YALE JOURNAL OF BIOLOGY AND MEDICINE 74 (2001), pp. 185-195.

THE ARTS IN MEDICINE

Anatomy and Leonardo da Vinci

Antony Merlin Jose[a]

Yale School of Medicine, New Haven, Connecticut

Leonardo da Vinci was born on the 15th of April, 1452, during the great "rebirth" — the Renaissance. He was born in the country village of Vinci, which lies high up on the Mount Albano, in the valley of the river Arno, dividing Florence from Pisa. This lovely village remains un-spoilt today. He was the son of Caterina, a peasant girl. He was illegitimate. His father, Ser Piero da Vinci, the son of a Florentine lawyer, was quickly persuaded to marry into a good family. His mother was married off to a cowherd. Nothing more is known of her, though forty years later Leonardo notes down paying the funeral expenses of a woman called Caterina, who may have been his mother. Leonardo's grandparents immediately took Leonardo into their care. However, after a few years, Ser Piero realized that his wife, Donna Albiera, would bear him no children. Meanwhile the young Leonardo was growing into a beautiful and promising child and so Ser Piero took his natural son into the family.

The innate skills that Leonardo da Vinci possessed are best illustrated by the words of Leonardo's famous biographer, Giorgio Vasari, when he speaks of young Leonardo:

> In arithmetic, during the few months he studied it, he made such progress that he frequently confounded his master by raising doubts and difficulties. He devoted some time to music and soon learned to play the lyre, and being filled with a lofty and delicate spirit he could sing and improvise divinely on it. Yet though he studied so many different things he never neglected drawing and working in relief, these being the things which appealed to his fancy more than any other [1].

The education of this extraordinary child was unusual because he was not taught Greek or Latin. This made it difficult for him to mix with the learned people of Florence. He regretted this and tried to teach himself. His early notebooks contain long lists of Latin words. But there are no lists of Greek words. He must have found this language too difficult. One gift absent in Leonardo, and the one from which he suffered, was the ability to learn languages. He wrote:

> I am fully aware that the fact of not being a man of letters may cause certain arrogant persons to think that they may with reason censure me, alleging that I am a man ignorant of book learning. They will say that because of my lack of book learning I cannot properly express what I desire to treat of. Do they not

[a] *To whom all correspondence should be addressed:* Department of Molecular Biophysics and Biochemistry, 333 Cedar Street, P.O. Box 208024, New Haven, CT 06520-8024. E-mail: antony.jose@yale.edu.

know that my subjects require for their exposition experience rather than the words of others [1]?

In spite of this limitation (or perhaps owing to it), Leonardo grew to be a self-taught giant in science, with interests spanning almost all fields of this subject. Every field that Leonardo was interested in, he made important contributions to. Some idea of how good an inventor he was is given in the letter that he wrote to Ludovico Sforza, Duke of Milan, in about 1481, offering his services. Here, Leonardo wrote:

When a place is besieged I know how to remove the water from the moats and make an infinite number of bridges, covered waterways, ladders and other instruments suitable for the said purposes. I have also plans of mortars most convenient and easy to carry, with which to hurl small stones similar to a storm and with their smoke cause great terror to the enemy and great damage and confusion. And if it should happen that the fight were at sea, I have plans for may instruments capable of offense and defense, and vessels which will resist the fire of the largest cannon, powder or smoke. Also I will make covered cars, safe and unassailable which will enter among the enemy with their artillery and will break up the largest body of men. And behind these the infantry will be able to follow unharmed and without any opposition. Also if need shall arise I can make cannon, mortar and light ordinance of very useful and beautiful shapes, different from those in common use. In times of peace, I believe I can give perfect satisfaction, equal to that of any other in architecture and the construction of buildings both private and public, and in conducting water from one place to another. Also, I can carry out sculpture in marble, bronze or clay; similarly in painting I can do whatever can be done as well as any other whoever he may be. Moreover, the bronze horse may be taken in hand, which shall endure with immortal glory and eternal honor the happy memory of the Prince your father, and of the illustrious house of Sforza.

And if any of the aforesaid things should seem impossible or impracticable I offer myself in readiness to make a trial of them in your park or in whatever place may please your excellency, to whom I commend myself with all possible humility [1].

