapy, the author applies electrodes to the cheeks of a woman to stimulate the facial muscles.*
Bottom Left | *Duchenne Medical Induction Machine, made by Charriere, Paris, French, 1849.*



Electricity in Medicine

From man's earliest observations of electrical phenomena, more than four millennia ago, to Galvani's momentous accident, the intimate relationship between electricity and physiology lay just beyond our grasp. In the 18th and early 19th centuries, as the fundamentals of electricity began to reveal themselves in the workshops and laboratories of experimenters — and in the minds of mathematicians and natural philosophers — the medical implications of the new science were never far from pioneering imaginations. Just what role electricity would play in the medical revolution to come was yet unknown. But, that it would have a role was already a certainty.

Researchers were fascinated with electricity and worked to harness this new power for good, as well as profit. Many inventions came and went; some proving useful and others, mere quackery. Several pioneers stand out as having developed applications for electricity that are now integral to every-day clinical practice. Their inventions help us to visualize, diagnose and treat patients in ways that were not possible 150 years ago.

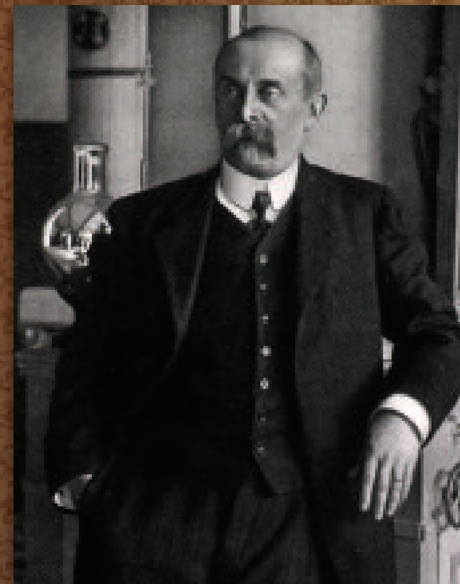
Much of what we now know about the function of the muscles in the human body is based on the discoveries by French neurologist **Guillaume Benjamin Armand Duchenne** (1806-1874). Drawing on Galvani's discovery that electric charges can cause muscle movement, Duchenne found that, when electric current was applied to a patient's skin, muscles contracted. He developed and used an induction coil to apply electricity to muscles to help diagnose a patient's problems, later expanding the device for therapeutic use. His studies helped him to map out muscle function and he later realized that for significant movements, such as smiling, multiple muscles need to contract. In patients with nerve injuries, he used electricity to force a muscle to contract. As long as there was still some electrical contractility remaining in the muscle itself, he could assume that the patient's recovery would be quick; if there were no contractions, the patient would recover slowly, if at all. Duchenne is also credited as the first to use an "artificial pacemaker" after he used an electrical current to induce electrophrenic stimulation in the resuscitation of a drowned girl. The development of the pacemaker eventually led to other inventions to stimulate muscles and solve physical ailments. For instance, in urology, we now use biofeedback to improve bladder function by electrically stimulating pelvic floor muscles to produce contractions, which give the patient the example of the proper contraction sensation so that he or she can work on producing contractions regularly to strengthen pelvic muscles.

Surgery

The use of heat to control bleeding and seal blood vessels dates back to ancient times. Though hot-iron cautery was replaced by ligatures in the 1500s and then languished for centuries, **Jacques-Arsene D'Arsonval** (1851-1940) helped reinvigorate interest in the procedure. D'Arsonval discovered that high-alternating current could be applied to tissues to control bleeding without affecting sensory nerves or producing muscular contractions. By the early 20th century, the technology was being used to destroy skin lesions. Others, including Doyen, W.L. Clark and Lee DeForest would make improvements to D'Arsonval's device, ultimately leading to what we now call electrosurgery. By 1910, these electro-cauterization units were being used to treat not only skin lesions, but also bladder tumors and hemorrhoids.

During this period, surgeons were also making significant advancements in sanitization, including **Enrico Bottini** (1835-1903), a physician in Pavia, Italy. Having shown the importance of destroying micro-organisms in infected wounds — which he called "microphytes" — Bottini described his use of carbolic acid to achieve a cleaner surgical field as early as 1866. Bottini had a keen interest in the field of urology and devoted himself wholeheartedly to this specialty. In 1900, he presented the results of his experience with an instrument he had first designed in 1874 in a treatise called *On Prostate Ischuria*. His "thermo-galvanic incisor of the prostate" was the first such incisor to allow a surgeon to electrically cauterize an incision. This new technique, wherein the heated incisor simultaneously cut and cauterized tissue while destroying micro-organisms, reduced the risk of infection and scar tissue buildup in the incision, a potential cause of discomfort and urination complications. Bottini's incisor was later improved upon by Freudenberg.

In the United States, as early as 1892, **William Niles Wishard** of Indianapolis (1851-1941) had picked up on Bottini's idea and designed an instrument that was introduced through a perineal incision into the urethra. Wishard became the first to perform an incision of the prostate under direct vision—a major feat. Wishard went on to become the second president of the American Urological Association in 1904. Shortly afterwards, **Charles Chetwood** (1869-1954), in New York, created an instrument that was also introduced through a perineal urethrotomy; however, it did not allow for direct observation. These instruments are the contemporaries of the Collins knife, a long blade that is still used today during a transurethral incision of the prostate (TUIP).



Top Left | *Professeur A. d'Arsonval*
Top Right | *Maximilian Nitze*
Center | *William N. Wishard*
Center Right | *Nitze's cystoscope with a closeup of the tip showing the filament wire.*
Bottom Left | *William N. Wishard in Surgery*

Diagnostics

A ground-breaking development for urology was the invention of the cystoscope by **Maximilian Nitze** (1848-1906). Prior to Nitze's design, the only instruments to look into the bladder were woefully inadequate. The Lichtleiter, created by **Philipp Bozzini** in 1806, used a candle as a light source and had no lens system. Designs by others did not do much better, though short hollow tubes – such as H.A. Kelly's instrument – provided adequate visualization of the female bladder.

The cystoscope is a lighted instrument that is used to look inside the bladder and is, perhaps, the most significant of all contributions of urology to medical technology. Paving the way for endoscopy and laparoscopy, the cystoscope was one of the earliest instruments to let us look into the human body.

Nitze's 1877 invention combined an instrument with a water-cooled electric platinum filament lamp at the tip of the instrument and a lens system to allow a clear view of the inside of the organ — the first cystoscope. Initial designs were hampered by a rather cumbersome cooling system that was necessary for the platinum wire in the tip of the instrument. But, in 1888, when he eventually allowed his instrument to be fitted with the miniaturized electric bulb (the mignon bulb developed by Koch and Preston in Rochester, NY), Nitze's instrument became widely used and accepted. The new light source made the cooling system unnecessary, and thus made the instrument affordable.

Nitze recognized the value of being able to diagnose intravesical and intraurethral diseases with the cystoscope, and in 1895 also designed an operating instrument with cutting loops that could remove tumors and cauterize the tumor bed. His cystoscope has been modified and improved; today we use a light source that is outside the human body with both light and image transmitted through fiber-optic bundles. The cystoscope fathered several great endoscopic instruments, which led in turn to a vast array of specialized instruments that allow us to operate inside of the living human body.

Imaging

The fascination with peering inside the body continued as physicists and mathematicians studied electricity and electromagnetism. In the late 19th century, notable researchers such as **Johann Hittorf** and **William Crookes** investigated the effects of energy discharges. Heinrich Hertz demonstrated that cathode rays could penetrate thin metals and Tesla discovered a process to produce electromagnetic radiation. However, it would be German physicist **Wilhelm Conrad Roentgen** (1845-1923) whose name would be forever attached to imaging. In 1894 – through experiments with vacuum tube equipment developed by Hittorf, Crookes, Hertz, Tesla and Philipp von Lenard – Roentgen began to observe and document X-rays. Roentgen found that invisible cathode rays could penetrate many substances, including soft tissue, to varying degrees. The first X-ray image ever published, taken Dec. 22, 1895, was of his wife's left hand, clearly showing the bones of her hand and her wedding ring. He immediately wrote a preliminary report *"On a New Kind of Ray: a Preliminary Communication,"* which he submitted to the *Physical-Medical Society Journal of Würzburg* on December 28, 1895. In this paper he first used the term "X-ray," which has been used ever since.

