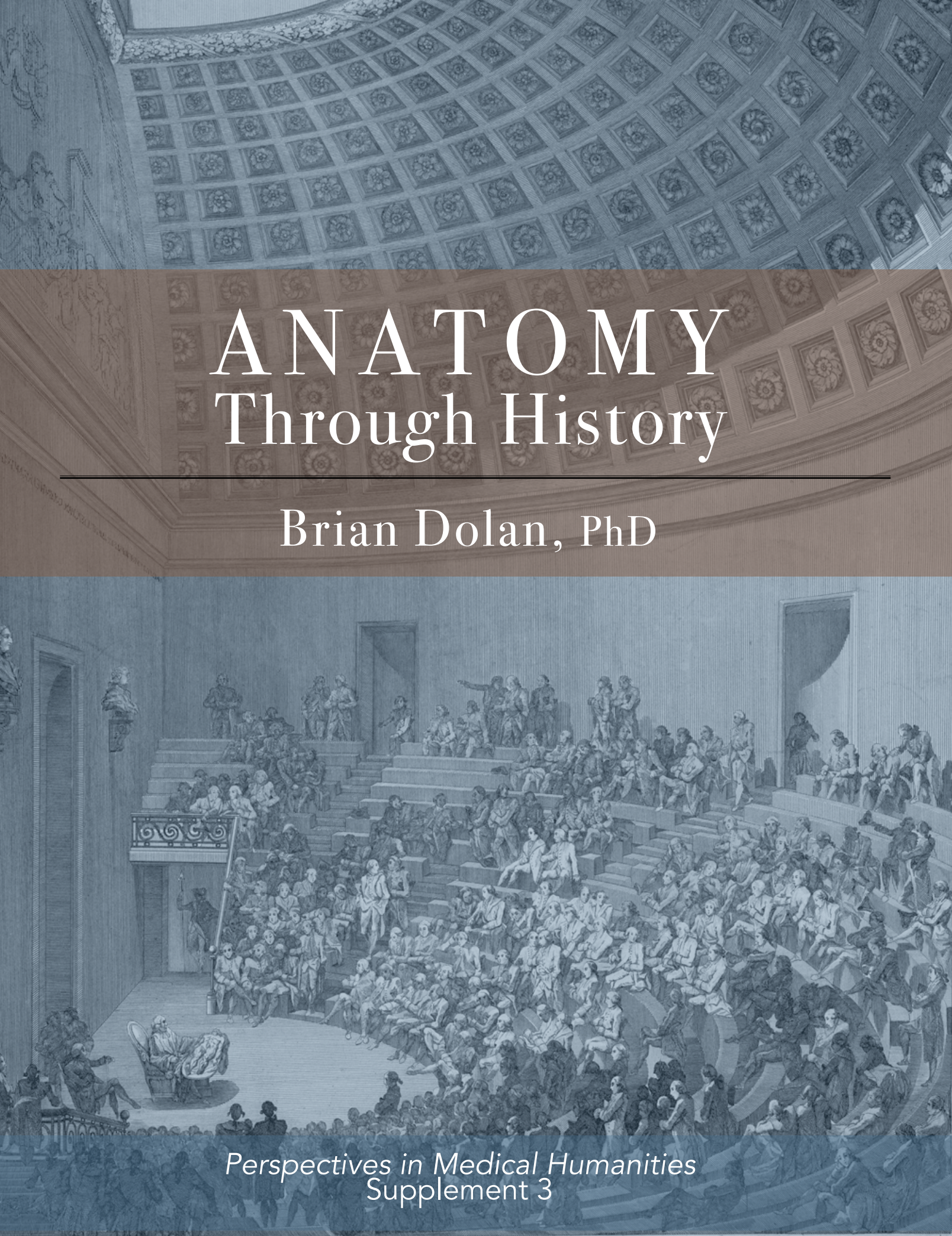

ANATOMY
Through History

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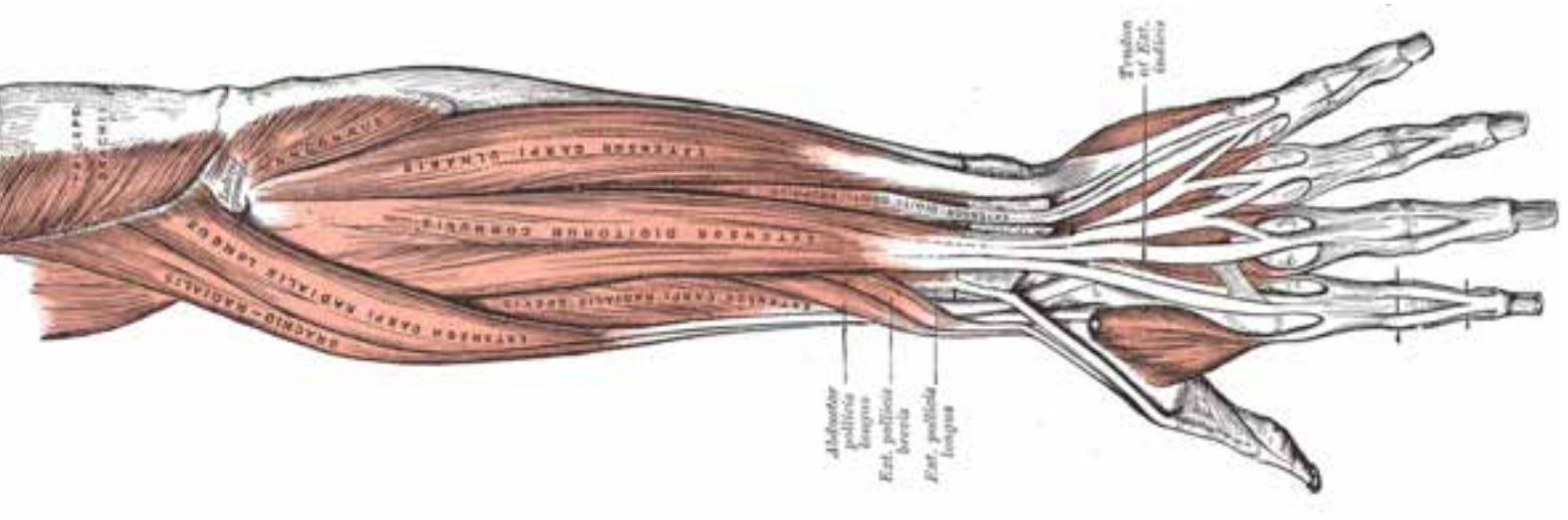

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ANATOMY

among the

Fig. 1: Achilles Tending to a Wound

ANCIENTS

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.

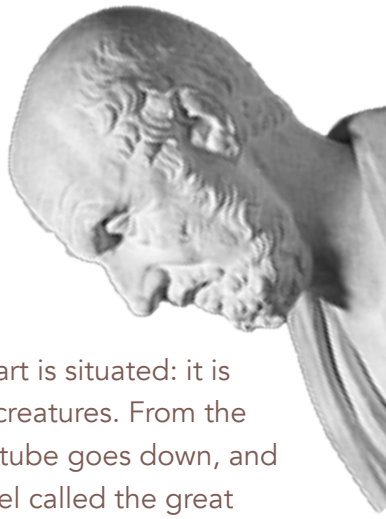
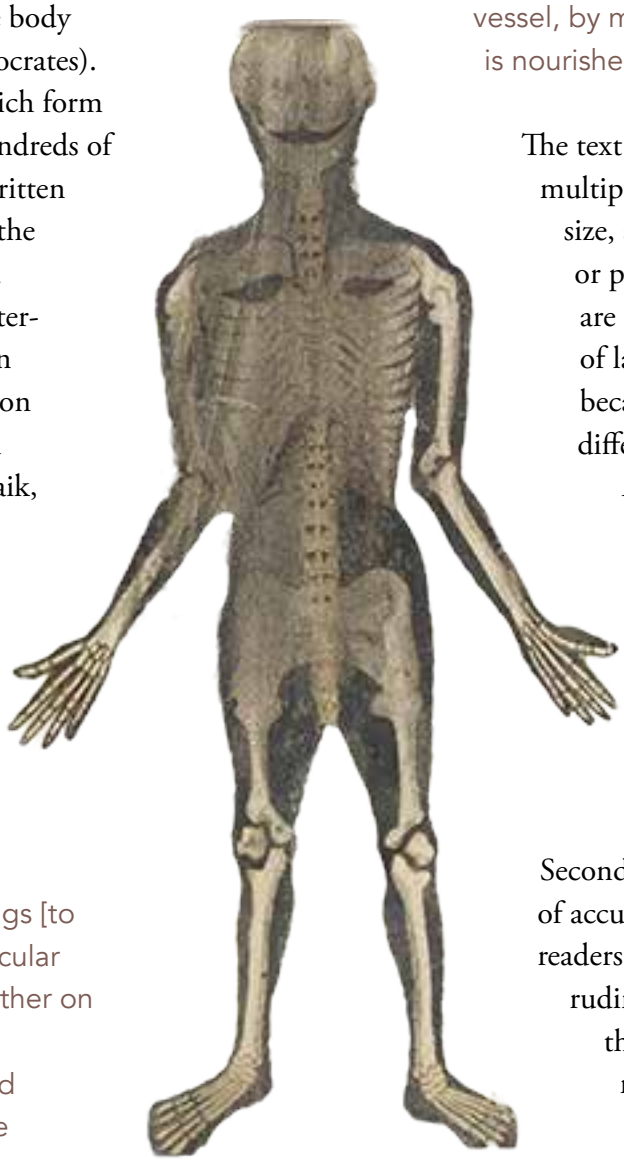


Fig. 2 (right): Bust of Hippocrrates
Fig. 3 (middle): "Skeleton Man," mid-fifteenth century

Hippocrates on Anatomy

The Vatican Library possesses manuscripts dating from the twelfth century (catalog Codex Vaticanus Graecus 276) 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 preserve the internal organization of the body. It is hypothesized 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 reigned supreme and it was translated and repeated for over a thousand years. 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*. The colored font and borders, with six anatomical illustrations, are not part of the original manuscript but were later added to "illuminate" the manuscript for added artistic value.

"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 atacking the "gospel of Galen," which was considered a sort of blasphemy.

Galen 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 very little biographical information on him. 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 that housed them, 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 knows 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.

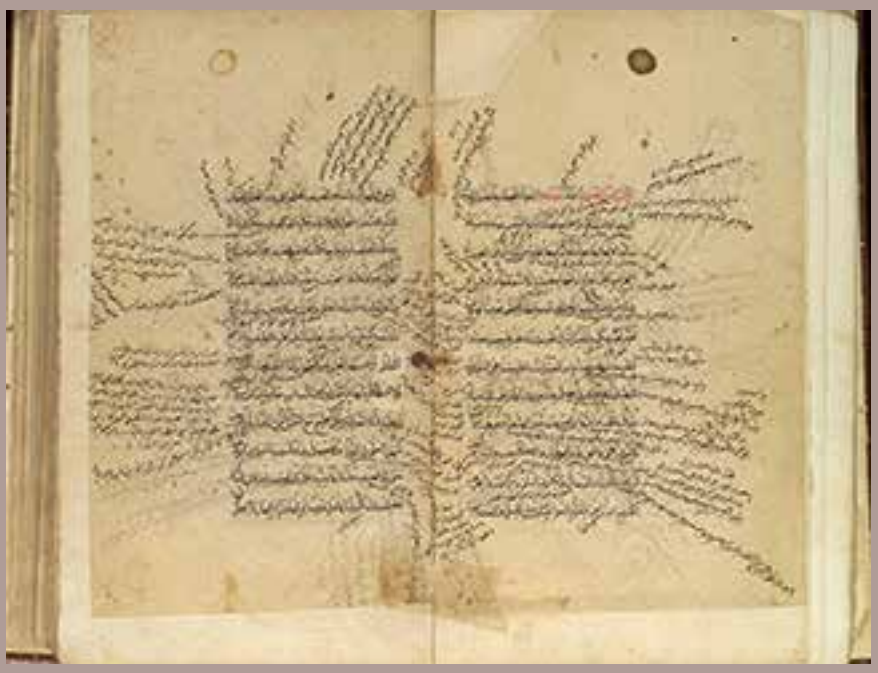
Fig. 5: Dissection of a Pig, from Galen, *Opera Omnia* (1565 edition, detail)

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 hapatic 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 suppposition 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.