One of the most astonishing things about this letter is that drawings for every one of these claims can be found in Leonardo's notebooks! Armed with his irrepressible spirit of inquiry, Leonardo made many important contributions in a variety of fields. Here I shall focus on his contributions to the field of anatomy, which was fueled further by his passion for painting and sculpture. I shall highlight some of the important technical innovations and discoveries made by Leonardo in the anatomical method and illustrative techniques and also present an analysis of a select few of his anatomical sketches, which exemplify the technique, accuracy, and clarity of Leonardo's work, and at the same time underscore some of the contemporary influences.

THE REIGN OF GALEN'S ANATOMY

A just estimate of Leonardo's contribution to anatomy can only be arrived at when the state of the science in his day is understood.

With the death of Galen at the end of the second century, the study of anatomy entered upon its dark days and for nearly thirteen centuries scarcely a single fact was added to the knowledge of the structure of the human body. During these years, people, for their knowledge of natural phenomena, were content to rely upon the writings of the Fathers, these statements in turn being based upon those of earlier writers, which were both corrupted and diluted as it was passed on down the generations. Under such circumstances, there was naturally no incitement to personal observation, and experiment and science languished.

During these times, for a physician, an intimate knowledge of anatomy was unnecessary; if he knew the positions of the individual organs and their presumed functions, he had all that he required, and this he could obtain from a translation of an Arabic summary of Galen's anatomical treatises, such as is found in Avicenna's Canon. So the study of anatomy became conventionalized into the reading of a translation into Latin of an imperfect summary by an Arab of Galen's teaching, and since it was Galen, the complete submission to the dictates of antiquity that characterized the Middle Ages gave it an authority and finality that well-nigh suppressed all stimulus for further inquiry. Indeed, ignorance of the original treatises concealed the fact that Galen's contributions to anatomy were based on dissection of animals, chiefly monkeys, that his anatomy was not really human anatomy. When this fact was revealed by the investigations of Vesalius in the sixteenth century, their unshaken confidence in the infallibility of Galen led at least one Galenist to the conclusion that the structure of the human body must have altered materially in some respects during the centuries that had elapsed since Galen's day!

TECHNICAL INNOVATIONS IN ANATOMY

"This my illustration of the human body shall be demonstrated to you, not otherwise than if you had the real man before you" [2].

Leonardo's opportunities for anatomical studies were no better than those available for others of his time. Why then did he, an artist, far excel in his results beyond even the professed anatomists who were his contemporaries? The answer is to be found in the spirit of the man and in the methods employed. He was in possession of an overmastering desire to know all things, to prove all things for himself, while his contemporaries were content to rely more or less implicitly on the statements of their predecessors and to interpret what observations they might make in accordance with those statements.

Leonardo's methods of acquiring knowledge were observation and experiment. In his early youth as a student of art in Verrocchio's *bottega* in Florence, Leonardo learned topographical anatomy, the study of the underlying structures that mold the human form, a study of great use to the artist [3]. But for Leonardo the study of anatomy became a science. In it he combined the study of structure, revealed through the quick eye and through his habit of precise artistic portrayal, with a study of function. He never did separate function from structure in his thinking.

In Leonardo's drawings of the human body, man lives, functions, and changes. Leonardo, the artist, renders these human figures in their most subtle spiritual expression. He succeeds, too, in showing the human form in quick motion, in violent motion, and in dramatic emotion. Behind all this is correct dynamic anatomy. All depends on the correct depiction of the functioning human frame. The use of the limbs and their working are to him a mechanical performance that is worthy of deep study. Leonardo's insatiable desire to know and his penetrating intelligence converted Leonardo the Artist into a Scientist now traveling along unexplored roads.

As Leonardo progressed in his anatomic studies, he realized that his investigation must comprise the study of the body from babyhood to old age and must include even the study of a fetus in its various stage (see below for a drawing of a fetus *in utero*). His general plan for this anatomy was to study each part, from the bones outward to the skin. Presenting views in rotation of each part, and in the case of the bones, in addition to those four views, a cross-section and a longitudinal section. At the end of his work, when he was an old man living in Clos Luce in France, he told De Beatis, who visited his studio, that he had dissected thirty bodies. The evidence shows that he also studied the bodies of animals, including pigs in the slaughterhouse immediately after they were killed. His favorite animal was the ox.

