

“I shall not keep in my bedroom several weeks bodies taken from graves...”¹:

Andreas Vesalius and the Impact of
De Humani Corporis Fabrica
on Anatomical Exploration

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People are always curious about things they cannot see. Throughout the course of history, humans have been interested in learning about the workings of the human body, though their investigations have varied in approach. Early exploration of human anatomy describing treatments for battlefield and workplace injuries traces back to Ancient Egypt, and Ancient Greek anatomists like Herophilus are known to have dissected humans, though scrolls recording Herophilus' work no longer exist. Galen, of Classical Greece, was prohibited from dissecting humans yet he produced extensive writings about the body. Then the study of anatomy stagnated throughout the Middle Ages until the Renaissance, when Andreas Vesalius, a medical student driven by his desire to work in the Court of the Holy Roman Emperor Charles V, began dissecting human cadavers. Comparing his dissection specimens to Galen's descriptions, Vesalius repeatedly encountered differences between what he viewed in front of him and the textbooks that had been dogma for the past 1300 years. Instead of dismissing his findings or declaring that human bodies had changed since Galen's work, he published *De Humani Corporis Fabrica (On the Fabric of the Human Body)*, a tome of human anatomy based on his own dissections and illustrated with numerous woodcuts of beautifully detailed anatomical studies. The *Fabrica* incited the practice of comparative anatomy, which is the basis of modern science, and a deeper understanding of anatomy was the revolutionary turning point in the development of surgery and medicine.

¹ Charles Donald O'Malley, *Andreas Vesalius of Brussels, 1514-1564*, (Berkeley: University of California Press, 1964), 222, accessed January 17, 2016, <https://books.google.com/books?id=HCA6wGaU8PUC&printsec=frontcover#v=onepage&q&f=false>. This quote is from a list describing things Vesalius did, but no longer wished to do.

Knowledge of anatomy in Ancient Egypt and Greece was fairly developed. Ancient Egyptians had a medical system familiar to us today with specialists, surgery, analgesics, sedatives, and bactericidal ointments. They wrote of using scalpels, splints, cauterization, and sutures; "...thou shouldest palpate his wound, [and] draw together for him his gash with stitching...."² The oldest surviving medical text, the Edwin Smith *Surgical Papyrus* (c. 1600 B.C.E.) contains written instruction for physicians on how to diagnose and care for different trauma injuries, as well as magic spells and prescription recipes.³ Early Greeks believed corpses polluted, and cutting skin was taboo. When these traditional concerns were briefly abandoned in Alexandria under Ptolemaic rule, Herophilus and Erasistratus became the only Ancient Greeks to dissect humans. Herophilus, a physician and anatomist who lived from 335-255 B.C.E. "...is recognized as the first person to perform systematic dissection of the human body."⁴ He explored the eyes, and the reproductive, digestive, nervous, and cardiovascular systems. He identified that the heartbeat causes the pulse, the brain controls thinking, and damaged nerves cause paralysis. Herophilus wrote at least eleven medical treatises, probably destroyed with the Great Library of Alexandria. He was accused of vivisectioning live prisoners,⁵ but no proof exists. Then attitudes

² Richard Sullivan, "The Identity and Work of the Ancient Egyptian Surgeon," *The Journal of the Royal Society of Medicine* 89, no. 8 (Aug 1996): 469, accessed February 18, 2016, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1295891/?page=6>.

³ "Edwin Smith Surgical Papyrus," c. 1600 B.C.E., Library of the New York Academy of Medicine, accessed January 22, 2016, <https://ceb.nlm.nih.gov/proj/flash/smith/smith.html>.

⁴ Noel Si-Yang Bay and Boon-Huat Bay, "Greek Anatomist Herophilus: The Father of Anatomy," *Anatomy & Cell Biology* 43, no. 4 (December 2010): 280-283, accessed February 21, 2016, <http://synapse.koreamed.org/DOIx.php?id=10.5115/acb.2010.43.4.280>.

⁵ Mary Roach, *Stiff: The Curious Lives of Human Cadavers*, (New York: W. W. Norton & Company, 2003), 40.

shifted and dissection was considered unnecessary for medical learning, as scholars believed the body changed too much after death to be useful.⁶

Anatomical exploration slowed down in Classical Greece, as comparative anatomy was limited to animals, with associations to human anatomy. Galen, the most famous Classical Greek anatomist, lived from 129-200 C.E. and studied anatomy in Pergamum, Smyrna, and Alexandria. He was physician to the gladiators of Pergamum and also to Emperor Marcus Aurelius and his son Commodus. He discovered arteries carry blood, not air. Galen believed a body was “...healthful when it is in good natural temper, when the seven Natural things, viz. Spirits, Elements, Complexions, Humors, Members, Vertues, [and] Operations keep a good decorum....”⁷ He explored anatomy through countless dissections and vivisections of animals, especially Rhesus monkeys and Barbary apes,⁸ but in his extensive publications he inferred the anatomy described was human; he discussed the “Distinctiveness of Muscles and Neglect of the Ancients in dissecting Them,”⁹ among other topics in his lectures. Galen wrote at least sixteen

⁶ Heinrich von Staden, “The Discovery of the Body: Human Dissection and Its Cultural Contexts in Ancient Greece,” *The Yale Journal of Biology and Medicine*, 65 (1992): 223-241, accessed April 3, 2016, <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2589595/pdf/yjbm00051-0069.pdf>.

⁷ Galen, *Galen’s Art of Physick...translated into English, and largely commented on: together with convenient medicines for all particular distempers of the parts, a description of the complexions, their conditions, and what diet and exercise is fittest for them*, translated by Nicholas Culpeper, (London: Peter Cole, 1652), 6, accessed February 21, 2016, <http://name.umdl.umich.edu/A69834.0001.001>.

⁸ Galen, *On Anatomical Procedures*, translated by Charles Singer, (London: Oxford University Press, 1956), xii, accessed February 24, 2016, https://archive.org/stream/b20457194/b20457194_djvu.txt.

⁹ Galen, *On Anatomical Procedures*, translated by Charles Singer, vii, https://archive.org/stream/b20457194/b20457194_djvu.txt.

books,¹⁰ which became the standard for medical writing, and all other anatomy texts published until the Renaissance were based on his.

During the Middle Ages, medical learning encountered a standstill. While the church did not oppose dissection, the fall of the Western Roman Empire and ensuing turmoil prevented the pursuit of scholarly studies there for centuries. The Byzantine (Eastern Roman) Empire remained strong, thus Galen's work was preserved and translated into Arabic there and in the Islamic countries.¹¹ Physicians viewed the functions of the body as being controlled by four humors: black bile, yellow bile, phlegm, and blood.¹² They thought disease resulted from an imbalance of these humors and attempted to re-balance them with bloodletting. Middle Ages physicians also believed in astrology, and thought certain constellations ruled and caused problems in particular parts of the body.¹³ Anatomical drawings were symbolized because they were not based on direct observation of real bodies. Circa 1100, Galen's anatomical treatises were translated from Arabic into Latin and returned to Western Europe. Almost simultaneously, universities opened in Padua, Montpellier, Oxford, and Bologna. In the late 1200s, the practice of human dissection was restarted and Holy Roman Emperor Frederick II allowed medical schools to dissect at least one human body every five years.¹⁴ Executed criminals were publicly dissected, which was

¹⁰ F Gonzalez-Crussi, *A Short History of Medicine*, (New York: Modern Library, 2007), 9.