Fig. 6: Engraving of Galen, Avicenna, and Hippocrates.



Islamic Anatomy

Fig. 7: Sixteenth-century Arabic medical text drawing on Hippocrates and 'Ala ad-Din 'Ali ibn abi l-Hazm al-Qurasi Ibn al-Nafis

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 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

Fig. 8: Image from a twelfth-century copy of Hunayn ibn Ishaq's Treatise on the Eye, a ninth-century tract which contained the earliest known description of the eye. This copy is from the Institute for the History of Arab-Islamic Science in Frankfurt, Germany.

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 prosection 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-Ashr 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,

Fig. 9: Arteries and Viscera accordig to Avicenna from *al-qanun Fi-T-Tibb* (*Canon of Medicine*), 1632.

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 as a systems-based approach, and then offered 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]

Fig. 10: Muscular System accordig to Avicennafrom *al-qanun Fi-T-Tibb* (*Canon of Medicine*), 1632.

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 semilunar 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]

Mondino da Luzzi was an anatomist working three hundred years later and was inspired by both Galen and Avicenna. However,

Fig. 11: Arteries and Viscera accordig to Avicenna from *al-qanun Fi-T-Tibb* (*Canon of Medicine*), 1632.

"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."

often repeated claims have been made that he was innovative because he wrote the first text exclusively devoted to human anatomy with observations derived from his own dissections. Mondino da Luzzi was a physician at the University of Bologna and penned his *Anathomia corporis humani* in 1316 (not printed until 1478). Yet more recent arguments have been made that his persistent errors were replicated from the age-old mistakes of Galen. Also, some statements about rather basic human anatomy were wrong, such as Mondino's claim that the uterus has horns, suggesting 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 entirely textual descriptions. Illustrations presented here are from later translations of the works. With the rise of Renaissance anatomy, this was about to change.

— 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]

The Bodies of DA VINCI

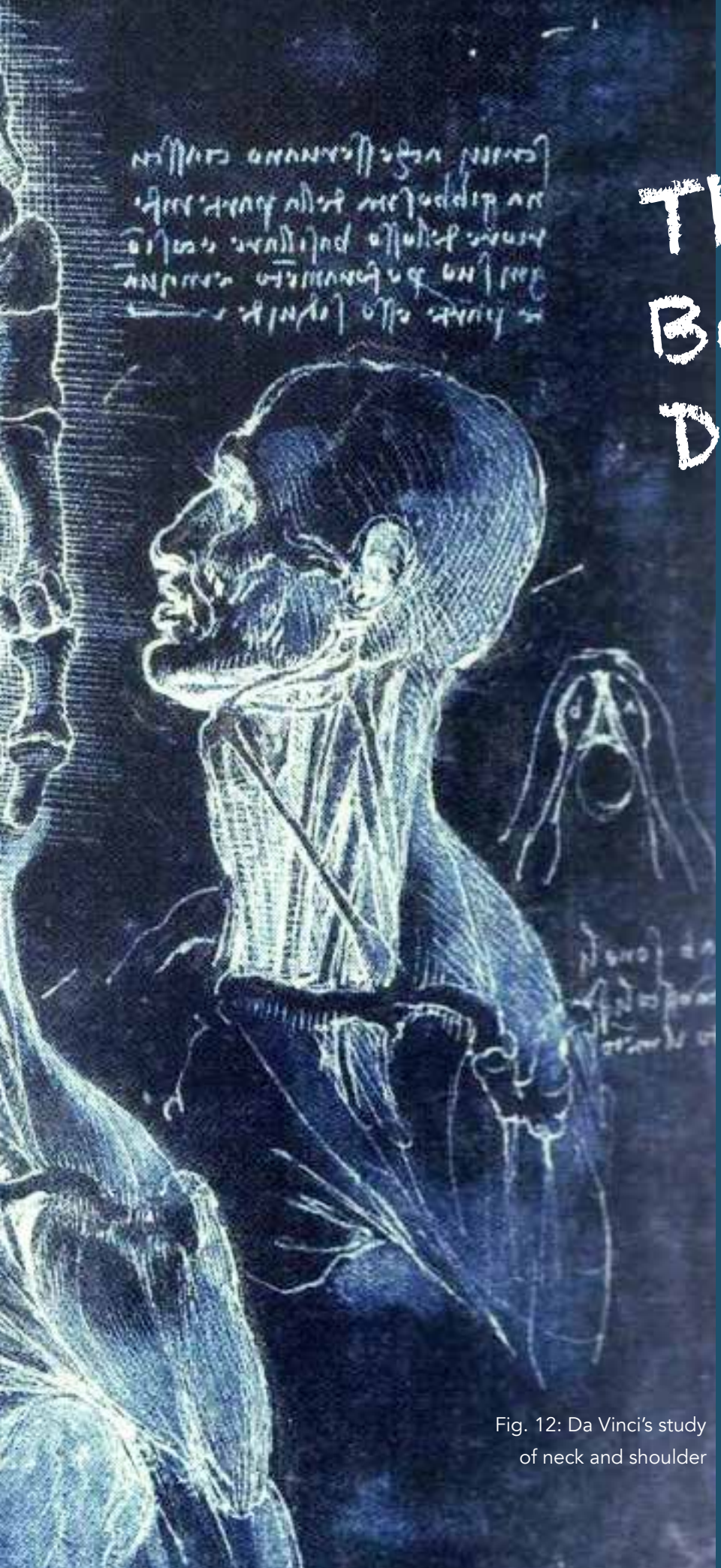
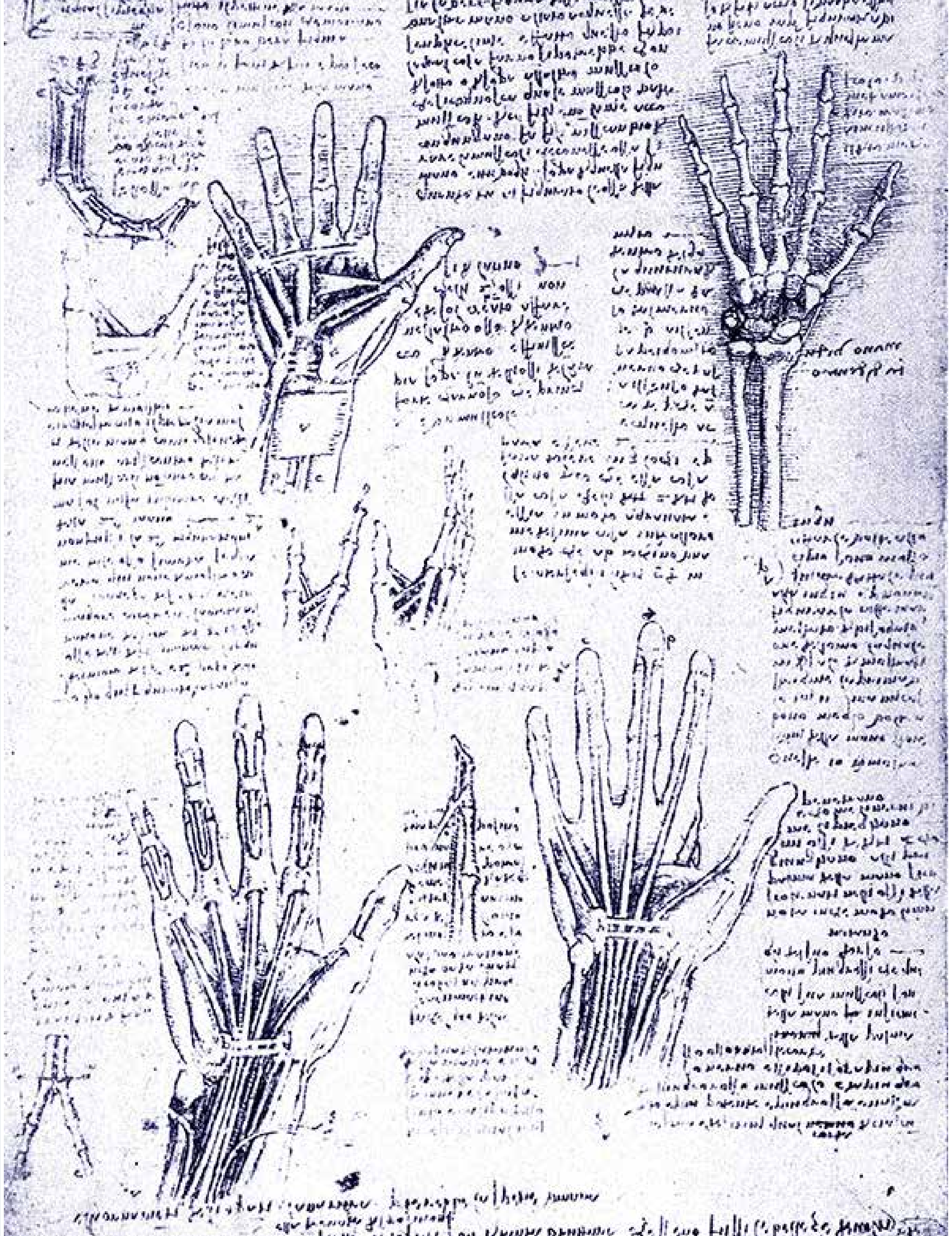
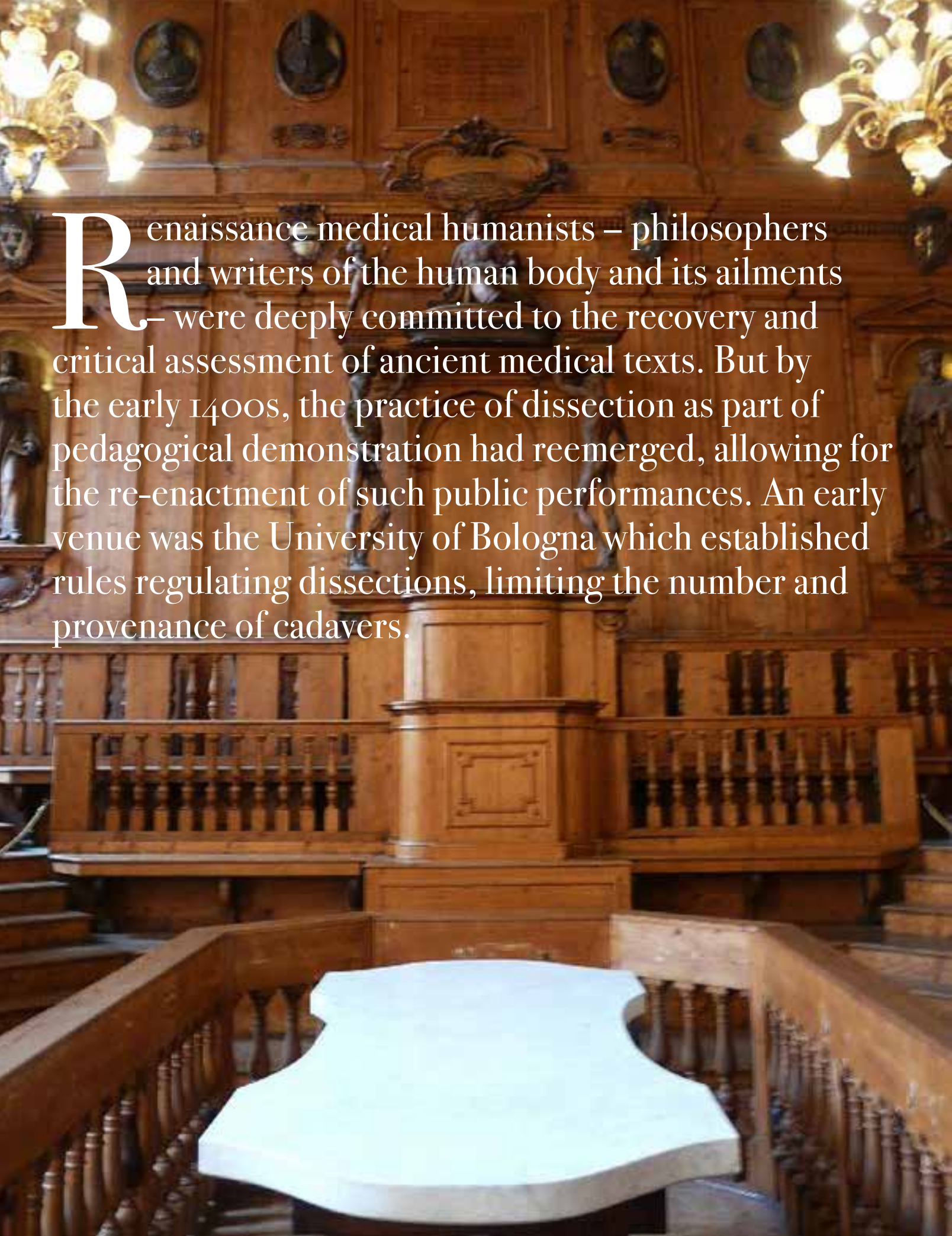