Thomas Edison is credited with designing and producing the first commercially available fluoroscope, a machine that uses X-rays to take radiographs. Roentgen's images were very faint; Edison discovered that calcium tungstate fluoroscopy screens produced brighter images than the barium platinocyanide used by Roentgen. Many will remember the fluoroscopes used in shoe stores that allowed you to see the bones of your feet and toes wiggling.

Early X-ray photography systems were relatively inefficient; because much of the radiation was absorbed by the body, high radiation levels were required to achieve a clear image. Photographic plates were initially used to produce the images; eventually film replaced these plates and today we use digital systems in place of film, though film technology remains in use in industrial radiography.

Radiation Therapy

Not long after Roentgen's discovery of X-rays, **Marie Sklodowska-Curie** (1867-1934) and her husband **Pierre Curie** (1859 –1906) isolated the first known radioactive elements, which Marie named *polonium* (after her homeland of Poland) and *radium*. These elements emitted a natural form of radiation, which would become known as gamma rays. X-rays had been

Top Left | *Wilhelm Conrad Roentgen*

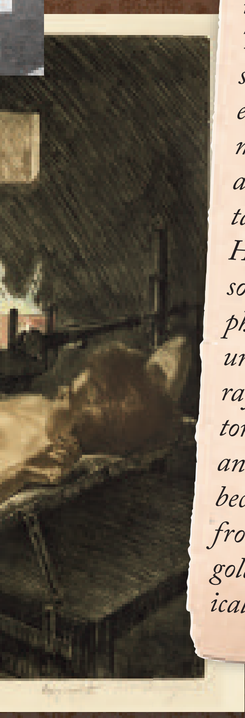
Top Right | *Marie and Pierre Curie,holding aloft a glowing specimen of Radium, 1904.*

Center Left | *Hand of Frau Roentgen with a ring, 1895.*

Bottom | *Print showing a physician using X-rays to repel Death, personified as a skeleton wearing a shroud, as it approaches a young woman on an operating table.*

quickly adopted to diagnose broken bones and locate foreign bodies, but, initially, radium appeared to have no practical value beyond its use as a luminescent paint for the dials on wristwatches and other timepieces. Though some had maintained that radium had curative powers, it was ultimately discovered that its use caused some very negative effects: cancer; damage to blood cells, internal bleeding, nausea, vomiting, skin problems, destruction of tissue, and loss of hair and appetite. The negative effects of radiation were not fully understood until several pioneering researchers became seriously ill from handling radioactive elements.

In remarkably rapid succession, scientists began to harness radiation and created several very effective treatments. At Chicago's Hahnemann Medical College in 1895, within two months of the X-ray discovery, **Emil Grubbe** (1875-1960) began an investigation into the capabilities of Roentgen's ray. Grubbe began to suffer from radiation-dermatitis and quickly made the connection between the lesions and the radiation with which he had been experimenting. On the suggestion of a friend, he began to experiment with the rays in the treatment of carcinoma and was met with almost immediate success: in 1896, while still a medical student, Grubbe became the first to use X-rays to radiate a cancer patient — a woman named Rose Lee, who was suffering from locally advanced breast cancer and was no longer responding to her treatments — and founded the world's first radiation therapy facility in Chicago.



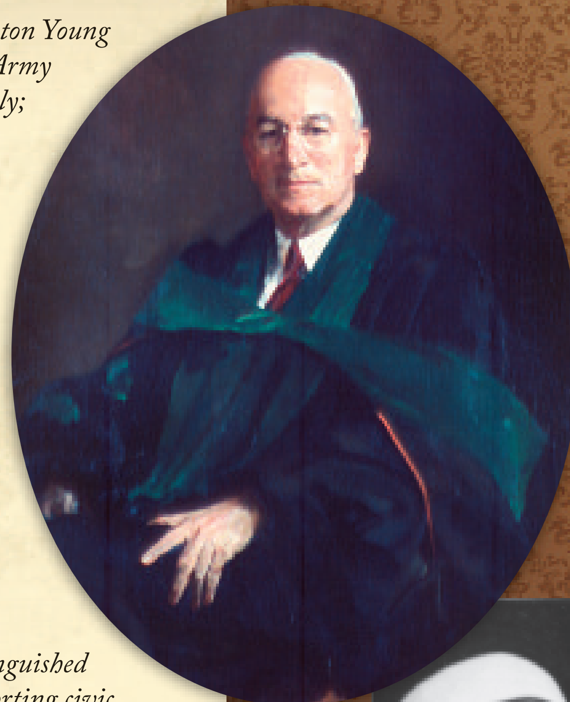
Emil Grubbe

Born to German immigrants in Chicago, Emil Grubbe got his first job at age 13 as bottle washer and errand boy in a drugstore. By age 15, with a growing interest in science and medicine, the bright young Emil moved on to a higher-paying office boy job at Marshall Field's famous store. Emil's intelligence and interests impressed Field, who encouraged him to become a physician. Though it was not unusual for a boy of his age to enter medical school at the time, Emil's modest background and minimal formal education prevented him from entering any of Chicago's selective medical schools. He enrolled at Northern Indiana Normal School at Valparaiso, where he worked as a night watchman and obtained his formal education. In 1895, Emil was admitted to Hahnemann Medical College of Chicago, where his progress was so rapid that he was given a teaching position – instructing in physics and chemistry – in his first year, while still working on his undergraduate degree. That same year, inspired by Roentgen's X-ray, he began the experiments that established his place in the history of medicine. The pioneering physician applied his intelligence and curiosity to medicine for the remainder of his long life, also becoming an ardent traveler and volcanologist. In 1964, a bequest from his estate to the University of Chicago established an annual gold medal prize in his honor, now awarded by the Chicago Medical Society at the Chicago Radiological Society meetings.

Within a few years, patients in America and Europe were receiving radiotherapy and **Claude Regaud** (1870-1940), a professor at the Radium Institute in Paris, noticed that radiation treatments were better tolerated when delivered in smaller doses over several weeks. Fractionation, as it would be called, remains at the heart of many modern treatments used in radiation oncology.

Early radiation therapy was limited by the inability of X-ray machines to produce high-energy beams that could penetrate deep-seated tumors without causing excessive external tissue damage. Radium was scarce and expensive, but was frequently used for insertion directly into cancers. A technique requiring the placement of radioactive sources close to the tumor, now known as brachytherapy, became the mainstay of treatment. In addition to skin cancer, physicians were now able to treat lymphatic, cervical and uterine cancers with radiation. Beginning in 1922, General Electric began to develop special tubes to deliver 200kv for lung, abdominal and pelvic tumors. Modern radiation therapy (XRT) uses ionized radiation to control and destroy malignant cells.

Hugh Hampton Young



(1870–1945) Urology pioneer, surgeon and inventor Hugh Hampton Young was born in Texas in 1870, the son and grandson of Confederate Army officers. In his mother's home state, Young distinguished himself early; graduating from the University of Virginia in 1891 — having acquired BA, MA, and MD degrees in just four years; an unprecedented feat. At age 25, Young would take a teaching position at Johns Hopkins Institute. Within two years time, in 1897, he would be appointed head of the genitourinary division at Johns Hopkins Hospital, where he would remain until 1940. Considered the father of American urology, Young's contributions to medicine include several surgical devices and procedures, including brachytherapy. ***Hugh Hampton Young (1870–1945) was the first to treat bladder and prostate cancers with radioactive seeds.*** *In 1904 Young would perform the first radical perineal prostatectomy for cancer of the prostate. During his long tenure at Johns Hopkins, he would establish the institute's urological residency — the Brady Residency, co-author Young's Practice of Urology, become president of the American Urological Association and found The Journal of Urology. Outside of his distinguished medical career, Young devoted himself to aviation and causes supporting civic development, the armed forces and the arts.*

After World War II, cyclotrons and nuclear reactors allowed production of other radioactive element delivery mechanisms for cancer therapy, such as the cobalt machine, which appeared in 1951. More than 1,000 of these machines were sold to hospitals within the first 10 years. Soon machines were produced that not only delivered hundreds of kilovolts, but megavolts, enabling doctors to treat and cure other diseases. By the 1970s, radiation treatment planning would involve computers, computed tomography (CAT) scans, and eventually magnetic resonance imaging (MRI), and positron emission tomography (PET) scans, allowing us to target tumors with a multi-port approach. This approach focuses the radiation on the cancer itself utilizing multiple "ports," todays radiation therapy, minimizes skin and deeper organ damage.