¹¹ Vivian Nutton, "Vesalius Revised: His Annotations to the 1555 *Fabrica*," National Library of Medicine, National Institutes of Health, October 2012, accessed February 21, 2016, <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3483767/>.

¹² *Bloody Beginnings—Blood and Guts: A History of Surgery*, (Films On Demand, 2008), accessed January 30, 2016, fod.infobase.com/PortalPlaylists.aspx?wID=16705&xtid=48253.

¹³ Gonzalez-Crussi, *A Short History of Medicine*, 4.

¹⁴ Alexandra Mavrodi and George Paraskevas, "Mondino de Luzzi: A Luminous Figure in the Darkness of the Middle Ages," National Library of Medicine, National Institutes of Health, February 2014, Accessed January 27, 2016, <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3944418>.

considered dishonorable, while family physicians autopsied patients upon request, and if the body was eviscerated for embalming, the physician might open those organs for examination.¹⁵

Early Renaissance brought a revival of interest in Classical Greek studies and knowledge. Medical schools held dissections somewhat regularly; a barber who doubled as a surgeon dissected the corpse while the professor, seated above the group, read or recited a Galenic text to the watching students. The 1300s-1500s yielded many textbooks on Galen's theories, as well as comments and annotations on his work. Even anatomists who dissected humans were blinded by Galen's influence and described anatomical details that did not exist, or failed to notice ones that did. Mondino de Luzzi of Bologna (1270-1326) was the first anatomist since ancient times to lead dissections of humans and write about them, but "...if the findings did not match the descriptions, they were interpreted as morphological transmutation."¹⁶ He wrote *Anothomia*, another Galenic work, which became a classic textbook used for at least two centuries in European universities. Physician Johannes de Ketham was credited with the first illustrated printed medical book: *Fasiculus Medicinae*, published in 1491. It was a collection of medieval medical treatises in which astrology was prevalent and dictated treatment; "Capricorn is the sign of the month of December; it is bad to treat the knees or their nerves,"¹⁷ (figure 1). In 1535, Berengario da Carpi (circa 1460-1530), chair of surgery and anatomy at Bologna, revised

¹⁵ Katharine Park, *Secrets of Women: Gender, Generation, and the Origins of Human Dissection*, (Brooklyn: Zone Books, 2006), 15.

¹⁶ Mavrodi and Paraskevas, "Mondino de Luzzi: A Luminous Figure in the Darkness of the Middle Ages," <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3944418>.

¹⁷ Johannes de Ketham, *Fasiculo de medicina*, National Library of Medicine, (Venice: Zuane & Gregorio di Gregorii, 1494), n.p., accessed February 12, 2016, <https://ceb.nlm.nih.gov/proj/flash/ketham/ketham.html>.

Mondino's *Anothomia* and included illustrations, which "...give little anatomical detail."¹⁸ In 1528, an improved translation of Galen's Greek text was published in Latin. It caused many anatomists to believe "...they had overthrown the defective anatomical writings and practices of the previous two centuries. That his description of the body was based largely on animal dissection did not present an obstacle to [them]..."¹⁹ Ironically, Galen emphasized doing one's own dissections and making direct observations.

Anatomical exploration became decidedly more productive when Leonardo da Vinci revisited his anatomy studies in 1506. Leonardo previously dissected and drew animals, and by 1513 had dissected about thirty cadavers. At first his drawings of humans were "...anatomically inaccurate representations of received wisdom about...the human body,"²⁰ but his natural curiosity, desire to understand the mechanics of the body, and "...painstaking empirical work got him there in the end. He discovered that the humours did not reside in three cerebral ventricles, [and] that the heart, not the liver, was at the core of the blood system..."²¹ Leonardo's artistic skill combined with first-hand observations produced the most detailed, accurate anatomical drawings and accompanying notes ever made, thirty years prior to the *Fabrica*. However, he was involved in many different projects and never published his findings, which remained

¹⁸ National Library of Medicine, "Dream Anatomy," May 1, 2014, accessed February 13, 2016, <https://www.nlm.nih.gov/dreamanatomy>.

¹⁹ Nutton, "Vesalius Revised: His Annotations to the 1555 *Fabrica*," <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3483767/>.

²⁰ Roger Jones, ed., "Leonardo da Vinci: Anatomist," National Library of Medicine, National Institutes of Health, June 2012, accessed January 27, 2016, <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3361109>.

²¹ Jones, ed., "Leonardo da Vinci: Anatomist," <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3361109>.

undiscovered for centuries. It is quite possible that if Leonardo had publicized his anatomical discoveries, Andreas Vesalius would not be nearly so famous.

Andreas Vesalius (1514-1564) was a brilliant Flemish anatomist, professor, and physician. His father and grandfather were physicians in the Holy Roman Emperor's court; likewise that was Vesalius' goal from his teenage years. Vesalius began medical studies at Louvain, where he stole his first dissection cadaver from the gibbet and boiled it to access the bones.²² He then studied at the University of Paris with Jacobus Sylvius, a leading anatomist who dissected animals. Sylvius advocated direct observation, but was a loyal Galenist,²³ therefore Vesalius' early work was clouded by Galen's errors (figure 2). While in Paris, Vesalius spent numerous hours "...turning over bones...in the Cemetery of the Innocents..."²⁴ to prepare skeletons. He completed his medical degree at the University of Padua in 1537, and promptly became the head of anatomy and surgery there. In 1539, the Paduan criminal court judge supplied Vesalius with executed criminals for his teaching and even delayed executions for his convenience.²⁵ Sometimes the number of corpses was still insufficient, so Vesalius encouraged

²² *Bloody Beginnings—Blood and Guts: A History of Surgery*, (Films On Demand, 2008), Accessed January 30, 2016, fod.infobase.com/PortalPlaylists.aspx?wID=16705&xtid=48253.

²³ Barclay W. Bakkum, "A Historical Lesson from Franciscus Sylvius and Jacobus Sylvius," *Journal of Chiropractic Humanities*. v. 18, 1 (December 2011): 94-98, accessed February 15, 2016, [http://www.journalchirohumanities.com/article/S1556-3499\(11\)00006-4/fulltext#s0020](http://www.journalchirohumanities.com/article/S1556-3499(11)00006-4/fulltext#s0020).

²⁴ O'Malley, *Andreas Vesalius of Brussels, 1514-1564*, 222, <https://books.google.com/books?id=HCA6wGaU8PUC&printsec=frontcover#v=onepage&q&f=false>.

