1 Basic concepts of anatomy

Objectives

In this chapter you will learn to:

- Describe the anatomical position.
- Describe the anatomical planes.
- Define the anatomical terms used in anatomy and clinical practice.
- Describe the terms of movement, including those of the thumb.
- Understand the structure of bone.
- List the factors that contribute to joint stability.
- Describe the classification of muscles according to their actions.
- Describe the organization and function of muscle.
- Draw a diagram of the components of a spinal nerve.
- Describe the layers of a blood vessel wall.
- Describe factors causing lymphatic fluid movement and functions of lymph.
- Outline the layout of the gastrointestinal system and general functions.
- Outline the layout of the urinary system and general functions.

DESCRIPTIVE ANATOMICAL TERMS

The anatomical position

This is a standard position used in anatomy and clinical medicine to allow accurate and consistent description of one body part in relation to another (Fig. 1.1):

- The head is directed forwards with eyes looking into the distance.
- The body is upright, legs together, and directed forwards.
- The palms are turned forward, with the thumbs laterally.

Anatomical planes

These comprise the following (Fig. 1.2):

- The median sagittal plane is the vertical plane passing through the midline of the body from the front to the back. Any plane parallel to this is termed paramedian or sagittal.
- Coronal (or frontal) planes are vertical planes perpendicular to the sagittal planes.
- Horizontal or transverse planes lie at right angles to both the sagittal and coronal planes.

Such anatomical planes are frequently used in computer tomography (CT) scans and magnetic resonance imaging (MRI), to visualize muscle, bone, lung and other soft tissues as well as pathologies, for example pancreatic cancer or a brain abscess.

Terms of position

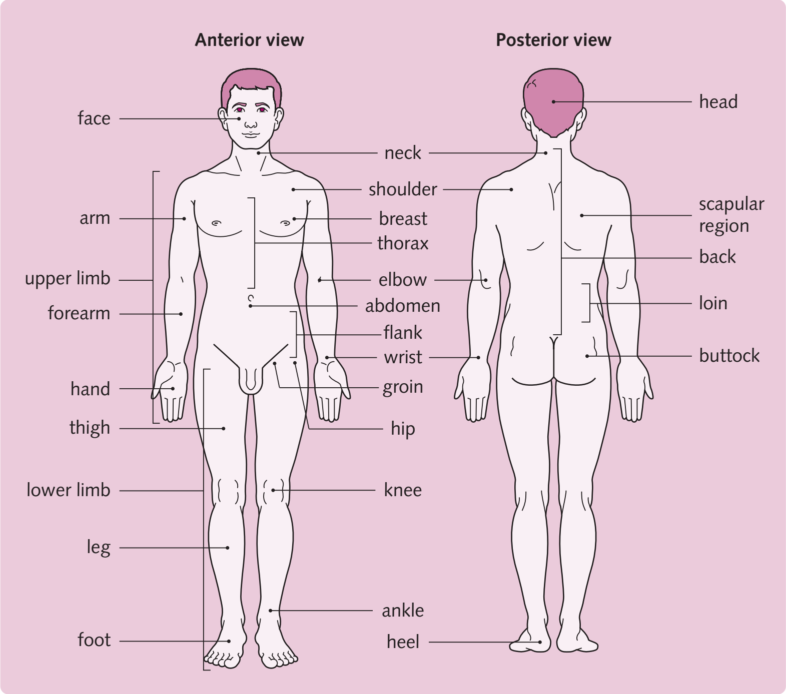
The terms of position commonly used in clinical practice and anatomy are illustrated in Figure 1.3.

Terms of movement

Various terms are used to describe movements of the body (Fig. 1.4):

- Flexion—forward movement in a sagittal plane which in general reduces the angle at the joint, e.g. bending the elbow. Exceptions are at the ankle joint (when the angle is increased) and the shoulder joint (when the angle between the upper limb and trunk is increased).
- Extension—backward movement in a sagittal plane which in general increases the angle at joints except at the ankle joint (when the angle is decreased) and the knee joint due to lower limb rotation during embryonic development.

Fig. 1.1 Anatomical position and regions of the body.



- Abduction—movement away from the median plane.
- Adduction—movement towards the median plane.
- Supination—lateral rotation of the forearm, causing the palm to face anteriorly.
- Pronation—medial rotation of the forearm, causing the palm to face posteriorly.
- Eversion—turning the sole of the foot outwards.
- Inversion—turning the sole of the foot inwards.
- Rotation—movement of part of the body around its long axis.
- Circumduction—a combination of flexion, extension, abduction, and adduction.

The terms used to describe movements of the thumb are perpendicular to the movements of the body, e.g. flexion of the thumb is at 90° to that of flexion of the fingers (Fig. 1.5).

To differentiate supination from pronation remember that you hold a bowl of soup with a supinated forearm.

BASIC STRUCTURES OF ANATOMY

Skin

The skin completely covers the body surface and is the largest organ of the body. The functions of the skin include:

- Protection from ultraviolet light and mechanical, chemical, and thermal insults.
- Sensations including pain, temperature, touch and pressure.
- Thermoregulation.
- Metabolic functions, e.g. vitamin D synthesis.

The skin is composed of the following (Fig. 1.6):

- The epidermis forms a protective waterproof barrier. It consists of keratinized stratified squamous epithelium, which is continuously being shed and replaced. It is avascular.
- The dermis supports the epidermis and it has a rich network of vessels and nerves. It is composed mainly of collagen fibres with elastic fibres giving the skin its elasticity.
- The hypodermis or superficial fascia. It consists of fatty tissue which provides thermal insulation and protection for underlying structures.

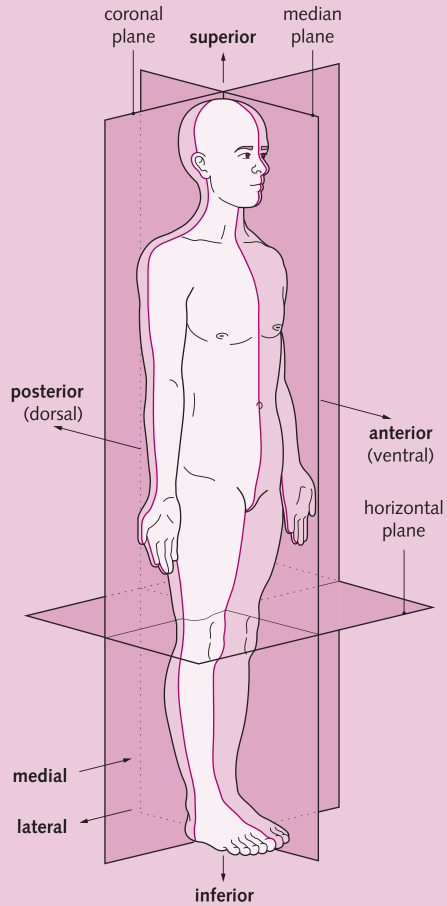


Fig. 1.2 Anatomical planes.