In his notes, Leonardo tells of dissecting in the hospital of Santa Maria Nuova in Florence. He also may have participated in the public dissections of Santa Croce which, according to the diary of the shopkeeper Landucci, took place in Florence in January of 1505. Leonardo is known to have dissected in the hospital Santo Spirito in Rome. He records having had to discontinue his work in this hospital when the "German deceiver," the mirror-maker Giovanni, who had been assigned by the Pope to help him, "hindered him in anatomy."

Leonardo often explains the advantage of pictorial over mere verbal demonstration. He states:

> With what words, O writer, can you with like perfection describe the whole arrangement of that of which the design is here? . . . How in words can you describe this heart without filling a whole book? Yet the more detail you write concerning it, the more you will confuse the mind of the hearer [2].

Although Leonardo emphasizes pictorial description, his own word-descriptions are remarkable for their clarity and brevity, which is in marked contrast to the involved "scientific prose" of his contemporaries.

Leonardo describes dissection by morselment, removing little by little minute portions of adventitious material from the vicinity of special structures under study within the body, preparing the exposed material left behind for demonstration and for sketching, much as is done today. No method of artificial preservation of the anatomic material thus under study is mentioned.

The purpose of Leonardo's drawings was to reveal structure and sometimes function through visual demonstrations of the actual dissected material. He said that he combined in each single drawing the experience from a number of dissections. He found ingenious ways of demonstration never used before to show simultaneously in one drawing not only what he had experienced in various dissections but also the various layers of the dissected specimen that could not be shown in a straight surface view. He thus maintained the characteristics of a study from nature. He seldom used diagrams.

In Leonardo's bones a lifelike portrayal is given to all of his pictures through the representation of proper carrying and supporting angles which are correctly shown, thus creating realism even in his skeletal drawings. Leonardo illustrated every bone in the body. He demonstrated the actions of the bones as levers when acted upon by muscles. He illustrated for the first time the proper double curvature of the spine, the true tilt of the vertebrae, accurately portraying each, especially those of the cervical spine and sacrum.

He described the teeth, presenting their proper number, strangely a matter of dispute then! Demonstrating the antra in the skull he shows the upward projection of the teeth of the upper jaw into the floor of the maxillary sinus. He was the first to show accurately the bones of the hand. He said that he had observed twenty-seven seasmoid bones, and he presented the mechanical principles by which these bones function. Leonardo stated that it was necessary to saw the bones longitudinally and also in cross-section in order properly to study their structure. Thus in sectioning the skull he discovered the spaces within the bones of the skull known as the sinuses and demonstrated for the first time the maxillary sinus or the antrum of Highmore and the teeth of the upper jaw which enter it.

As visual aids Leonardo used rope strands to indicate the direction, origin, and attachment of the muscles. He realized that in the body muscle groups are balanced, an anterior group against a posterior group, and he ingeniously used cord and wire ion diagrams to represent muscle groups as a means of clarifying their action. This is the first use of this method of illustration in the history of anatomy.

Leonardo presented drawings as seeming transparencies. This method of showing visceral layers of organic structure as if transparent with overall outline of the parts removed in dissection, ingeniously anticipates modern principles of didactic demonstration. At an age when X-rays were not known and not even dreamt of, Leonardo's power of imagination seems miraculous. In the famous drawing of the legs he indicates for the first time in the history of anatomy the correct position of the femur.

Leonardo was the first to depict cross-sectional anatomy. Here again he used the principle simultaneously showing in the pictorial demonstration what the eye is not able to discern at a glance. The surface of each cross section is shown within the contour of the limb from which it is taken. In Leonardo's studies of the complicated structures of the shoulder girdle and in the studies of the bones of the foot, he used exploded views with guide lines to indicate the source of the elevated structures, another innovation now often used to illustrate the relation of the parts in complicated machinery. Equally ingenious were his glass models of the heart to show the action of the valves. These were three-dimensional objects for demonstration, similar to those used today.

