Spring 2023

An Investigation of the Galenic Influence on the Artistic Depiction of Anatomical Concepts During the Renaissance

Fatima Amjad

An Investigation of the Galenic Influence on the Artistic Depiction of Anatomical Concepts during the Renaissance

by

Fatima Amjad

Bachelor of Arts
Salem College, 2021

Bachelor of Science
Salem College, 2021

Submitted in Partial Fulfillment of the Requirements

For the Degree of Master of Arts in

Art History

College of Arts and Sciences

University of South Carolina

2023

Accepted by:

Andrew Graciano, Director of Thesis

Anna Swartwood-House, Reader

Lydia Mattice Brandt, Reader

Cheryl Addy, Interim Vice Provost, and Dean of the Graduate School

ACKNOWLEDGEMENTS

The idea of building upon the interdisciplinarity of art and science stemmed from my interest in Biology and Art History. I double majored in Art History and Biology during my undergraduate studies because both fields fascinate me equally. Dr. John Hutton was my first Art History professor, and I am sincerely grateful for his continued support and encouragement that led me to pursue this master's degree.

Dr. Andrew Graciano's 'Art and Anatomy' course in the Spring of 2022 further motivated me to select this topic for my thesis research. I appreciate Dr. Graciano's willingness to guide me through this whole thesis writing process, as my thesis advisor. I would also like to acknowledge Dr. Brandt's and Dr. Swartwood-House's feedback and valuable advice during the editing and revision process.

ABSTRACT

The Renaissance era was a period marked by an intellectual and artistic resurgence in Europe, during which artists sought inspiration from Classical sources. This resulted in a move away from stylized medieval aesthetics and towards a renewed emphasis on accuracy and humanity in art. Renaissance artists developed art styles that emphasized perspective, proportion, and anatomy, creating more lifelike and naturalistic representations of the human figure and the natural world. The adoption of naturalism and individualism in the arts paired with the rediscovery and retranslation of ancient anatomical texts propelled artists and anatomists to deepen their understanding of the human body.

My thesis focuses on the impact of Claudius Galen's (129-216 CE) anatomical Corpus on the works of artists like Leonardo da Vinci and anatomists, Mondino de Luzzi, Berengario da Carpi and Vesalius. I identify and pinpoint the specific aspects of illustrations and drawings that show heavy Galenic influence. This is significant because while art historical and anatomical scholarly sources discuss Galen's influence on the Renaissance artists and anatomists, there is room for greater specificity of detail in the identification of Galenic ideals that were adopted by these artists and anatomists.

Moreover, my thesis presents the potential reasons for the heavy Galenic influence during the Renaissance in the form of the common problem that is prevalent in the disciplines of art and science, i.e., the dilemma between mimicking nature and

sticking to empirical evidence versus building upon the naturalistic qualities of a subject and perfecting it. I argue that due to artistic reasons that stemmed from the rise of Humanism and the revival of Classicism, artists and anatomists chose to adopt the universal truth (which was reduced to Galenic interpretation of the body at that time). This universal truth was preferred over the objective and empirical evidence collected through the dissection of human bodies. In my thesis, I postulate that in the works of Leonardo da Vinci, Mondino de Luzzi, Berengario da Carpi (and at times Vesalius), aesthetic and compositional choices prevalent during the Renaissance and related to the depiction of the human body took precedence over the more utilitarian aspects of the body such as its function, its internal phenomena and most importantly, the accuracy of its workings.

Methodology: My thesis contains an in-depth literature review of several primary and secondary sources by art critics and art historians in addition to medical journals, peer-reviewed articles and the most up to date online sources for medical research. Additionally, I conduct formal and scientific analyses of the drawings and illustrations from the treatises and books of Leonardo da Vinci, Mondino de Luzzi, Berengario da Carpi and Vesalius.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

During the Italian Renaissance (1340-1550), there was a shift towards a more naturalistic and realistic representation of the human form, and away from the idealized and stylized depictions of the Middle Ages. This shift is often referred to as the "rediscovery of the human body," and it was marked by a renewed interest in anatomy and the study of perspective.[1] One of the earliest examples of this new approach can be seen in the work of the Italian painter Giotto di Bondone (1267-1337).[2] His frescoes in the Scrovegni Chapel in Padua, Italy, are known for their realistic depictions of human figures and emotional expressions.[3]

However, the most famous Renaissance artists who exemplified this naturalistic style were Leonardo da Vinci (1452-1519) and Michelangelo Buonarroti (1475-1564). Leonardo was a true Renaissance man, known not only for his paintings but also for his scientific and engineering innovations. His paintings, such as the *Mona Lisa* (painted between 1503 to 1519) and *The Last Supper* (1494-96) are characterized by their lifelike representation of human figures, with careful attention paid to anatomy and perspective.[4] Renaissance Humanism can be attributed to the rise of individualism and naturalism in

[1] Henry E. Sigerist, "The Foundation of Human Anatomy in the Renaissance." S*igma Xi Quarterly* 22, no. 1 (1934): 10.
[2] Eva Frojmovič "Giotto's Circumspection." *The Art Bulletin* 89, no. 2 (2007): 199.
[3] Frojmovič, "Giotto's Circumspection", 200
[4] Don Gelasio Caetani, "The Myriad-Minded Leonardo Da Vinci, Forerunner of Modern Science." *The Scientific Monthly* 19, no. 5 (1924): 451

art styles during the late 13th-century Italy. Artists began to focus on the individual human form, and to depict it in a more realistic and naturalistic way. This included the study of anatomy, as well as the use of perspective and light to create a more lifelike representation of the world. Humanism also led to a greater interest in classical art and literature, as scholars and artists looked to the achievements of the ancient Greeks and Romans for inspiration. This Classical revival had a significant influence on Renaissance art, leading to a renewed interest in classical themes and styles. The Classical style was characterized by a focus on harmony, proportion, and balance, drawing on the principles of classical art and architecture.[5] The classical canon refers to the set of ideal proportions and measurements that were believed to define beauty in classical Greek and Roman art. These proportions were later adopted and further developed during the Renaissance, becoming a fundamental part of the visual language of Western art.

The canon was based on a system of ratios, in which the length of various body parts was related to one another in specific ways. For example, the height of the head was one eighth of the total height of the body, while the length of the foot was one sixth of the length of the leg. These ratios were believed to create a harmonious and balanced composition and were used to create idealized representations of the human form.

In Renaissance art, artists such as Leonardo da Vinci further refined and expanded upon the classical canon, using it as a basis for their own work. They studied the proportions of the human body in detail, making precise measurements and sketches to create anatomically accurate and lifelike figures. While many Renaissance artists did value the study of nature and the human form as the foundation for creating realistic and

[5] Daniella Rossi, "Humanism and the Renaissance". *The Year's Work in Modern Language Studies* 69 (2007): 477.

naturalistic art, not all artists copied directly from nature in the same way or to the same degree.[6] Leonardo da Vinci was known for his ability to idealize the human form, creating figures that were more perfect and beautiful than real life. He used their knowledge of anatomy and proportion to create balanced, harmonious compositions that were both naturalistic and idealized.[7] This practice of idealizing the natural forms permeated the field of anatomy. Anatomists such as Mondino de Luzzi and Berengario da Carpi performed dissections to understand the inner workings of the body. Their dissection studies, however, were not exact records of all that was seen and discovered during the procedure.[8]

My thesis magnifies and explains these discrepancies between what the Renaissance artists and anatomists must have seen during the exploratory dissections of subjects versus what they recorded in their drawings, treatises, and books. My thesis research started with a thorough reading of Martin Clayton's and Ron Philo's *Leonardo da Vinci Anatomist* (2012) followed by a review of the English translations of Mondino de Luzzi's *Anathomia* (1500-1560), Berengario da Carpi's *Commentaria cum amplissimis additionibus super Anatomia Mundini* (1521) and Andreas Vesalius' *De humani corporis fabrica libri septem* (1543). I discovered that several illustrations in these books were not anatomically correct by modern standards. Further research revealed that during the Renaissance, the readily available translations of the widely popular Galenic Corpus provided a blueprint for those who were eager to learn about the

[6] Daniella Rossi, "Humanism and the Renaissance". *The Year's Work in Modern Language Studies* 69 (2007): 478.
[7] Daniella Rossi, "Humanism and the Renaissance", 479.
[8] Susan Standring, "A Brief History of Topographical Anatomy," *Journal of Anatomy* 229, no. 1 (September 2016): pp. 38.

internal phenomena of the body.[9] As mentioned earlier, humanism was a key contributor to the incessant urgency to learn more about the human body and ways to represent it accurately. [10]

What propelled me to consider the artistic choices made by Leonardo for his anatomical drawings was the relationship that has existed between mimicking nature empirically or idealizing it to suit the subject matter,[11] throughout the history of art. I observed and questioned the presence of Galenic influence in drawings that were made to record dissection procedures. Curious still was the lack of acknowledgement for Galen's teachings within Leonardo's illustrations and the accompanying notes. My work gauges the levels of Galenic influence that exists in Leonardo's anatomical drawings. It does the same for illustrations and drawings made for and by specific Renaissance anatomists. The purpose of these interrogations is to understand and explain why artists and anatomists of the Renaissance adhered to Galenic conventions. What artistic and cultural reasons resulted in a preference for the generalized and popular truth which was reduced to Galen's Corpus and its teachings during the Renaissance?

The current state of the question regarding Galen's influence on Renaissance artists and anatomists concludes that such influence transcended decades and managed to permeate the creative minds during the Renaissance.[12] What I add to this question is the 'how' and the 'why'. How and why did Galen's teachings retain their popularity and authority? Why did artists and anatomists continue to be influenced by Galen? How did

---

[9] Standring, "A Brief History of Topographical Anatomy", 38-39
[10] Daniella Rossi, "Humanism and the Renaissance", 479.
[11] Peter Lamarque, "The Aesthetic and the Universal." *Journal of Aesthetic Education* 33, no. 2 (1999): 13
[12] Sanjib Kumar Ghosh, "The Evolution of Epistemological Methodologies in Anatomy: From Antiquity to Modern Times." *The Anatomical Record* 305, no. 4 (2021): 804-810.

they incorporate this influence in their works while simultaneously adhering to the artistic styles of the Renaissance in general and humanism in particular? How did these artists and anatomists merge the gap between dissection studies and aesthetically pleasing and acceptable depictions of the human body?

To answer these questions, I reference my primary sources that include the aforementioned books by Clayton and Philo, Mondino, da Carpi and Vesalius. Moreover, I do literature reviews and incorporate art historical ideas about naturalism and Galenic influence by Giorgio Vasari. My secondary sources include Susan P. Mattern's book "Galen and the Rhetoric of Healing" (2008) plus several commentaries on the mimetic theory of art and on Immanuel Kant's *Critique of Judgement* (1790) Johann Joachim Winckelmann. In particular, I make use of Kant's definition of 'aesthetics' and Peter Lamarque's commentary on Kant's concept of the 'universal' and the 'subjective' in artistic interpretation.

The first chapter of the thesis details the methodology and scope of my argument and supporting research. The second chapter provides Galen's biography in addition to answering the question of his popularity and the pervasiveness of his ideas. The third chapter summarizes the procedures of Mondino de Luzzi and Berengario da Carpi's dissections. I analyze the illustrations made for these anatomists' treatises and discuss several reasons for the presence of Galenic influence in the light of the rise of naturalism and aesthetical interpretations of nature during the 13th and 14th centuries. The fourth chapter considers Leonardo da Vinci's and Andreas Vesalius's anatomical drawings within the framework of the artistic tradition of the mimesis of nature with idealism and

perfection of form as additives. Lastly, the fifth chapter concludes my thesis and provides a summary of my proven points.

As one will see, the influence of Galenic anatomy on Renaissance art was a complex and multifaceted issue that has been widely discussed by art historians and critics. Some saw it as a positive development that allowed for greater accuracy and realism, while others believed it hindered creativity and imagination. In this thesis, I explore Galenic influence seen in the works of the Renaissance artists and anatomists and will explain the choices and reasons that led to the creation of drawings and illustrations that represent the human body.

CHAPTER 1

THE METHODOLOGY AND SCOPE OF THE ARGUMENT

Art historians and critics, such as Giorgio Vasari and (1511-1574) Johann Joachim Winckelmann (1717-1768), praised the Classical revival during the Renaissance and emphasized the importance of artistic accuracy in their writings.[13] Vasari, in his famous work, *The Lives of the Artists* (1568) championed the idea that artists should imitate nature as closely as possible to achieve true artistic greatness. He believed that the Classical style represented a pinnacle of artistic achievement and advocated for its revival as a means of restoring order and harmony to contemporary art. Vasari stated that the key to achieving artistic accuracy was through careful observation and study of nature.[14]

Similarly, Winckelmann, in his seminal work *History of Ancient Art* (1764), extolled the virtues of Classical art and argued that Greek art, in particular, represented the highest expression of human achievement in art. He stated that the idealization of forms and figures in art should be based on a thorough understanding of their natural proportions and characteristics.[15] Both Vasari and Winckelmann wrote about how the study of Classical art was essential for artists seeking to attain mastery in their craft. Based on Winckelmann's and Vasari's descriptions of refined art, Leonardo da Vinci 's

---

[13] Alina Payne. "Vasari, Architecture, and the Origins of Historicizing Art." *RES: Anthropology and Aesthetics,* no. 40 (2001): 57

[14] Alina Payne. "Vasari, Architecture, and the Origins of Historicizing Art.", 57-60

[15] James Rubin. Review of *Flesh and the Ideal: Winckelmann and the Origins of Art Histor*y, by A. Potts. *The Art Bulletin* 78, no. 2 (1996): 359. https://doi.org/10.2307/3046180.

works not only meet the criteria for naturalistic art, but they also exceed it. His works reveal both humanistic and naturalistic tendencies, as he was interested in portraying the human figure in a realistic and emotionally expressive way, as well as capturing the natural world in all its beauty and complexity.[16]

One of the questions that I address is whether Leonardo's anatomical drawings are truly mimetic of the human body or if he was idealizing the structures of the organs to harmonize, balance and complete all that was missing or that which was not explained by Galen's Corpus and yet was revealed in a dissected body. In their book, *Leonardo da Vinci: Anatomist,* Martin Clayton (head of Prints and Drawings at the Royal Collection Trust and a Leonardo specialist) and Ron Philo (senior lecturer in the Department of Cellular and Structural Biology at the University of Texas Health Science Center at San Antonio) argue that none of the translated notes from Leonardo's original *Anatomical Treatise* show any acknowledgement of Galen. They state that Leonardo was drawing the internal organs of the body as accurately as he could and yet they are puzzled by the continued appearance of Galen's mistakes in Leonardo's drawings.[17]

I would argue, to the contrary, that while Leonardo was conducting dissections and learning about Galen from Marcantonio Della Torre (a doctor he shadowed and made illustrations for), he was also reconciling the humanist merits of copying nature directly versus portraying the more well-known and readily accepted truth i.e., Galenic teachings of the human body. The continued presence of Galen's conventions in Leonardo's anatomical drawings then become an artistic choice to build upon that which was

[16] James S. Ackerman, "Leonardo Da Vinci: Art in Science." *Daedalus 127,* no. 1 (1998): 207-210
[17] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 56

empirical and visible (yet largely incomprehensible) to him during the dissections. Another method of approaching this subject is through Immanuel Kant's interpretation of the 'aesthetic' and the 'universal' in art. Immanuel Kant (1724-1804) was a German philosopher who is considered highly influential in the field of aesthetics, and his interpretation of the aesthetic experience is still widely discussed and debated today.[18] Kant argued that aesthetics concern the judgment of taste, and that such judgment is subjective, but also has a universal aspect that can be shared by all rational beings. He believed that beauty is a unique kind of experience that is distinct from other experiences. In his view, the beauty of an object is not a property of the object itself, but rather a response that the object elicits in the observer. This response is based on the observer's sensibility, or the way in which they perceive and process sensory information.

According to Kant, there are two main components to aesthetic experience: the subjective and the universal. The subjective aspect of the aesthetic experience involves the individual's personal response to the object, which is shaped by their individual sensibility. This means that different people may have different reactions to the same object, and that these reactions are influenced by factors such as personal taste, culture, and upbringing.[19] My argument about the artistic (idealized or generalized) depiction of the dissected body in the Renaissance has to do with the universal aspect of the aesthetic experience. Kant explained that there are certain characteristics of beauty that are universally recognized by all rational beings, regardless of their individual differences.

[18] Peter Lamarque. "The Aesthetic and the Universal." Journal of Aesthetic Education 33, no. 2 (1999): 3-5. https://doi.org/10.2307/3333683.
[19] Lamarque, The Aesthetic and the Universal, 8-11

The universal aspect of beauty is based on the object's ability to stimulate our cognitive faculties in a certain[20]

Considering this, I tie Leonardo's choices of realism and naturalism in his anatomical drawings with his decision to not ignore the universal aspect of the depiction of the human body. I discuss the details of his drawings in detail in Chapter four, but the crux of my theory is that Leonardo as an anatomist drew exactly what he saw during his dissections. However, as an artist, he 'humanized' and 'aestheticized' the universal and general truth of Galenic teachings. Peter Lamarque (born 1984), an art historian and analytical philosopher, explains that it is "possible to pursue aesthetics as an inquiry and recognize certain experiences as aesthetic without subscribing to aestheticism."[21] This school of thought is a departure from the Kantian logic of aesthetical critique, however, I agree that there are several artists (and people of science) within the Renaissance (and outside of it) who toy with and tease the boundaries of the empirical, the specific and the logical with undertones of the universal, the popular and the ephemeral without delving completing into the aestheticism.

It is evident that Leonardo was one such character. Others include Mondino de Luzzi, Berengario da Carpi and Andreas Vesalius. The discrepancies between Mondino's dissections and their illustrative records can be explained by a number of reasons. I detail several such reasons in Chapter three; however, a key component of my argument is the idea of 'morphological variations' that was used to generalize individual and specific dissection procedures. Alexandra Mavrodi and George Paraskevas (professors of anatomy at the Aristotle University of Thessaloniki, Greece) explain that art historians

[20] Lamarque, The Aesthetic and the Universal, 8-11
[21] Lamarque, The Aesthetic and the Universal, 4

and anatomists alike have explained the discrepancies between what Mondino most likely Saw during his dissections and what was made into illustrations for his book, *Anathomia* via morphological variations in the human body.[22]

Mavrodi and Paraskevas discuss the presence of Galenic influence in Mondino's work and the subsequent illustrations that were based on Mondino's work. They argue that when Mondino would sit and read from the Galenic Corpus while his students dissected a body, anything that was visible yet not explained by Galen's words was chalked up to chance and probability i.e., a structure not mentioned in Galen's works but discovered in the body was not ignored. It was concluded that it may or may not exist in all humans.[23] This is the crux of my argument about universality over specificity in the anatomical drawings of Renaissance artists and anatomists. I concur that Mondino was merging what he knew as the universal truth with empirical evidence that he was gaining through the close observation of the human body. I also theorize that Kant's concept of the sublime loosely fits Mondino's anatomical experiences. Kant's view of the universal aspect of aesthetic experience is closely tied to his concept of the sublime.

According to Kant, the sublime is an experience that transcends the limits of our sensory and cognitive abilities, and that involves a sense of awe and wonder in the face of something that is vast, powerful, or mysterious. Sublime is not a personal response but is also a universal experience that is based on our shared human nature.[24] By no means am I tying the concepts of the uncanny or surrealism to Mondino or his dissection practices.

---

[22] Alexandra Mavrodi and George Paraskevas. "Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages." *Croatia Medical Journal*, 55(1), 50-3.
[23] Mavrodi and Paraskevas. "Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages." 54
[24] Lamarque, The Aesthetic and the Universal, 7

My goal is to explain the preference for a collective, widely popular and readily accepted thought process (Galen's convention) that had been in 'use' for decades. Anatomists like Mondino and da Carpi were seeking the truth about the human body (encouraged by the Humanist school of thought). Simultaneously, these anatomists were considering the merits of believing in what they (and most other anatomists and artists) knew through Galenic teachings.[25]

Lastly, in my thesis, I discuss Vesalius' role in anatomy and his attitude towards the incorporation of Galenic influence in his works as a measure of adopting universality over specificity. In the book, *Visualizing the Body in Art, Anatomy, and Medicine since 1800:Models and Modeling* (2019), Rebecca Messbarger, a professor and the founding director of Medical Humanities at Washington University, St. Louis talks about Vesalius' approach to Galenic orthodox Corpus and the changes he proposed as a reaction to it.[26] She claims that Vesalius' illustrated plates show the dissected human body in such a way that they "elevate both the unmade body and the anatomist who unmakes it to the universal level of sublime art and artist".[27] Where Leonardo, Mondino and da Carpi showcased their preference for naturalism while holding on to the general acceptance of the Galenic works, Vesalius' research did not shy away from shunning redundant and 'old' knowledge.

I argue that Vesalius stayed partial to and biased towards the universality of human depiction in art. He did so by having Van Calcar add landscapes behind the

[25] Mavrodi and Paraskevas. "Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages." 55
[26] Andrew Graciano, Visualizing the Body in Art, Anatomy, and Medicine since 1800, (Routledge, 2019), Prologue: Modeling the Modern Body.
[27] Graciano, Visualizing the Body in Art, Anatomy, and Medicine since 1800, Prologue: Modeling the Modern Body.

images of dissected bodies and through the use of Classical figural proportions.[28] The idealized figures in Vesalian illustrations were meant to represent the ideal proportions of the human body similar to the drawings of classical sculpture. These figures were based on the classical principles of art, which emphasized symmetry, proportion, and balance. Therefore, while Vesalius steered heavily towards the empirical in art and science, he continued using aesthetical elements that imbued his illustrations with the quintessential Renaissance art traditions.

To conclude, art historians and anatomists have identified Galen as the source of heavy influence on the works of Renaissance artists and anatomists. My thesis unpeels the layers of this influence to reveal the artistic tendency of artists and anatomists to enmesh universality and generally accepted facts with empirical and objective evidence. The following chapters provide continued support for my arguments by analyzing the works of Galen, Leonardo, Mondino and da Carpi and identifying the ways in which they steered away from empiricism and towards idealism and generality.

