

The Science of Anatomy

A historical timeline

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HUMANS HAVE LONG BEEN INTERESTED in the form and structure of living things. The focus on anatomy in the ancient world began as a way to determine the nature of the soul.¹ Ancient anatomical drawings and sculptures have been found in caves in Western Europe, Africa, Asia and Australia; while the exact dating of such artefacts is uncertain, some are at least 25,000 years old.² Regardless of how crude some of these illustrations are, they represent evidence that ancient artists had some knowledge of the formation of muscles and *viscera*.

The Stone Age (750000–500000 BCE)

Ancient skulls from the late Palaeolithic period have shown evidence of trephining or trepanning (i.e. the process of cutting a hole in the skull).³ Notably, some of these skulls demonstrate evidence of new bone formation around the holes, indicating that some of the victims of these primitive rituals survived the procedure.^{4,5} Such practices are thought to have been carried out to release 'evil spirits' from people suffering from mental health disorders as well as other physical symptoms, such as cranial fractures or headaches.^{4,5} Until recent times, similar practices were still being performed amongst certain native tribes.⁶

The Ancient Egyptians (3150–332 BCE)

The earliest records indicate that medicine was first recognised as a craft by the ancient Egyptians; medical practitioners were highly thought of, although there is little evidence that these early 'doctors' had anything but a superficial knowledge of anatomy, as demonstrated by their drawings and sculptures.⁷

Their mummification practices, which required the evisceration of human bodies, did not provide them with an exact knowledge of internal organs.⁸ Mummification only required a small incision to remove the *viscera* for the sake of embalming and the priests who carried out the process were not interested in studying the extracted organs. Ancient civilizations such as the Sumerians and Babylonians appear to have had equal or even greater ignorance of human anatomy.⁹

The Ancient Greeks (500–336 BCE)

The ancient Greeks appear to have made the first real scientific advances in the field of anatomy.¹⁰ It is claimed that Alcmaeon of Croton, who lived in approximately the fifth century BCE, practised human dissection; unfortunately, none of his notes on these dissections have ever been found.¹¹ Another notable Greek anatomist was Hippocrates, whose elementary anatomical work dates from around 400 BCE. Subsequently, Aristotle contributed much information to the fields of comparative anatomy and embryology; he was the first of the ancient Greeks to dissect animals in a systematic way. His anatomical studies led him to the conclusion that the soul was the life source of the body.^{1,12}

With the fall of the Greek empire, some outposts of civilisation survived and emerged as centres of learning. A particularly famous one was Alexandria; some of the anatomists from this school—such as its founder, Herophilus of Chalcedon, and his disciple, Erasistratus of Chios—greatly contributed to existing knowledge of the nervous system, blood vessels and lymphatics.¹³ In particular, Herophilus developed a library of anatomical knowledge which was much more informed regarding the actual structure of the

human body in comparison to previous works.¹⁴ Additionally, Herophilus was the first physician to dissect human bodies and is considered to be the founder of anatomy; he contradicted Aristotle's notion that the heart was the "seat of intelligence", arguing instead that it was the brain.¹⁰ However, he was eventually accused by his contemporaries of dissecting live criminals. His disciple, Erasistratus, believed that the animal form was determined by environmental rather than innate factors, in line with Aristotle's views. Accordingly, Erasistratus introduced the diametric notions of heredity and environment (e.g. nature versus nurture), both at the level of the individual and the species as a whole.¹⁵

The Ancient Romans (670 BCE–480 CE)