Fig. 12: Da Vinci's study of neck and shoulder

"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]





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 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.

A Captivated Student

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 observed 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 the Soul and Life are? Whereas those things which at any time can be clearly known and proved by experience remained unknown for many centuries unknown or falsely understood." [20]

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

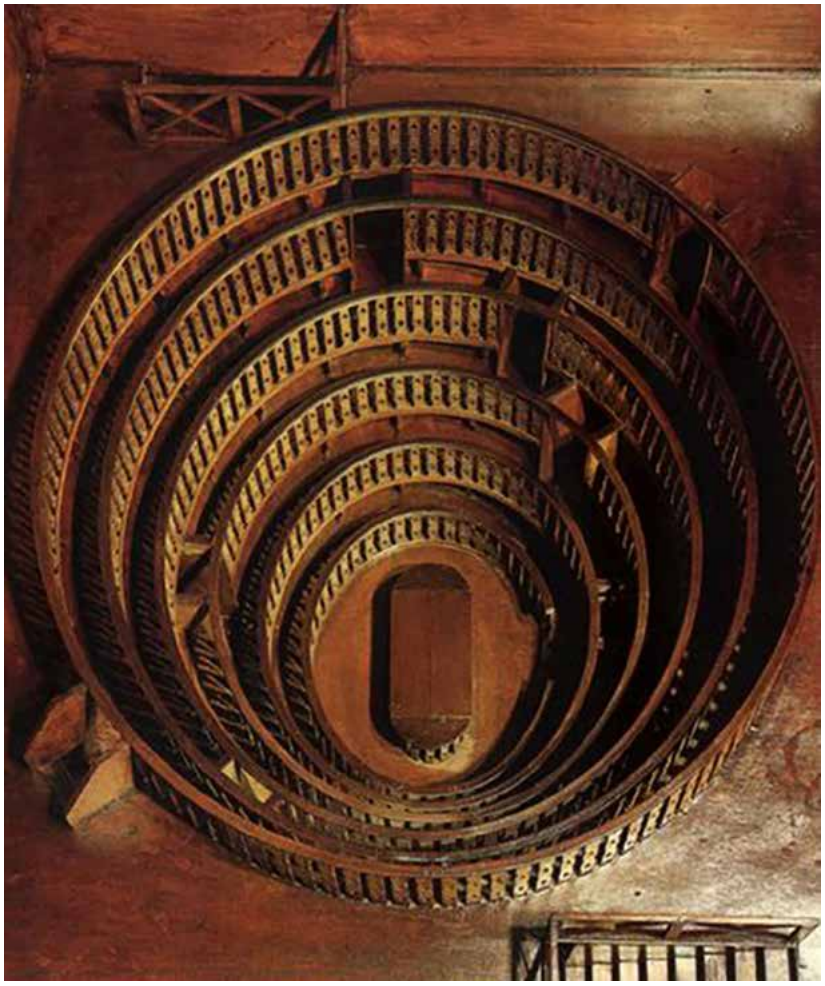


Fig. 13 (opposite page): Anatomical Theater, University of Bologna
Fig. 14 (above): Anatomical Theater, Padua University

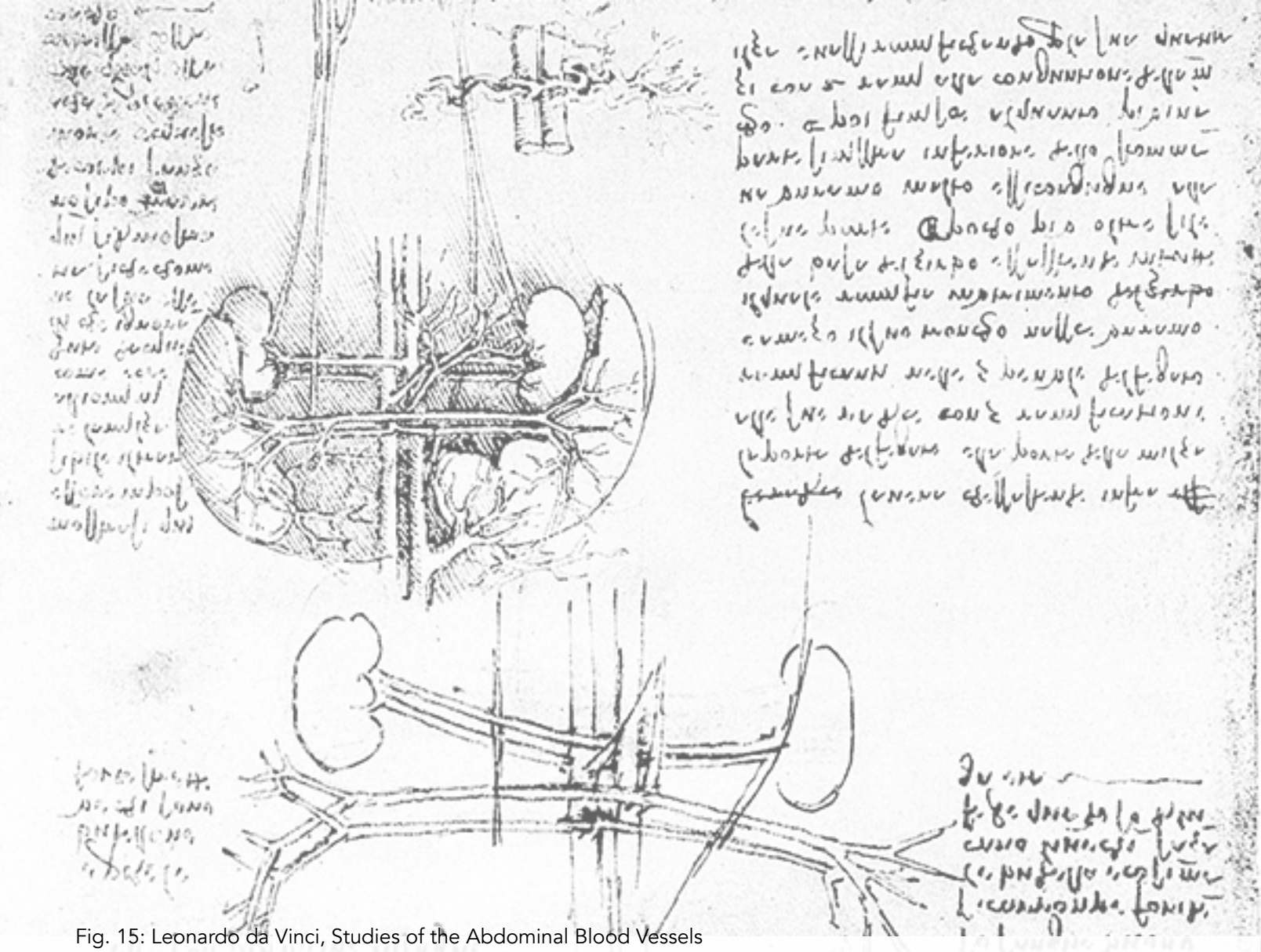
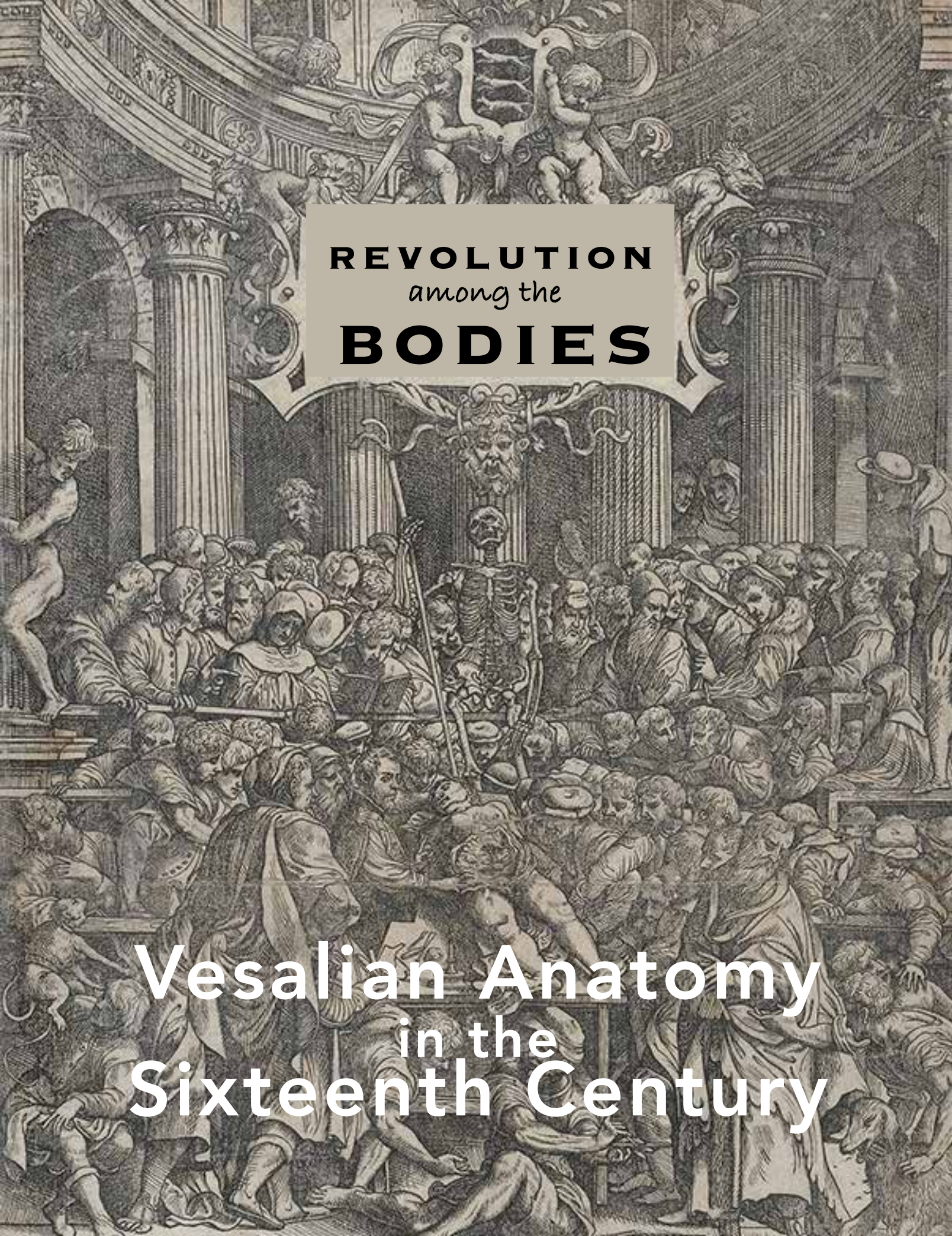


Fig. 15: Leonardo da Vinci, Studies of the Abdominal Blood Vessels

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 wood-cut." [21] Indeed, the expense of producing engravings to illustrate anatomy books would itself impact the way we understand its history, a matter discussed further 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 *Fabrica*." [23] It is to this latter anatomist that we now turn.



