Doctors: The History of Scientific Medicine Revealed Through Biography

Professor Sherwin B. Nuland, M.D., FACS

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Clinical Professor of Surgery, Yale School of Medicine

Physician, surgeon, teacher, medical historian, and best-selling author, Sherwin B. Nuland, M.D., F.A.C.S. is Clinical Professor of Surgery at the Yale School of Medicine, from which he received his M.D. degree in 1955. He is a faculty member of the university's Institution for Social and Policy Studies; served as Chairman of the Board of Managers of the *Journal of the History of Medicine and Allied Sciences* for 25 years; is a member of the editorial board of *Perspectives in Biology and Medicine*; and serves on the executive committees of Yale's Interdisciplinary Bioethics Forum. He is also Fellow of Yale's Whitney Humanities Center. He continues to teach an undergraduate course on the history of medicine at Yale and at New York University.

Dr. Nuland is a graduate of the Bronx High School of Science and New York University (summa cum laude). After graduating from the Yale School of Medicine and training in surgery at Yale-New Haven Hospital, he practiced and taught there from 1962 until 1992, when he began a full-time career in writing. His first book for the general reader, *Doctors: The Biography of Medicine*, was published in 1988 and tells the story of medicine in the form of biographies of fourteen of its most prominent contributors. In 1994, he published *How We Die*, which remained on the *New York Times* best-seller list for 34 weeks, received the 1994 National Book Award, and was a finalist for the 1995 Pulitzer Prize and the 1995 Book Critics Circle Award. His book, *The Wisdom of the Body* (paperback edition entitled *How We Live*) grew out of his interest in history, human biology, ethics, and the nature of humanity. *The Mysteries Within* was a description of the ways myth and religion have influenced both medicine and how we think about our bodies.

Dr. Nuland was a contributor to the PBS series, *American Thinkers*, and, for six years, wrote a regular column on medicine for *The American Scholar*. He has written features for *The New Yorker*, *Time*, *Life*, *National Geographic*, *Discover*, *The New Republic*, *New York Review of Books*, *New York Times*, *Boston Globe*, *Los Angeles Times*, *Newsweek*, and other periodicals. He is a member of Alpha Omega Alpha, the honorary medical society.

His most recent books are *Leonardo Da Vinci*, the result of Nuland's twenty-year quest to understand the unlettered man who was accomplished as a painter, architect, engineer, philosopher, mathematician, and scientist, and *Lost in America: A Journey with My Father*, a memoir. He is currently working on a biography of Jewish philosopher and physician, Moses Maimonides to be published in September, 2005. Dr. Nuland is married to Sarah Peterson, a professional actor and director; they are the parents of four children.

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Note: This course contains some discussion about certain historical medical practices and experiments that while common in their time may seem barbaric and unusual to today's sensibilities. The professor does not necessarily describe them in graphic detail, but due to the subject matter of this course some descriptions of these practices do arise. Care should be taken in selecting this course for the young or sensitive individual.

Doctors: The History of Scientific Medicine Revealed Through Biography

Scope:

This course focuses on Western, scientific medicine only—not Asian or alternative medicine—and uses biography as a point of reference. We start with Hippocrates, the "father of medicine," whose name was given to a new form of medicine distinguished by its reliance on keen observation of the sick to diagnose and cure disease, rather than religion or superstition. The next great contribution came from Galen, whose study of anatomy and physiology—using vivisected animals—brought the theory and practice of medicine forward by a huge leap, but whose dogmatism stifled further progress in medicine for a millennium and a half.

Among the first pioneers to challenge Galenic medicine was Andreas Vesalius, who during the late Renaissance, meticulously dissected human cadavers and wrote *de Humani Corporis Fabrica* ("*On the Workings of the Human Body*") to clarify our understanding of anatomy and function. Later, William Harvey, also dissatisfied with Galenic explanations, conceived a series of experiments and measurements to demonstrate the heart's function as a pump to drive the circulation.

Next, Giovanni Morgagni demonstrated that symptoms arise from a specific pathological process in a particular structure of the body. Expanding on Morgagni, John Hunter dissected large numbers of animals to study comparative anatomy and introduced the idea that surgeons could also be medical researchers. René Laennec's invention of the stethoscope was an important development in the evaluation of patients to localize the origins of symptoms, and to develop the concept of the physical examination.

Surgery, however, could not advance until the development of anesthesia. In the 1840s, nitrous oxide, ether, and chloroform were discovered to have anesthetic properties, resulting in an increase in the possibilities for surgical treatment. Leaders in this effort included dentists Horace Wells and Thomas Morton, chemist Charles Jackson, and physician Crawford Long.

The next great leap forward in Western medicine came with the German pathologist Rudolf Virchow, who introduced the idea that disease is caused by some pathological change in a previously normal cell. This, in turn, spurred Joseph Lister's work in combating infection. Further developments in surgery came with William Halsted's adoption of a slow, meticulous technique. Halsted's "surgery of safety" eventually became the model used by all U.S. hospitals and medical schools, while Johns Hopkins became the prototype for American medical education. We close with Helen Taussig's work at Johns

Hopkins in the new field of pediatric cardiology, which led to the first major steps in the development of cardiac surgery, including heart transplantation.

Lecture One

Hippocrates and the Origins of Western Medicine

Scope: Though Hippocrates is commonly called the "father of medicine," very little is known about him beyond his birthplace on the Island of Cos, around 460 B.C.E. His name was given to a new form of healing that arose during the Golden Age of Greece. The fundamentals of the new medicine were its separation from reliance on religion or superstition for diagnosis or cure; the importance of keen observation of the sick and the writing of books that recorded the details of diseases for future generations to study; an ethical code that spelled out the obligations of physicians to their patients and to one another; and the importance of teaching each new generation of doctors the knowledge that had been acquired by their predecessors. The underlying philosophy of the Hippocratic physicians was that disease involves a patient's entire body and mind, so that therapy must be directed to the whole context of the patient's life situation rather than some small part of it.

Outline

I. In this course, we will focus on Western scientific medicine, not Asian or alternative medicine, and we will use biography as our point of reference. Any discipline or aspect of history should be traceable through the lives of its greatest contributors.

- **A.** A number of interesting topics will arise as we discuss these people, including:
  1. The rise of universities and the ways in which they influenced medical education
  2. The appearance of the scientific method and inductive reasoning
  3. The influence of individual personality on achievement
  4. The influence of national character and surrounding culture
  5. The role of the Church
  6. The pervasive part played in discovery by the discoverer's psychological makeup.
- **B.** Ultimately, this course is a series of character studies of the great doctors.

II. We begin with the father of medicine, the great Hippocrates.

- **A.** When we look at the writings of Hippocrates—the *Hippocratic corpus*—we find that they weren't written by a single man.
- **B.** They were written over a period of approximately 200 years by a large group of men and, perhaps, some women, whose primary focus was to separate the supernatural from the natural.

C. These writers taught that sickness arises from the environment or the patient, not from supernatural influences. Therefore, sickness must be treated using natural methods, not by appealing to deities.

III. According to prevailing practice, sickness was treated by prayers to Aesculapius, the putative offspring of Apollo, the god of healing, and the nymph Coronis.

A. Rituals in the temples of Aesculapius included belief in the healing power of snakes. The god was said to hold a staff, around which his healing serpent was wound; from this, we get the modern symbol of medicine, the *caduceus*.

B. The primary focus in these temples was the "therapeutic dream," which was interpreted by a priest.

C. This was not the way of the Hippocratic physicians.

IV. We know that Hippocrates existed.

A. His father was Heraclides, a hereditary Aesculapian physician.

B. Hippocrates was born around 460 B.C.E. in Cos, an island off of what is now Turkey.

C. Itinerant physicians somehow came together, probably starting on Cos and migrating to the mainland.

V. The Hippocratic documents are thought to be the remains of a library found on the island of Cos.

A. Scholars believe that most of the documents were transported to the great library in Alexandria, which was later destroyed.

B. The documents consist of 70 different texts, covering a wide span of topics.

C. Authorities who studied these documents, especially in the 19th century, reached the conclusion that some of the texts had particularly high moral or ethical value or were particularly useful in understanding the disease process. At some point, 19th-century medical historians called those texts the "genuine" works of Hippocrates.

D. They are distinguished by a particular clarity of thought, a high moral message, and scientific objectivity.

E. One of the most famous books is *The Aphorisms of Hippocrates*, a collection of pithy, sententious statements on how to care for sick people and live a moral life.

F. Of those hundreds of aphorisms, the most famous is the first: "Life is short. The Art is long. Opportunity is fleeting. Experience is delusive. Judgment is difficult."

1. No doctor can learn what he or she needs to learn in a lifetime.

2. The patient comes at a particular point in his or her disease, offering only a small window of opportunity to make a diagnosis.
3. Any individual's experience can be deceiving. We use statistics now, which are the combined experiences of thousands of patients and doctors, with all their inherent errors.
4. Doctors must learn judgment: when to operate or not operate; how to understand the disease; when to consult with others; which therapies are best for individual patients.

VI. What are some of the principles of Hippocratic medicine that changed what had come before?

A. Diseases are events that happen within the entire life of an individual.

B. Equilibrium must be maintained within a body. This is partly accomplished with "innate heat," which is said to be generated in the heart.

C. Balance must be maintained among a group of four fluids, a concept inherited from Egyptian and earlier medicine and codified.

1. Blood: A person who has excess blood in his or her body is filled with energy, *sanguine*.
2. Yellow bile: A person with an overabundance of yellow bile is choleric or *bilious*, quick to anger.
3. Black bile: A person who has an excess of black bile has a melancholic disposition.
4. Phlegm: A person with a surplus of phlegm has a slow temperament, or is *phlegmatic*.

D. If any of these four fluids was out of balance, a person became sick.

E. Another basic principle is that the human body tends to heal itself.

F. The basis of Hippocratic medicine lies in the concept: "First, do no harm." How did the Hippocratics achieve this objective?

1. They kept accurate notes and passed them on to their students.
2. They examined patients, studying bodily secretions, and looking at temperature, color of skin, and other physical characteristics for signs that the humors were out of balance. They took medical histories from patients.
3. They believed that nature tried to get rid of excesses, but the doctor had to help. For instance, if a patient had a fever, that meant there was too much blood in the body, so the patient was bled to eliminate excess blood.

G. Another characteristic of these physicians was that, because they kept such precise records, they were the first to be able to give patients a relatively accurate prognosis.

1. Highly developed knowledge of disease allowed the Hippocratics to make such predictions.

2. Their accuracy and ethical principles earned them a good reputation, which was important, because they were itinerant and needed to make a living.
3. In turn, their reputation helped to draw many young men to the Hippocratic schools of medicine.

H. These physicians did surgery, splinted fractures, took blood and pus out of the chest, and if blood accumulated in the skull after injury, they poked holes in the skull, as the ancient Egyptians had done.

I. They learned to be dexterous; some of their literature tells how to move the hands for particular operations and how to cut fingernails so as not to hurt patients.

VII. The Hippocratic doctors developed a code of ethics, which formed the original basis for modern Western medical ethics.

A. Why was the code of ethics developed? It set the Hippocratic doctor apart from other physicians.

B. The ethics are expressed in the great oath of Hippocrates, which has two parts: the covenant promising to uphold the code and the code itself. The code offers the ground rules of a professional society and the ethical principles that permeate the entire Hippocratic corpus.

1. In taking the oath, a physician promised not to help anyone commit suicide, facilitate abortions, or cut for bladder stones.
2. Most important in the code were matters of tact, personal morality, confidentiality, and the assurance that a doctor would never take advantage of his position.

C. The importance of the Hippocratic oath is that for the first time in the history of medicine, an ethical code brought a group of doctors together and marked this group as different from all others.

VIII. For me, the Hippocratic corpus is exemplified by two statements that are not in the oath but in other parts of the writing:

A. With purity and holiness, I will pass my life and practice my Art.

B. Where there is love of humankind, there is also love of the Art of medicine.

Readings:

Miles, S. H., *The Hippocratic Oath and the Ethics of Medicine*.

Edelstein, L., *Ancient Medicine*.

Jones, W. H. S., *The Works of Hippocrates*.

Questions to Consider:

1. In what ways did the methods of the Hippocratic physicians change the face of medicine as practiced in ancient Greece?

2. What impact do the Hippocratics have on later and modern medicine?

Lecture Two

The Paradox of Galen

Scope: Galen, born in 130 C.E. in Asia Minor, based his career on the notion that disease can be understood only if physicians know how the body works. He carried out experiments and gave extremely popular public lectures—using vivisected animals—throughout his life, relentlessly pursuing his goal of learning anatomy and physiology. Galen's discoveries in such areas as nerve and muscle action, respiration, speech, and urinary excretion established his reputation throughout the Roman Empire, as did his extraordinary skill as personal physician to Emperor Marcus Aurelius. A vain and boastful man, Galen convinced the world that the 22 thick volumes of his writings contained all the medical knowledge that would ever be discovered. Such was his overwhelming influence that his teachings prevailed virtually unchanged until the 16th century, when a daring few began to point out certain errors he had made, paving the way for a renewal of research.

Outline

I. After Hippocrates, the most well known name in the 2,000-year history of Western medicine is that of Galen, whose legacy permeated medical thinking until the late 19th century and, in certain ways, into the 20th century.

- **A.** He codified the notion of the humors and organized it in such a way that one could predict not only the presence or absence of disease, but also changes in temperament by gauging the level of a particular humor in the system.
- **B.** Galen's legacy was, in many ways, disastrous for medicine. At least until the 16th and 17th centuries, to know medicine was to know it as Galen wrote about it in the 2nd century.
- **C.** The notion of predeterminism, the idea that everything is ordained to follow some divine master plan, permeates Galen's writings.
    1. To Galen, the purpose of medical study was to learn about nature, with the aim of discovering the work of the demiurge—a divine master plan.
    2. For example, when Galen studied the liver, his desire to see a divine plan in human anatomy led him to conclude that the liver's location near the stomach had a specific purpose: food must be able to move easily from the stomach to the liver so that the liver can make blood from it. Likewise, Galen believed that the spleen was under the ribcage on the left side specifically to balance the liver.
    3. Like the Hippocratics, Galen did not believe that the demiurge caused or cured disease.

D. Interestingly, even after conducting experimental medicine, early physicians doing research would continue to look for the demiurge.

E. For Galen, the purpose of medical study and research was to learn about nature. But once that research was done and discoveries had been made, Galen saw no need for further research; he believed he had discovered everything there was to discover, and explained it as the demiurge wanted and had created it.

II. Galen died in 201 A.D. and left a body of writings that his successors treated as so conclusive that it inhibited further seeking for some 1,300 years.

A. To study medicine was to study Galen, and subscribe to the theory that humors determine our state of health.

B. As late as 1863, for example, Stonewall Jackson would raise his arm before battle to drain certain humors and enable himself to think clearly.

III. After Hippocrates' death c. 350 B.C., physicians increasingly used a solid body of Hippocratic teachings.

A. Over the centuries, the teachings became schismed into different medico-philosophical sects, including: empirics, pneumatics, methodists, dogmatics, and eclectics, along with many subsects.

B. Galen aimed to bring back whole Hippocratic texts and codify them, overturning the later sects and subsects.

IV. Galen's most important contribution was his effort to determine actual anatomical and physiological functioning.

A. The Hippocratics believed that diagnosis of disease must be based on observation, but their method did not focus on actual human anatomy. In Hippocratic medicine, the humors can be treated and disease can be diagnosed without knowing where organs are or what they look like.

B. Of Galen's many writings, *On the Uses of the Parts of the Body* is the most useful to modern historians.

V. Galen was born in 130 A.D. in a town called Pergamon in what is now Turkey; he was the son of a wealthy architect and landowner.

A. His father had a Hippocratic dream telling him that his son should be a doctor.

B. Galen was known to be contentious, vain, self-centered, and boastful.

C. His father sent him to study medicine at a school of Hippocratic physicians in Pergamon.

D. In 152 A.D., Galen traveled to Alexandria to further his studies.

E. In 158 A.D., he returned to Pergamon and became surgeon to gladiators, a position that afforded the opportunity to see inside the body. Galen began to realize that he needed to know how all the parts work.

F. In 162 A.D., Galen went to Rome, where he took it upon himself to coordinate the myriad types of physicians under one philosophical and scientific roof.

G. Galen was a skilled physician and became the "doctor to the stars."

H. When plague broke out in Rome, Galen returned to Pergamon.

I. In 168 A.D., Marcus Aurelius asked Galen to return to Rome as one of the emperor's personal physicians. Galen did most of his significant work under the protection of Marcus Aurelius and later emperors.

J. If one looks at Galen's writings, he proclaims the importance of wisdom, justice, fortitude, and temperance, though he embodied none of those virtues. He was what he himself would have called *choleric*.

VI. Galen changed the previous philosophical approach to disease to one that was experimental.

- **A.** Hippocrates had introduced the notion that healing is an art. Galen introduced the notion that healing is a science.
- **B.** His system was based on animal dissection, experiments in physiology, and observation of patients.
- **C.** He was a man of his time, though, and some of his observations were so influenced by predeterminism and the notion of a demiurge controlling the world that they were more than imperfect.
  1. The Greeks believed that living creatures differ from inanimate objects because they are endowed with some special spiritual essence—the life principle—that came from the demiurge: *pneuma*.
  2. *Pneuma* from the surrounding atmosphere was said to come in through the lungs, enter the left ventricle, and leave through the arteries, eventually reaching the brain, where it was converted to what Galen called *psychic pneuma*, which was disseminated through the nerves.
  3. Galen thought the function of the veins was to carry blood, made in the liver, to the rest of the body.
  4. It is noteworthy that he never saw human dissection outside his observations in the Roman and Pergamon gladiatorial arenas.
- **D.** Galen made some useful observations:
  1. He saw that pulsebeat is related to heartbeat.
  2. He showed that arteries contain blood.
  3. He studied the mechanics of breathing.
  4. He tied off the ureter to show that urine is made in the kidneys, not in the bladder.
  5. He cut the spinal cord at various levels to show paralyses and loss of sensation.