Leonardo experimented with animals, for the most part they were cadavers, but these animal experiments led him to some of his most important discoveries. Leonardo pithed a frog spinal column and thereby was able to demonstrate the abolition of the frog's spinal reflexes. He inflated and thereby forcibly deflated the lung of a goose, producing the characteristic goose "honk," in the study of the mechanism of voice. He studied the pierced hearts of pigs in Tuscany at their slaughter, demonstrating by this means the coincidence of three events: the pulse wave in the arteries, the beat of the heart against the chest wall, and the systolic contraction of the heart. His conclusions were a tremendous departure from the established opinion of the day.

In the muscular system Leonardo suggested a system of nomenclature for the muscles which would use a separate name for each muscle, a name designed to express its origin, insertion, direction of pull, and purpose. He defined for each separate muscle an individual innervation, individual blood supply, separate origin, insertion, and purpose.

Leonardo identified the muscles of the face. He described the action of muscles in general as a pulling action, the muscle using its force to pull along the line of its length. The exceptions to this pulling action were the tongue and penis which push. He stated that muscles do not move the member to which they are fixed at their origin but that they move it at their point of insertion, to which the sinew which leaves the muscle is attached. He also stated that muscular movement is by a continuous infinity of successive phases of motion. He indicated that posture is maintained by a constant interplay of reciprocally antagonistic muscles. He described the deltoid as a separate muscle and stated that the pectoralis minor had as its primary action an accessory muscle of respiration pulling upward upon the rib cartilages.

He illustrated the biceps as being the chief supinator of the forearm, showing that it is only secondarily a flexor; he also showed that the pronator teres is its antagonist in action to pronate the arm. He described the restriction of rotation of the forearm with the arm in flexion as having a radius of one-half a circle while the extension of three-fourth of a circle can be effected. He stated that four muscles

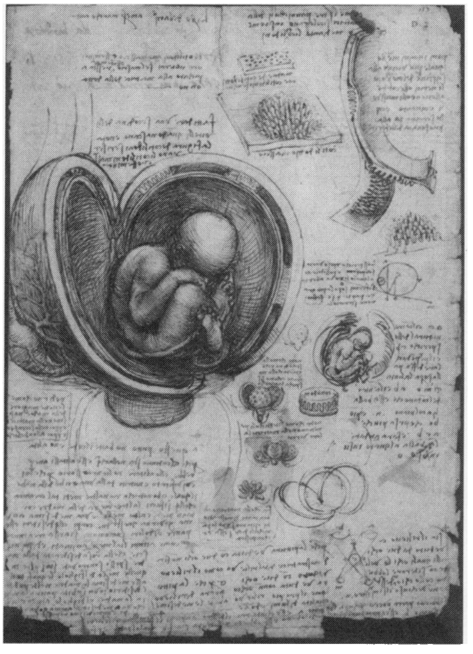

Figure 1. Representations of human fetus at term and of ungulate placenta. The Royal Collection © 2001, Her Majesty Queen Elizabeth II.

control the action of the eye. He identified the heart muscle and, following his own criteria, searched for a nerve supply to this muscle, finally deciding upon the left branch of the vagus as the nerve of the heart.

THE DRAWINGS

Figure 1 is the first ever, clear representation of a human fetus in utero. In this wonderful drawing of the fetus still within the womb, it is curious to note cotyledons of the ungulate type on the walls of the uterus, while the discoidal placenta is entirely overlooked, even though there is a memorandum to "Note well the umbilical vein where it ends in the uterus." It is evident that Leonardo had examined a pregnant human uterus at full term — he gives a number of drawings of the fetus as it lies curled up within the womb — but in none of them is a placenta shown. Where the uterus is also shown there is usually no indication of how the fetus is connected with it; only in the above figure are the cotyledons represented, on the assumption that what he had seen in the cow occurred also in the human pregnant uterus.