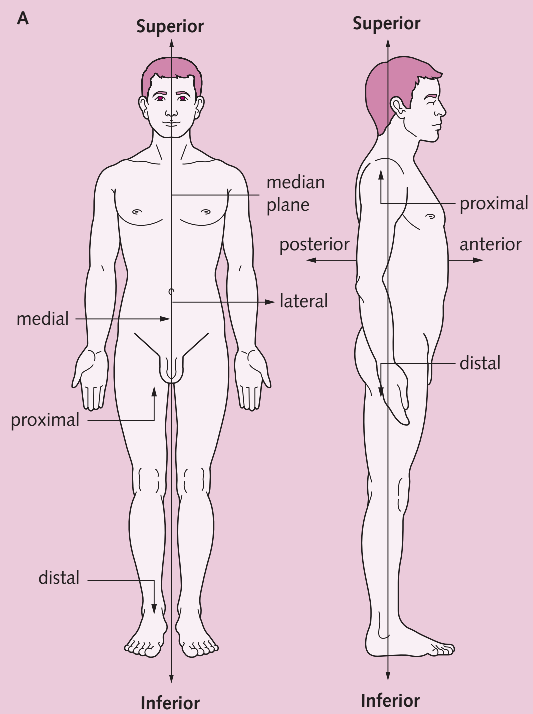


Fig. 1.3 Relationship and comparison (A) and classification (B) of terms of position commonly used in anatomy and clinical practice.

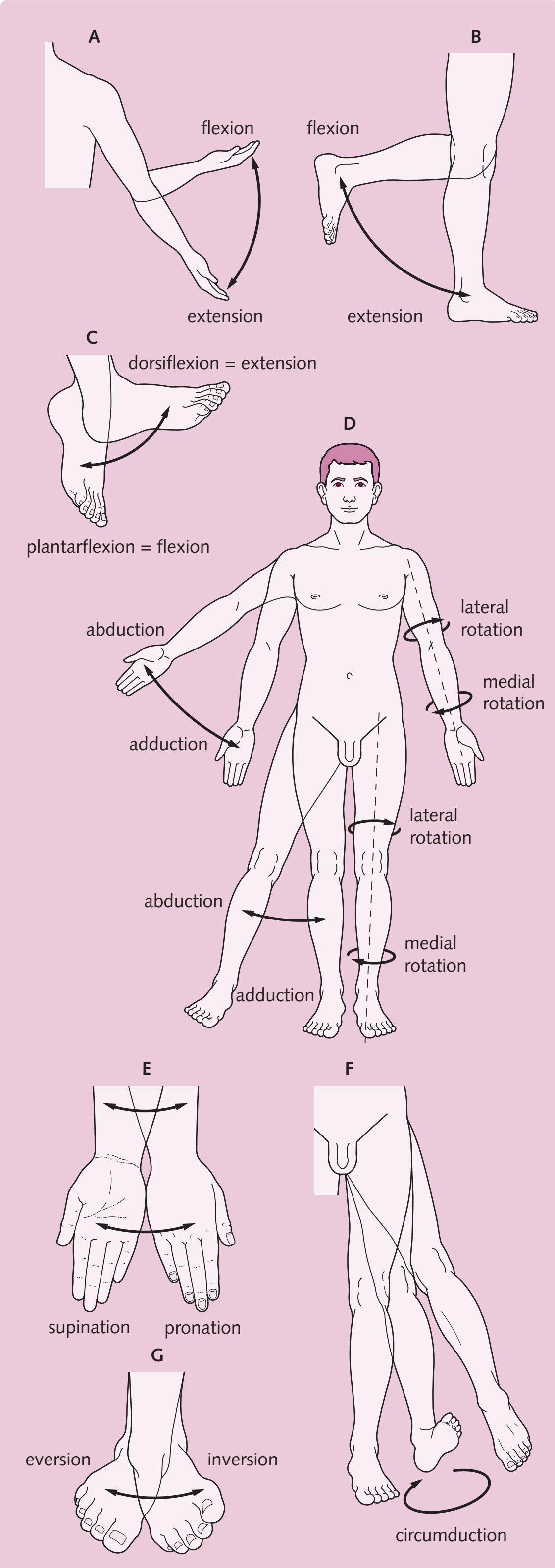
Position	Description
Anterior	In front of another structure
Posterior	Behind another structure
Superior	Above another structure
Inferior	Below another structure
Deep	Further away from body surface
Superficial	Closer to body surface
Medial	Closer to median plane
Lateral	Further away from median plane
Proximal	Closer to the trunk or origin
Distal	Further away from the trunk or origin
Ipsilateral	The same side of the body
Contralateral	The opposite side of the body

Dermatology

A genetic mutation in collagen synthesis affects the protein's function. Dermal collagen is normally resistant to stretch, preventing excessive elasticity. However, this is lost in Ehlers–Danlos syndrome where individuals have very elastic skin as well as other features due to collagen in joints (are hyperextendable) or heart valves (mitral valve regurgitation).

The skin appendages include:

- Hairs—highly modified, keratinized structures.
- Sweat glands—produce sweat, which plays a role in thermoregulation.
- Sebaceous glands—produce sebum, which lubricates the skin and hair.



- Nails—highly specialized appendages found on the dorsal surface of each digit.

Fascia

The fascia of the body may be divided into superficial and deep layers.

The superficial fascia (subcutaneous fatty tissue) consists of loose areolar tissue that unites the dermis to the deep fascia. It contains cutaneous nerves, blood vessels and lymphatics that supply to the dermis. Its thickness varies at different sites within the body and women have a thicker layer than men.

In some places sheets of muscle lie in the fascia, e.g. muscles of facial expression.

The deep fascia forms a layer of fibrous tissue around the limbs and body and the deep structures. Intermuscular septa extend from the deep fascia, attach to bone, and divide limb musculature into compartments. The fascia has a rich nerve supply and it is, therefore, very sensitive. The thickness of the fascia varies widely: e.g. it is thickened in the iliotibial tract but very thin over the rectus abdominis muscle and absent over the face. The arrangement of the fascia determines the pattern of spread of infection as well as blood due to haemorrhaging into tissues.

Bone

Bone is a specialized form of connective tissue with a mineralized extracellular component.

The functions of bone include:

- Locomotion (by serving as a rigid lever).
- Support (giving soft tissue permanent shape).
- Attachment of muscles.
- Calcium homeostasis and storage of other inorganic ions.
- Production of blood cells (haematopoiesis).

Fig. 1.4 Terms of movement.

(A) Flexion and extension of forearm at elbow joint.
(B) Flexion and extension of leg at knee joint.
(C) Dorsiflexion and plantarflexion of foot at ankle joint.
(D) Abduction and adduction of right limbs and rotation of left limbs at shoulder and hip joints, respectively.
(E) Pronation and supination of forearm at radioulnar joints.
(F) Circumduction (circular movement) of lower limb at hip joint.
(G) Inversion and eversion of foot at subtalar and transverse tarsal joints.