²⁵ Mickey S. Eisenberg, *Life in the Balance: Emergency Medicine and the Quest to Reverse Sudden Death*, (New York: Oxford University Press, 1997), 45, accessed February 25, 2016, <https://books.google.com/books?id=3SgrQwUCseQC&pg=PA290&lpg=PA290&dq#v=onepage&q&f=false>.

his students to raid graveyards for dissection specimens, resulting in freshly buried bodies reported missing wherever he traveled to lecture.²⁶

In 1543, Vesalius published *De Humani Corporis Fabrica*, the seven-book culmination of his life's work, and the *Epitome*, a summarized and condensed version intended for reference during dissections. The *Fabrica* was the groundbreaking first of a new species of medical textbook, based entirely on Vesalius' empirical study and anatomical dissections he did with his own hands. It was the first textbook to contain an abundance of large woodcut illustrations, which artists (including Jan van Calcar) drew as Vesalius dissected, ensuring accuracy. The cadavers illustrated were very realistic; they were posed naturally except they consisted only of bones, had flayed muscles, or lacked skin (figure 3). The *Fabrica*, a "...new description of the whole human body, of which nobody understood the anatomy,"²⁷ revealed Galen's inaccuracies, and "...declared that human anatomy could only be learned from dissection and observation of the body."²⁸ Vesalius dedicated the book to Holy Roman Emperor Charles V, and upon receiving his own hand-colored copy of it, the Emperor employed Vesalius as his personal physician. Vesalius served in the Royal Court until his death.

Although the *Fabrica* was widely successful, Vesalius encountered controversy over it. Like Galen, Sylvius advocated seeing and dissecting for oneself, but when Vesalius did so and pointed out Galen's mistakes, Sylvius defended Galen, saying the body had undoubtedly

²⁶ Park, *Secrets of Women*, 215.

²⁷ O'Malley, *Andreas Vesalius of Brussels, 1514-1564*, <https://books.google.com/books?id=HCA6wGaU8PUC&printsec=frontcover#v=onepage&q&f=false>.

²⁸ Eisenberg, *Life in the Balance: Emergency Medicine and the Quest to Reverse Sudden Death*, 46, <https://books.google.com/books?id=3SgrQwUCseQC&pg=PA290&lpg=PA290&dq#v=onepage&q&f=false>.

changed over time. In 1551, he appealed to “...his imperial Majesty to punish severely...this monster...suppress him so that he may not poison the rest of Europe with his pestilential breath...”²⁹ Sylvius’ irrational claims against the greatest anatomist of the century caused his professional demise.³⁰

The *Fabrica* became the “...founding text of modern anatomy and inspired a host of successors. Like Vesalius, they compared their results with existing texts, corrected errors, and produced new texts with illustrations.”³¹ There was an exchange in methodology, and comparative anatomy took over. Vesalius’ students, including Eustachi, Fallopius, and Colombo, followed in his steps and compared their observations to the Vesalius canon, then published their findings. Medical illustrations also evolved from figures in landscapes reflecting art of the time, to figures that were increasingly useful references for anatomists, isolated in space and based on observation of complex function.³² Although corrections have been made to the *Fabrica* in the past 473 years, it is still the most important anatomical work ever published. It set the standard for scientific research in all fields of study to follow empirical evidence and is considered “...the greatest medical book ever to appear.”³³

²⁹ Bakkum, “A Historical Lesson from Franciscus Sylvius and Jacobus Sylvius,” [http://www.journalchirohumanities.com/article/S1556-3499\(11\)00006-4/fulltext#s0020](http://www.journalchirohumanities.com/article/S1556-3499(11)00006-4/fulltext#s0020).

³⁰ Bakkum, “A Historical Lesson from Franciscus Sylvius and Jacobus Sylvius,” [http://www.journalchirohumanities.com/article/S1556-3499\(11\)00006-4/fulltext#s0020](http://www.journalchirohumanities.com/article/S1556-3499(11)00006-4/fulltext#s0020).

³¹ National Library of Medicine, “Dream Anatomy,” <https://www.nlm.nih.gov/dreamanatomy>.

³² National Library of Medicine, “Dream Anatomy,” <https://www.nlm.nih.gov/dreamanatomy>.

³³ Meyer Friedman, and Gerald W. Friedland, *Medicine’s 10 Greatest Discoveries*, (New Haven: Yale University Press, 1998), 10.

Vesalius is regarded as the father of modern anatomy. He "...discovered the beauty of bodily interiors...when the beauty of bodily exteriors was the focus of an entire artistic epoch."³⁴ His comparative anatomy exploration not only yielded more accurate findings, it formed the basis for modern scientific study. "Those who are now dedicated to the ancient study of medicine...are beginning to learn...how little and how feebly men have labored in the field of Anatomy to this day from the times of Galen, who...did not dissect the human body; and...described...the fabric of the ape's body, although the latter differs from the former in many respects."³⁵ Continuing in the Vesalian tradition seventy-five years later, English physician William Harvey "...was the first to definitively describe the circulatory system."³⁶ Between 1680 and 1800, medical illustration rose to even greater levels of technical precision. Anatomist William Hunter asserted that "...what was actually seen...[would carry]...the mark of truth...[and be]...almost as infallible as the object itself."³⁷

Today there are many methods of seeing inside the body for medical diagnostics: X-rays, CT scans, MRI scans, and sonograms all provide a window into the body not previously accessible without dissection or vivisection. Professional anatomists and medical students conduct modern-day dissections on legitimately donated bodies, and dissections are also

³⁴ Gunther Von Hagens, *Body Worlds: The Anatomical Exhibition of Real Human Bodies*, DVD, (Heidelberg: Institute for Plastination, 2005).

³⁵ Andreas Vesalius, *The Epitome of Andreas Vesalius*, translated by L. R. Lind, (New York: Macmillan, 1949), xxxv, accessed February 22, 2016, <http://catalog.hathitrust.org/Record/001691603>.

³⁶ Eisenberg, *Life in the Balance: Emergency Medicine and the Quest to Reverse Sudden Death*, 47, <https://books.google.com/books?id=3SgrQwUCseQC&pg=PA290&lpg=PA290&dq#v=onepage&q&f=false>.

