

1. Introduction to the Human Body

Essential reading for those who have not done ANHB 1101 and / or ANHB 1102.

In this chapter :

- “The Anatomical position”.
- Frame of reference – important planes.
- A review of the organ systems of the body.

The anatomical position.

In day-to-day language we use directional terms with reference to our surroundings. When at our desk, looking at the computer screen our eyes look ‘forward’, the front of the chest faces forward and the back is, well, at the back. When lying in bed face up, we say that our eyes look upwards, the front of the chest faces up, and the back faces down. Such variation of expression can create confusion and inaccuracy when we describe structures within the body. In scientific communication we need to be particularly precise. Precision comes from standardising these terms. For all anatomical descriptions, we assume that body is in such a standardised position. We call this the ‘anatomical position’.

In the anatomical position, the body is assumed to be standing erect, with feet close to each other and parallel to each other, arms by the side with the palms of hand facing forward with the thumb and fingers held straight, head held straight and eyes directed forwards. We can see that in this position the head is at the top (‘up’) the feet at the lower end, and the palms face forward. The interrelationships among all other parts of the body assume this position. Now, imagine sitting on chair, with forearms resting on the arm-rests, elbows, hips and knees folded. The knees, for example, are still described as being ‘below’ the hips, *not* ‘in front of the hips’; and the elbows are ‘above’ the wrists. Even if our hands rest on the desk with the palms facing the desk, the palms are still described as facing forwards. In practical terms, when you see a cadaver on a table in the anatomy laboratory, the back is still ‘at the back’, not ‘below’. The examples given here are simple ones, but the concept of the anatomical position is valid even if we see complex body positions like those of a ballerina or a gymnast.

The anatomical position is a ‘standardised’ position. It is by no means a ‘natural’ position. Ordinarily when we stand erect, our forearms have a natural tendency to turn so that the palms face the thigh.

Three sets of planes as a frame of reference.

Next, we need a frame of reference. This is in the form of planes which are mutually at right angles to each other. (These can be compared with X, Y and Z axes if you have studied coordinate geometry!)

1. The median plane. The first plane is unique, and it divides the body into two symmetrical halves. This vertical plane passes through the midlines of the body on the front and the back surfaces. One may say that this plane passes through the middle of the nose, the middle of the chin through the umbilicus (‘belly button’)...and through the middle of the back. This plane is called *the* median plane. (Note the ‘*n*’ at the end.) There is only one plane that can divide the body into right and left halves.

2. Sagittal planes. Any plane parallel to the median plane is called *a* sagittal plane. There can be many such sagittal planes, all parallel to the median plane. Sometimes, *a* sagittal plane close to the median plane is called a paramedian (‘near the median’) plane.

Median and sagittal planes are vertical. They run ‘front-to-back’. (Or ‘back-to-front!’)

3. Coronal planes. A vertical plane at right angles to the sagittal plane is called *a* coronal plane. Theoretically there can be an infinite number of coronal planes. A coronal plane divides the body into a front part and a back part. The two parts are not equal, and they are not symmetrical.

**Coronal planes are vertical.
They run from one side to another. (Right-to-left or left to right).**

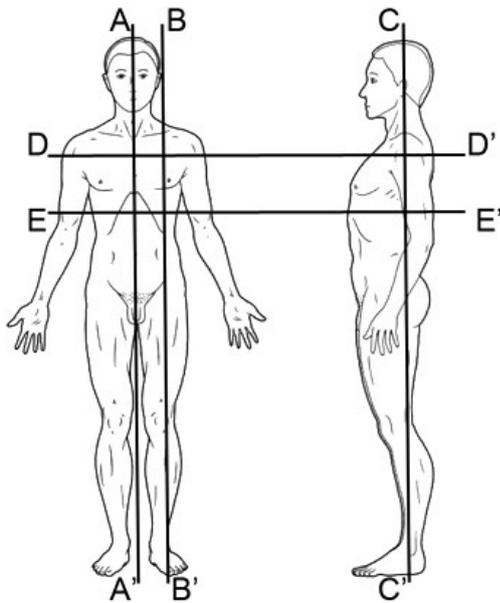


Fig 1. Anatomical position (left) and principal planes of reference.
AA':median plane. BB':sagittal plane.
CC':coronal plane.
DD' and EE' : Horizontal planes.