REVOLUTION among the BODIES

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 (f. 1088), 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 becomes a prominent message throughout the sixteenth century 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 organization. In 1517, the German theology professor Martin Luther 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

Fig 16: Portrait of Vesalius from *Fabrica*

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 years, an imperial war between King Francis

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-cetury French humanist monk Francois 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]

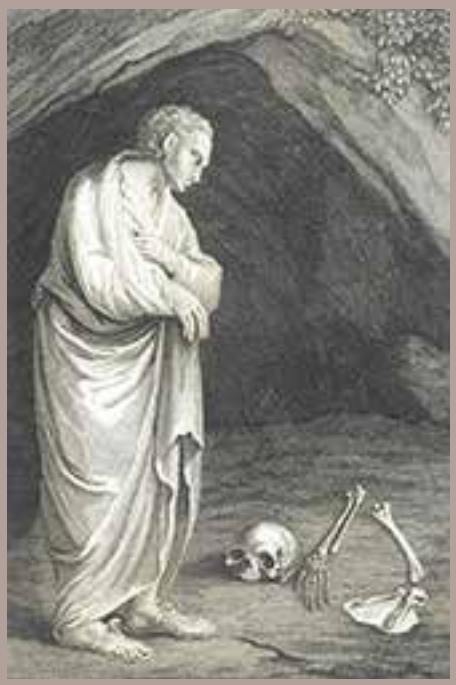


Fig. 17 (top): Rabelias
Fig. 18 (below): Eighteenth-century engraving of Galen studying bones

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.

"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*

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, was crucial to the establishment of modern medical knowledge.

Third, Vesalius underscored the

Fig. 19: Folio spread of Vesalius's *Fabrica*

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.

Fig. 20: Dissected woman pointing to her uterus. From Carpi, *Short Introduction to Anatomy* (1535)

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]

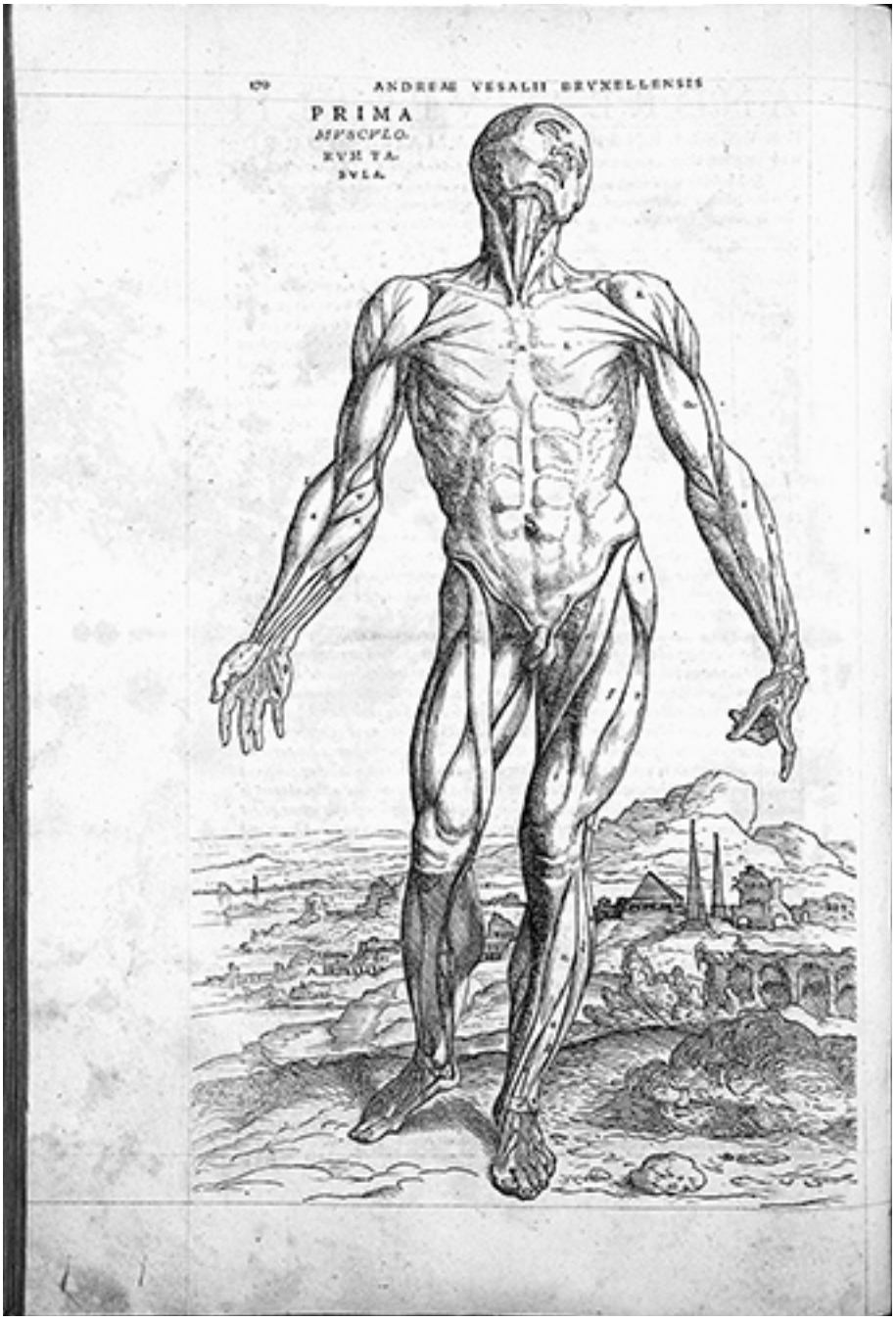


Fig. 21: "First table of Muscles," from Vesalius's *Fabrica* (1543)

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 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.

Why Defend the Ancient Authority of Galen?

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.

How many fingers?

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.

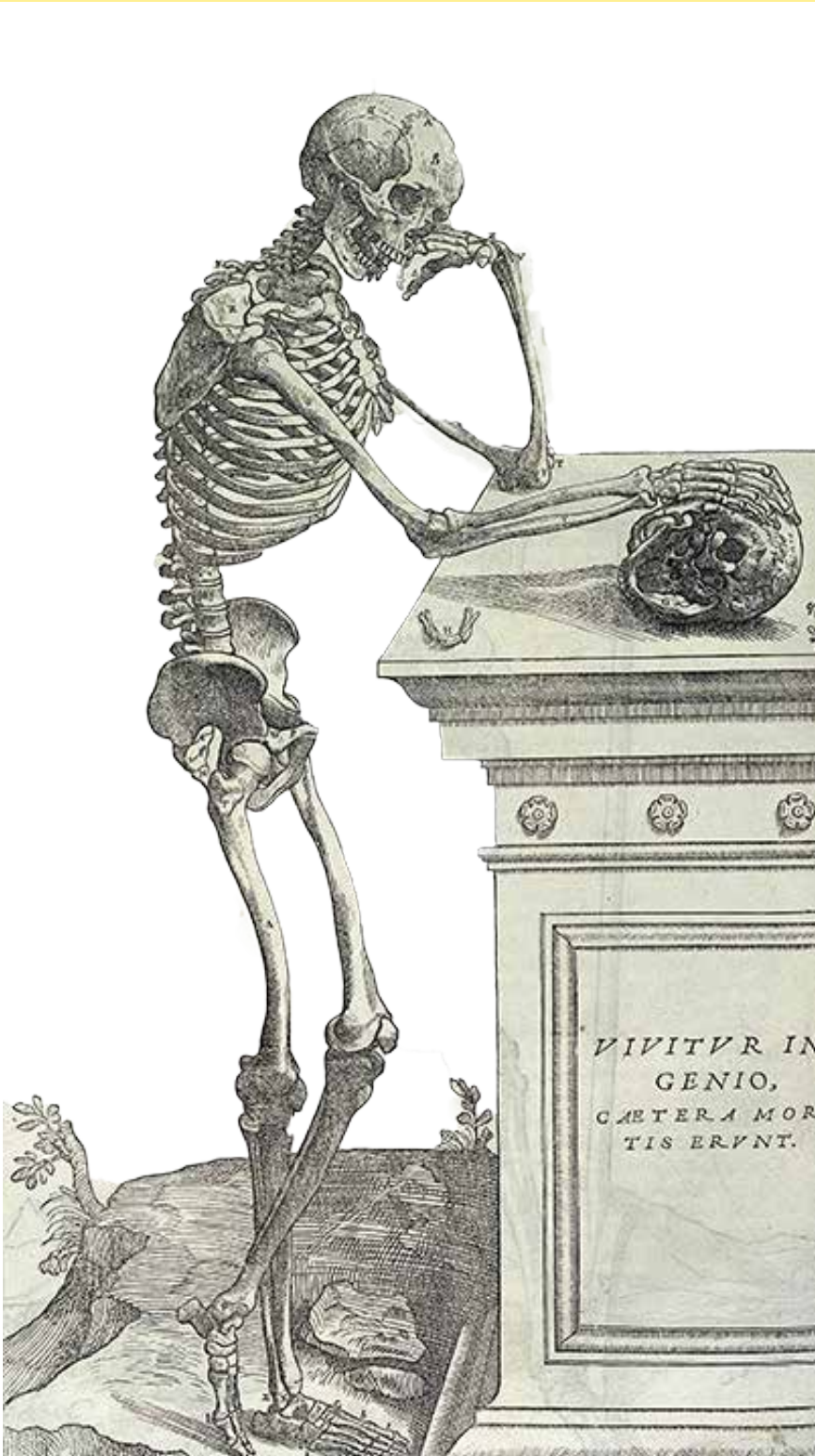


Fig. 23: "The Anatomy Lesson of Dr. Nicolaes Tulp" (1632) by Rembrandt. Oil painting on canvas showing Dr. Tulp explaining the musculature of the arm

The new methods of hands-on anatomical training yielded new insights that became foundational to medical knowledge, opening a path for physiological studies. It was owing to his anatomical studies at Padua that the English physician William Harvey was able to write *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus* (*Anatomical Exercise on the Motion of the Heart and Blood in Animals*, 1628), the magnificent treatise describing how blood circulates through the body.