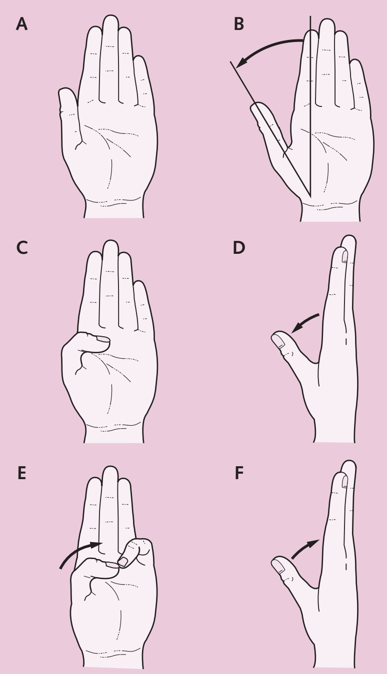


Fig. 1.5 Terms of movement for the thumb. (Adapted from *Crash Course: Musculoskeletal System* by SV Biswas and R Iqbal. Mosby.)

(A) Neutral hand position.
(B) Extension (radial abduction).
(C) Flexion (transpalmar adduction).
(D) Abduction (palmar abduction).
(E) Opposition.
(F) Adduction.

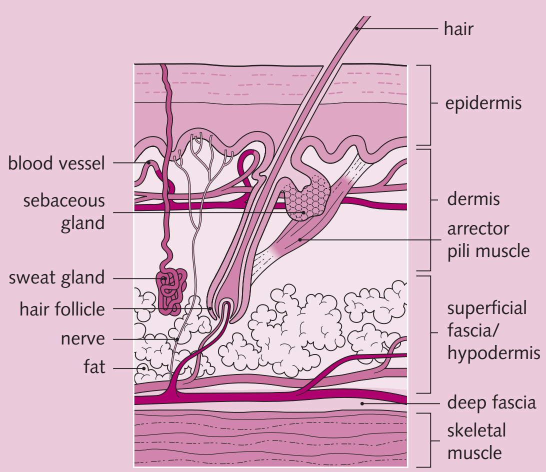


Fig. 1.6 Structure of skin and subcutaneous tissue.

Classification of bone

Bones are classified according to their position and shape.

The position can be described as:

- Axial skeleton, consists of the skull, vertebral column including the sacrum, ribs, and sternum.
- Appendicular skeleton, consists of the pelvic girdle, pectoral girdle, and bones of the upper and lower limbs.

Types of shape include:

- Long bones, e.g. femur, humerus.
- Short bones, e.g. carpal bones.
- Flat bones, e.g. skull vault.
- Irregular bones, e.g. vertebrae.

General structure of bone

Bone is surrounded by a connective tissue membrane called the periosteum (Fig. 1.7). This is continuous with muscle attachments, joint capsules and the

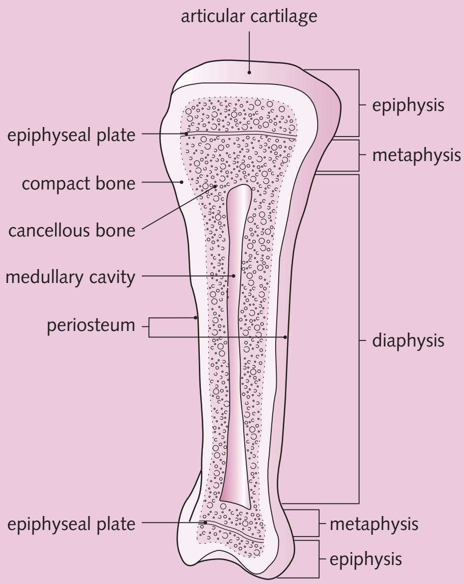


Fig. 1.7 Long bone and its components.

deep fascia. There is an outer fibrous layer and an inner cellular layer. The inner layer is vascular, and it provides the underlying bone with nutrition. The periosteum is an osteogenic layer consisting of osteoproginator cells that can differentiate into osteoblasts, e.g. at a fracture site and cause formation of a bone cuff (callus) which stabilizes the fracture.

Bone includes the following components:

- The outer compact layer or cortical bone provides great strength and rigidity.
- The cancellous or spongy bone consists of a network of trabeculae arranged to resist external forces.
- The medullary cavity of long bones and the interstices of cancellous bone are filled with bone marrow. At birth virtually all the bone marrow is red (haematopoietic), but this is replaced by yellow (fatty) marrow—only the ribs, sternum, vertebrae, clavicle, pelvis, and skull bones contain red marrow in adult life.
- The endosteum is a single layer of osteogenic cells lining the inner surface of bone.

Orthopaedics

As an individual ages their bone density is reduced (osteopenia). The cortical bone becomes thinner and the trabeculae decrease in number. As a result, bone structure is weaker and predisposes to fractures, especially in osteoporotic postmenopausal women. Fractures tend to occur where, in normality, there is a greater amount of trabecular bone to cortical bone, e.g. radius (Colles fracture), femoral neck and vertebral body. Fractures occurring secondary to another process, e.g. osteoporosis, are known as pathological fractures.

Blood supply of bones

There are two main sources of blood supply to bone:

- A major nutrient artery that supplies the marrow.
- Vessels from the periosteum.

The periosteal supply to bone assumes greater importance in the elderly. Extensive stripping of the periosteum, e.g. during surgery or following trauma, may result in bone death.

Joints

These are unions between bones of which there are three major types (Fig. 1.8).

Synovial joints

These are moveable joints and have the following features:

- The bone ends are covered by hyaline articular cartilage.
- The joint is surrounded by a fibrous capsule.
- A synovial membrane lines the inner aspect of the joint and its capsule, except where there is cartilage and it secretes synovial fluid. This lubricates the joint and transports nutrients, especially to the cartilage.
- Some synovial joints, e.g. the temporomandibular joints, are divided into two cavities by an articular disc.

Blood supply of joints

A vascular plexus around the epiphysis provides the joint with a very good blood supply.

