ANATOMY
Through History

Medical History for Medical Students

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ANATOMY
As with the history of surgery or the history of therapies, our understanding of anatomical knowledge in the ancient world derives from verses within Homer’s Iliad and Odyssey (7th-8th century BCE) that provide graphic descriptions of wounds and internal trauma suffered by soldiers during the Trojan War. While careful reading of the poems presents a guide to medical terminology and a schematic of anatomical knowledge, a more standardized articulation of anatomy is presented hundreds of years later through the work of Hippocrates.
Hippocrates on Anatomy

The Vatican Library possesses manuscripts dating from the twelfth century (catalog number Vaticanus graecus 276, hopefully soon to be digitized for online viewing at their website) that comprise some of the extant works of the Hippocratic Corpus (the body of writings attributed to Hippocrates). Among these manuscripts, which form the basis of translations for hundreds of years subsequently, is a tract written in Greek titled Anatomy. It is the shortest preserved treatise, and provides descriptions of the internal configuration of the human thorax and abdomen. Relying on a recent translation by classical scholar Professor Elizabeth Craik, it begins like this:

1. The trachea, taking its origin from each side of the throat, ends at the top of the lung; it is composed of similar rings [to other creatures], the circular parts touching one another on the surface.

2. The actual lung, inclined towards the left, fills the chest cavity. The lung has five projecting parts, which they call lobes; it has an ashen colour, is punctuated by dark spots, and is in mature like a honey-comb.

3. In the middle of it the heart is situated: it is rounder than [that of] all creatures. From the heart to the liver a large tube goes down, and with the tube the vessel called the great vessel, by means of which the entire frame is nourished.

The text continues with descriptions of multiple organs focusing on placement, size, and color. The organs’ function, or physiological concepts generally, are eschewed, perhaps because of lack of knowledge, or perhaps because their divine role was a different level of enquiry.

A couple of aspects of this work deserve comment. First, at the risk of sounding frivolous, there are no illustrations. This book, like many others produced over hundreds of years to come, was simply a written account of body parts. Second, while clearly a work with aims of accuracy and precision, to modern readers the descriptions can be glaringly rudimentary and wrong. For instance the account of the heart never mentions valves or chambers, and the repeated comparisons to the anatomy of animals are striking.

While the words are attributed to Hippocrates (or his ‘disciples’) who lived in the fifth century BCE, the
manuscript itself dates from the twelfth century. In between that time, broader anatomical knowledge was provided through the biological writings of Aristotle (384-322 BCE) and research at Alexandria in Egypt (founded in the third century BCE) where mummification provided opportunities to see the internal organization of the body. It is supposed that the lack of detail in the Hippocratic anatomical text is a consequence of it belonging to a period when dissection on human cadavers was not practiced. Yet despite incidental findings through battlefield trauma, accidents, or surgical interventions, the authority of Hippocrates as it was articulated and repeated for over a thousand years reigned supreme. Examining other medical writers who saw anatomy in ways that differed from Hippocrates’ account reveals the challenges of asserting medical authority, and providing new views of what the human body looked like internally.

Fig. 4: Page spread from mid-fifteenth-century Middle English translation of Galen’s Anathomia. Nicely colored font and borders, with six anatomical illustrations not part of the original manuscript added for some effect.

“For anyone wishing that the works of the Creator be made apparent, it is incumbent upon him not to trust in books devoted to anatomy but rather in what he sees with his own eyes, and after that make up his own mind.”

— Galen. It becomes ironic that later anatomists who challenged Galen’s writings with their own observations would be condemned for attacking the “gospel of Galen,” a sort of blasphemy.
Galene on Anatomical Procedures

Claudius Galenus, commonly called Galen (129 – c. 217), was a Roman physician (born in Pergamum, Asia Minor, which was part of the Roman Empire). While one of the most famous figures in the history of medicine, historians have on him very little biographical information. What we know about his medical work and thinking comes mainly from his extensive writings, deriving from some extant Greek manuscripts (about one-third of his corpus) and later Arabic translations made before the originals were destroyed along with libraries during ancient wars. We know of his self-professed lifelong commitment to studying the works of Hippocrates and dedication to developing a “rational” foundation for extending ancient medical wisdom. [2] Galen’s writings have long been valued for their significant contributions to anatomy and physiology. One reason for this devotion to studying anatomy was his belief that the body’s perfection reflected God’s wisdom. He referred to his treatise De usu partium (On the usefulness of parts of the body) as “a sacred discourse,” refuting claims by the unorthodox views of the philosophical sect known as the Epicureans that the body’s design was no proof of divine craftsmanship. [3]