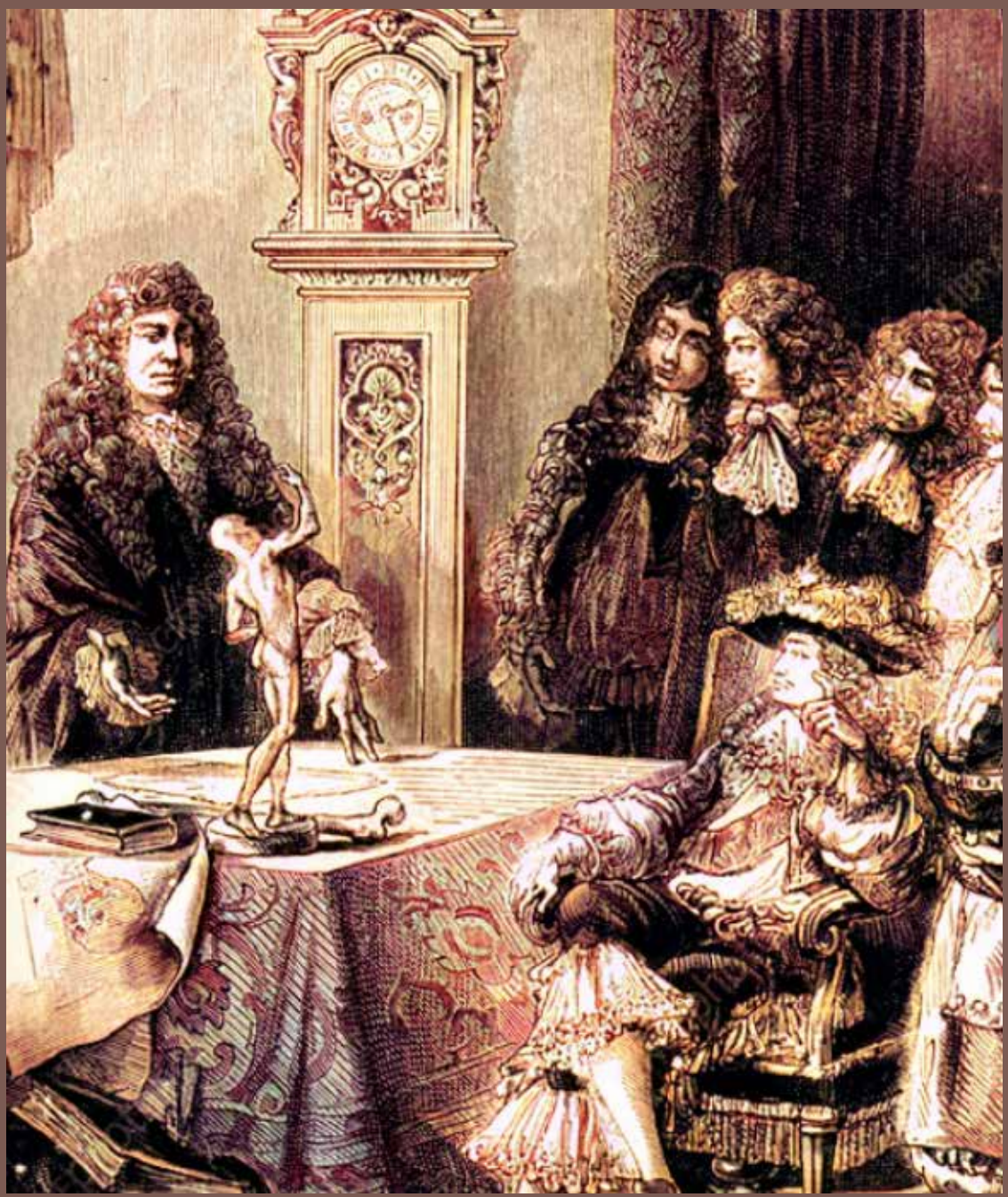
But anatomy also became emblematic of the power of medicine, demonstrating mastery over a sacred form. The public was captivated: no other scholarly discipline had done anything as dramatic as expose the inner secrets of the human body. These new opportunities for anatomical instruction were famously portrayed by artists in paintings such as Rembrandt's "The Anatomy Lesson of Dr. Nicolaes Tulp" (1632 – one of a number of 'Anatomy Lessons' portrayed by the artist), capturing simultaneously the privilege of medical training, the ascendancy of secularization within universities, and the transformation of earthly existence shown through the remains of lacerated flesh. [29] Interestingly, this painting created a visual tradition of representing anatomical instruction that inspired generations of group photographs taken in dissecting rooms in the twentieth century, depicting a rite of passage to a new professional identity, which will be discussed in a later section. [30]

These inquiries helped to boost the authority of the profession of medicine. While students were typically supervised in private while performing dissection, some medical schools built anatomical theaters to accommodate a public gallery where bodies were dissected in front of an audience. [31] Not only did these events make the public aware of this rite of passage in medical training, but the spectacle of human dissection was a money maker for medical schools. As the historian Giovanna Ferrari pointed out, in the 1640s Bologna started hosting annual public anatomy demonstrations to coincide with the Carnival, where spectators would appear in the "magnificently decorated theater" wearing masks and would applaud in amazement at the unraveling of the human body. [32]

The underlying importance of these developments in anatomy, both in terms of the new visceral observations made by practitioners and the observations of their work by the public, was that it demonstrated that medical knowledge is not static; it is not fixed in words inscribed on a page that could be relied upon for hundreds of years. Indeed, these acts informed the mindset that was emerging in the sixteenth century that observation and experiment are necessary to fostering human improvement. It was this line of thinking that led to what historians call the Scientific Revolution. This set the stage for a turn toward practical, hands-on training in medical education and the rise of experimental inquiry as a foundation for medical science.

Fig 24: Anatomical theater in the Archiginnasio, Bologna

ENTREPRENEURIAL ANATOMISTS



OF THE ENLIGHTENMENT

The popularity of anatomical lectures caught on and by the beginning of the eighteenth century, lectures across Europe were offered to the public for a fee by entrepreneurial instructors. [33] As early as the 1730s in London, for example, advertisements for medical teaching were widespread in newspapers and bulletins. What's interesting about these lectures is that they were offered by individuals, sometimes in association with a hospital, sometimes in a private parlor. Such instruction was unregulated, and the popularity of these lectures created an immensely competitive environment for entrepreneurial medical "training." However, despite the popularity, the open marketplace for medical education and unenforced licensing requirements for medical practice created conditions that challenged the credibility of the medical profession. [34]

The anatomical lectures took on a dual role in the medical marketplace. Within the context of clinical instruction, anatomy was seen as a precursor to medical practice. The Scottish surgeon and anatomist Charles Bell said that during his anatomical lectures, "regular and full Demonstrations of the Parts dissected are given; where the Application of Anatomy to Surgery is explained, and the Methods of operating shown on the Dead Body." [35] However, many other lecturers were "anatomical entrepreneurs," capitalizing on the popularity of the subject by offering demonstrations purely for entertainment or as a way to discuss wider topics in natural philosophy or theology.

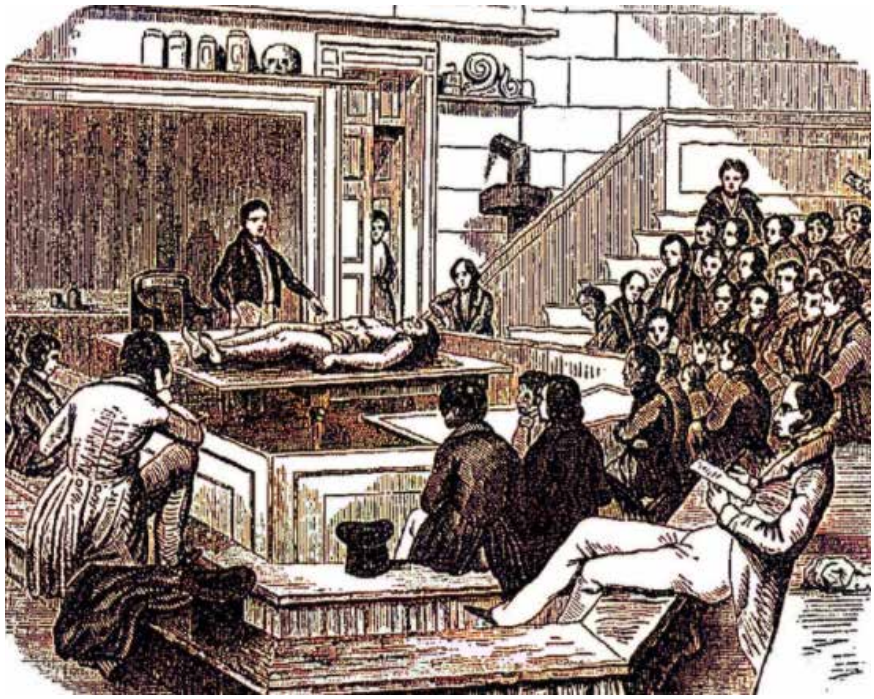
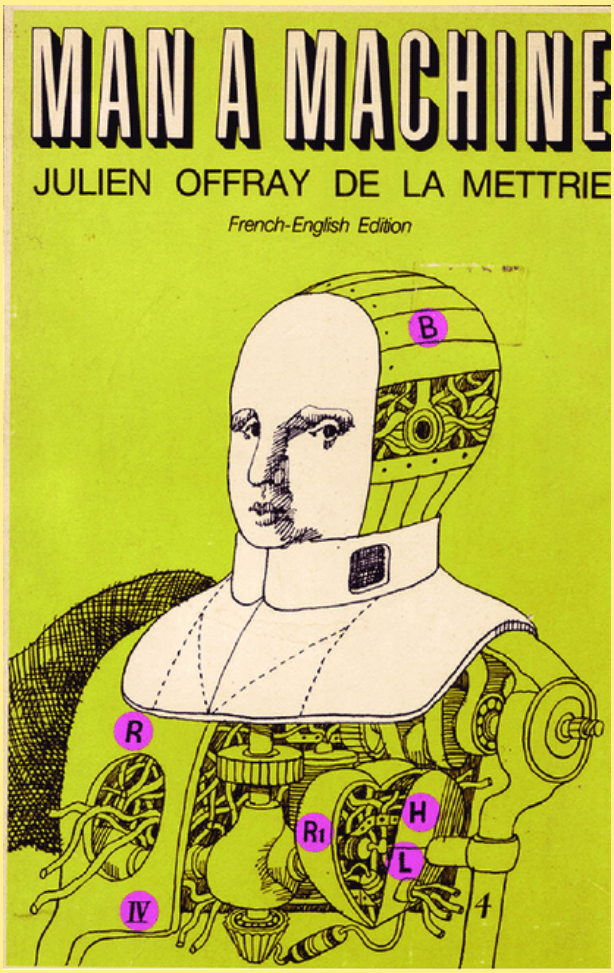


Fig. 25 (opposite page): Anatomy Lesson in 1778 represented in 1864 illustration. Fig. 26 (above): Students depicted attending anatomical lectures in eighteenth-century London

Bones, Muscles, and Machines

In 1699, a crowd gathered to watch a feat of physical prowess by William Joy, known as "the strong Kentish man." He lifted a 2000 lb weight and then pulled on a rope that was thick enough to hoist a 3000 lb weight with such force that he ripped the rope in half. One astonished witness to this was the physician Hans Sloan, who took home a fragment of the rope and added it to his portfolio of curious specimens that later formed the founding collection for the British Museum. Sloan was perplexed by what he saw, saying that when he looked at the strong Kentish man "nothing appears outwardly to give him such force." Sloane's friend, John Locke, was equally dumbfounded by the spectacle of the super-strong Joy as to declare him "a subject of speculation and enquiry to the philosophical world." For many years the man's muscle mass and size were the focus of attention. While William Joy did not look particularly different in external appearance, the thought was that some anatomical anomaly must account for his strength.