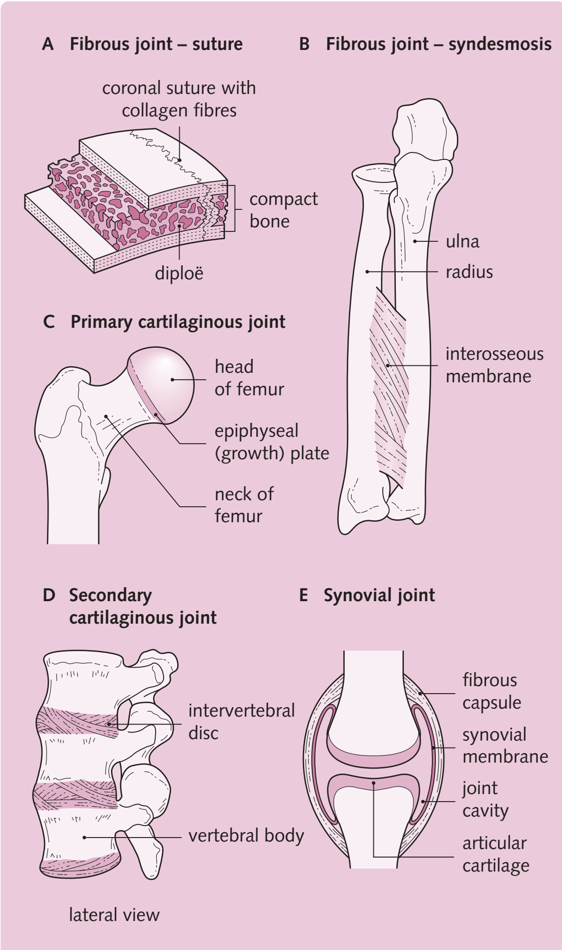


Fig. 1.8 Types of joints.

(A) Fibrous joint—sutural (bones are united by fibrous tissue, as in sutures of the skull).
(B) Fibrous joint—syndesmosis (bones are joined by a sheet of fibrous tissue).
(C) Primary cartilaginous joint (where bone and hyaline cartilage meet).
(D) Secondary cartilaginous joint (articular surfaces are covered by a thin lamina of hyaline cartilage; the hyaline laminae are united by fibrocartilage).
(E) Synovial joint.

Nerve supply of joints

According to Hilton's law, the motor nerve to a muscle tends also to give a sensory branch to the joint that the muscle moves and another branch to the skin over the joint. The capsule and ligaments are supplied by afferent nerve endings, including pain fibres. Innervation of a joint and the muscles that move that joint allow proprioception to occur. This is the sensation of joint position and it is necessary for motor control and posture.

Stability of joints

Stability is achieved by the following components:

- Bony—e.g. in a firm ball-and-socket joint such as the hip joint, bony contours contribute to stability.
- Ligaments—these are important in most joints, and they act mainly to prevent excessive movement.
- Muscles—these are an important stabilizing factor in most joints.

Muscles and tendons

Skeletal muscles are aggregations of contractile fibres that move the joints of the skeleton.

Muscles are usually joined to bone by tendons at their origin and insertion.

Muscle action

Muscles can be classified according to their action:

- Prime mover—the muscle is the major muscle responsible for a particular movement, e.g. brachialis is the prime mover in flexing the elbow.
- Antagonist—any muscle that opposes the action of the prime mover: as the primer mover contracts the antagonist relaxes, e.g. triceps brachii relaxes during elbow flexion.
- Fixator—prime mover and antagonist acting together to 'fix' a joint, e.g. muscles holding the scapula steady when deltoid moves the humerus.
- Synergist—prevents unwanted movement in an intermediate joint, e.g. extensors of the carpus contract to fix the wrist joint, allowing the long flexors of the fingers to function effectively.

In general, if a joint is very stable it has a reduced range of movement, e.g. the stable hip joint compared with the less stable shoulder joint; the latter has a greater range of movement.

Muscle design

Muscle fibres may be either parallel or oblique to the line of pull of the whole muscle.

Parallel fibres allow maximal range of movement. These muscles may be quadrangular, fusiform, or strap shaped, e.g. sartorius and sternocleidomastoid.

Oblique fibres increase the force generated at the expense of a reduced range of movement. These muscles may be unipennate (e.g. flexor pollicis longus), bipennate (e.g. dorsal interossei), multipennate (e.g. deltoid) or triangular (e.g. deltoid).

Muscle organization and function

Motor nerves control the contraction of skeletal muscle. Each motor neuron together with the muscle fibres it supplies constitutes a motor unit.

The size of motor units varies considerably: where fine precise movements are required, a single neuron may supply only a few muscle fibres, e.g. the extrinsic eye muscles; conversely, in the large gluteus maximus muscle, a single neuron may supply several hundred muscle fibres. The smaller the size of the motor unit, the more precise are the possible movements. If powerful contractions are required then larger motor units are recruited (activated) which cause contraction of larger muscles.

Clinical examination

During a neurological and musculoskeletal examination muscle power is assessed by asking the patient to perform movements against resistance, e.g. asking the patient to flex the elbow while the examiner tries to prevent this by holding the wrist and supporting the patient's elbow. The power is graded (5 to 0) by the UK Medical Research Council (MRC) scale:

Grade 5: Full power
Grade 4: Contraction against resistance
Grade 3: Contraction against gravity
Grade 2: Contraction with gravity eliminated
Grade 1: Flicker of muscle contraction
Grade 0: No muscle contraction

Muscle weakness is seen in myasthenia gravis when autoantibodies are produced that attack the receptors on the neuromuscular junction (NMJ). Rapid repeated movements cause muscle fatigue.

The force generated by a skeletal muscle is related to the cross-sectional area of its fibres. For a fixed volume of muscle, shorter fibres produce more force but less shortening.

In muscles, there is an optimum length of muscle filaments, which produces optimum tension and contraction. Optimum tension is reduced if the muscle becomes stretched beyond this length or is compressed. This is a property of the muscle length–tension relationship.

Muscle attachments

The ends of muscles are attached to bone, cartilage and ligaments by tendons. Some flat muscles are attached by a flattened tendon, an aponeurosis or fascia.

When symmetrical halves of a muscle fuse to form a seam like intersection, e.g. in mylohyoid muscle, a raphe is formed.

When tendons cross joints they are often enclosed and protected by a synovial sheath, a layer of connective tissue lined by a synovial membrane and lubricated by synovial fluid.

Bursae are sacs of connective tissue filled with synovial fluid, which lie between tendons and bony areas, acting as cushioning devices.

Nerves

The nervous system is divided into the central nervous system and the peripheral nervous system: the central nervous system is composed of the brain and spinal cord; the peripheral nervous system consists of the cranial and spinal nerves, and their distribution. The nervous system may also be divided into the somatic and autonomic nervous systems.

The conducting cells of the nervous system are termed neurons. A typical motor neuron consists of a cell body which contains the nucleus and gives off a single axon and numerous dendrites (Fig. 1.9). The cell bodies of most neurons are located within the central nervous system, where they aggregate to form nuclei. Cell bodies in the peripheral nervous system aggregate in ganglia.

Axons are nerve fibres that conduct action potentials generated in the cell body to influence other neurons or affect organs. They may be myelinated or non-myelinated.

