The Beginnings of Human Anatomy

Boston University School of Medicine History Club

Introduction

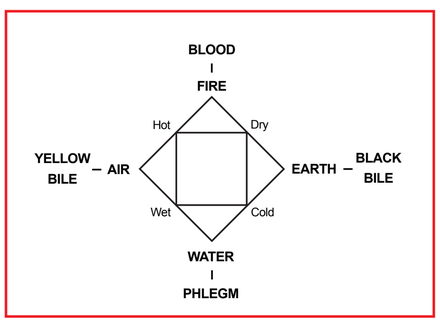
The study of the history of anatomy will lead one to an appreciation of the evolution of the field of medicine. For 3000 years medical thought and theory were stagnant, immersed in myth, superstition and ignorance. A centuries long process of anatomical study successfully challenged and displaced long standing dictums ultimately setting in motion the birth of modern medicine.

Early Civilization

Paleolithic cave paintings exhibit the hunter's rudimentary understanding of the heart's location critical for hunting large mammals. ***"The Dying Lioness"*** sculpture from the ***Palace of Assurbanipal (650 BCE),*** shows the wounded lioness still fighting as she drags her paralyzed hind limbs with arrows in her spinal cord.

The Dying Lioness

The British Museum contains a 2000 year old Mesopotamian clay model of a sheep's liver, used for divination ceremonies. Before the Greeks, there were the Minoan culture, the Babylonian civilization on the Euphrates and the ancient Egyptian Nile civilization. The Greeks obtained a certain amount of anatomical information from each of these preexisting cultures. The earliest Greek writings are fragments from ***Alcmeon(500 BCE),*** who wrote from a Greek colony in southern Italy. Using animal dissection he described the optic nerves and small tubes which later came to be known as the Eustachian tubes. He also performed embryological studies in which he observed the development of the fetal head. ***Empedocles (480 BCE)*** promoted a theory that blood was the seat of ***"innate heat",*** which lead to an understanding that the heart was the center of the vascular system and the source of the ***"pneuma"*** found in the vascular system. His concepts ultimately evolved into the ***"Pneumatic School"*** of anatomical understanding. Around ***300 BCE Polybus,*** (Hippocrates' son-in-law) wrote ***"On the Nature of Man"*** describing four humors, Blood, Phlegm (pituita), Black bile (melancholia) and Yellow bile (chole) which make up the living as Fire, Water, Earth and Air constitute non-living matter. This view of nature would prevail for the next 2000 years.



The Four Humors

Early Athenian Period (400-350 BCE)

Plato produced a work entitled ***"Timaeus"*** in which he proposed a schema for the human body. He theorized that there existed an outer world, ***"macrocosm"*** and man's body which he labeled ***"microcosm"*** or small world. He represented the world as a living being and proposed that all matter was endowed with life. He proposed a theory of ***"pangenesis"*** or heredity and also placed the seat of feeling and thought in the brain.

Around 340 BCE another treatise of the Hippocratic collection entitled ***"On the Heart"*** appeared. While it is doubtful that the work was based on human dissection, it proposed that ***"innate heat"*** resides in the heart and not in blood and that the intellect resides in the heart. The work also contained descriptions of auricles, the a-v and semilunar valves as well as the chordae tendinae.

The Late Athenian Period 350-290 BCE

Aristotle (384-322 BCE), son of a physician, left three works, ***"History of Animals", "Parts of Animals"*** and ***"Generation of Animals".*** Intensely interested in generation he observed the developing chick embryo. He concluded that the heart had three chambers and at the same time recognized the ***"ductus arterious".*** Observing the tiny developing heart early in gestation he proposed that intelligence resided in the heart and that the brain served to cool the body. Aristotle theorized that in procreation the female contributed the passive formable material, much like ***"soil"*** in which the embryo grows, while the male gave the life principle, the soul (psyche). This soul was not material and it was not necessary for anything material to pass from male to female. The male's contribution was not matter but form and principle. Aristotle's conception of the nature of life revolved around the distinction between living and non-living substance and the presence or absence of ***"psyche"*** or soul. He distinguished three orders of soul, the vegetative or nutritive and reproductive, the animal, and lastly the rational or intellectual soul - (man).

Although the Greeks were intellectually brilliant, anatomically their contributions were less than impressive possibly because of their lack of experience in human dissection.

The Alexandrians 300 BCE to 50 BCE

Following Alexander the Great's conquest of Egypt, the establishment of Alexandria, and ***the Ptolemaic dynasty (332-30 BCE),*** numerous Greek scholars took advantage of Egyptian culture to further their anatomical knowledge. The Egyptians believed in mummification requisite for participation in the afterlife. Mummification was provided by the guild of embalmers who were skilled in their craft although they understood little about the organs they handled. They did, however, recognize the homology between human and animal organs and crudely understood the action of the heart, pulse and its continuity with blood vessels. Thought to be the seat of personality and intelligence, the heart was always preserved in-situ. The eyes, tongue and aortic arch were also left in-situ as they were regarded as vital for the afterlife. The brain was disposed of following transnasal removal via the ethmoid or sphenoid sinuses. The 20th Century American neurosurgeon Harvey Cushing reintroduced this approach as an access to the pituitary fossa.