[28] Jinpo Xiang and Santhana Venkatesan, "The Role of Vesalius and His Contemporaries in the Transfiguration of Human Anatomical Science," Journal of anatomy (U.S. National Library of Medicine, February 2023), 126

CHAPTER 2

THE EVOLUTION OF ANATOMY IN ART:

GALEN AND HIS CONTRIBUTIONS TO THE FIELD OF ANATOMY

To understand the extent of Galenic influence on Renaissance artists, it is important to get to know Galen as an anatomist and as a man of medicine. This chapter serves as a window into the historical background of Galenic anatomy and it provides the reasons for the transcendent popularity of Galen and his teachings through the decades.

Galen's Popularity Transcends Time

Galen was a Greek philosopher, scholar, physician, anatomist, writer, and an illustrator.[29] He was born on September 129 CE in the town of Pergamum in Asia Minor (current day Bergama, Turkey).[30] Galen grew up feeling a strong push to gain an education in Greek culture and literature and be fluent in the Greek language.[31] He studied in Alexandria in Egypt, Smyrna in Asia Minor and in Corinth in Greece. Galen prolonged his stay in Alexandria until 157 CE to gain medical knowledge from the Hippocratic Corpus preserved there.[32] The Hippocratic Corpus is worth mentioning

[29] O'Malley and Saunders, The Illustrations from the Works of Andreas Vesalius of Brussels.
[30] O'Malley and Saunders, The Illustrations from the Works of Andreas Vesalius of Brussels.
[31] Mattern, Galen and the Rhetoric of Healing, 3
[32] Mattern, Galen and the Rhetoric of Healing, 3-4

because it was one of the fundamental units of knowledge that Galen referenced and used throughout his lifetime.[33] The Corpus consisted of seven books called *Epidemics*. These books contained teachings by the Greek physician Hippocrates and his pupils as they travelled around the Aegean Sea and performed experiments and dissections at the Hippocratic School of Medicine on the island of Kos.[34]

In addition to the Hippocratic Corpus, Galen was deeply influenced by the god of medicine, Asclepius.[35] As per Galen's accounts in his Corpus, Asclepius guided Galen's father, Aelius Nicon through vivid dreams. As a result, Galen was encouraged to pursue medicine as a profession at the age of sixteen.[36] Galen's medical foundation was complex and hinged upon several modes of treatment.[37] He references Hippocratic human dissections in the case histories in his Corpus while also attributing patients' recurrent fevers to Asclepius' wrath.[38] This style of diagnosis was not uncommon during Galen's time.[39] His keen senses of observation and evaluation and his willingness to test his ideas via the scientific method of his time [40] made his writings and teachings stand out against the works of his contemporaries.

---

[33] Vivian Nutton, Galen: A Thinking Doctor in Imperial Rome (London: Routledge Taylor & Francis Group, 2020), 7
[34] Christos Yapijakis "Hippocrates of Kos—the Father of Modern Medicine." Clinical Research in Cardiology Supplements 5, no. S1 (2010): 5.
[35] Nutton, Galen: A Thinking Doctor in Imperial Rome, 7
[36] Nutton, Galen: A Thinking Doctor in Imperial Rome, 8
[37] Brockmann et al, "A God and Two Humans on Matters of Medicine: Asclepius, Galen and Aelius Aristides", 118
[38] Brockmann et al, "A God and Two Humans on Matters of Medicine: Asclepius, Galen and Aelius Aristides", 118-120
[39] Nutton, Galen: A Thinking Doctor in Imperial Rome, 13
[40] Nutton, Galen: A Thinking Doctor in Imperial Rome, 99

Galen was the first physician to have written extensively about the inner workings of the body.[41] Over 200 books are loosely attributed to him.[42] Most of his disease treatments were based on extensive experimentation and they became popular in medical schools throughout Alexandria by 500 CE.[43] The survival of Galenic texts over the centuries can be attributed to the Islamic Golden Age (8^{th}-14^{th} century).[44] The hub of wisdom and progress, Baghdad became a place of refuge for Galenism.[45] Hunayn ibn Ishaq al-Ibadi was an Arab physician and translator. He was a Galenist and translated over 129 of Galen's works from Greek to Arabic and Syriac.[46] He summarized complex Galenic theories into smaller sections and littered Avicennian and Hippocratic explanations within the sections.[47] This helped create bodies of work that had contextual roots as well as easily understandable versions of Galen's theories.[48]

The High Middle Ages saw a revival of the European powers.[49] The establishment of medical schools led to the retranslation of Galenic texts from Arabic to Greek and Latin. This retranslation is supposed to have helped further popularize the

[41] Mattern, Galen and the Rhetoric of Healing, 12
[42] Mattern, Galen and the Rhetoric of Healing, 12
[43] Nutton, Galen: A Thinking Doctor in Imperial Rome, 55
[44] Rachel Hajar. "The Air of History Part III: The Golden Age in Arab Islamic Medicine, An Introduction." Heart Views 14, no. 1 (2013): 43.
[45] Hajar, "The Air of History Part III: The Golden Age in Arab Islamic Medicine, An Introduction.", 44
[46] Hajar, "The Air of History Part III: The Golden Age in Arab Islamic Medicine, An Introduction.", 44
[47] Hajar, "The Air of History Part III: The Golden Age in Arab Islamic Medicine, An Introduction.", 45
[48] Hajar, "The Air of History Part III: The Golden Age in Arab Islamic Medicine, An Introduction.", 45
[49] Rachel Hajar, "The Air of History (Part II) Medicine in the Middle Ages." Heart Views 13, no. 4 (2012): 159. https://doi.org/10.4103/1995-705x.105744.

Galenic teachings.[50] As mentioned earlier, physicians like Hunayn ibn Ishaq added contextual information to Galen's Corpus (Figure A.1) As a result, after the translation into Greek and Latin, Galen's works became easier to understand and implement. Even though these translations of translated original work had been edited, amended and revised multiple times in various parts of the world, in the absence of ongoing dissections to further anatomical knowledge, the medical student of that time had only these manuals to consult.

In the Renaissance era, Galen experienced yet another boom in widespread popularity and acceptance. The Arabic translations of Galen's works became popular in western Europe when art academies started focusing on naturalistic drawings of the human body.[51] The interest in 'life-like' portrayal of the human body made the learners go back to available anatomical text in the field, and the Arabic textbooks were the most comprehensive treatise they could find. During the Medieval Period, the translated texts were handwritten. This meant that they had few copies and were not able to be distributed to the public freely. These translations stayed confined to the educated social circles. The invention of the printing press during the Renaissance allowed for their easy circulation and distribution. Italian humanists strived to track down the Greek originals to retranslate them and to get rid of misleading additions that had been made to Galen's works over the years. In 1526, the first full Greek edition of Galen's Corpus was printed.[52] Thirty-six years prior to that, the first full Latin edition of his works appeared in Europe.[53] The printing and translation of Galen's works over the decades helps us understand the extent

[50] Hajar, "The Air of History (Part II) Medicine in the Middle Ages.", 160
[51] Hajar, "The Air of History (Part II) Medicine in the Middle Ages.", 160
[52] Hajar, "The Air of History (Part II) Medicine in the Middle Ages.", 160
[53] Nutton, Galen: A Thinking Doctor in Imperial Rome, 134

of his popularity. It is important to get an idea of why and how his works survived if we are to understand the reasons behind his popularity amongst Renaissance artists.

Galen and the Humoral Theory

Galen's initial medical approach was largely based on the Hippocratic humor theory.[54] Like his predecessors, he believed that the balance of the four primary bodily fluids (phlegm, blood, yellow bile, and black bile) determined the health of an individual.[55] However, unlike Hippocrates, who thought that the humorous imbalance spread throughout the body to cause disease, Galen determined that any imbalance could be contained within the individual organs.[56] Furthermore, Galen added the fluctuation of temperament and behavior within the Hippocratic humor theory. Galen was a huge proponent for balance and symmetry in all health-related things. That meant that the perfect balance and harmony of the four main fluids in the body were necessary for health and wellness otherwise disease could get a hold of the body. For example, if a patient had developed a fever, then cooling down the body or prescribing remedies with 'cooling effects' would counterbalance the high temperature thus thermoregulating the body's harmony. This could mean simply prescribing a cold drink, or in some ancient practices, even bloodletting to restore the balance between warm and cold fluids of the body.[57]

To some extent this concept of cooling off a feverish or inflamed part of the body with cold water or compresses is still in practice in many parts of the world. The four

[54] Jacques Jouanna and Neil Allies, "The Legacy of the Hippocratic Treatise, The Nature of Man: The Theory of the Four Humors," *in In Greek Medicine from Hippocrates to Galen: Selected Papers,* ed. 6, Pilip van der Eijk (Brill, 2012), pp. 335.
[55] Jouanna and Allies, "The Legacy of the Hippocratic Treatise", 336
[56] Jouanna and Allies, "The Legacy of the Hippocratic Treatise", 336
[57] Jouanna and Allies, "The Legacy of the Hippocratic Treatise", 336

Galenic fluids were also deemed responsible for emotional and behavioral traits like experiencing anger, grief, hope and fear. The theory of the four bodily fluids was closely linked to the four Aristotelian elements of nature i.e., the earth, water, fire and air. Earth was represented by black bile, water by phlegm, air by blood and fire by yellow bile. Moreover, these humors were connected to celestial bodies, seasons, body parts and stages of life (Figure A.2).[58] Galen's physiology of human body comprised of 4 humors (blood, phlegm, black bile, and yellow bile), and 3 pneuma or spirits (natural, vital, and animal).

The humoral theory had a strong and long-lasting effect on the practices of medicines and philosophy as well as on European culture, literature and art in general.[59] Albrecht Dürer's (1471–1528) *Melancholia* is a famous engraving that was completed in 1514, during the Renaissance period in Europe. The engraving depicts a seated figure, believed to be an allegorical representation of melancholy or depression. The figure is surrounded by various objects, including a magic square, a compass, a bell, and a set of scales. The image has a brooding, contemplative mood, which reflects the melancholic state of mind that was often associated with artistic and intellectual pursuits during the Renaissance. The modern-day term 'melancholy' derives its origins directly from ancient Galenic humoral theory. 'Melas' means dark or black and 'chole' means bile. Galen

[58] Jouanna and Allies, "The Legacy of the Hippocratic Treatise", 336
[59] Karen Lyon, "The Four Humors: Eating in the Renaissance," Shakespeare & Beyond (Folger Shakespeare Library, December 18, 2015), https://shakespeareandbeyond.folger.edu/2015/12/04/the-four-humors-eating-in-the-renaissance/.

believed that an excess of black bile in the body could lead to excess sadness and lethargy.[60]

The humoral theory is now obsolete as there is no scientific basis for it. However, many common phrases in literature and common religious and cultural practices still find their roots in this centuries old pseudo-medical belief system.[61]

Galen and the Human Circulatory System

Both Galen and Hippocrates believed that the circulatory system consisted of two separate sets of vessels & tubes (arteries and veins).[62] Before Galen, the Greeks believed that the heart was at the center of living physiology. They called it 'a seat for the soul'[63]. Pre-Galenic concepts dictated that nourishment from the gut was carried to the liver where it was transformed into blood and was then carried to the brain, the rest of the body and to the lungs.[64] Air was taken up from the lungs into the left side of the heart and pumped into the arteries (thus air flowed into the arteries).[65] It was Galen who got rid of these theories and postulated that the blood was formed in the liver and transported to the right side of the heart by veins and then ultimately to the lungs. [66] He noted that arteries contained blood in addition to air so there must be a connection somewhere between the left and right chambers of the heart to allow blood to flow in both veins and arteries

---

[60] Philip J van der Eijk. "Rufus' On Melancholy and Its Philosophical Background." In On Melancholy: Rufus of
Ephesus, edited by Peter E Pormann, 166. Mohr Siebeck GmbH and Co. KG, 2008.
[61] Lyon, "The Four Humors: Eating in the Renaissance", Folger Shakespeare Library.
[62] Santoro et al., "The Anatomic Location of the Soul", 637
[63] Santoro et al., "The Anatomic Location of the Soul", 634
[64] W.C Aird, "Discovery of the Cardiovascular System: From Galen to William Harvey," Journal of Thrombosis and Haemostasis 9 (2011): pp.
120.
[65] Aird, "Discovery of the Cardiovascular System", 120
[66] Aird, "Discovery of the Cardiovascular System", 120-121

(Figure A.3).[67] He came up with the idea of 'invisible pores' to allow for this intermingling of blood & air between the left and right sides of the heart. This theory stayed popular for several centuries before William Harvey (1578-1657), an English physician and anatomist clearly demonstrated that there were no fenestrations in a normal human heart and the blood flowed throughout the circulatory system while picking up air (which we now know is oxygen) in the lungs through a system of fine capillaries.[68] *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus* (An Anatomical Study of the Movement of Heart and Blood in Animals) is a landmark work in the history of medicine, written by Harvey. The book was published in 1628 and represented a major shift in the understanding of human anatomy and physiology.[69]

In *De Motu Cordis*, Harvey describes his discovery of the circulation of blood in the human body. He used his knowledge of anatomy and dissection to demonstrate that blood circulates continuously through the body, rather than being produced and consumed as previously believed. Harvey also showed that the heart is responsible for pumping blood through the circulatory system, and that the arteries and veins are connected in a continuous loop.[70] Galen was the first to observe and show that blood flowed through arteries and not just air. The 'invisible pores' theory went unchallenged for about 1500 or so years since the time it was put forward.[71]

Galen and *Rete Mirabile*

[67] Aird, "Discovery of the Cardiovascular System", 121
[68] Aird, "Discovery of the Cardiovascular System", 122
[69] William Harvey. "Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus (An Anatomical Study of the Movement of Heart and Blood in Animals)." Ind Med Gaz 64, no. 5 (May 1929): 260
[70] Harvey. "Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus (An Anatomical Study of the Movement of Heart and Blood in Animals)." 180
[71] Aird, "Discovery of the Cardiovascular System", 122-127

Rete mirabilis is a complex network of blood vessels found at the base of the brain of some animal species (commonly found in fish and the avian family). It is absent in humans.[72]Since Galen's observations were primarily based on animal dissections and vivisections, he believed that this network of vessels existed in man. He postulated that the *rete mirabile* transformed or converted a person's 'vital spirit' (that resided in the blood) into the 'psychic' or 'animal spirit' (that was stored in the brain and was responsible for cognitive functions).[73] This animal spirit was thought to manifest in the nervous system thus carrying out motor and sensory functions of the human body.[74] This concept lingered on throughout most of the Renaissance period until it was finally refuted by Vesalius.[75] The *rete mirabile* becomes important later in the thesis when I discuss the works of artists and illustrators who believed that *rete mirabile* was present in humans.

Galen and Reproductive Anatomy

Before Galen's contributions to anatomy, the female body was considered a mere vessel for the growing fetuses and all the contribution to new life was from the male body.[76] Galen, on the other hand, believed that both male and female partners contributed to the conception of the child.[77] Since he based his knowledge on animal dissections, Galen stated that the human uterus had 7 cells (or chambers), 2 on one side and 5 on the

---

[72] Giuseppe Viale, "The Rete Mirabile of the Cranial Base: A Millenary Legend," Neurosurgery 58, no. 6 (2006): pp. 1199
[73] Viale, "The Rete Mirabile of the Cranial Base", 1200
[74] B. A. Bell, "A History of the Study of the Cerebral Circulation and the Measurement of Cerebral Blood Flow," Neurosurgery 14, no. 2 (1984),
240
[75] Nutton, Galen: A Thinking Doctor in Imperial Rome, 161
[76] Sophia M Connell, "Aristotle and Galen on Sex Difference and Reproduction: A New Approach to an Ancient Rivalry," Studies in History
and Philosophy of Science Part A 31, no. 3 (2000): pp. 415.
[77] Connell, "Aristotle and Galen on Sex Difference", 415-417

other. He explained that the gender of the fetus was dependent on the side of the body in which it was growing.[78] It was not until the Renaissance that this convention was dispelled.[79] The human uterus has a single chamber and the organ itself has no contribution whatsoever to gender selection.

Other important Galenic reproductive teachings include the formation of twins in the body (Figure A.4),[80] the idea that women were more susceptible to miscarriage if they 'misbehaved'[81] and the science behind the structural stability of the male genital system.[82] These concepts are discussed in more detail in Chapter four of my thesis in which I analyze Leonardo da Vinci's anatomical drawings under the light of Galenic reproductive beliefs.

Galen and Hepatic Anatomy

Galen believed that the liver had five lobes, each with a specific function. He believed that the right lobe was responsible for processing food and drink, the left lobe was responsible for producing bile, the right posterior lobe was responsible for the formation of the semen, the right anterior lobe was responsible for nourishing the veins, and the middle lobe was responsible for maintaining the balance between the other four lobes.[83] Galen's ideas about the liver were based on his dissections of animals, including

[78] Connell, "Aristotle and Galen on Sex Difference", 419
[79] Connell, "Aristotle and Galen on Sex Difference", 422
[80] Jean-Baptiste Bonnard, "Male and Female Bodies According to Ancient Greek Physicians," Clio, no. 37 (2014): pp. 5
[81] Bonnard, "Male and Female Bodies", 7
[82] Bonnard, "Male and Female Bodies", 8
[83] Nils O. Sjöstrand, "Den medicinska illustrationen som uttryck för föreställning och villa--levern som historiskt exempel [The medical illustration as the expression of illusion and imagination--the liver as an example from history]," Svenska Medietidskriften 11, no. 1 (2007): 23-26. https://www.ncbi.nlm.nih.gov/pubmed/18548944.

pigs and apes, as it was considered inappropriate to dissect human bodies at the time. Although Galen was incorrect about the number of lobes in the liver and the specific functions he attributed to each lobe, his ideas about the liver's function were highly influential and were widely accepted for centuries.[84]

It was not until the late Renaissance and early modern period that anatomists were able to conduct more comprehensive dissections of the human body and gain a more accurate understanding of the anatomy of the liver. Today, we know that the liver performs a wide range of functions, including detoxification, production of bile, and regulation of metabolism.[85]

Galen's Concepts of Neuroanatomy

Like his predecessors, Galen believed that the brain was the organ that controlled cognition and will. He believed that the five senses of touch, taste, smell, sight, and hearing were controlled by the 'soft' sensory nerves and the actions in response to these senses were carried back to the body through 'hard or firm' motor fibers. While Galen understood that cognition and will were the functions of the brain, he did not believe that personality traits and emotions were generated by that organ, rather they were a function of the body with contributions from the heart, liver, and the spleen.[86]

Galen postulated that the ventricles of the brain were communicating with a network of cavities filled with cerebrospinal fluid. These cavities occupied a central

---

[84] Gulik, Thomas, Rosmalen, Julia, Gulik, Merel and Rosmalen, Belle. " The Liver in the Middle Ages, according to Galen, ". Prometheus and the Liver through Art and Medicine. Amsterdam: Amsterdam University Press, 2022, pp. 67-72. https://doi.org/10.1515/9789048557417-007.
[85] Gulik, Thomas, et al. "The Liver in the Middle Ages, according to Galen, pp. 67-72
[86] F.R. Freemon, "Galen's Ideas on Neurological Function," Journal of the history of the neurosciences (U.S. National Library of Medicine, October 1994), 3(4):266.

location within the brain tissue. In humans, this ventricular system had two lateral ventricles, a third central ventricle, the cerebral aqueduct and a fourth ventricle as pictured (Figure A.5).[87]

The cerebral ventricles were of great interest to ancient anatomists and philosophers. During Galen's time, they were thought to harbor the vital spirit responsible for higher bodily functions. Christian influence modified the function of the ventricles, and they became conceptualized as 3 cavities (in relation to the Holy Trinity) where common sense, creative imagination and memory were stored.[88] Galen believed in pneuma, a breath that arises from the cosmos which circulates through the brain cavities and serves as a mediator between the body and soul. Though Galen recognized the ventricular system as three cavities with animal spirit flowing inside, he did not ascribe a specific function to each cavity. These cavities were erroneously assigned specific functions in later years, most significantly because of the Church's interest in brain function. These functions ultimately became associated with the Galenic Corpus.[89] This concept of three cavities in the brain with specific functions (tricameral view) was not challenged until more refined and accurate anatomical research became available by way of da Vinci and Vesalius in the Renaissance (Figure A.6).

---

[87] Laura Anne Lowery and Hazel Sive, "Totally Tubular: The Mystery behind Function and Origin of the Brain Ventricular System," BioEssays : news and reviews in molecular, cellular and developmental biology (U.S. National Library of Medicine, April 2009), 31(4):450. https://pubmed.ncbi.nlm.nih.gov/19274662/.

[88] C. L. Scelsi et al., "[PDF] the Lateral Ventricles: A Detailed Review of Anatomy, Development, and Anatomic Variations: Semantic Scholar," American Journal of Neuroradiology, 41(4):570, January 1, 1970.

[89] Jorge Duque, John Barco Rios, and Johnny Fernando Garcia-Aguirre, "A Historical Approach to the Ventricular System of the Brain" (Universidad Nacional de Colombia, 2017), 475

It is fair to conclude that Galen provided an incredibly detailed, and comprehensive anatomical and physiological blueprint for generations of medical students, anatomists, and physicians to come. These teachings were considered gospel by anatomists and artists for several centuries, until the Renaissance scientists and artists revived the desire to learn, mold and question these teachings.

CHAPTER 3

MONDINO DE LUZZI & BERENGARIO DA CARPI'S DISSECTIONS

Mondino de Luzzi was an Italian physician and anatomist who lived in the late 13th and early 14th centuries. He is known for performing public dissections of human cadavers and writing the first recorded anatomy textbook in the Western world, called *Anathomia*. This work, written in 1316, was based on his own dissections and provided detailed descriptions of the human body, including the bones, muscles, nerves, organs, and blood vessels. Mondino was a professor of anatomy at the University of Bologna, and he performed dissections as part of his teaching and research.[90]

The authenticity of the claim that Mondino performed rather than merely observed dissections remains a subject of considerable debate and is in significant doubt. Regardless, Mondino's research challenged a few of the major Galenic concepts but he continued to rely heavily on Galen's teachings and his work remained influenced by Galenic ideas. In his book, *Anathomia*, Mondino 'describes' his dissections and the discoveries he made about the human body. However, the illustrations made for Mondino's book were so heavily influenced by the Galenic Corpus that art critics have questioned the circumstances surrounding his dissection procedures.[91] For my thesis, I

[90] Clive Lee, "Observing the Body," Irish Arts Review 27, no. 3 (2010): 102-105, http://www.jstor.org/stable/20789393.
[91] Alexandra Mavrodi, and George Paraskevas. "Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages." Croat Med J. 55, no. 1 (2014): 50-3. doi: 10.3325/cmj.2014.55.50. PMID: 24577827; PMCID: PMC3944418.

consider Mondino de Luzzi because his dissections and research helped establish anatomy as a formal discipline and contributed to the growing body of knowledge about the human body during the Renaissance. I recognize that Mondino, like his anatomist-artist predecessors and successors, was at times relying on anatomical conventions to fill in the holes in his knowledge.[92] I argue that whether Mondino personally performed dissections or not, the content of his book was heavily influenced by Galen. The primary reason for this influence was to adhere to the received universal truth in anatomical scholarship which was mostly reduced to Galen's Corpus. It is necessary to analyze the illustrations that were made for Mondino's book in order to understand how the gap between the empirical (dissection based) data and the generalized Galenic knowledge was closed by the illustrators.