Galen was a brilliant self-promoter, performing vivisections (dissection of a living animal) on pigs in the middle of Rome, impressing spectators with his medical powers by silencing a pig’s squeals from compressing its recurrent laryngeal nerves. [4] While such displays of anatomical insight may have helped Galen gain notoriety for his skill and earn him a place as physician to the gladiators and attendant to emperor Marcus Aurelius, it foreshadowed the important role of public performance in the accreditation of medical knowledge.

Fig. 5: Detail, Dissection of a Pig, from Galen, Opera Omnia (1565 edition)
As an example of the boldness of his experiments on living animals, he observes that although a ligature on the inguinal or axillary artery causes the pulse to cease in the leg or arm, the animal is not seriously injured, adding that even the carotid arteries may be tied with impunity. Glimpses of the accuracy of his work are evinced when he corrects the error of prior experimentalists who, omitting to separate the contiguous nerves in tying the carotids, suppose that the consequent loss of voice depended on the compression of those arteries, and not on that of the accompanying nerves. [5]

There has been much debate about whether, or the extent to which, Galen derived his anatomical knowledge from dissecting humans. Rhetorically, Galen invites readers into the dissecting room where they encounter a detailed description of his technique and observations. For instance, when discussing the vasculature of the liver, he instructs readers to insert a probe into the vena portae (hepatic portal vein), and gently dissect throughout the greater ramifications – alluding to the superior mesenteric and splenic veins and other components of the hepatic portal system where blood is drained into the liver. Galen notes that with a knife one can remove the parenchyma and he advises on the convenience of dividing the cellular membrane with the finger or scalpel handle.

Whereas many passages refer to his own dissections of animals including apes, bears and goats, in certain passages of his treatises, particularly On Anatomical Procedures, he recommends dissection of human cadavers but does not say that he himself performed them. [6] The absence of a declaration of his own first-hand experience is suggestive of the caution used when the practice of human dissection might have been culturally sensitive. Elsewhere he mentions how physicians who attended the emperor Marcus Aurelius in his wars had an opportunity to dissect the bodies of “the barbarians.” [7] The important point about this question is that for over a thousand years it was assumed that Galen had used the human body as the bedrock of his knowledge and claims about the anatomy of the human body. When contrasting this supposition against the anatomical knowledge debated over the following thousand years, whether Galen did or did not “see for himself” is important to the question of expert knowledge.
The Question of Dissection

Evidence suggests that dissection of human cadavers was practiced at least in the third century BCE, and then again around 1300. What happened in between is a matter of interpretation, if not also debate.

The seventh century CE ("common era") was the first century of Islam, the birth of the Islamic state and the beginnings of the spread of the empire over the next 600 years. The conquests of the Arab-Islamic Caliphate (dominion of the Caliph, the “successor”) covered much of Persia, Arabia, North Africa and Spain – territories that in Galen’s day were part of the Roman Empire. Arabic was the official language of the empire. As a consequence of cultural wars, cities were sacked, libraries were leveled. For two centuries, Persian scholars worked to save surviving non-Arabic literature from destruction through rapid translation.

Scholars are not of uniform opinion about whether Muslim medical practitioners disavowed human dissection. It has often been asserted that “Islamic law” prohibited dissection, whether animal or human. Islamic law, shari‘ah, makes no distinction between religious and secular law and is based on the Qur’an, sayings attributed to the Prophet Muhammad (called hadith), and “customary practices” of early Muslim community (called sunnah).

[8] One writer, the thirteenth-century Islamic physician Ibn al-Nafis, explicitly asserted that Islamic law “discouraged” dissection, yet he provided no reference to legal authority. In fact, scholars have searched in vain for documents providing any legal tenet supporting this claim. Statements such as “disapproval” exist, particularly in reference to bad burial practices and (as in this case) dissection, but a number of acts that are disapproved, such as drinking wine or even mutilating bodies (enemies or criminals), are known to have occurred.