The Edwin Smith papyrus (1700 BCE), which was intended as a surgical guidebook, demonstrates an understanding of anatomy particularly related to neurological deficits and musculoskeletal trauma.

Many Greek scholars were attracted to Alexandria, some of whom became great names in anatomy and medicine, including ***Herophilus of Chalcedon (330-260 BCE)*** called by some ***"the father of anatomy"*** and ***Erasistratus (about 290 BCE)*** called ***"the father of physiology".*** The opportunity to perform human dissection was available in Egypt. While both of these men taught and wrote extensively, their works were lost but were often cited by Galen. Herophilus recognized the primacy of the brain and understood that nerves could be motor or sensory in function. He described the meninges, cerebrum, cerebellum, the 4th ventricle, prostate, duodenum and the lacteals. His work on the CNS helped to reverse Aristotle's theory that the heart was the seat of intelligence.

Vesalius De Fabrica Corporis Humani, Basel 1543.

Erasistratus theorized that every organ was supplied by a vein, an artery and a nerve. Minute divisions of the vessels were woven together to form the tissues (capillaries?). He believed that veins carried blood, that air was taken in by the lungs where it changed into ***"pneuma"*** (vital spirit) which was then transported to the organs. ***"Pneuma"*** transported to the brain was changed into a second type of ***"pneuma"*** (the animal spirit) in the ventricles and conveyed to the body by way of the nerves which he believed were hollow. Through animal vivisection and experimentation, he came close to discovering the circulation of blood which would not come until William Harvey's great work in 1628.

In 250 BCE, the Alexandrian School of Anatomy began to stagnate but the city remained an intellectual center for the study of mathematics, astronomy, geography and mechanics until the Ptolemaic dynasty collapsed in 30 BCE with the death of Cleopatra. The center of medicine and anatomy shifted to Rome where the first language continued to be Greek.

The Roman Period 50 BCE-AD 1050

In the Roman period, the greatest influence came from ***Galen of Pergamum (AD 129-199),*** also known as the ***"Prince of Physicians".*** Galen studied in Smyrna and Corinth and completed his studies in Alexandria before returning to Pergamum as a surgeon to the gladiators. It is not believed he performed human dissections but certainly saw lots of human anatomy while caring for the gladiators. He dissected a wide variety of animals including primates. Galen's his influential book, ***"Uses of the Parts of the Body of Man",*** proposed that human organs were perfectly formed and could not be improved upon as proof to justify the ways of God to man.

Galen's writings were the standard throughout the Middle Ages and into the 16th Century. As the Roman Empire gradually disintegrated science and anatomy slipped into darkness. However, in the southern Italian city of Salerno, efforts were made to preserve and translate the ancient Greek writings and to teach medicine. With the rise of Christianity and strong spiritual belief in the soul and the hereafter, interest in nature and the natural world sharply waned. Plato's old ideas (400 BCE) of the world's macrocosm and man's microcosm remerged greatly influencing science and anatomy of the Middle Ages.

The Middle Ages and the Renaissance

Between 1050 and 1250 AD, the Latin world began to experience an intellectual reawakening. Beginning in the 8th Century, Arabic translators started to translate ancient Greek writings into Arabic which were then translated into Latin for consumption in the West. The monk, Constantine the African, who had traveled extensively in the Middle East took residence in the monastery of Monte Casio in Southern Italy and proceeded to translate a large volume of Arabic writings into Latin. Included were descriptions of pig dissections done at the school in Salerno. By the 12th Century works of the Persian physicians Hali Abbas, and Rhaze as well the Arabic physician Avicenna's ***"Canon of the Bokhariote"*** were available. Much of the anatomy in these works was strongly dependent on Galen's writings. While there was not a rebirth of anatomy, the Arab cultural influence sparked interest in a variety of scholarly pursuits which, combined with the Scholasticism movement, hastened the rise of the great Universities.

Perhaps the strongest influences were the very widely read translations of ***Gerard of Cremona (1155-85)*** who worked in Toledo. Gerard was also a strong force in the University movement. Although many Universities had medical faculties there was little useful anatomical instruction.

