How do we know the human body?

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What is a human being?

Who are we and how do we know who we are?

One way of answering this question is to use deductive reasoning. For example, we might say:

> All humans are animals. I am a human. Therefore I am an animal.

This sounds logical. But the question is, how do we know that all humans are animals? This is a generalisation. But how can we know that this general thing is true in the first place? How do we come to know the first principals?

According to some ways of thinking, one way we know the first principles is through some sort of natural intuition. Some people believe that the human mind has an innate capacity to recognize the starting points of the sciences - the generalisations that we need in order to understand the natural world.

Maybe you are thinking, well, isn't it obvious? You might argue that we do have some intuitive knowledge that all humans are animals. However, others may counter that this generalisation is actually based on particular observations of humans and animals.

Let's consider another example of deductive reasoning, which is connected to the question of who we are:

> All humans have 206 bones. I am human. Therefore I have 206 bones.

The question is, how do we know that all humans have 206 bones? Clearly someone must have had to **observe** a number of human bodies in order to make this generalisation. At least in this case, doesn't the generalisation require direct observations?

> ACTIVITY:
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> How many bones are there in the human body?
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> How can you find the answer to this question? List as many ways as you can, and use a few different ways to try to find the answer. [Hint: use observation as well as oral and written authority.]
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> Note down any difficulties you have in finding the answer in each way, and tell if you find any ambiguities or contradictions.

An example of deductive reasoning by Galen

Throughout the Middle Ages, one of the ways that Europeans, Arabians, and Africans learned about human anatomy was through the writings of the ancient Roman, Galen.

'Scientists', as we now know them, did not exist in ancient times. However, there were a number of people who studied and wrote about topics that now are studied by scientists, and whose work has survived. One such person is the 2nd century Roman (of Greek origin), Galen.

Galen was a practicing physician and an influential member of the ruling elite. He was a personal physician to the Roman Emperors. He wrote hundreds of treatises on anatomy, medicine, and philosophy. Even centuries after the fall of the Roman Empire, Galen's work was carried on (in translation) by Arab anatomists. For more than 1000 years it was used as the basis for medical training and studies of anatomy in the Islamic Empires. Then, in the 1100's, Europeans began translating Galen from Arabic into Latin and other European languages.

Perhaps Galen can be most accurately called a 'philosopher', because his work was based largely on rational argument. He wrote (in Greek) detailed descriptions of human anatomy. People assumed that Galen's ideas about human anatomy were based on direct observations of the human body. However, we now know that he did not actually dissect the human body in

order to understand human anatomy. He based his descriptions on philosophical rationalisations and on observations of apes and other animals.

Galen began with the generalisation that humans are similar to apes and other animals. He dissected apes and other animals. He then deduced that humans had similar anatomy. This is an example of deductive reasoning.

There are various ways of knowing. We may know something because we directly observe it through our senses. Science is based on this way of knowing. Another way of knowing is on the basis of authority. We may gain knowledge by listening to someone who has some authority on the subject. Or we may gain knowledge by reading something in a book which is source of authority.

For hundreds of years in Europe, southwestern Asia, and northern Africa, Galen was considered to be the main authority on human anatomy. It took tremendous courage to contradict Galen.

Some of Galen's anatomy is disproved by direct observation

However, there were a few Islamic anatomists who we know made corrections to Galenic anatomy on the basis of direct observations of the human body. For example, Al-Baghdadi travelled to Egypt at the time of the horrific famine of 1200-1201 and saw many thousands of human corpses piled up. He wrote:

> In considering these corpses we saw the shape of the bones and their joints, fitting them together in their respective proportions and positions, which gave us knowledge not obtainable from books, because the books did not mention them, or because their wording was insufficiently precise for one to form a just idea. Also the idea in the book [of Galen] is contrary to that which we have recognized by inspection, for the best evidence is from feeling [i.e., seeing and touching] rather than from hearing. Although Galen was the first in science to examine and be most careful and exact in what he said and reported, yet the witness of our senses is better than reading Galen … For instance, the lower jawbone; all the anatomists agree in saying this jawbone is composed of two bones which are firmly joined near the chin. When I say here all the anatomists, it is as though I say Galen only, for it is he only who has practiced personally anatomical operations, and who has made this the particular object of his studies and researches, and who has composed the greater part of those works of which we possess the principal; the others have not been translated into Arabic.
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> What I saw of this part of the corpses convinced me that the bone of the lower jaw is all one, with no joint nor suture. I have repeated the observation a great number of times, in over two thousand heads. I have employed all kinds of means to assure myself of its truth, and I have never seen anything but a single bone. I have been assisted by various different people, who have repeated the same examination, both in my absence and under my eyes and, like myself, they have never seen anything but a single bone, as I have said.

Al-Baghdadi was using the scientific method. However, Al-Baghdadi's discovery did not have much impact. Probably the medical establishment was not prepared to believe direct observation and experimentation over the word of authority. This, despite the fact that 10-20 years before this, Saladin's physician, Ibn Jumay al-Israeli had suggested that each part of the human body should be enumerated through anatomical dissection. He wrote that it was necessary to gain knowledge "through experience and observation of the characteristics of the nature of each [part] with regard to the colour, the normal state, ... its structure,..., its smoothness or its roughness, whether there is a cavity or duct in it and what this cavity or duct contains; ... the extent of its size and the number of its component parts and the nature of each component, if it has component parts; of its position, that is, its position in the body and whatever association and connection there may be between it and other parts; and of its function and useful purpose or purposes for which it is needed."

In the 15th and 16th centuries, Europe was undergoing a cultural Renaissance as its feudal systems were being replaced by capitalism. New technologies were needed for the new economic structure of society. These technologies were based on knowledge of the natural world. Science was developing. European scholars began going back to the original writings of ancient Greeks and Romans to find answers to their questions. They believed that knowledge would be reborn by the restoration of the teachings of the ancient Greeks and Romans.

The Flemish anatomist Andreas Vesalius (1514-1564) wanted to restore the glory of the ancient study of anatomy by Galen. He studied the writings of Galen. But Vesalius went a step further - he made his own observations. This led him to question some of Galen's anatomy. He dissected human corpses and found out that Galen had made many errors. For example, Galen claimed that the human breastbone has 7 segments. Vesalius observed only 3 segments.

Vesalius reread Galen, some of which had just been retranslated from the original Greek. He figured out that the reason Galen had made so many mistakes was that he had never dissected a human body. He had deduced human anatomy from the anatomy of the Barbary macaque and other animals.

ACTIVITY:

Compare the following descriptions of human anatomy made by Galen [On Bones for Beginners] and by .... with the drawings of human anatomy made by Vesalius and others, and with the drawings of the anatomy of other primates. Make a list of the similarities and dissimilarities between all of these.

Since Roman times, there had been taboos against dissecting human bodies. Medical students would learn anatomy by reading texts, not by performing or observing human dissections. This began to change with the Renaissance. Perhaps the taboos had arisen because it is difficult to understand death. Social and personal morals and ethics prevent us from hurting another living human. But what happens after death? Is there anything wrong with dissecting a human corpse? In many cultures, human bodies are considered to be special in some ways, even after death. Perhaps such taboos exist for good reasons. One good reason is to protect us from diseases we could contract from a decaying human corpse.

Even Vesalius at first had a hard time obtaining human bodies for study. When he was a student in Paris, he would take human bones from a charnel house, where they were brought when the "Cemetery of the Innocents" (containing victims of the Plague) was dug up in order to reconstruct the city wall. Or he would sneak outside the city gates in the middle of the night to rob human bodies that were hanging for public display after executions. Once he heard that the mistress of a monk had died, and he obtained her body, quickly removing the skin so that the monk would not be able to recognise her. But eventually, the importance of dissection gained acceptance, and some authorities granted permission to obtain bodies for study in the universities of Europe.