³⁷ National Library of Medicine, "Dream Anatomy," <https://www.nlm.nih.gov/dreamanatomy>.

published via video and made available by universities for the benefit of students. Gunther von Hagens is the anatomist who invented the method of plastination, which preserves a specimen for study by exchanging its liquids for plastic. Von Hagens has opened the world of anatomy to the public, after centuries of study only by physicians, anatomists, and medical students. He published his work with the modern technology of DVDs, and his exhibition of plastinated bodies, *Body Worlds*, has been touring for the past twenty-one years, educating the public about anatomy. His inspiration comes from "...the Renaissance anatomists who pioneered the initial enlightenment to this field, Leonardo da Vinci and Andreas Vesalius."³⁸

Early exploration of anatomy is evident in Ancient Egyptian papyrus scrolls that outline trauma injuries, their survivability, and reactionary treatments, in the story of the Ancient Greek scholar Herophilus, who made advanced observations about the workings of the body but whose records were destroyed, and in the works of Galen of Classical Greece, who dissected apes in place of humans, but published extensive writings on human bodies and medicine. Galen's work was viewed as unchallengeable throughout the Middle Ages, and subsequent anatomy writers simply revised and annotated his works, wrote textbooks touting his discoveries, and ignored his mistakes for thirteen centuries. The Renaissance's diversely talented Leonardo da Vinci carefully documented his many human and animal dissections. Though he made some discoveries even beyond those Vesalius would reach, he did not publish, so his contributions to the field of anatomy went unrecognized for centuries after his death. The impetus for modern science and driving force behind comparative anatomy, Andreas Vesalius changed the way anatomists conducted their research. Following his complex and vividly illustrated textbook, *De Humani Corporis Fabrica*, other anatomists expanded on Vesalius' work using his technique of hands on

³⁸ Von Hagens, *Body Worlds: The Anatomical Exhibition of Real Human Bodies*, DVD.

dissecting to learn by empirical study rather than memorizing from treatises. Vesalius examined the whole body to learn and see for himself what was really there instead of believing writings from centuries before. His *Fabrica* mapped out the entire body as the foundation for learning about anatomy, and later anatomists compared their observations to the Vesalius canon. Post-Vesalian anatomists “...inherited the intimate conviction that anatomical knowledge was to be plucked out with their own hands...and that credence was to be given to their own eyes, not to the word of the ancients or the power of authority,”³⁹ and thus the *Fabrica* changed the trajectory of medicine.

³⁹ Gonzalez-Crussi, *A Short History of Medicine*, 19.

ILLUSTRATIONS

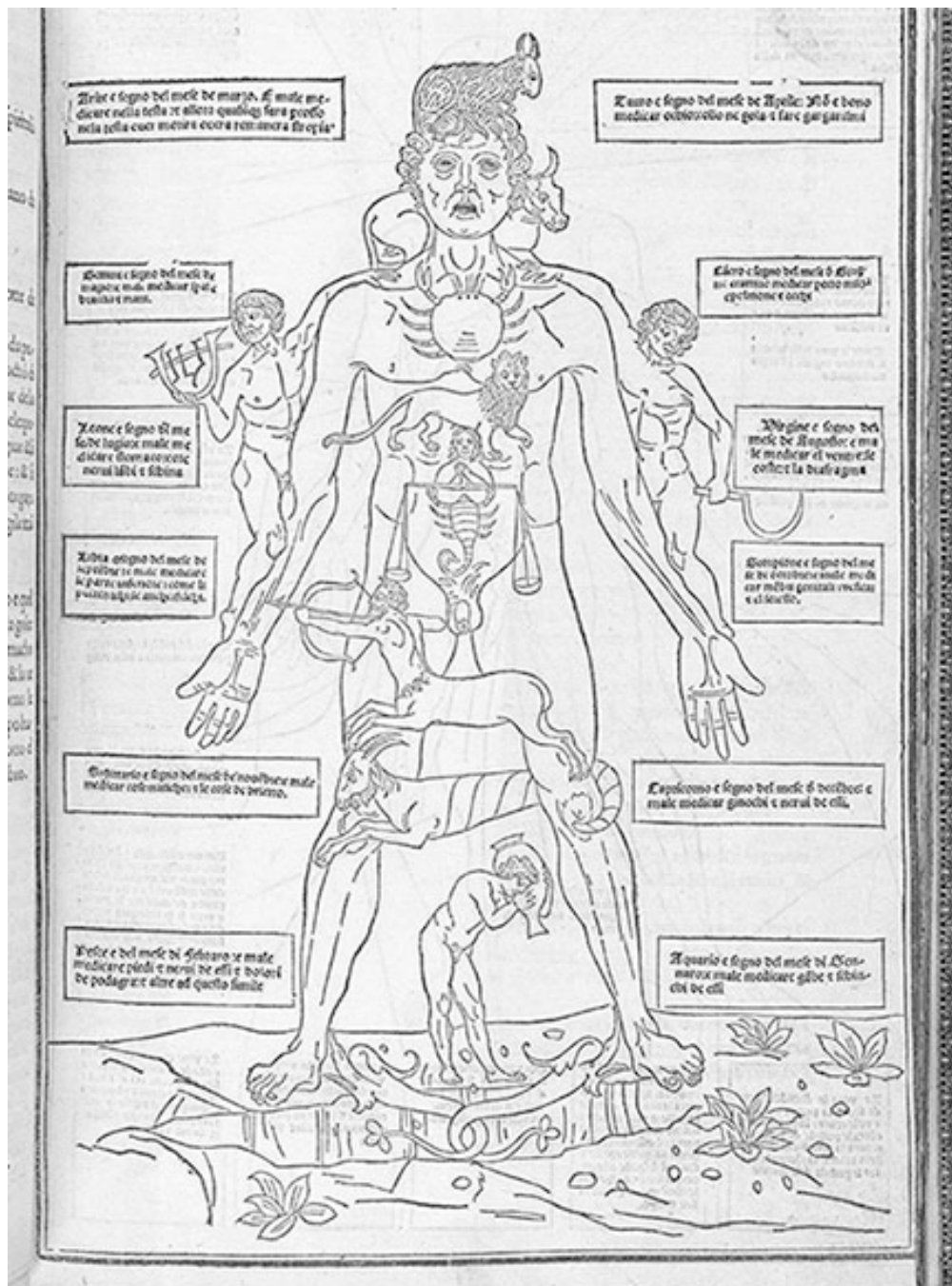


Figure 1.

This drawing correlates parts of the body with their astrological signs.

Source: Johannes de Ketham, *Fasiculo de medicina*, National Library of Medicine, (Venice: Zuane & Gregorio di Gregorii, 1494), accessed February 12, 2016, <https://ceb.nlm.nih.gov/proj/ttp/flash/ketham/ketham.html>.