4. Horizontal planes. A horizontal plane is also called a *transverse plane*. It is at right angles to both sagittal and coronal planes. It 'cuts' the body *across* the long axis. There can be a number of such planes at different levels in the body. Some horizontal planes are important landmarks in the body. These will be described when appropriate.

(In the language of CT and MRI scans, to be described later in the unit, a horizontal plane is also called an *axial plane*, because such a plane always cuts across the axis of the body. The concept of the axis of the body is also elaborated later.)

With these planes, we can describe the position of any part/s of the body in absolute terms or relative to each other. The terms we may use would be 'front' or 'back', 'up' or 'down' and 'close to' or 'away from' the median plane. Alas, anatomy has its own language and to be understood by another anatomist, human biologist or a medical person, we need to use the accepted anatomical language.

Historically, sciences as we understand today evolved in Europe. The story began with ancient Greece. With the rise of the Roman Empire, Latin superseded Greek as the prime

language. The language of communication among scientists was Latin for a long time. In the modern era most of us communicate in our native languages, but biological and medical sciences have clung to terminology rooted in the classical languages, Latin and Greek.

Among the directional terms:

'In front' is **anterior**.

(Latin 'ante' = before, in front of. Note : it is spelt with an 'e').

'Towards the back' is **posterior**.

(Latin 'post' = after, behind).

'Up' is **superior**.

'Down' is **inferior**.

A structure 'In the midline', that is, in the median plane, is described as being **median**. (Note the 'n' at the end.)

However, 'towards the midline' is **medial** ('l' at the end) and 'away from the midline' is **lateral**.

These six terms are the essential terms. They are often used in a relative sense. For example, a structure may be **anterior to** another structure. We can also use these terms in combinations. For example, a structure may be in front and below another, in which case we say "**it is anteroinferior to...**".

Sometimes we use these terms (or combinations) in an 'absolute' sense. For example, an organ may have superior, inferior, anterior, posterior, medial and lateral *surfaces*.

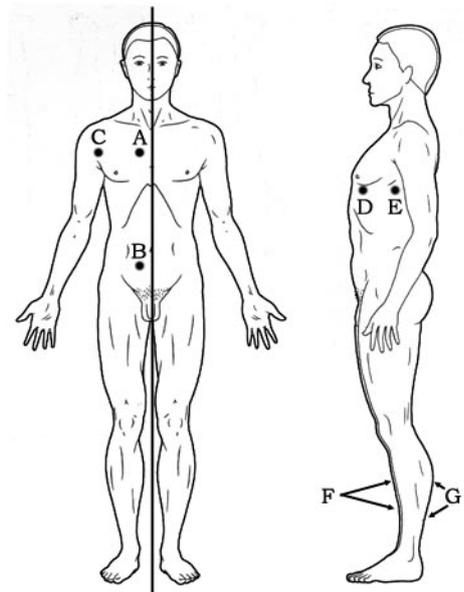


Fig. 2. 'A' is superior to 'B' and medial to 'C'. 'D' is anterior to 'E'. How will you describe C with reference to B? 'F' is the anterior surface of the leg, 'G' is its posterior surface.

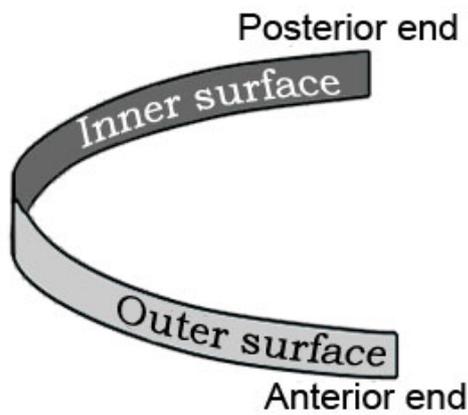


Fig. 3. Surfaces of a rib.

There are occasions when we need even more precision and use more specific terms.

Consider ribs, which are curved, flat strips of bone in the wall of the chest. A rib has two surfaces. One surface always faces outward, though it is anterior in front and posterior at the back. The other surface always faces inward. To avoid confusion, these surfaces are best described as *outer (external)* and *inner (internal)*.

Consider the heart within the cavity of the chest. It is posterior to the front ends of the ribs, but anterior to the rear ends of ribs. In this situation it is **best to describe the heart as being deep to the ribs**.