The structure of the cotyledons interested him greatly. He recognized that at birth each cotyledon divides, part remaining connected with the uterus and part adhering to the chorion, and provides figures showing the separation (not shown here), but is somewhat uncertain of their structure. He perceived that half of each cotyledon remains a fetus "When it is born covered," that is to say in a "caul," and the other half remains with the uterus. His understanding of embryology was derived from both dissections of animals (the ox being his favorite) and from the dissection of at least one pregnant woman at term. He was also able to deduce function from many of his embryological studies, for example, stating that, "The beating of the

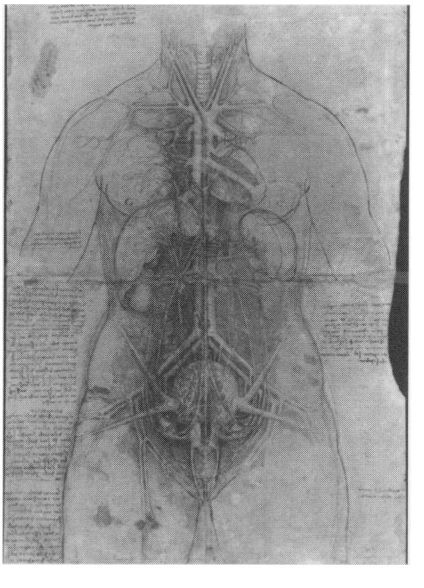

Figure 2. Dissection of the principal organs of a woman, the great *Situs* figure. The Royal Collection © 2001, Her Majesty Queen Elizabeth II.

heart and the breathing of the mother serve also for the child joined to her by the umbilical cord."

The situs drawing, Figure 2, represents a mixture of traditional notions and accurate observation. The heart is the two chambered heart of the ancients with a thick ventricle and, as in an ox, moderator bands in both ventricles. The vena cava opens directly into the right ventricle. The branching of the aorta are similar to those of the ox. The large, possibly pregnant, uterus has a single cavity, but the scalloped edges of this cavity are remnants of the seven cells of Michael Scott.

The tubular structures seen to emerge from the lateral walls of the uterus are the uterine cornu of earlier authorities. The long wandering blood vessels carrying the retained menses of the pregnant woman from the uterus to the breast for the manufacture of milk are also shown.

Yet, even with its many throwbacks to Galenic authority, Leonardo's demonstration represents an astonishing advance when compared with illustrations current in his day. With his situs figure as a start, Leonardo was soon to advance into a myriad of new observations in all of the systems, which his dissections laid bare. It is little wonder that with his almost daily excursion into the world of the unknown, Leonardo was unable to crystallize his thoughts into copy for printed presentation; so his great work remained as laboratory notes only.

It was Leonardo the artist rather than Leonardo the anatomist who was dominant in the endeavor to formulate a canon of the proportions of the human body. He was indebted to the Roman writer Vitruvius, who in the reign of Augustus, wrote a treatise on architecture in which he advocated the observance of a definite symmetry in the various parts of an architectural design, and advanced in support of this idea the fact that such symmetry occurred in natural objects. As proof of this he gives the proportional lengths of several parts of the human body, pointing out for example that the length of the body is eight times the height of the head from the point of the chin to the vertex and six times the length of the foot. The drawings in Figure 3 are evidently illustrations by Leonardo of two of Vitruvius' proportions, namely that in which he states that in a man standing erect with the arms stretched horizontally, the distance between the tips of the fingers will be equal to the height of the body and the figure may therefore be inscribed within a square, and secondly, if a man lie supine with arms and legs abducted, a circle drawn with the umbilicus as the center will touch the tips of the fingers and the toes.

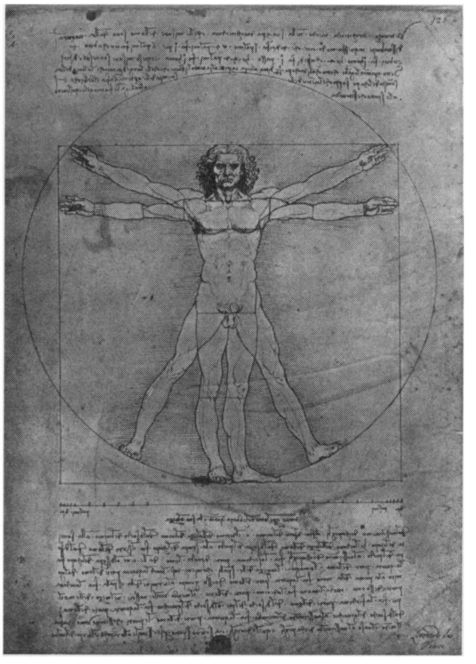

Figure 3. Human figure in a circle in a square, illustrating its proportions. Arttoday.com © 2001.