Mondino's dissections were groundbreaking in the field of anatomy, as they stood for a departure from the traditional approach to anatomy, which relied on the teachings of the ancient Greek physician Galen. As mentioned in Chapter 2, Galen's work was based on animal dissections, and although it was highly regarded in the medieval period, it was often inaccurate when applied to the human body. In his dissections, Mondino followed the methods and teachings of Galen, but he also made significant contributions of his own. For example, he was one of the first to describe the structure of the spinal cord in detail, and he made important discoveries about the anatomy of the brain and nerves. Mondino's dissections helped to correct many but not all the inaccuracies present in Galen's teachings and paved the way for future anatomists to build a more accurate

[92] Mavrodi and Paraskevas," Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages", 50-3

understanding of human anatomy.[93]

Another difference between Galenic teachings and Mondino's work is that he was able to see the structure of the spinal cord more closely than Galen, and he made important discoveries about the anatomy of the brain and nerves that challenged Galen's ideas.[94] For example, Galen used the method of "artificial dissection" where he dissected animals that had been artificially inflated to study the internal organs. Mondino, on the other hand, performed dissections without inflating the cadavers, which allowed him to study the natural position and relationships of the organs more closely and accurately.[95]

The Authenticity of Mondino's Dissections is Questioned

The method of public dissections in the 1300s is one of the main reasons why there is a possibility that Mondino 'copied' Galenic conventions without thoroughly testing them via dissections.[96] Public dissections were typically conducted as part of a larger anatomical demonstration, such as a lecture or workshop given by an anatomist. These demonstrations were often held in universities or medical schools, and were attended by students, faculty, and members of the public who were interested in learning about anatomy. Typically, the dissections were performed on the bodies of executed criminals or other individuals who were not claimed by their families. During the dissection, the anatomist would explain the various structures and organs of the body,

[93] Efrain A. Miranda, "Mondino De Luzzi," Mondino de Luzzi (Clinical Anatomy Associates, Inc., February 24, 2014), https://clinicalanatomy.com/mtd/548-mondino-de-luzzi.
[94] Mavrodi and Paraskevas," Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages", 52
[95] Mavrodi and Paraskevas," Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages", 52
[96] Mavrodi and Paraskevas," Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages", 52

pointing out their functions and relationships to each other. The dissections were conducted in a lecture format, with the anatomist explaining the anatomy as they went along. [97]

In Mondino's case, he would act as a conductor for the whole performance. He would sit on an elevated chair and read instructions and text from Galen's Corpus. His students (often medical students or barber-surgeons from the University of Bologna) would cut open the body per his instructions and an 'exhibitor' would hold up and point out specific organs/parts for the audience (Figure A.7). Technically, because of his high status, Mondino never performed a dissection with his own hands.[98] Moreover, there was a race against time to dissect the body quickly, while also lecturing the audience, before it started decaying, stiffening, and bloating. Art critics and medical professionals argue that the lack of advanced preservation and storage techniques could have resulted in several botched or rushed dissections.[99] Additionally, we know that Mondino preferred not to embalm the cadavers he wanted to dissect. Considering that, it is highly likely that Mondino oversaw only parts of a dissection at a time. He either collaged findings from multiple dissection sessions into complete records for his book, *Anathomia* or he was overseeing the dissection of a body over a period of several days.[100] Either way, the accuracy of the dissection findings is questionable.

---

[97] Berardo Di Matteo et al., "Art in Science: Mondino De' Luzzi: The Restorer of Anatomy," Clinical orthopedics and related research (U.S. National Library of Medicine), 2017 Jul;475(7): 1792

[98] Berardo Di Matteo et al., "Art in Science: Mondino De' Luzzi: The Restorer of Anatomy," 1792

[99] Mavrodi and Paraskevas, Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages, 52

[100] Mavrodi and Paraskevas, Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages, 52

Mondino reported the findings from most of his dissection sessions in his book, *Anathomia.* His followers, such as Berengario da Carpi added illustrations to his text in the 1400s.[101] The illustrations were based on the text he wrote and on the visual accounts of the students who watched Mondino perform his dissections. A formal and anatomical analysis of these illustrations reveals that Mondino was prioritizing Galenic teachings over visual evidence gained from his dissections. Another way of looking at this is to concur that he was merging the visual facts he gained from observing dissection with the more popular and widely accepted Galenic conventions.

Anathomia provides limited information about female anatomy. Mondino's focus was primarily on male anatomy, and his description of female anatomy was limited to the reproductive system. He did not provide extensive details or comparisons between male and female anatomy, and his descriptions of female anatomy were based on Galenic teachings such as the female anatomy being similar to male anatomy but reversed in orientation.[102]

I would like to point out that the later addition of illustrations to Mondino's book could have introduced varying levels of inaccuracy and alternative interpretations of dissection procedures.

Several historians of art and of science agree that Mondino started a trend of disagreement and questioning of the Galenic texts. However, his texts reinforce and reimplement Galenic errors in the study of organ anatomy. Regis Olry, an anatomy professor at the University of Quebec in Trois-Rivières, with extensive research on

[101] Berardo Di Matteo et al., "Art in Science: Mondino De' Luzzi: The Restorer of Anatomy," 1793
[102] Mavrodi and Paraskevas, Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages, 52

Mondino de Luzzi and the study of dissection procedures argues that the illustrations in *Anathomia* mark Mondino's clear move away from Galen's influence.[103] I am of the opinion that Mondino parted with Galenic theories at times but for the most part, he tried to find a way to fit together what he saw during his dissections with what he learned through reading Galen's teachings.

A Deep Dive into *Anathomia* and its Illustrations

Figure A.9, taken from *Anathomia* shows the kidneys, aorta/vena cava, ureters, and the uterus of a female cadaver. In the text accompanying this illustration, Mondino describes the connection of the aorta to the kidneys. He also connects the oviducts or Fallopian tubes directly to the vascular structures in the abdomen, which is not correct.[104] In the female body, the renal system resembles the image on the left in Figure A.8. The female renal system, also known as the urinary system, is responsible for filtering waste and excess fluids from the bloodstream and removing them from the body in the form of urine. The main components of the female renal system include the two kidneys, two ureters, the bladder, and the urethra. The kidneys are in the lower abdomen, one on each side of the spine. The bladder is a muscular sac that stores urine until it is ready to be

[103] Regis Olry, "Medieval Neuroanatomy: The Text of Mondino Dei Luzzi and the Plates of Guido Da Vigevano," Journal of the history of the neurosciences (U.S. National Library of Medicine, August 1997), 6(2):116. https://pubmed.ncbi.nlm.nih.gov/11619515/.
[104] Johann Dryander, and Dryander. *Anatomia Mvndini . Anatomia Mvndini: collata,iustoq, suo ordini restituta.* Publisher: Marpvrgi, In officina Christiani Egenolphi, 1541.

expelled from the body. The urethra is a tube that carries urine from the bladder to the outside of the body. In females, the urethral opening is located near the clitoris.[105] The proximity of the urethral opening to the clitoris is a plausible explanation for why the illustration from *Anathomia* shows the Fallopian tubes connected directly to the dorsal vascular structures. A closer look at the illustration from Mondino's book shows shaded areas to mark the recession of the organs in space and to create a three-dimensional image of the renal system. This was an artistic choice born out of the popular conventions of the Renaissance at that time.

Mondino and Galen agreed on the anatomical structural details of the female uterus.[106] Mondino described two female cadaveric dissections in detail in his book (Figure A.9). The female figures are perfectly posed and both figures have somewhat elaborate architectural background. The detail with which the non-anatomical features of the composition are rendered shows a preference for relatability and naturalism. The illustrator has tried to humanize the experience of a dissection for us through these images. Kant's definition of aesthetics and aestheticism can be applied here. The poses of the figures in addition to the architectural backgrounds serve no scientific purpose for the illustration. However, the idealized setting and position of the dissected body do not take anything away from the scientific interpretation either. Hence, this artistic choice hinges upon personal preference like the preference for the universally accepted truth versus the attention to newly discovered, empirical evidence.

---

[105] Ifeanyichukwu Ogobuiro; and Faiz Tuma, "Physiology, Renal," National Center for Biotechnology Information (U.S. National Library of Medicine, July 25, 2022), https://pubmed.ncbi.nlm.nih.gov/30855923/.
[106] Mavrodi and Paraskevas, Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages, 52

Mondino explained the variable morphology and anatomy of the interior uterine cavity with significant accuracy. Like Galen, he reached the conclusion that a female uterus had seven chambers that the colder chambers were responsible for the conception of the female zygote and the warmer chambers conceived a male child.[107] We now know that the human uterus has three main parts: the fundus, the body, and the cervix. It is not divided into separate chambers. The uterus is a hollow, pear-shaped organ that is in the pelvic cavity of the females. Its main function is to provide a supportive environment for a developing fetus during pregnancy. The fundus is the rounded upper portion of the uterus, the body is the main part of the uterus, and the cervix is the lower part of the uterus that opens into the vagina.[108] A dissected human uterus would clearly show a lack of seven chambers. The idea of a seven chambered uterus originated from Galen's observations of animal anatomy. He believed that the uterus was divided into seven separate compartments, each with a specific function.[109] Mondino 'confirmed' Galen's observations of the female anatomy via his dissections. This was a clear attempt by Mondino to reconcile the popular anatomical narrative with empirical evidence.

Mondino departs from Galen's ideas about the structure of the heart and claims that his own dissections revealed a three chambered heart, instead of two.[110] However, he adhered to the Galenic concept of vital spirit being created in the heart and attributed the 'newly discovered' third, middle cardiac ventricle for the conversion of blood into the

---

[107] Mavrodi and Paraskevas, Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages, 52

[108] Muhammad Atif Ameer et al., "Anatomy, Abdomen and Pelvis, Uterus," National Center for Biotechnology Information (U.S. National Library of Medicine, December 6, 2022), https://pubmed.ncbi.nlm.nih.gov/29262069/.

[109] Connell, "Aristotle and Galen on Sex Difference", 419

[110] Mavrodi and Paraskevas, Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages, 52

vital spirit. According to Galen, the vital spirit was created by the heart and was responsible for maintaining life. He believed that it was a refined substance that was lighter than air and that it circulated throughout the body via the blood vessels, providing vitality and nourishment to the body's tissues.[111]

Another organ that Mondino de Luzzi observed closely during his dissections and described in his book is the liver. Like Galen, Mondino described the liver with five lobes with each lobe having its own specific function (Figure A.10a)[112]. The liver was divided into a right lobe, a left lobe, a caudate lobe, a quadrate lobe, and a spherical lobe. He believed that the right lobe was responsible for producing and storing bile, while the left lobe was responsible for processing and filtering the blood that came from the heart. He also believed that the caudate and quadrate lobes were involved in the regulation of the other lobes, and that the spherical lobe was involved in the overall regulation of the liver.[113] Figure A.10 shows a comparison between a liver illustration from *Anathomia* (top) and an image of the liver as we know it now (bottom). Note the five clearly labelled lobes in the illustration (Figure A.10a).

Today, we know that the liver is one of the largest organs in the human body and is located in the upper right quadrant of the abdomen, under the diaphragm. It has a complex structure and is composed of four lobes, each of which is divided into many small lobes called lobules (Figure A.10b). The liver performs many important functions,

---

[111] Johann Dryander, and Dryander. *Anatomia Mvndini . Anatomia Mvndini: collata,iustoq, suo ordini restituta.* Publisher: Marpvrgi, In officina Christiani Egenolphi, 1541, pp. 87

[112] Johann Dryander, and Dryander. *Anatomia Mvndini . Anatomia Mvndini: collata,iustoq, suo ordini restituta.* Publisher: Marpvrgi, In officina Christiani Egenolphi, 1541.

[113] Nils. O. Sjöstrand, "Den medicinska illustrationen", 23-26.

including detoxification, protein synthesis, storage of nutrients, and production of bile, a substance that helps digest fats and none of these functions are specifically localized to any particular lobe (liver parenchyma is homogenously spread across all lobes).[114]

Lastly, Mondino also stayed faithful to Galen's interpretation of *rete mirabile.*[115] Interestingly, he never claimed to have located this network of vessels in his dissections. Instead, he chose to rely upon Galen's teachings and decided to include the structure in his book. However, he proposed some changes to the function of *rete mirabile* and reinforced its presence in humans with a suggestion of its general presence in most species of the animal kingdom.[116] We can conclude that he did not find rete mirabile in the human body because it does not exist in humans. We can also conclude that not being able to locate the vessel bundle was not enough to deter Mondino from believing that it did exist in humans regardless. The absence of *rete mirabile* propelled Mondino to rely on the general Galenic truth that had been accepted and in place for decades.

It is unknown whether Mondino ever dissected any bodies himself. It depends on how one describes the act of dissecting. Does it suffice to instruct and direct individuals to cut and incise a certain way or does one need to hold the scalpel in order to experience a true dissection? Regardless, it can be concluded that Mondino had a deep knowledge of the inner workings of the body.[117] He reviewed new potential anatomical discoveries in the light of Galenic conventions. At times he broke away from what Galen had proposed

---

[114] Sherif R.Z Abdel-Misih and Mark Bloomston, "Liver Anatomy," The Surgical clinics of North America (U.S. National Library of Medicine, May 2014), https://pubmed.ncbi.nlm.nih.gov/20637938/.
[115] Mavrodi and Paraskevas, Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages, 52
[116] Viale, "The Rete Mirabile of the Cranial Base", 1200
[117] Mavrodi and Paraskevas, Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages, 52-53

but more often than not, Mondino confirmed and supplemented Galenic teachings. An important caveat in this discussion of Mondino's work is his tendency to attribute structural and functional discrepancies, between Galenic concepts and the dissected body parts, to fluctuating morphology.[118] For instance, Mondino was not able to locate *rete mirabile* in the human cadavers he dissected. He explained its absence by assuming that it might not be present in every single human.[119] Although not applicable in general to human anatomy, this logic had the potential of being brilliant and deeply objective. An extrapolation of this type of thinking could have helped him explain the key differences between infant and adult anatomy and variations between the male and female morphology.

Berengario da Carpi Comments on Mondino's *Anathomia*

Another important figure in regard to Mondino's *Anathomia* is Berengario da Carpi (1466–1530). He was an Italian anatomist, surgeon, and an artist. He is attributed as one of the people who updated and added illustrations to the version of Mondino's *Anathomia* to which we now have access to.[120] He was heavily influenced by Mondino and thus, his research and discoveries also reached the same conclusion of adherence to the general and the universal.

---

[118] Mavrodi and Paraskevas, Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages, 51-52

[119] Johann Dryander, and Dryander. *Anatomia Mvndini . Anatomia Mvndini: collata,iustoq, suo ordini restituta.* Publisher: Marpvrgi, In officina Christiani Egenolphi, 1541, pp. 98

[120] André Parent, "Berengario Da Carpi and the Renaissance of Brain Anatomy," Frontiers (Department of Psychiatry and Neuroscience, Faculty of Medicine, Université Laval, Quebec, QC, Canada, January 22, 2019), https://www.frontiersin.org/articles/10.3389/fnana.2019.00011/full.

Carpi is considered one of the pioneers of Renaissance anatomy and is best known for his book *Commentaria cum amplissimis additionibus super anatomia mundini* which was a commentary on the works of Mondino de Luzzi.[121] Berengario challenged aspects of the traditional Galenic anatomy and performed dissections himself to gain a better understanding of the human body. His works had a significant impact on the development of anatomy and surgery during the Renaissance. Despite the persistent pursuit of truth by artist-anatomists like Berengario da Carpi, Galenic influence on anatomical conventions remained strong and steadfast. Figure A.12 shows an illustration from Carpi's *Isagogae breves* (1523). Galen proposed that there were pores between the left and right sides of the heart that allowed for the mixing of oxygenated and deoxygenated blood.[122] These 'pores' can be clearly seen in Figure A.11.

Like Galen, Carpi believed that the brain had three ventricles and that they were responsible for different functions, such as movement, sensation, and thought (Figure A.13). He also depicted the uterus as an inverted pear with horn like projections and multiple chambers (Figure A.12)[123]. This is similar to Mondino's description of the uterus and by extension harkens back to Galenic theories about the female anatomy.[124] Carpi's texts and illustrations show heavy Galenic influence in dissection records that were supposed to be objective compilations of the findings from cadaveric exploration.[125]

---

[121] André Parent, "Berengario Da Carpi and the Renaissance of Brain Anatomy," 4
[122] Aird, "Discovery of the Cardiovascular System", 122
[123] Jacopo Berengario da Carpi, "Isagoge Breves," Wellcome Collection (Bonona : Benedictus Hector, 1460), https://wellcomecollection.org/works/ujm5ynjj.
[124] Enrico Crivellato & Ribatti, Domenico. (2006). *Mondino de' Luzzi and his Anothomia: A milestone in the development of modern anatomy.* Clinical anatomy (New York, N.Y.). 19, 584. doi: 10.1002/ca.20308.
[125] Jacopo Berengario da Carpi, "Isagoge Breves," Wellcome Collection (Bonona : Benedictus Hector., 1460), https://wellcomecollection.org/works/ujm5ynjj, pp. 160

However, Carpi did not always follow Galenic conventions. He is known for having disagreed with Mondino's views on anatomy, particularly regarding the nature of the *rete mirabile*, a network of veins and arteries that according to Galen was located at the base of the brain. Berengario did not believe in the existence of *rete mirabile* and thought that the veins and arteries were continuous and not divided into different parts. This disagreement with Mondino's views was one of the first open criticisms of Galen's anatomical teachings and marked a step towards the development of more accurate views on anatomy during the Renaissance.[126] In his commentary on Mondino's *Anathomia,* he said the following on the absence of *rete mirabile*:

> I have careful eyes, hands, and instruments suited to separating the dura mater from the cranium, and I have dissected many heads, as I said above, and did not find such a rete (…). It is my opinion that if there is a rete there in the latter location, it must be concluded that Galen erred, because he says that when the ascending arteries are above the base of the skull, immediately they are divided very minutely and form the rete; then he says that from all the branches of the rete again two branches of arteries are formed that perforate the dura mater and ascend to the brain. This, however, is not true, because many times I have inserted a little stylus (styllum) above the dura mater into the aforesaid large ascending branches which are near the optic nerves [internal carotids], and I have found that the stylus penetrates directly downwards through those arteries without any obstacle as far as the base of the skull […] Thus I believe that Galen imagined the rete mirabile but never saw it, and I believe that all others after Galen that spoke of the rete mirabile did so on the strength of his opinion rather than their own perception of it.[127]

Thus, Berengario's approach to anatomical experimentation differs from Mondino. However, his tendency to draw his illustrations naturalistically yet with a lot of idealized details shows us that he too was trying to solve the problem of cohesively depicting visual and known evidence.

---

[126] André Parent, "Berengario Da Carpi and the Renaissance of Brain Anatomy," 4-9
[127] Berengario, quoted in: André Parent, "Berengario Da Carpi and the Renaissance of Brain Anatomy," 6

To conclude, both Barengario da Carpi and Mondino de Luzzi were curious about the inner workings of the body. They both built upon the work of Galen, were based in Italy and were influential in the study of anatomy in the Middle Ages. Despite some differences in their views, they both made significant contributions to the field of anatomy and helped to lay the foundation for future generations of anatomists. Where Carpi was able to follow the objective steps of the scientific method and shun claims that were not supported by visual evidence, Mondino chose to uphold the popular Galenic conventions and continued to support the application and popularity of the Galenic Corpus.

CHAPTER 4

LEONARDO DA VINCI AND ANDREAS VESALIUS:

AN IMPETUS FOR QUESTIONING GALENIC CONVENTIONS

Leonardo da Vinci (1452-1519) is famously known as the 'Renaissance Man' who excelled as a talented painter, sculptor, architect, engineer, and draftsman.[128] At the time of his death in France in 1519 at the age of 67, Leonardo's [129] *De humani corporis fabrica libri septem* (1543)[130]. However, it is important to note that had Leonardo's anatomical treatise and his notebooks been published during his lifetime, he and not Vesalius would be dubbed the 'Father of Modern Anatomy'.[131]

Leonardo da Vinci's Anatomical Treatise

In several of his anatomical drawings, Leonardo da Vinci was assumed to have represented mimetically what he saw in real-life dissections.[132] An evolutionary arc can be identified in his drawings as he goes from depicting what Marcantonio Della Torre

[128] James S. Ackerman, "Leonardo Da Vinci: Art in Science." *Daedalus 127,* no. 1 (1998): 207-210

[129] Leonardo da Vinci, Anatomical Drawings from the Royal Library, Windsor Castle. Edited by Kenneth D. Keele and Jane Roberts. New York: The Metropolitan Museum of Art; New Haven: Yale University Press, 1983.

[130] Martin Gumpert, "Vesalius: Discoverer of the Human Body." Scientific American 178, no. 5 (1948): 27

[131] A.K. "Leonardo Da Vinci as Anatomist." The British Medical Journal 1, no. 3673 (1931): 950–51. http://www.jstor.org/stable/25339724.