Hugh Young was one of the first to apply radium directly onto cancers. We are showing his applicator, and the optical system do not have the sheath used for the procedure. Young started hi prior to joining the US "Expeditionary Force" in 1917. While front, his wife wrote to him that the government had requisit radium supply "for military use." We have no information as t how they used it.

Top Left | *Hugh Hampton Young*
Top Right | *Prokhorov and Basov showing their lab to Charles Townes, 1965.*
Center | *Maiman's first laser, dissembled. ca. 1987*
Bottom | *LASER disintegrating stone.*

LASERs: Radiation in the OR

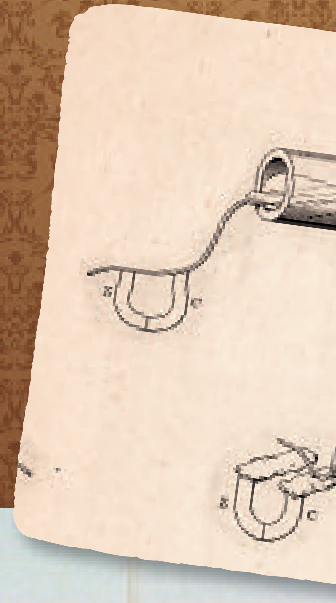
In 1917, building on Max Planck's law of radiation, **Albert Einstein** laid the theoretical groundwork for the development of today's lasers in his *On the Quantum Theory of Radiation*. The LASER, for "**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation," is a mechanism to produce a controlled emission of electromagnetic radiation. When discussing lasers, we generally imagine those that emit visible light; however, light, in this context, broadly refers to any electromagnetic radiation. Lasers also operate in the spectrums of gamma rays, X-rays, ultraviolet and infrared light, microwaves and radio waves.

The first working laser was demonstrated by **Theodore H. Maiman** in 1960 at the Hughes Research Laboratories in Malibu, CA. He used a flashtube to shine pure white light on a synthetic ruby crystal, producing red laser light. In 1964, Townes, Basov and Prokhorov (from the United States and the U.S.S.R.) shared the Nobel Prize in Physics "for fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle."

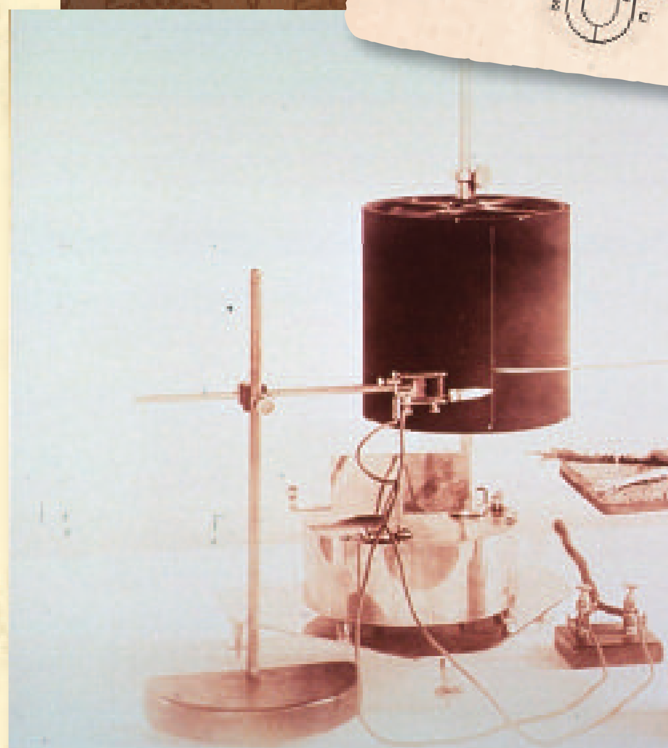
The first lasers were nicknamed "solutions looking for a problem." Today they find thousands of applications in every field of our lives from consumer use and entertainment to medicine and science. In medicine, the laser allows for near-bloodless surgery, laser cauterization, kidney stone treatment, eye treatment and a whole new subfield of dentistry. Laser healing is also a relatively new technique where low-light laser beams penetrate the skin without producing heat and stimulate cells to promote natural healing and pain relief.

In urology, lasers are most commonly used to pulverize stones and to treat benign prostatic hyperplasia (BPH). Lasers have been used to treat stones since the 1980's. Lasers have also led to less invasive treatments for BPH; an alternative to traditional transurethral resection of the prostate (TURP), laser prostate therapies can offer quicker recovery times and fewer side effects.

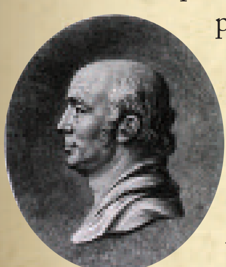
Regulating the Body's Electrical Impulses



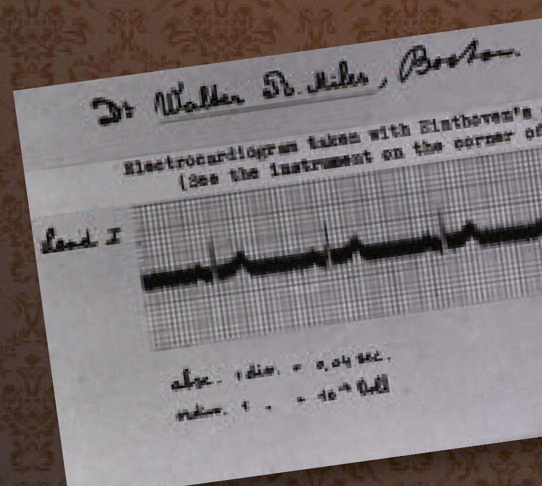
As early as the 1770's, prior to Galvani's laboratory observations, experimenters and physicians exposed human and animal bodies to electrical currents for the purpose of resuscitation. From the accounts it is often difficult to properly categorize the earliest successful resuscitation cases where electricity had been applied: did the applied shocks restart the heart, correct an erratic rhythm or had something else occurred?



A report published in 1774 by the Humane Society of London relates the surprising case of a three-year old girl who had fallen from a window. After an attending apothecary declared that he could do nothing for the seemingly lifeless girl, a neighbor – one Mr. Squires – "…with the consent of the parents very humanely tried the effects of electricity. At least 20 minutes had elapsed before he could apply the shock, which he gave to various parts of the body without any apparent success; but at length, upon transmitting a few shocks through the thorax, he perceived a small pulsation: soon after the child began to sigh, and to breathe, though with great difficulty. In about 10 minutes, she vomited: a kind of stupor, occasioned by the depression of the cranium, remained for some days, but proper means being used, the child was restored to perfect health and spirits in about a week." In 1775, **Peter Christian Abildgaard** published details of his electrical experiments with hens: "With a shock to the head, the animal was rendered lifeless, and arose with a second shock to the chest; however, after the experiment was repeated rather often, the hen was completely stunned, walked with some difficulty, and did not eat for a day and night; then later it was very well and even laid an egg."



In the next century, researchers would begin to systematically measure electrical activity in the body and apply the accumulating knowledge to create new diagnostic tools and therapies.