A century earlier, the explanation for such power would likely relate to some supernatural force, perhaps even demonic possession. However, by the eighteenth century, anatomy and physiology became increasingly linked to mechanical philosophy, the view that everything—from the macrocosm of the universe to the microcosm of the human body—was designed like clockwork and regulated by physical laws. [36]



It was a philosophy that inspired the French inventor Jacques de Vaucanson to build automata, mechanical "living dolls" and that inspired Julien La Mettrie to write *L'homme machine* (1746) which suggested that bodies were no more than automata, regulated by heart "pumps" and moved with tendinous levers. [37] Of course, the Enlightenment enthusiasm for machines and how they relate to the power of men (it was a very gendered discourse) goes beyond medical metaphors. Overwhelmingly the main discussions related to the industrial economy, with steam-engines and spinning Jennys informing analyses of productivity and cost-effective labor. [38]

When Locke suggested that William Joy be the focus of philosophical enquiry, what he was recommending was an examination of the physics of moving weights.

Automata & Anatomy

The model for such investigation was a machine. At a meeting of the Royal Society in 1733, John Desaguliers offered a presentation on the subject of "Natural and Artificial strength." Desaguliers was an Oxford-trained clergyman and engineer and Isaac Newton's protégé. He produced a device for measuring and comparing strength, and explained that with some wooden frames, a girdle, and some hooks, "any Person of ordinary Strength" who positioned their body the right way could easily appear to have superior strength.

While it seemed that the swindle of superhuman strength was exposed as merely a function of mechanical leverage, the examination nevertheless produced new insights to anatomy and physiology. Interestingly, a number of physicians in attendance at Desaguliers' demonstration went on to write books on osteology and myology—the study of bones and muscles—areas of study pioneered by the Royal Society at that time. Along with the books came a series of lectures offered at the College of Physicians "upon the nature and laws of muscular motion, which shall be accompanied with some experiment, dissection, or other anatomical demonstration, tending to illustrate and explain the subject of the lecture, and promote a more perfect knowledge of the animal economy." [39] Thus were the intertwined worlds of anatomy, physics, physiology, and engineering.

Fig. 27 a, b (above): "The Draughtsman," front and rear views of an automaton by Pierre Jaquet-Droz at the Musée d'art et d'histore, Neuchâtel. Circa 1768. The automaton was programmed to draw four pictures, including a portrait of Louis XV, royal patron of the arts

Anatomy & Pathology

Understanding anatomy through dissection yielded more than bodily structures. As layers of tissue were removed, sometimes surprising things were found inside bodies that became objects of curiosity and put on display in newly formed museums of pathology. In the seventeenth and eighteenth centuries, the medical interest in anatomy moved beyond the acquisition of knowledge about archetypical human form, toward the investigation of pathology—deviations from the norm that may be linked to illness. Pathological specimens provided a link between illness and anatomical specificity. In other words, through anatomical dissection, one could see a disease *in situ* and localized to an organ. Cutting open dead bodies was no longer simply a matter of revealing knowledge about the internal structure of human form, but now included a search for the cause of death. The study of anatomy had now created the practice of postmortem examinations.

Fig. 28 (opposite page): Exhibition Hall of the Hunterian Museum at the Royal College of Surgeons in London. The collection was formed by John Hunter (brother of William Hunter) in the 1700s

Fig. 29 (right): Specimen of part of a tumor of the parotid gland of John Burley, removed and preserved by John Hunter in 1785

Thus, because of anatomical dissection, specimens of disease became a focus of attention, displayed in medical museums and propagated through illustration. Specimens were preserved in jars (and some collections, such as the Hunterian Museum, John Hunter's collection, at the Royal College of Surgeons exist to this day), and their history was described in catalogues that referred to the context of the patient's illness. In the eighteenth century, illustrated anatomical atlases grew in popularity and became precursors to the modern anatomical textbooks. In 1793, Matthew Baillie, nephew of the famous London anatomist William Hunter, published *The Morbid Anatomy of Some of the Most Important Parts of the Human Body*, the first systematic treatment of pathology in English. [40]

Yet what was normal and pathological, or abnormal, was not as straight-forward as identifying something like a tumor. This was not merely a study of healthy as opposed to diseased organs, but a question of anatomical differences between types of people. In the eighteenth century, the emergence of classification systems was a way to organize the kingdoms of nature, but the process was driven by cultural assertions of a hierarchy of superior and inferior types of being, underscoring racist and sexist prejudices. While superficial characteristics (such as skin color) were often used to represent different human 'types,' anatomists searched for ways that *internal* structures might indicate racial differences. In claiming to find anatomical differences, and to assert that certain types did not meet the standard of perfection set by the anatomical design of white, European males, science was used to justify social and political policies of exclusion and subordination. [41]

Celebrating this newfound claim to cultural authority—a position that transcended a mere claim to medical minutiae—the bodies that anatomists dissected and displayed for the public now claimed to represent knowledge about the

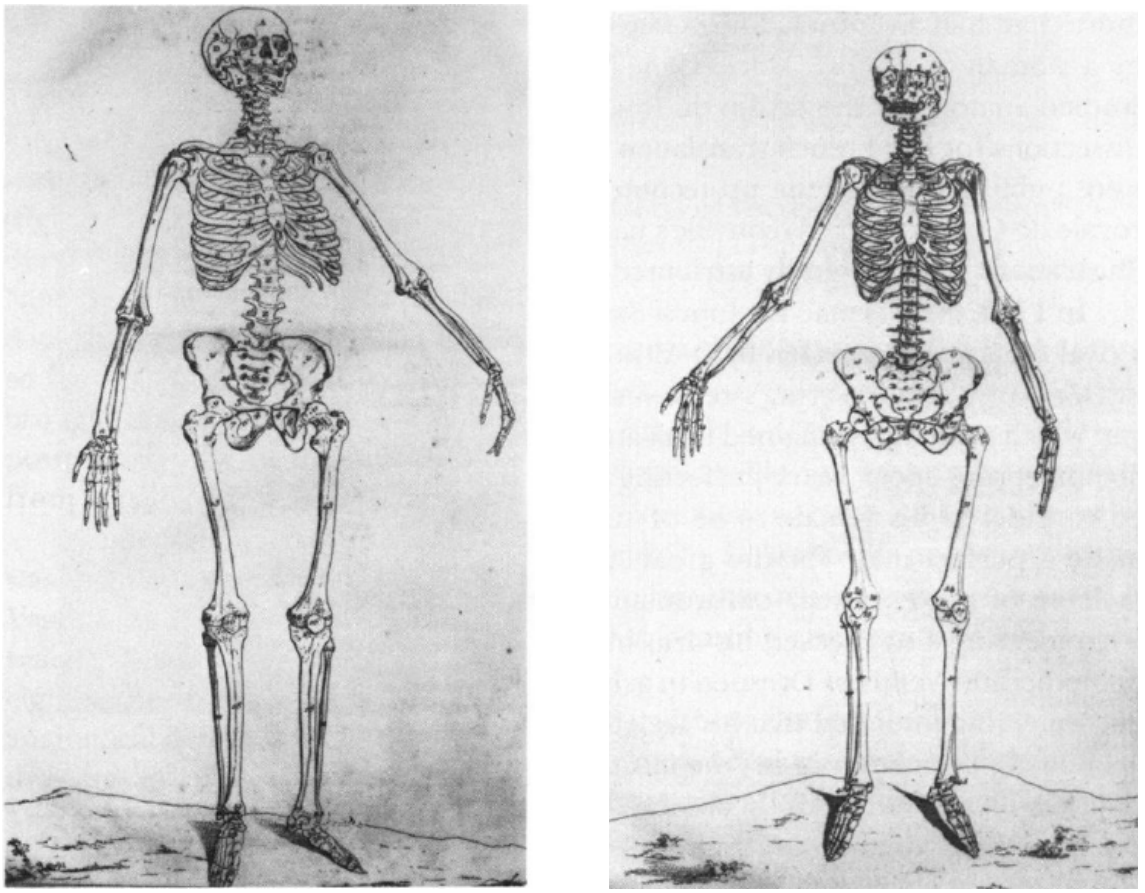


Fig. 30, a, b: Marie-Genevieve-Charlotte Thiroux d'Arconville], "Male Skeleton Studied from Front" (left) and "Female Skeleton, Drawn from Front View Only, Studied for Its Deviation from the Male Skeleton" (right) from Jean-J. Sue, *Traite d'osteologie* (Paris, 1759)

structure of civilization. This is what allowed anatomists to claim originality when producing female skeletons for study in the eighteenth century. The illustrations of their specimens ostensibly followed the conventions of scientific exactitude and objectivity. Yet, as Londa Schiebinger discusses, they portrayed the female skull as smaller than the male, a depiction "used to prove that women's intellectual capabilities were inferior to men's." [42]

The expansion of anatomy beyond the illustration of the "normative" male form into pathology and the study of anatomical variety created new spaces for specialization. The production of obstetrics atlases provides an example. In the second half of the eighteenth century, two anatomists, who were also among the first "man-midwives" to specialize in childbirth, each published elaborately illustrated books showing stages of pregnancy. Smellie's *A Sett of Anatomical Tables* (1754) and Hunter's *The Anatomy of the Human Gravid Uterus* (1774) were influential publications. [43] For centuries, the rituals of child delivery were a "domestic" affair, where women were assisted with birth by female midwives. But Smellie's and Hunter's books aimed to transform pregnancy into a medically controlled and clinically-oriented practice, and by doing so to put it into the domain of male physicians.

Fig. 31: Engraving from a drawing by Jan van Riemsdyk, from William Hunter, *Anatomia uteri humani gravidi*, Birmingham, 1774

This was facilitated by creating a new medical language to discuss obstetrics, and the highly detailed if also provocative images of human fetuses—some drawn from the anatomists' own dissections of pregnant women—offered a perspective never provided before in medical manuals for women's health. By drawing on the authority of anatomical history, these works sought to legitimize the male presence in the delivery room and justify the expansion of their practice into areas traditionally tended to by women.

In his book *The Birth of the Clinic,* the well-known French philosopher Michel Foucault opined that the birth of modern medicine was characterized by what he called the "clinical gaze," which was linked to new observations of pathological states made visible through post-mortem practices. In other words, when dissection stopped being a show celebrating the divine architecture of the human body and began deriving knowledge about disease through autopsy, the clinical environment in which these observations were made was no longer open to public viewing. Instead, anatomical atlases and other carefully illustrated books and museums took on a new pedagogical role in the dissemination of anatomical knowledge.

Virtual Bodies

The Intersection of Art & Anatomy

From the Middle Ages until the nineteenth century, authorities struggled with the justification to sanction human dissection, and, in England, Henry VIII limited it to the bodies of hanged murderers. Therefore, bodies were not easy to procure. As historian Ruth Richardson observed, cultural and religious beliefs forged a relationship between the soul and the sanctity of an intact corpse which made dissection morally objectionable. These challenges limited the availability of corpses to supply the demand among anatomy teachers and medical schools, leading to the underground activities of grave robbers, known as body-snatchers or "resurrectionists." [45]

In Britain, the 1832 Anatomy Act outlawed dissection of condemned murderers but allowed dissection to proceed with "unclaimed bodies" of deceased paupers from public hospitals, poorhouses, and workhouses, turning dissection from an act of retribution against murderers into a punishment for poverty. Owing to the lack of enforcement powers and personnel in this regulatory office, the rules and regulations of the Anatomy Act were circumvented from the time of their passage until the 20th century by hospitals, medical schools, physicians, and students. In a relentless quest for bodies for dissection, the poor were preyed upon by unscrupulous cadaver purveyors. More insidiously, the demand for cadavers created an incentive for serial killers, such as the notorious duo William Burke and William Hare, to commit murder for medical supply. Developing a skill for suffocating victims without leaving marks on the body, they sold their corpses (16 in all at £10 each) to the unwitting Edinburgh anatomy professor Robert Knox in the early nineteenth century, but were later tried and convicted. [46]

The sensitivity that had long surrounded the dissection of human bodies encouraged the development of alternative ways to preserve and accurately represent each demonstration for the benefit of sharing knowledge. This provided a unique opportunity for artists. Since the Renaissance, realism as an artistic genre had prompted artists to study closely the human form to create naturalistic renderings of their subjects. The benefits of studying anatomy to the artist was reciprocated when artists used their skills to produce highly detailed anatomical models and drawings for use in medical books. The relationship led to the creation of the field of medical illustration.