[132] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 8-12

selected and described to shadowing surgeons firsthand and performing his own dissections.[133] A comparative analysis of da Vinci's anatomical drawings alongside Galenic texts and theories shows that da Vinci's anatomically mimetic drawings borne out of real-life dissections were not merely based on the visual information derived from empirical experience. He was instead using art to bridge the gaps between what he was seeing and what Galen had proposed in his texts. Leonardo can be categorized as a follower of the mimetic theory of art. His paintings such as *The Last Supper* and *The Mona Lisa* not only capture the intricate details of the subjects, but they also render the expressiveness and emotions of the scenes realistically. With that mind, one would assume that as a humanist, Leonardo would tend to depict his art subjects as realistically as possible. I argue that that was not the case. Leonardo was more concerned with the role of his art than he was with the accuracy of his works in regard to mimicking nature. He used his artistic skills to create anatomical illustrations that were not at odds with Galenic conventions. This was an artistic choice by Leonardo to honor and accept the universal and the aesthetically relevant truth while simultaneously pursuing empirical evidence through dissections.

In the late 1400s, da Vinci's interest in human anatomy and physiology became stronger when he started working for Ludovico Sforza, Duke of Milan.[134] On April 2nd, he sat down to begin his book entitled *On the Human Figure*.[135] After executing a sequence of stunning drawings of a skull, though, his studies seemed to have hit a wall,

[133] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 8-31
[134] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 8-20
[135] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 9

probably because he lacked access to corpses that he could dissect.[136] He outlined this projected treatise as follows:

> This work should begin with the conception of man, and describe the form of the womb, and how the child lives in it, and to what stage it resides in it, and in what way it is given life and food. Also, its growth, and what interval there is between one stage of growth and another; and what it is that pushes it out of the body of the mother, and for what reason it sometimes comes out of the mother's belly before due time. Then you will describe which parts grow more than others after the infant is born and give the measurements of a child of one year.[137]

The outline of his treatise, as described in his notebooks, sheds light on the type of evidence da Vinci aimed to gather for his book. He wanted to break away from textual knowledge and rather focus on anatomical phenomena in action. His goals also included the description of attitudes and movements of the body, the senses and functions of the organs and the effects of outside stimuli on the human body (thus, alluding to future vivisections that he would conduct under the guidance of Della Torre).[138] In the early 1500s, he performed multiple human dissections at the Ospedale di Santa Maria Nuova.[139] In 1510, he met and collaborated with Marcantonio della Torre who was a famous anatomist and needed an artist's talent and perspective on medical drawings for his publications.[140]

---

[136] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 9
[137] Leonardo, quoted in" Clayton and Philo, "Leonardo da Vinci- Anatomist.", 9.
[138] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 55-71
[139] Martin Kemp, "Dissection and Divinity in Leonardo's Late Anatomies." Journal of the Warburg and Courtauld Institutes 35 (1972): 205
[140] Maurizio Viviani, Pasquale Gallo, and Carlo Mazza, "Marc 'Antonio Della Torre and Leonardo Da Vinci: An Encounter That Changed the History of Medicine, Art and Anatomy: Semantic Scholar," Child's Nervous System (National Library of Medicine, January 1, 1970), 495

This alliance with Della Torre proved beneficial for da Vinci since he could read neither Latin nor Greek.[141] He had no way of educating himself on the famous Greek Galenic medical texts that were widely accepted during the Renaissance. Della Torre, as an anatomist, was familiar with these texts and knew the basics and the terminologies used in the anatomy field. Della Torre is well known as one of the first physicians to illustrate the Galenic teachings in a practical and implementable way.[142]

Leonardo da Vinci's Illustrations and Dissection Records

Leonardo's drawings of the major organs and vessels of the human body were made primarily as an illustration of Galen's teachings.[143] It is plausible that at this point, he had not partaken in major dissections, nor had he dissected any animals himself.[144] The Galenic text observed the vessels travelling from the intestines to the liver supporting the notion that the liver was the source of nutrition or 'natural spirit', creating blood that was distributed by the veins to nourish the body. Galenic teachings had no mention of circulation or return of the blood.[145] A portion of the blood was thought to pass from the right ventricle of the heart through the interventricular septum into the left ventricle, thus acquiring 'vital spirit,' the 'life force,' which was distributed through the body by the arterial system.[146] The lungs existed to cool the heart. A comparison of da Vinci's drawing to the cardiovascular system of the human body as it is known today highlights the odd placement of the heart and the linkage of the vena cava to the liver (Figure A.14),

[141] Viviani et al., " Marc 'Antonio Della Torre and Leonardo Da Vinci: An Encounter That Changed the History of Medicine, Art and Anatomy: Semantic Scholar, 495
[142] Viviani et al., " Marc 'Antonio Della Torre and Leonardo Da Vinci, 495-98
[143] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 32-33
[144] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 32-33
[145] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 32-33
[146] Clayton and Philo, "Leonardo da Vinci- Anatomist.",140-141

thus, following the Galenic explanation of that organ as the source of the 'natural spirit'.[147]

In Figure A.15, the uterus is drawn perfectly spherical and scalloped in addition to its greatly exaggerated ligaments extending like horns towards the flanks of the pelvis.[148] According to the Galenic teachings, the leftover menses were carried to the breasts where they would turn into milk after the conception of a child.[149] In da Vinci's drawing, vessels can be seen moving upwards from the upper surface of the uterus, alongside the ascending lumbar veins.[150] A close visual observation of the female uterine system during a dissection should have revealed a lack of upward transcending vessels carrying menses blood. [151] Leonardo's drawings were meant to serve as an in-between medium for the reconciliation of visual evidence with the popular and accepted Galenic anatomical knowledge that was perceived as factual during the Renaissance. drawing.[152] The 'female spirit' was believed to give the breasts the volume and weight which was responsible for the way they looked on a female body.[153] A lack of this spirit would make the breasts on women look masculine. The drawing reveals masculine breasts perched between heavy shoulders. It is possible that he was referencing the lack or loss of 'female spirit' as the

---

[147] Amaker et al.," Galen's Anatomical Anomalies & Discoveries, 2020. Hackett and Proctor, Three-Dimensional Display Technologies for Anatomical Education: A Literature Review ", Science, Technology; Society: A Student-Led Exploration, July 29, 2020., 644

[148] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 140-141

[149] R. I. Tubbs et al., "The Influence of Ancient Greek Thought on Fifteenth Century Anatomy: Galenic Influence and Leonardo Da Vinci.," National Library of Medicine (Childs Nervous System, January 1, 1970), 34: 1097

[150] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 140-141

[151] Lorus J. Milne. "Accuracy in Anatomical Drawing." Science 92, no. 2376 (1940): 43–44.

[152] _____,"Leonardo Da Vinci." The British Medical Journal 2, no. 3167 (1921): 413.

[153] Amaker et al." Galen's Anatomical Anomalies & Discoveries", 612

cadaver tensed over time with the onset of *rigor mortis*.[154] However, equally plausible is the theory that Leonardo added the breasts and the uterus to this drawing after referencing a male cadaver.

Another one of Leonardo's drawings that shows heavy Galenic influence is the Hemi Section of a Man and Woman in the act of Coition (Figure A.16). As mentioned earlier, da Vinci's goal for his anatomical treatise was to look beyond the static human figure and to see the phenomena of life in action. The first step of this goal was achieved by studying the act of conception. In his illustration of a man and woman in the act of coition, Leonardo depicts three components that would be involved in conception.[155] In the male body, he drew channels into the penis from the lumbosacral plexus at the bottom of the spinal column (to transmit an 'animal spirit'), from the heart (a 'spiritual' element), and from the testes (a 'material' element), thus following the Galenic division of the body into animal (head), spiritual (thoracic) and material (abdominal) regions.[156] The drawing shows Leonardo's effort to create a humanist depiction of a body undergoing coitus (Figure A.16). He does so by sticking to an objective image of the body in profile while adding hair and muscles to the profile to make it more aesthetically acceptable and universally relatable. I would like to point out that since the phenomena of sexual reproduction is action based and it is unlikely that he drew Figure A.16 through the

[154] Milne, "Accuracy in Anatomical Drawing.",43-44
[155] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 34-35
[156] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 34-35
Denis Noble, Dario DiFrancesco, and Diego Zancani. "Leonardo da Vinci and the Origin of Semen." Notes and Records of the Royal Society of London 68, no. 4 (2014): 391–402.
Randall, John Herman. "The Place of Leonardo Da Vinci in the Emergence of Modern Science." Journal of the History of Ideas 14, no. 2 (1953): 196

observation of such an action, Leonardo's drawing most likely stemmed from the visualization of the process in conjunction with the Galenic explanation of the act.

The drawing had a note scribbled alongside it which read, "consider how the testes are the cause of ferocity." [157] This note alludes to the Galenic explanation of emotions being felt in the heart and the testes being the reason for men's ferocity and stereotypically male behaviors (violence, sex-driven lifestyle, etc.).[158] Therefore, Leonardo might have seen fit to create a channel between the heart and the testes for the transmission of emotions from the heart and ferocity from the testes.[159] In the female body, da Vinci shows the spine bifurcating and a branch of the spinal cord passing directly into the uterus, but the ovaries and heart are not shown.[160] The female contribution to coitus is kept at a minimum because according to Galenic principles pertaining to conception, the woman's contribution was limited to carrying the child and converting menses into milk.[161]

Leonardo was also interested in the location of the 'soul' in the body. of "three cells" or three ventricles in the brain being responsible for major intellectual and higher functioning was prevalent before the Renaissance. It was believed that the power of communication resided in the anterior ventricle (now called lateral ventricles), rational thinking in the middle ventricle (now third ventricle) and memory in the posterior ventricle (now known as fourth ventricle). His earliest surviving anatomical drawings

[157] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 34-35
[158] Amaker et al.,"Galen's Anatomical Anomalies & Discoveries,", 613
[159] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 34-35
[160] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 34-35
[161] Amaker et al.,"Galen's Anatomical Anomalies & Discoveries,", 613

(circa 1485-93) include that of brain and ventricles.[162] Like Galen, Leonardo initially drew cerebral ventricles as three communicating cells (Figure A.17), however, he observed the optic nerves entering the brain and crossing over of the optic fibers (known as optic chiasma) and inferred that these nerves converge on the anterior ventricle.[163] He then labeled the anterior or front ventricle '*imprensiva'* (processing of sensory information particularly from the eyes). He wrote in his notes, "

Objects send their images to the five senses by which they are transferred to the *imprensiva*, and from this to the *senso comune.* From thence, being judged, they are transmitted to memory, in which according to their power they are retained more or less distinctly."[164] We now know that the workings of the brain are a function of brain parenchyma (or tissue), rather than that of hollow ventricles carrying cerebrospinal fluid.

After a 10-year interval in the early 1500s, Leonardo resumed his anatomical studies and developed a new method of wax casting of the ventricles derived from his familiarity with hot wax in sculpting.[165] Thus, in his later drawings, he seems to depart from his original depiction of ventricles (modelled after Galenic convention) as three serial bulbous structures, to correctly shaped structures, although still connected with one another but not in a straight line (Figure A.19). Nonetheless, although he correctly grasps the shape of the ventricles, he adjusts the proportions of the brain and ventricles to fit in a

[162] Pevsner, Jonathan. "Leonardo da Vinci's studies of the brain." Lancet (London, England) vol. 393,10179 (2019): 1471.
[163] Nicky Penttila, "The Hidden Neuroscience of Leonardo Da Vinci," Dana Foundation (Dana Foundation, October 25, 2021), https://dana.org/article/the-hidden-neuroscience-of-leonardo-da-vinci/.
[164] Nicky Penttila, "The Hidden Neuroscience of Leonardo Da Vinci," Dana Foundation.
[165] Nicola Di Stefano, Giampaolo Ghilardi, and Sergio Morini, "The Cerebral Ventricles in Leonardo's Anatomical Drawings," The Lancet (Elsevier, April 6, 2019), https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)32847-2/fulltext.

human brain drawing, and still draws the *rete mirabilis* at the base of the skull (only observed in animals), exactly like Galen (extrapolating from animal studies) (Figure A.18 and A.19). I use the word 'correctly' very flexibly here. My intention is to explain that Leonardo broke away from Galenic theories and steered towards the objective and the empirical.

Lastly, another example that shows heavy Galenic influence entwining with visual observation is the drawing of Brachial Plexus (Figure A.20). The brachial plexus is the network of nerves that runs from the spine to the arm. Leonardo has shown twelve stylized cervical vertebrae, rather than the correct seven, and the way the spinal nerves project out from the vertebrae is very indistinct. Alongside the cervical vertebrae are vessels such as the internal jugular vein and common carotid artery, shown separately in the subsidiary diagrams at lower right in the two perspective views with the elements teased apart, and a cross-section. Along the right side of the thoracic vertebrae and appearing to pass downwards from the spinal and intercostal nerves, are components of the sympathetic trunk and thoracic splanchnic nerves, which contribute to the nervous system of the internal organs.[166] The notes scribbled alongside the drawings have reminders to depict the systems of nerves, muscles, and vessels independently from each other, which 'will be most useful to those who treat wounds', and alongside the main drawing Leonardo wrote 'any one of the five branches saved from a sword-cut is enough

[166] Clayton and Philo, "Leonardo da Vinci- Anatomist.", 114

for sensation in the arm'.[167] Galenic treatment often focused on changes in sensations around wounds caused by sword fighting.[168]

Considering the trend of heavy Galenic influence in Leonardo da Vinci's drawings, that he was making for his anatomical treatise, it can be concluded that he was merging what he had learnt from his association with anatomists, with visual observations that he was making during his dissections. He was trying to achieve peak accuracy for his future treatise by accepting the most famous and accepted medical texts and reconciling them with what he was seeing during surgeries and dissections. Whether it was related to conception or to the nervous system controlling muscular contractions and movements, there is ample evidence that proves that Leonardo was attempting to use Galenic knowledge to make sense of the dissections he was performing.[169] A crucial point to note is that the Galenic influence did not take away any credibility from Leonardo's works. Rather, the incorporation of Galenic teachings within the pool of visual evidence he had personally gained allowed him to create illustrations that were universally relevant and did not focus too heavily on the specific discrepancies between Galenic conventions and discoveries made through dissecting bodies. What he was trying to achieve and how he was making sense of existing medical knowledge as he gathered observational evidence was a testament to how insightful and careful, he was as an experimental scientist and artist. As compared to Della Torre who explained conflicting visual evidence through the existence of disease or sin,[170]

---

[167] James S. Ackerman, "Leonardo Da Vinci: Art in Science." Daedalus 127, no. 1 (1998): 216
[168] R.J. Hankinson, "Galen's Anatomy of the Soul." Phronesis 36, no. 2 (1991): 200
[169] Hankinson, "Galen's Anatomy of the Soul.", 200
[170] Hankinson, "Galen's Anatomy of the Soul.", 200

Andreas Vesalius Continues Leonardo da Vinci's Research

Andreas Vesalius is considered the father of modern anatomy. [171] Although da Vinci's notes and detailed anatomical diagrams predated Vesalius research, da Vinci's work was not published until much later. As a result, da Vinci's contribution to the advancement of anatomical knowledge remained minimal until the end of the 17th century. Vesalius was born in Brussels in 1514 (five years before da Vinci's death) and came from a family of renowned physicians and pharmacists. [172] He moved to Paris later in his life to pursue an education in medicine. He obtained his degree in medicine from the University of Padua in 1537, and he stayed on as a professor of surgery.[173] He used his own dissections and drawings to teach his students, and 6 of these initial illustrations were published in 1538, known as *Tabulae.*[174] This set of illustrations had an imprint of Galenic ideas.[175] During Vesalius' time, the study of anatomy and anatomical dissections had become mandatory in most well-established medical universities in large cities of Italy like Padua and Florence. At the University of Padua, Vesalius finished working on

[171] Fabio Zampieri et al., "Andreas Vesalius: Celebrating 500 Years of Dissecting Nature," Global Cardiology Science & Practice (National Library of Medicine, January 1, 1970), 66 doi: 10.5339/gcsp.2015.66.
[172] Fabio Zampieri et al., "Andreas Vesalius: Celebrating 500 Years of Dissecting Nature," Global Cardiology Science & Practice (National Library of Medicine, January 1, 1970), 66 doi: 10.5339/gcsp.2015.66.
[173] Jinpo Xiang and Santhana Venkatesan, "The Role of Vesalius and His Contemporaries in the Transfiguration of Human Anatomical Science," Journal of anatomy (U.S. National Library of Medicine, February 2023), 126 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9877481/.
[174] Fabio Zampieri, Cristina Basso, and Gaetano Thiene, "Andreas Vesalius' Tabulae Anatomicae Sex (1538) and the Seal of the American College of Cardiology," Journal of the American College of Cardiology (U.S. National Library of Medicine, October 16, 2013), 694-695 https://pubmed.ncbi.nlm.nih.gov/24140673/.
[175] Zampieri et al. "Andreas Vesalius' Tabulae Anatomicae Sex", 694

his anatomical text, the *De humani corporis fabrica libri septem* (translated as the fabric of the human body in 7 books) in 1542. [176] This treatise was illustrated by Jan van Calcar, who was one of Titian's apprentices. This text had more than 600 illustrations.[177] After the publication and printing of this book, we see a stark departure from original Galenic teachings. This work becomes a new reference point for all the upcoming generations of anatomists.

Vesalius did not shy away from deviating from ancient teachings and reporting very accurately the things he saw. He corrected several previously held wrong anatomical beliefs. For example, he pointed out that the breastbone is made of three segments rather than seven, a common Galenic convention[178]. He also correctly refuted the existence of pores in the interventricular septum as a means of blood flow passage from the right ventricle to the left ventricle.[179] We still come across rare Galenic conventions in Vesalius's work. For example, Figure A.21 shows a drawing of the liver by Vesalius from his *Tabula II.* This figure shows a liver with five lobes. Like Galen, he also believed that air was brought back to the left side of the heart from the pulmonary vein (labeled Q in Figure A.22),[180] and that the liver was the source of the blood. This adherence to Galenic

[176] Zampieri et al., "Andreas Vesalius: Celebrating 500 Years of Dissecting Nature," 66
[177] Evandro Tinoco Mesquita, Celso Vale de Souza Júnior, and Thiago Reigado Ferreira, "Andreas Vesalius 500 Years - a Renaissance That Revolutionized Cardiovascular Knowledge," Revista Brasileira de Cirurgia Cardiovascular : órgão oficial da Sociedade Brasileira de Cirurgia Cardiovascular (National Library of Medicine, January 1, 1970) 262, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4462973/.
[178] Standring, "A Brief History of Topographical Anatomy", 41
[179] Gaetano Thiene and Jeffrey E. Saffitz, "Autopsy as a Source of Discovery in Cardiovascular Medicine: Then and Now" (National Library of Medicine, June 19, 2018), 2684 https://pubmed.ncbi.nlm.nih.gov/29915093/.

[180] Fabio Zampieri, Cristina Basso, and Gaetano Thiene, "Andreas Vesalius' Tabulae Anatomicae Sex (1538) and the Seal of the American College of Cardiology," Journal of

conventions shows Vesalius' choice to incorporate the universal truth within his strictly empirical research. Vesalius had dissected both apes and humans, therefore, some of the cardiovascular system schematics resemble those of apes' rather than humans (Figure A.23). It is hard to know why Vesalius's work had a tether to old, dated Galenic concepts (especially when the majority of his work is distinctly accurate, authentic and breaks free from prior norms). I have compiled several plausible reasons for this incorporation of old concepts.

Vesalius was pursuing his medical education first in Paris and then later in Padua. The material he was studying was of primarily Galenic origin. The Arabic translations or the Latin and Italian retranslations of the Arabic translations of Galen's work, which had been modified and edited multiple times, were the only blueprints of theoretical knowledge to learn anatomy until that time. It was only later when Vesalius performed his own dissections and created his own diagrammatic representations that he was able to correct most of his original theories. So, it is possible that while he was discovering new anatomical details and trying to explain the workings of the organ systems based on his findings, he reverted to older medical teachings that did not outright contradict his theories. For example, believing that air went back from the lungs to the left side of the heart made sense to him as it had done to Galen, because neither of these physicians had seen pulmonary circulation. It was not until 1559 when one of Vesalius' students, Matteo Realdo Colombo, discovered pulmonary circulation by in vivo dissection of dogs, and correctly identified that it was blood that was carried back from the lungs into the heart

---

the American College of Cardiology (U.S. National Library of Medicine, October 16, 2013), 694-695 https://pubmed.ncbi.nlm.nih.gov/24140673/.

and not air. [181] Vesalius filled the knowledge gap with original teachings when he could not find an alternative explanation or a reason to refute the original Galenic knowledge. When he did find a compelling argument against conventional wisdom, he would openly admit so. For example, in the first edition of the *Fabrica*, he admits to being amazed and astonished by the presence of the invisible pores in the interventricular septum in the heart, but by the second edition of the same book in 1555, he refutes the idea as he was unable to see any evidence of the connection between the two cardiac chambers:[182]

Consider Vesalius's excerpt from the first edition of his book: "Thus we are compelled to astonishment at the industry of the Creator who causes the blood to sweat from the right ventricle into the left through passages which escape our sight." Now compare it to an excerpt from the second edition of the same book:

> However much the pits may be apparent, yet none, as far as can be comprehended by sense, passes through the septum of the heart from the right ventricle into the left. I have not seen even the most obscure passages by which the septum of the ventricles is pervious, although they are mentioned by professors of anatomy since they are convinced that blood is carried from the right ventricle to the left. As a result—as I shall declare more openly elsewhere—I am in no little doubt about the function of the heart in this part.[183]

The second reason has to do with the techniques to preserve the inner organs of cadavers. Large-scale cold storage units were not available to medical schools until centuries after Vesalius and Leonardo performed their dissections. We see meticulously detailed presentations of external body features, muscles and ligaments and bones in Vesalius' and Leonardo's work (with no inclination whatsoever to revert back to ancient knowledge), however at times the depiction and functioning of internal organs is not

[181] Thiene and Saffitz, "Autopsy as a Source of Discovery in Cardiovascular Medicine: Then and Now" 2684

[182] Zampieri et al. "Andreas Vesalius' Tabulae Anatomicae Sex", 695

[183] Zampieri et al. "Andreas Vesalius' Tabulae Anatomicae Sex", 695

completely accurate and incorporates Galenic conventions. This could be because of the deterioration of internal organs at the time of dissections, or incomplete dissections due to rapid decay and putrefaction of the cadavers, resulting in the inability of the anatomist to discover the correct number of lobes of an organ or their vascular supply.