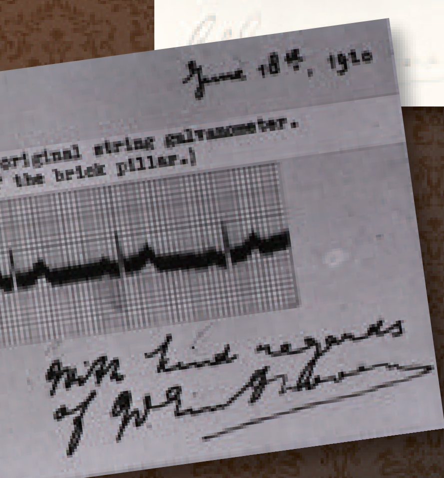
Top Right | *figs. 4 and 5, rheoscopic frog, From: Traite des phenomenes electro-physiologique des animaux. By: Carlo Matteucci*

Center Left | *Physiology Early Electrocardiogram*

Center Right | *Portrait of Williem Einthoven*

Bottom | *Electrocardiogram taken with Einthoven's original string galvanometer*





Regulating the Heart

In 1838, **Carlo Matteucci**, a physics professor at the University of Pisa, utilized a 'rheoscopic frog' to demonstrate that an electrical pulse accompanies the beating of the heart. In his demonstration, the cut nerve of a frog's leg was used as an electrical sensor to detect the electrical pulses accompanying the frog's heart beat. Matteucci also used an early galvonometer to detect electrical activity in muscles.

Using a more advanced galvanometer, German researchers **Rudolph von Koelliker** and **Heinrich Müller** confirmed in 1856 that an electrical current accompanies each heartbeat. In 1869 or 1870, the electrical engineer **Alexander Muirhead** is purported to have recorded what might be the first electrocardiogram using a recorder designed for use in telegraphy.

In 1872, a British surgeon, **Mr. Green**, published an article on the resuscitation of several patients who had suffered cardiac and/or respiratory arrest during anesthesia with chloroform. Using 300 volts of galvanic current, he shocked each person's heart back into action. That same year, French neurophysiologist **Guillaume Benjamin Amand Duchenne** described the electrical resuscitation of a drowned girl in the 3rd edition of his textbook on the medical uses of electricity.

The genesis of the pacemaker began in 1889 when **J. A. McWilliam** reported on his experiments with electrical stimulation of the human heart in the *British Medical Journal*. These experiments showed that electrical impulses applied to the heart could restore regular ventricular contractions in cases of cardiac failure and that a heart rate of 60-70 beats per minute could be stimulated with electrical impulses of the same frequency.

Willem Einthoven (1860-1927), in 1893, was the first to use the term "electrokardiogram" (EKG) at a meeting of the Dutch Medical Association. Together with a British company, he designed a special galvanometer and, in 1906, published a presentation of normal and abnormal electrokardiograms. He won the Nobel Prize in 1924 for his invention of the electrokardiograph.

In 1899, professors of biochemistry and physiology, **Jean-Louis Prevost** and **Frederic Batelli,** in Geneva, Switzerland, applied high voltages to an animal's heart to stop ventricular fibrillation. They would also prove that fibrillation could be induced with low voltages.

In 1926, at the Royal Prince Alfred Hospital of Sydney in Australia, **Dr. Mark Lidwell**, an anesthesiologist, and physicist **Edgar Booth** devised a portable apparatus to stimulate the beating of the heart. The device featured variable pulse rate and voltage and was used, that year, to revive a stillborn infant. The term 'artificial cardiac pacemaker' was coined by the American physiologist **Albert Hyman**, whose first such device, designed in 1931, was bulky, very heavy, and required a trans-thoracic needle to revive the heart. He worked to create a smaller device and, a year later, his new design had been used 43 times with successful outcome in 14 patients. Several cumbersome external pacemakers would follow, but today's implantable pacemakers date to the late 1950s, when new technology allowed transistors with leads and rechargeable cells to be embedded in the patient to control cardiac contractions. These devices were periodically recharged with an external induction coil generator.

Claude Beck, a cardiovascular surgeon in Cleveland, Ohio, successfully defibrillated the human heart during surgery in 1947. The prototype was modified and improved and led in 1949 to a 75-lb backpack that could record EKGs and transmit them. The device was created by Jeff Holter, MD, of Montana; today's Holter Monitor is a small transmitter worn around the waist with the leads taped onto the patient's skin.

In 1958, the first implantable pacemaking device failed within a few hours of implantation, in Sweden. The recipient, Arne Larsson, would receive 26 devices over the course of his lifetime. He died 43 years after he received his first implant.

Spinal cord stimulation (SCS) therapies were introduced in the 1960s for the treatment of chronic pain. In this form of electrotherapy, spinal nerves are stimulated via electrodes and an external pulse generator to disrupt pain. Implantable SCS devices are now available to chronic pain sufferers who respond well to the treatment. Neurostimulation therapies can also be conducted via electrodes applied to peripheral nerves, the motor cortex and the deep brain.

Today's urinary bladder pacemaker was approved by the U.S. Food and Drug Administration (FDA) in 1997, and significantly improves symptoms of incontinence in patients with severe neurologic disease. The implantable device is implanted after a successful trial with a temporary external stimulator. Diaphragmatic pacemakers, developed in the 1970s by **William W. Glenn**, had a long trial period as there were problems with malfunction and nerve damage. The device was finally approved by the FDA in 1986 and is used to treat patients with respiratory insufficiency, replacing the need for mechanical ventilation in, for instance, patients with upper motor paralysis or dysfunction of the respiratory control center. In 2000, the FDA approved the gastric stimulator, which enhances motility and facilitates emptying of the stomach; electrodes are implanted laparoscopically. The electric generator is placed under the skin.

Like all implantable pacemakers and stimulators, cardiac pacemakers have undergone major changes and improvements since 1958. Batteries were replaced in the earlier models; today, obsolete pacemakers can be removed and exchanged for an updated version and reconnected to the implanted leads.

Top Left | *Claude S. Beck*

Top Right | *2010 InterStim Bladder Pacemaker*

Center Right | *1972 Bladder Strimulator*

Bottom Left | *Cardiac Pacemaker*

Bottom Right | *Field medical services view showing patient with electro-encephalograph equipment.*

Understanding and Treating the Brain

At least two 19th century researchers noted electrical phenomena within animal brains, but the 20th century would be well along before scientists had begun to map electrical activity within the human brain. The electroencephalograph (EEG) was created to record the electrical activity emitted by the firing of neurons within the brain. German physiologist and psychiatrist **Hans Berger** (1873–1941) began his studies of the human EEG in 1920. He gave the EEG its name and is sometimes credited with inventing it, though others had performed similar experiments as far back as 1912. The EEG is used to document epileptic activity of the brain; it was also used in the diagnosis of coma and various encephalopathies, and is the first-line diagnostic tool for tumors, stroke, and other focal brain disorders. Today, it is supplanted by anatomical imaging modalities such as the computed tomography (CT) and magnetic resonance imaging (MRI).

Better known as *electric shock therapy*, electroconvulsive therapy (ECT) has been a controversial treatment method since its inception in the 1930s. **Ugo Cerletti** (1877-1963), an Italian neurologist and neuropsychiatrist, is widely accepted as its inventor. Cerletti, as chair of the Department of Mental and Neurological Diseases at the University of Rome, was studying the consequence of multiple epilepsy attacks on animals, which he induced with an electroshock apparatus. After watching pigs being anesthetized with electroshock before being butchered, he wondered if humans could also be anesthetized with electrical currents.

Cerletti first used ECT in a human patient who was a diagnosed schizophrenic with delusions, hallucinations, and confusion. In April 1938, he and colleague **Lucio Bini** gave a series of electroshocks to an incoherent wandering vagrant, picked up by police for loitering and muttering to himself. After the second such treatment, the patient awoke completely lucid and seemingly cured and purportedly said, "Not another one – it will kill me!" Cerletti and Bini had shown that electric shocks had the potential to cure some forms of schizophrenia. After this patient returned to a normal mental state, Cerletti and his coworkers continued their investigation of ECT to determine its safety and efficacy.