6. He discovered the nerves to the voice box. It had been thought since Aristotle that the voice came from the heart.

E. Galen also made some egregious errors:

1. In some animals, he thought he found a coiled network of vessels at the base of the brain, which he called the *rete mirabile*, where vital *pneuma* transits to become psychic *pneuma* in the brain.
2. He believed that veins bring blood to the body via ebb and flow to tissues.
3. He made a number of mistakes in describing the origins of muscles and bony structures because he was looking at animals, not humans.

F. Galen's therapeutics were similar to those of the Hippocratic physicians. In addition to the "heroic measures," he also concocted huge prescriptions, with 10 to 20 ingredients, usually botanicals, oils, and some minerals. These became known as *galenicals* and were prescribed until the early 20th century.

G. Galen recorded everything, leaving us 22 thick volumes of material on such topics as ethics, philosophy, religion, and contemporary life, as well as medicine.

VII. Galen left us this dictum: "Whoever seeks fame by deed, not alone by learned speech, need only become familiar, at small cost of trouble, with all that I have achieved by active research during the course of my entire life."

A. He was believed. By the 4th century, Galen was established as medicine's leading authority and the heir and interpreter of the entire Hippocratic corpus.

B. After the Roman Empire was established, Byzantine doctors translated much of Galen's writings into Latin. Those documents were translated into Arabic by Muslim and Jewish physicians of the medieval period. Thus, the entire canon of medicine during the Middle Ages became, ultimately, Galenic medicine.

C. The irony is that when Galen's reputation was overthrown, it was by the very same experimental methods that he had espoused and that others had forgotten in their pursuit of his philosophy.

Readings:

May, M. T., *Galen on the Usefulness of the Parts of the Body*.

Ballester, Luis Garcia, *Galen and Galenism: Theory and Medical Practice from Antiquity to the European Renaissance*.

Temkin, O., *Galenism: Rise and Decline of a Medical Philosophy*.

Questions to Consider:

1. How did Galen's work and writings further the progress of scientific medicine?

2. How did he hinder that same progress?

Lecture Three

Vesalius and the Renaissance of Medicine

Scope: When Andreas Vesalius, a Flemish medical student at the University of Padua during the late Renaissance, began to dissect human cadavers with meticulous care, he soon came to realize that some of the structures about which Galen had written were either incorrectly described or existed only in animals. Enlisting the aid of a young apprentice of Titian, Stephan van Calcar, he published a magnificently illustrated volume in 1543—when he was 28 years old—*de Humani Corporis Fabrica*, whose title is best translated as "*On the Workings of the Human Body*." By exposing Galen's errors and adding many new findings, this book clarified the understanding of anatomy and function in ways never previously imagined and began to loosen the ancient icon's stifling hold on medical thought. Being both contentious and aggressively ambitious, Vesalius did not shrink from attacking Galenic theory at every opportunity, which earned him as many enemies as disciples, subverted his career, and eventually resulted in his ignominious death.

Outline

I. Every so often, a book appears in the history of medicine that becomes a turning point. This lecture is as much about such a book as about a man. The man is Andreas Vesalius and the book is *De Humani Corpus Fabrica*, or "*On the Workings of the Human Body*."

- **A.** *Fabrica* has been interpreted to mean not just "structure" but "workings." Vesalius was as interested in the functions of the human body as he was in the anatomy itself.
- **B.** Published in 1543, *Fabrica* gave the world its first accurate knowledge of anatomy and a method by which it could be studied.
- **C.** Vesalius provided directions by which anyone with appropriate instruments and access to cadavers could perform dissections.
- **D.** Vesalius's book began the process of debunking Galen, though this would take centuries.
- **E.** Although Vesalius's text brought about the change, the work of its artist, Jan van Calcar, a protégé of Titian, is what is most commented on today.
- **F.** The story of this book and of Vesalius himself is also the story of a series of events representative of the Renaissance, including:
  - **1.** A return to interest in the human body
  - **2.** A return to Greek learning

3. The rise of the universities, which were the focus of Renaissance thought.

II. The first university to focus on medical teaching was the school of Salerno, founded in the 9th century, which later became the model for others of the Renaissance.

- **A.** Most Greek medical knowledge at the time was in the hands of Jewish and Arabic physicians. Teachers and students at the universities came from these, as well as Catholic, backgrounds.
- **B.** By the 11th and 12th centuries, as Arabic texts were being translated into Latin, scholars congregated in various cities to study together. These became communities of scholars in which the students had as much authority as the professors.
- **C.** Universities were open to all sorts of scholars, not just Catholics; therefore, they were not as tightly dominated by the Church as might be expected.
- **D.** The University of Padua was among the first of these institutions and was even less restrictive than most, because it lay within the Venetian Republic, which traded with the East and all over Europe. The university eventually became one of the great centers for studying medicine in the 16th century, with students from every European country. Students were organized into nations, each of which elected a "president" to intervene with university authorities.
- **E.** Adding to the freedom at the universities was the fact that the Catholic Church gradually recognized its own interest in allowing dissection of the human body to a degree.
    1. A high prelate might die unexpectedly, and the pope would allow a dissection to look for the cause of death.
    2. In 1482, Pope Sixtus IV was petitioned by one of the German schools to use the corpses of executed criminals for dissection to confirm Galenic anatomy. Sixtus, who had been a student at the University of Bologna, issued a papal bull allowing local bishops to determine whether the bodies of executed criminals or others who died without wills could be given to universities for doctors to dissect.

III. Where did Vesalius come from, and why did he want to do dissections?

- **A.** Vesalius was the fifth generation of a line of doctors. He grew up close to an area called Gallows Hill, where criminals were executed and left to rot. As a child, he would look at bodily structures and take bones apart; he became interested in living anatomy.
- **B.** By age 10 or 11, Vesalius was taking animals to dissect. He focused not just on the structure of the body but on how the muscles and, possibly, digestion worked.

C. At 15, Vesalius went to the local university, where he spent four years.

D. He then went to the great University of Paris, where he studied Hippocrates and Galen. He devoted his second and last year there to Galenic anatomy.

E. He returned home to get a bachelor's degree in medicine.

F. In 1537, Vesalius returned to Padua and earned a doctoral degree in a year, along with a reputation as an excellent technical dissector.

G. He became a professor of anatomy and surgery the day after he graduated, at age 23.

H. Vesalius didn't like the way he had been taught anatomy.

1. He did dissections himself, rather than having an assistant do them, while he read from Galen, with a skeleton hung next to the body to use as reference.
2. He also obtained animals (dogs, cats, monkeys) to vivisect.
3. Meanwhile, young van Calcar drew everything that seemed to be new and unexplained in Galen.
4. Vesalius discovered things he hadn't expected. The anatomy he saw didn't look like the depictions in the old texts.
5. Vesalius teamed with the artist to produce a more accurate book, and in 1538, the two men created six huge anatomical plates, with Vesalius's text alongside. This transitional work was the start of their creative collaboration.

IV. Students were powerful in the universities, and they began to invite Vesalius to come and spend time demonstrating what he had learned.

A. He demonstrated with a man called Corti, who was an expert in Galenic anatomy.

B. Vesalius would find things in Galen and demonstrate why they were wrong. This spurred him to return to Padua and begin work in earnest on developing a new anatomical text with van Calcar.

C. In 1543, this book was ready for publication. It was a masterpiece from every viewpoint: book publication, pedagogy, medicine, and art.

D. Some of the errors Vesalius found in Galen and disclosed in the book included the following:

1. He realized that Galen had dissected only animals, thus making errors regarding human anatomy.
2. The insertions and positions of many muscles were wrong.
3. Most important was the fact that there was no *rete mirabile*, the keystone of Galenic theory, where *pneuma* converted to psychic *pneuma*.
4. Vesalius wrote, "Galen was deceived by his monkeys."

E. The book itself, written in Latin, has instructions for performing one's own dissections. This is different from Galen, who directed people to look to him.

V. Vesalius was attacked on all sides because he refuted Galen.

A. He shared certain personality characteristics with Galen; he was vain, contentious, and sure of himself. He was angry with the great professors who attacked him because he refuted Galen.

B. In December 1543, Vesalius did his last public dissection in Padua. He burned every bridge to the Padua academic community by destroying all his papers.

C. He left to become physician to Charles V, the Holy Roman Emperor. This couldn't have happened suddenly; it was probably planned for some time.

D. That position didn't work out as Vesalius had expected. A number of doctors were advising the king, many of whom were Galenists.

E. The emperor abdicated, and Philip II assumed the throne, but he wouldn't let Vesalius leave.

F. Vesalius got permission to go on a pilgrimage and died in a shipwreck on a small island in the Mediterranean on his return voyage.

G. Vesalius left us the first accurate anatomy text ever written. But he also demonstrated the importance of skepticism: the idea that nothing should be believed that cannot be personally verified.

Readings:

O'Malley, C. D., *Andreas Vesalius of Brussels*.

Saunders, J. B. de C., and C. D. O'Malley, *Vesalius: The Illustrations from His Works*.

Questions to Consider:

1. Why is the art in *Fabrica* as important as the text to the development of medical science?
2. What role did the church and the structure of the academic communities of the time play in the development of Vesalius's work? In what ways did they help or hinder him?

Lecture Four

Harvey, Discoverer of the Circulation

Scope: Like Andreas Vesalius, the Englishman William Harvey studied medicine at the University of Padua, where he absorbed the spirit of free inquiry and intellectual independence that characterized the Italian universities during the Renaissance. Being of a restless and skeptical nature, he was dissatisfied with the old Galenic notion that organs receive their supply of nutrition by a process of drenching, in which blood ebbs and flows to them through large veins originating in the liver, the site at which it was thought to be manufactured anew to fill the needs of each outpouring. Harvey conceived a series of ingenious experiments and measurements that demonstrated the heart's function as a pump, which, as he described it in 1628, ensures that "the blood in the animal body moves around in a circle continuously." Generally considered to be the greatest contribution ever made to the art of healing, Harvey's discovery of the circulation was the product of the curiosity and wide-ranging thought that characterized the Scientific Revolution of the glorious 17^{th} century, during which the likes of Galileo, Newton, van Leeuwenhoek, Halley, Descartes, Bacon, Hooke, and Bernoulli were at work to establish the basis of modern observational and experimental research.

Outline

I. By general agreement, the greatest gift ever made by one man to the science and art of medicine was the discovery of the circulation of the blood by William Harvey, who described his findings in a book in 1628.

- **A.** In the first place, Harvey's discovery solved what had been, up until that time, an elusive puzzle: the pathway of the blood within the body.
- **B.** Harvey's discovery also reintroduced the notion of the experiment.
- **C.** His book presented the first use of quantitative methods in medical science.
- **D.** Harvey, a contemporary of Francis Bacon, also introduced to medicine the method of inductive reasoning.

II. Modern science was born in the 17^{th} century, a period that has been called the age of the Scientific Revolution.

- **A.** This revolution was largely based on skepticism, very much like the Enlightenment that was soon to take place. Scientists were beginning to question everything that had been handed down. Many were motivated by Vesalius.

B. According to the current theories of bloodflow when Harvey started his work:

1. Blood was manufactured in the liver.
2. According to Galenic theory, food was swallowed, cooked up in the stomach, then went to the liver via the portal vein, where it was converted to blood.
3. The large veins that leave the liver and the vena cava from the heart carry blood all over the body, drenching the tissues.
4. The tissues take what they need—nearly all of it—and what is left flows back to the liver.
5. How the blood flowed back to the liver was never explained. It was thought that the *pneuma* was inhaled constantly into the lungs, then transferred to the left ventricle, where it mixed with blood and was carried to the rest of the body via the blood. This was why it was bright red, while the blood in the veins was dark.

III. Harvey was born in 1578 in Folkstone, Kent, the oldest of seven sons. His father was a Turkey merchant who traded with the East.

A. In addition to being interested in medicine, Harvey studied the classics—to the point of having nothing but contempt for contemporary literature, such as the works of Shakespeare, Marlowe, and Milton.

B. He is described as short, dark, and in constant, frenetic motion.

C. Harvey went to Caius College in Cambridge at age 16. Then, as now, it was known as a place of study for those who wanted to be doctors.

D. Harvey then went to the University of Padua for medical school, where he was elected president of the English students. Harvey's family seal can still be seen at the school today.

E. As soon as he got out of medical school, Harvey got the job of assistant physician at St. Bartholomew's Hospital, at age 27.

F. He had a successful career as the doctor for nobility and royalty, including James I, Charles I, and Lord Chancellor Sir Francis Bacon.

G. Harvey pursued scholarly endeavors in his spare time. In 1616, at age 38, he was given a signal honor: He was appointed to the Lumleian Lectureship at the Royal College of Physicians. This position required him to give two lectures per week in anatomy and surgery, including new additions to knowledge if possible.

IV. Bit by bit, Harvey decided what interested him most was to figure out how the heart actually worked. No one had tackled this before because it seemed like an impossible problem to solve.

A. During those Lumlian lectures, he was trying to discover the exact mechanism by which the various parts of the heart function.

B. Two reservoirs called the *atria* lie on top of the heart, while two large pumping chambers—the *left* and *right ventricles*—lie below.

C. The right ventricle pumps blood to the lungs. The blood returns to the left ventricle, which pumps it to the rest of the body.

D. The world learned this because Harvey figured it out and wrote about it. Until then, doctors had been working with Galenic physiology.

E. Harvey's original intent was to discover how the heart beats. He had been working on this problem for only a few years when he gave his first Lumlian lecture.

F. Harvey's studies turned out to be the material of the first seven chapters in the book he would eventually write about circulation: *Anatomical Studies on the Motion of the Heart and the Blood in Animals* (*De Motu* Cordis *et Sanguinis in Animalibus*).

G. One problem Harvey faced was the rapidity of heart beats.

1. He worked on cold-blooded animals, particularly snakes, whose hearts beat much slower than a human's.
2. Also, as an animal dies, the heart slows down, but the beat is still normal until fibrillation and death. Harvey was essentially opening the chests of animals and watching them die so that he could make his observations.

V. The first thing Harvey identified was the clenching, thrusting motion—*systole*—in which blood is pumped into the lungs and body.

A. Harvey was able to show that blood comes back through the vena cava and empties into the right atrium, while it is coming back from the lungs via the pulmonary veins and emptying into the left atrium.

B. When the atria become full, they empty into the ventricles, which pump the blood out to the body.

C. During this process, Harvey discovered, blood cascades down, but at the last instant, the atria contract; that contraction is passed to the ventricles. As Harvey put it: "The atria arouse the somnolent heart."

D. By the time Harvey had finished the first cycle of Lumleian lectures, he was ready to begin working on the rest of his book.

VI. It never made sense to Harvey that there was a huge amount of blood going out to drench tissues and so little coming back. Could the liver make that much blood?

A. Harvey found that a human cadaver heart held two ounces of water.

B. The heart beats 72 times per minute, and there are 60 minutes in an hour. Thus, 8,640 ounces of blood are pumped out of the heart each hour. Harvey's work marked the first time that any quantitative measurement was used in a medical experiment.

C. The only way to explain all the blood going out is if it is the same blood coming back, then going out again.

D. Harvey's teacher at Padua was Fabricius, who had discovered valves in veins, though he couldn't figure out what the valves did. He thought their purpose was to slow the blood down.

E. Harvey, by compressing veins at various places, showed that the blood in veins goes from the periphery of the body to the center. Thus, he concluded that the valves were to keep the blood from reversing, to keep it flowing to the center.

F. Finally, Harvey wrote: "It must, therefore, be concluded that the blood in the animal body moves around in a circle continuously and that the action or function of the heart is to accomplish this by pumping."

G. Harvey knew that blood was being carried out through the arteries and back through the veins and that the heart is the mechanism by which it is pumped.

H. But how does blood get from the most peripheral arteries to the most peripheral veins? To answer this question, Harvey did what scientists have done over and over since that time and through the centuries: He formed a hypothesis.

   1. He postulated that something would be discovered, a passageway between the peripheral arteries and veins. He said that the blood must move through pores of some sort.
   2. Remarkably, 32 years later, Marcello Malpighi, an Italian microscopist, was able to demonstrate the existence of capillaries.

VII. Harvey's work brought an end to the *pneuma*, the theory of innate heat, and much of the Galenic hocus-pocus. He knew exactly how blood circulates and almost all the mechanics of the heart, but his book had little effect on medical practice.

A. Doctors continued bleeding, purging, and so on. They thought these methods worked and that there was no reason to change.

B. They found no practical use for the notion of the circulation of blood.

C. Predictably Harvey's huge practice started to shrink. Harvey was angry but was not hurt financially because he continued to be physician to King Charles.

D. Harvey persisted in his research. He became interested in reproduction and embryology. He studied fertilized eggs.

   1. In 1651, he published another book, *On the Generation of Animals*, about embryology. It wasn't an important book, but it was again based on all the principles that Harvey had used in coming to an understanding of circulation, namely, inductive reasoning.
   2. A scientist makes observations, forms a hypothesis, tests the hypothesis by doing experiments, then comes up with a theory. That's the scientific method.

3. Harvey was the first physician to use the scientific method. He was also the first physician to apply the principles of inductive reasoning, uninfluenced by his patient Sir Francis Bacon.

VIII. Vesalius and Harvey, between them, converted the "age of the ear," in which people listened to and learned only from authority, to the "age of seeing," "the age of the eye," the age in which one had to see for oneself and prove one's theories to others.

A. Galen had actually done this some 1,500 years earlier, but his experimental studies had been forgotten.

B. In his book on embryology, Harvey wrote a beautiful description of inductive reasoning: "Nature herself must be our advisor. The path she chalks must be our walk. For as long as we confer with our own eyes and make our ascent from lesser things to higher, we shall be at length received into her closet of secrets."

Readings:

Keele, K., *William Harvey, the Man, the Physician and the Scientist*.

Gregory, A., *Harvey's Heart: The Discovery of Blood Circulation*.

Questions to Consider:

1. How did Harvey apply quantitative measurement and inductive reasoning to his research on human circulation? What is the significance of this to the progress of medical science?
2. How did Harvey's work help to move scientific study from reliance on established authorities to reliance on first-hand observation and experimentation?