The discovery of the structure-to-function relationship of the organs required the study of live organs in motion. William Harvey, an Englishman, who also graduated from the University of Padua in 1602, correctly identified the circulation of blood in the human body by observing the beating hearts of fallow deer in the forests of Windsor Castle.[184] With these observations, he was able to calculate the cardiac output, which was stable throughout the cardiac cycle with every beat, and he concluded that blood was pumped out from the heart through the vessels (and circulated repeatedly in the body) rather than being created in the liver with every beat (it was impossible for the liver to generate huge amounts of blood in a short period of time).[185] Thus, the observation of a dynamic and 'alive' phenomenon dispelled a long standing Galenic convention which Vesalians were not able to.

Lastly, Galen and ancient Greek teachings on the subject of anatomy were of biblical reverence. As Vesalius openly contradicted his theories, he fell out of favor with his peers and teachers. It is believed that because of this undue criticism, he curtailed his further anatomical dissections and pursuits. [186] Like Leonardo discovering the correct shape and geometry of cerebral ventricles later in his life, and then redrawing these

[184] Thiene and Saffitz, "Autopsy as a Source of Discovery in Cardiovascular Medicine: Then and Now" 2685
[185] Thiene and Saffitz, "Autopsy as a Source of Discovery in Cardiovascular Medicine: Then and Now" 2685
[186] Kent M. Van De Graaff. "Chapter 1." Essay. In Human Anatomy, 6th ed., pp. 14–15. Boston: McGraw-Hill, 2002.

structures, perhaps Vesalius would have been able to correct most if not all the anatomical inaccuracies in prevalent knowledge, had he continued his pursuit of the anatomical sciences.

CHAPTER 5

CONCLUSION: GALENIC TEACHINGS, THE OBJECTIVE VS. THE UNIVERSAL TRUTH

In the preceding chapters, we can clearly see the long-lasting effects of Galenic teachings. During the Renaissance, there was a renewed interest in the study of science, including anatomy, as well as the flourishing of the arts. This period saw an increase in anatomical studies and dissections, and the development of more accurate anatomical illustrations. Unlike literature or language, anatomy is a distinctly visual field of study, in which observing and witnessing an anatomical structure is easier than reading a text and trying to visualize a three-dimensional live structure functioning in relation to other live organs. Surgical practices of the modern day are entirely founded on precise knowledge of anatomy. However, the evolution and advancement of this field was very slow until the Renaissance.

The Ancient Greek anatomical teachings, especially those of Galen were the only source of learning medicine until at least the 1300s-1500s. There was a relative paucity of human dissections until the 1300s, and it appears that there was a lack of interest in general in the anatomical field. In the Renaissance, Christianity and the Church continued to play an important role in society, but their relationship with the secular world and with the arts underwent significant changes. While the Church had long been a powerful institution, with significant political and economic influence, the Renaissance saw a

growing interest in humanism, which placed greater emphasis on the individual and the natural world.

At the same time, the Church had long recognized the importance of the arts in promoting its message and exerting its influence, and so it continued to be a major patron of the arts during the Renaissance. It also held the power of allowing or banning dissections for the benefit of art and anatomy as it saw fit. Artists like Leonardo and Raphael started performing their own dissection, at great personal risk (legally and spiritually), to further their knowledge of human shape and form. In the case of da Vinci, this led to his inquisitiveness for further pursuit of correct inner anatomical details. This keen interest from artists in the human body revolutionized the academic and medical fields and paved the way for future anatomists. In the mid-15th century, the ability to print and distribute texts and illustrations to the masses propelled the advancement of not just the medical sciences but it also made artworks and illustrative drawings accessible to the masses.

By the Italian Renaissance, dissections of cadavers had become somewhat acceptable. However, the emergence of accuracy and precision in human anatomical drawings was a gradual process, and we see artists breaking free from traditional anatomical teachings, that were laden with flawed observations and theories. We see how Renaissance artists initially went by the conventional wisdom, and created works that showed a blend of data derived from Galenic teachings and newly observed accurate topographical and structural anatomical details. The reasons for this slow liberation from Galenic influence were not only the great reputation of Galen's works, accessibility, and traditional teaching methods, but also the choices made by artists and anatomists to prefer

the acceptance of the universal truth and the ‘aesthetic’ of Humanist depiction of the human body.

The Renaissance artists and anatomists discussed in my thesis showed a tendency to incorporate Galenic influence in their artworks, texts and illustrations. Oftentimes, this was done to either fill the holes in their knowledge or to rely upon that which was popular and widely accepted. My argument supports the theory that these artists and anatomists were greatly influenced by the rise of naturalism and individualism during the Renaissance. This influence propelled them to make artistic choices that resolved the common problem of universal vs. specific, ideal vs. naturalistic, and general vs. empirical. As these people performed dissections and gathered visual evidence, they imbued Galenic influence within these discoveries to stay aligned with the universal truth and the customs prevalent during the Renaissance.

The purpose of this exploration is not to criticize the artists of that time, but to study their works objectively and recognize the tendrils of Galenic influence. In the light of all the evidence provided in my thesis, through formal and anatomical analyses of drawings and illustrations and through comparative analyses, I prove that the dissection records and works by da Vinci, Vesalius, Carpi and Luzzi were deeply objective and empirical however, they simultaneously incorporate Galenic influence to provide context for their existence and to fit into the bigger, universal picture. It was not that these artists and anatomists were ignoring evidence that was contradictory to the Galenic Corpus. Instead, they were facing the problem of copying directly from nature versus adhering to what was known as the convention at that time. The illustrations discussed in my thesis

show the ability of the artists and anatomists to transcend the specific and to contribute to the universal truth.

REFERENCES

Abdel-Misih, Sherif R.Z, and Mark Bloomston. “Liver Anatomy.” The Surgical clinics of North America. U.S. National Library of Medicine, May 2014. https://pubmed.ncbi.nlm.nih.gov/20637938/.

Aird, W.C. “Discovery of the Cardiovascular System: From Galen to William Harvey.” Journal of Thrombosis and Haemostasis 9 (2011): 118–29. https://doi.org/10.1111/j.1538-7836.2011.04312.x.

Ackerman, James S. “Leonardo Da Vinci: Art in Science.” Daedalus 127, no. 1 (1998): 207–24.

A.K. “Leonardo Da Vinci as Anatomist.” The British Medical Journal 1, no. 3673 (1931): 950–51. http://www.jstor.org/stable/25339724.

Amaker, Tyler, Charles Barber, Amaya Benson, Zack Beyerl, Katerina Bogdan, Lauren Crocker, Emory Doppelheuer, et al. “Galen's Anatomical Anomalies & Discoveries, 2020. Hackett and Proctor, Three-Dimensional Display Technologies for Anatomical Education: A Literature Review.” Science, Technology; Society: A Student-Led Exploration, July 29, 2020.

Ameer, Muhammad Atif, Sarah E. Fagan, Jessice N. Sosa-Stanley; and Diana C. Peterson. “Anatomy, Abdomen and Pelvis, Uterus.” National Center for Biotechnology Information. U.S. National Library of Medicine, December 6, 2022. https://pubmed.ncbi.nlm.nih.gov/29262069/.

Bay, Noel Si-Yang, and Boon-Huat Bay. “Greek Anatomist Herophilus: The Father of Anatomy.” Anatomy & Cell Biology 43, no. 4 (December 2010): 280–83. https://doi.org/10.5115/acb.2010.43.4.280.

Bell, B A. “A History of the Study of the Cerebral Circulation and the Measurement of Cerebral Blood Flow.” Neurosurgery 14, no. 2 (1984): 238-246. https://doi.org/10.1097/00006123-198402000-00023.

Berengario da Carpi, Jacopo. “Isagoge Breves.” Wellcome Collection. Bonona : Benedictus Hector, 1460. https://wellcomecollection.org/works/ujm5ynjj.

Bonnard, Jean-Baptiste. “Male and Female Bodies According to Ancient Greek Physicians.” Clio, no. 37 (2014): 1–18. https://doi.org/10.4000/cliowgh.33Brenna

Connor T. “Bygone Theatres of Events: A History of Human Anatomy and Dissection.” The Anatomical Record 305, no. 4 (2021): 788–802. https://doi.org/10.1002/ar.24764.

Brockmann, Christian, Milena Melfi, Robert Parker, and Florian Steger. “A God and Two Humans on Matters of Medicine: Asclepius, Galen and Aelius Aristides.” in In Praise of Asclepius: Aelius Aristides, Selected Prose Hymns, edited by Heinz-Günther Nesselrath, Donald A. Russell, and Michael Trapp, 115–28. Mohr Siebeck GmbH and Co. KG, 2016.

Caetani, Don Gelasio. “The Myriad-Minded Leonardo Da Vinci, Forerunner of Modern Science.” The Scientific Monthly 19, no. 5 (1924): 449–64.

Clayton, Martin and Ron Philo. “Leonardo da Vinci- Anatomist.” Royal Collection Publications. Royal Collection Enterprises Limited, 2012: 18-260

Connell, Sophia M. “Aristotle and Galen on Sex Difference and Reproduction: A New Approach to an Ancient Rivalry.” Studies in History and Philosophy of Science Part A 31, no. 3 (2000): 405–27. https://doi.org/10.1016/s1369-8486(00)00007-8.

Crivellato, Enrico and Ribatti, Domenico. "Mondino de' Luzzi and his Anothomia: A milestone in the development of modern anatomy." Clinical anatomy (New York, N.Y.), vol. 19, 2006, pp. 581-587.

Da Vinci, Leonardo. Anatomical Drawings from the Royal Library, Windsor Castle. Edited by Kenneth D. Keele and Jane Roberts. New York: The Metropolitan Museum of Art; New Haven: Yale University Press, 1983.

Dryander, and Dryander, Johann. *Anatomia Mvndini: collata,iustoq, suo ordini restituta*, Publisher: Marpvrgi, In officina Christiani Egenolphi ,1541.

Duque, Jorge, John Barco Rios, and Johnny Fernando Garcia-Aguirre. “A Historical Approach to the Ventricular System of the Brain.” Universidad Nacional de Colombia, 2017, 65(3):473-477

Eijk, Philip J van der. “Rufus’ on Melancholy and Its Philosophical Background.” In On Melancholy: Rufus of Ephesus, edited by Peter E Pormann, 159–78. Mohr Siebeck GmbH and Co. KG, 2008. http://www.jstor.org/stable/j.ctv9b2w2k.10.

Evans, Elizabeth C. “Galen the Physician as Physiognomist.” Transactions and Proceedings of the American Philological Association 76 (1945): 287–98. https://doi.org/10.2307/283342.

Freemon, F R. “Galen's Ideas on Neurological Function.” Journal of the history of the neurosciences. U.S. National Library of Medicine, October 1994. 3(4):263-71. https://pubmed.ncbi.nlm.nih.gov/11618827/.

Frojmovič, Eva. “Giotto’s Circumspection.” *The Art Bulletin* 89, no. 2 (2007): 195–210. http://www.jstor.org/stable/25067314.

Ghosh, Sanjib Kumar. “The Evolution of Epistemological Methodologies in Anatomy: From Antiquity to Modern Times.” The Anatomical Record 305, no. 4 (2021): 803–17. https://doi.org/10.1002/ar.24781.

Graciano, Andrew. Visualizing the Body in Art, Anatomy, and Medicine since 1800. 1st ed. 2019. Reprint, Taylor and Francis, 2019. https://www.perlego.com/book/1375673/visualizing-the-body-in-art-anatomy-and-medicine-since-1800-models-and-modeling-pdf.

Gulik, Thomas, Rosmalen, Julia, Gulik, Merel and Rosmalen, Belle. " The Liver in the Middle Ages, according to Galen, " Prometheus and the Liver through Art and Medicine (Amsterdam: Amsterdam University Press, 2022), pp. 67-72. https://doi.org/10.1515/9789048557417-007.

Gumpert, Martin. “Vesalius: Discoverer of the Human Body.” Scientific American 178, no. 5 (1948): 24–31.

Gurunluoglu, Raffi, Aslin Gurunluoglu, Susan A Williams, and Safiye Cavdar. “The History and Illustration of Anatomy in the Middle Ages.” Journal of Medical Biography 21, no. 4 (2013): 219–29. https://doi.org/10.1177/0967772013479278.

Hackett, Matthew, and Michael Proctor. “Three-Dimensional Display Technologies for Anatomical Education: A Literature Review.” Journal of Science Education and Technology 25, no. 4 (2016): 641–54.

Hankinson, R. J. “Galen’s Anatomy of the Soul.” Phronesis 36, no. 2 (1991): 197–233

Hajar, Rachel. “The Air of History (Part II) Medicine in the Middle Ages.” Heart Views 13, no. 4 (2012): 158-162. https://doi.org/10.4103/1995-705x.105744.

Harvey, William. "Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus (An Anatomical Study of the Movement of Heart and Blood in Animals)." Ind Med Gaz 64, no. 5 (May 1929). PMC5164835.

Hajar, Rachel. “The Air of History Part III: The Golden Age in Arab Islamic Medicine, An Introduction.” Heart Views 14, no. 1 (2013): 43-46. https://doi.org/10.4103/1995-705x.107125.

Jouanna, Jacques, and Neil Allies. “The Legacy of the Hippocratic Treatise the Nature of Man: The Theory of the Four Humors.” Essay. In In Greek Medicine from Hippocrates to Galen: Selected Papers, edited by Pilip van der Eijk, 335–260. Brill, 2012.

Kemp, Martin. “Dissection and Divinity in Leonardo’s Late Anatomies.” Journal of the Warburg and Courtauld Institutes 35 (1972): 200–225.

Kushner, Irving. “The 4 Humors Erythrocyte Sedimentation: The Most Influential Observation in Medical History.” The American Journal of the Medical Sciences 346, no. 2 (2013): 154–57. https://doi.org/10.1097/maj.0b013e31826cad55.

Lamarque, Peter. “The Aesthetic and the Universal.” *Journal of Aesthetic Education* 33, no. 2 (1999): 1–17. https://doi.org/10.2307/3333683.

_____, “Leonardo Da Vinci”. The British Medical Journal 2, no. 3167 (1921): 413.

Lowery, Laura Anne, and Hazel Sive. “Totally Tubular: The Mystery behind Function and Origin of the Brain Ventricular System.” BioEssays : news and reviews in molecular, cellular and developmental biology. U.S. National Library of Medicine, April 2009, 31(4): 446-58. https://pubmed.ncbi.nlm.nih.gov/19274662/

Lyon, Karen. “The Four Humors: Eating in the Renaissance.” Shakespeare Beyond. Folger Shakespeare Library, December 18, 2015. https://shakespeareandbeyond.folger.edu/2015/12/04/the-four-humors-eating-in-the-renaissance/.

Malomo, Adefolarin O., Olufemi E. Idowu, and Ferdinand C. Osuagwu. “Lessons from History: Human Anatomy, from the Origin to the Renaissance.” International Journal of Morphology 24, no. 1 (March 2006): 99-104

Mattern, Susan P. *Galen and the Rhetoric of Healing*. Baltimore, MD: Johns Hopkins University Press, 2008.

Matteo, Berardo Di, Vittorio Tarabella, Giuseppe Filardo, Massimiliano Mosca, Mirco Lo Presti, Anna Viganò, Patrizia Tomba, and Maurilio Marcacci. “Art in Science: Mondino De' Luzzi: The Restorer of Anatomy.” Clinical Orthopedics and Related Research. U.S. National Library of Medicine, 2017 Jul;475(7):1791-1795. doi: 10.1007/s11999-016-5213-5.

Mavroudis, Constantine, Gary P. Lees, and Rachid Idriss. “Medical Illustration in the Era of Cardiac Surgery.” World Journal for Pediatric and Congenital Heart Surgery 11, no. 2 (2020): 204–14. https://doi.org/10.1177/2150135119893671.

Mavrodi, Alexandra., & Paraskevas, George. (2014). “Mondino de Luzzi: a luminous figure in the darkness of the Middle Ages.” Croat Medical Journal, 55(1), 50-3. doi: 10.3325/cmj.2014.55.50. PMID: 24577827; PMCID: PMC3944418.

Mesquita, Evandro Tinoco, Celso Vale de Souza Júnior, and Thiago Reigado Ferreira. “Andreas Vesalius 500 Years - a Renaissance That Revolutionized Cardiovascular Knowledge.” Revista Brasileira de Cirurgia Cardiovascular: órgão oficial da Sociedade Brasileira de Cirurgia Cardiovascular. National Library of Medicine, January 1, 1970, 30(2): 260–265. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4462973/.

Milne, Lorus J. “Accuracy in Anatomical Drawing.” Science 92, no. 2376 (1940): 43–44.

Miranda, Efrain A. Mondino de Luzzi. Clinical Anatomy Associates, Inc., February 24, 2014. https://clinicalanatomy.com/mtd/548-mondino-de-luzzi.

Noble, Denis, Dario DiFrancesco, and Diego Zancani. “Leonardo da Vinci and the Origin of Semen.” Notes and Records of the Royal Society of London 68, no. 4 (2014): 391–402.

Randall, John Herman. “The Place of Leonardo Da Vinci in the Emergence of Modern Science.” Journal of the History of Ideas 14, no. 2 (1953): 191–202.

Nutton, Vivian. *Galen: A Thinking Doctor in Imperial Rome*. London: Routledge Taylor & Francis Group, 2020.

Ogobuiro, Ifeanyichukwu, and Faiz Tuma. “Physiology, Renal.” National Center for Biotechnology Information. U.S. National Library of Medicine, July 25, 2022. https://pubmed.ncbi.nlm.nih.gov/30855923/.

Olry, Regis. “Medieval Neuroanatomy: The Text of Mondino Dei Luzzi and the Plates of Guido Da Vigevano.” Journal of the history of neurosciences. U.S. National Library of Medicine, August 1997; 6(2):113-23. https://pubmed.ncbi.nlm.nih.gov/11619515/.

Parent, André. “Berengario Da Carpi and the Renaissance of Brain Anatomy.” Frontiers. Department of Psychiatry and Neuroscience, Faculty of Medicine, Université Laval, Quebec, QC, Canada, January 22, 2019, pp. 1-14 https://www.frontiersin.org/articles/10.3389/fnana.2019.00011/full.

Payne, Alina. “Vasari, Architecture, and the Origins of Historicizing Art.” RES: Anthropology and Aesthetics, no. 40 (2001): 51–76.

Penttila, Nicky. “The Hidden Neuroscience of Leonardo Da Vinci.” Dana Foundation. Dana Foundation, October 25, 2021. https://dana.org/article/the-hidden-neuroscience-of-leonardo-da-vinci/.

Pevsner, Jonathan. “Leonardo Da Vinci's Studies of the Brain.” The Lancet. Elsevier, April 6, 2019: 1465-1472 https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(19)30302-2/fulltext.

Randall, John Herman. “The Place of Leonardo Da Vinci in the Emergence of Modern Science.” Journal of the History of Ideas 14, no. 2 (1953): 191–202. https://doi.org/10.2307/2707470.

Rossi, Daniella. “Humanism and the Renaissance.” *The Year’s Work in Modern Language Studies* 69 (2007): 476–90.

Rubin, James. Review of *Flesh and the Ideal: Winckelmann and the Origins of Art History*, by A. Potts. *The Art Bulletin* 78, no. 2 (1996): 358–61. https://doi.org/10.2307/3046180.

Santoro, Giuseppe, Mark D. Wood, Lucia Merlo, Giuseppe Pio Anastasi, Francesco Tomasello, and Antonino Germanò. “The Anatomic Location of the Soul from the Heart, through the Brain, to the Whole Body, and Beyond.” Neurosurgery 65, no. 4 (October 2009): 633–43. https://doi.org/10.1227/01.neu.0000349750.22332.6a.

Scelsi, C. L., T. A. Rahim, Jerry A. Morris, G. J. Kramer, B. Gilbert, and S. Forseen. “ The Lateral Ventricles: A Detailed Review of Anatomy, Development, and Anatomic Variations: Semantic Scholar.” American Journal of Neuroradiology, 41(4):566-572. January 1, 1970.

Simpson, Carol F. “Heat, Cold, or Both?” The American Journal of Nursing 83, no. 2 (1983): 270–73. https://doi.org/10.2307/3470302.

Sjöstrand, Nils. O. (2007). Den medicinska illustrationen som uttryck för föreställning och villa--levern som historiskt exempel [The medical illustration as the expression of illusion and imagination--the liver as an example from history]. Svenska Medietidskriften, 11(1), 17-51. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/18548944

Sooke, Alastair. “Leonardo Da Vinci's Groundbreaking Anatomical Sketches.” BBC Culture. BBC, October 21, 2014. https://www.bbc.com/culture/article/20130828-leonardo-da-vinci-the-anatomist.

O'Malley, Charles Donald, and J.B de C.M Saunders. *The Illustrations from the Works of Andreas Vesalius of Brussels.* 1st ed. The World Publishing Company, Cleveland & New York, 1950.

Sigerist, Henry E. “The Foundation of Human Anatomy in the Renaissance.” Sigma Xi Quarterly 22, no. 1 (1934): 8–12.

Standring, Susan. “A Brief History of Topographical Anatomy.” Journal of Anatomy 229, no. 1 (2016): 32–62. https://doi.org/10.1111/joa.12473.

Thiene, Gaetano, and Jeffrey E. Saffitz. “Autopsy as a Source of Discovery in Cardiovascular Medicine: Then and Now.” National Library of Medicine, June 19, 2018, 137(25):2683-2685. https://pubmed.ncbi.nlm.nih.gov/29915093/.

Tubbs, R. I., Jocelyn Gonzales, J. Iwanaga, M. Loukas, R. Oskouian, and R. Tubbs. “The Influence of Ancient Greek Thought on Fifteenth Century Anatomy: Galenic Influence and Leonardo Da Vinci.” National Library of Medicine. Childs Nervous System, January 1, 1970 (34): 1095-1101

Van De Graaff, Kent M. “Chapter 1.” Essay. In Human Anatomy, 6th ed., 14–15. Boston: McGraw-Hill, 2002.

Viale, Giuseppe. “The Rete Mirabile of the Cranial Base: A Millenary Legend.” Neurosurgery 58, no. 6 (2006): 1198–1208. https://doi.org/10.1227/01.neu.0000216118.31290.65.