Though considered by some to be barbaric, the treatment rose to widespread psychiatric application (though often involuntary) in the 1940's and 50's. Due to growing anti-depressant use and increasing public criticism, the use of ECT declined during the 1960's and 70's. In the late 1970's significant changes in the way the treatment was applied were introduced. Today, though ECT still conjures up images of convulsions, great pain and loss of memory, ECT has re-emerged as a treatment for some forms of severe depression after other available treatment options have failed. More than 1 million patients now receive ECT annually, worldwide. Convulsions are no longer an accepted effect of the treatment.

Telehealth

Technological advances in communications have always enhanced the capabilities and reach of healthcare providers. By the early 1900's physicians of the Royal Flying Doctor Service of Australia were using dynamo-powered two-way radios to communicate with other physicians and patients in remote locations. In the 21st century, medicine, communications technologies and robotics converge at the cutting edge of medical practice in telemedicine and telesurgery.

Telecardiology

On March 22nd 1905, Willem Einthoven, inventor of the electrokardiograph (EKG), employed telephone lines to transmit data from the hospital where he worked to his laboratory, nearly a mile away, where he recorded the first telecardiogram. Today, patients with chronic heart disease can receive thorough heart monitoring without having to leave their homes.

Thanks to the global spread of internet access, doctors can now provide clinical services from, and to, virtually anywhere – often, in real-time. Doctors are enabled to share patient information and access specialist services, no matter where they or the patients are. Remote monitoring allows physicians to closely attend patients without requiring frequent hospital visits, thus reducing costs and improving care. Store and forward technologies allow the accumulation of vast quantities of patient medical data (radiological data, imagery, bio-signals, prescription and treatment records) for independent assessment and consultation. Patients benefit from telemedicine; greater continuity when being treated by multiple healthcare providers; costly duplication is reduced and harmful interactions avoided.


A Modern Charlatan
By A. B. TRIPP

With robotic surgery already well established, the first remote surgical operation was conducted in 2001 when a surgeon in New York, **Dr. Jacques Marescaux,** performed gall bladder surgery over a fiber optic line on a patient in Strassburg, France, in what is known as the *Lindbergh Operation.* While not yet frequently utilized, though not uncommon, the field of telesurgery promises ever-greater ease and effectiveness, combining specialist knowledge with robotic accuracy and remote capability.

Top Right | *Elektroller, c. 1928, Jos. Gesmachor & Company (Prague)*

Current is generated by an internal magnet as the instrument is rolled over the body; that current is transmitted to the skin through metal rings on the rollers, producing an electric massage to stimulate muscles and nerves.

Center Right | *"Dr." Albert Abrams*

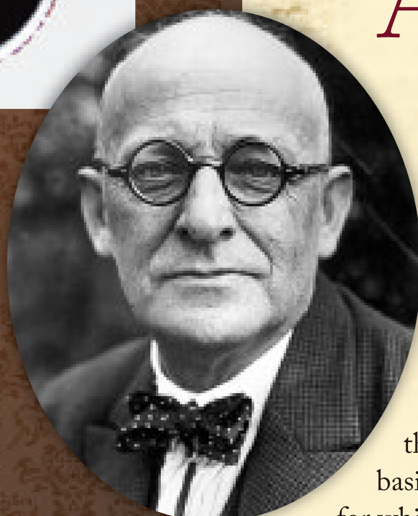
Bottom Left | *Article for the E.R.A.*

Bottom Right | *Abram's Oscilloclast*

Racing with the Current: Quackery in Electrical Medicine

In our search for the universal panacea, we continually seize upon new inventions and apply them to medicine, hoping that we have finally found something that will cure all of humanity's ills. As serious investigators and physicians began to evaluate the potential use of electricity as a method to treat medical diseases, so did entrepreneurs and quacksalvers who claimed to develop "Cure-Alls" for a large variety of diseases.

Albert Abrams: The Dean of Quackery



In the field of electric medicine, the dean of quackery was **Albert Abrams, MD, LLD, FRMS,** of San Francisco. Abrams, a purported graduate of the University of Heidelberg (there is no record to confirm this) who pioneered a therapy called spondylotherapy – a percussive treatment involving electricity – was most notably known for his "Electronic Reactions of Abrams" theory (E.R.A.), based on the principle that electrons were the basis of life. A number of devices were based on this theory, devices for which a gullible public was willing to pay.

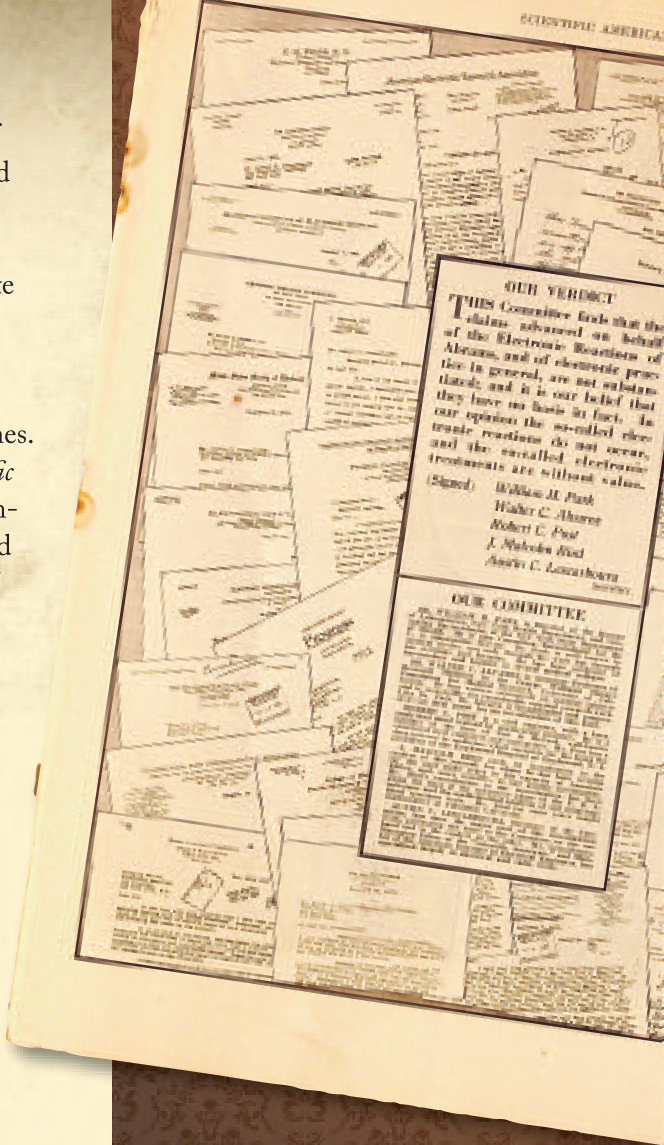
One of Abrams' most "famous" machines was the Dynomizer, which could diagnose a patient using a drop of blood or a handwriting sample (either would do). Patients far and wide would send blood and/or handwriting samples to Abrams which allowed him to "treat" the patients long-distance. By 1918, he had built quite a business, leasing equipment and teaching courses in E.R.A. and spondylotherapy. Abrams had one condition for those who leased his machines: they could not open them.

As business improved, so did Abrams' productivity as an "inventor". Soon, machines were not limited solely to diagnosis; they could be used to treat the condition diagnosed. His *Radioclast* and *Oscilloclast* gained significant popularity as more and more patients – and E.R.A. practitioners – began using the equipment. By 1921, there were more than 3,500 people using E.R.A. techniques and machines to treat patients.

Abrams' house of cards began to crumble when, in 1923, a man with incurable stomach cancer (said to have been diagnosed at the Mayo Clinic) went to an E.R.A. practitioner for treatment. After a number of "treatments," the so-called doctor pronounced the man completely cured of his cancer. The man died a month later and a public uproar ensued, prompting many to question the efficacy of Abrams' machines. The American Medical Association actively denounced the machines, despite their many notable defenders (said to include Sir Arthur Conan Doyle and Upton Sinclair).