Lecture Five

Morgagni and the Anatomy of Disease

Scope: The Hippocratic thesis that illness originates in an entire person rather than an organ proved to be an inhibiting factor in discovery, until the work of one man demonstrated that virtually every symptom can be shown to arise from some specific pathological process in a particular structure of the body. In describing the 700 autopsies analyzed in his landmark three-volume work, *On the Seats and Causes of Disease as Indicated by Anatomy* (*De sedibus et Causis Morborum per Anatomen Indigatis, called De Sedibus for short*, 1761), Giovanni Morgagni correlated hundreds of symptoms to their causes in abnormalities of one or another organ. No longer would it be acceptable to indict such vague and generalized factors as atmospheric influences, humoral imbalances, or generalized "badness" as the causative factors in disease. Following the work of Morgagni, the focus of medical investigation became centered on the autopsy and the tracing of what he called "the cries of the suffering organs" directly to their sources.

Outline

I. We start the story of Giovanni Battista Morgagni with a clinical case report going back to 1705.

- **A.** A man of 72 years of age had the following history:
  - **1.** About two weeks prior to admission to hospital, he experienced some pain around the navel, accompanied by nausea and vomiting.
  - **2.** The pain migrated to the right lower quadrant of his abdomen. By the fifth day, his symptoms had rapidly worsened; he became feverish and red in the face.
  - **3.** A day or two later, he was limping on his right leg; About two days after that, he took to his bed.
  - **4.** On the 12th day, he had convulsions, and stopped urinating. He went into a coma on day 13. By day 15, he was obviously dying.
  - **5.** After two and a half weeks of illness, he died.
- **B.** His body was taken to a hospital to be dissected by a young man of 23—Giovanni Morgagni—who was assistant to the famous professor of anatomy Antonio Vasalva. Morgagni opened the body from sternum to pubis and was astonished by the horrid odor coming from deep inside the abdomen—an abscess had burst in the right lower quadrant of the abdomen. The man had clearly died of peritonitis.
- **C.** As Morgagni dissected, toward the base of the cecum, he found a tiny structure that had never been described, though anatomists had noticed it during dissections. The structure later would be called the appendix.

D. The man had died of a ruptured appendix many years before anyone had described appendicitis.

E. Leonardo da Vinci, in 1505, had not only identified the appendix but had also recognized the fact that it sometimes became inflamed and burst, but this information had been lost and no one knew about it.

F. Morgagni and Vasalva decided to dissect everyone who died and keep detailed notes of the patients' illnesses and of the autopsies.

II. What Morgagni found in 1705 had nothing to do with humors, or with a vague, generalized notion of disease that affects the entire body, or with innate heat, or where a patient lived. It had to do with some specific thing that happened in a specific place in the body.

A. Fifty-five years later, when he was 78 or 79, Morgagni published a book with 700 case reports on patients, most of whom he and/or Vasalva had dissected over the years.

B. After the book was published in 1761, doctors realized they should no longer look for the origin of disease in the entire body but in one specific place—a concept that came to be called the *anatomic concept of disease*: A doctor had to know anatomy in order to make a diagnosis.

C. Morgagni had laid the foundations for the modern medical practice of physical examination and the idea that disease is localized and should be treated as early as possible

D. At the heart of Morgagni's discovery is his famous claim that symptoms are "the cries of the suffering organs."

E. The Hippocratic notion that the cause of disease was generalized was now on the verge of dissolution.

III. Giovanni Morgagni was born in Forli in 1682.

A. He went to Bologna to study medicine under Vasalva and received his degree in 1701 at the age of 19.

B. Such was his brilliance that Vasalva asked Morgagni to be his assistant.

C. Morgagni worked with Vasalva for about six years before returning to Forli to be, essentially, a family physician. He stayed there for five years and built up an understanding of clinical, patient-centered medicine that would serve him well.

D. At end of that time, Morgagni was invited to become a professor of anatomy and surgery at Padua, which was still the center of medical learning in the 18th century.

E. Although primarily an anatomist, he continued to think of himself as a physician. He did anatomical studies to learn more about diagnosis.

F. Other doctors learned about Morgagni's studies and, from around the world, began to send him letters seeking consultations for their patients.

These letters were rediscovered and published 25 or 30 years ago as the *Consulti* of Morgagni. They describe the clinical thinking of the perfect physician of that time.

IV. Over the previous century, doctors had been dissecting patients who had died of diseases that had been recognized and treated earlier.

A. In 1679, Theophilus Bonetus brought a number of these case reports together in the first book of its kind, called *A Repository of Anatomy Practiced on Corpses*.

1. The book outlined 3,000 cases by some 470 authors.

2. Morgagni had studied this book, but found it unhelpful; there was no index; its organization was inadequate and there were many inaccuracies.

B. Morgagni decided to write a book that would have not only accurate symptoms, case histories, and autopsies but also an index.

C. He worked on his book for 55 years, shaping it as a set of letters to a young acquaintance. When the book was published in 1761, it was composed of 70 letters describing 700 case histories.

D. Entitled *The Seats and Causes of Disease as Demonstrated by Anatomy* (*De Sedibus*), Morgagni's opus was a turning point in medical history.

1. The 700 cases are divided into five books in three volumes: diseases of the head, thorax, and belly, along with surgical and universal disorders.

2. The fifth book is a supplement, which contains indexes that allow the reader to find pertinent cases by symptom, anatomical characteristic, and other features.

3. There is also an index of names of passages that are most worthy of notice, similar to *Bartlett's Familiar Quotations*.

E. Morgagni did not name any of the diseases he described, but over the next few hundred years, others accurately described and named them.

V. With the publication of this extraordinary work, the first distinct sounds of the humoral theory's death knell could be heard.

A. Morgagni is called the father of pathological anatomy. He was also the father of the physical examination.

B. Essentially, he took the patient's history and did the physical examination after death. The trick, physicians realized soon after Morgagni's book came out, was to examine a patient to anticipate what an autopsy would reveal.

C. Morgagni's book spelled the end of the prevailing belief in predeterminism—that there could be no control over disease.

D. Physicians began to realize that they could not construct a general theory, and then force all their observations to fit that theory. The method that Sir Francis Bacon had started—inductive reasoning—increasingly became the hallmark of medical research.

1. As small observations were made, eventually, they would come to tell a story that led to a hypothesis, then to an experiment, then to a theory.
2. What was required at this time was the accumulation of many observations and large amounts of factual data.

E. Unlike some of the other books we have discussed in these lectures, Morgagni's book was almost immediately in demand.

1. There were multiple translations from the original Latin.
2. Physicians began to make as their goal the premortem prediction of autopsy findings; this is how the modern physical examination developed.
3. Interestingly, when the physical examination was developed, the center of medical progress had shifted to Paris.

VI. At his death in 1771, Morgagni was one of the most renowned physicians in the world. His greatest memorial is his book, which was one of the most significant turning points in the long history of medicine.

Readings:

Jarcho, S., "Giovanni Battista Morgagni: His Interests, Ideas and Achievements," *Bulletin of the History of Medicine* 33 (1948): 503-527

Klemperer, P., "Morbid Anatomy Before and After Morgagni," *Bulletin of the New York Academy of Medicine* 37 (1961):741-760.

Questions to Consider:

1. How did Morgagni's postmortem dissections lead to development of the modern physical examination?
2. What was the impact of Morgagni's book on the notion of predeterminism? How did this change the course of progress in medical science?

Lecture Six

Hunter, the Surgeon as Scientist

Scope: At a time when surgeons were primarily artisans who amputated, lanced, and bled at the behest of physicians, John Hunter introduced the notion that they could also be medical researchers. It is correctly said of him that he brought science into surgery, and he began by dissecting large numbers of animals of many species in order to study and write about comparative anatomy. His investigations into the nature of inflammation, syphilis, wound healing, blood circulation, artificial insemination, and even transplantation were landmarks in the understanding of these processes, especially so because he never hesitated to use his own body as an experimental subject, going so far as to inoculate himself with material from a syphilitic sailor's penis. As a teacher and author, he had a major influence not only on the next generation of surgeons but on medical theory in general.

Outline

I. If there were a theme or text to put us in a frame of mind to study the life of John Hunter, who lived from 1728 to 1793, it would surely be something that Sir Francis Bacon said in the previous century: "No natural phenomenon can be adequately studied in itself alone, but to be understood, must be considered as it stands connected with all Nature."

- **A.** From earliest childhood, Hunter took all of nature and all of life to be the domain of his investigations.
- **B.** The result was that he transformed surgery in his lifetime from something done by a workman—and not an educated workman—into something much more in the domain of science.
- **C.** The entire history of professionalism comes into play when thinking about John Hunter.
  1. We start with rough, uneducated craftsmen.
  2. Someone (such as Hunter) comes along and finds in that field something intellectually exciting.
  3. In turn, people of higher intellect are attracted into the field; they discover new things, thus making the discipline still more attractive to people of higher intellect.
  4. Centuries pass, the cycle continues, and the original field is unrecognizable.

II. John Hunter was born in Lanarkshire in south central Scotland, one of 10 children.

- **A.** He was fascinated from the beginning by everything around him. He was not much of a student and spent his time, instead, exploring nature.
- **B.** His older brother William had gone to London to become a surgeon. He invited John to work in his anatomy school. John had great technical skill in dissecting and was soon teaching.
- **C.** John studied surgery at Chelsea Hospital under William Cheselden.
- **D.** After that, he went to St. Bartholomew's to work with Sir Percival Pott.
- **E.** William arranged for John to go to Oxford, but he left after about eight months, realizing that he was not cut out for formal education.
- **F.** At age 28, John was appointed house surgeon to St. George's Hospital in London, where he continued an interest he had had since childhood—dissecting animals. He began doing comparative studies of animals' anatomies to develop a system of classification.
- **G.** He enlisted as an army surgeon in the Seven Years War. He didn't see action but spent three years (1760–1763) studying marine life.
- **H.** After his military service, Hunter returned to St. George's.
- **I.** He went into practice but his true interest was dissection. He began to gather animals for a museum, ultimately collecting 14,000 specimens, preserved and described in ten volumes of handwritten notes.

III. Hunter had also been working on human subjects.

- **A.** In 1766, he snapped his Achilles tendon while exercising. He saw this as an opportunity to observe the healing process.
    1. Over the course of the succeeding weeks and months, he took a series of live animals and cut their Achilles tendons.
    2. He sacrificed one animal every few weeks to dissect and observe the healing process.
    3. He eventually wrote the first description of the way a tendon forms a scar and heals.
    4. He was his own experimental subject and this started a tradition of auto-experimentation.
- **B.** Hunter's most famous auto-experiment was on syphilis, conducted in 1767. There was a debate at that time about whether syphilis was one or two diseases—syphilis *and* gonorrhea or syphilis *with* gonorrhea. Hunter believed it was one disease.
    1. He found a sailor who had primary syphilis and took discharge from the sailor to infect himself.
    2. After being infected with both primary and secondary syphilis, he made careful observations of himself day by day, and wrote, in his *Treatise on Venereal Disease*, the first thorough description of the

changes brought on by the early stages of syphilis and the proper way to study disease.

C. This was the prelude to Hunter's career-long study of inflammation, which was one of the major problems of the time.

1. Since Hippocrates, it had been noted that the site of an injury is often marked by redness, pain, a lump, and heat, or, as the classical writers put it, *rubor dolor, tumor and calor*.
2. These symptoms are caused by the fact that blood vessels are broken or become permeable in an injury, and blood, lymph, plasma, white and red cells, and platelets get into the area. There are ingredients in these substances that tend to wall the injury off; then, gradually, similar ingredients lead to scar formation and healing. If the injury is not walled off, infection spreads through the body, something we might call blood poisoning.
3. Hunter eventually wrote the first book on inflammation, his *Treatise on the Blood, Inflammation and Gunshot Wounds*, though it was not published until after his death.

IV. With Hunter's two books, we have prototypes of how one should study a clinical disease in its entirety.

A. Hunter used inductive reasoning to discover the general physical principles of healing and used animal experiments to verify the hypotheses he developed. Once he had a theory, he would reason backwards, deductively, to study specific inflammatory diseases.

B. What were some of the experiments that Hunter performed and recorded that taught us something new?

1. One of the major surgical problems of the day was aneurysm. Hunter decided that the best way to treat an aneurysm is to tie it off. Of course, if an aneurysm is tied off, what is beyond that vessel is deprived of blood.
   - **a.** In his dissections, Hunter had noted that the body had a tendency to develop collateral vessels that bypassed the blockage.
   - **b.** Hunter captured a young stag, tied off a vessel leading into an antler, and followed the course of healing: The antler became cold, then shrunk, then got warmer, then began to grow again.
   - **c.** He dissected the antler to show the collateral vessels that had developed.
2. A man came to Hunter who had hypospadias, a deformity of the penis that makes it difficult to ejaculate in the normal way, and who wanted to have children. Hunter took the man's semen and put it into his wife's cervix—the first recorded case of artificial insemination—and the procedure worked.

3. Hunter was able to transplant a rooster's foot into a rooster's comb, rooster testicles into the abdominal cavities of various animals, and a human tooth into a rooster's comb.
4. Terms used by dentists to describe teeth, such as *bicuspid* or *incisor*, were invented by Hunter, who studied the jaw.
5. One of the most famous stories about John Hunter is the so-called Irish giant tale. Charles Byrne was 8 feet, 2 inches tall by the time he was 17. Being so tall and quite thin, he was subject to many diseases, including tuberculosis. Hunter wanted his corpse. Byrne, knowing that he was dying, made arrangements with a funeral director to have his body dumped in the sea so that Hunter could not get it. Hunter bribed the funeral director and got Burn's corpse; the skeleton became part of his museum.

V. In 1776, Hunter was named Surgeon Extraordinary to the king. In 1788, when Sir Percival Pott had died, Hunter was acknowledged as the greatest surgeon in London.

A. At age 55, Hunter bought his "ultimate house" in Leicester Square, with a 25-by-52-square-foot museum for his specimens, a separate lecture theatre with shelves for additional specimens, and a great literary salon for his wife.

B. In 1785, at 57, Hunter began to experience episodes of chest pain on exertion—classical angina.

1. He would rush to a mirror during these attacks and write notes on his own appearance.
2. In October 1793, at a board meeting to obtain positions for two Scotsmen on the surgical service, Hunter had a severe angina attack and ran out of room; he collapsed into the arms of a colleague passing by and died.

C. He was initially buried in St. Martin-in-the-Fields in London, but 66 years later, his body was transferred to Westminster Abbey. The tablet on his gravesite reads: "The Royal College of Surgeons has placed this tablet on the grave of Hunter to record admiration of his genius as a gifted interpreter of the divine power and wisdom at work in the laws of organic life, and its grateful veneration for his services to mankind as the founder of scientific surgery."

D. William Qvist, one of Hunter's early biographers, wrote about him: "John Hunter worshipped nature with profound humility. He was not just a disciple of natural history. He was its high priest."

Readings:

Dobson, J., *John Hunter*.

Knobler, J., *The Reluctant Surgeon*.

Questions to Consider:

1. In what ways did Hunter transform the art and science of surgery?
2. What are the pros and cons of doctors acting as their own experimental subjects?
3. How did some of Hunter's work predate advanced surgical techniques and research?

Lecture Seven

Laennec and the Invention of the Stethoscope

Scope: Morgagni's work stimulated generations of physicians to perform autopsies on every person who died, to localize the origins of symptoms and facilitate diagnosis on subsequent patients while action could still be taken. Thus was born the physical examination, based on looking, listening, tapping, and feeling the bodies of people with symptoms. To listen to the heart and lungs, it was necessary for a doctor to apply the side of his head to the bare and usually unwashed chest of any man or woman whose evaluation required it. Because he found this both embarrassing and distasteful, the short, slight, and intensely shy Rene Laennec, one day in 1816, created a paper tube by rolling up a notebook, which he then placed between his ear and the breast of an intimidatingly buxom young woman recently admitted to a Paris hospital with heart disease. This was the first stethoscope, soon to be replaced by a wooden cylinder 10 inches in length and, decades later, by double-tubed models that would evolve into those of today. Using these instruments, 19^{th}-century physicians described many of the lung and heart sounds that would prove so helpful in diagnosis.

Outline

I. Having accepted the fact that every symptom should be traceable to some specific abnormality in a specific part of the body, the next logical step was to trace that part of the body from which the symptom had arisen while the patient was still alive. This required development of the physical examination, with its looking, feeling, tapping, and listening. In this development, the single most important moment was the invention of the stethoscope in 1816.

- **A.** Until Morgagni and Hunter, most physicians blamed diseases on humors, miasmas, lax morals, or God's anger. With Morgagni's work, the search for the real seats and causes of diseases could begin.
- **B.** Looking was an ancient method; doctors had always looked at patients but not in a systematic way. Feeling and touching had been done, too, but, again, it was also done in an organized way.
- **C.** A new technique was introduced—*percussion*—tapping.
- **D.** What can we learn by percussion? If a box is empty and you tap on it, it has a rather resonant note. If you fill it with something and tap on it, it has a dull note. The same is true of the chest.

II. The man who discovered percussion was the son of an innkeeper who tried to find out how much beer was left in his kegs by tapping on them.

A. This young man—Leopold Auenbrugger—realized that the condition of the chest could be determined in the same way.

B. He started examining patients who had tuberculosis, a common disease in the 1750s. He made hundreds of observations and finally wrote a small book about percussion.

C. The book came out in the early 1760s, just after Morgagni's had been published, but because most people didn't understand the importance of percussion, the book was completely forgotten.

III. The French Revolution (1789) had a profound effect on medical education. The old medical schools that were based on hierarchy were closed down. Becoming a professor at a great medical school soon came to depend on what one had written and one's ability as clinician; it was a system much like our own.

A. One of the products of this system was a man named Jean-Nicolas Corvisart, a physician at the Charité Hospital in Paris. He eventually became the founder of the French method of physical examination.