Ancient Roman physicians gained much of their anatomical knowledge of the human body by treating wounded gladiators. As the dissection of human bodies was forbidden, ancient Roman anatomists had to rely primarily on animal dissections to further their knowledge.^{16,17} They were therefore limited in what they could learn about human anatomy. Galen was an experimentalist and investigator who was born in the Greek city Pergamon but later travelled to Rome in pursuit of knowledge, where he became a successful practicing physician.¹⁸ He is known for his anatomical observations and experimental approaches in emphasising the interrelationships between function (i.e. physiology) and form (i.e. anatomy). The majority of his anatomical knowledge was based on his dissections of animals, especially monkeys. He noted the importance of the spinal cord, motor and sensory loss following the ligation of a peripheral nerve in the area of its distribution and experimentally demonstrated the function of the recurrent laryngeal nerve.¹⁹ Galen also noted that blood must pass from the right side of the heart to the left side, although he was unaware of the concept of pulmonary circulation. Great credit is owed to Galen for explaining many of the mysteries of the human body during that period, as his beliefs were to last for a long time.²⁰

The Islamic Golden Age (701–1300 CE)

While Europe was in the midst of the Dark Ages, Arabia was a beacon of medical knowledge. Baghdad in particular was a noted haven for scholars who had scattered after the fall of Constantinople.²¹ During this era, many notable Muslim scholars made discoveries

which provided greater anatomical insight, such as the contributions of Muhammad Al-Razi (862–930 CE) to the field of neuroanatomy, Ibn Al-Haytham (965–1040 CE) who provided new insight into optics, Avicenna or Abu ibn Sina (980–1037 CE) who famously wrote the *Canon of Medicine* and Ibn Al-Nafis (1210–1288 CE) who explained pulmonary circulation, paving the way for William Harvey (1578–1657 CE), many centuries later.^{22–24}

The Late Middle Ages (1000–1300 CE)

In approximately 1000 CE, an educational revival began in Europe with the foundation of the medical school Schola Medica Salernitana in Salerno. This southern Italian port became the main hub of medical knowledge in Europe, after having imported important translations of medical knowledge from Arab and Muslim scholars.²⁵ Two centuries later, the University of Bologna, which was initially a law school, incorporated medicine and other disciplines into its curriculum; it is believed that post-mortems were carried out here, possibly for medico-legal reasons, potentially leading to a revived interest in anatomical dissections to increase knowledge.²⁶ At that time, Thaddeus Alderoti (c. 1206–1295 CE) was the most active anatomist in this field.²⁶ The first human dissection manual ever written, the *Anathomia corporis humani*, was produced by one of Alderoti's students, Mondino de Luzzi (also known as Mundinus), in approximately 1316 CE.²⁷

The Renaissance Period (1301–1700 CE)

During the Renaissance period, various anatomical sketches of the human body were made by artists like Leonardo Da Vinci and, to a lesser extent, Michelangelo di Buonarroti, Rembrandt van Rijn, Albrecht Dürer and Raphael da Urbino [Figures 1–3]. These sketches contributed to anatomical knowledge, but were later disregarded with the production of newer updated anatomical drawings.²⁸ Artists were keen to gain accurate knowledge of the inner workings of the human body, which would allow them to paint and sculpt the body in many different positions. Even though it was banned by the Catholic church, many artists and scientists performed dissections to better understand the human body. However, dissection required readily available bodies and the most readily available subjects for dissection in those days were executed criminals.²⁹ During these dissection sessions,

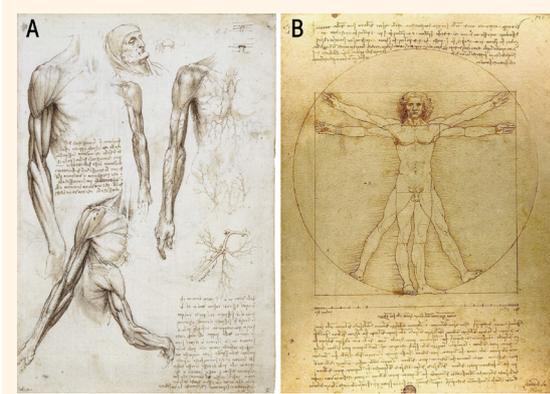


Figure 1: Pen and ink sketches by Leonardo da Vinci entitled (A) *A Dead or Moribund Man in Bust Length* (c. 1487 CE), detailing the muscles of the arm and the veins of the arm and trunk, and (B) *The Vitruvian Man* (c. 1490 CE), showing the proportions of the human body.