Historically, human structure has often been compared with other mammals and vertebrates, and with good reason. This is especially true in embryology and neuroanatomy. Our erect posture creates some problematic situations. For a quadrupedal animal, the head is anterior, the tail is posterior. The belly is inferior and the back is superior. Not quite the way we describe our own anatomy... isn't it? In many instances the head end of the body is therefore called the cranial (of the skull) end, and the opposite end is the tail end or caudal (cauda = tail) end. In embryology and neuroanatomy, we also use the term ventral ('towards the belly') for anterior, and dorsal ('towards the back') for posterior.

Yes, we do have a little bone representing the tail. Moreover, the real 'end of the body' is our tail, not the feet. We shall explain this later in the unit.

One more pair of terms needs to be mentioned here. These are 'proximal' and 'distal'. Literally, proximal means 'nearer' and distal means 'farther'. In the anatomical context, *these terms are used with reference to some point, plane or structure*. Often the reference point or plane is the head end or the median plane. For example, the forearm is distal to the shoulder, and proximal to the hand. In case of nervous system structures, anything closer to the central nervous system (brain or the spinal cord) is proximal. In the cardiovascular system, blood vessels closer to the heart are proximal, farther away from the heart, distal.

Anatomical language.

To the uninitiated, anatomical terms, even for familiar parts of the body are often intimidating. Most of these terms are of Greek or Latin origin, with a few Arabic ones. It is *not* our aim to study the classical languages. *However*, understanding the meanings of many of them – though certainly not all! – goes a long way towards remembering them. In this Reader, anatomical terms are explained wherever they are mentioned first.

At times, the classical roots of anatomical terms have more of an amusement value than instructional. These make a welcome break in our study ☺.

Like most areas of learning, anatomy has its own big share of structures or phenomena named after person/s who have discovered or described such entities first. Such terms are called **eponymous terms**. Unfortunately in anatomical and medical sciences the vast number of such terms causes undue burden on the memory of the student. Other arguments against eponymous terminology are beyond the scope of this reader. By international convention, eponymous terms are avoided these days, instead, descriptive anatomical terms are used. As the last word I may say that this certainly helps the student, but we tend to lose the historical perspective by avoiding them altogether.

Despite the trend towards using more of English and less of Greek and Latin, anatomical terms persist in usage, resulting in a curious mixture of classical terms and English form. The neck has the Latin name cervix, but the derived English form 'cervical' is used to mean 'of the neck' or 'pertaining to the neck'. (Well, the English language does have a significant influence of Latin, and the English cervical indeed descends from the Latin 'cervicalis'.) Thus the vertebrae in the neck are the cervical vertebrae. Incidentally, 'vertebrae' is the plural form of vertebra. We are not going to learn Latin grammar ☺, but a few remarks are in place here. Even inanimate objects have genders in Latin. A muscle is masculine, an

artery or a vein is feminine and a ligament (a structure that joins other structures) is neuter. Then there are different ways for plural forms and noun declensions. The long and short of it is, make it a practice to spell names of anatomical structures correctly, for a misspelling might alter the meaning.

Regions of the body.

Obvious physical features lead us, even as lay persons, to distinguish between parts of the body such as head, neck, limbs and trunk. These are convenient features which form the basis of anatomical study as well. Anatomically, we do recognise boundaries between the regions, for anatomical description demands precision. Most of these boundaries are arbitrary or defined by convention.

What is more important is the use of proper, anatomical terms with precision. The limbs are not just 'arms and legs'. They are upper or lower limbs. The terms arm, forearm, wrist, hand, thigh, leg and foot have specific meanings. The chest in the lay person's terms is the thorax, and the belly or 'stomach' is abdomen in anatomical language. The last mentioned example is of particular importance – no more 'stomach ache' for the student of anatomy – it must be 'pain in the abdomen'. The stomach is an organ of the digestive system, located in the abdomen.

The head includes the part above a line drawn along the lower jaw (mandible), further backwards just beneath the ear and beyond it, just beneath the skull. The neck extends down to the level of the clavicle (collar bone) in front, across the tip of the shoulder and along the upper margin of the shoulder blade (scapula) to a point just above the first vertebra of the thorax.