It was the beginning of the end of the public's acceptance of the machines. After a public debunking of Abrams' technology in the pages of *Scientific American* magazine, physicians around the country challenged practitioners. When several AMA members opened one of the hermetically sealed oscilloclast machines, they found it was nothing more than a box full of wires, lights and buzzers.

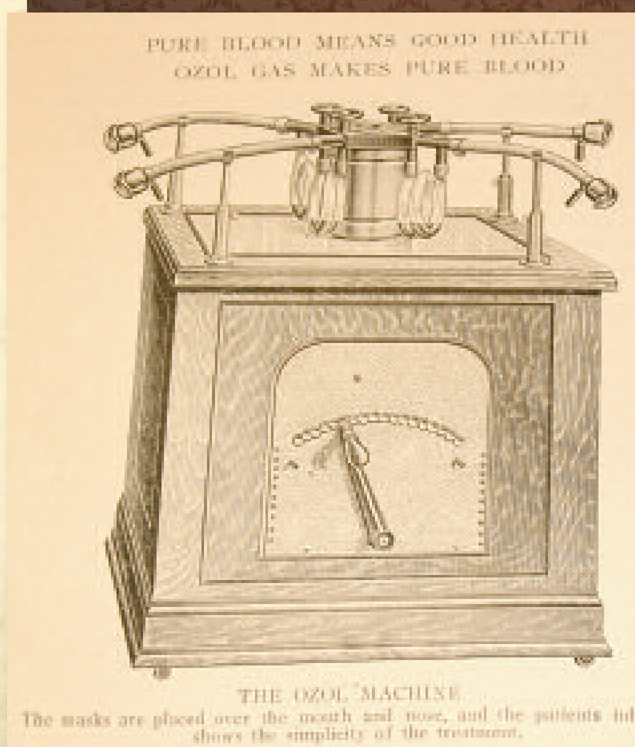
Despite all the negative publicity, E.R.A. did not end with Abrams' death; it was alive and well into the late 1920s, in part due to the many clinics offering this therapy. In the 1930s, **Ruth Drown** stimulated resurgence and even today there are still users in the "New Age" movement who firmly believe in this "technology."



Purifying the Humors

Blood has played a key role in the practice of medicine since it was first considered one of the body's "humors." As it has also been a target for quackish treatments, it is only natural that electricity be used to heal the blood and cure disease.

H.C. Bennett, MO, ME, PhO, OP, MPH-TH, described a process, which he called "electrification" which supposedly supplied oxygen through the skin to treat a variety of diseases. Bennett would go on to found a school on electrotherapeutics in Lima, OH, which he named the *National College of Electrotherapeutics.* He published a book entitled *The ElectroTherapeutic Guide,* in which he described how, by modifying ozone to a substance he called "ozol," he was able to treat a variety of medical conditions, "increasing appetite, inducing regular and natural movement of the bowel, clearing the urine of its heavy deposits and giving back its



Top Left | *Scientific American, 1924*

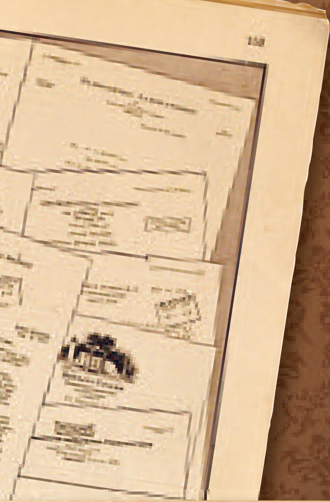
Top Right | *The Bidet Bath or Chair Bath: it has six lamps and mirrors in the floor "which give both a radiated and reflected heat and light application... good for menstruation, vaginitis, also for rectal and genito-urinary affections, in both sexes..." From the ElectroTherapeutic Guide.*

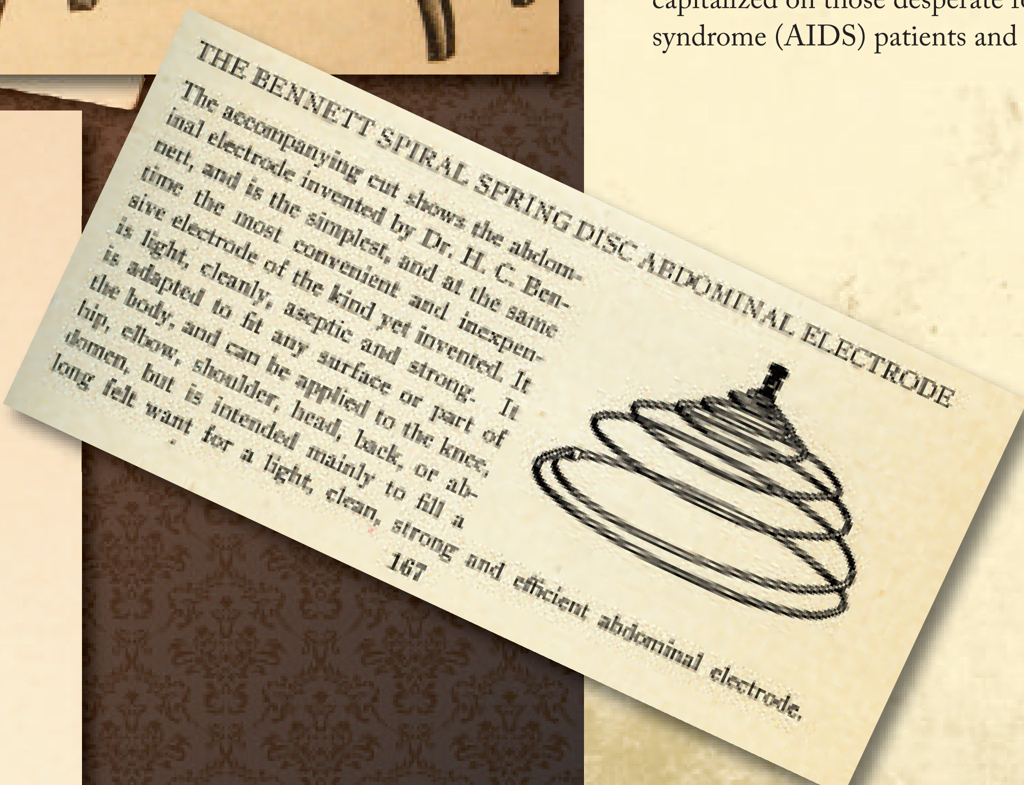
Bottom Left | *The Ozol Machine*

Bottom Right | *Bennet's Spiral Spring Disc* natural color and specific gravity. Coated tongue, foul breath, heart palpitations, despondency, gloomy foreboding, cold hands and cold feet soon disappeared with this treatment."

He also discussed X-rays, ultraviolet light, oxidizing the blood and more. He stated that ultraviolet light could treat migraine, sprains, fractures, bronchitis, eczema, varicose veins, ulcers, X-ray burns, various cancers, tuberculosis and other diseases. Bennett also stated that he himself was severely jolted in an auto accident leading to an acute neuritis in the entire right brachial plexus with intense pain for several months. Other than opiates, the only thing that relieved him of pain was not electricity or vibration, which he had tried, but exposure to the strongest ultraviolet light for an hour each night after retiring. Subsequently, he could sleep all night and was cured after about 10 treatments over the course of two months.

But blood oxidizers, purifiers and electrifiers, which all proclaim their ability to purify blood and restore health, were not just limited to the early 20th century. In the 1990s, **Robert C. Beck**, stimulated by research from leading New York institutions, created a system that applied electric current to the skin to neutralize pathogens in the blood. The New York researchers, who applied for and received a patent for their procedure, had removed blood from the body and applied micro currents to destroy the pathogens. Inspired, Beck developed a unit that could be used on the blood without removing it from the body. Using the machine on himself, he purportedly developed more energy and started losing his excess weight. He was so impressed with his result that he gave free lectures, showing the schematic and structural information of his device without charge. Beck capitalized on those desperate for cures, such as acquired immunodeficiency syndrome (AIDS) patients and those with viral or bacterial diseases.