Italy in the seventeenth century was home to the innovations of artists who developed models made from wood, ivory, leather, and wax as anatomical teaching aids. One notable artist was Gaetano Giulio Zummo (1656–1701, better known as Zumbo), who worked in Genova alongside the chief surgeon and anatomist Guillaume Desnoues to reproduce in colored wax the dissections performed at the hospital. [47]

Fig. 32 (opposite page): Gaetano Giulio Zummo (1656-1701) anatomical model made of wax, 17th century. From Specola Collection, University of Florence, Italy

In Bologna, once the leading European center for anatomical studies, some of the most exciting advances in artistic anatomy would capitalize on earlier efforts. Attributed to the patronage of Pope Benedict XIV (1740-1758), the first museum of anatomy was established, and the production of anatomical waxworks was pioneered. Artists such as the painter and sculptor Ercole Lelli produced intricate life-size figures called écorchés, or models of "muscle-men" that had no skin or superficial tissue, and are still on display in the anatomy room at

Fig. 33: The anatomy room, with figures by Ercole Lelli, in Palazzo Poggi, Bologna (detail shown above)

Palazzo Poggi in Bologna. [48]

Before long the technique spread throughout Europe, with artist-anatomists gaining attention by making full-length wax anatomical models of the female body. The most famous of these celebrated 'Venuses' were also exhibited at the Anatomy Museum (now the Palazzo Poggi Museum) in Bologna and at the Royal Museum of Physics and Natural History at Florence, commonly referred to as 'La Specola.' As art historian Corrina Wagner writes, "From her perfect exterior, with her pearls and real hair, she can be dismantled, layer by layer, taking the observer down through the various strata of the body: through the musculature to the mammary glands; under the ribcage to the lungs and the heart; under the intestines to the uterus and other organs of the lower abdomen. Finally, the heart, stomach, and uterus could be opened, the latter organ revealing a tiny curled foetus." [49]

The history of anatomical art is a history of evolving styles, from the scale and embellished magnificence of Renaissance naturalism to the "warts and all" realism of John and William Hunter. In 1858 another style emerged, described as a "non-style style" by art historian Martin Kemp: Henry Gray's *Anatomy: Descriptive and Surgical*, with 363 woodcuts from drawings made by the surgeon and artist Henry Vandyke Carter. The declared aim of this book was strictly pragmatic, rendering a diagrammatic view of the body for didactic purposes. Its plainness, according to Kemp, served the institutionalized interests of instructors well. Focused on matter-of-fact descriptions, the illustrations provided an "anonymous

Fig. 34: Clemente Susini and workshop, Venerina, c. 1780–82, created for the Museo di Palazzo Poggi, Bologna. Photograph by Corrina Wagner

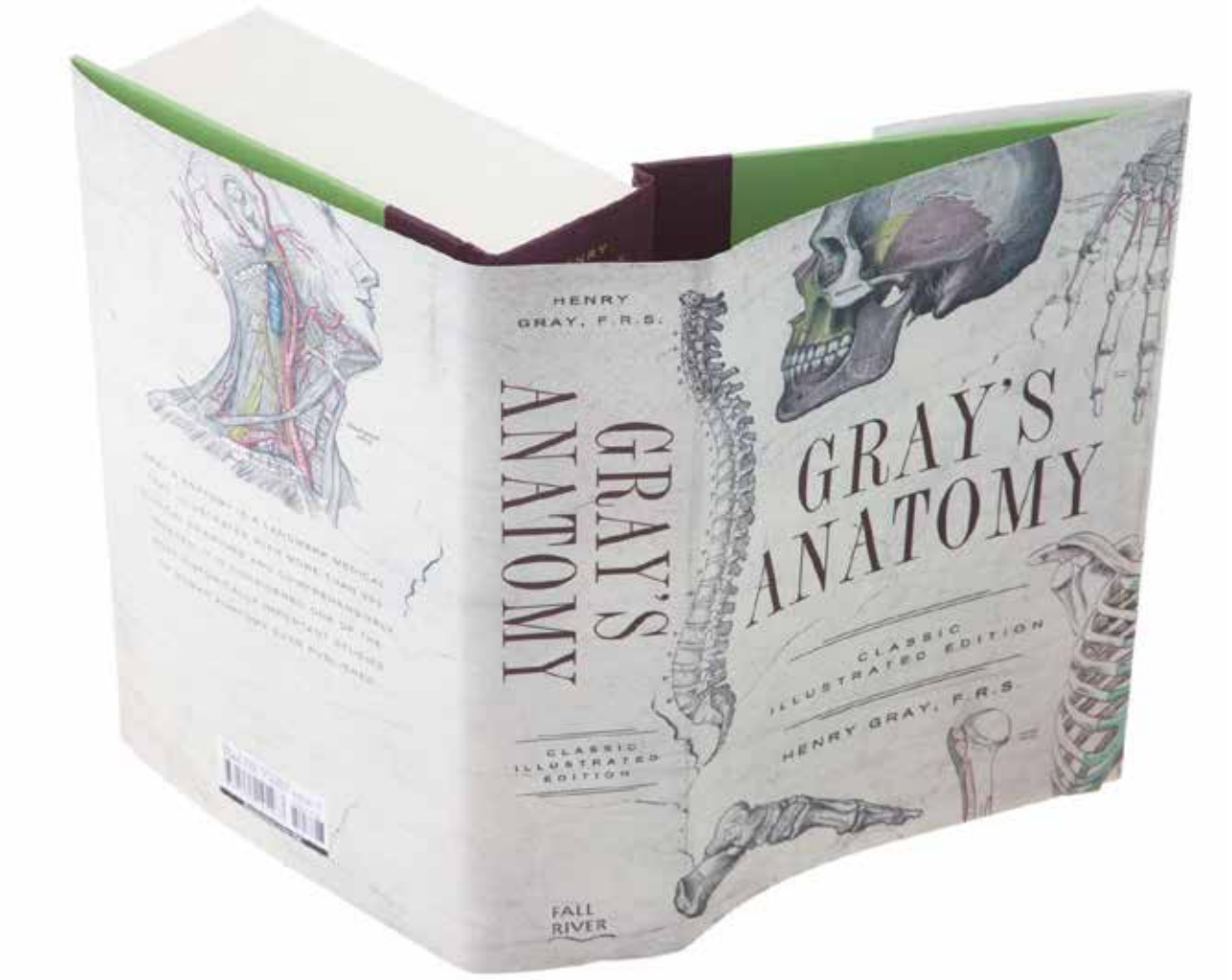


Fig. 35: 2008 edition of *Gray's Anatomy*

flatness" for less distraction. [50]

So appealing was the simplicity of the book that it became a classic, with generations of editors taking advantage of new technologies of reproduction—from x-ray visuals to color printing—so that by its 150th anniversary edition in 2008 it had grown to 1551 pages. [51]

In their book, *Dissection: Photographs of a Rite of Passage in America, 1880-1930*, medical historian John Harley Warner and photographer James M. Edmonson examine over 100 photographs taken in medical schools that took advantage of the accessibility of photography to expose "the secrets of the dissecting room" through portraiture. The idea was to capture the moment when students gained an intimate knowledge of human anatomy, with students dressed in white coats, aprons, and bowler hats. However, many photographs of the macabre were compositions of dark humor, showing students propping up cadavers or posing with skeletons, pretending to play cards or reversing roles of dissector and dissected in staged tableaus.

While irreverent, taking pictures such as these might also be seen as a way of taming a stressful encounter with the remains of an eviscerated life, but nevertheless such photography contrasted with the implicit honor codes in medical education. To encourage professionalism in training, increased attention is now given to the fact that cadaveric dissection operates within the moral economy of medicine, for without dead or diseased human bodies, medicine itself would not exist.

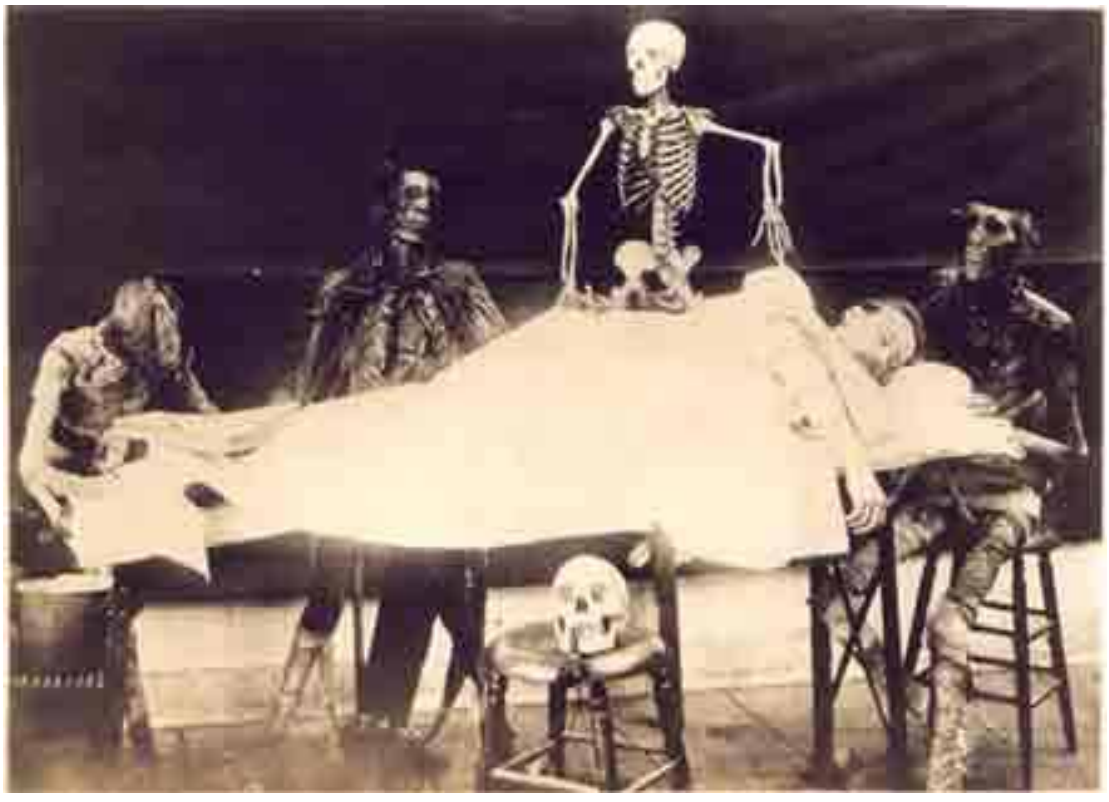


Fig. 36 (top) and 37 (bottom): "Tomfoolery" in the anatomy room. Examples of macabre humor from the early 1900s in photographs staged by medical students

Fig. 38: A Virtual Reality Temporal Bone Stimulation Station, from Fang, et al. [53]

Many of the photographs for the Warner and Edmonson book are located at the Dittrick Medical History Center at Case Western Reserve University. It is no coincidence that in 1950, Carl C. Francis, anatomy professor at Case Western, initiated the Willed Body program and established the first memorial service to honor those who had donated their bodies. In 1968, the Uniform Anatomical Gift Act provided regulations for gifting one's body to medical programs for dissection. In contrast to the pervasiveness of criminal bodies used for dissection for centuries, today in the United States few prisons allow prisoners to donate their bodies.