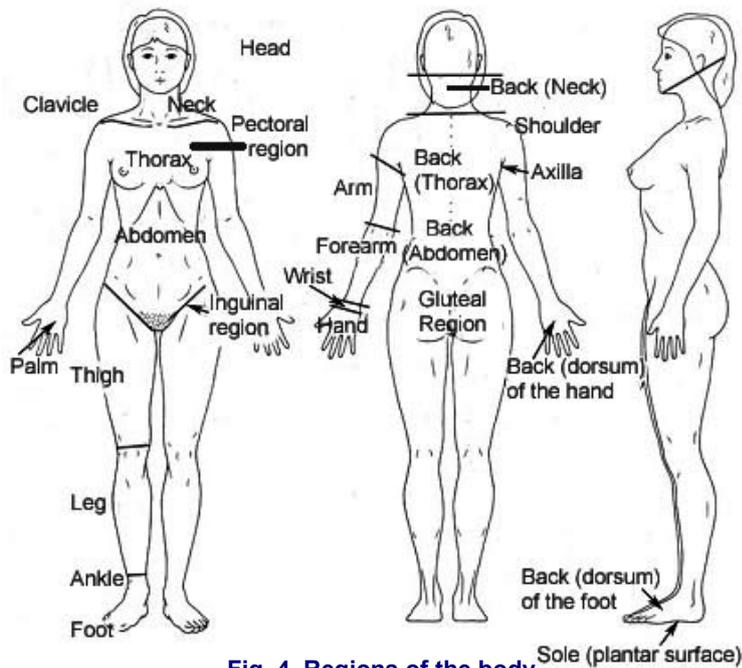


Fig. 4. Regions of the body

Between the clavicles and the groins (inguinal region), the central part of the body is the trunk. It comprises the thorax and the abdomen. The boundary between the thorax and the abdomen is not easy to define on the surface, since internally these two regions overlap significantly due to the dome shape of the diaphragm that separates them. The lowest part of the abdomen, between the hips is the pelvis, better appreciated when you look at a skeleton mounted on a stand. The thorax and the abdomen are cavities with firm walls. The region of the thoracic wall in front, including the breast, is called pectoral region. In the back, extending through the neck and the trunk, the key feature is the vertebral column or the backbone. This series of bones occupies a midline position along with muscles associated with it.

The limbs are extensions of the wall of the body. The upper limb extends from the armpit (axilla) down to the fingers. In the upper limb we speak of the axilla, the shoulder region, the arm between the shoulder and the elbow, the forearm between the elbow and the wrist and the hand beyond the wrist. In the lower limb, the region of the buttocks is the gluteal region, the part between the hip and the knee is the thigh, that between the knee and the ankle is the leg, and beyond the ankle is the foot.

In anatomy one must use these terms with precision – this is especially true for the parts of the limbs.

Regional and systemic approaches.

The major regions mentioned above form a convenient basis for learning the gross structure of the body. Such an approach gives an overall picture of an entire region. In the limbs for example, we have bones, they form joints which move, and there are muscles that bring about movement. Nerves control muscles and carry sensations. Blood vessels nourish these structures and skin clothes the entire ensemble. All this illustrates the integrated functioning of these structures.

On the other hand, functionally the body comprises a number of systems. The digestive system takes in food, digests it, absorbs the digested food and discards waste. The system runs from the head, through the neck and thorax, with most of its major components (organs) in the abdomen. In the circulatory (cardiovascular = formed by the heart and the blood vessels) system the heart pumps blood to all parts of the body through arteries. Blood from the body is collected by veins and returned to the heart, which in turn pumps it to the lungs for replenishing oxygen. The blood returning from the lungs is pumped back to the body. With a couple of notable exceptions, every bit of the body has blood vessels, that is, parts of the circulatory system. If we focus on specialised function, the structure of the body is best studied by this systemic (*not* 'systematic'!) approach.

Both approaches have their advantages. In this unit, we study the gross structure with an emphasis on the regional approach. However, embryonic development is better understood with individual systems. You will notice that the two approaches blend in a seamless manner – you will not even realise it!

Systems of the body.

We now survey the major systems of the body. The purpose *at this stage* in the unit is merely to start you off on this journey. It introduces you to 'what is where' and provides a basis for study in this unit.

Musculoskeletal system.

Muscles and bones take a lion's share of the total weight of the body. The skeleton is made largely of bones. Bones form hard, strong supports for the body, in many places protect delicate structures, have joints with various degrees of movement, and also act as a store of calcium in the body. Muscles move the bones at joints, bringing about movement of the whole body or its parts. For this reason muscles and bones are usually grouped together in one system.