In the words of Leonardo:

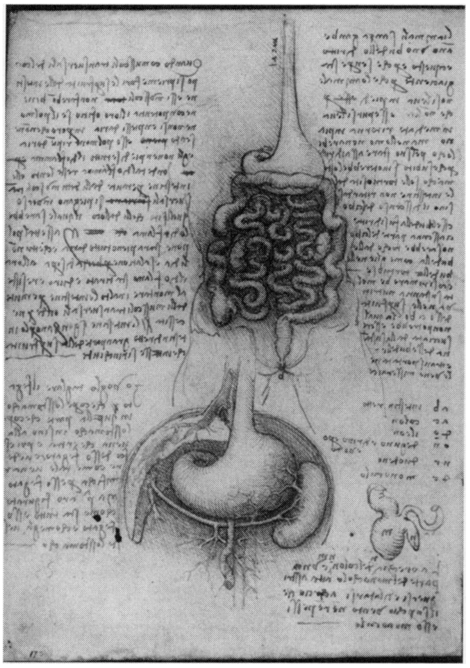

Figure 4. Above, a supposed arrangement of intestine and stomach. Below, left, stomach, liver, and spleen with splenic vein. Below, right, the caecum and appendix. The Royal Collection © 2001, Her Majesty Queen Elizabeth II.

> The span of a man's outspread arms equals his height. If you open your legs so as to decrease your height by 1/14, spread out and raise your arms so that your middle fingers are level with the top of your head, you will find that the navel will be the center of a circle of which the outspread limbs touch the circumference; and the space between the legs will form an equilateral triangle [1]. (These words can be seen in Figure 3.)

Leonardo thus often extended the canon of proportions that were propounded earlier, deriving for himself artistic "rules of proportion" for the representation of the human form. He also made a study of the proportions of the human face, and arrived at the most acceptable proportions that would result in a beautiful face (akin to the studies of Francis Galton on beauty). He then used these rules and distorted them on purpose to arrive at disproportionate faces, which he sketched out as the famous series of da Vinci's grotesques.

Leonardo's figures illustrating the digestive system are fewer in number than those of some other portions and probably all were made at an early period, but nevertheless even the poorest of his drawings are superior to those that were current then.

Figure 4 is not exactly that of a human stomach. The esophagus gradually widens as it approaches the stomach, so that there is no abrupt transition from one to the other as in man, and the fundus of the stomach is not so sharply defined, even though the esophagus opening is somewhat farther to the right than is usual. But more striking is the course of the pyloric end and first portion of the duodenum. In the majority of the figures, instead of passing upward, backward, and to the right, the direction is upward, backward, and to the left, so that the duodenum descends behind the stomach and makes its appearance from behind it opposite the middle of the greater curvature.

In man, it is true, the esophagus does enlarge in its subdiaphragmatic to form what has been termed the cardiac antrum, but its union with the stomach is abrupt and not gradual as Leonardo depicts it. One must suppose that Leonardo was drawing what he was seeing, and accordingly one must suppose that he was not representing a human stomach, but that of some animal, the pig most probably since it presents the peculiarities that Leonardo figures.

However, he had an understanding of the function of the digestive system, for example, he probably observed the peristaltic contraction of the esophagus, for he writes:

> Since all the muscles have a dilating and extending motion, note, in making the anato-

my, there are the nerves which, between the esophagus and the cervical vertebrae, enter the muscles in that place (i.e., the esophagus), which by their dilation constrict and close successively the esophagus when food is propelled through its narrow canal to the stomach; so in this case be diligent to note every least circumstance [4].

Figure 5 was drawn with red crayon and subsequently outlined with ink. It represents a sagittal section through the skull, with labels indicating the various structures cut, and is the translation into drawing of a description by Avicenna. On the surface there are the hairs (*capigli*) of the scalp; beneath these a layer termed the *codiga*, corresponding to the epidermis and the superficial fascia; then follow the galea aponeurotica, termed however, *carne musculosa*; then the pericranium, the layer of areolar tissue being disregarded; then the bony cranium; then in succession the dura mater, pia mater and brain (*celabro*). Nothing of the structure of the brain is shown except the ventricles, and these are represented as three cavities separated by constrictions and placed in a row, one behind the other, a prolongation of the anterior one extending into the eye and probably represents the optic nerve. Though in Figure 5 Leonardo has relied largely on prior authority, he had later refined the representation of the ventricles by injecting wax into the brain.