B. Corvisart found Auenbrugger's book and translated it into French. As Auenbrugger had done, he examined many patients and followed every one to the autopsy room; thus, he had a good idea of how accurate he had been in tapping out a diagnosis.

C. Corvisart wrote an important book that established tapping (or percussion) as a way of examination; from then on, the practice became common.

D. Corvisart established the uniquely French method of teaching medicine.

1. Surrounded by students and trainees and, as the years went by, visitors from other countries, Corvisart would go from bed to bed.

2. First, a student would examine a patient, then Corvisart would examine the patient, demonstrate percussion and deliver a short lecture on the patient.

3. When the students and doctor finished these *grand rounds*, they went to the lecture room, and Corvisart would deliver a lecture on the current group of patients.

4. Next, in the autopsy room, because he had seen every patient there, Corvisart could confirm his diagnoses of the causes of their deaths.

E. This three-part method became the traditional French pedagogical system: first, the careful history and medical examination; then, visits to the autopsy room; then, the correlation.

1. The focus of teaching changed from the university to the hospital and was directed at least as much on patients as on cadavers.

2. The French claimed that they were able to develop the physical examination because they were fascinated by the evidence of their five senses.

IV. Of all those who advanced science during what might be called the golden age of French medicine, nobody made a contribution as great as that of René Theophile Hyacinthe Laennec.

- **A.** Laennec was born in Brittany; his father was a minor civil servant who later in life became a judge. His mother died when Rene was 6, and he was sent to live with his uncle, who was a physician.
- **B.** At age 14, he began medical studies, including hospital work.
- **C.** At about age 17, he began to develop what he insisted was asthma.
- **D.** At the age of 18, in November 1799, he went to Paris for the specific purpose of studying with the great Corvisart.
- **E.** By the year 1802, he published his first scientific paper, on valvular disease of the heart. In the same year, he wrote a paper on venereal disease and another on peritonitis.
- **F.** The work of another French scientist—Marie François Bichat—revealed that not only organs but also tissues could become diseased. Laennec was interested in tissues and organs and found himself studying the liver, including a disease that he named *cirrhosis*.
- **G.** He began to study a structure that he found in the lungs of people who had what was then called *consumption*.
  - **1.** He described much of what we know of pulmonary tuberculosis.
  - **2.** He began a tradition of naming diseases after the pathological anatomical finding, rather than after the main symptom.
- **H.** During the Napoleonic wars, Laennec worked in a hospital taking care of sick and wounded soldiers. It was difficult, demanding, tedious work, and he became sicker, but his renown increased.
- **I.** He was appointed chief physician at a hospital on the outskirts of Paris, the Necker.

V. Shortly after taking the position, Laennec was confronted with a problem.

- **A.** As he was making his hospital rounds, Laennec came to a new patient—a pretty, buxom young woman, who was said to have heart disease. He found himself unable to engage in the customary practice of placing his ear directly on the patient's chest to listen for sounds.
- **B.** Later, walking through a courtyard of the Louvre, Laennec saw a group of children playing a game with a length of wood. One child was scratching one end with a pin. At the other end, another child had his ear to the wood in an attempt to interpret the scratching sounds. Laennec was inspired by the sight.
- **C.** Back at the hospital, Laennec rolled up a notebook to make a cylinder, placed one end to the woman's chest, and listened to the sounds of her heart.

D. Laennec refined his invention into a tubular piece of wood, which he named a *stethoscope*, and he began to make careful observations with his new invention.

E. By August 15, 1819, he had enough data to publish a book in two volumes: *On Mediate Auscultation, or a Treatise on Diagnosis of Diseases of the Lungs and Heart Based Principally on the New Method of Investigation*. In this work, he presented a new instrument, new terminology, a new method of classification of heart and chest diseases, and a new philosophy of diagnosis.

F. While the usefulness of Laennec's stethoscope was not universally endorsed, the consensus was that his volume on the treatment of diseases of the chest was the most complete ever written to that point.

VI. The exhausting flurry of writing resulted in a worsening of Laennec's physical condition. In October of 1819, he resigned his hospital post and returned to Brittany.

A. Two years later, at age 40, he was offered a professorship at the College de France and was able to do his clinical work at the Charité.

B. Physicians flocked to Laennec from around the world. He did all his grand rounds, except for the questioning of patients, in Latin so that all nationalities could understand.

C. The history of medicine in America, Germany, and other countries reveals that the great majority of distinguished physicians in the early 19th century had studied in Paris.

D. Laennec's physical condition continued to deteriorate; finally, when he was 41 years old, he had to be taken care of. He was living with his nephew, who was also a doctor. They invited a distant widowed cousin to live with them; she became Mme. Laennec.

E. In 1826, at age 45, Laennec returned to Brittany, where he died of tuberculosis.

F. He left to his nephew all his medical books and papers and, as he put it in his will: "above all, my stethoscope, which is the best part of my legacy."

Readings:

Duffin, J., *To See with a Better Eye: A Life of R. T. H. Laennec*.

Ackerknecht, E. H., *Medicine at the Paris Hospital, 1794–1848*.

Questions to Consider:

1. How did the French teaching method affect the development of medical science in America and other countries?
2. Discuss the cultural, as well as the scientific, significance of the stethoscope.

Lecture Eight

Morton and the Origins of Anesthesia

Scope: Since the Greeks and even earlier, surgeons had used such means as opium, liquor, and freezing with ice to alleviate the torturous pain of their operations. But these were only partially effective, and operating always required powerful leather restraints and a cohort of strong men to hold the patient down as he screamed in agony. In the 1840s, nitrous oxide, ether, and chloroform were each revealed to have anesthetic properties, resulting not only in a great surge in the possibilities for surgical treatment but also in acrimonious debates over priority in discovery, made more intense by a prize of $100,000 to be given by the U.S. Congress to the man judged to be the winner. All but one of the four American claimants eventually became irrational in behavior, with one committing suicide in prison and another dying after many hopelessly psychotic years in an asylum. A third suffered a fatal apoplectic stroke after his return from making a vain appeal in Washington. The prize was never awarded.

Outline

I. The invention of surgical anesthesia was the first major contribution that American medical science made to the world. It is probably still the greatest of America's many medical discoveries.

A. Before that day in 1846 when ether suddenly appeared, anesthesia had not really changed much since classical antiquity.

B. The *anodynes* (painkillers) were still primarily opiates. Some came from a class of pharmacological agents called *belladonna alkaloids*, which tend to make people dopey and sleepy.

C. In the Middle Ages and the Renaissance, the *soporific sponge* was used; several painkilling ingredients, usually including opium, would be mixed together in liquid form and soaked into a sponge, which patients would then suck on.

D. Surgery was required for amputations, cancers on the body surface, and certain infectious diseases.

1. Patients were given opiates or alcohol to deaden the pain.

2. Operating rooms were not located in the center of the hospital, as they are now; they were deliberately kept in remote parts of the institution.

3. The floor of the operating room would be covered with sawdust, because the results of surgery were so bloody.

4. Patients were strapped down, but the straps were never quite good enough, and six strong men were required to hold patients down.

Patients were given an opiate or liquor sufficiently early so that they were somewhat doped up by the time of the operation.

II. All this would change suddenly and dramatically on the morning of October 16, 1846. But before that date—when ether was shown to be a surgical anesthetic—there was nitrous oxide.

A. Nitrous oxide had first been discovered in 1772 by Joseph Priestley, who was a nonconformist minister and a chemist. Humphrey Davy began experiments with it in 1785, when he was 17 years old.

B. By the early 19th century, nitrous oxide had developed one particular use: it had become known as an apparently harmless and often hilarious form of entertainment at parties, and a form of public demonstration by itinerant "chemists."

C. On December 10, 1844, a dentist in Hartford, Connecticut—Horace Wells—went to one of these performances and volunteered from the audience to sniff the nitrous oxide. When the entertainment was over, Wells walked down the stairs to his seat, and as he did so, he hit his knee against the side of the seat hard enough to cause a bruise. At the time, however, he didn't realize that he had hurt himself. Late that evening, he realized that he could use nitrous oxide to pull teeth and began using it on his patients. It was safe and had no complications.

D. Wells saw that dentistry wasn't the only application for nitrous oxide. Surgeons never dreamed that it would be possible to put someone to sleep during an operation, yet Wells knew that if a patient took enough nitrous oxide and got past the laughing phase, he or she would fall asleep and not feel anything.

E. Wells attempted to demonstrate the anesthetic quality of nitrous oxide at Boston's Massachusetts General Hospital. In an amphitheater filled with students and members of the faculty a student volunteer was given nitrous oxide, and one of his teeth was pulled; he screamed in pain. Later on, the he said that he hadn't felt anything, but his admission came too late; the experiment was perceived to be a failure.

F. Wells was devastated. He sold his practice and devoted all his time to working on nitrous oxide.

III. In the meantime, William Morton, formerly a student of Wells, had been experimenting with sulfuric ether since 1844 and promoting its use.

A. Ether had been synthesized by a Prussian botanist in 1540. In the early 19th century, observers had noticed that sniffing ether caused a dopey feeling and general numbness. Just as there were laughing-gas parties, there were ether frolics.

B. Morton had anesthetized dogs and claimed to have anesthetized birds and insects. He asked John Collins Warren, senior surgeon at Massachusetts General Hospital, if he could try ether on a patient.

C. After the "failed" experiment of February, 1845, Warren was skeptical that there would ever be a substance that would allow surgical sleep, yet Morton seemed to offer a possibility.

D. Once again, the medical students and staff were assembled. This time, they chose a patient, upon whom Warren had wanted to operate for a long time to remove a tumor at the left angle of the jaw. Warren knew that the operation would be difficult and would take more than the usual three to four minutes.

E. Within a few minutes of inhaling the gas, the patient was asleep. Morton said to Warren, "Sir, your patient is ready."

F. Warren began to operate slowly and carefully. It took 25 minutes to dissect and remove the tumor, and the patient didn't move a muscle. Warren walked to the edge of the amphitheater and said, "Gentlemen, this is no humbug." With those words, the era of modern surgery began, on October 16, 1846.

G. Results were published within six weeks in the *Boston Medical and Surgical Journal*, predecessor of the *New England Journal of Medicine*, and news spread around the world.

IV. Morton was suddenly an international figure. He wouldn't tell anyone what the anesthetic substance was. He believed that he could obtain a patent and sell the rights to distribution.

A. However, within a week of Morton's demonstration, Charles Jackson, a professor of chemistry at Harvard, appeared on the scene.

B. Jackson met with Morton and asked Morton to admit that he, Jackson, had suggested using ether for anesthesia, pointing out its use to numb the gums, and its use at ether frolics. The two men finally decided that they could get a patent on ether together, and, indeed, a patent was issued giving the name *letheon* to the new agent.

C. Horace Wells, who had been working with nitrous oxide and knew that he had been superseded, claimed priority, not for ether, but for the notion of anesthesia. As Morton and Jackson began talking with Wells, they realized that he was not in full possession of his faculties.

1. In fact, Wells went to France in 1847, to the French Academy of Medicine and the French Academy of Sciences, and presented his case, asking to be named the inventor of the notion of anesthesia. His claim was rejected.
2. After he returned to America, Wells left his family. He eventually turned up in New York City, where he was arrested for pouring acid on a prostitute in the street.
3. Wells was imprisoned. He had someone smuggle in a small bottle of chloroform—which had meanwhile been discovered by James Simpson—and a knife. He sniffed enough chloroform to eliminate

the most acute sense of pain but not enough to make him unconscious. He then drew the knife across the femoral artery in his groin while lying naked in a bathtu, and hemorrhaged to death.

V. In March of 1848, Congress decided that the best way to decide who should receive credit for the invention of anesthesia was to offer a prize of $100,000 to the one who could provide the best evidence that he was the inventor.

- **A.** Both Jackson and Morton competed for the prize, and also Crawford Long, a physician from a small town in Georgia. Long claimed that he had anesthetized one of his patients to take cysts off his neck four years before Morton's experiment at Massachusetts General Hospital, and he had used ether a few times since then.
- **B.** Morton and Jackson infringed on their own patent by using ether freely during the Mexican War—the first time ether was used in a war.
- **C.** Long didn't press his claim, but Morton and Jackson were suing others for infringing the patent and writing angry letters to each other. Finally, in 1864, Morton was censured by the American Medical Association. Four years later, an article in the *Atlantic Monthly* supported Jackson's claims to the invention.
- **D.** Morton rushed to Washington to meet with members of Congress to argue his case. Driving in a horse-drawn cab with his wife, after returning to New York, he suffered a stroke and died a few hours later.
- **E.** In 1873, Jackson found himself in the cemetery where Morton was buried, and he read the monument on Morton's grave: "Dedicated to William Morton, who discovered anesthesia and gave the world this great gift." Jackson became acutely psychotic and never recovered, dying seven years later in a mental hospital.
- **F.** Long died of a stroke in June 1878.

VI. Of all these men, only Long was destined for a peaceful life and a peaceful death. Wells, Morton and Jackson all lived and died under tragic circumstances. Their great contribution, which was intended to bring serenity and peace to millions, brought only turmoil and anguish to them.

Readings:

Wolfe, R. J., *Tarnished Idol: William T. G. Morton and the Introduction of Surgical Anesthesia*.

Fenster, J. M., *Ether Day: The Strange Tale of America's Greatest Medical Discovery and the Haunted Men Who Made It*.

Robinson, V., *Victory over Pain: A History of Anesthesia*.

Questions to Consider:

1. How did the discovery of anesthesia change surgery for patients? For surgeons?

2. How did it change the layout and design of hospitals?

Lecture Nine

Virchow and the Cellular Origins of Disease

Scope: Shortly after it was shown that all human tissues and organs are composed of the building blocks called *cells*, the German pathologist Rudolf Virchow introduced the concept that disease is caused by some pathological change in a previously normal cell. After Morgagni, a sick man was seen as a man in whom a healthy organ had become diseased, and after Virchow, he was a man in whom there were healthy cells that had become diseased. Not only that, but Virchow was able to show that in certain diseases, such as cancer, for example, the sick cell reproduced itself into offspring with the same disease as its parent. His 1858 book *Cellular Pathology* became the bible of the new medicine, which was now focused on studying the physical and biochemical changes that cause abnormalities and seeking ways to prevent or treat them. Virchow also introduced the notion that many illnesses are caused by social conditions, such as poverty and ignorance. Not content with being what his colleagues called "the pope of German medicine," he became a politically active social reformer as well, famous for such ringing statements as "Physicians are the natural attorneys of the poor."

Outline

I. Even after physical examination had been well developed by about 1840, therapy remained far behind. Doctors still had nothing truly effective with which to treat disease, partly because nobody knew exactly where disease started. The credit for pointing out that disease begins in one basic unit—the cell—goes to the German pathologist Rudolf Virchow.

- **A.** Virchow saw that disease was an abnormality of cellular function and that the structural changes in the cell were a reflection of whatever physiological or functional process was occurring in that cell. The distorted physiology of a cell or a group of cells or the fluid around the cells caused the disorder. In any event, the cell was the focus.
- **B.** Pathophysiology was recognized as being the cause of disease.
- **C.** When we treat disease with modern pharmacological agents, we're treating disordered biochemical functions going on within the cells or the fluid around the cells.

II. The key to understanding sickness is to understand the ways in which normal function becomes abnormal function. There have been many theories about this throughout history, but not until the *cell theory* came into existence with the work of Virchow was light shed on the facts.

- **A.** Virchow was born in Pomerania in 1821.

B. In 1839, he enrolled in a branch of the University of Berlin whose purpose was to train surgeons for the military.

C. In 1843, he earned his M.D., then he received the equivalent of a rotating internship at a large hospital in Berlin called the Charité.

D. At the same time, he began working in the laboratory of Robert Froriep, the autopsy pathologist there. In France, autopsies were done by clinical physicians, but in German-speaking countries, specialization in autopsy was beginning to evolve. The clinician would watch the autopsy, but the pathological anatomist would perform it.

E. Froriep taught Virchow how to use the microscope, and for the rest of his life, just about everything of consequence that Virchow contributed was attributable to his skill with a microscope.

III. Within three years of graduation from medical school, Virchow had made two of the three great discoveries with which he is now associated.

A. He first discovered, in 1845, that the blood of certain patients with symptoms of fatigue, weakness, and difficulty in healing wounds was characterized by a large white portion when it formed a sediment in a thin tube. Virchow named this disease *leukemia*.

B. Virchow also worked on blood clotting. Nobody could quite figure out why blood clots. As Virchow studied blood clots, he realized that in certain situations, blood would actually clot within blood vessels.

1. He also recognized that certain types of clot could be dangerous. He named this form of clot a *thrombus*.
2. Virchow noticed that if these clots did not tightly adhere to the wall of the vessel where they were formed, they might break free and travel. He called this type of clot an *embolus*.

C. In 1846, Virchow succeeded Froriep as the pathological anatomist at the Charité.

D. In 1847, he established a journal that still exists—*The Archive of Pathological Anatomy and Physiology and Clinical Medicine*, also known as *Virchow's Archive*.

E. Because he evinced certain left-wing political tendencies, powerful physicians in Berlin were anxious to get rid of Virchow. Hewas given a position at the University of Wurzburg, which was, at the time, an important medical school in Germany.

1. He became Germany's first professor of true pathological anatomy.
2. Within a few years, he produced a six-volume handbook of what he called *special pathology and therapeutics*, and in 1851, he started a yearbook of medical achievements.

IV. In Wurzburg Virchow also started the teaching technique for which he became famous. He wanted students to learn to look at tissue the way he did, down the barrel of a microscope.

A. He used a large oval table, around the edge of which was a sort of railroad track that he could control with a button. A number of microscopes were situated at crucial places where the students sat.

B. Virchow set up slides in the microscopes and instruct the students.

C. When each student had seen what he needed to see in a certain preparation, Virchow would push the button and the railroad of microscopes would move to the next student.

D. During his lectures, Virchow constantly repeated: "Learn to think microscopically." Students looking at a slide in only two dimensions would have to imagine how it would look in three dimensions.

E. Virchow's *table railroad* was still being used in American universities as late as the middle of the 20^{th} century.