Viviani, Maurizio, Pasquale Gallo, and Carlo Mazza. “ Marc'Antonio Della Torre and Leonardo Da Vinci: An Encounter That Changed the History of Medicine, Art and Anatomy: Semantic Scholar.” Child's Nervous System. National Library of Medicine, January 1, 1970, 493-499

Von Staden, Heinrich. Anatomy as Rhetoric: Galen on Dissection and Persuasion." Journal of the History of Medicine and Allied Sciences 50, no. 1 (1995): 47–66.

Wade, Nicholas J., Hiroshi Ono, and Linda Lillakas. "Leonardo Da Vinci's Struggles with Representations of Reality." Leonardo 34, no. 3 (2001): 231–35

Xiang, Jinpo, and Santhana Venkatesan. "The Role of Vesalius and His Contemporaries in the Transfiguration of Human Anatomical Science." Journal of anatomy. U.S. National Library of Medicine, February 2023, 124-131. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9877481/.

Yapijakis, Christos. "Hippocrates of Kos—the Father of Modern Medicine." Clinical Research in Cardiology Supplements 5, no. S1 (2010): 3–6. https://doi.org/10.1007/s11789-010-0014-y.

Zampieri, Fabio, Mohamed Elmaghawry, Alberto Zanatta, and Gaetano Thiene, "Andreas Vesalius: Celebrating 500 Years of Dissecting Nature," Global Cardiology Science & Practice (National Library of Medicine, January 1, 1970), 66 doi: 10.5339/gcsp.2015.66.

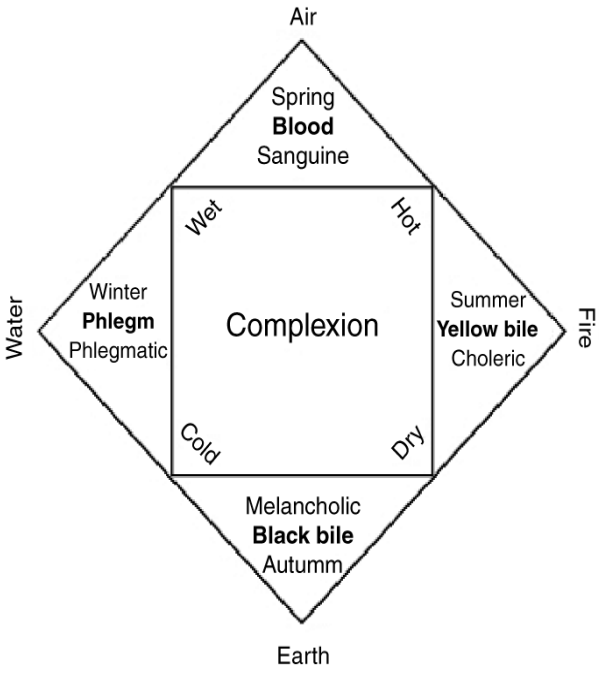
Zampieri, Fabio, Cristina Basso, and Gaetano Thiene. "Andreas Vesalius' Tabulae Anatomicae Sex (1538) and the Seal of the American College of Cardiology." Journal of the American College of Cardiology. U.S. National Library of Medicine, October 16, 2013, 694-695 https://pubmed.ncbi.nlm.nih.gov/24140673/.

APPENDIX A

FIGURES AND ILLUSTRATIONS

Figure A.1: Hunayn ibn Ishaq's Arabic translation of Galen's *De ossibus ad tirones* (On Bones for Beginners).

Note: Image sourced from the Islamic Culture and the Medical Arts, US National Library of Medicine.



Sanguine (hot,wet)	Prone to optimism
Phlegmatic (cold, wet)	Prone to apathy
Melancholic (cold, dry)	Prone to sadness
Choleric (hot, dry)	Prone to anger

Figure A.2: Representation of the Greek (Galenic) theory of the four humors.

Note: Image sourced from the “Humoralism and the colonial body,” published online by the Cambridge University Press: 05 August 2012.

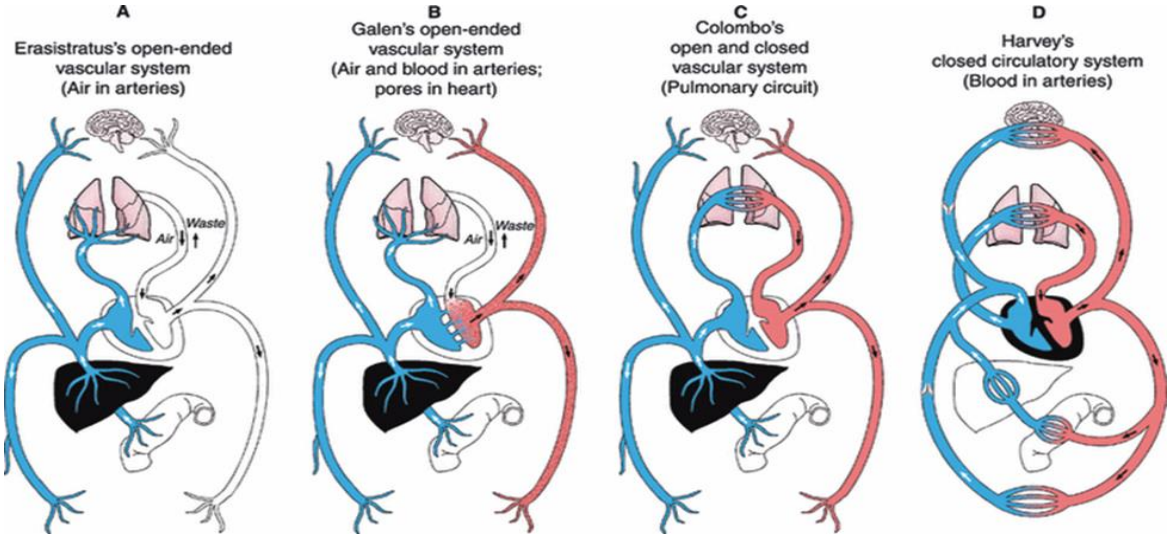


Figure A.3: Schematic of the Cardiovascular System over Time

Note: Image sourced from the "Discovery of the cardiovascular system: from Galen to William Harvey" by W.C Aird. https://doi.org/10.1111/j.1538-7836.2011.04312.x.

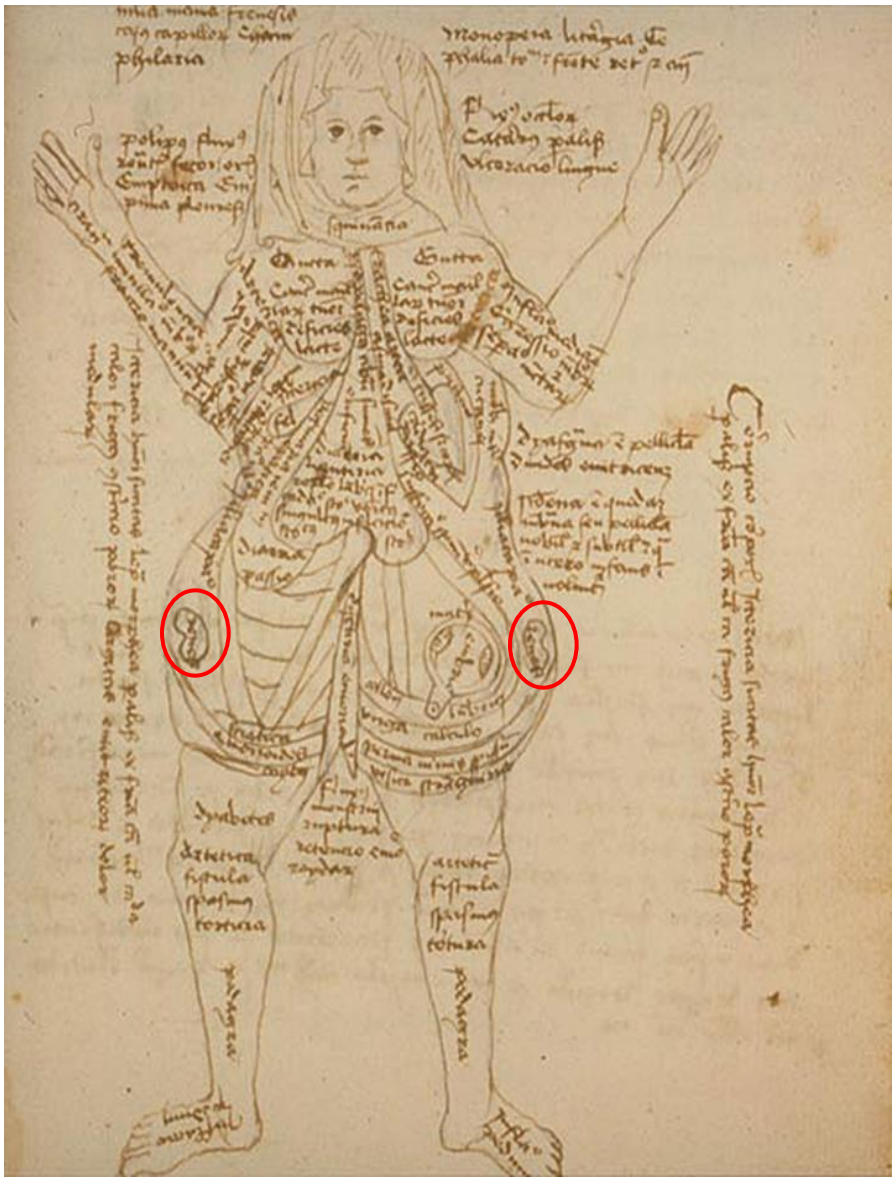


Figure A.4: The image shows an ancient teaching device called the *figura infirmitatum*. It was used to explain the locations and causes of diseases. Note the presence of twins (marked in red) in the two uterine chambers on either side of the body. This idea of twins being formed in separate chambers was proposed by Galen.

Note: Image and caption sourced from the "Annual Association for Medical Humanities Conference", University of Aberdeen 8th – 10th July 2013 – Review https://medicalhumanities.wordpress.com/2013/07/17/annual-association-for-medical-humanities-conference-university-of-aberdeen-8th-10th-july-2013-review/

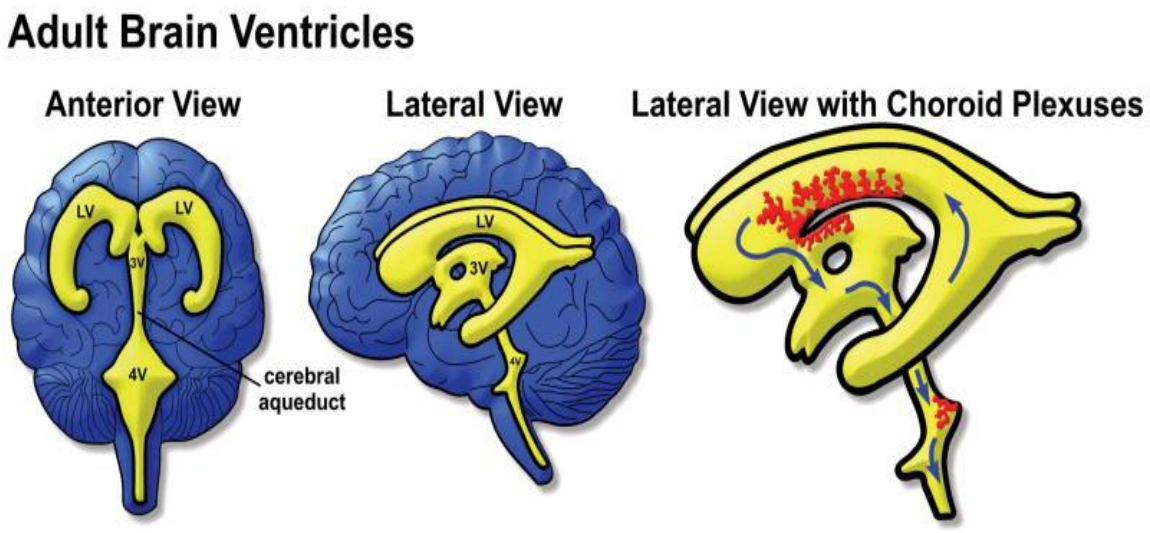


Figure A.5: The image shows the ventricular system of an adult brain. Blue represents brain tissue and yellow shows brain ventricles. Choroid plexuses are in red, blue arrows designate direction of CSF flow.
LV: lateral ventricle, 3V: third ventricle, 4V: fourth ventricle.

Note: Image sourced from the "Totally Tubular: The Mystery behind Function and Origin of the Brain Ventricular System" by Laura Anne Lowery and Hazel Sive.
https://www.researchgate.net/publication/24189927_Totally_Tubular_The_Mystery_behind_Function_and_Origin_of_the_Brain_Ventricular_System

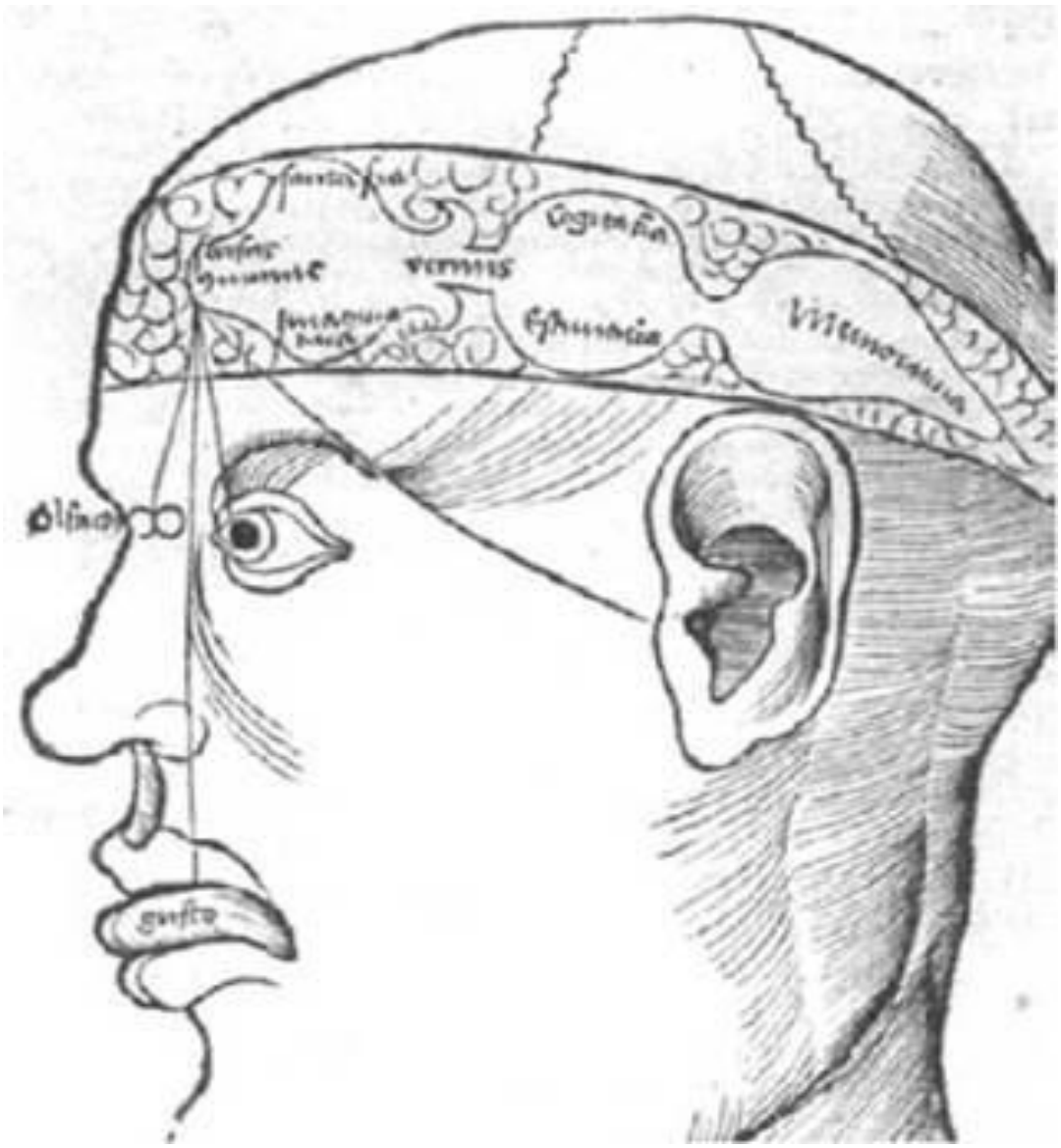


Figure A.6: Gregord Reisch's scheme (1503). The image shows the medieval interpretation of the human brain and its ventricles.

Note: Image sourced from “A historical approach to the ventricular system of the brain” by Duque et al.
https://www.researchgate.net/publication/321338607_A_historical_approach_to_the_ventricular_system_of_the_brain

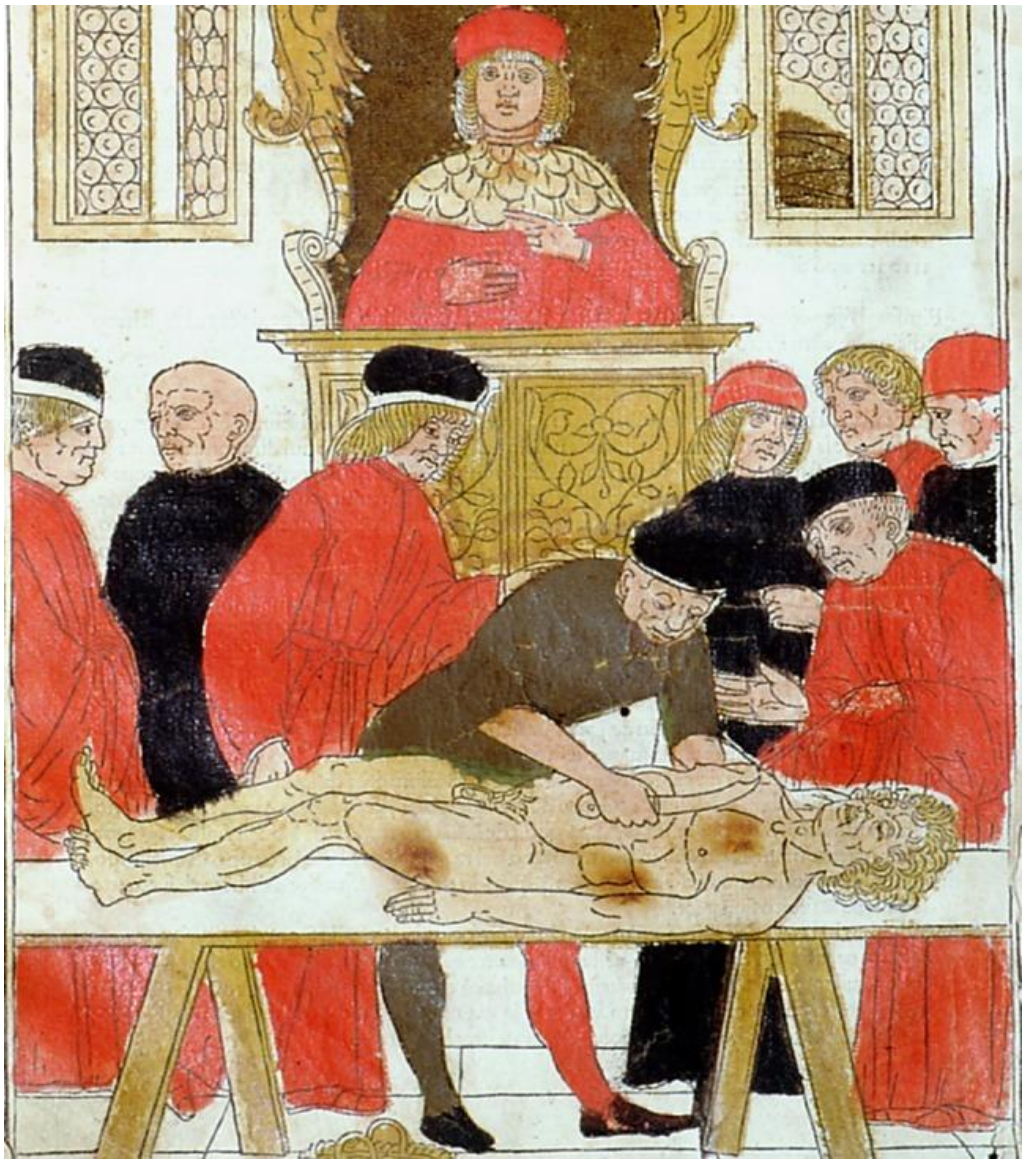


Figure A.7: The image is from Johannes de Ketham's book, *Fasciculus*. It shows Mondino de Luzzi overseeing a public dissection.

Note: Image sourced from Di Matteo, B., Tarabella, V., Filardo, G. et al. Art in Science: Mondino de' Luzzi: The Restorer of Anatomy. Clin Orthop Relat Res 475, 1791–1795 (2017). https://doi.org/10.1007/s11999-016-521

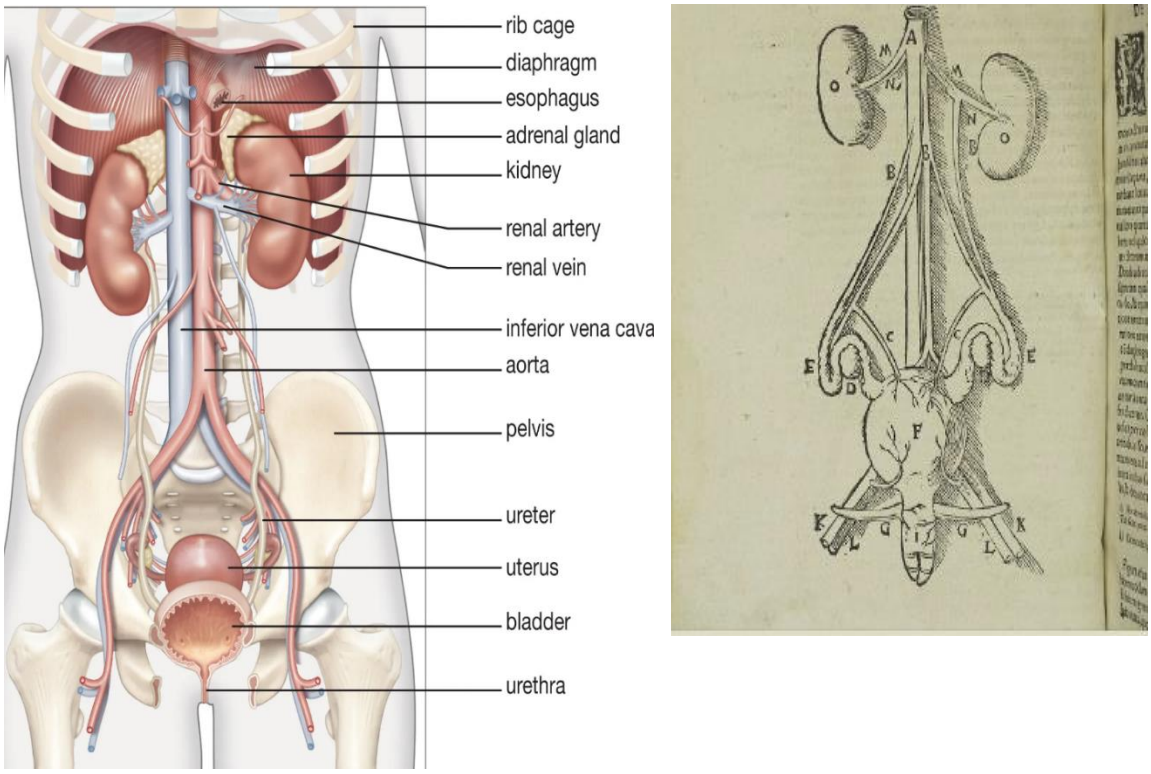


Figure A.8: The illustration on the right is from Mondino's *Anathomia*. The image on the left is of the human renal system as we know it now.