THE BENNETT SPIRAL SPRING DISC ABDOMINAL ELECTRODE

The accompanying cut shows the abdominal electrode invented by Dr. H. C. Bennett, and is the simplest, and at the same time the most convenient and inexpensive electrode of the kind yet invented. It is light, cleanly, aseptic and strong. It is adapted to fit any surface or part of the body, and can be applied to the knee, hip, elbow, shoulder, head, back, or abdomen, but is intended mainly to fill a long felt want for a light, clean, strong and efficient abdominal electrode.

167

Light to Heal

Violet ray machines remain one of the more fascinating applications of electricity from the early 20th century. These vacuum electrodes used high-frequency current and were used to treat virtually any known disease. The glass tubes, which have a metal base that is inserted into the handheld current rheostat, come in different shapes and were used to cure strabismus, thyroid problems, nasal problems, pharyngeal diseases, problems with the cervix, vagina, rectum and prostate; really, any organ accessible to these probes could be treated with these devices. Dandruff was reportedly treated with ultraviolet lamps or violet ray combs.

Though some practitioners would use these devices to treat any ailment, others approached their use with a hopeful skepticism. In his book *Physical Therapeutic Technic,* published by Saunders Company in 1932, **Frank Butler Granger, MD**, described the use of an ultraviolet ear probe to treat deafness by saying, “I always undertake the treatment of a case with considerable reluctance as the chance of success is slight, though occasionally the results are startling.”

Other inventors created fascinating electromagnetic equipment, claiming they were able to cure a large variety of the most common diseases. Some of these include clever wood-cased induction machines such as the Theronoid “horse collar” device, a large coil that was plugged into the 110 volt mains and worn around the neck or torso to bathe that part of the body in an electromagnetic field; the “Magneto-Electric Machines” from the 1840s, which included electrical stimulation of a variety of body parts, including the scalp for hair growth; and the “Elec-Treat Mechanical Heart” from the 1930s, which used Faradic treatment to alleviate pain, reportedly forcing oxygen through the skin into the body.

Galvanic batteries were also said to be able to cure virtually all diseases except yellow fever, cholera, dysentery, croup, congestion of the brain, bloody urine, influenza, pneumonia, spasm, worms, whooping cough and consumption. *Boyd’s Battery*, a booklet published in 1879, is full of testimonials that serve as proof for a battery that was worn on the chest like a pendant. The device came with the warning not to allow any other person to use the battery because, if you did, the battery could transfer diseases from the original owner to another. What a wonderful marketing ploy – everyone had to buy his or her own battery!

Top Right | *Theronoid “horse collar”*

Center Left | *Violet Ray Machine*

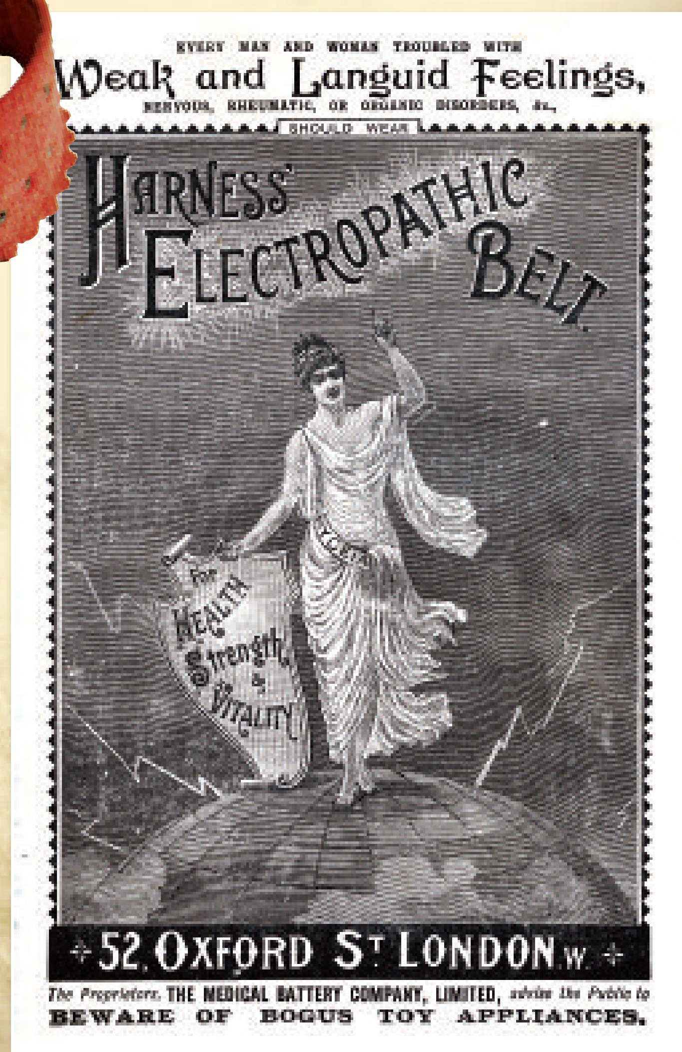
Center Right | *Heidelberg Belt*

Bottom Left | *Galvanic Battery*

Bottom Right | *Electrotherapy Pendant, c. 1890*

Quackery was rampant across the field of medicine. Even urology was not immune to the quackish application of electricity. The most famous examples of this were the Heidelberg and Pulvermacher Belts (from the late 1800s), which were cloth-covered voltaic batteries soaked in a vinegar solution and worn around the waist; reportedly, they would cure "weaknesses peculiar to men" – incontinence, impotence and multiple other nervous maladies.

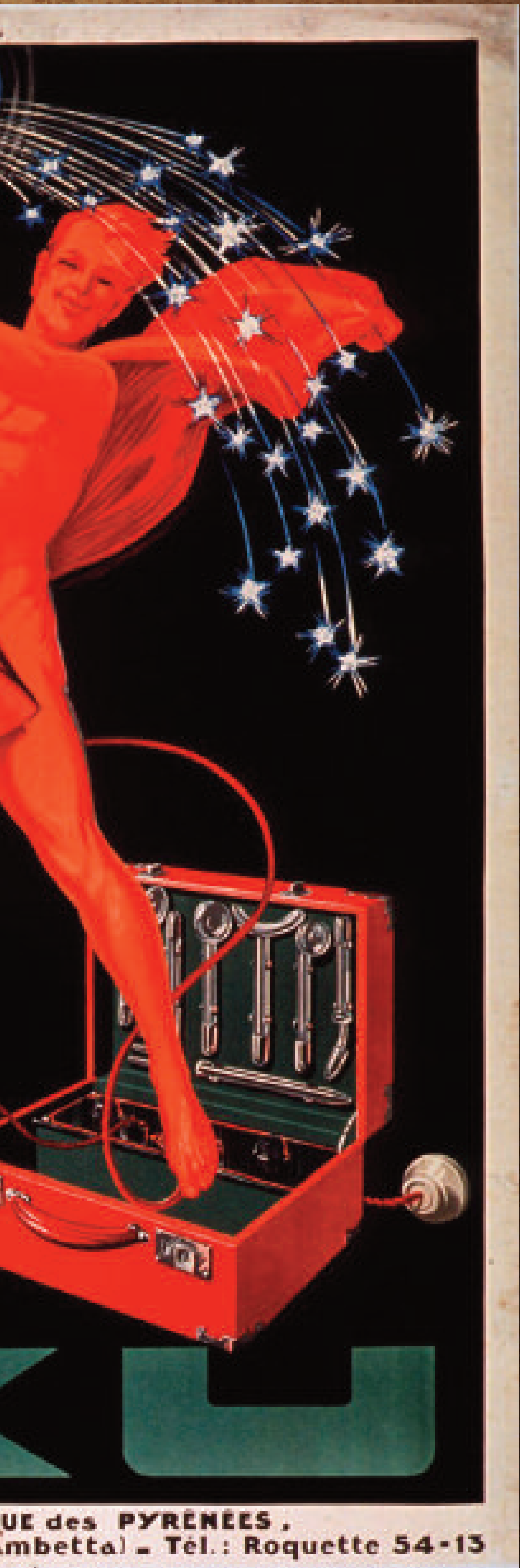
One of the first books to describe a particular application of electricity within urology was Beard and Rockwell's Electricity (1871). In the chapter on the diseases of the male genital organs, the authors discuss using electricity to treat seminal emissions, premature discharge and deficient secretion of semen (these diseases were, according to the medical tenet of the time, caused by excessive sexual indulgence). Treatment for urinary incontinence in children was preferentially done by applying an electrode at the level of the symphysis and the second one to the perineum, aiming for "faradization" of the bladder neck. The authors also refer to an instrument designed by Duchenne, "the double vesical exciter," an instrument with a curved tip with two metal branches that could be opened up to "electricize" the bladder internally. Cases of hysteria, a medical condition described as neurotic behavior peculiar to women due to problems of the uterus, however, required "central and general electrization."