Of the parts of the brain other than the ventricles, Leonardo gives little information. In the basal views of the brain of an ox, the temporal lobes of the cerebral hemispheres and the cerebellum are clearly shown, and the infundibulum, cut across and surrounded by the *rete mirabile*, is indicated in one figure, while a T-shaped structure projecting from the third ventricle may represent the hypophysis. These, together with the ventricles, form the sum total of Leonardo's contribution to the structure of the brain.

The mechanics of the movements of the head upon the summit of the vertebral column exercised him not a little, since he seemed to associate with these movements a necessity for a considerable rigidity of the column, inasmuch as the muscles that produced these movements rise from the vertebrae. How the rigidity could be imparted is illustrated by Figure 6, in which the muscles are represented by stout cords, and concerning which he writes:

First you will make the spine of the neck with its tendons, like the mast of a ship with its stays, without the head; then make the head with its tendons that give it movement on its pole [4].

The cords cannot be identified with any actual muscles, and the figure must be regarded as a representation of an idea rather than of actual conditions. At first he

Figure 5. Section through the skull and brain showing brain membranes. The Royal Collection © 2001, Her Majesty Queen Elizabeth II.

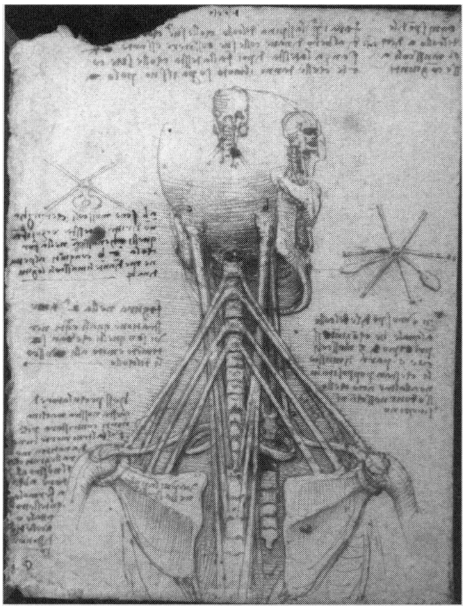

Figure 6. A cord diagram of the muscles supposed to stabilize the cervical vertebrae in movements of the head. Also, a sketch showing the insertion of muscles into the spine of a vertebra. The Royal Collection © 2001, Her Majesty Queen Elizabeth II.

supposed that the stabilizing muscles passed from the cervical vertebrae to the shoulder girdle, but later on, when he returns to the idea of the mast and its rigging, he concludes that:

> The muscles of the shoulder do not aid (in the fixation of the vertebrae), nor those of the clavicle (*forcula*), since the man will relax these muscles arising in the shoulders and *forcula* when he raises the shoulders to the ears and will take away the power of his muscles. And with such relaxation and shortening, movement is not wanting in the neck (head?) and there is not wanting the resistance of the spine in sustaining the head [4].

Then he proceeds to assign the main stabilizing action of the superior posterior serratus, which he invariably describes as formed of three separate slips.

This figure illustrates one of da Vinci's unique attributes. He attempts to ascribe function and draws heavily from his architectural and inventive abilities. This is most profound in his drawings of the musculo-skeletal system.

Figure 7 shows the earliest known drawings of the coronary arteries. In these drawings both the left and the right coronary arteries are shown sending their branches to the muscles of the heart. These are followed in detail. Leonardo shows the coronary arteries "crowning" the top of the heart. This is how they got their name "coronary." It is noteworthy that neither in his figures nor in his text does Leonardo take definite cognizance of the atria of the heart. He figures in some cases the auricles (as above) and speaks of them in various passages as *orecchi* or *additamenti del core*, this latter term recalling their Avicennian description; but of the more important atria never a word.

In his discussion of the heart Leonardo was the first to state that it is composed of muscle; he was the first to describe it as being four-chambered. Leonardo saw and drew the auricles correctly, depicting them as receiving chambers for the peripheral blood. He maintained this idea in his descriptions and showed it in his drawings.