A glance at the picture reveals more. A part of the skeleton runs through the centre of the body, along and around the long axis of the body. This is the axial skeleton, comprising the skull, vertebral column and the ribs. The limbs develop as extensions of the trunk and are seen as appendages (attachments) of the trunk. The bones of limbs form the appendicular skeleton.

Bones display a variety of form, and can be thought of as long bones, short bones, flat bones and irregular bones.

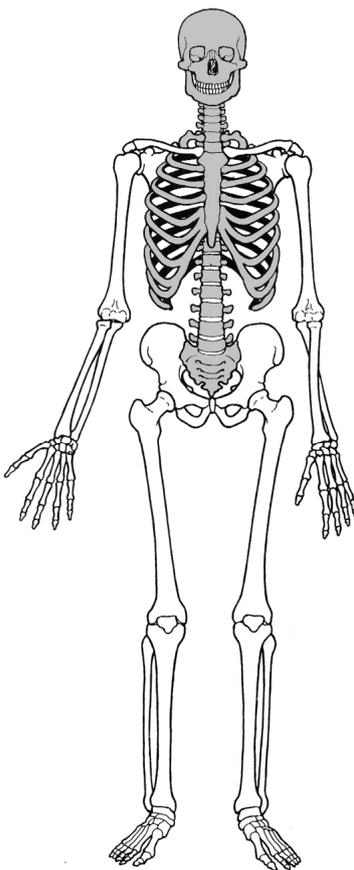


Fig. 5. Skeleton, anterior view

Depending on the structures that join bones and on the degree of movement, joints are also classified into structural or functional types. Though these areas have been studied in the Level one units, we shall be taking another look at joints towards the end of the semester. In the meantime, some relevant features will be introduced along with the vertebral column.

Digestive system.

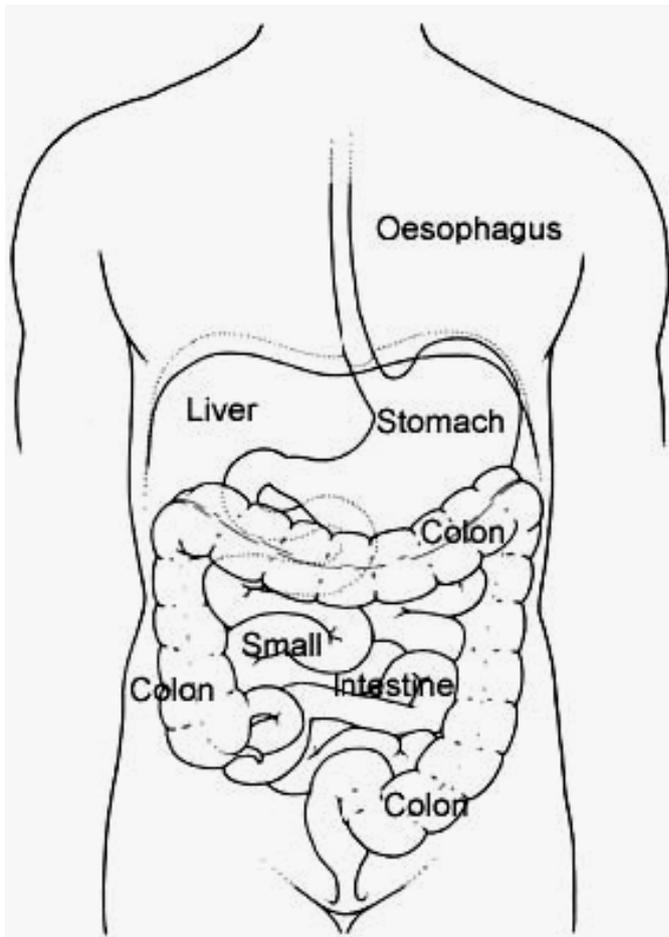


Fig. 6. Digestive system.

The functions of this system have been outlined above. The system begins at the mouth. The mouth cavity is equipped with teeth to cut, tear and grind food. The tongue moves the food around in the mouth during this process and also helps in swallowing. The tongue is also an organ of taste and helps in speech. The mouth is kept moist by saliva produced by three major pairs of salivary glands around the mouth and numerous smaller glands in the lips, cheeks and tongue. Swallowing takes food through the pharynx, from where the oesophagus carries it through the neck and thorax to the stomach in the abdomen. The baglike stomach stores food for a short while and initiates digestion of proteins. The rather long, tubular small intestine completes digestion, helped further by digestive juices from the pancreas and bile from the liver. The small intestine is also the major organ for absorption of digested food. Indigestible parts of food and other wastes are eliminated by the large intestine (colon) through the last part of the system, the rectum and the anal canal. It should be borne in mind that each organ has more to its function than outlined here. In this unit we shall focus on the parts of the digestive system in the thorax and the abdomen.