V. Virchow became increasingly impressed by the notion of cells.

A. The word *cell* had been introduced by Robert Hooke in 1665.

1. Hook had cut across a piece of cork with a razor and looked at it with some lenses; he noticed that the cork was arranged in boxes that reminded him of prison cells.

2. From then on, any similar biological structure was called a cell.

B. In 1838, German biologist Matthias Schleiden published a paper in which he pointed out that all plant tissues were composed of cells.

1. .Schleiden convinced the botanist Thomas Schwann that if he studied animal cells, he would find the same thing.

2. Schwann started putting animal tissues under his microscope and found that every sort of animal tissue he examined was, indeed, made up of cells.

3. Schwann wrote *Microscopic Investigations about the Similarities in Structure and Function between Plants and Animals*, asserting that all organic life is built the same way—from cells.

C. Virchow read this book and concluded that disease must arise in cells.

1. When Virchow looked at cancer, certain inflammatory diseases, and what we later discovered were autoimmune diseases, he recognized that it is always the cells that are sick, either because they're secondarily sick from what is going on around them or because they're primarily sick and cause disease around them.

2. Virchow wrote an article in his own *Archive* about what he called "the pathology of the future"—the pathology that must deal with events that occur within the cell and whose anatomic changes are clues to the cell's physiological or biochemical changes.

VI. Virchow developed his thesis about spontaneous generation.

A. Throughout time, tissues were believed to arise spontaneously. At the time that the cell theory came into being, cells were thought to spontaneously generate or arise from a fluid, the *mother liquor*, within the body.

B. As Virchow did his studies, it became obvious to him that every cell in the body came from other cells and that everything is traceable back to the first cell—the egg that is fertilized, the *zygote*.

C. This finding had extraordinary implications. For example, Virchow could now show that every cancer cell, traceable back through its generation, had once been a perfectly normal cell to which something had happened. By now, Virchow was Germany's leading pathologist.

D. In 1856, he was called to the chair of pathology in Berlin. He started giving public lectures to doctors and wrote *Cellular Pathology*.

1. As one great historian said in the early part of this century: "This book deserves to be placed with Vesalius' *Fabrica*, Harvey's *De Motu Cordis*, and Morgagni's *De Sedibus* as the greatest tetrad of medical books since Hippocrates."
2. *Cellular Pathology*, written by the "pope of German medicine," was read by every physician and medical scientist, translated into many languages, and solved problems for the increasing number of people who were trying to study in an academic, scientific way, especially in Germany.
3. Whereas the French had been sensualists and were good at physical examination, that meticulous, careful German personality was perfectly suited to a laboratory.

E. With a single stroke, Virchow's book finally and completely eliminated miasmas and humors and proclaimed to the medical world that abnormal cellular function is the cause of disease.

1. One of the cornerstones of Virchow's thesis was the idea that an abnormal cell must arise only from a normal cell. At the time the book came out, this idea caused a sensation.
2. But 20 years later, another sensation arose when the Frenchman Claude Bernard pointed out that all cells were bathed in what he called the *extracellular fluid*.

VII. Virchow's genius extended beyond his medical contributions.

A. Early in his life, when he was 27, Virchow was sent by the government to help with an outbreak of typhus. He realized that one of the primary causes of sickness in the disease victims was their poverty.

1. For the rest of his life, Virchow devoted himself to public health measures: elevating the economic and social conditions of the poor and cleaning up living conditions in certain cities.

2. Berlin was a mess when Virchow first became involved in public health issues; he was elected to the Berlin City Council, where he served for 42 years. Part of his work on the council was to sanitize the city with new sewer systems.
3. He was also elected to the Prussian House of Delegates, where he became the founder of the German Progressive Party.
4. In 1883, he was elected to the Reichstag.

B. In the middle of his life, Virchow became increasingly interested in anthropology. He was one of the leading anthropologists of the 19th century.

1. He took part in the famous dig that discovered the ruins of Troy, and he went on digs to Egypt in his 50s and 60s.
2. Roentgen discovered x-rays in 1895, and Virchow is credited with the idea of examining mummies using this technology.
3. By the end of his life, he had published 1,180 papers and a few books in anthropology.

C. Virchow became famous, especially during the Nazi era, for a study of German schoolchildren.

1. He was determined to discredit Teutonic notions of racial superiority.
2. He showed that no more than 40 percent of German youth were blond and blue-eyed.
3. He also pointed out that 11 percent of Jewish schoolchildren had blond hair and blue eyes.

D. Virchow was hardly modest. He said, "When they speak of German medicine, it is me that they mean."

E. On January 4, 1902, Virchow was on his way to a meeting, when he leaped out of a streetcar and broke his femur. He recovered, but re-fractured his leg a few months later. He never regained full health and finally died in December 1902. It was said at his death that Germany had lost not one but four great men: her leading pathologist, leading anthropologist, leading sanitarian, and leading liberal.

Readings:

Ackerknecht, E. H., *Rudolf Virchow: Doctor, Statesman, Anthropologist*.

Virchow, R., *Letters to His Parents, 1839–1864*, M. Rabl, ed.

Questions to Consider:

1. What were the practical implications for clinical medicine of Virchow's cell theory?
2. What role did the microscope play in development of that theory?

Lecture Ten
Lister and the Germ Theory

Scope: Surgeons had long believed that there was no way to lower the approximately 45-percent mortality rate—almost all of it caused by infection—resulting from any operation they did, including one so simple as amputation of a finger. They were convinced that the problem was insurmountable because of the unavoidable entry of surrounding air into the surgical site, with consequent destruction of the tissues by oxidation. Then, in 1865, Joseph Lister of the Glasgow Royal Infirmary placed some pus from the wound infection of one of his patients under a microscope and saw bacteria similar to those that Louis Pasteur had identified in putrefying wine and beer a few years earlier. After carrying out experiments in which he found that he could kill the organisms with carbolic acid, Lister used the chemical on a series of patients and lowered his frequency of wound infection to a third of its previous level. In spite of continuing to improve the results of this method, which Lister called *antisepsis*, he was at first unable to convince the medical world to embrace it, and some 20 years passed before the vigorous campaign of this modest, self-effacing—but indomitable—Quaker physician began to make significant headway. When finally accepted, the so-called germ theory revolutionized not only surgery but all of medical thinking.

Outline

I. We might think that, with the invention of surgical anesthesia and its rapid acceptance, surgery would achieve a revolution, and many new operations would be performed, but this was not the case. Although the number of operations increased, the kinds of operations performed did not vary much. It was still not possible to enter the abdomen and the infection rate remained extremely high.

- **A.** Surgeons recognized three types of pus.
  - **1.** An amputation was always left open because infection was virtually inevitable. By the third or fourth day, the stump would leak thick, whitish, non-odorous pus. This was called *laudable pus* and was thought to be a sure sign that healing and scarring would gradually take place. It was actually caused by *staphylococcus*, not a germ notorious for spreading all over the body.
  - **2.** If the stump turned red and the redness rapidly moved up the leg, the patient was experiencing *erysipelas*, which we now know is the result of *streptococcus*. This condition burned its way centrifugally and killed nearly every time.

3. The third type of pus, very common, was known as *hospital gangrene*, and it stank. It was composed of a mix of microbes, some of them *anaerobes*, which do not need oxygen to survive. This thin, liquid pus was referred to as *ichorous*, or *watery pus*.
4. Except for laudable pus, the appearance of any other kind of infection virtually meant certain death.

B. There was also the danger of tetanus, especially if the wound was suffered in the open or in a field.

C. In 1867, James Simpson, a distinguished surgeon and gynecologist in Edinburgh, reported after an extensive study that 41 percent of patients who had amputations died if the amputations were performed in hospitals with more than 300 beds; this figure included finger and toe amputations.

D. The figures in Paris were worse—60 percent of patients with amputations died; in Zurich, 46 percent; in Glasgow, 34 percent. The American hospitals were somewhat better. The statistic for the Pennsylvania Hospital was 24 percent; Massachusetts General, 26 percent.

E. After Joseph Lister's discovery of antisepsis, a method for stopping these infections, in the 1860s and 1870s, surgery changed completely, although it took years for universal acceptance.

II. Lister was born to a Quaker family in a country village near the eastern extremity of London.

A. He went to Quaker schools, where he learned to speak fluent French and German.

B. His father was Joseph Jackson Lister, a wine merchant who had another hobby that tended toward the scientific: optics. Indeed, the elder Lister discovered a law of optics that enabled him to craft improved lenses for microscopes.

C. Young Joseph grew up speaking French and German, the two major medical languages of the period, and was an expert in the use of the microscope by the time he was in his teens. Those two facts were key to everything he accomplished.

D. Lister attended University College London. He enrolled in its medical school and graduated with honors in 1852.

E. A year after graduation, he went to Edinburgh to study with the distinguished Scottish surgeon James Syme, who offered him the post of house surgeon. Lister stayed for about a year, then Syme asked Lister to remain as his assistant.

F. Lister married Syme's daughter, Agnes; on their honeymoon, they went to all the leading medical centers in France and Germany. When they went back to Edinburgh, they created a laboratory in their kitchen. Lister was the chief scientist, but Agnes was his working partner.

G. Lister studied the function and structure of muscle, blood clotting, and inflammation, trying to find out what starts inflammation and blood coagulation. As he studied clots microscopically, he concluded that some foreign body must start a chemical process that causes the clot.

H. He was appointed professor of surgery at Glasgow and quickly became a popular teacher.

III. Lister kept thinking about the high rate of infection and mortality in patients.

A. Professor of chemistry Thomas Anderson pointed Lister toward a 10-year-old French medical journal article, in which a young chemist related how he solved a problem of fermentation that was causing putrefaction in wine and beer.

1. Louis Pasteur had been told by the wine and beer makers in his region that their products were putrefying, and they didn't know why.

2. Pasteur looked at normal wine under his microscope and saw yeast, which had not been noticed before.

3. Then, he looked at the putrefied wine and saw rod-shaped structures. Bacteria had been known for hundreds of years, but nobody thought they caused problems. Pasteur determined that these bacteria—*bacilli*—were the cause of the putrefaction.

4. To kill them, he heated the wine to a certain level—not enough to kill the yeast, just enough to kill the bacteria.

B. Lister read the article and concluded that this was also the cause of infection in wounds.

1. The most common theory held that wound infection was inevitable; when the body was exposed to air, the tissues were oxygenated and destroyed.

2. Lister looked at some of the pus from a wound infection and saw the bacilli, but he didn't know how to kill them.

3. Lister recalled that a nearby town had solved its problems with foul-smelling sewage and diseased cows near the place where sewage was collected by spraying the area with carbolic acid.

IV. Lister looked for a subject with a wound he could spray with carbolic acid.

A. On August 12, 1865, Lister was called to see a boy of 11 who had a compound fracture of his tibia.

B. Lister knew that the injury would become infected and that the only cure would be amputation, an operation with a mortality rate of about 45 percent.

C. He soaked bandages in a dilute solution of carbolic acid and applied them to the wound, changing the dressing every day. After about six weeks, the wound was healed.

D. This experience encouraged Lister to start treating worse fractures, local infections, and certain types of abscesses with carbolic acid. He would drain abscesses and apply dressings soaked in carbolic acid to them. Although some people died despite the treatment, many recovered.

E. In 1867, Lister published a series of five papers in the *Lancet* to announce the invention of what he called *antisepsis*.

F. Lister's technique entailed spraying the operating room and sheets or drapes with carbolic acid, and soaking the bandages in it. The surgeon repeatedly dipped his hands in carbolic acid during the operation and the instruments were also dipped in it. The operating room smelled unpleasant, but patients survived their operations.

G. Ultimately, Lister published a comparison of amputations done with and without carbolic acid.

1. Before using carbolic acid, 16 of 35 patients had died after surgery.
2. With carbolic acid, only 6 of 40 patients had died. This figure did not include patients who had not required amputations because the carbolic acid prevented infection of the original wound.

V. The reaction to Lister's discovery was not as enthusiastic as one might think. Some surgeons simply expected germs to live in wounds; others claimed that germs appeared in wounds only after the infection started.

A. Lister's ability to demonstrate his theory through bacteria cultures viewed through a microscope was unconvincing to other doctors.

1. In England, no one even knew about microscopy. The microscope was something doctors saw for a day or two in medical school; it had nothing to do with the day-to-day practice of medicine, much less surgery.
2. Surgeons were rough-and-ready artisans; they worked fast in the hope of minimizing oxidation.

B. Lister was determined to spread his doctrine. He lectured on it twice a week, demonstrating the spray and dressings.

C. Acceptance finally came after the Franco-Prussian War, in light of the following statistics:

1. In the French army, there had been 13,173 amputations, of which 10,006 resulted in death.
2. The chief surgeon of the German army had attempted 36 amputations through the knee joint, and every patient had died of infection.

D. French and German surgeons and physicians read Lister's work and filled his lecture hall to learn the new techniques. They took the information home and performed antiseptic surgery on the Continent, but the method was still not accepted in Scotland, Ireland, or England.

E. In America, debate raged until the late 1880s or 1890s about the validity of Lister's techniques.

1. Lister's lectures were on bacteriology and physiology, but American doctors didn't understand science and didn't think it was important for the day-to-day practice of medicine.
2. Further, American doctors had no experience with microscopes.
3. Instead of merely striding into an operating room, amputating a leg in a minute or two, and washing their hands afterward, surgeons were now being asked to change their clothes, spray their hands and instruments with carbolic acid, spray the wound repeatedly, and apply a complicated dressing. The whole procedure took much longer.

VI. In 1875, Lister was invited for a triumphant tour through France and Germany, where he was regarded almost as a god because he had changed surgery.

A. Bit by bit, this missionary zeal was beginning to have an effect in England and Scotland.

B. A position opened at Kings College Hospital, which gave Lister a chance to go to England and find a larger audience among his countrymen. Though many came to his first lecture, Lister's main audience remained the Germans and the French.

C. Acceptance of Lister's technique was gradual. More meticulous surgery was performed, the importance of laboratory work became more evident, and striking information from France and Germany began to emerge.

1. In 1876, the German Robert Koch was the first to identify a specific bacterium as the cause of a disease—anthrax.
2. The most powerful evidence in support of Lister came in the form of a book Koch wrote in 1878, in which he linked six different kinds of surgical infection to six specific bacteria.
3. Lister now received international honors and was knighted by Queen Victoria.

VII. Near the end of Lister's crusade, a paradox arose. Antisepsis is essentially disinfecting. The Germans began to think in terms of prophylaxis, inventing, instead of antisepsis, *asepsis*—no infection.

A. What is *asepsis*? The technique involves scrubbing one's hands, boiling surgical instruments and drapes, and having surgeons wear sterile gowns and caps. In 1889, an American surgeon, William Halsted, enhanced asepsis by inventing rubber gloves.

B. In 1886, Ernst von Bergmann, a surgeon at the University of Berlin, invented steam sterilization.

C. Within a year or two, the steps that must be taken for the ritual of surgical asepsis were outlined: the scrubbing, the particular way a doctor enters the operating room, how the nurse puts on the doctor's gown and gloves, and how the doctor functions in the operating room. From then on, surgery was carried out using these procedures.

D. In 1907, Lister's 80th birthday was celebrated around the world.

E. A great public funeral was held in 1912, when he died at the age of 85.

Readings:

Fisher, R. B., *Joseph Lister*.

Treves, F. "The Old Receiving Room" in *The Elephant Man and Other Reminiscences*.

Questions to Consider:

1. What was the role of the microscope and its use in the development of antisepsis?

2. Why were other countries faster to adopt Lister's antiseptic techniques than his own nation or America?

Lecture Eleven

Halsted and American Medical Education

Scope: William Halsted, a flashingly brilliant young New York surgeon, became addicted to the cocaine with which he was experimenting in an attempt to study the drug's effects as a local and regional anesthetic. After his slow recovery, he was appointed the first professor of surgery at the new Johns Hopkins Medical School, which opened in 1893. Though it was not generally known until long after his death, he remained somewhat of an addict for the rest of his life, and it affected his surgical style: He was converted into a slow, meticulous operator whose techniques were so carefully gentle that complications were few in the many new operations he devised. Halsted developed an entire school called the *surgery of safety* by training the leaders of the next two generations in his methods. At the same time, other innovators in medical education were using Johns Hopkins as a laboratory and transforming the ways in which young doctors were trained. The medical school later became the model on which all others in the United States were patterned, leading, in time, to American dominance in teaching and research.

Outline

I. The new order that came to surgery with the contributions of Joseph Lister was exemplified in the United States by the career of William Stewart Halsted. With him, the idea of meticulous surgery based on scientific principles reached America and spread across the country. In a relatively short time, American medicine became the gold standard against which the medicines of all other countries would measure themselves.

- **A.** In 1874, Johns Hopkins left $7 million in his will to found a hospital and a university. The original trustees, mostly Quakers, decided that the university would be led by Daniel Coit Gilman, and the hospital, by John Shaw Billings.
- **B.** These two consulted medical leaders from around the world and chose their faculty based on a philosophy that involved the new scientific medicine and the influence of laboratory science on clinical medicine.
- **C.** They chose a youthful faculty of six men whose names read like an honor roll in the history of medical education; every one of them had studied at German universities and was strongly influenced by German medical scientists. They were: Franklin P. Mall, anatomy; John Jacob Abel, pharmacology; William Welch, pathology; Howard Kelly, gynecology; William Osler, internal medicine; and William Halsted, surgery.

D. In May 1989, the hospital opened, but the medical school couldn't, because its endowment was tied up in depressed B&O Railroad stocks. The medical school was left with a shortfall of some half a million dollars.

E. A committee of four young women, every one a daughter of a university trustee, approached the trustees and said that they would incorporate themselves to raise the needed money, provided that several conditions were met. Their conditions were that women would be admitted on the same basis as men and that all students would be required to have graduated from college, have studied biology, have a reading knowledge of French and German, and have high academic averages.

F. The women were turned down several times until the trustees became desperate. They ultimately agreed to the provisions, and the women raised the needed money and more. The school opened in October 1893 as America's first medical school, with a complete array of laboratory courses.