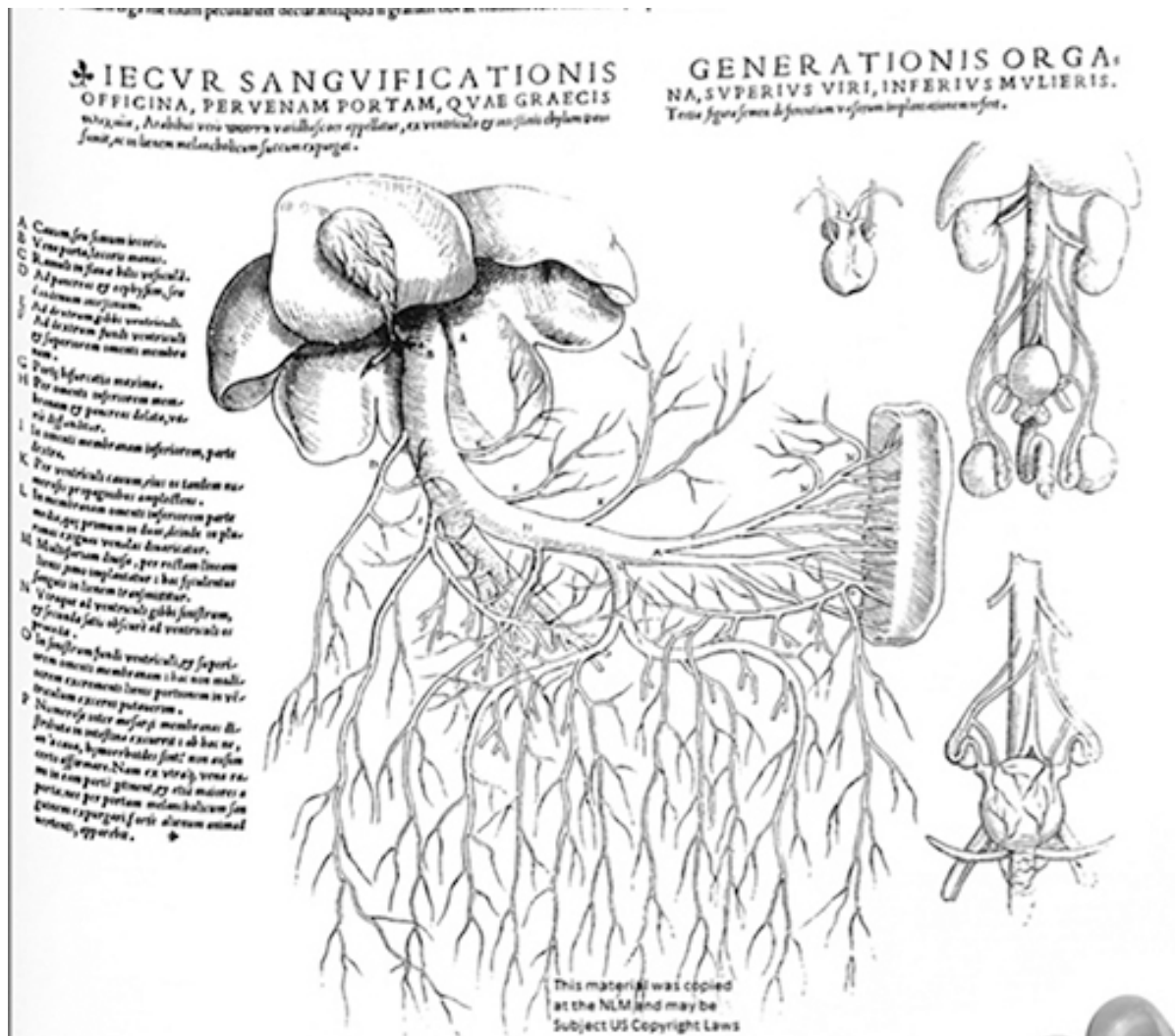


Figure 2.

This drawing, done by Vesalius and first published in his *Tabulae Anatomicae* prior to the *Fabrica*, illustrates a five-lobed liver as described by Galen (center) as well as a correct two-lobed liver (top right).

Source:

Andreas Vesalius, *The Illustrations from the Works of Andreas Vesalius of Brussels*, translated by John Bertrand de Cusance Morant Saunders and Charles Donald O'Malley, (Mineola: The World Publishing Company, 1950). Courtesy of the National Library of Medicine.

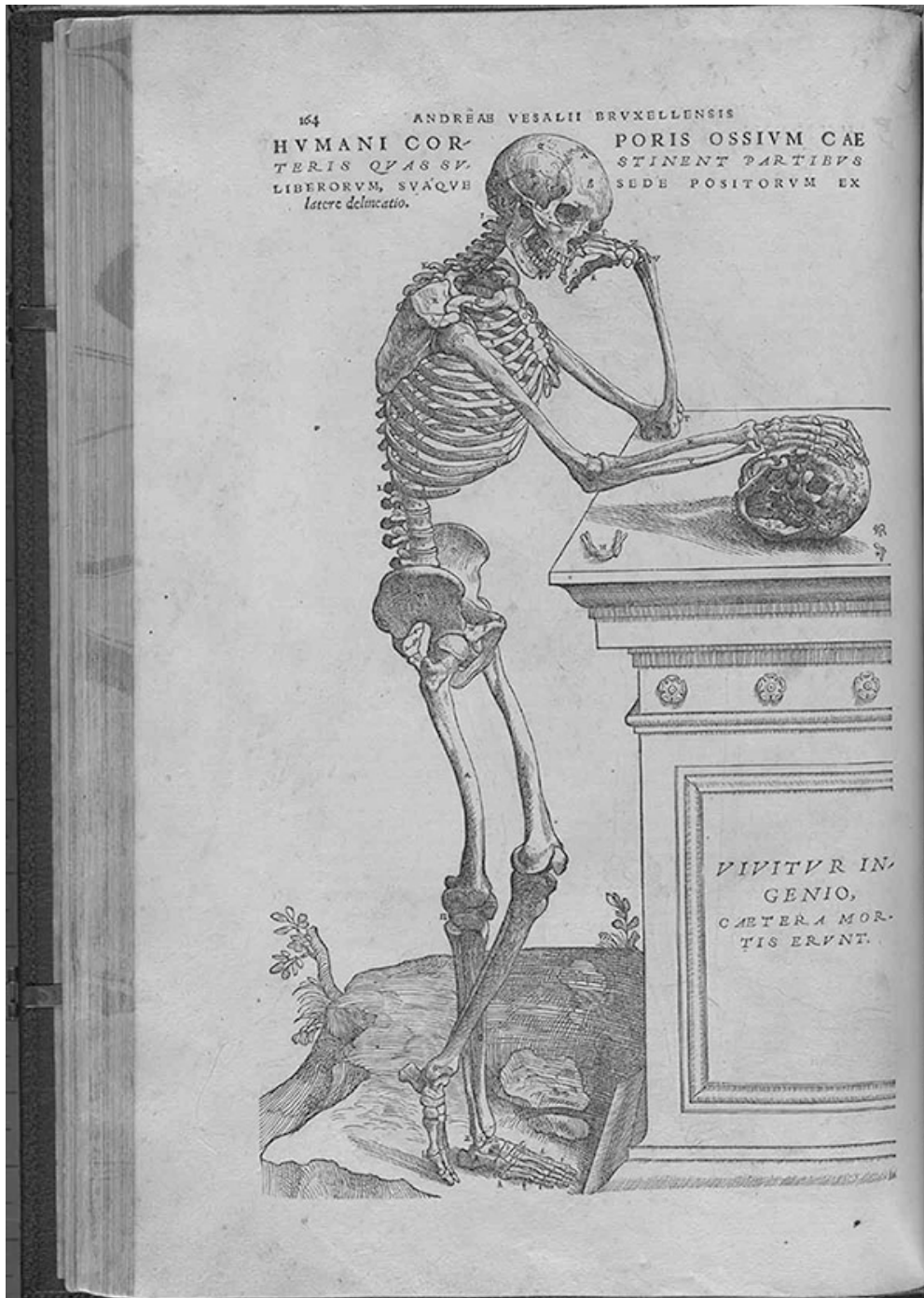


Figure 3.