Most nerves in the peripheral nervous system are bundles of motor, sensory and autonomic axons. The head is largely supplied by the 12 cranial nerves. The

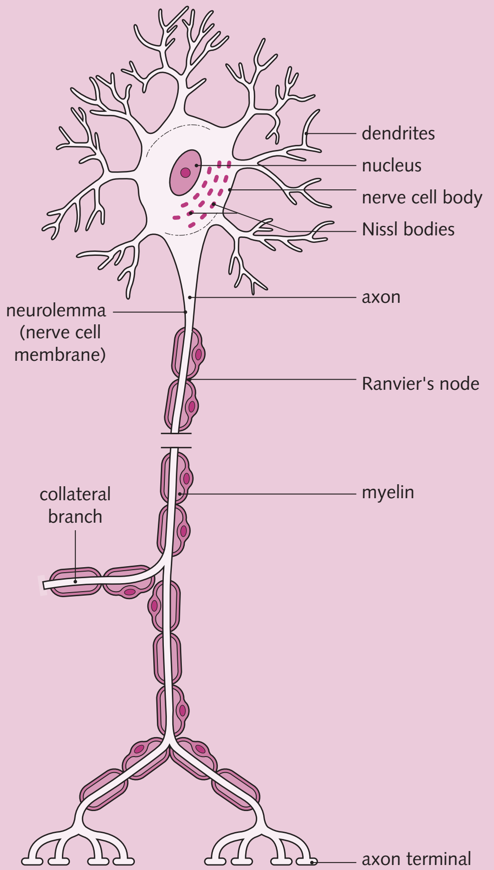


Fig. 1.9 Structure of a typical neuron.

trunk and the limbs are supplied by the segmental spinal nerves.

Motor nerves originate in the ventral (anterior) horn of the spinal cord (Fig. 1.10) and synapse with the sarcolemma (plasma membrane) of muscle to form a structure called the motor endplate. A nerve impulse reaches the end of the nerve fibre causing the release of neurotransmitter. This leads to depolarization of the sarcolemma and initiation of muscle contraction.

Sensory nerves carry impulses from receptors in skin, muscle or viscera to the dorsal (posterior) horn of the spinal cord. Receptors respond to specific stimuli, e.g. stretch, noxious substances or pressure. Sensory neurons synapse with neurons, which ascend in the spinal cord and travel to higher centres, e.g. cerebral cortex or cerebellum. They also synapse with motor neurons directly or via an interneuron. This is

Clinical examination/neurology

When testing reflexes the reflex arc is being assessed at a particular spinal cord level. On striking a tendon with a hammer it stretches the tendon and a receptor within the muscle (a muscle spindle). This receptor monitors muscle length and prevents over-stretching by initiating a reflex arc and causing muscle contraction to counter the stretching. This is witnessed as a jerk of the limb; for example, on striking the patella tendon the quadriceps muscle contracts, causing knee extension. The common limb reflexes and their spinal cord segment levels, which are tested, are:

- Biceps brachii (C5–6)
- Triceps brachii (C7–8)
- Brachioradialis (C6–7)
- Quadriceps femoris (L3–4)
- Gastrocnemius (S1–2)

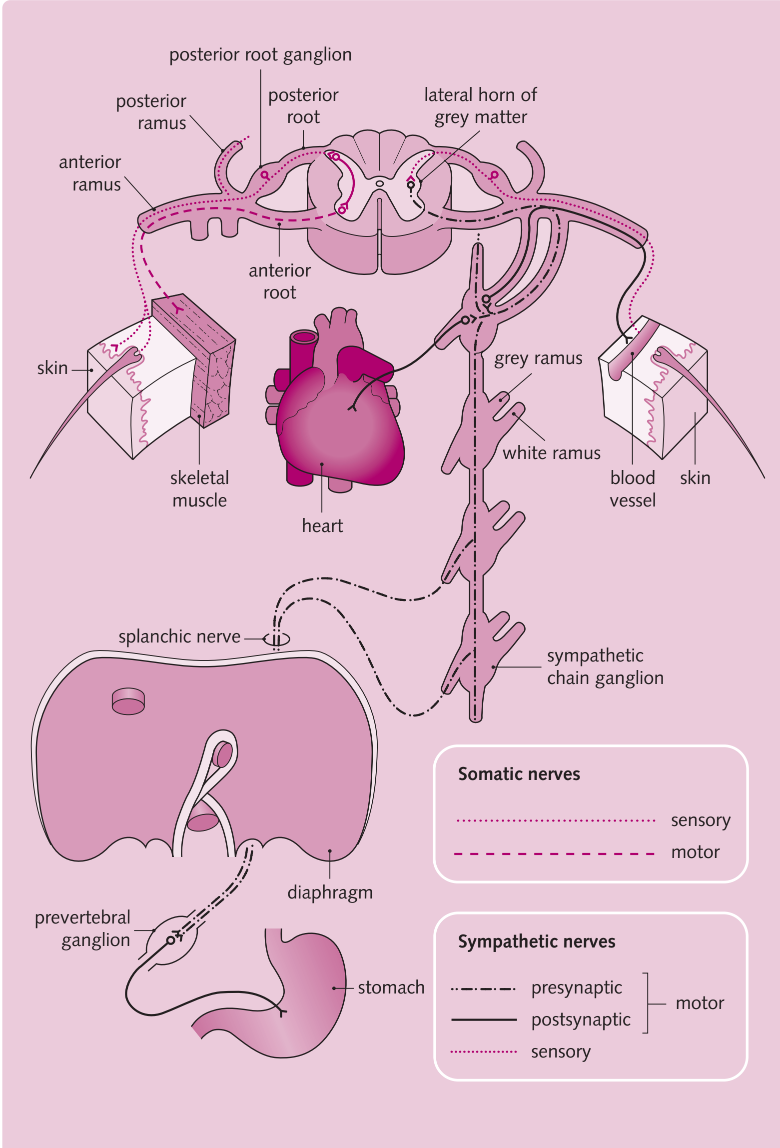
the structural basis of a reflex arc (Fig. 1.10). The reflex arc is an involuntary protective mechanism that occurs unconsciously although higher centres can influence its activity, i.e. increase or decrease activity. In a stroke the inhibitory input of higher centres that dampens the reflex arc activity is lost and hyperreflexia (exaggerated limb reflexes) occurs.

Autonomic nerves are either sympathetic or parasympathetic. Sympathetic preganglionic fibres arise from the thoracic and upper two lumbar segments of the spinal cord. The preganglionic fibres synapse in a ganglion of the sympathetic chain which runs either side of the vertebral column. The postganglionic fibres that arise from the sympathetic chain ganglia can either enter a spinal nerve to supply the limbs or body wall. Some preganglionic fibres do not synapse in the sympathetic chain. Instead they pass through the chain and synapse in a prevertebral ganglion, e.g. coeliac ganglion. Postganglionic fibres arise from prevertebral ganglia and supply viscera, e.g. stomach. Parasympathetic preganglionic fibres arise from cranial nerves and sacral nerves (S2–S4). They synapse in ganglia associated with organs, e.g. a pulmonary ganglion, to form postganglionic fibres that innervate an organ, e.g. lung.