   1. A large number of medical schools existed in America at the time, because any local doctor could open a school. There were almost no laboratories.

   2. Hopkins was different: here were crackerjack students—a significant proportion of whom were women—who were in close contact with researchers and were given great responsibility in the care of patients.

   3. For the first time in an American medical school, the *full-time system* was instituted, which meant that every professor worked only for the medical school; they did not have private practices. Some, like Halsted, were allowed to earn private fees, but this practice was kept to a minimum.

   4. In addition, the Johns Hopkins Hospital and Johns Hopkins Medical School were under single management. All hospital policy was decided by the professors.

G. This grand experiment in medical education was so successful that a 1910 report commissioned by the Carnegie Foundation and researched by Abraham Flexner advised that all medical schools in the country should be based on the general principles of the Johns Hopkins Hospital.

   1. The one principle that was never accepted was that women should be admitted on the same basis as men.

   2. The Rockefeller Foundation later provided $50 million to fund medical schools that were willing to institute the full-time system and develop a close affiliation with a hospital in which their students would be trained.

II. When William Stewart Halsted came to Hopkins to be the first professor of surgery, he entered an extraordinarily heady atmosphere of research and clinical work destined to transform medicine, not just in the United States but, eventually, in the entire world.

A. Halsted was born to wealth, the son of a successful New York City textile importer.

B. He went to Yale, where he was an athlete but not a very good student.

C. He began hanging around the medical school and attending lectures during his senior year at Yale. He applied to the College of Physicians and Surgeons, at that time, loosely associated with Columbia University.

D. Halsted graduated and took an internship at Bellevue Hospital, before a further period of training at New York Hospital.

E. Then, he went to walk the wards in Europe, as had been done since Laennec. Americans were still traveling to European centers of medicine, but now it was to the German-speaking centers. Halsted would spend weeks or months at a particular institution, learning technical surgery and research methods, learning how to combine the two, and learning methods of training.

F. In 1880, at age 28, Halsted returned to New York to start a practice. By this time, he was an adept clinical surgeon, and his practice grew rapidly.

  1. He had learned the Listerian methods of antisepsis, now being converted to asepsis, and he saw that his fellow New York surgeons were uncomfortable with the idea.

  2. He collected $10,000 from friends to build an "antiseptic tent" on the grounds of Bellevue Hospital, where he could carry out the antiseptic and partly aseptic methods that he had learned.

  3. Halsted was the only surgeon that we know of who was using antiseptic and aseptic methods at that time in New York City.

III. Halsted received word from one of the surgeons he had worked with in Vienna that Karl Kohler, an ophthalmologist, had introduced the idea of putting drops of cocaine in the eye to provide local anesthesia.

A. The idea came from Sigmund Freud, who was trying to use cocaine by mouth to ameliorate the pain of some of his neurology patients.

B. Halsted had the idea of injecting cocaine into nerve roots. He began to experiment with nerve blocks and regional and local anesthesia using cocaine.

C. Halsted and his colleagues also discovered that cocaine could be used for recreational purposes. He and some of the others became addicted to cocaine.

D. William Welch invited Halsted to work in the laboratory at Johns Hopkins, in part to help him overcome his addiction and gradually restore his surgical career.

E. Ultimately, Halsted received the appointment as professor of surgery at Hopkins. He was no longer a flashy New York surgeon but, rather, a slow, compulsively meticulous, and studious surgeon.

F. Halsted's research was also meticulous, and his record-keeping was obsessive. In the laboratory, he gradually learned how tissues heal.

G. Halsted called his very careful method of surgery—which took some three times as long as most operations of the time—the *surgery of safety*.

H. Halsted also created the modern surgical residency program by taking on the best of the German methods.

1. During the course of his 30-year career, he trained 17 chief residents.
2. Of these 17, 11 went on to start university residency programs just like his, operating with what was called the *Halstedian technique*.
3. They trained, in turn, 136 surgeons. Across the country, American surgeons became Halstedian surgeons.

I. It was not until the 1970s that British, German, and French surgery began to be more Halstedian. Doctors from these countries adopted many of the American teaching and science methods, but they couldn't bring themselves to slow down during surgery.

IV. What did Halsted attack clinically? What problems was he trying to solve?

A. One of Halsted's concerns was the problem of hernia, for which the mortality rate was quite high.

1. A *hernia* is a hole in the abdominal wall in which a loop of intestine has become trapped.
2. Numerous ways of treating hernia had been developed.
3. Halsted did a careful gross and microscopic anatomical study of the abdominal wall in the groin and developed a technique of sliding tissues together to close the gap. His *radical hernia repair* resulted in only a five percent rate of recurrence.
4. This repair technique was subsequently used by all surgeons in America and, eventually, around the world.

B. The innovation for which he is best known and has most recently been reviled is the *Halsted radical mastectomy*.

1. When Halsted started his surgical career at Hopkins, no women who had surgery for breast cancer lived longer than three years. The only women who were operated on were those with advanced cancers.
2. Halsted did an experimental and literature-search study of the lymphatic drainage of the breast, the musculature of the chest wall, and the way in which cancer in general spreads through the body.

3. He concluded that the only way to stop the cancer was to take out significant amounts of tissue and all the lymph glands from the arm; he actually removed the two major muscles of the chest wall.
4. By the mid-1890s, Halsted was able to report not only a significant number of women who had lived beyond three years, but also a very low number of women who had local recurrences.
5. As a transitional operation for many decades, radical mastectomy was indeed the answer. With earlier diagnoses, x-ray therapy, and chemotherapy, such radical surgery is no longer always necessary.

C. Halsted perfected thyroid surgery, which was extremely hazardous at the time.

1. Most people were operated on for hyperactivity of the thyroid. During the operation, the surgeon's manipulation of the gland released thyroid hormone into the bloodstream, causing rapid pulse and high fever, a condition called thyroid storm. Many patients died on the operating table.
2. Halsted operated with such meticulous technique that he avoided releasing the hormone.
3. Eventually, he reported 650 cases of thyroid surgery, very few of which had resulted in *thyroid storm*.

D. One day in 1889, Halsted looked at the hands of his scrub nurse, which she habitually disinfected with mercuric chloride before beginning work; her hands looked terrible. He invented rubber gloves to prevent her having beefy, red hands. The nurse and Halsted eventually married.

E. He encouraged young men to go into specialties that didn't exist yet, including Harvey Cushing for brain surgery and Samuel Crowe for ear, nose, and throat surgery.

F. After his death, it was discovered that Halsted had remained an addict all of his life, but not to cocaine; he had switched to morphine.

Readings:

Warren, M. *Johns Hopkins: Knowledge for the World*, 1876-2001

Leopold, A. *A Darker Ribbon: Breast Cancer, Women, and Their Doctors in the 20th Century*.

Questions to Consider:

1. How did the innovations at the Johns Hopkins Hospital and Medical School create an environment conducive to Halsted's contributions?
2. How did Halsted's German training influence development of Halstedian surgery? In what ways did Halsted's techniques advance beyond the standard German methods of the day?

Lecture Twelve

Taussig and the Development of Cardiac Surgery

Scope: The Johns Hopkins Medical School was founded on the principle that women must be admitted on the same basis as men. After Helen Taussig graduated from the school in 1923, she undertook an investigation into the many inborn cardiac defects that medical science could do nothing to prevent or treat. Her work resulted in the establishment of the new field of pediatric cardiology, and it gave her the idea for a surgical correction of one of the most common congenital heart diseases, *Tetralogy of Fallot*. Taussig suggested her method to the chief of surgery at Hopkins, Alfred Blalock, who followed her advice by designing a technique for operating on these so-called *blue babies*, a procedure that became the first major step in the development of the field of cardiac surgery. Two decades later, in the early 1960s, Helen Taussig recognized that thalidomide, a sedative frequently taken by pregnant women, was distorting development in the arms and legs of their babies in utero. She lobbied successfully against the continued manufacture of the drug and, thus, became not only a pioneer in the foundation of pediatric cardiology and cardiac surgery but also in the prevention of drug-induced congenital defects.

Outline

I. In this final lecture, we will see how the Johns Hopkins experience led gradually to the openings of great new vistas, including specifically, the field of pediatric cardiology, which in turn, led to advances in heart surgery in general. We will close by discussing the cutting-edge field of transplantation.

- **A.** Pediatric cardiology had its greatest impetus with the so-called *blue-baby* operation, first done in the Johns Hopkins Hospital in the early 1940s.
  - **1.** Blue babies had been described from time to time since antiquity, but the first Morgagni-like description was by a Dutch anatomist named Edward Sandifort in 1771. He described a child who was unable to carry out any normal activities because the least exertion made him blue. Even at rest, he was somewhat blue.
  - **2.** When the child died, Sandifort found at autopsy a very small pulmonary artery and a hole in the septum, the wall between the left and right ventricle; unoxygenated blood was being released into the body, which made the patient blue.

B. Approximately 100 years later, a professor of pathological anatomy at the University of Marseilles, Etienne Louis Fallot, described a disease that has since come to be known as *Fallot's Tetrology*.

   1. This collection of defects includes a small opening of the pulmonary artery, a hole between the two ventricles, a thickened ventricular wall on the right, and an aorta that doesn't come only out of the left ventricle but also overrides the right somewhat.

   2. The result of these defects is a mixing of oxygenated and unoxygenated blood and a cyanotic—or blue—child.

   3. Hearts like these were studied once the children died, because nothing could be done for such patients.

C. Maude Abbott, a specialist in pathological anatomy at McGill Hospital in Montreal, spent her career dissecting the hearts of children who died of congenital cardiac disease. In 1936, she published a book called *Atlas of Congenital Cardiac Disease*, which became the bible for anyone trying to study these conditions.

II. The problem was eventually solved, or at least, an early solution was found, by another woman—Helen Taussig—who used Abbott's book to begin her studies.

A. Taussig was born in Boston. Her father was a professor of economics at Harvard and discouraged her from becoming a doctor.

B. Nonetheless, when she finished her liberal arts course at Radcliffe, she enrolled in Boston University, where she took classes in anatomy, physiology, and chemistry and got a job in the Boston University cardiac clinic.

C. Taussig was admitted to Hopkins, graduated in 1923 with nine other women, and took a fellowship in cardiology.

D. Edwards Park, a professor of pediatrics, suggested that Taussig take an internship in pediatrics, and for a year and a half, she did so. She was then put in charge of the pediatric cardiology clinic.

   1. Most of the children she saw had the residua of rheumatic fever, but she also saw children with congenital heart disease and became interested in that.

   2. Because Taussig was slightly deaf, she refined her ability to use a stethoscope and to feel a chest wall to discern which ventricle was larger or the actions it was taking in trying to pump blood.

   3. Taussig began to use a fluoroscope in a way that no one had done before. She turned her young patients from side to side so that she could see the atria and ventricles from different perspectives.

   4. Taussig became expert at diagnosing congenital heart disease.

III. At that point, cardiac surgery did not exist. Two related operations had been performed a few times.

A. One such operation was called a *coarctation* of the aorta. Some children are born with an aorta that is narrowed in the chest, and several surgeons had learned to cut out that narrow part and bring the edges together.

B. The other operation was the division or suture of what was called a *patent* or *persistent ductus arteriosus*.

   1. In embryological life, the blood is shunted past the lungs because the lungs are not functioning. The blood goes out the pulmonary artery, and an opening into the aorta allows the blood to keep flowing. But the moment a child is born, that opening normally closes.

   2. Occasionally, it does not close, the aortic blood flows into the pulmonary artery, and the lungs are flooded with too much blood.

   3. The procedure performed to prevent a child from going into pulmonary failure is to divide that ductus or tie it off.

C. Taussig sometimes saw children who had both the tetrology and ductus arteriosis. Because of the ductus, these children were not nearly as cyanotic; the blood was flowing through the ductus from the aorta to the lungs, bypassing the tight pulmonary outflow tract. Taussig concluded that to treat the Tetrology of Fallot, she needed to build a ductus in affected children.

D. Because Taussig had no idea how to approach the problem technically, she went to the chief of surgery at Hopkins, Alfred Blalock, who had done some important work on surgical shock and pulmonary hypertension.

   1. Blalock had induced high blood pressure in the lungs of experimental animals essentially by building a ductus.

   2. Blalock also had an excellent technical assistant, Vivien Thomas, an African American who had wanted to attend medical school but couldn't even afford to go college. Over the years, Blalock had put Thomas in charge of developing the technical aspects of some of the experiments he was working on, and Thomas had built the ductus apparatus for Blalock.

   3. After talking with Taussig, Blalock and Thomas decided they would divide the subclavian artery and hook it into the pulmonary artery to bypass the obstructed pulmonary artery.

   4. Thomas began operating on dogs, picking the smallest he could find to mimic small children.

E. In late November 1944, Taussig presented to Blalock a patient, 11 months old, who would probably die in a couple of weeks from tetrology. The child, Eileen Saxon, weighed just 9 ½ pounds.

   1. Blalock and his two assistants—the resident William Longmire, who went on to become chief of surgery in the University of California system, and the intern Denton Cooley, who went on to become one of the great surgeons at the Texas Heart Institute—performed the procedure.

2. Blalock also insisted that Vivien Thomas be present in the room, essentially overseeing Blalock's operation.
3. The child lived, and became pink.
4. The next two patients were older and larger.

F. Patients began coming to Johns Hopkins from across the globe. By November 1945, 55 patients had been operated on, and as time went on, the mortality rate, which had started out around 20 percent, was down to less than 5 percent.

IV. This was the first real cardiac operation. It not only meant the survival of many children, but it also revealed that the tissues and great vessels around the heart and, perhaps, the heart itself could be manipulated safely.

A. Surgeons were encouraged to try operations within the heart. The early operations for mitral stenosis were carried out by a surgeon putting a finger into the heart and cracking the tightened valve open. Nowadays, such valves are replaced in open-heart surgery.

B. In 1947, Blalock and Taussig went to a number of European capitals to demonstrate the surgery. Taussig would pick the patients and Blalock would operate. The real effect of this tour was to encourage new attempts at cardiac surgery.

C. In 1947, Taussig wrote a book called *Congenital Malformations of the Heart*.

1. It was the first textbook of pediatric cardiology.
2. Thanks to the book and the innovative procedure, the field of pediatric cardiology expanded rapidly. A second edition of Taussig's work would be required within a decade, with two volumes of 1,000 pages each.
3. Taussig trained an entire generation of pediatric cardiologists.

D. Interestingly, Taussig didn't make professor until 1959, 15 years after her great contribution.

E. Taussig is also remembered for her effective campaign against the marketing of thalidomide in the United States.

1. This drug—first approved for sale in Germany—was proven to produce a problem called *phocomelia* in infants; they were born without forearm bones or with decreased length of forearm bones.
2. With Frances Kelsey of the Food and Drug Administration, Taussig, in March 1961, at age 63, succeeded in stopping thalidomide from being sold in this country.

F. Taussig retired at age 65, yet 41 of her 100 major publications were written after that time. Three weeks before her 88th birthday, she was killed in a minor car accident.

V. Taussig's work started cardiac surgery and led, eventually, to cardiac transplantation and transplantation of other organs. Open-heart machines and heart-lung machines came into being in the mid-1950s and made further advances possible.

- **A.** The story of cardiac transplantation is really the story of our evolving understanding that the cells of each individual harbor within them something that is unique to that organism.
  1. Medical centers all over the world sought to inhibit the immune response to enable the acceptance of transplanted organs in the body.
  2. Inhibition of the immune response has been achieved with a number of drugs, particularly steroids, but the mainstay since the 1970s has been the drug cyclosporine, a fungus-based drug.
- **B.** Unfortunately, surgeons jumped the gun with transplantation, conducting the operation before the immunological response was fully understood.
  1. On December 3, 1967, Christiaan Barnard of Groote Schuur Hospital in Cape Town, South Africa, took it upon himself to perform a cardiac transplantation.
  2. He had studied at Stanford University on the service of Norman Shumway, chief of cardiac surgery there. Shumway didn't think he was ready to try a transplantation because he didn't know enough about the immune response.
  3. Barnard operated on a man named Louis Washkansky, replacing his heart with that of a young woman who had been killed in a car accident. Washkansky lived 18 days.
  4. Rather than discouraging Barnard, this encouraged him. On January 2, 1968, he operated on a dentist named Philip Blaiberg, who lived 19 months.
  5. Shumway then operated on a patient, who lived only 15 days. But he wasn't discouraged.
  6. Eventually, far less qualified people jumped on the bandwagon. Around the world, heart-transplant surgery was being performed and patients were dying because the rejection phenomenon wasn't understood and because there were no proper agents to decrease the immunological response.
  7. In 15 months, 118 people in 18 countries had heart transplants, and every one of those recipients died.
  8. By late 1971, everyone but Shumway and Barnard had stopped performing the surgery, and soon afterward, they also stopped.
  9. Shumway continued his immunological studies. Gradually, he began to resume his work.
  10. Shumway's work was so successful that by the mid-1980s, 29 centers in the United States had done some 300 cardiac

transplantations with extraordinary results. Perhaps 95 percent of recipients lived at least a year; at least 80 percent lived about five years. The operation has become almost routine.

C. The remaining problem with cardiac transplantation is availability, the same problem with transplantation of all organs. But we now live in an era of molecular wonders, an era of genetic engineering; we are looking at the almost unlimited potential of stem cells in the near future.

D. No matter how far medicine progresses, it will always be indebted to the pioneers of its first two millennia, and in their lives, there will always be lessons to learn about the process of discovery.

Readings:

Baldwin, J., *To Heal the Heart of a Child: Helen Taussig, M.D.*

Weisse, A. B., "Into the Heart: The Surgical Treatment of Heart Disease Becomes a Reality," in *Medical Odysseys: The Different and Sometimes Unexpected Pathways to Twentieth-Century Medical Discoveries*.

Hawthorne, P., *The Transplanted Heart: The Incredible Story of the Epic Heart Transplant Operations by Professor Christiaan Barnard and His Team*.

Frist, W. H., *Transplant: A Heart Surgeon's Account of the Life-and-Death Dramas of the New Medicine*.