While the University of Bologna (1156) had the oldest organized medical faculty, its Law School was much more prominent and, indeed, the most important in Europe. Interestingly, the early anatomical dissections at Bologna (late 13th Century) may have been done for forensic purposes at the behest of the Law School. ***Thaddeus of Florence (1223-1303),*** produced accurate Latin translations of Greek writings before becoming the first Professor of Anatomy at Bologna. One of his students, ***Mondino de Luzzi (1270-1326),*** followed Thaddeus to Bologna and was credited with preparation of the first ***modern*** anatomy textbook. ***"Anothomia" (1316)*** which was hastily prepared, written in poor Latin and relied heavily on previous Arab works, added little new to the field. That being said, his book provided a measure of the state of the early 14th Century anatomical knowledge.

Conduct of anatomical dissection was influenced by the fact that books in the middle ages were rare, expensive and seldom available to students. The Professor ***"lector"*** would sit in an elevated chair reading from an anatomy text while a colleague, known as the ***"ostensor"*** would point to the structures to be dissected and a third person, ***"sector"***, would perform the actual dissection often without regard as to what the Professor had read. Students took notes and thereby acquired a hand written personal text. Arab translations of Greek anatomical terms were frequently employed but by the 16th Century the nomenclature became largely Greek or Latin. Clavicle, albugineus, iris, pia mater, dura mater and nucha are surviving Arabic terms.

Late Middle Ages 1325-1500

Human dissection received official recognition at Bologna in 1405, at Padua in 1429, the University of Montpellier in 1377, and at the University of Paris in 1478. Bologna reigned as a seat of anatomy for nearly three centuries.

In the 15th Century, the ***"naturalism movement"*** came into fashion and Latin became a scholarly language. Artists had long strived to produce accurate representations of the human body and it is recognized that Leonardo, Dürer, Michangelo and Raphael all performed dissections to gain practical knowledge. Leonardo's osteology was a significant advancement in that his illustrations represented the skeleton and its parts from the front, back and side. His drawings of the anatomy of the hand are nearly perfect and he was the first to make wax injection specimens of the brain. Artists influenced the quality of anatomical illustration which made books more aesthetically pleasing. The evolution of moveable printing type made the books cheaper and more widely available. ***"Fugitive anatomical sheets"*** bare outlines which could be filled in, became widely available for both medical and art students

Padua and Vesalius

In the mid to late 14th Century Padua began to rise as a center of anatomical study with scholars from all over Europe attracted to study at Padua. ***Benedetti (1455-1525)*** was instrumental in the ascendancy as were ***Montanus,*** the Englishman ***Thomas Linacre, Johannes Gunter, Sylvius*** of Paris and ***Andreas Vesalius (1514-1564).*** Gunter asked the young Vesalius to assist him in editing the first complete Latin edition of Galen, which he was translating from the original Greek. Vesalius did the nerves, vessels and the dissection manual and identified many instances where Galen's observations were at significant variance with his personal experience. His doubts and open disagreements sparked Vesalius to produce ***"De Human Corporis Fabrica" (Basel 1543).*** Wood block prints richly illustrated the plates of the Folio. Pear wood blocks, cut by Calcar, a student of Titian, were carried over the Alps by mules to Basel and printed by Vesalius' friend Oporinus. The blocks are believed to have been lost in an Allied bombing raid over Munich in WWII. The ***"Fabrica"*** of 1543 consisted of a large folio of 663 pages in seven books, containing 73 large plates, a portrait of Vesalius' dissecting arm and an intricately detailed frontispiece. Harvey Cushing (20th century Harvard neurosurgeon) is said to have pointed out that the background scenery for the living anatomy plates constituted a diorama of the 15th Century Paduan countryside.

Second Skeleton from Fabrica | *First Muscle Tabula from Fabrica* | *Andreas Vesalius Dissecting the arm*

Historically, it is notable that 1543 marked the appearance of Vesalius' ***"Fabrica"*** which unyoked human anatomy from Galen but it was also the publication year of Copernicus' masterpiece, ***"On the Revolution of the Celestial Spheres".*** Both giants stood boldly in the face of centuries of ignorance which had stifled science and launched modern science and medicine.

At the age of 29 in 1544, Vesalius left Padua, and returned to Brussels to become the court physician to Charles the V. In 1559 he would become the physician to the Spanish King Phillip II. In a strange turn of events he was charged with murder for having performed a dissection on a nobleman whose heart was allegedly still beating. His sentence was commuted to performing a pilgrimage to the Levant. He died shipwrecked on the island of Zante while returning to Padua to become the Professor of Anatomy in October 1564. The School at Padua thrived into the 18th Century continuing to attract great numbers of students from all over Europe many of whom would become leaders. John Casius returned to Cambridge to introduce anatomical dissection at Cambridge, Linacre to Oxford and, of course, the Englishman William Harvey, who began modern physiology with the publication of ***"The Circulation of Blood"*** in 1602. Today, one can view the ***"Palazzo Bo"*** at Padua, built in 1594 as the first permanent anatomical dissection theater, a standing monument to all those who struggled in the birth of human anatomy.

Anatomical Theater Padua 1594

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