Spinal nerves

There are 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and the coccygeal nerve.

Fig. 1.10 Components of a typical spinal nerve.



The spinal cord ends at the lower border of the first lumbar vertebra in the adult. Below this, the nerve roots of the cord form a vertical bundle: the cauda equina.

Each spinal nerve is formed by the union of the anterior and posterior roots (Fig. 1.10):

- The anterior root contains motor fibres for skeletal muscles. Those from T1 to L2 also contain preganglionic sympathetic fibres; S2 to S4 also contain preganglionic parasympathetic fibres.
- The posterior root contains sensory fibres whose cell bodies are in the posterior root ganglion.

Immediately after formation, the spinal nerve divides into anterior and posterior rami. The great nerve plexuses, e.g. the brachial, lumbar and sacral, are formed by anterior rami. The posterior rami supply the erector spinae muscles and skin that cover them.

The spinal nerves each supply an area of skin called a dermatome (except the face, which is supplied by the fifth cranial nerve). The nerve supply of each dermatome overlaps above and below with adjacent dermatomes. Testing for loss of sensation over a dermatome indicates the level of a lesion within the spinal cord. Dermatomes of the limbs and trunk are illustrated in the relevant chapters.

Cardiovascular system

The cardiovascular system functions principally to transport oxygen and nutrients to the tissues and carbon dioxide and other metabolic waste products away from the tissues.

The right side of the heart pumps blood to the lungs via the pulmonary circulation. The left side of the heart pumps oxygenated blood through the aorta to the rest of the body via the systemic circulation (Fig. 1.11A).

Blood is distributed to the organs via the arteries and then arterioles, which branch to form capillaries where gaseous exchange occurs. Deoxygenated blood is eventually returned to the heart first by venules then by veins (Fig. 1.11A). Valves in the low-pressure venous system are required to prevent back-flow of blood. However, some veins have no true valves, e.g. venae cavae, vertebral, pelvic, head and neck veins.

The general structure of the blood vessel wall consists of three layers or tunicas (Fig. 1.11B). The contents of each vary with vessel type and its function. Arteries have a well-developed tunica media of smooth muscle. The walls of the largest arteries contain numerous elastic tissue layers; however, veins have relatively little smooth muscle and elastic tissue. Capillaries consist of an endothelial tube.

The larger vessels, e.g. aorta, also contain an additional external layer of blood vessels (vasa

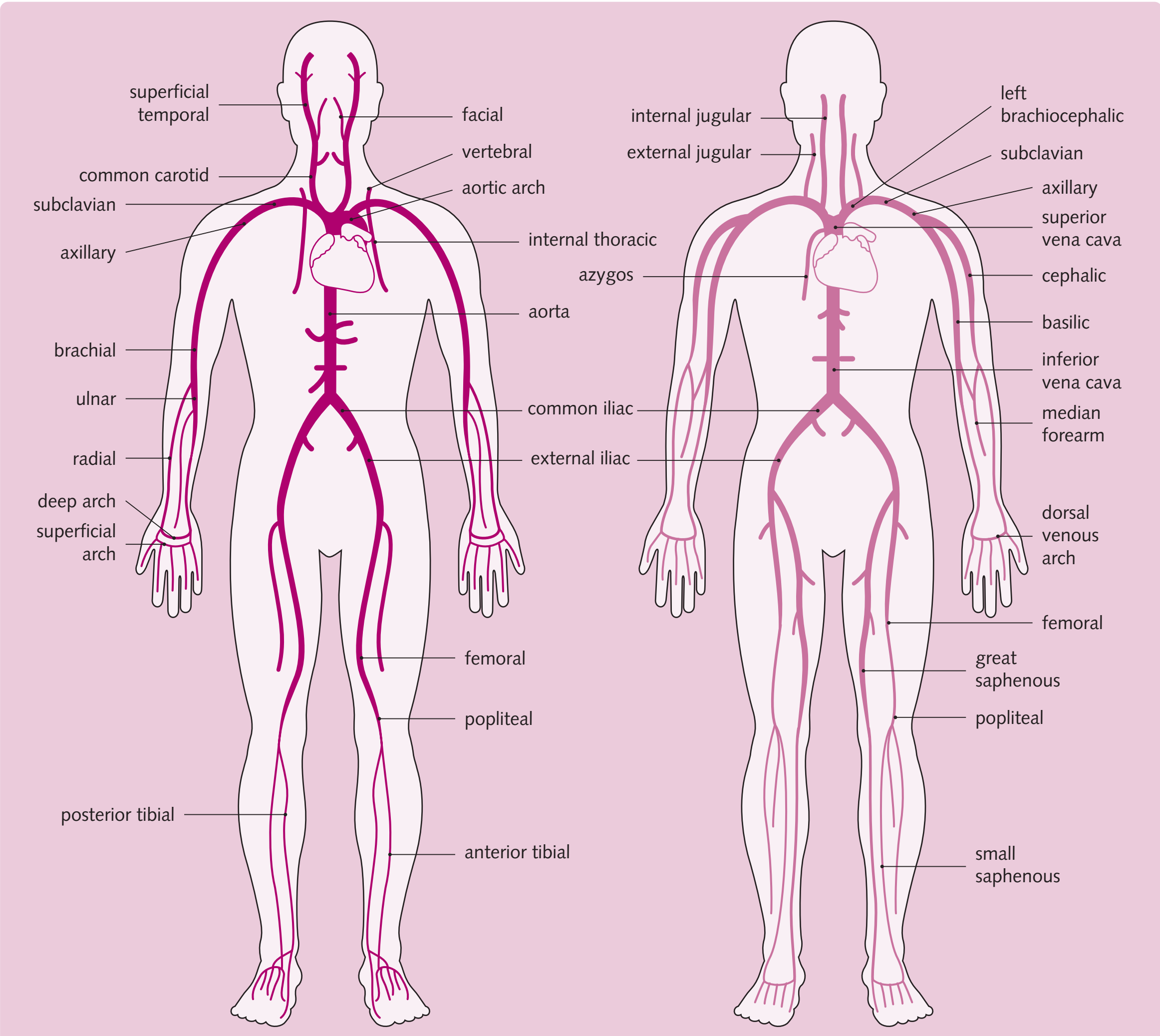
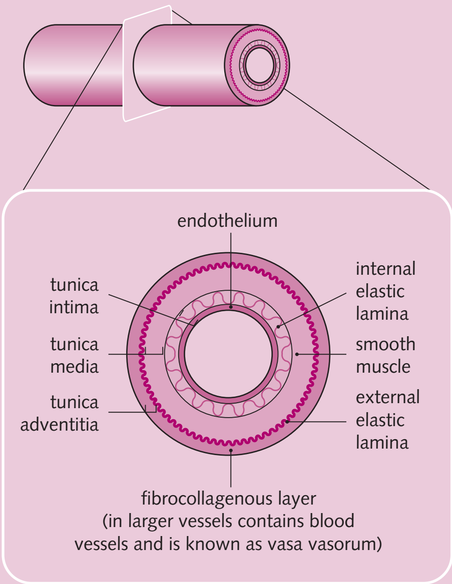


Fig. 1.11(A) The arterial tree (A) and venous tree (B) of the cardiovascular system.