Questions to Consider:

1. How did Helen Taussig's work with pediatric cardiac patients spur a boom in general cardiac surgery?
2. Discuss the relationship between immunology and heart transplant surgery.

Timeline

c. 460 B.C. .... Hippocrates born (d. 370 B.C.).

c. 130 .... Galen born (d. c. 200).

1514 .... Andreas Vesalius born (d. 1564).

1543 .... Vesalius publishes *On the Workings of the Human Body* (*De Humani Corporis Fabrica*).

1578 .... William Harvey born (d. 1657).

1628 .... Harvey publishes *On the Movement of the Heart and Blood in Animals* (*De Motu Cordis*).

1679 .... Theophilus Bonetus of Geneva publishes *A Repository of Anatomy Practiced on Corpses*.

1682 .... Giovanni Morgagni born (d. 1771).

1722 .... Leopold Auenbrugger born (d. 1809).

1728 .... John Hunter born (d. 1793).

1761 .... Morgagni publishes *On the Seats and Causes of Disease as Indicated by Anatomy* (*De Sedibus*).

1772 .... Joseph Priestley discovers nitrous oxide.

1781 .... René Laennec born (d. 1826).

1786 .... Hunter publishes *A Treatise on Venereal Disease*.

1794 .... Hunter publishes *A Treatise on the Blood, Inflammation, and Gunshot Wounds*.

1799 .... Humphrey Davy discovers the anesthetic properties of nitrous oxide.

1805 .... Charles Jackson is born (d. 1880).

1808 .... Jean-Nicolas Corvisart rediscovers Auenbrugger's technique of percussion.

1815 .... Horace Wells is born (d. 1848); Crawford Long is born (d. 1878).

1816 .... Laennec invents a prototype stethoscope.

1819 .... Laennec publishes *On Mediate Auscultation*; William Morton is born (d. 1868).

1820 .... Rudolf Virchow is born (d. 1902).

1822 .... Louis Pasteur is born (d. 1895).

1827 .... Joseph Lister is born (d. 1912).

1842 .... Crawford Long uses ether as a surgical anesthetic (not publicized).

1844 .... Gardiner Quincy Colton demonstrates laughing gas to Horace Wells.

1846 .... William Morton publicly demonstrates ether used as an anesthesia.

1847 .... James Simpson introduces chloroform as an anesthesia; Lister begins correspondence with Louis Pasteur.

1852 .... William Halsted is born (d. 1922).

1858 .... Virchow publishes *Cellular Pathology*.

1865 .... Lister's first clinical experiment with antisepsis.

1882 .... Pasteur develops rabies vaccine.

1890 .... Halsted introduces the use of rubber gloves in surgery.

1893 .... Johns Hopkins Medical School opens; Halsted becomes its first professor of surgery.

1895 .... W. C. Roentgen discovers x-rays.

1898 .... Helen Taussig is born (d. 1986).

1910 .... Vivien Thomas is born (d. 1985).

1944 .... Taussig, Blalock, and Thomas develop surgery for *blue babies*.

Glossary

Anesthesia: Chemical compound used to induce insensibility to pain; named by the 19th-century physician Oliver Wendell Holmes.

Aneurysm: Localized pathological dilation of a blood vessel.

Antisepsis: Method of killing harmful bacteria in a wound, first named by Joseph Lister.

Aorta: Primary artery of the circulatory system.

Artery: Blood vessel that carries blood away from the heart.

Ascultation: Careful listening to sounds in the human body to diagnose disease; term coined by Laennec.

Asepsis: Method of sterilizing the environs of the surgical field, first named by Lister.

Blue babies: Infants born with congenital heart defect that causes a bluish tint to the skin and mucous membranes. (See **Cyanosis**.)

Carbolic acid: A toxic, white, soluble crystalline acidic derivative of benzene; first used as a surgical antiseptic by Joseph Lister; also known as phenol.

Chloroform: A volatile, colorless, and inflammable liquid once used as a general anesthetic; first introduced as an anesthesia in 1847 by the Scottish physician Sir James Simpson.

Cirrhosis: Disease of the liver; the term was coined by René Laennec.

Clinic: From the Greek word meaning "one who is lying down," a medical health facility.

Consumption: Early term for tuberculosis, a disease, primarily, of the lungs.

Cyanosis: Bluish discoloration of the skin and mucous membranes. (See **Blue babies**.)

Deductive reasoning: Reasoning from the general to the particular (or from cause to effect).

Embolism: Blockage of a blood vessel by a clot that travels (embolus) or abnormal particle; Rudolf Virchow was the first to recognize that blood clots in the pulmonary artery originate as venous thrombi (see **Thrombus**).

Ether: The chemical compound diethyl ether (sometimes called sulfuric ether) was first synthesized in the 16th century. In the 19th century, it was first used as an anesthetic by Crawford Long, although William Morton was originally given the credit for this discovery.

Florescope: Instrument combining an x-ray machine and a fluorescent screen to examine internal organs.

Germ theory: Louis Pasteur and Robert Koch postulated that "a specific disease is caused by a specific type of microorganism." The theory was proved accurate and directly influenced Joseph Lister's development of antiseptic surgery.

Hippocratic oath: Ascribed to Hippocrates, the oath defines ethical rules governing medical practice, which physicians continue to follow to this day.

Inductive reasoning: Reasoning from the particular to the general.

Laughing gas: Early popular name for the chemical compound nitrous oxide. The name derives from its effect after inhalation of a small quantity. Discovered by Joseph Priestley in 1772, it was demonstrated in the United States as an entertainment by Gardiner Quincy Colton. A member of the audience at one of Colton's demonstrations, the dentist Horace Wells, would discover its anesthetic quality.

Leukemia: Literally meaning "white blood," a cancerous disease of the blood; the term was coined by Rudolf Virchow.

Microscope: Instrument that magnifies the size of very small objects so that they can be seen more clearly. Robert Hooke was among the early developers of the microscope. The instrument was crucial to Rudolf Virchow's path-breaking work in cellular pathology. "Learn to think microscopically" was his mantra with his students.

Nitrous oxide: See **Laughing gas**.

Percussion: Technique of tapping the human body to examine resonance as an aid to diagnosis; first discovered by Leopold Auenbrugger in the 18th century.

Peritonitis: Inflammation of the peritoneum.

Stethoscope: Instrument used to conduct sound from within the human body as an aid to diagnosis; the prototype was invented by René Laennec.

Tetralogy of Fallot: Named after the French physician Étienne-Louis Fallot (1850–1911), a complex congenital heart disease that causes bluish discoloration of the skin and mucous membranes (cyanosis).

Thrombosis: Blockage of an artery or vein by a blood clot (thrombus).

Thrombus: Name given to a blood clot by Rudolf Virchow. (See **Embolism** and **Thrombosis**.).

Vaccination: Introduction of a weakened form of a disease into the body in order to stimulate immunity to a more serious form of that disease.

Ventricle: Pumping chamber; in the human heart, there are two ventricles: The right ventricle pumps blood into the pulmonary circulatory system, and the left ventricle pumps blood into the circulatory system of the rest of the body (systemic circulation).

X-ray: Electromagnetic radiation; applied in medicine to produce visual images of internal anatomical structures; discovered in 1895 by W. C. Roentgen, who called it *x-ray* because he did not know what its composition was at the time.

Biographical Notes

Auenbrugger, Leopold (1722–1809): Austrian physician who discovered the technique of percussion and published his findings in 1761. His discovery was not recognized by the medical community until Jean Nicolas Corvisart (see below) revived it some 40 years later.

Blalock, Alfred (1899–1964): American surgeon and chief surgeon at Johns Hopkins University Medical School who, with Helen Taussig and Vivien Thomas (see below), pioneered a surgical procedure that greatly extended the lives of babies born with Tetralogy of Fallot, also known as *blue-baby syndrome*.

Bonetus, Theophilus (1620–1689): Genovese anatomist who was the first to attempt to correlate exhibited symptoms of disease in a living person with postmortem findings.

Byrne, Charles (1761–1783): Irish giant, standing 8 feet, 2 inches tall, whose skeleton was studied by John Hunter.

Colton, Gardiner Quincy (1814–1898): American itinerant showman/lecturer who introduced Horace Wells (see below) to laughing gas (nitrous oxide) in 1844.

Corvisart, Jean-Nicolas (1755–1821): French physician and chief physician of the Charité Hospital in Paris who rediscovered Auenbrugger's percussion technique and founded the 19th-century French school of medicine.

Galen (b. 130 C.E.): Greek physician who premised his medicine on the belief that disease can be understood only through knowledge of anatomy. Galen experimented and lectured continuously. His anatomical and physiological discoveries—recorded in 22 volumes—established his reputation throughout the Roman Empire. So great was his influence that his teachings remained virtually unchallenged for a millennium and a half.

Halsted, William (1852–1922): American surgeon who brought to modern medicine many of the surgical techniques still in use today: sterilization of all medical equipment, use of surgical gloves and general anesthesia, and the emphasis on inflicting minimal injury to bodily tissues and organs during surgery. These techniques minimized the patient's pain, tissue trauma, infection, and blood loss and led to quicker recovery. As the first professor of surgery at Johns Hopkins, Halsted passed on his approach to modern medicine and helped establish one of the premier surgical training programs in the world.

Harvey, William (1578–1657): English physician who challenged the traditional Galenic theory of blood that failed to comprehend the circulatory system and discovered, through painstaking scientific methodology, the heart's function as a pump effecting continuous circulation of the blood around the body. In 1628, he published his findings in his *Anatomical Essay Concerning the Movement of the Heart and the Blood in Animals* (*Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus*- usually referred to as *de Motu Cordis*). Although controversial in its day, the work became the foundation for modern cardiovascular research.

Hippocrates (b. c. 460 B.C.E.): Greek physician commonly called the "father of modern medicine." Hippocrates's name is connected with a system of healing, developed during the Golden Age of ancient Greece, which insisted that diseases have natural, as opposed to supernatural, causes and that they arise in the entire body rather than in a specific organ. The Hippocratic method was also characterized by careful observation of the sick; detailed, written records of symptoms and treatment; and an ethical code spelling out physicians' obligations to their patients and to one another (the Hippocratic oath exemplifies this code).

Hunter, John (1728–1793): Scottish polymath who pioneered research in many diverse fields, including physiology, pathology (including venereal disease and inflammation), dentistry, comparative anatomy, zoology, geology, and embryology. Considered one of medical history's greatest anatomists, Hunter raised the status of surgery through scientific methodology, insisting on experimentation and direct observation. Two of his landmark publications are *A Treatise on Venereal Disease* (1787) and *A Treatise on the Blood, Inflammation and Gunshot Wounds* (1794).

Jackson, Charles (1804–1880): American geologist and chemist who introduced William Morton to the idea of using ether as an anesthetic. After Morton's successful public demonstration of ether's anesthetic quality in 1846, Jackson tried to claim the credit for himself and spent the rest of his life fighting Morton for it. He eventually became insane.

Laennec, René (1781–1826): French physician who discovered the technique of "mediate auscultation," a term he coined, meaning listening to the sounds of the body through the use of an instrument. Laennec invented the prototype of the stethoscope and was able to diagnose disease by careful listening and observation. His famous work, *On Mediate Auscultation*, was published in 1819.

Lister, Joseph (1827–1912): British surgeon who introduced the concept of antiseptic surgery, based on Pasteur's theory that bacteria cause infection. Having noted, early in his medical career, the very high incidence of infection in wounds and doubting the existing theory that infection was caused by "bad air," Lister devised a number of techniques that brought about dramatic decreases in postoperative fatalities, including the use of carbolic acid to disinfect wounds and sterilize surgical instruments. He is considered a pioneer of preventive medicine.

Long, Crawford (1715–1778): American physician credited with the discovery of anesthesia. Long had used ether as an anesthetic since 1842 but did not publish his discovery until after William Morton claimed the credit for discovering its anesthetic quality. (See also Charles Jackson, William Morton, and Horace Wells.) Long's achievement was posthumously recognized in 1879.

Morgagni, Giovanni (1682–1771): Italian anatomist and physician who refuted the prevailing theory that disease originates in a generalized way, from humoral imbalances and other vagaries, pointing out instead that symptoms are correlated to specific anatomical structures. His *On the Seats and Causes of Disease Investigated by Anatomy* (*De Sedibus et Causis Morborum per Anatomen Indagatis*), published in 1761, represents decades of clinical and anatomical research and demonstrates, through 700 case studies, that diseases have their origins in specific organs. His work laid the foundation for modern anatomical pathology.

Morton, William T. G. (1819–1868): American dentist who claimed to have discovered the use of ether as an anesthetic after his public demonstration of it in 1846. His assertion was disputed by the chemist Charles Jackson. Morton fought Jackson for the rest of his life to gain credit for the discovery. In fact, Crawford Long had been using ether since 1842 but had not publicized that fact. Morton died of a stroke.

Pasteur, Louis (1822–1895): French chemist and microbiologist best known for inventing and successfully testing vaccines to prevent anthrax, rabies, and chicken cholera. Pasteur first rose to prominence in French science through his experiments with bacteria, which disproved the theory of spontaneous generation and led to the germ theory of disease. His pioneering work in stereochemistry led to the invention of the process used to kill harmful organisms in food, *pasteurization*, which now bears his name.

Priestley, Joseph (1733–1804): English scientist and non-conformist minister who discovered nitrous oxide (laughing gas) in 1772.

Taussig, Helen (1898–1986): American cardiologist who developed an innovative surgical technique to save the lives of *blue babies*. Considered the founder of pediatric cardiology, Taussig pioneered a technique that has prolonged innumerable lives and is considered to have been the first step in the field of adult open-heart surgery. Taussig was also instrumental in preventing untold numbers of birth defects by identifying thalidomide as the drug responsible for congenital malformations of babies in utero.

Thomas, Vivien (1910–1985): African-American surgical technician who perfected a method of diverting blood flow that enabled Taussig and Blalock to operate successfully on babies suffering from the congenital heart defect known as *blue-baby syndrome*. Though his education ended with high school, Thomas was awarded an honorary doctorate by Johns Hopkins University in 1976.

Vesalius, Andreas (1514–1564): Flemish physician, surgeon, and professor of anatomy whose dissection of human cadavers led him to challenge the teachings of Galen. In 1543, he published the most accurate and comprehensive anatomical text to that time, *On the Workings of the Human Body* (*De Humani Corporis Fabrica*), which exposed Galen's errors and added new findings.

Virchow, Rudolf (1821–1902): German scientist and social reformer who founded modern cellular pathology, introducing the idea that disease is caused by a pathological change within a cell and that diseased cells arise from preexisting cells. His landmark *Cellular Pathology* was published in 1858. Virchow also made important contributions to anthropology.

Wells, Horace (1815–1848): American dentist who discovered the anesthetic ability of nitrous oxide ("laughing gas") but failed to prove its efficacy at a public demonstration at Boston's Massachusetts General Hospital in 1845. Unsuccessful at subsequent attempts to prove nitrous oxide as effective an anesthetic as ether, Wells gradually lost his mind, and eventually committed suicide in prison.

Bibliography

Essential:

The books on this list are among the most highly regarded of the standard textbooks in medical history, which have been read by medical students and historians since early in the 20th century. To build a library in the subject, these volumes are essential. Though some of these texts may be found through such outlets as Amazon, the best source is the catalog of a dealer in second-hand medical-historical texts.

Ackerknecht, E. *A Short History of Medicine*. Baltimore: Johns Hopkins University Press, 1982. This book is precisely what it purports to be: 275 pages of densely packed material written as though to get everything in.

Castiglioni, A. *A History of Medicine*. New York: Alfred A. Knopf, 1947. In 1,200 pages of remarkably well-written text—and with more than 500 illustrations—the great Italian historian Arturo Castiglioni takes his readers on a vast journey from the pagan rituals of prehistoric times to the 20th century, omitting nothing of any significance.

Clendening, L. *Source Book of Medical History*. New York: Dover Publications, 1942. Selections from 124 papers covering some of the most important writings in medical science, from the Egyptian papyri to Roentgen's 1895 description of his discovery of x-rays.

Garrison, F. H. *A History of Medicine: With Medical Chronology, Suggestions for Study and Bibliographic Data.* Philadelphia: Saunders & Co., 1913. The single most consulted of medical history texts, noted for its attractive and often idiosyncratic thumbnail sketches of hundreds of fascinating contributors to progress, all of which are arranged chronologically so that a full overview is provided, beginning in prehistory before any noted figures could be identified. Many photographs.

Mettler, C. C. *History of Medicine*. Philadelphia: Blakiston Company, 1947. Unlike the Garrison, this equally large book (1,215 pages) is arranged by subject matter, making it an accessible history of each specialty, and it provides correlations within fields.

Sigerist, H. E. *The Great Doctors: A Biographical History of Medicine from the Ancient World to the Twentieth Century*. Garden City: Doubleday Anchor, 1958. This is the exemplar of medical history treated as biography. Its 70 chapters of less than 10 pages each are brief biographies of every significant figure in medical history, from Egypt's Imhotep to William Osler of Johns Hopkins and Oxford.

Singer, C., and E. A. Underwood. *A Short History of Medicine*. Oxford: Oxford University Press, 1962. Though anything but short (854 pages), this book has the advantage of its senior author's experience as one of the most scholarly medical historians of the 20th century. The significance of the various advances is woven into the text, as in a series of erudite lectures.

Supplementary:

Acierno, L. J. *The History of Cardiology*. New York: Parthenon Publishing Group, 1994. ISBN 1-85070-339-6. The history of the understanding of cardiac anatomy and function and the development of diagnosis and therapy.

Ackerknecht, E. H. *Medicine at the Paris Hospital, 1794–1848*. Baltimore: Johns Hopkins University Press, 1967. This is the definitive description of the role of the teaching hospitals of Paris in the early 19th century, to which physicians and students flocked from all over the world. The great teachers of French medicine devised the most advanced methods of studying pathological anatomy and diagnosis, which became the model on which all theory and practice would be based until the second half of the century, when German-speaking institutions took the lead.