This woodcut from the *Fabrica* demonstrates correct human skeletal anatomy while still being a beautiful work of art.

Source: Andreas Vesalius, *De Humani Corporis Fabrica*, National Library of Medicine, (Basel: Joannes Oporinus, 1543) accessed February 13, 2016, https://www.nlm.nih.gov/exhibition/historicalanatomies/vesalius_home.html.

Annotated Bibliography

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Anatomy of Circulation. DVD. Anatomy for Beginners. Films for the Humanities and Sciences. Princeton: 2006.

I watched this video to understand how Gunther von Hagens, a professional anatomist whom I view as the modern Vesalius, dissects a cadaver and explains his procedure to medical students and future body donors. In this video, von Hagens revealed the structure and function of the circulatory system. It also showed the human circulatory system projected on a live model. It gave me a better understanding of how Vesalius must have taught his students anatomy.

Anatomy of Movement. DVD. Anatomy for Beginners. Films for the Humanities and Sciences. Princeton: 2006.

In this video lecture, Gunther von Hagens dissected a cadaver to reveal the anatomy of movement. He demonstrated how pulling certain tendons in the wrist causes the hand to close, and muscles in the thigh extend the lower leg. I used it to further understand how Vesalius revealed structures of the body and figured out how they worked.

Da Vinci, Leonardo. *Anatomical Manuscript A*. In *The Mechanics of Man*. Martin Clayton and Ron Philo. Los Angeles, CA: Getty Publications, 2010.

This book is a collection of Leonardo da Vinci's anatomical notes and drawings, known as "Anatomical Manuscript A." The manuscript is in the Royal Collection of HM Queen Elizabeth II, at Windsor Castle, where Martin Clayton is the deputy curator of the Print Room. The book first shows an original drawing and page of notes, then the translation. It showed me how great Leonardo's anatomical knowledge was, because his drawings were incredibly realistic.

De Ketham, Johannes. *Fasiculo de medicina*. National Library of Medicine. Venice: Zuane & Gregorio di Gregorii, 1494. Accessed February 12, 2016.
<https://ceb.nlm.nih.gov/proj/ttp/flash/ketham/ketham.html>.

This book, originally published in 1491, was the first illustrated medical book. It is a collection of six treatises of medieval medicine, and was owned by Johannes de Ketham, a German physician. It is in Italian, so I used this book to compare the illustrations to those in the Fabrica. I saw the contrast between Medieval and Renaissance beliefs, knowledge, and style.

“Edwin Smith Surgical Papyrus.” c. 1600 B.C.E. Library of the New York Academy of Medicine. Accessed January 22, 2016. <https://ceb.nlm.nih.gov/proj/ttp/flash/smith/smith.html>.

The *Edwin Smith Surgical Papyrus* is the oldest surviving surgical text. It is from Ancient Egypt, c. 1600 B.C.E. and is written instruction for physicians on how to care for trauma injuries ranging from broken arms to shifted vertebrae to gaping head wounds with split skulls. This showed me that Ancient Egyptians were at least somewhat familiar with anatomy and had developed ways to treat injuries.

Galen. *Galen’s Art of Physick...translated into English, and largely commented on: together with convenient medicines for all particular distempers of the parts, a description of the complexions, their conditions, and what diet and exercise is fittest for them*. Translated by Nicholas Culpeper. London: Peter Cole, 1652. Accessed February 21, 2016. <http://name.umdl.umich.edu/A69834.0001.001>.

From this translation of Galen’s *Art of Physick*, I learned about Galen’s opinion of healthful and unhealthful bodies, and why a body would be one or the other. He discusses how to tell if a particular organ is too hot, cold, wet, or dry, and which parts of the body are “Principals” and govern other parts of the body. I used this to understand how differently we view the body today.

Galen. *On Anatomical Procedures*. Translated by Charles Singer. London: Oxford University Press, 1956. Accessed February 24, 2016. https://archive.org/stream/b20457194/b20457194_djvu.txt.

This translation was done for the Wellcome Historical Medical Museum. It is a translation from Greek to English of the text from Galen’s lectures on anatomy delivered in Rome around 177 C.E. I learned that most of his dissections were on Rhesus monkeys and Barbary apes. It was helpful to my knowledge of Galen’s understanding (or lack of, in some cases) of the workings of the human body.

Van Riemsdyk, Jan and William Hunter. *Gravid Uterus*. 1774. National Library of Medicine. Accessed February 16, 2016. https://www.nlm.nih.gov/exhibition/dreamanatomy/da_g_II-B-1.html.

This copperplate engraving of a gravid uterus by Jan van Riemsdyk showed me that by the 18th century, anatomical illustrations had become very accurate depictions of the body, but less the works of art of the 16th century. I also learned that specialization was becoming more common, as anatomist William Hunter focused specifically on pregnant women in his dissections.

Vesalius, Andreas. *De Humani Corporis Fabrica Libri Septem*. Basel: Joannes Oporinus, 1543.

At the National Library of Medicine, I got to hold and look through this first edition copy of *De Humani Corporis Fabrica*, which the librarian said is worth about 1.75 million dollars. It is two large volumes, each about as thick as a dictionary, but twice as tall and wide. Although I couldn't read it because it is in Latin, I found Galen's name many times on many pages. I enjoyed feeling the handmade linen paper and looking at the chapter heading illustrations of cherubs boiling bones, taking bodies down from gallows, vivisectioning a pig, sawing a head in half, and unearthing a body from a grave. This contributed to my understanding of Vesalius' personality because it showed me he was not afraid to put illustrations of many illegal things he had done in the book that he hoped would secure him a job in the Royal Court.

Vesalius, Andreas. *De Humani Corporis Fabrica. Epitome*. Basel: Joannes Oporinus, 1543.

When I looked at this first edition copy of Vesalius' *Epitome* at the National Library of Medicine, I noticed that it had crease marks where it had been folded into fourths, probably for ease of transportation, as it was a very big book. It also had a tiny piece of sealing wax on it. I was thrilled to see this book in person.

Vesalius, Andreas. *De Humani Corporis Fabrica. Epitome*. "Treasures of the Library." University of Cambridge. Basel: Joannes Oporinus, 1543. Accessed April 7, 2016. <http://cudl.lib.cam.ac.uk/view/PR-CCF-00046-00036/39>.

In the University of Cambridge digital library, I saw the assembly stages of the hand colored, cut out illustrations of Vesalius' *Epitome*. It showed clearly how Vesalius intended the *Epitome* to be used and made me realize Vesalius was ahead of his time as this is a contemporary teaching tool, and in the 1500s books were valuable; not generally meant to be cut apart.