Note: Images are sourced from, (left) 2012 Encyclopedia Britannica, Inc. and (right) *Anathomia* by Mondino de Luzzi (1541) https://galileo.ou.edu/exhibits/anatomy-1541

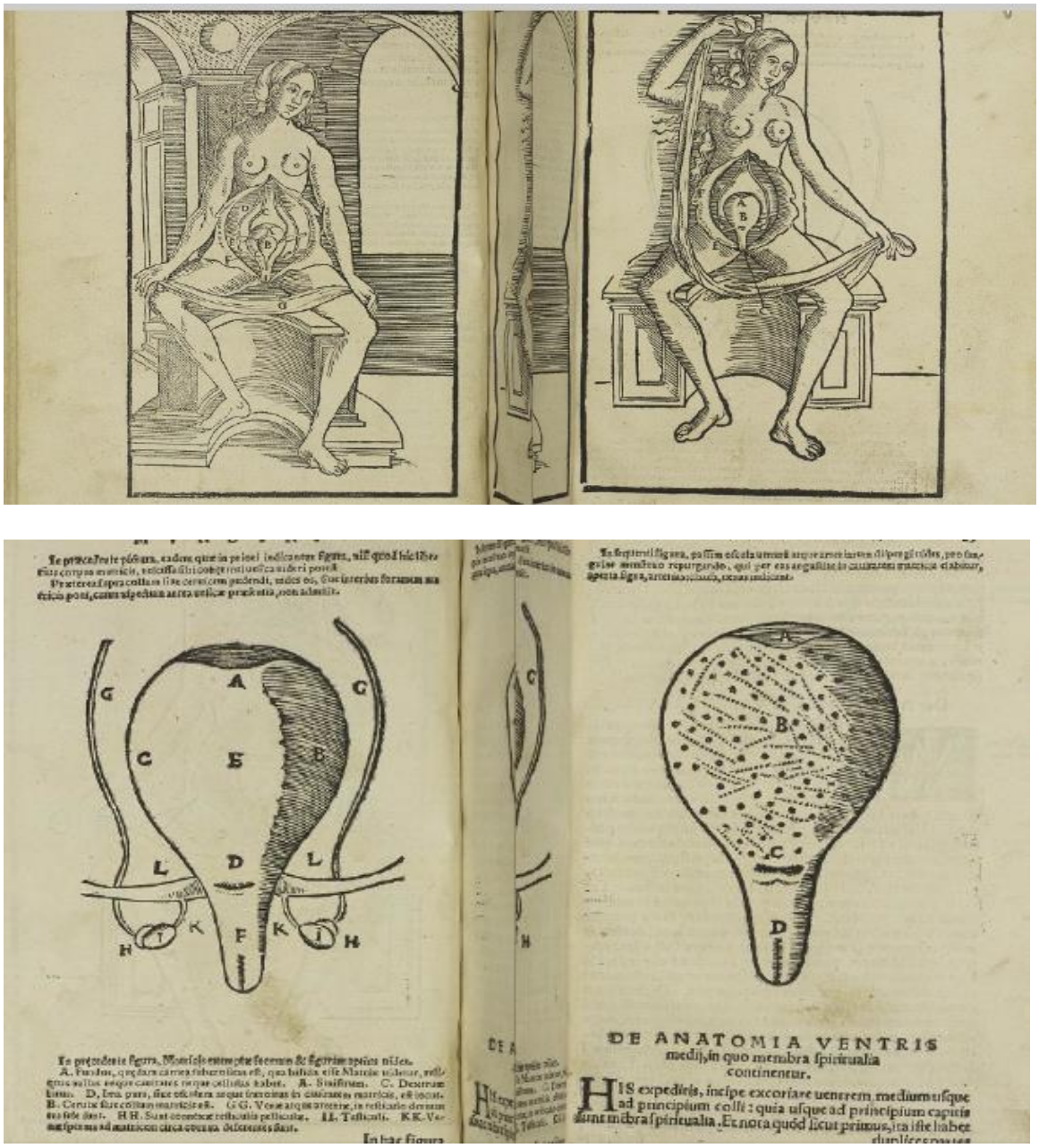


Figure A.9: Illustrations from Mondino's *Anathomia* showing the multi-chambered uterus with the attached ureters.

Note: Image sourced from *Anatomia Mvndini* by Mondino dei Luzzi, edited by Johann Dryander 1500-1560.
https://ourimo.hosted.exlibrisgroup.com/permalink/f/sl6asd/NORMANLAW_ALMA21420349480002042)

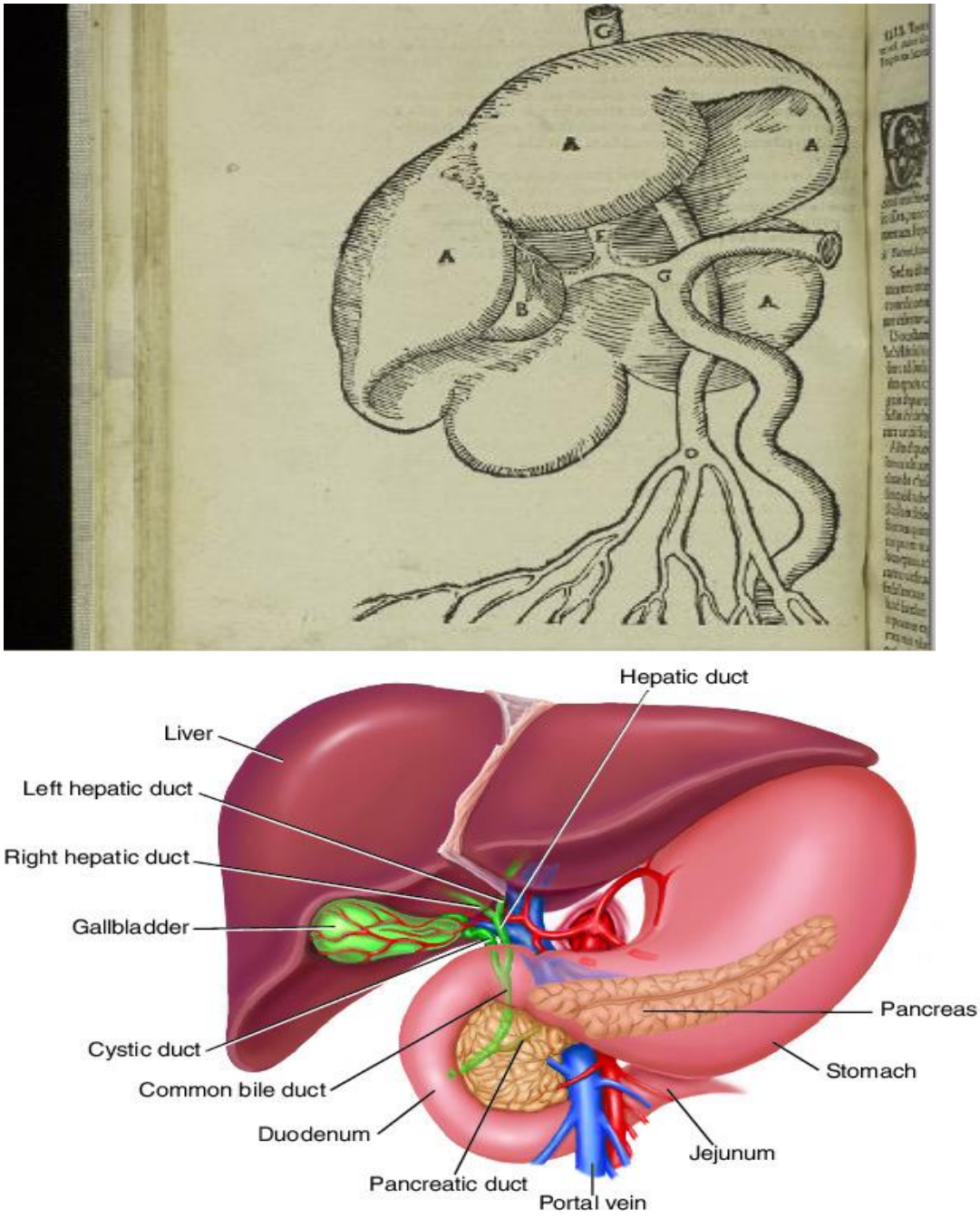


Figure A.10 (a): Illustration of a 5-lobed liver from Mondino's 'Anathomia'
(b). The anatomy of a liver and the gallbladder

Note: Images sourced from *Anatomia Mvndini* by Mondino dei Luzzi, edited by Johann Dryander 1500-1560.
https://ouprimo.hosted.exlibrisgroup.com/permalink/f/sl6asd/NORMANLAW_ALMA21420349480002042)
https://www.tabers.com/tabersonline/view/Tabers-Dictionary/734219/all/liver)

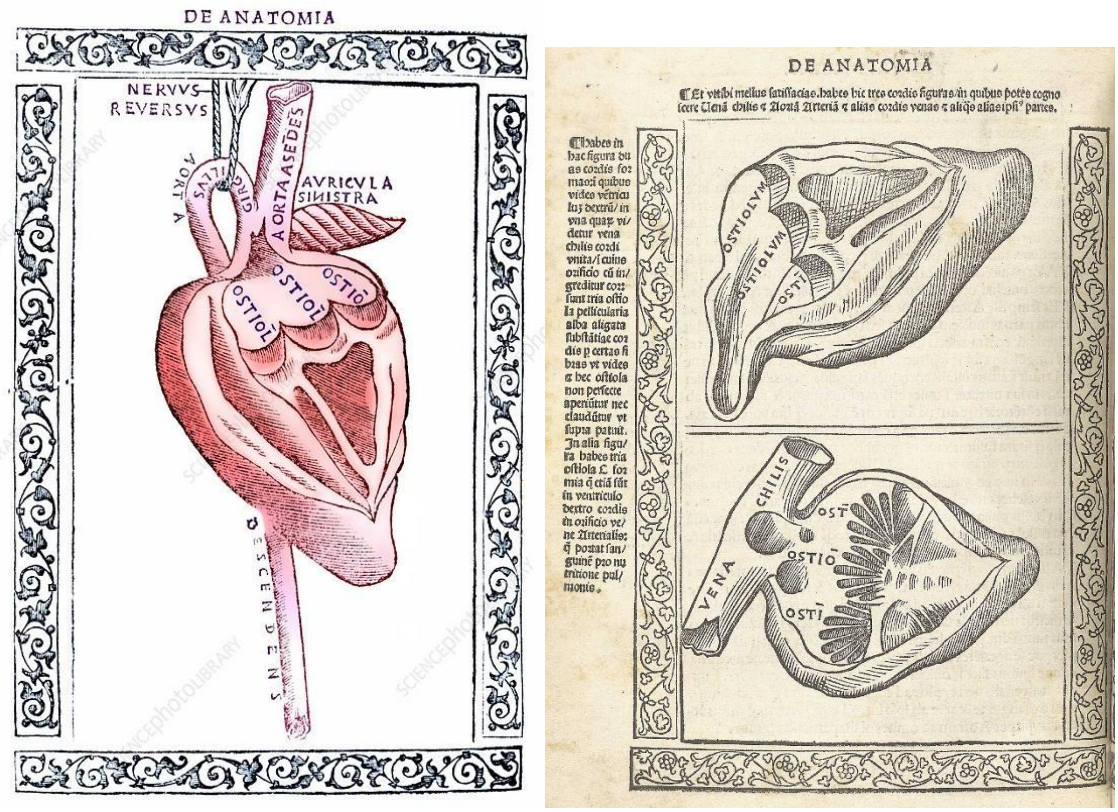


Figure A.11: Heart anatomy.
Left: Colored 16th-century artwork of the anatomy of the heart, its blood vessels, and nerves (showing three chambers of the heart). These artworks are from 'Isagogae breves' (1523), an anatomical work by Jacopo Berengario da Carpi (1460-1530). The text labels are in Latin.
Right: Heart anatomy showing the ‘Galenic’ pores in the interventricular septum.

Note: Images sourced from Berengario da Carpi’s “Isagoge Breves.” Welcome Collection. Bonona: Benedictus Hector, 1460. https://wellcomecollection.org/works/ujm5ynjj.

Figure A.12: Two female figures with their uterine anatomy on display. The illustrations are from Berengario da Carpi's *Isagoge breves* published in 1522-23.

Note: Image sourced from *Isagoge breves prelucide ac uberime in anatomiam humani corporis* by Carpi. https://wellcomecollection.org/works/ujm5ynjj/items?canvas=51

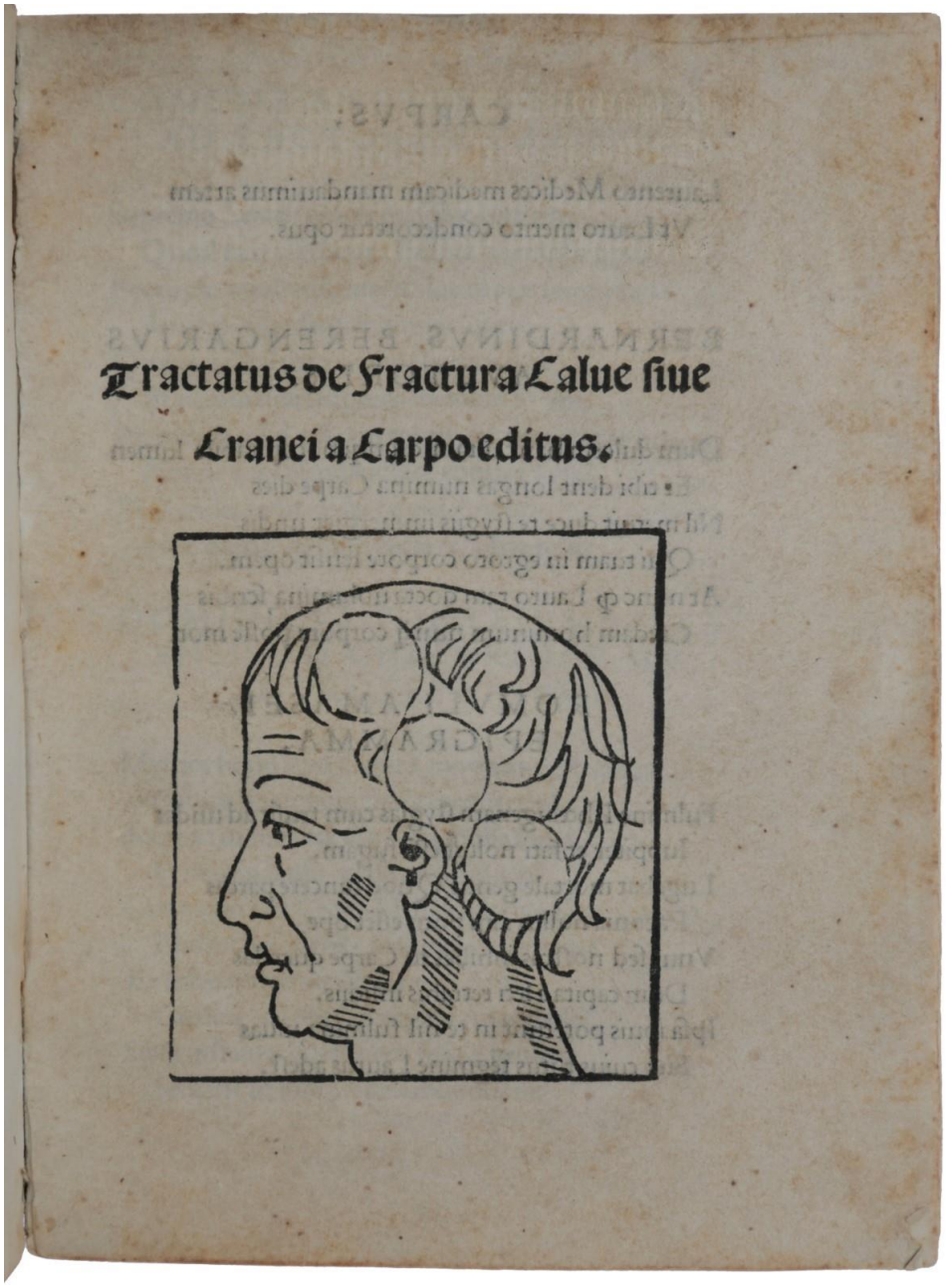


Figure A.13: *Tractatus de Fractura Calve Sive Cranei by* Jacopo Berengario da Carpi. (Human ventricles are drawn as three spheres of equal size and shape)

Note: Image sourced from Carpi, Tractatus de Fractura Calve sive Cranei. https://www.sophiararebooks.com/pages/books/5182/jacopo-berengario-da-carpi/tractatus-de-fractura-calve-sive-cranei

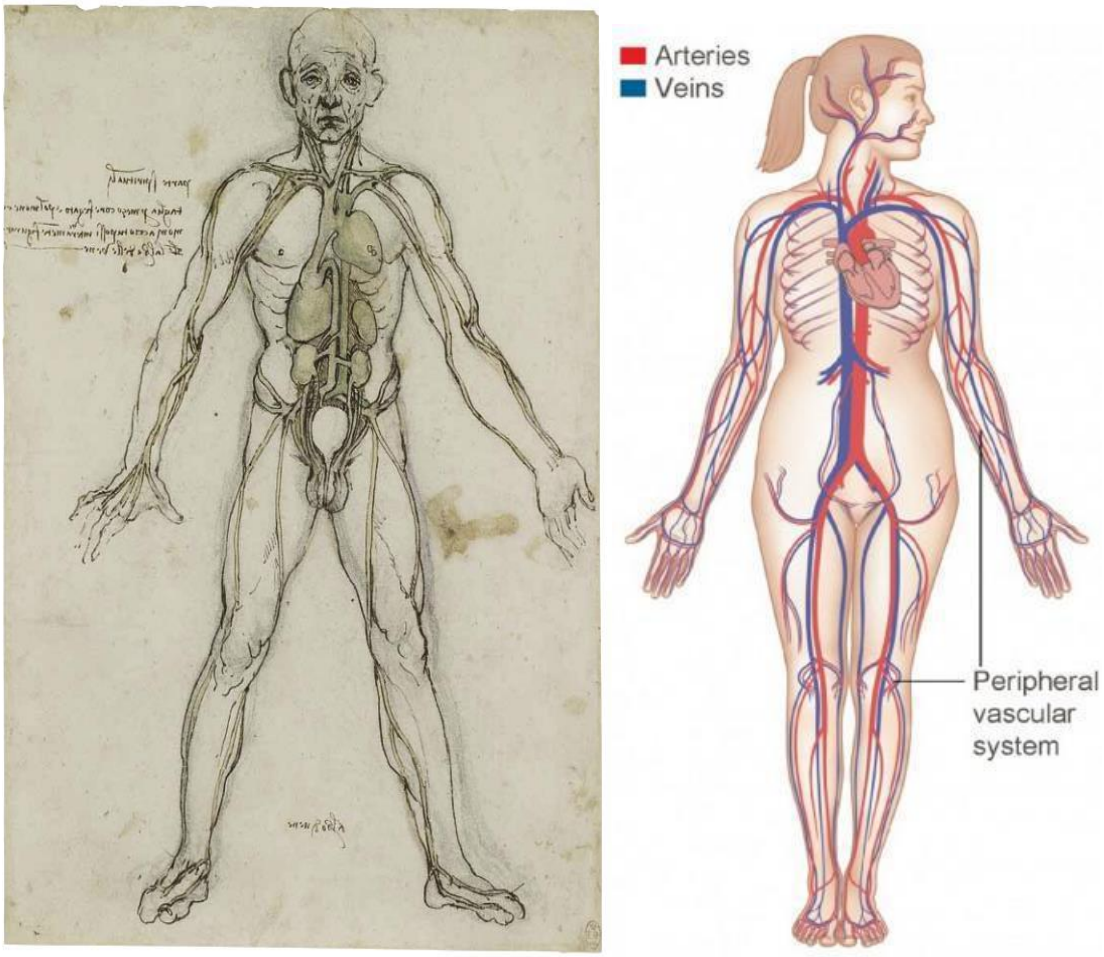


Figure A.14: Left: The Major Organs and Vessels, c.1485–90. Pen and ink with brown and greenish wash, over black chalk
Right: The vascular system of the human body.

Note: Images sourced from *Leonardo da Vinci*, *The Anatomist* by Clayton and Philo, Royal Collection Trust.