Fig. 1.11(C) Cross section of vessel wall showing basic layers.



vasorum) and nerves (vasa nervosa) that supplies the wall.

Anastomosis

Not all blood traverses a capillary bed. Direct connections (anastomoses) between arterioles and venules (arteriovenous shunts) exist. Pre-capillary sphincters regulate flow through the capillary bed under sympathetic nerve control. In the skin such shunts are involved in thermoregulation. Capillary beds can be opened up or closed off depending on metabolic requirements, e.g. during exercise.

Direct communication between larger vessels can be advantageous. If an artery becomes occluded anastomoses maintain the circulation to an organ. When an artery is slowly occluded by disease, new vessels may develop (collaterals), forming an alternative pathway, e.g. coronary arteries.

When such communications are absent (e.g. the central artery of the retina) between arteries the vessel is known as an end artery. Occlusion in these vessels causes necrosis.

Lymphatics

Figure 1.12 illustrates the lymphatic system in man.

Fluid moves out of capillaries into tissues at the arterial end due to hydrostatic pressure, which is created by blood pressure. At the venous end of the capillary oncotic pressure acts to draw fluid back into the vessel. Oncotic pressure is created by proteins, e.g. albumin and cations (sodium ions). However, not all fluid is returned to the blood and excess within the tissues drains into the lymphatic system. Movement of lymphatic fluid through the vessels is the result of (i) muscle contraction, (ii) pulsation of an adjacent artery, (iii) a suction action by the negative intrathoracic pressure, and (iv) pressure within the lymphatic vessels.

The lymphatics on the right side of the head, neck, upper limb and thorax drain into the right lymphatic duct which enters the venous circulation at the junction of the right subclavian and right internal jugular veins. The rest of the body drains into the thoracic duct, which enters the venous circulation at the junction of the left subclavian and left internal jugular veins (Fig. 1.12).

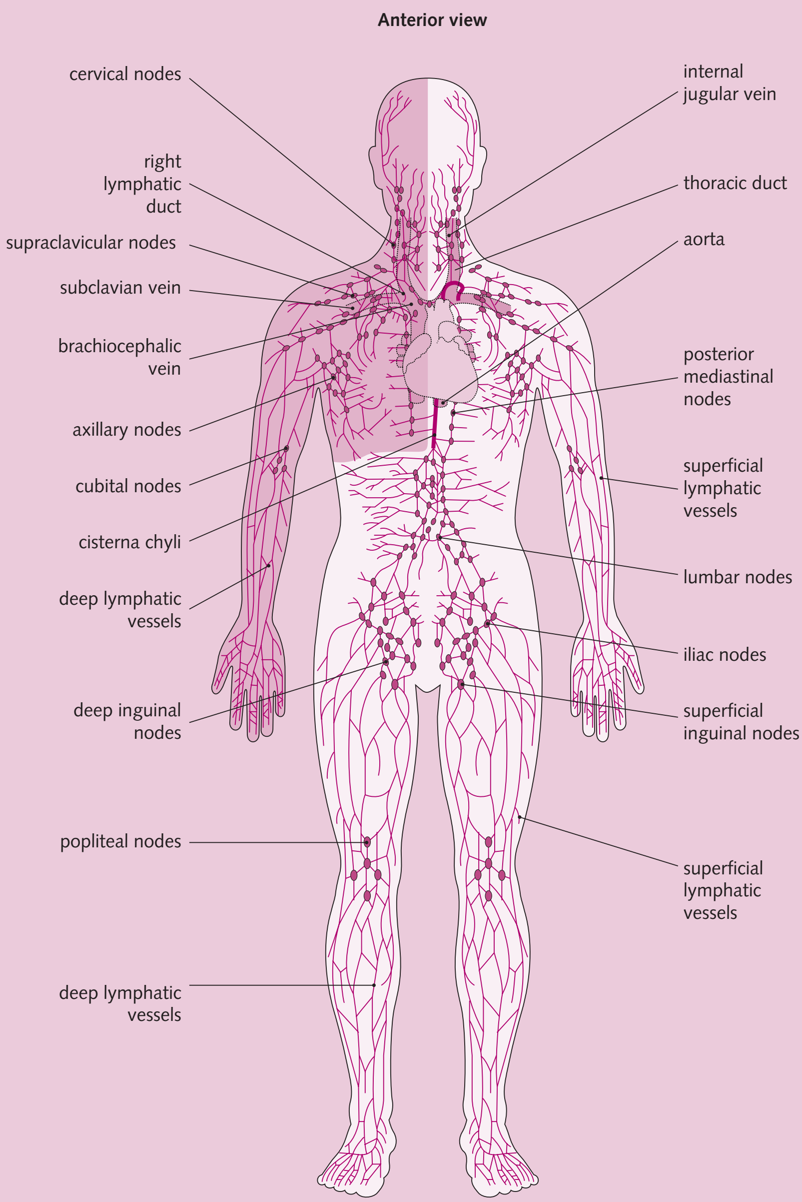


Fig. 1.12 The lymphatic system (shaded area drains into the right lymphatic duct; unshaded area drains into the thoracic duct).

Lymph carries foreign material (not recognized as self), which may be presented by special cells in the lymph nodes (antigen-presenting cells) to cells of the immune system to mount an immune response. The lymphatics also are involved in the absorption and transport of fats. Lacteals (end lymphatic vessels) of the intestinal villi contain chyle (a milky lymph fluid), which drains into larger lymphatic vessels and eventually into the thoracic duct.

Lymphatics are found in all tissues except the central nervous system, eyeball, internal ear, cartilage, bone, and the epidermis of the skin.

Oncology

Lymphatic drainage of organs provides one of the routes by which a cancer can spread to other anatomical sites (metastasis). In breast carcinoma, metastasis can be to the lymph nodes of the armpit (axilla), or in gastric carcinoma spread can be to the left supraclavicular nodes only and this is known as Troissier's sign.

Gastrointestinal system

The gastrointestinal system has three functions:

- Digestion of food material starting with mastication and continuing in stomach and duodenum.
- Absorption of the products of digestion in the small intestine.
- Absorption of fluid and formation of solid faeces in the large intestine.

The process of digestion begins in the mouth with enzyme secretion by the salivary glands and chewing (mastication). In the stomach, acid and enzyme secretion continue the process; then, in the second part of the duodenum, pancreatic enzymes, along with bile from the liver, complete this process. The majority of absorption occurs in the jejunum, which has an increased surface area due to plicae circularis (folds), villi (finger-like projections) and microvilli (microscopic projections on individual cells). Carbohydrates and proteins enter the portal circulation (see below) via the intestinal villi capillaries and fats enter the lacteals of the lymphatic system.