Ibn al-Nafis himself provided a description of the pulmonary transit of the blood – the earliest account of which we know to demonstrate an alternative to Galen’s declaration that blood from the right ventricle passes into the
left ventricle through pores – which, it has been argued, must be based on direct observation. [9] Therefore lack of reference to human dissection could mean that their anatomical descriptions are purely theoretical, re-conveyances of previous authors’ views, or perhaps that they performed them in private and only presented results. Furthermore, there appears to be evidence of dissection of particular organs, such as the human eye. The ninth-century Persian physician Abu Zakariya Yuhanna ibn Masawaih, Mesue (often referred to as Mesue Major or Mesue Senior), founded a scientific academy in Baghdad where it is known that he dissected apes for his anatomical studies based on their similarity to humans. Several ancient medical treatises are attributed to him, including a textbook of medical consultation, works on embryology, and detailed ophthalmological studies. [10] His student, Hunayn ibn Ishaq continued these studies and published the first anatomical diagram of the eye in his treatise *Al-Asbr Maqalat fi al-Ayn* (*Ten Treatises on the Eye*), prepared around the year 860 CE. Hunayn, along with his son and nephew, who were all Nestorian Christians (a protected community under the Persian Church), also translated Galen’s anatomical writings into Arabic. These ninth-century translations of Galen formed the basis of all subsequent anatomical tracts of Islam. Like Galen, subsequent writers on anatomy posited the benefits of human dissection, yet they acknowledged the necessity of first acquiring skills from extensive animal dissection. Yet, instead of reading these as proclamation of their own skills,
scholars have tended to interpret such statements as endorsements for the authority of Galen. Just as Galen subtly disagreed with statements by Hippocrates, Aristotle, and Plato on anatomy but remained overwhelmingly reverential to their ancient authority, so these medieval authors deferred to Galen in print if not in experience.

One of the most influential figures in this chronology is the physician, philosopher, astronomer and statesman Ibn Sina, known better by his Latinized name Avicenna (980-1037). As the author of Al-Qanun fi al-Tibb (The Canon of Medicine), written around 1020, he introduced anatomy in systems-based approach at the beginning of each chapter followed by a discussion on the diseases of that system—an approach that became the template for modern clinically-oriented anatomy. The text was translated into Latin in the twelfth century and into Hebrew in the thirteenth, and was a main medical text in Western schools until the eighteenth century, with the famous physician and medical humanist William Osler calling it “the most famous medical textbook ever written.” [11]

Encyclopedic in its coverage of medical topics, the Canon draws special historical interest in its own declaration of the need for a modern methodology of medical investigation, namely empirical inquiry. An unquestionably keen observer who possibly gleaned physiological insights through vivisection, he described the aortic valve as comprised of three semi-lunar cusps which open when the heart contracts and blood rushes out and closes to stop its regurgitation. He asserted that muscular movements are caused by supply nerves which also convey sensations of pain; he explained that the liver, spleen and kidney did not contain nerves; he described six extra-ocular muscles and differentiated the trigeminal nerves and tendons; and he described vertebra and cerebellum in detail. [13]

An anatomist working three hundred years later was inspired...
by both Galen and Avicenna, however an oft-repeated claim was long made that he was innovative because he wrote the first text exclusively devoted to human anatomy with observations derived from his own dissections. The anatomist was Mondino da Luzzi, a University of Bologna physician, who penned his *Anathomia corporis humani* in 1316 (not printed until 1478). Yet more recent arguments have been made that his persistent errors, replicated from the age-old mistakes of Galen. Also, statements about rather basic human anatomy were wrong, such as Mondino’s claim that the uterus has horns, suggest if anything that he himself was relying on animal dissection (where he probably saw uterine horns of sows). [14]

If claims to novel observations are to be made, it might be more sensible to look at the work of Mondino’s contemporary, the French royal surgeon Henri de Mondeville (c. 1260 -1316). A military surgeon from Paris, Mondeville developed a particular interest in head wounds leading to a familiarity of crania that lead him to correct Aristotle’s statement regarding differences in cranial sutures in men and women (Aristotle positing that men had three sutures and women one, but Mondeville illustrated there is “absolutely no difference between them”). Mondeville illustrated it quite literally during his lectures, where he produced anatomical drawings – perhaps the most significant feature of his contributions to the history of anatomy. [15]

For what is striking about all the anatomical works discussed thus far is that none of them relied on visual illustrations, but were nearly entirely textual descriptions. Illustrations presented here are from later translations of the works. With the rise of Renaissance anatomy, this was about to change.