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a professor would read aloud from Galen's works, while a demonstrator attempted to isolate or point to the various body parts mentioned.³⁰

In the 16th century, Andreas Vesalius, a student from Brussels who frequently assisted at human dissections, decided to investigate the accuracy of these Galenic concepts and so began to fastidiously record his dissection findings.³¹ In 1537 CE, he obtained his doctorate from Padua University, which was the location of the first established anatomical theatre for human dissections; a day after graduating, he was made a professor of anatomy and surgery. Six years later, at the age of 27 years, he completed writing *De humani corporis fabrica* [Figure 4].³² This seminal work was a key milestone in the history of human anatomy and was the first illustrated scientific work to evoke astonishment and admiration from the

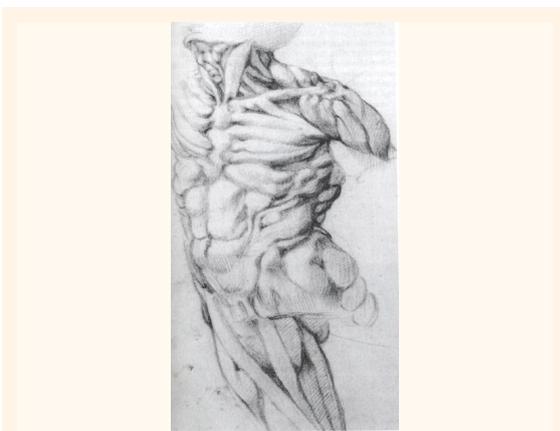


Figure 2: A sketch by Michelangelo di Buonarroti entitled *Écorché (Skinned)* (c. unknown), detailing the muscles and anatomical structure of the torso.

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Figure 3: Oil painting by Rembrandt van Rijn entitled *The Anatomy Lesson of Dr. Nicolaes Tulp* (c. 1632 CE), demonstrating an educational dissection session.

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scientific community. Vesalius died in 1564 while on a pilgrimage to Jerusalem. He is credited for raising the field of anatomy from merely a mixture of facts and fiction to an exact science, a fundamental basis of medicine.³³ In 1553 CE, Michael Servetus proved that blood flows from the heart, through the lungs and back to the heart; he was burnt alive for this finding, which was deemed heretical by the Catholic Church.³⁴

17th–20th Century (1601–2000 CE)

Over time, many eminent scientists, physicians and academics have attempted to refine the existing anatomical knowledge available. Their names are often used to label the anatomical structures or diseases they described, for example: Antonio Pacchioni (Pacchioni's granulations), Antonio Scarpa (Scarpa's fascia and Scarpa's fluid, among many others), Alfonso Giacomo Gaspare Corti (organ of Corti), Filippo Pacini (Pacini corpuscles), Camillo Golgi (Golgi apparatus), Johann Friedrich Meckel (Meckel's diverticulum), Leopold Auerbach (Auerbach's plexus), Georg Meissner (Meissner's plexus), Ludwig Edinger (Edinger's tract), Heinrich Lissauer (tract of Lissauer), Johann Christian Reil (Reil's finger and the Islands of Reil, among many others), Anders Retzius (Cave of Retzius or Retzius' space), Alfred Wilhelm Volkmann (Volkmann's canals), Franciscus Sylvius (Sylvian fissure and Sylvian aqueduct), François Magendie (foramen of Magendie), Pierre Paul Broca (Broca's area), Charles-Édouard Brown-Séquard (Brown-Séquard syndrome), Jean-Martin Charcot (Charcot disease), Vladimir Betz (pyramidal cells of Betz), William Edwards Horner (Horner muscle), Santiago Ramón y Cajal (interstitial cell of Cajal), Thomas Willis (circle of Willis), Alexander Monro *secundus*