Vesalius, Andreas. *The Epitome of Andreas Vesalius*. Translated by L. R. Lind. New York: Macmillan, 1949. Accessed February 22, 2016. <http://catalog.hathitrust.org/Record/001691603>.

The Epitome of Andreas Vesalius is a condensed version of the *Fabrica*, intended for students to take to the dissecting table. It contains, among other things, anatomical pictures that are meant to be cut out and pasted together in the correct order. I used a quote from the *Epitome* to describe why Vesalius is considered the father of modern anatomy.

Vesalius, Andreas. *The Fabric of the Human Body*. Translated by Daniel H. Garrison and Malcolm H. Hast. Basel: Karger, 2015.

At the National Library of Medicine, I compared this translation of *De Humani Corporis Fabrica* to the one translated by Richardson and Carman and noticed differences in the way they interpreted Vesalius' Latin. Garrison and Hast added annotations to elaborate on or clarify Vesalius' points, which I found helpful in understanding the text.

Vesalius, Andreas. *On the Fabric of the Human Body*. Translated by William Frank Richardson and John Burd Carman. San Francisco: Norman Publishing, 1999.

I went to the Library of Congress to look at this English translation of *De Humani Corporis Fabrica Libri Septem*, Vesalius' masterpiece. Vesalius' area of expertise was probably osteology, as the first book of the *Fabrica* (on the bones) is by far the largest. Vesalius also used bones to prove Galen's ignorance; when lecturing, he would set up skeletons of humans and Barbary apes and point out the hundreds of differences between them. Seeing the *Fabrica* in person was helpful to my understanding of why it was so revolutionary. For the first time in history, comparative anatomy was illustrated in a way so that people could actually comprehend the way the human body worked.

Vesalius, Andreas. *The Illustrations from the Works of Andreas Vesalius of Brussels*. Translated by John Bertrand de Cusance Morant Saunders and Charles Donald O'Malley. Mineola: The World Publishing Company, 1950.

I read part of this book at the National Library of Medicine and scanned an illustration drawn by Vesalius illustrating a Galenic five-lobed liver and, smaller, a correct two-lobed liver. This showed me that although prior to the *Fabrica* he was not willing to openly contradict Galen, he was willing to display correct anatomical illustrations along with the old-fashioned ones. In the *Fabrica*, however, Vesalius had gathered enough empirical proof of his ideas to frequently criticize Galen and point out many of his errors.

Vesalius, Andreas. *Vesalius: The China Root Epistle: A New Translation and Critical Edition*. Translated by Daniel H. Garrison. New York, NY: Cambridge University Press, 2015. Accessed January 29, 2016. <https://books.google.com/books?id=fT-iBQAAQBAJ&pg>.

I learned about how the Holy Roman Emperor used the China Root decoction. I also realized that Vesalius used the cover of writing about a popular herbal remedy to publish his response to Sylvius' accusations, and also to emphasize more ways in which Galen was wrong. This is the original source of my title quote, but I chose to use O'Malley's book instead because I liked his translation better.

Von Hagens, Gunther. *Body Worlds: The Anatomical Exhibition of Real Human Bodies*. DVD. Heidelberg: Institute for Plastination, 2005.

Gunther von Hagens, a modern-day German anatomist, invented the method of plastination for preserving anatomical specimens. This DVD shows how von Hagens and his team plastinate whole bodies and smaller parts for exhibition in von Hagens' traveling show *Body Worlds*, which I consider to be a 21st century comparison to the *Fabrica*. Instead of showing detailed illustrations of the bones, muscles, nerves, arteries, veins, and organs, *Body Worlds* exhibits the real body parts, preserved indefinitely with plastic.

Secondary Sources

Andrews, Evan. "Eight Reasons Why Rome Fell." History. January 14, 2014. Accessed April 7, 2016. <http://www.history.com/news/history-lists/8-reasons-why-rome-fell>.

I read this article to learn the things that factored into the fall of the Western Roman Empire because Galen's work was lost to Western Europe for centuries during the Middle Ages.

Bakkum, Barclay W. "A Historical Lesson from Franciscus Sylvius and Jacobus Sylvius." *Journal of Chiropractic Humanities*. v. 18, 1 (December 2011): 94-98. Accessed February 15, 2016. [http://www.journalchirohumanities.com/article/S1556-3499\(11\)00006-4/fulltext#s0020](http://www.journalchirohumanities.com/article/S1556-3499(11)00006-4/fulltext#s0020).

From this article, I learned that although Jacobus Sylvius advocated learning by empirical observation, he staunchly defended Galen, and even went so far as to say that the human body had changed since Galen's time, accounting for differences. He also complained to the Emperor that Vesalius was a "...crude and confused farrago of filth and sewage."

Bay, Noel Si-Yang and Boon-Huat Bay. "Greek Anatomist Herophilus: The Father of Anatomy." *Anatomy & Cell Biology* 43, no. 4 (December 2010): 280-283. Accessed February 21, 2016. <http://synapse.koreamed.org/DOIx.php?id=10.5115/acb.2010.43.4.280>.

This article gave me an overview of Herophilus' life and work. I learned that he is credited as performing the first "systematic dissection of the human body" and that he made important connections about how the cardiovascular system, the nervous system, and the brain work, but that his writings were housed in the Library of Alexandria and possibly destroyed with it.

Bloody Beginnings—Blood and Guts: A History of Surgery. Films On Demand. 2008. Accessed January 30, 2016. fod.infobase.com/PortalPlaylists.aspx?wID=16705&xtid=48253.

In this BBC film, narrator Michael Mosley discussed the history of surgery, including leeches and Vesalius boiling rotting cadavers from the gibbet for their bones. After a criminal was hung, sometimes they were tarred and displayed in the gibbet (a cage in the town square) for the birds to peck apart. I used it for background understanding of medicine of the time.

Eisenberg, Mickey S. *Life in the Balance: Emergency Medicine and the Quest to Reverse Sudden Death*. New York: Oxford University Press, 1997. Accessed February 25, 2016. <https://books.google.com/books?id=3SgrQwUCseQC&pg=PA290&lpg=PA290&dq#v=onepage&q&f=false>.

From this book, I learned Vesalius legally obtained cadavers through the judge of the Padua criminal court. I also saw that William Harvey followed Vesalius' lead and learned from his own dissections and direct observations. This was important to my paper because it showed a local judge supported Vesalius' work, and that his influence extended beyond his lifetime to incite the scientific method used by his successors.

Friedman, Meyer, and Gerald W. Friedland. *Medicine's 10 Greatest Discoveries*. New Haven: Yale University Press, 1998.

I read the chapter of this book on Vesalius and the founding of modern anatomy. It gave me an overview and timeline of Vesalius' life and career, and it is where I first learned that while a professor of anatomy and surgery at the University of Padua, he dedicated the *Fabrica* to Holy Roman Emperor Charles V as a successful attempt to get himself into employment as a physician in the Royal Court, following in the footsteps of his father and grandfather.

Gonzalez-Crussi, F. *A Short History of Medicine*. New York: Modern Library, 2007.