“*As for the parts of the body and their functions, it is necessary that they be approached through observation and dissection, while those things that must be conjectured and demonstrated by reason are diseases and their particular causes and their symptoms and how disease can be abated and health maintained.***”

— Avicenna, echoing the sentiments of Galen quoted earlier regarding the importance of empirical observation, while leaving the nature of diseases and their cause — such things as are invisible — to a philosophical process: “conjecture” and “reason.” See reference [12]
Though you have a love for such things you will perhaps be hindered by your stomach, and, if that does not impede you, you will perhaps be impeded by the fear of living throughout the night hours in the company of quartered and flayed corpses fearful to behold.” [16]

Fig 12: Da Vinci’s study of neck and shoulder.
Renaissance medical humanists – philosophers and writers of the human body and its ailments – were deeply committed to the recovery and critical assessment of ancient medical texts. But by the early 1400s, the practice of dissection as part of pedagogical demonstration had once again reemerged, allowing for the re-enactment of such public performances. An early venue was the University of Bologna which established rules regulating dissections, limiting the number and provenance of cadavers.
About a hundred years later, in 1507, dissections at the Hospital of Santa Maria Nuova in Florence and at Padua University under the instruction of the Professor of Anatomy Marcantonio della Torre attracted the attention of one unique student. Leonardo da Vinci proved an alert observer, but in the early stages of his ambition to compose a treatise on anatomy he rather sees what previous authorities such as Galen and Avicenna told people to believe. [17] (His anatomical works were not published until 1632 under the title *Treatise on Painting*.) For instance in his drawing of nerves Leonardo identified a nerve that connects the testicles to the spine, where, according to the Hippocratic theory of generation, semen was created. [18]

Yet as his research continued, ultimately amounting to over two hundred pages of drawings, his contributions to anatomy become pronounced. In his notes, Leonardo describes how he was careful to remember to pull each tendon “to make certain of the origin of each muscle” and interrogates the form and function of successive layers of the body. He also reflected on the pronouncements of former writers, asking, “what trust can we place in the ancients, who tried to define what

Leonardo’s removal of contemplation of the “supreme Truths” about the Soul and the mysteries of God (questions fit for friars and metaphysical philosophers) from the empirical work of natural philosophers (physicians and investigators of nature) marks an emerging effort in the Renaissance to make anatomy scientific. Leonardo’s approach was emphatically observational, but whereas in the past this translated into thousands of words of descriptive text, Leonardo elevated visual illustration to a new epistemological status. As
he said, his representations “will give a true knowledge of their shapes that neither the ancient writers nor the moderns could ever have been able to give without an immense, tiresome and confused amount of writing and time.” He added, “let not avarice constrain you to make the prints in woodcut.” [21] Indeed, the expense of producing engravings to illustrate anatomy books would itself impact the way we understand its history, a matter discussed a bit more below.

The epitome of Renaissance humanist, Leonardo is equally scientist and artist. As works of art his anatomical drawings convey a power of expression unprecedented. His contributions challenge our thinking about whether anatomical drawings are best considered scientific or artistic artifacts. The development of artistic realism – of perspectivism and diagrammatic modes to illustrate structural proportions and physiological principles – was new. Both Leonardo and his similarly innovative successor, Andreas Vesalius, created a “rhetoric of reality” through pictures that transformed the viewer into a “surrogate eyewitness” of the dissected body.