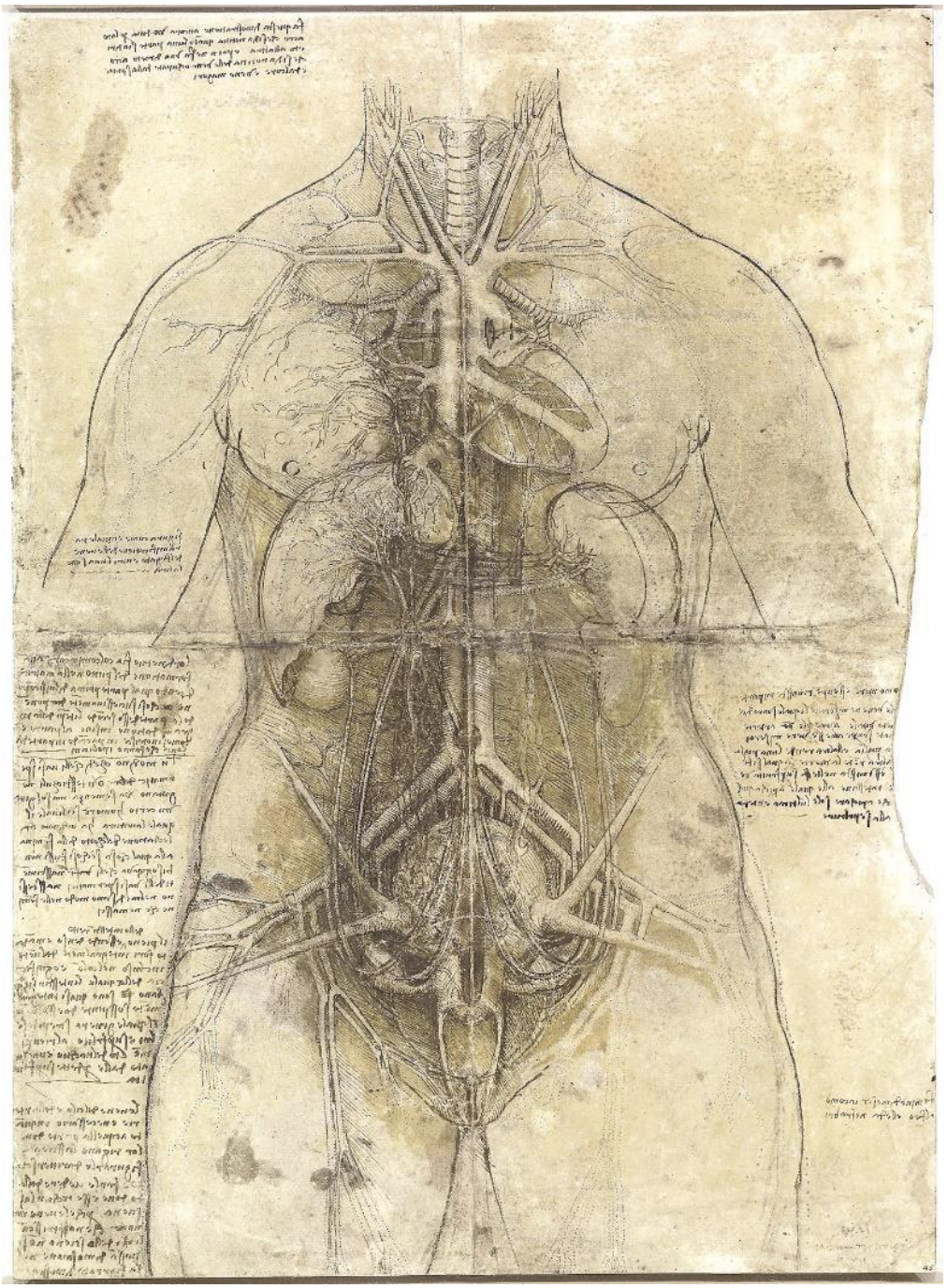


Figure A.15: The Principal Organs of a Woman.c.1509–10
Black and red chalk, ink, yellow wash, finely pricked through.

Note: Image sourced from *Leonardo da Vinci, The Anatomist* by Clayton and Philo, Royal Collection Trust.

Figure A.16: The Hemi Section of a Man and Woman in the Act of Coition, c.1490–92
Pen and ink.

Note: Image sourced from *Leonardo da Vinci, The Anatomist* by Clayton and Philo, Royal Collection Trust.

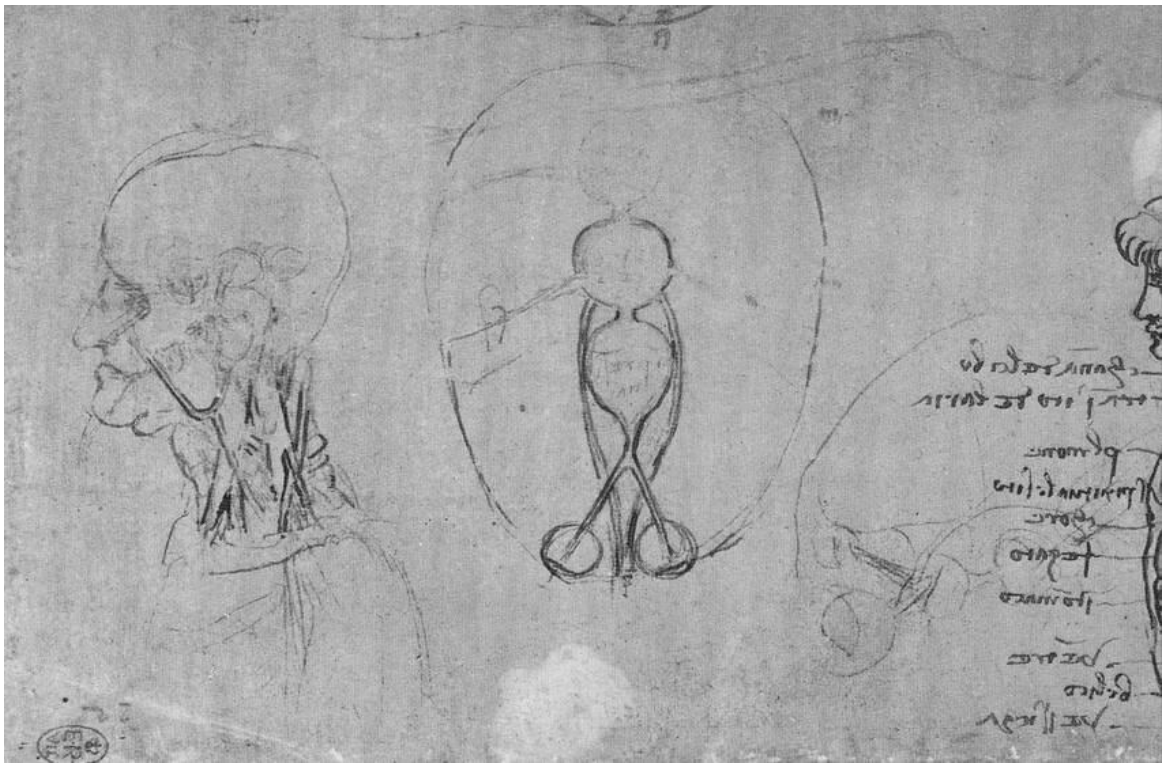


Figure A.17: Leonardo da Vinci draws the three cerebral ventricles in a linear fashion. The front one handles the sensory information *(imprensiva)*, the second one handles classical *sense commune* and the third one stores it.

Note: Image sourced from the Royal Collection Trust / © Her Majesty Queen Elizabeth II 2019.

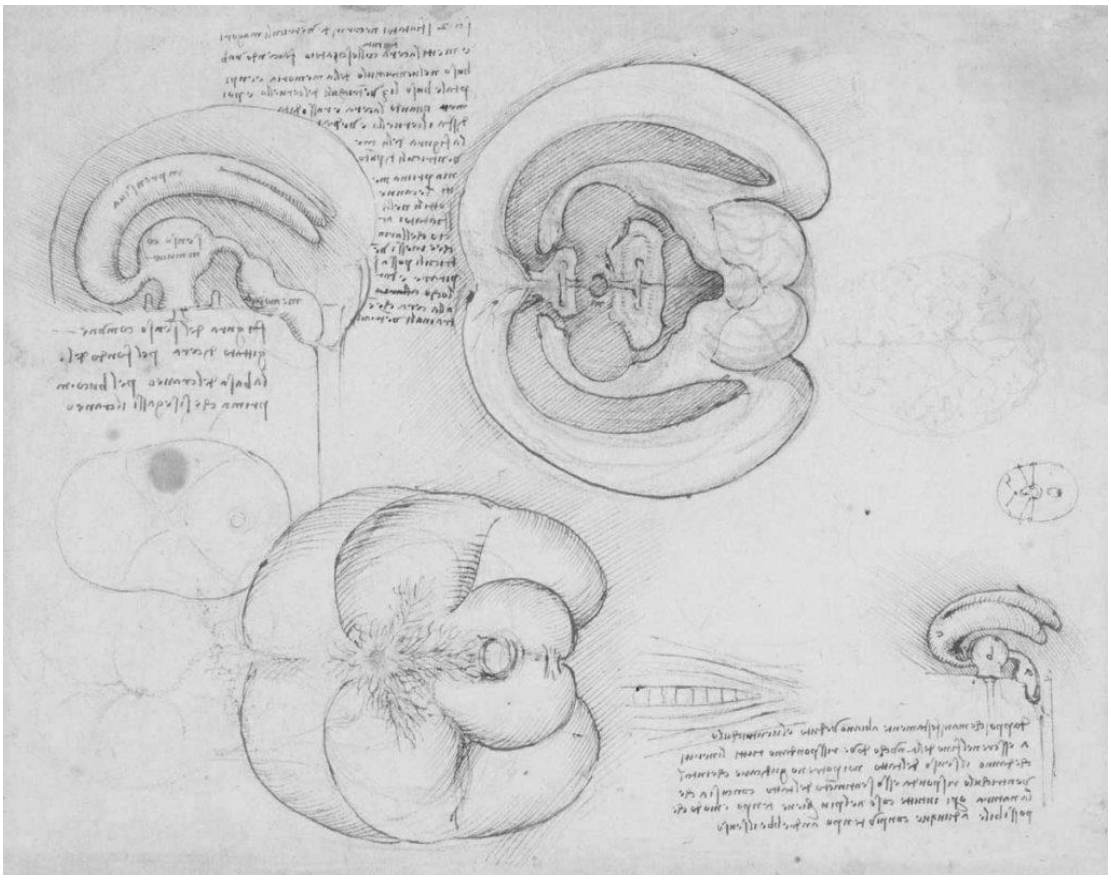


Figure A.18: Leonardo's drawing of the cerebral ventricular system from various angles and dimensions based on ox-wax model. Please note the feathery structure on the bottom central diagram, which is *rete mirabilis* (absent in humans).

Note: Image sourced from The Royal Collection Trust / © Her Majesty Queen Elizabeth II, 2019.

Figure A.19: da Vinci draws human ventricles by extrapolating from his ox anatomical studies.

Note: Image is sourced from Rolando F. Del Maestro's "Leonardo da Vinci: the search for the soul." https://doi.org/10.3171/jns.1998.89.5.0874)

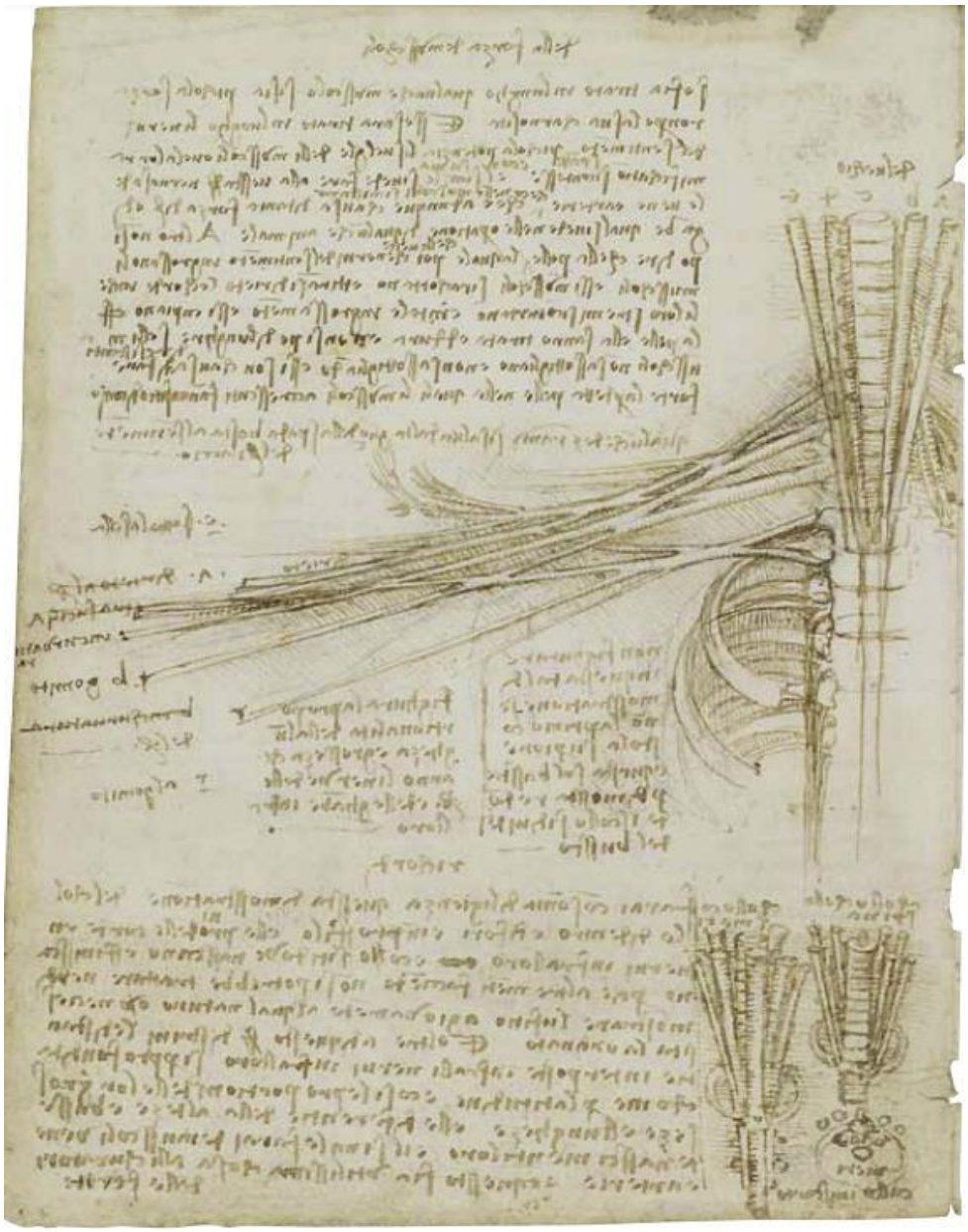


Figure A.20: The Brachial Plexus, c.1508. Pen and ink over black chalk.

Note: The image is sourced from *Leonardo da Vinci, The Anatomist* by Clayton and Philo, Royal Collection Trust.

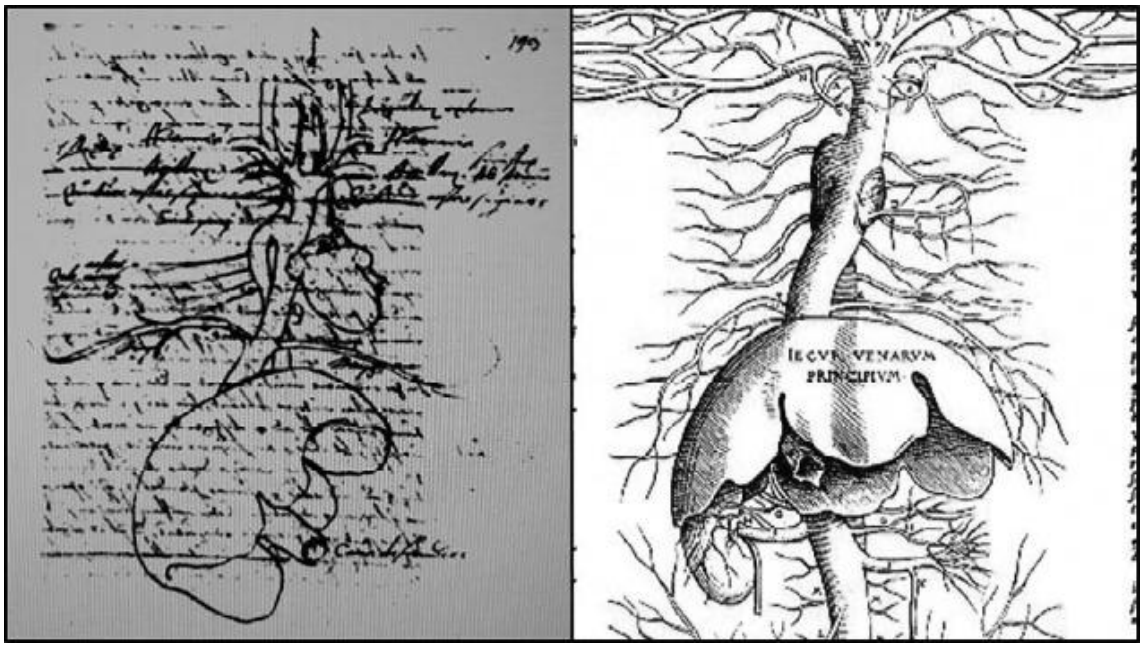


Figure A.21: Drawing of liver by Vesalius (1538).

Note: The image is sourced from Vesalius's digital image collection which can be found at https://www.researchgate.net/figure/On-the-left-drawing-of-the-liver-and-vena-cava-made-by-Vitus-Tritonius-Athesinus-friend_fig16_292672408

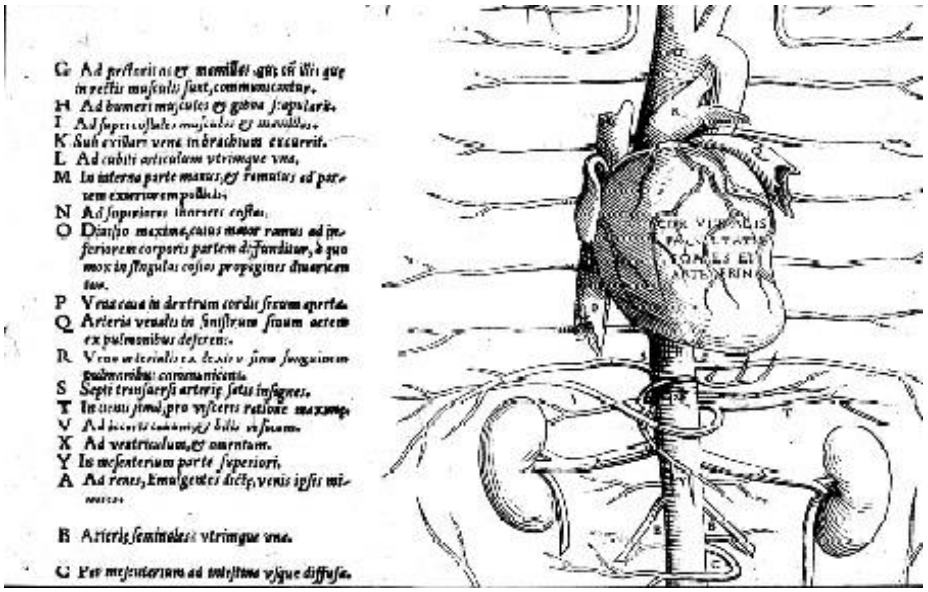


Figure A.22: Schematic of cardiovascular system (Vesalius 1538). This figure shows the heart as the central source of vital spirit, and pulmonary vessels bring back air from lungs to the heart. (letter "Q" of the caption on the left, *Arteria venalis*). The Latin inscription at the center of the heart reads "Cor Vitalis facultatis fomes et arte princ*" (*the heart is the source of vital spirit and beginning of arteries).

Note: The image is sourced from Fabio Zampieri, Cristina Basso, and Gaetano Thiene, "Andreas Vesalius' Tabulae Anatomicae Sex (1538) and the Seal of the American College of Cardiology," Journal of the American College of Cardiology (U.S. National Library of Medicine, October 16, 2013), 694-695 https://pubmed.ncbi.nlm.nih.gov/24140673/.)

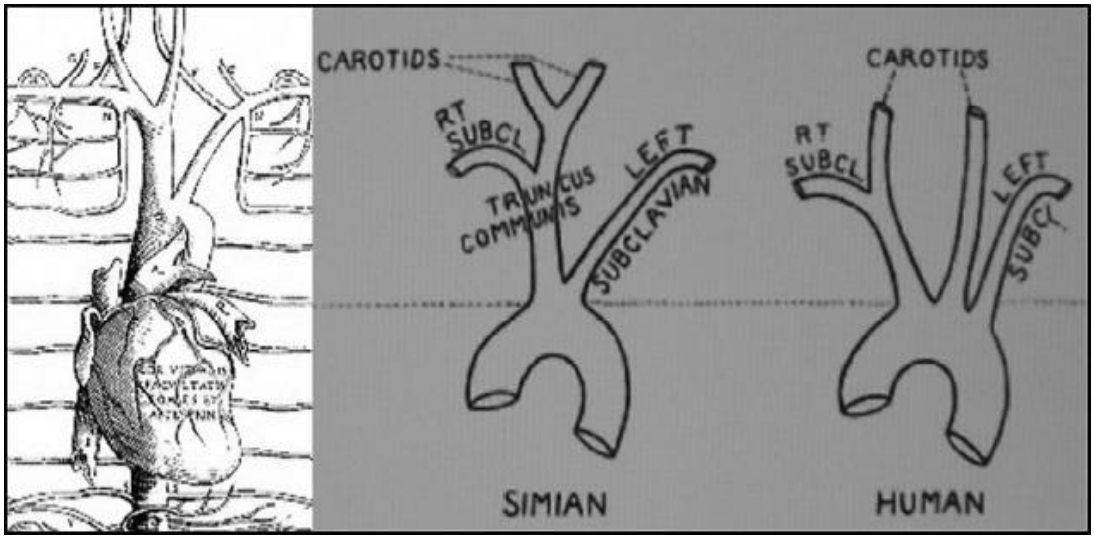


Figure A.23: Left: *Cardiovascular system from Tabula III* of Vesalius' *Tabulae anatomicae sex* (Vesalius 1538), the right side of the figure shows Simian (or apes) great vessel origin from arch of aorta compared to that of humans on extreme right. Please note that left subclavian and left common carotid arteries of separate origins from arch of aorta in humans whereas they have a common origin in apes, and they later bifurcate. This is how the origin of great vessels was depicted by Galen as well.

Note: The image is sourced from Andreas Vesalius' *Tabulae anatomicae sex* (1538) and the Seal of the American College of Cardiology.