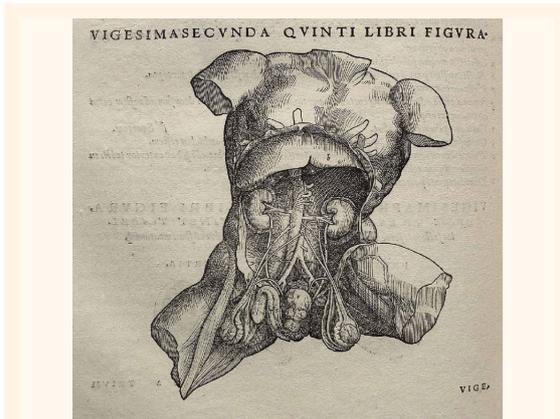


Figure 4: An anatomical sketch by Andreas Vesalius from the *De humani corporis fabrica* (c. 1543).
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(*foramen* of Monro) and Sir Charles Bell (Bell's palsy). These eponymous terms, which are routinely used in medical practice, remind us of the monumental efforts that these anatomists made in the advancement of medical knowledge. Sadly, these names are now being discarded in modern texts and are also often considered to be a nuisance by young medical students. Pioneers who devoted their lives to the science and art of medicine deserve to have their names immortalised. Such great achievements were not easily attained as, more often than not, such important work was performed during times of religious or political prejudice, repression, superstition, persecution and sometimes even execution.³⁴

After the development of the microscope by Anton van Leeuwenhoek (1632–1723 CE) and his assistant, Marcello Malpighi, new frontiers were opened up for anatomical research. Van Leeuwenhoek managed to magnify and display the fine details of various tissues and is regarded as the founder of microscopic anatomy (i.e. histology).³⁵ Subsequently, Robert Hooke (1635–1703 CE) was the first to recognise and name cells in the tissues and, two centuries later, Robert Brown (1773–1858 CE) recognised the presence of *nuclei*.³⁵ In 1989 CE, following these discoveries, Theodor Schleiden and Matthias Schwann proposed the theory that cells are universal in all tissues, where they play a vital role.³⁵ This theory is the basis for modern concepts of histology, embryology and pathology. In 1761, Giovanni Battista Morgagni, an Italian researcher, made several discoveries which resulted in him being regarded as the first morbid anatomist or pathologist.³⁶

Up until the recent past, there was mass hostility towards anyone who carried out dissection practices and it was very difficult to secure cadavers for this purpose.³⁰ However, with the increasing number of

medical schools came an escalating demand for bodies and 'body-snatching' became increasingly common. Unless legislation was made to regulate the donation of bodies for medical and educational purposes, the authorities anticipated that such demands would soon implicitly encourage murder in order for doctors and medical students to obtain the bodies necessary for their research.^{30,37} At the turn of the twentieth century, Abraham Flexner wrote his famous report on medical education and the importance of the basic medical sciences.³⁸ This highlighted anatomy as an essential science for basic medical training. However, in the years since, there has been an ongoing debate as to how much anatomy education is needed in the medical curriculum.³⁹ While there are many methodologies for anatomy teaching, the consensus seems to be that the optimal teaching method for anatomy education is to use prosected cadaveric material with other adjunct facilities.⁴⁰ This necessitates a continuous supply of cadaveric material. In certain cultures, bequeathal programmes have been founded to regulate body donations to medical schools.^{30,41} Full bodies, body parts and specific organs are maintained using preservation techniques including plastination and advanced digital imagery, all of which aim to ensure an adequate provision of material for medical students.⁴²

Conclusion

Currently, teachers and students of anatomy have the necessary illustrations and information they need to conduct anatomical research. Modern technology ensures that this information is readily available and of the utmost clarity. However, the past eminent scholars who discovered and developed the various tenants of today's anatomical knowledge should be remembered for the mental, physical and social challenges they faced in the course of their research, which sometimes cost them their lives.

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