Vesalius rejected a form of education based merely on memorising texts and gaining knowledge by accepting the writing of an authority. He demanded to learn by doing - i.e. to learn about the human body through direct observation of the human body, just as (probably unknown to him) Ibn Jumay al-Israeli had suggested centuries before.

Perhaps the most important innovation of Vesalius was that he drew pictures and had others draw pictures in order to understand and explain human anatomy. After dissecting the human body, he rearticulated the bones, using iron rods and chains to hold them in place in order to obtain an entire human skeleton posed in an upright, realistic manner. He would then draw the skeleton, by looking and drawing what he observed. He also got artists (possibly from the atelier of Titian) to draw the skeletons. He went to great extents to get the pictures engraved and printed as books in which he presented his findings to the scholars and physicians of Europe. His drawings and books were copied and widely disseminated in Europe.

Of course, what we see when we look is inevitably shaped by our past experience, understanding, and knowledge. On the left is an early drawing of one of the rearticulated skeletons made by one of Titian's artists. Compare it to the drawing on the right, which was (it is believed) made later on by Vesalius himself. In the first one, the artist was drawing many things as he "knew" they should be, according to the teachings of Galen. Even the seven segments of the breastbone are shown, as they appear in the macaques that Galen had studied.

ACTIVITY:

(1) Draw a picture of a femur bone from memory.

(2) Then draw another picture of a femur bone while looking at an actual femur bone (the femur of a chicken could be used if you do not have one of a larger animal).

(3) Do some research about femur bones. Find out how muscles attach to the bone, and how the bone articulates to the tibia, fibula, patella, and pelvis. Find out how the joints function. Observe the actual femur bone carefully and redraw it, based on your research.

(4) Compare the three drawings you have made. What are the differences and similarities? How has your knowledge and experience influenced what you saw and what you drew? How has the act of drawing influenced your knowledge?

(5) How has this activity changed your answer to the question, "Who am I?" and your understanding of methods to use to answer this question? Why is it important (or unimportant) to study anatomy? Why is the question, "Who am I" important or unimportant?

The study of human anatomy by Vesalius and others had an enormous influence not only in the field of medicine, but also on the way the human body was depicted in works of art. Since the beginning of the Renaissance in Italy, many artists - most notably Leonardo Da Vinci and Michelangelo - based their depictions of the human body on a reassessment of works of art from ancient Greece and Rome, and also on their own dissections and observations of the human body. The field of science was being established in its natural interrelation with the field of art.

Leonardo Da Vinci wrote, "First I shall make some experiments before I proceed further, because my intention is to consult experience first and then by means of reasoning show why such experiment is bound to work in such a way. And this is the rule by which those who analyze natural effects must proceed;"

Thus, we see that as much as Vesalius, Leonardo Da Vinci, and others admired the ancient Greeks, their work also demonstrates a departure from the ancient Greek methods of reasoning based on deduction. They demonstrated that, at least in some cases, we cannot really know the general without first knowing the particular. Observations of particular human bodies were needed in order to make generalisations.

So how many bones are there?

On the question of the number of bones in the human body, early anatomists had opposing opinions, which they forcefully defended. But Vesalius became bored with this controversy, remarking, "If you count all the bones seen in children, good God, what a great pile of bones you will heap up." He was pointing out that there is actually no such thing as a correct number of bones in the human body. The number of bones changes with age, as bones gradually ossify from the largely cartilaginous skeletons of babies. The very definition of what constitutes a bone is after a point just a matter of semantics. There is also a fair amount of normal variation between individual skeletons. Before trying to count bones, we have to decide whose bones to count.

Even today, if you look through different books and other sources of knowledge, you will find that it is not so easy to make a generalisation on the number of bones in the human body. You will find sources claiming that all humans have 206 bones - or 212 bones - or various other numbers (in Vesalius's time most people argued for much higher numbers). The number of bones in a baby is even more variable, with some sources claiming that there are more than 300 bones.

What seemed at first like a simple question has turned out to be rather difficult to answer. This is not unusual in scientific investigations. We see that as science progresses, the answers to our questions may change.