I read part of this book for an overall history of medicine from the Ancients, through the Middle Ages, and to Vesalius' life and work, and the impact that *De Humani Corporis Fabrica* had on the teaching and study of anatomy, surgery, and medicine. This was helpful to me because I learned that before the *Fabrica*, medical school dissections were conducted with the professor sitting well above the dissecting table, reading from Galen's works, while a barber dissected the cadaver and the students watched and listened.

Hanson, Ann Ellis. "Hippocrates: The 'Greek Miracle' in Medicine." *Medicina Antiqua*. University College London. n.d. Accessed January 31, 2016.
http://www.ucl.ac.uk/~ucgajpd/medicina%20antiqua/sa_hippint.html.

From this University College London website, I learned that Hippocratic physicians attributed sickness to a bodily process instead of a god or deity. This helped me understand the state of medicine in Classical Greece, and how backward thinking people were in the Middle Ages.

Jones, Roger, Ed. "Leonardo da Vinci: Anatomist." National Library of Medicine, National Institutes of Health. June 2012. Accessed January 27, 2016.
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3361109>.

I used this article, originally published in the *British Journal of General Practice*, for information about Leonardo da Vinci's life as an anatomist. I learned that he overcame inaccurate teachings about the human body and discovered many of the things Vesalius published in *Fabrica* 30 years later, but Leonardo abandoned his anatomy work so it remained unpublished and undiscovered for centuries.

Mavrodi, Alexandra and George Paraskevas. "Mondino de Luzzi: A Luminous Figure in the Darkness of the Middle Ages." National Library of Medicine, National Institutes of Health. February 2014. Accessed January 27, 2016.
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3944418>.

From this National Library of Medicine article, I learned that Mondino de Luzzi was the first person to dissect a human and publish a book about it. His work ushered in a new era of dissection at universities. De Luzzi trusted Galen, and if he made an observation during a dissection that did not coincide with Galen's, he attributed it to "morphological transmutation."

National Library of Medicine. "Dream Anatomy." May 1, 2014. Accessed February 13, 2016.
<https://www.nlm.nih.gov/dreamanatomy>.

On this National Library of Medicine website, I saw digital photos of original anatomical illustrations covering the entire history of illustrated anatomy. It showed me the progression of anatomical illustration. I realized how over time the artist's interpretation was viewed as interference, and anatomical illustrations evolved into very precise diagrams based on empirical observation, not works of art.

Nutton, Vivian. "Vesalius Revised: His Annotations to the 1555 *Fabrica*." National Library of Medicine, National Institutes of Health. October 2012. Accessed February 21, 2016. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3483767/>.

From this National Library of Medicine article, I learned that in 1528, Galen's writings were re-translated from Greek to Latin. Before that, the works had gone from Greek to Arabic to Latin and a lot of the meaning Galen wished to get across to his readers had been lost, including that anatomists should do their own dissecting and use empirical evidence rather than relying on other people's books.

O'Malley, Charles Donald. *Andreas Vesalius of Brussels, 1514-1564*. Berkeley: University of California Press, 1964. Accessed January 17, 2016. <https://books.google.com/books?id=HCA6wGaU8PUC&printsec=frontcover#v=onepage&q&f=false>.

This book is a biography of Andreas Vesalius, and contains many of Vesalius' quotes, which were helpful to me in understanding his personality a bit more, and also his determination and dedication to his studies, because most people would not repeatedly go to a place where they were attacked by savage dogs just because there were a lot of bones to be (illegally) found there. I chose my title quote from O'Malley's book instead of from the primary source translation of Vesalius' Epistle by Garrison because I liked the way O'Malley phrased it better.

Park, Katharine. *Secrets of Women: Gender, Generation, and the Origins of Human Dissection*. Brooklyn: Zone Books, 2006.

From this book, I learned that dissection was not prohibited in the Middle Ages; public dissection was considered shameful, but autopsies and eviscerations conducted in private homes were not uncommon, and "holy people" were sometimes dissected by friends who were curious to discover if the person contained "holy objects."

Pearcy, Lee. "Galen: a Biographical Sketch." *Medicina Antiqua*. University College London. n.d. Accessed February 4, 2016. http://www.ucl.ac.uk/~ucgajpd/medicina%20antiqua/bio_gal.html.

I used this article for background information about Galen's life and career.

Roach, Mary. *Stiff: The Curious Lives of Human Cadavers*. New York: W. W. Norton & Company, 2003.

This book inspired me to research more about the use of human cadavers. Along with an overview of the history of cadaver use, it showed me how differently cadavers are used today in scientific studies. It is what originally got me interested in studying Vesalius.

Sullivan, Richard. "The Identity and Work of the Ancient Egyptian Surgeon." *The Journal of the Royal Society of Medicine* 89, no. 8 (August 1996): 467–473. Accessed February 18, 2016. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1295891/?page=6>.

From this online article, I learned that the Ancient Egyptians had a medical system familiar to us today with many specialists, surgery, analgesics, sedatives, and bactericidal ointments. They also used sutures, scalpels, splints, and cauterization.

Understanding Evolution. "Comparative Anatomy: Andreas Vesalius." 2016. University of California Museum of Paleontology. Accessed February 10, 2016. http://evolution.berkeley.edu/evolibrary/article/0_0_0/history_02.

From this University of California website about the history of evolution, I realized that comparative anatomy is the basis of all modern science and that Vesalius's *Fabrica* was the impetus for comparative anatomy studies.

Von Staden, Heinrich. "The Discovery of the Body: Human Dissection and Its Cultural Contexts in Ancient Greece." *The Yale Journal of Biology and Medicine*. 65 (1992): 223-241. Accessed April 3, 2016. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2589595/pdf/yjbm00051-0069.pdf>.

I read this article by a Yale Professor to find out why human dissection stopped after Herophilus and Erasistratus. I learned that in Greece there was taboo against cutting skin, that corpses were believed to pollute, and it was very unusual that dissection would be permitted. In Alexandria, under Ptolemaic rule, some traditional Greek values were disregarded as patron kings sought to develop an intellectual community. They provided criminals for dissection to Herophilus and Erasistratus (Rationalists). Later, Empiricist thought became dominant, and dissection was considered unnecessary for medical learning, as they believed the body changed after death.

Yapjakis, C. "Hippocrates of Kos, the father of clinical medicine, and Asclepiades of Bithynia, the father of molecular medicine. Review." National Library of Medicine, National Institutes of Health. July 2009. Accessed February 4, 2016. <http://www.ncbi.nlm.nih.gov/pubmed/19567383>.

From this PubMed abstract, I learned that Hippocrates (460-377 BCE) is recognized as the father of modern medicine because his practice was based on observation and rational conclusions, even though his practice was still based on the four 'humors' (black bile, yellow bile, phlegm, and blood). I also learned that Asclepiades of Bithynia (124-40 BCE) is considered the father of molecular medicine because he believed the body was composed of molecules and diseases were the result of altered molecules. This made me realize how advanced they were in their thinking.