Respiratory system.

The large and functionally important organs are the lungs in the thorax, they bring about gas exchange between blood and air. Oxygen from the air goes into the blood and carbon dioxide is given out. The movement of air in and out of lungs is due to their expansion and return to original size. This in turn is brought about by movements of the walls of the thorax and the diaphragm. The rest of the respiratory system includes the air passage, beginning with the nose (not shown in this diagram) and the trachea (windpipe). Just above the trachea is the larynx, a mechanism which can control the flow of air and also produce sound for speech. The respiratory system can also excrete volatile wastes. The diagram on the right shows the system larynx downwards.

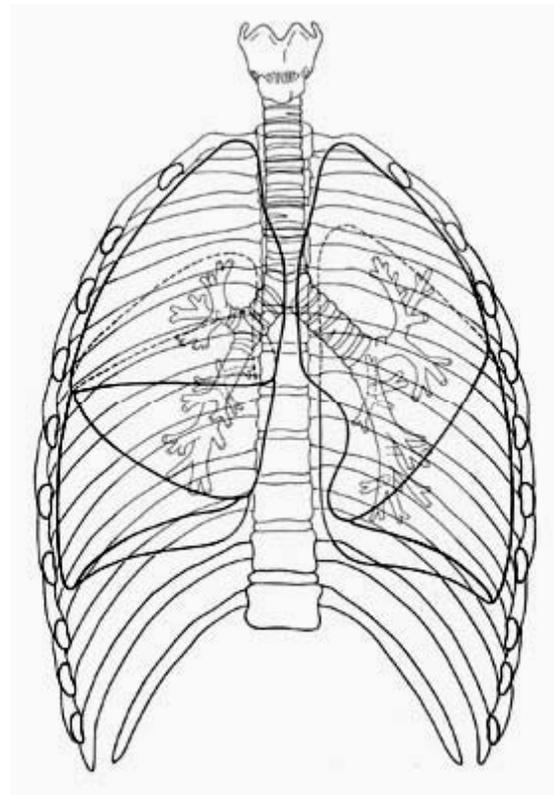


Fig. 7. Respiratory system

Circulatory (Cardiovascular) system.

Blood is a fluid which circulates through the body. It serves as an excellent medium to move a vast variety of substances from place to place. The central organ is the heart which has two pumps side-by-side. The left side pumps oxygenated blood to the entire body.

Deoxygenated blood from the body returns to the right side of the heart which pumps it to the lungs for oxygenation.

A blood vessel which carries blood *away* from the heart is an *artery*; one that brings it back to heart is a vein.

This distinction is important, because *these definitions are true irrespective the kind of blood (oxygenated or otherwise) carried by the vessel*. An artery branches repeatedly, until finally the vessels are reduced to a microscopic size with a very thin wall that allows exchange of substances. These small vessels are capillaries.

Fig. 8 shows the location of the heart and major arteries of the trunk and the head. Not all arteries are depicted in full, as *this is not intended to be an anatomically detailed diagram*. This figure does not include special areas of circulation like the lungs or the liver, which will be studied later in this unit.