The drawings are both scientific and artistic, and as such they occupy an interstitial space between two cultures we now commonly think of as opposed. As the art historian Martin Kemp suggests, a sheet of his drawings “shares as many of the formal and emotional beauties of Raphael’s Madonna della Sedia as it does the scientific qualities of Vesalius’s Fáblica.” [23] It is to this latter anatomist that we now turn.
Vesalian Anatomy in the Sixteenth Century
The Rebirth of the Corpse

In 1540, a medical student attending the University of Bologna, the oldest university in the world, sat in the elaborate anatomy theater and watched the professor slice into the pleural cavity of a living dog. The student described watching the exposed heart pounding moments before the animal died. When asked by the observers what the anatomist thought of the vital mechanisms of the heartbeat, the instructor, Andreas Vesalius, reportedly replied: “I do not want to give an opinion. You yourselves should feel with your own hands, and trust them.” [25] This appeal to direct experience throughout the sixteenth century becomes a prominent message among anatomists who wished to distinguish between the inaccurate work of dead authors and living knowledge. But in an age when scholarly pursuits were dominated by reverence for esteemed ancient authors, recognizing mistakes or inaccuracies among their writings was a sensitive matter. After all, this was the Renaissance, when the past was in the process of being “reborn,” not destroyed.

Born in 1514, five years before the death of da Vinci, the world into which Vesalius emerged was witnessing change in many arenas. In 1516, the English philosopher-lawyer Thomas More published Utopia, his popular critical commentary on royal politics which posited a radical view of social reorganization. In 1517, the German theology professor posted his “ninety-five theses,” disputations alleging misconduct in the Catholic Church, on the door of All Saints’ Church in Wittenberg, launching what history records as the Protestant Reformation. In 1518, Magellan set sail to circumnavigate the globe, celebrating new geographical knowledge following Columbus’s arrival in the “New World.” But amidst the excitement of intellectual inquiry and voyages of discovery was resistance and risk.

In 1535 Thomas More was beheaded on the orders of King Henry VIII, whom More had condemned for declaring himself the Head of the newly established Church of England. Luther was excommunicated and declared an outlaw by the Holy Roman Emperor Charles V and travelled incessantly while suffering ill health until his death in 1546. Magellan died four years into his journey, in 1522, when wounded with a bamboo spear in the Philippines after meddling in a local tribal dispute. For the career Vesalius would embark upon, nothing was to be taken for granted.

Born in Brussles, Vesalius traveled to Paris in 1533 to study medicine at the University of Paris. While there he attended the lectures of the anatomist Jacobus Sylvius and read Galen. Sylvius performed practical demonstrations dissecting the human body, and to supplement his education Vesalius claimed to spend hours in the burial-ground of the Church of the Innocents in Paris examining bones. After three
Galen published his anatomical works in the second century, and reigned supreme as the authority on human anatomy for the next 1300 years. To some, he was overrated. The sixteenth-century French humanist monk François Rabelais scribbled a marginal note in his copy of Galen saying, "This Galen is an uncommon dull fellow, a dud, a lump of lead." Employing only lengthy textual description of muscles, vasculature, nerves, and skeletal structure, with no illustrations, one feels for all the students raised in the Galenic tradition. [24]

years, an imperial war between King Francis of France and the Holy Roman Emperor prompted Vesalius to return to Leuven, Belgium, where he independently continued his anatomical studies. The next year, 1537, he produced his first anatomical treatise, his translation of the ninth book of Rhazes, the Arab-Persian physician whose tenth-century writings raised criticisms of Galen’s work. [26] This is suggestive of Vesalius’s intellectual growth, his future work, and his reputation in history.

Fig 17 (Top): Rabelias; Fig. 18 (Below): Eighteenth-century engraving of Galen studying bones
Vesalius then migrated to Italy, where he befriended a group of Jesuit scholars planning to start a medical school at Padua, and soon became a member of the faculty enabling him to teach anatomy and perform dissections for his students. A scene of him doing so was prepared as an elaborate woodcut engraving that served as the frontispiece to his *magnum opus* (and which introduces this section), his *De humani corporis fabrica* (*On the fabric of the human body*), which was published in 1543. We will focus on this because of its historical value.

The *Fabrica* is a remarkable work in the history of anatomy in many ways, and it is often taken as a foundational work in the steps toward modern anatomical knowledge. Three main elements distinguish it.