———. *Rudolf Virchow: Doctor, Statesman, Anthropologist*. Madison: University of Wisconsin Press, 1953. The only full-scale biography of Virchow, written by one of the most eminent medical historians of the mid-20th century.

Altman, L. K. *Who Goes First? The Story of Self-Experimentation in Medicine*. New York: Random House, 1987. ISBN 0-394-50382-1. Altman, medical editor of the *New York Times*, tells the dramatic stories of innovators throughout history who were their own experimental subjects.

Baldwin, J. *To Heal the Heart of a Child: Helen Taussig, M.D.* New York: Walker and Company, 1992. Though written for a young adult readership, this book is an excellent biography of the salient events in Helen Taussig's life.

Ballester, Luis Garcia. *Galen and Galenism: Theory and Medical Practice from Antiquity to the European Renaissance*. Burlington: Ashgate, 2002. A life of Galen and a description of his dominating influence on the medicine of every era until the Renaissance.

Bett, W. R., ed. *The History and Conquest of Common Diseases*. Norman: University of Oklahoma Press, 1954. Essays on some 20 diseases, describing the evolution of scientific understanding of their nature and treatment, from tonsillitis to cancer.

Bliss, M. *William Osler: A Life in Medicine*. Toronto: University of Toronto Press, 1999. The best biography of the greatest medical educator America has ever known; this book also narrates the story of the early days of the Johns Hopkins Medical School.

Bynum, W. F., and R. Porter, eds. *Companion Encyclopedia of the History of Medicine*, 2 vols. London: Routledge, 1994. ISBN 0-415-16418-4. A series of essays categorized under a wide variety of headings, each of which treats some aspect of medicine and describes its historical development.

Dobson, J. *John Hunter*. London: E&S Livingstone, Ltd., 1969. Jessie Dobson was, for many years, the curator of the Hunterian collection at the Royal College of Surgeons of England and is the ultimate authority on its collections and their history. This biography is filled with fascinating quotations from Hunter's personal correspondence and scientific writings.

Duffin, J. *To See with a Better Eye: A Life of R. T. H. Laennec*. Princeton: Princeton University Press, 1998. Dr. Duffin won the Welch Medal, the highest literary award of the American Association for the History of Medicine, for this splendid and beautifully written biography. It brings its subject to vivid life, while it offers a thoroughgoing analysis of the effect of Laennec's contributions on the course of medical progress.

Duffy, J. *From Humors to Medical Science: A History of American Medicine*, 2nd ed. Urbana: University of Illinois Press, 1993. ISBN 0-252-01736-6. The rise of organized medicine in the United States, including matters of licensure, education, medical sects, state and national societies, and women and minorities. This book is a valuable source for learning about all of them.

Duke, M. *The Development of Medical Techniques and Treatments: From Leeches to Heart Surgery*. Madison, CT: International Universities Press, 1991. ISBN 0-8236-1232-5. The author, an experienced physician, divides his historical narrative into three parts: basic clinical techniques, such as blood-pressure reading and the electrocardiogram; drug and hormone therapy, including oxygen and leeches; and cardiac care, from nitroglycerine to transplantation.

Edelstein, L. *Ancient Medicine*. Baltimore: Johns Hopkins University Press, 1967. This series of 21 essays is by an author generally considered the leading historian of the topic. All but three of the essays relate to the Greek medical, magical, cultural, and philosophical principles on which the Hippocratic physicians based their precepts of diagnosis, treatment, and ethics.

Fenster, J. M. *Ether Day: The Strange Tale of America's Greatest Medical Discovery and the Haunted Men Who Made It*. New York: Harper Collins, 2001. ISBN 0-06-019523-1. Written for the general reader, this book tells the entire story of the events leading up to the introduction of ether inhalation anesthesia and their aftermath.

Fisher, R. B. *Joseph Lister*. New York: Stein and Day, 1977. ISBN 0-8128-2156-4. The best and most readable modern biography of Lister.

Frist, W. H. *Transplant: A Heart Surgeon's Account of the Life-and-Death Dramas of the New Medicine*. New York: Atlantic Monthly Press, 1989. ISBN 0-87113-322-9. This narrative of a single year in the heart-transplant program at Vanderbilt University describes the scientific, clinical, and human details of these procedures as seen through the eyes of the chief surgeon, now the majority leader of the U.S. Senate. It provides insight into the personality of a man who is the prototypical cardiac surgeon.

Gregory, A. *Harvey's Heart: The Discovery of Blood Circulation*. Cambridge: Icon Books, 2001 (in the United States, Totem Books, 2001). A popular biography of Harvey and the story of his research.

Hawthorne, P. *The Transplanted Heart: The Incredible Story of the Epic Heart Transplant Operations by Professor Christiaan Barnard and His Team*. Chicago: Rand, McNally & Co., 1968. This book tells the story of the first cardiac transplantation, which captured the imagination of the world but proved to be only a tantalizing exercise in clinical prematurity. Written by a journalist, it does have a somewhat breathless character, matching the hullabaloo of publicity that surrounded Barnard's accomplishment.

Heynick, F. *Jews and Medicine*. Hoboken: Ktav Publishing House, 2002. ISBN 0-88125-773-7. A panoramic overview of the many contributions made by Jewish physicians since the first centuries C.E.

Hunter, R., and I. Macalpine. *Three Hundred Years of Psychiatry: 1535–1860*. London: Oxford University Press, 1963. Selections from the writings of contributors before the age of modern psychiatry.

Jarcho, S. "Giovanni Battista Morgagni: His Interests, Ideas and Achievements." *Bulletin of the History of Medicine* 22 (1948): 503–527. In the absence of a full-scale biography, this essay, written by the physician who translated Morgagni's consultation letters, is the best source.

Jones, W. H. S. *The Works of Hippocrates*. Cambridge: Harvard University Press, 1957. This translation of several of the most well-known of the Hippocratic texts is a standard, to which scholars have been referring for several generations.

Jonsen, A. R. *A Short History of Medical Ethics*. New York: Oxford University Press, 2000. One of America's most prominent bioethicists traces the development of his field from the 5th century B.C.E. to today.

Keele, K. *William Harvey, the Man, the Physician and the Scientist,* London: Thomas Nelson and Sons, 1965. A readable life of Harvey, in his distinctive roles as both a researcher and a clinical physician. Written by one of the most admired medical historians of the 20th century, who was also a highly respected practicing physician.

Klemperer, P. "Morbid Anatomy Before and After Morgagni." *Bulletin of the New York Academy of Medicine* 37 (1961): 741–760.This essay details the profound effects of Morgagni's contributions on the concept of pathological anatomy.

Knobler, J. *The Reluctant Surgeon*. London: Heinemann, 1960. This is a popularized biography of John Hunter that reads like a novel. Though it is filled with imagined dialogue, it presents a reliable summary of the highlights of Hunter's life, both professional and personal.

Leonards, R. A. *History of Gynecology*. New York: Froben Press, 1944. A standard history of the field, from primitive times until the mid-20th century.

Loudon, I. *Western Medicine: An Illustrated History*. Oxford: Oxford University Press, 1997. ISBN 0-19-820509-0. Artistically illustrated with a wide variety of photographs, illuminated manuscripts, paintings, caricatures, and other forms (some of the illustrations are well-known classics). This book contains many essays on various topics in medical history, beginning with the classical period and concluding with modern times. The book's first half is history told chronologically, and the second deals with specific areas, such as hospitals, medical education, epidemics, nursing, childbirth, and political and social issues.

Ludmerer, K. M. *Learning to Heal: The Development of American Medical Education*. New York: Basic Books, 1985. ISBN 0-465-03880-8. The most authoritative history of the development of medical education in the United States.

———. *Time to Heal: American Medical Education from the Turn of the Century to the Era of Managed Care*. New York: Oxford University Press, 1999. Ludmerer follows *Learning to Heal* with this masterpiece of history and scholarly narrative. Eminently readable, it is the ultimate analysis of the past, present and future of American medical education.

Lyons, A. S., and R. J. Petrucelli. *Medicine: An Illustrated History*. New York: Harry N. Abrams, 1978. ISBN 0-8019-1054-3. A huge and magnificently illustrated book in full color, whose text and pictures trace the history of medicine.

May, M. T. *Galen on the Usefulness of the Parts of the Body*, 2 vols. Ithaca: Cornell University Press, 1968. Elizabeth May's beautiful translation of the single most frequently referenced of Galen's books has become a classic. It reflects the ancient Greek physician in all of his bombastic certainty and reads as though one can hear him speaking at the public lectures that made his contemporary reputation.

Miles, S. H. *The Hippocratic Oath and the Ethics of Medicine*. New York: Oxford University Press, 2004. ISBN 0-19-516219-6. The author dissects the oath into its component parts, presenting each of them in the context of antiquity, specifically, Greek civilization, so that the reader is given a perspective on the background in which the Hippocratic physicians developed their concepts. In addition, the author provides applications and implications of the oath for the modern-day world.

Morantz, R.M., C.S. Pomerleau, and C.H. Fenichel. *In Her Own Words: Oral Histories of Women Physicians*. New Haven: Yale University Press, 1982. An introductory chapter on women physicians in American medicine from 1600 to 1980 is followed by extensive interviews with nine prominent women who overcame major barriers to the progress of their careers.

Norman, J.M. *Morton's Medical Bibliography*, 5th edition. Brookfield, VT: Scolar Press, 1991. The classic annotated list of every medical text of consequence, from the time of Hippocrates to the end of the 20th century.

Nuland, S. B. *Doctors: The Biography of Medicine*. New York: Vintage Books, 1989. ISBN 0-679-72215-7. The book on which this course is based, telling the story of Western medicine's development by means of 14 biographical essays, each approximately 35–40 pages long.

———. *The Mysteries Within: A Surgeon Explores Myth, Medicine and the Human Body*. New York: Touchstone, 2001. ISBN 0-684-85486-4. Descriptions of the often bizarre ways in which several organs of the body (heart, liver, spleen, stomach, reproductive organs) have at first been misunderstood since primitive times and a narrative of how science finally solved the riddles of their function.

———. *The Doctors' Plague; Germs, Childbed Fever and the Strange Story of Ignac Semmelweis*. New York: W.W. Norton & Co., 2003. ISBN 0-393-05299-0. The history of the discovery of the cause and prevention of childbed fever and its relationship to the germ theory of Pasteur and Lister.

O'Malley, C. D. *Andreas Vesalius of Brussels*. Berkeley: University of California Press, 1964. (Reprinted by Jeremy Norman Company, San Francisco, 1997.) The standard biography of Vesalius, written by a distinguished historian whose forte was the relationship between 16th-century science and the sociopolitical structure of the culture in which it developed.

Pearce, J. M. S. *Fragments of Neurological History*. London: Imperial College Press, 2003. ISBN 1-86094-338-1. Thumbnail sketches of diseases, discoveries, and contributors, with selections from their writings, Renaissance to today.

Porter, R. *The Greatest Benefit to Mankind: A Medical History of Humanity*. New York: W.W. Norton & Co., 1997. ISBN 0-393-04634-6. A wide-ranging and colorful history of medicine, told from the perspective of not only the science but the social forces that shaped it.

———. *Blood and Guts: A Short History of Medicine*. New York: W.W. Norton & Co., 2002. ISBN 0-393-03762-2. Covers the same material as the above but entirely rewritten and concise.

Proctor, R. N. *Racial Hygiene: Medicine under the Nazis*. Cambridge: Harvard University Press, 1988. ISBN 0-674-74578-7. Not all medicine is beneficent. This book deals with a black chapter in the history of the profession and describes how German doctors willingly became part of the Final Solution.

Rather, L. J. *The Genesis of Cancer: A Study in the History of Ideas*. Baltimore: Johns Hopkins Press, 1978. ISBN 0-8018-2103-7. Theories of the origins of cancer, from Hippocrates to the discovery of tissue and cell function in the 19th century.

Robinson, V. *Victory over Pain: A History of Anesthesia*. New York: Henry Schuman, 1946. This is the classic, written for the general reader and covering every aspect of anesthesia's history, from antiquity to the period when modern innovations were beginning.

Rosen, G. *A History of Public Health* (expanded ed.). Baltimore: Johns Hopkins University Press, 1993. ISBN 0-8018-4645-5. Rosen, the leading historian of the field, describes the development of public health from the Greek period to the late 20th century.

Rosenfeld, L. *Foundations of Clinical Chemistry*. Amsterdam: Gordon-Breach Science Publishers, 1999. ISBN 90-5699-6452. This book tells the story of mankind's attempts to understand the chemistry of the human body and to develop blood, urine, and other tests to study it in health and disease. Covers the days of alchemy and the hoax of uroscopy to the modern diagnostic laboratory and managed care.

Rothman, D. J., S. Marcus, and S. A. Kiceluk, eds. *Medicine and Western Civilization*. New Brunswick: Rutgers University Press, 1995. ISBN 0–8135-2190–4. Readings from original sources, from the Bible to the late 20th century, including selections from the writings of almost all the historical figures described in this course.

Rutkow, I. M. *Surgery: An Illustrated History*. St. Louis: C.V. Mosby, 1993. ISBN 0-8016-6078-5. Does for the specialty of surgery what Lyons and Petrucelli (*Medicine: An Illustrated History*) do for medicine in general.

Saunders, J. B. de C., and C. D. O'Malley. *Vesalius: The Illustrations from His Works*. Cleveland: World Publishing Co., 1950. Saunders, a distinguished anatomist and medical historian at the University of California, teams up with O'Malley to present all the Vesalian drawings and the authors' translation of the accompanying text. The 44-page introduction is a biography of Vesalius and a description of the events leading up to the publication of the *Fabrica*, including notes on its production.

Shumacker, H. B. *The Evolution of Cardiac Surgery*. Bloomington: Indiana University Press, 1992. ISBN 0-253-35221-5. In 38 chapters, each about a specific disease and the development of diagnostic methods and surgical treatment, Shumacker—a pioneer in this field—provides one rich description after another.

Simmons, J. G. *Doctors and Discoveries: Lives That Created Today's Medicine, from Hippocrates to the Present.* New York: Houghton Mifflin, 2002. ISBN 0-618-15276-8. Similar to Nuland's *Doctors*, except that there are 85 brief essays of 3–6 pages each, including a section on contributors to the biomedicine and basic science of the late 20th century.

Temkin, O. *Galenism: Rise and Decline of a Medical Philosophy*. Ithaca: Cornell University Press, 1973. A scholarly study of the basis on which Galen's thought became the paramount underpinning of medical thinking and the historical reasons for its downfall.

Thorwald, J. *The Century of the Surgeon*. New York: Pantheon, 1956. A bestseller when published 50 years ago, this well-illustrated, semi-fictional account of the development of surgery in the 19th century is a gripping narrative of unimpeachable historical accuracy—and a great read.

Tomes, N. *The Gospel of Germs: Men, Women and Microbes in American Life*. Cambridge: Harvard University Press, 1998. ISBN 0-674-35707-8. The story of infectious disease and the American public health movement, told by a leading historian of this subject.

Virchow, R. *Letters to His Parents, 1839–1864.* M. Rabl (Virchow's granddaughter), ed.; translation revised and edited, with an introduction and two appendices, by L. J. Rather. Canton, MA: Science History Publications, 1990. ISBN 0-88135-090-7. Virchow kept up an affectionate correspondence with his parents from the age of 18 until he was 43, the time during which he studied medicine; married and began his family; discovered leukemia; identified phlebitis and pulmonary embolism; wrote his magnum opus, *Cellular Pathology*; developed his theory of medicine's role in society; was appointed professor of pathology in Berlin; and began his career as a liberal politician. In addition to the insights provided regarding these matters, this book contains notes on the letters, written by Leland Rather, who has been the leading American authority on Virchow's life and work. Also included are four letters to Virchow's wife written in 1864 and nine letters to two of his daughters, written between 1879 and 1897. Rather has appended two essays of commentary.

Warner, J. H. *Against the Spirit of System: The French Impulse in Nineteenth-Century American Medicine*. Princeton: Princeton University Press, 1998. ISBN 0-691-01203-2. A scholarly and anecdote-filled analysis of the Paris clinical school to which so many American and other foreign students flocked to learn the new medicine of Laennec and his successors.

Weisse, A. B. *Medical Odysseys: The Different and Sometimes Unexpected Pathways to Twentieth Century Medical Discoveries*. New Brunswick: Rutgers University Press, 1991. ISBN 0-8135-1617-X. A series of interesting essays on medical discoveries of the 20th century and the unusual circumstances in which some of them were made. In the third essay entitled "Into the Heart: The Surgical Treatment of Heart Disease Becomes a Reality," cardiologist and medical historian Allen Weisse describes the origins of the surgical treatment of heart disease and the role played by Helen Taussig. Other of the book's chapters deal with such an assortment of historical topics as the discovery of penicillin, cancer chemotherapy, the artificial kidney, and the therapeutic use of electricity in heart disease.

Wolfe, R. J. *Tarnished Idol: William T. G. Morton and the Introduction of Surgical Anesthesia*. San Anselmo: Norman Publishing, 2002. ISBN 0-930405-81-1. There will never be a more comprehensive study of the central figure in the story of anesthesia's origins. Wolfe, the former Curator of Rare Books and Manuscripts at Harvard's Countway Library, has exposed Morton's dishonesty, contentiousness, and ineptitude in a biography that is as gripping a piece of literature as it is a work of historical scholarship.

Youngson, A. J. *The Scientific Revolution in Victorian Medicine*. New York: Holmes and Meier, 1979. ISBN 0-8419-0479-0. Youngson describes the controversies surrounding British medicine's reception of Lister's theories and the introduction of anesthesia. Much of the material in this book comes from the author's review of the medical periodicals of the time. The final chapter is a thoughtful analysis of the factors that shape the attitude of a profession to any new concept.

Zilboorg, G., and G. W. Henry. *A History of Medical Psychology*. New York: W.W. Norton & Co., 1941. The standard history of psychiatry.

The Classics of Medicine Library has published facsimile editions of the works of each of the physicians studied in this course (and many others), with the exception of Helen Taussig and Galen. They can be obtained by contacting the library directly at 1-800-633-8911.