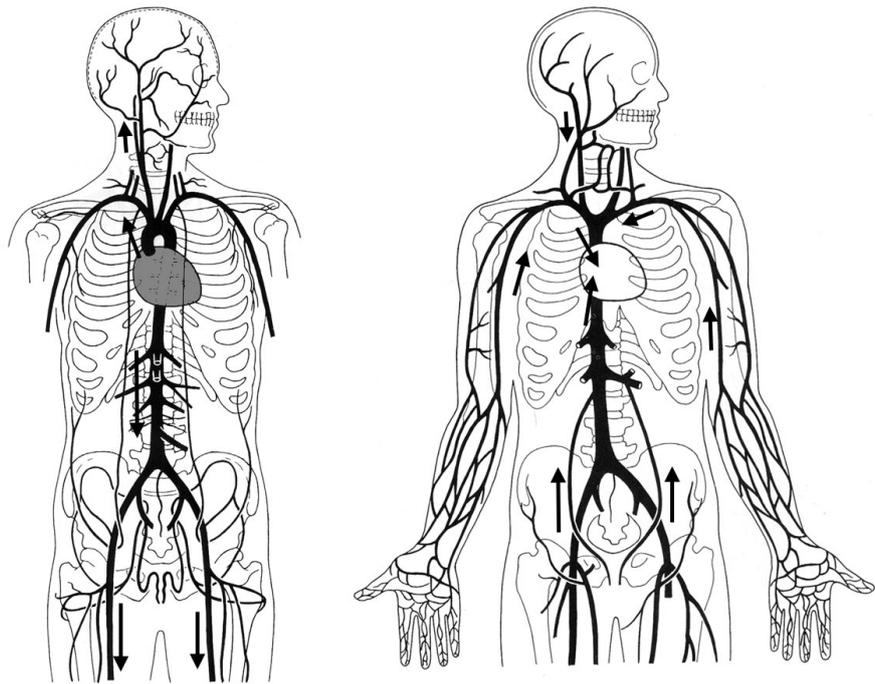


Fig. 8. Heart and blood vessels

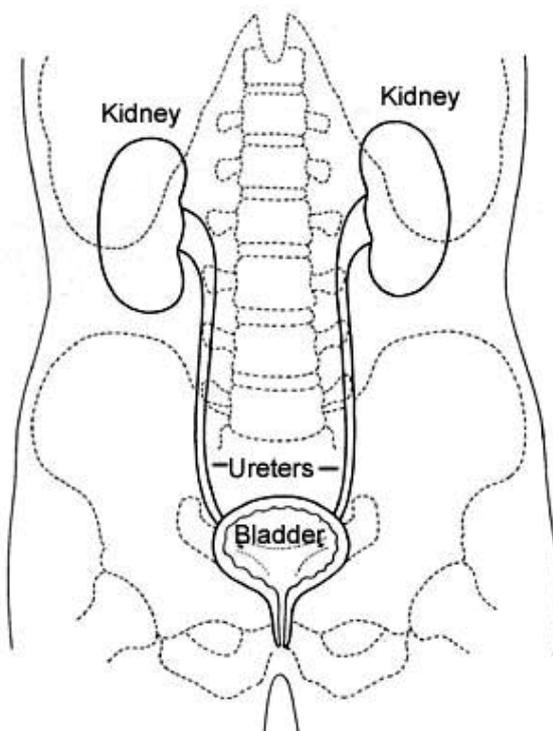


Fig. 9. Urinary system.

Urinary system.

Waste products arising from biochemical processes in the body, altered forms of drugs and other soluble waste are eliminated through urine. The two kidneys in the abdomen filter out the fluid from a large volume of blood continuously. Useful substances are recovered from the filtrate and waste is eliminated as urine. Besides this elimination, kidneys have a stellar role in the regulation of a large number of ions and also contribute to the regulation of blood pressure. Urine formed by each kidney is carried by a tube, the ureter, to the urinary bladder, a temporary storage organ. When full, the muscular wall of the bladder empties it through another, single tube called the urethra. In females the urethra is short, straight and opens independently. In males it is long, curved, passes through the penis and is shared by the reproductive system.

Reproductive system.

Humans have a sexual mode of reproduction. The female produces the eggs, the male produces sperm to fertilise the egg. The resulting new human being is nurtured, as it develops, in the womb by the female, to be born approximately 40 weeks from fertilisation.

In the female, eggs (oocytes) are produced by ovaries, located in the pelvis. One egg is released every month (average 28 days), fertilised in the uterine tube which then takes it to the uterus. When development is complete, the process of childbirth involves powerful contraction of muscle in the wall of the uterus.

In the male the sperms are produced in the testes (singular : testis). The testes are suspended just below the abdomen in a sac of loose skin called scrotum. Sperms are carried to a small organ called epididymis lying in contact with the testis, and further by a tube, the ductus deferens (vas deferens) enters the pelvis and travels to the back of the urinary bladder. They are joined by tubes from two small structures, the seminal vesicles and the joint tube enters the prostate. The seminal vesicles and the prostate add fluid to the sperms forming a thick, viscous fluid, semen. The reproductive tract then shares the urethra through the penis which transmits semen to the vagina of the female during sexual intercourse.

The reproductive system is controlled to a significant extent by hormones from the endocrine system.