Speaking of an "old man" who died quietly while conversing with him at his bedside in the hospital, Leonardo states:

> And when I opened the body in order to ascertain the cause of so peaceful a death, I found that it proceeded from weakness through failure of blood and of the artery that feeds the heart and the other lower members, which I found to be parched and shrunk and withered; and the result of this autopsy I wrote down very carefully and with great ease, for the body was devoid of either fat or moisture, and these form the chief hindrance of its parts. The other autopsy was on a child of two years and here I found everything the contrary to what it was in the case of the old man. The old who enjoy good health die through a lack of sustenance. And this is brought about by the passage to the mesaraic

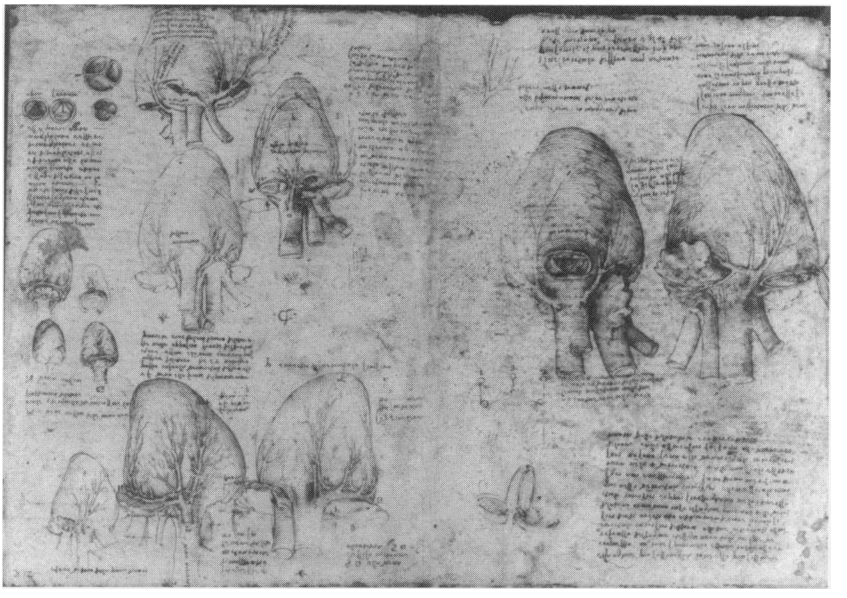

Figure 7. Mechanisms of the ventricles of the heart. The Royal Collection © 2001, Her Majesty Queen Elizabeth II.

veins becoming continually restricted by the thickening of the skin of these veins; and the process continues until it affects the capillary veins, which are the first to close up all together" [2].

These observations make Leonardo the father of a modern branch of medicine; gerontology. His dissection of the old man yielded him a large number of pathologic findings associated with arteriosclerosis, the significance of which he did not fail to point out:

The artery and the vein which in the old extend between the spleen and the liver, acquire so great a thickness of skin that it contracts the passage of the blood that comes from the mesaraic veins, through which this blood passes over to the liver and the heart and the two greater veins, and as a consequence through the whole body; and apart from the thickening of the skin these veins grow in length and twist themselves of the manner of a snake and the liver looses the humor of the blood which was carried there by this vein; and consequently this liver becomes dried up and grows to be like frozen bran both in color and substance" [2].

The last of his written notes reads: "June 24, 1518, Saint John's Day, at Amboise, in the palazzo of Cloux; I shall go on" [1]. This intellectual giant who arguably did more in one lifetime than any man parted in all humility saying, "I have offended God and mankind because my work did not reach the quality it should have" [5].

REFERENCES

1. Keele, K. *Leonardo da Vinci and the Art of Science*. River Forest, Illinois: Priory Press, Ltd.; 1997.
2. Belt, E. *Leonardo the Anatomist*. Lawrence, Kansas: University of Kansas Press; 1955.
3. Vasari, G. *Le Vite de piu Eccellenti Pittori Scultori e Architetti*. Milanesi, Florence: Sansoni; 1906.
4. McMurrich PJ. Leonardo da Vinci — The Anatomist. Baltimore: Williams and Wilkins; 1940.
5. Frequently quoted apocryphal remark.