First, it is read as “anti-Galenic.” That is, it openly criticizes Galen’s anatomical accounts. This was considered a big deal because, as mentioned earlier, his contemporaries inherited a tradition of reverence for ancient authorities, and Galen was THE authority. As Vesalius explained in a letter intended for his mentor, Sylvius (who was upset with his student’s criticisms),

> Many persons are hostile to me because in my writings I seem to hold in contempt the authority of Galen, the prince of physicians and preceptor of us all, because I do not agree indiscriminately with all his opinions, and especially because I have demonstrated that some errors are discernible in his books. Surely scant justice to me and to our studies and indeed our times! Sylvius did not agree, and in 1551, a 72-year-old Sylvius published a pamphlet ridiculing Vesalius titled *The Refutation of the Calumnies of Vesanus*, purposely misspelling Vesalius’s name to a term which translates into “madman.” [27]

The second reason Vesalius’s book is notable is linked to his criticism of Galen, specifically his appeal to direct observation and first-hand experience with dissecting to support his claims. Vesalius simply could not understand the practice of NOT dissecting and instead putting faith in long textual descriptions written 1300 years earlier. He wrote in his preface, “there comes to my mind the judgment of certain men who vehemently condemn the practice of seeing before the eyes of students, as we do with the parts of plants, delineations, be they never so accurate, as the parts of the human body.” Establishing the importance of having students experience first-hand dissection, witnessing with their own eyes the fabric of the human body, is crucial to the establishment of modern medical knowledge.

> “Moderns who know things only by name, and by trusting the dicta and questions current in the schools, have failed to observe.” — Niccolò Massa (1536), Italian anatomist, in *Anatomiae Libri Introductorius*
Third, Vesalius underscored the importance of “seeing” by commissioning elaborate illustrations of human anatomy that interlace the pages of his book. Everyone has seen one or another of these striking illustrations. To be clear, Vesalius kept with the long tradition of providing long narrative descriptions of anatomical features. His book is large: it is a folio; the size of a page is about the same as the screen on a 27” iMac. It is thick: 663 pages of text. And it is illustrated: it has 278 woodcuts. But it is important to note that Vesalius was not the first to have illustrations accompany his text. The professor of surgery at Pavia and Bologna, Jacopo Berengario da Carpi, performed hundreds of dissections and in 1535 published his Anatomia, with woodcuts like the one shown here.

However, in the words of Carpi’s and Vesalius’s contemporary, fellow anatomist Gabriele Falloppio (yes, of the fallopian tubes): what Carpi started, Vesalius perfected. Vesalius’s illustrations were highly detailed and represented an achievement in realism that characterizes Renaissance artistic technique and skill. He asserted that the chief function of the illustrations was to aid the memory of what had been observed in the theater. [28]
How do we interpret the aesthetics of these images? Why are bodies, stripped of skin and rendered progressively invisible through layers of engravings, posing in elegant positions against scenic backgrounds? One thought is that standing – posturing – cadavers evoke a symbolic representation of their rebirth for the vitality of knowledge. We recall that when Vesalius fled France it was in the midst of a war wherein it is possible that soldiers were slain in fields outside cities. Anyone studying anatomy would know that knowledge was historically based on an opportunity to examine cadavers whatever the circumstances of their death. It is feasible that having an artist portray cadavers in a dignified position, their bodies rendered available for medico-scientific investigation, against the backdrop of the land of their demise, representing the place where new knowledge is born, explains the context of the images.
Galen paid special attention to the anatomy of the hand. Because of all the musculature, vasculature, and nerves which work to control the movements of the hand, Vesalius followed suit. However, as an example of the ways Vesalius notes Galen’s errors, he points out that the phalanges and metacarpal bones are not solid, and that it was Galen’s dependence on apes that had led him to overlook at least thirteen muscles of the human hand.

For anyone puzzled about why publishing findings, based on dissection in a medical school’s anatomical theater, would be controversial because they contradict an author who published over a thousand years earlier, here are some things to consider.

First, The Catholic Church and the Holy Roman Empire were under pressure. Martin Luther launched the Protestant Reformation and England’s Henry VIII established the Church of England. Religious powers, which gave Kings and Queens the “divine right to rule,” were fragmenting, and battles over political power were vested in religious authority. The Word of God, delivered through the ancient text of the bible, was itself emblematic of ancient authority. Galen’s anatomy was seen as a celebration of God’s most important temple – the human body. To criticize Galen was another sign of erosion of the tenets of ancient authority.

Second, asking students to “see for themselves” by dissecting humans was not an easy request, and those trained under an old regime could be defensive of others claiming unique knowledge based on their own experiments. Dismantling the human body was considered in some religions a violation of a sacred space, a challenge which is addressed in the next section.