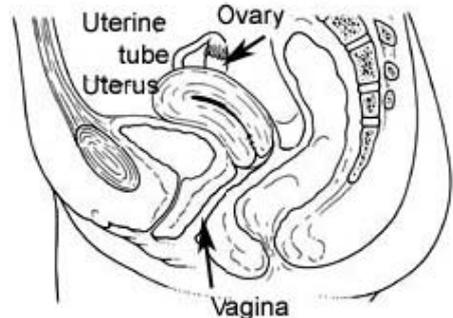
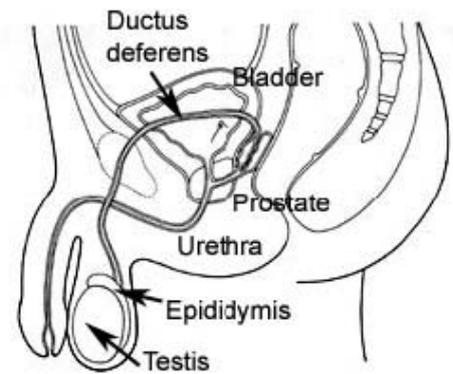


Fig. 10 Reproductive system

Endocrine system.

This is a collection of functionally diverse structures, located in different parts of the body. The common feature they all exhibit is that they deliver their products, hormones, into the blood stream. Many of them act in an interdependent manner. The major endocrine glands are the pituitary at the base of the brain, the thyroid and the parathyroid glands in the front of the neck, the adrenal (also known as suprarenal) in the abdomen at the upper ends of the kidneys and a part of the pancreas (which otherwise belongs to the digestive system). In addition, the testis and ovary, collectively known as the gonads also have an endocrine function. The endocrines form one of the control systems of the body, through hormones.

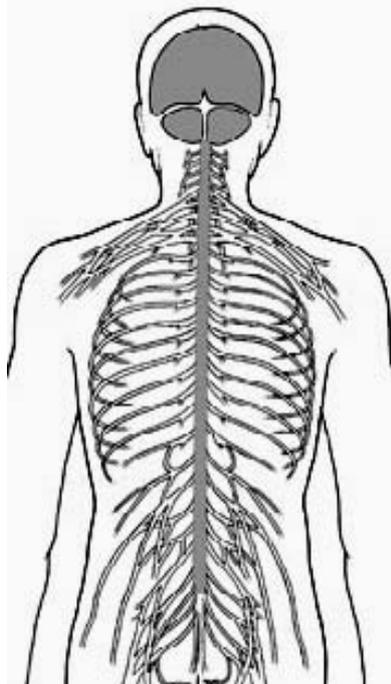


Fig. 11 Nervous system

Nervous system.

The nervous system is the largest control system of the body. Unimaginably more complex than the best computer designed by mankind, it is an amazing information processing system. It gathers information from all parts of the body and from the environment, in the form of what we call sensations. It also controls all activity of the body (motor control) including production (secretion) by most glands. While a lot of motor activity is in response to sensory input, the nervous system can generate a great deal of control messages on its own. Besides this, it is the seat of thought, imagination, judgment and a number of attributes of our personality.

The basis of function in the nervous system is largely electrical activity, conducted by long, very fine wire-like structures called nerve fibres. The processing parts of the system are protected by the skull and the vertebral column – the brain and the spinal cord respectively. These two together form the ‘central nervous system’. Bundles of nerve fibres running from the CNS to the rest of the body are nerves – these comprise the ‘peripheral nervous system’. The accompanying diagram only gives a general picture of the locations; many details are omitted.

Integumentary system.

The skin itself is a huge organ, spread all over the body. Besides being a protective covering, it also has specialised structures for the production of sweat and an oily substance. Hair and nails are yet other specialised structures of the skin. These, along with the blood vessels and nerves of the skin are often described together as a system of the body, the integumentary system.

Blood and the Defense systems.

Blood is arguably the most amazing fluid in the biological world. So diverse are its functions that it is impossible to group it under any specific system. However, many components of the defense systems of the body are either located in the blood or derived from blood. It is not unreasonable to include blood along with the complex defense system cells and organs outside the bloodstream as one system.

It must be borne in mind that a living organism is far too complex to be rigidly compartmentalised under such labels. The main purpose served by such a listing is that it gives us a fair idea of what and where in the human body. Further, the above descriptions are extremely elementary. The accompanying diagrams should be helpful in creating a fair mental picture of these entities.