Today, it is common for medical schools to hold a memorial service for those who gifted their bodies for medical research, and medical student dissectors are asked to consider the cadaver as a "first patient." [52] Yet there are alternatives available to the study of anatomy that use advances in radiology and computer animation to produce graphic 3-D renderings for digital dissection. Companies have developed integrated software and hardware where trainees can use styluses that produce hepatic feedback to emulate the touch of procedures when simulating dissection or surgery.

Conclusion

Cadaveric dissection is the oldest existing form of interventional medical knowledge. Though its history is fraught with ecclesiastical conflict and moral discomfort, its immersive learning experience of investigating dead bodies remains an essential part of preparing for a career helping living bodies. Studies of modern training programs have shown that active, manual dissection provides unique insights to anatomical and clinical competencies. Unravelling the complexity within anatomical details requires careful observation and an inquisitiveness that is fundamental to the clinical reasoning process. The rite of passage also indoctrinates students to the vulnerabilities of life and the professional responsibilities of healthcare providers.

Despite the emergence of genomic-based precision medicine, what remains unquestioned is the value of seeing the whole patient, rather than reducing medical knowledge to disembodied fragments of code. Yet given the costs and time constraints in ever more complex health professions' curricula, the practicality of detailed anatomical study is questioned, encouraging the implementation of alternative teaching modalities, such as plastinated prosections (a technique where water and fat are removed from biological specimes and replaced with a type of plastic for preservation), 3D printing, web-based platforms, multimedia programs, medical imaging software, and virtual reality. [54] What anatomy through history shows us is that there are many viable modalities for studying the fabric of the human body. Just as artists supplemented anatomical studies in the seventeenth century with wax models, the art and science of digital representation is another chapter in the evolution of anatomical education.

Fig. 39: Medical students inspecting a model skeleton in the anatomy learning center at UCSF. From the Willed Body Program website

References

1. S.G. Marketos and G.J. Androutsos, "The Healing Art in the Iliad," in S.A. Paipetis, ed., *Science and Technology in Homeric Epics* (New York: Springer, 2008), 275-281.
2. For a recent analysis of Galen's life and work, see Susan Mattern, *Galen and the Rhetoric of Healing* (Baltimore: Johns Hopkins University Press, 2008).
3. Margaret Tallmadge May, *Galen on the Usefulness of the Parts of the Body*, Translated from the Greek with an Introduction (Ithaca: Cornell University Press, 1968), 2 Volumes.
4. Roger French, "The Anatomical Tradition," in W.F. Bynum and Roy Porter, eds, *Companion Encyclopedia of the History of Medicine,* Volume 1 (London and New York: Routledge, 1995), p. 83.
5. Details regarding Galen's anatomical knowledge are provided by Dr. Kidd, "Cursory Analysis of the Works of Galen, so far as they relate to Anatomy and Physiology" in *Transactions of the Provincial Medical and Surgical Association* 6, No. 2 (1837).
6. Emilie Savage-Smith, "Attitudes Toward Dissection in Medieval Islam," *J. Hist of Med and Allied Sciences* 50 (1995), 67-110, p. 90 for references.
7. See William Alexander Greenhill, "Galen," in William Smith, ed., *Dictionary of Greek and Roman Biography and Mythology* Volume 2 (London, 1899), p. 213.
8. Savage-Smith, op. cit. (n. 6) p. 69.
9. Leonard Wilson, "The problem of the discovery of the pulmonary circulation," *J. Hist Med and Allied Sciences* 17 (1962), 229-44. Though others have indeed argued that Ibn an-Nafis simply argued through logical inference the theory of pulmonary circulation, ie, Max Meyerhof, "Ibn An-Nafis (XIIIth Cent) and his theory of the lesser circulation," *Isis* 23 (1935), 100-120.
10. Mohammadali M. Shoja and R. Shane Tubbs, "The History of Anatomy in Persia," *Journal of Anatomy* 210, no. 4 (April 1, 2007): 359–78, https://doi.org/10.1111/j.1469-7580.2007.00711.x., p. 364.
11. William Osler, *The Evolution of Modern Medicine: A Series of Lectures Delivered at Yale University* (1913), online through Project Guttenberg, http://www.gutenberg.org/files/1566/1566-h/1566-h.htm#2H_4_0019.
12. Avicenna quoted by Savage-Smith, op. cit. (n. 6) p. 92.
13. For this account see Shoja and Tubbs, op. cit. (n. 10) p. 368.
14. M.H. Infusino, D. Win and Y.V. O'Neill, "Mondino's book and the human body," *Vesalius* 1 (1995), 71-76.
15. Ibid., p. 74.
16. M. Kemp et al., *Spectacular Bodies: The Art and Science of the Human Body from Leonardo to Now* (Hayward Gallery, 2000).
17. Giovanna Ferrari, "Public Anatomy Lessons and the Carnival: The Anatomy Theatre of Bologna," *Past and Present* 117 (1987), 50-106.
18. Martin Kemp, "Dissection and Divinity in Leonardo's Late Anatomies," *J of the Warburg and Courtauld Institutes* 35 (1972), 200-225, p. 201.
19. C.D. O'Malley, J.B. Saunders, C.M. Saunders, *Leonardo Da Vinci on the Human Body* (Gramercy, 2003).

20. Kemp, "Dissection and Divinity," op. cit. (n. 18) p. 212.
21. Quoted in ibid., p. 216.
22. Kemp, *Spectacular Bodies*, op. cit. (n. 16) p. 35.
23. Kemp, "Dissection and Divinity," op. cit. (n. 18) p. 225.
24. Quoted in M. F. Ashley Montagu. "Vesalius and the Galenists." *The Scientific Monthly* 80, no. 4 (1955): 230-39. Accessed July 6, 2021. http://www.jstor.org/stable/20970, p. 231.
25. Cynthia Klestinec, "A History of Anatomy Theaters in Sixteenth-Century Padua," *J. Hist of Med and Allied Sciences* (59) 2004, 375-412, p. 376.
26. Abdul Haq Compier, "Rhazes in the Renaissance of Andreas Vesalius," *Medical History* 56 (2012), 3-25.
27. Montagu, op. cit. (n. 24) p. 238.
28. Andrea Carlino, "Knowe thyself: Anatomical figures in early modern Europe," *RES: Anthropology and Aesthetics* 27 (1995), 52-69.
29. Gary Steiner, "The Cultural Significance of Rembrandt's 'Anatomy Lesson of Dr. Nicolaas Tulp,'" *History of European Ideas* 36, no. 3 (September 1, 2010): 273–79, https://doi.org/10.1016/j.histeuroideas.2010.02.004
30. J.H. Warner and J.M. Edmonson, *Dissection: Photographs of a Rite of Passage in American Medicine, 1880-1930* (Blast Books, 2009)
31. Michael Stolberg, "Learning Anatomy in Late Sixteenth-Century Padua," *History of Science* 56, no. 4 (September 30, 2018): 381–402, https://doi.org/10.1177/0073275318794581
32. Giovanna Ferrari, "Public Anatomy Lessons and The Carnival: The Anatomy Theatre of Bologna," *Past & Present* 117, no. 1 (November 1, 1987): 50–106, https://doi.org/10.1093/past/117.1.50.
33. A. Guerrini, "Anatomists and Entrepreneurs in Early Eighteenth-Century London," *Journal of the History of Medicine and Allied Sciences* 59, no. 2 (2004): 219–39, https://doi.org/10.1093/jhmas/jrh067
34. Susan C. Lawrence, "Entrepreneurs and Private Enterprise: The Development of Medical Lecturing In London, 1775-1820," *Bulletin of the History of Medicine* 62, no. 2 (1988): 171–92
35. Carin Berkowitz, "Systems of Display: The Making of Anatomical Knowledge in Enlightenment Britain," *The British Journal for the History of Science* 46, no. 3 (2013): 359–87, https://doi.org/10.1017/S0007087412000787.
36. Kemp, Spectacular Bodies, op. cit. (n. 16).
37. Corinna Wagner, "Replicating Venus: Art, Anatomy, Wax Models, and Automata," *19: Interdisciplinary Studies in the Long Nineteenth Century*, no. 24 (2017), https://doi.org/10.16995/ntn.783
38. Alan Q. Morton, "Concepts of Power: Natural Philosophy and the Uses of Machines in Mid-Eighteenth-Century London," *The British Journal for the History of Science* 28, no. 1 (1995): 63–78.
39. John H. Appleby, "Human Curiosities and the Royal Society, 1699-1751," ed. Desmond George King-Hele, *Notes and Records of the Royal Society of London* 50, no. 1 (1996): 13–27, https://doi.org/10.1098/rsnr.1996.0002.
40. Berkowitz, "Systems of Display" op. cit. (n. 35).
41. Londa Schiebinger, "The Anatomy of Difference: Race and Sex in Eighteenth-Century Science," *Eighteenth-Century Studies* 23, no. 4 (1990): 387–405, https://doi.org/10.2307/2739176
42. Londa Schiebinger, "Skeletons in the Closet: The First Illustrations of the Female Skeleton in Eighteenth-Century Anatomy," *Representations* (Berkeley, Calif.), no. 14 (1986): 43, https://doi.org/10.2307/2928435.
43. Lyle Massey, "Pregnancy and Pathology: Picturing Childbirth in Eighteenth-Century Obstetric Atlases," *The Art Bulletin* (New York, N.Y.) 87, no. 1 (2005): 73–91, https://doi.org/10.1080/00043079.2005.10786229.

44. A. Wilson, *The Making of Man-Midwifery: Childbirth in England, 1660-1770, Concepts in Social Thought* (Harvard University Press, 1995).
45. R. Richardson, *Death, Dissection and the Destitute* (University of Chicago Press, 2000).
46. L. Rosner, *The Anatomy Murders: Being the True and Spectacular History of Edinburgh's Notorious Burke and Hare and of the Man of Science Who Abetted Them in the Commission of Their Most Heinous Crimes* (University of Pennsylvania Press, 2010)
47. Alessandro Riva et al., "The Evolution of Anatomical Illustration and Wax Modelling in Italy from the 16th to Early 19th Centuries," *Journal of Anatomy* 216, no. 2 (February 2010): 209–22, https://doi.org/10.1111/j.1469-7580.2009.01157.x.
48. L. Dacome, *Malleable Anatomies: Models, Makers, and Material Culture in Eighteenth-Century Italy, Past & Present Book Series* (Oxford University Press, 2017).
49. Wagner, "Replicating Venus," op. cit. (n. 37).
50. Martin Kemp, "Style and Non-Style in Anatomical Illustration: From Renaissance Humanism to Henry Gray," *Journal of Anatomy* 216, no. 2 (February 2010): 192–208, https://doi.org/10.1111/j.1469-7580.2009.01181.x.
51. R. Richardson and Ralph Erskine Conrad Memorial Fund, *The Making of Mr Gray's Anatomy: Bodies, Books, Fortune, Fame* (Oxford: Oxford University Press, 2008).
52. John L. Coulehan et al., "The First Patient: Reflections and Stories about the Anatomy Cadaver," *Teaching and Learning in Medicine* 7, no. 1 (January 1, 1995): 61–66, https://doi.org/10.1080/10401339509539712.
53. Te-Yung Fang et al., "Evaluation of a Haptics-Based Virtual Reality Temporal Bone Simulator for Anatomy and Surgery Training," *Computer Methods and Programs in Biomedicine* 113, no. 2 (February 1, 2014): 674–81, https://doi.org/10.1016/j.cmpb.2013.11.005.
54. Arunan Jeyakumar, Bhanuka Dissanayake, and Lakal Dissabandara, "Dissection in the Modern Medical Curriculum: An Exploration into Student Perception and Adaptions for the Future," *Anatomical Sciences Education* 13, no. 3 (2020): 366–80, https://doi.org/10.1002/ase.1905.

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