Consider the Past and You Shall Know The Future

This exhibit showcases the interaction of electricity, as a new technology, and medicine: from the 1800s, when we saw a gradual introduction and slow acceptance of this new technology with a number of pioneers who pushed our knowledge further, to the 1900s, when new methods and applications of electricity in medicine expanded rapidly as the decades passed. Now, in the 21st century, we are beginning to see an exponential increase in new devices and new uses driven by computer science and miniaturization of circuit boards as well as small, powerful and long-lasting batteries.

From the time of the telegraph and galvanometers to today's cellular phones, internet, telesurgery and advanced imaging, our understanding and application of electricity has driven communications and medical technologies on a parallel course towards ever more effective state-of-the-art solutions for our most vexing challenges. Today, as medical and information technologies begin an unprecedented merger, physicians and engineers apply their disciplines to provide efficient, quality care to patients across previously impenetrable barriers. New inventions and technologies will continue to emerge in the next century, changing the way we examine and treat patients. What is modern today will be equipment of historical, not clinical, interest tomorrow. We do not know which roads such new discoveries will have us travel, but one thing is certain: it will be challenging and exciting, and will open ever-new frontiers for medicine.



BIBLIOGRAPHY

Lechtman, H.; Erlij, A.; and Barry, E.J., Jr.: New Perspectives on Moche Metallurgy: Techniques of Gilding Copper at Loma Negra, Northern Peru. Society for American Archaeology, 1982

http://en.wikipedia.org/wiki/Electroplating. Accessed May 12, 2010

http://news.bbc.co.uk/2/hi/science/nature/2804257.stm. Accessed May 12, 2010

http://en.wikipedia.org/wiki/Parthian_Battery. Accessed March 11, 2010

Kramer, B.: Electrocommunication in Teleost Fishes: Behaviour and Experiments, 1990

http://penelope.uchicago.edu/~grout/encyclopaedia_romana/aconite/largus.html . Accessed May 12, 2010

http://inventors.about.com/od/dstartinventors/a/Humphry_Davy.htm . Accessed May 12, 2010

http://en.wikipedia.org/wiki/Joseph_Swan. Accessed May 12, 2010

http://en.wikipedia.org/wiki/Thomas_Edison. Accessed May 12, 2010

http://www.hrsonline.org/News/ep-history/timeline/1800s.cfm#elec . Accessed March 10, 2010

http://en.wikipedia.org/wiki/Artificial_pacemaker. Accessed March 10, 2010

http://www.chi-rad-soc.org/grubbe.htm. Accessed May 12, 2010

Annual Report 1774: Humane Society, London. pp 31-32, 1775

Abildgaard, P. C.: Tentamina electrica in animalibus. Inst Soc Med Havn, 2:157-61, 1775

Matteucci, C.: Sur un phenomene physiologique produit par les muscles en contraction. Ann Chim Phys, 6:339-341, 1842

Prevost, J.L. and Batelli, F.: Sur quelques effets des descharges electriques sur le coeur des mammiferes. [On the effects of electric shocks on the hearts of mammals.] Acad. Sci. Paris, FR, 129:1267-1268, 1899

http://www.ecglibrary.com/ecghist.html. Accessed March 15, 2010

Duchenne, G.B.: De l'electrisation localisee et de son application a la pathologie et la therapeutique par courants induits at par courants galvaniques interrompus et continus. [Localized electricity and its application to pathology and therapy by means of induced and galvanic currents, interrupted and continuous] 3 ed. Paris, J.B. Bailliere et fils; 1872

Moukabary, T.: Willem Einthoven (1860–1927): Father of Electrocardiography. Cardiology Journal,

Vol. 14, No. 3, pp. 316-317, 2007

http://urology.jhu.edu/about/young.php. Accessed May 12, 2010

http://urologichistory.museum/content/collections/uropeople/young/p1.cfm. Accessed May 12, 2010

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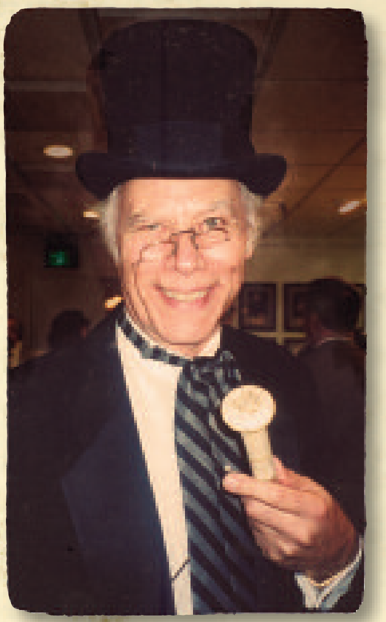

Dr. Rainer Engel has been curator of the William P. Didusch Center for Urological History since 1993, transforming a small group of tabletop exhibits into an elegantly-housed museum and research center still growing at the American Urological Association Headquarters in Maryland. Every year he creates and executes an exhibit and brochure on some aspect of the history of medicine and urology to bring to the AUA's annual meeting. Through his efforts, the Didusch Center and AUA historical activities have developed world-renowned acclaim in the field of urology.

In this year 2010, Dr. Engel will become AUA Historian as we search for a new curator to carry on his legacy of excellence at the William P. Didusch Center for Urologic History (founded as the William P. Didusch Museum in 1972 to honor Bill Didusch, AUA Secretary for many years and the first museum curator). We the staff of the AUA salute both the man and his accomplishments and look forward to many years of collaboration no matter what his title.

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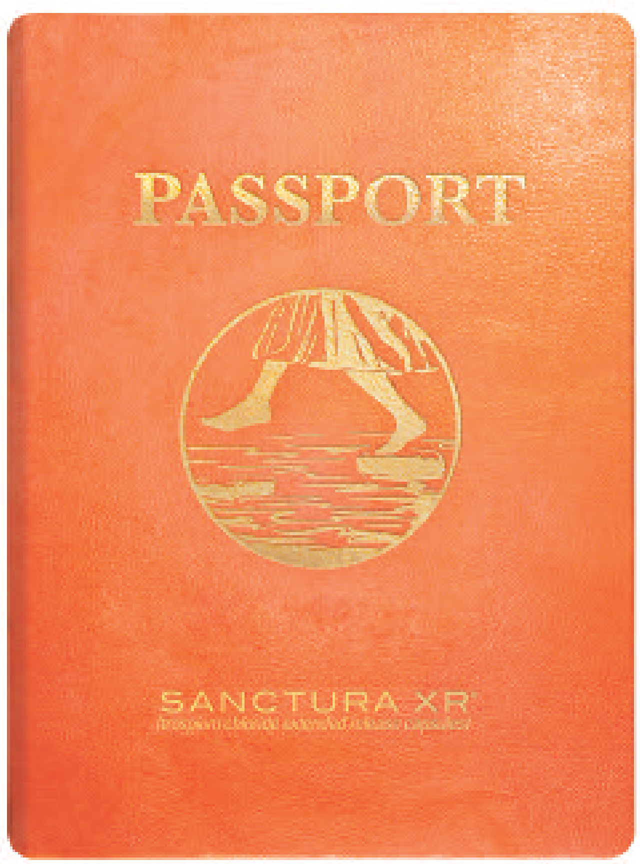

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May 2010

Published by the

American
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