The portal circulation is a circulation consisting of two capillary beds. Capillaries originating in the intestine enter veins that eventually drain into the hepatic portal vein and this drains into the liver capillaries (sinusoids). Hepatic veins drain blood from the liver into the systemic circulation and it returns to the heart. The portal vein also receives tributaries from the stomach, spleen and pancreas. There are anastomoses with the systemic venous circulation at the gastro-oesophageal and recto-anal junctions (portosystemic anastomoses).

The general structure of the gastrointestinal tract wall is illustrated in Figure 1.13. Modifications to this denote its underlying function, e.g. there are more folds and villi in the jejunum than in the ileum or colon.

Respiratory system

The upper part of the respiratory tract, consisting of the nasal and oral cavities, pharynx, larynx and trachea, is responsible for conditioning the air by (i) humidifying and warming e.g. blood vessels in the nasal cavity, and on conchae that increase the surface area avaliable, (ii) trapping of foreign material e.g. hair in the nasal vestibule and mucus secretion. The lower respiratory tract consists of a series of branching tubes that form the bronchial tree (see Chapter 3), which ends in the alveolar sacs where gaseous exchange occurs.

The general structure of the respiratory tree wall changes with function, e.g. the bronchi walls contain cartilage whereas the bronchioles lack cartilage. The alveoli consist of a sphere of epithelium surrounded by a network of capillaries.

Respiratory epithelium of the trachea, bronchi and bronchioles consists of cells which contain cilia (small hairs) that beat rhythmically and propel trapped foreign particles (within mucus) towards the pharynx. Moreover, the alveoli consist of thin epithelial cells (pneumocytes) which reduce the distance that gases have to diffuse across between it and the capillaries of the lung. This increases gaseous exchange efficiency.

The functions of the respiratory system include:

- Gaseous exchange.
- Metabolism and activation or inactivation of some proteins, e.g. angiotensin-converting enzyme.
- Acting as a reservoir for blood.
- Phonation (vocal sound production).
- Olfactory function.

Urinary system

The urinary system is composed of the kidneys, ureters, bladder and urethra (Fig. 1.14). The kidneys filter the blood at the glomerulus, and along the length of the nephron unit selective absorption and secretion occurs. The urine that is formed from these processes enters the renal pelvis and the ureters. The latter empty into the bladder, which stores urea until such time that it may be voided (micturation). The functions of the kidneys are:

- Excretion of waste products, e.g. urea (produced in the liver).
- Absorption of filtered substances, e.g. glucose, ions, proteins.

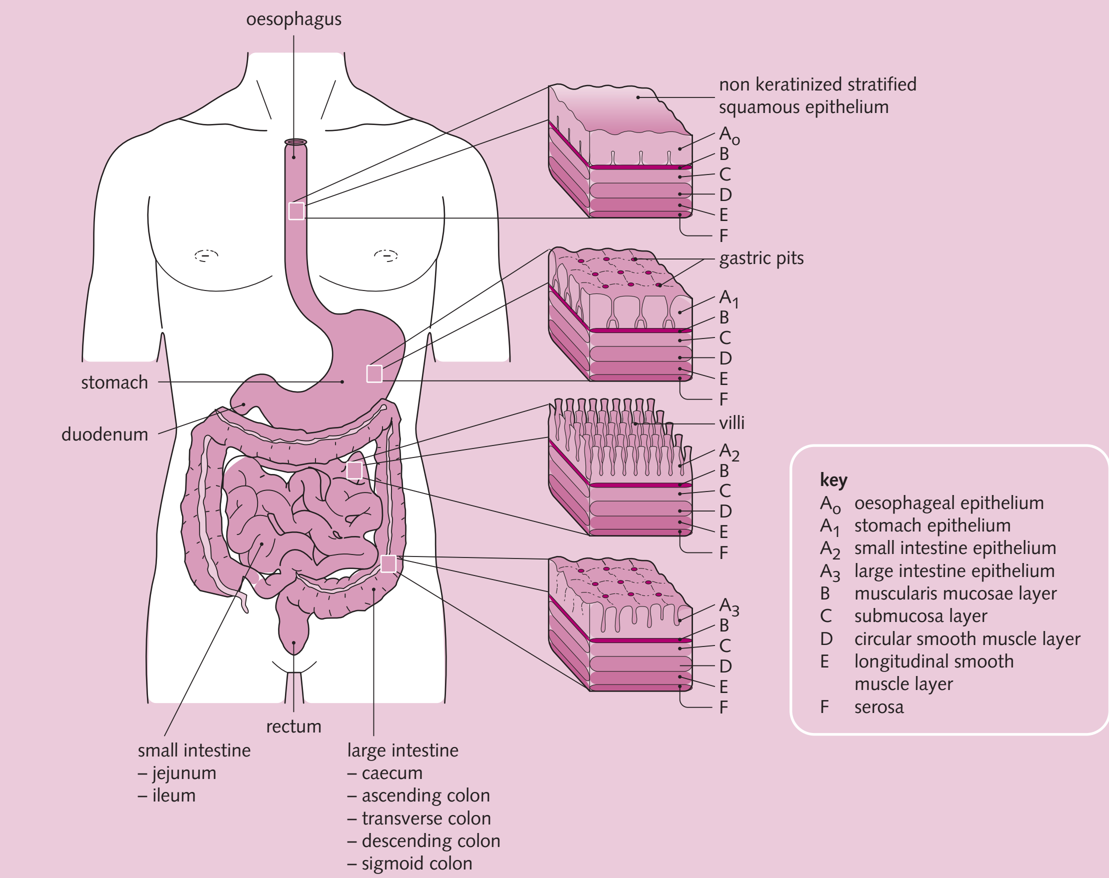


Fig. 1.13 The gastrointestinal system. The illustration shows the basic layers of the gastrointestinal tract wall with epithelial adaptions, which dictate function.

- Metabolism of vitamin D.
- Blood pressure and sodium regulation (renin secretion).
- Rate of red blood cell production, e.g. erythropoietin secretion.

The ureters and bladder have a muscular wall and are lined by urothelium (transitional epithelium). This is a specialized stratified epithelium allowing distension, especially of the bladder to accommodate large volumes of fluid.

RADIOLOGICAL ANATOMY

Introduction

The use of plain radiography is frequently requested to detect and aid the diagnosis of disease within the thorax, abdomen or in bones. Using contrast studies to distinguish adjacent structures of similar lucency on a film can enhance the clinical usefulness of this investigation, especially in the gastrointestinal tract to detect a perforation of the bowel wall or a lesion. A contrast study uses a substance, e.g. barium, which appears radio-opaque (white) on an X-ray film and allows internal anatomical structures not normally seen to be visualized. The contrast study can be single

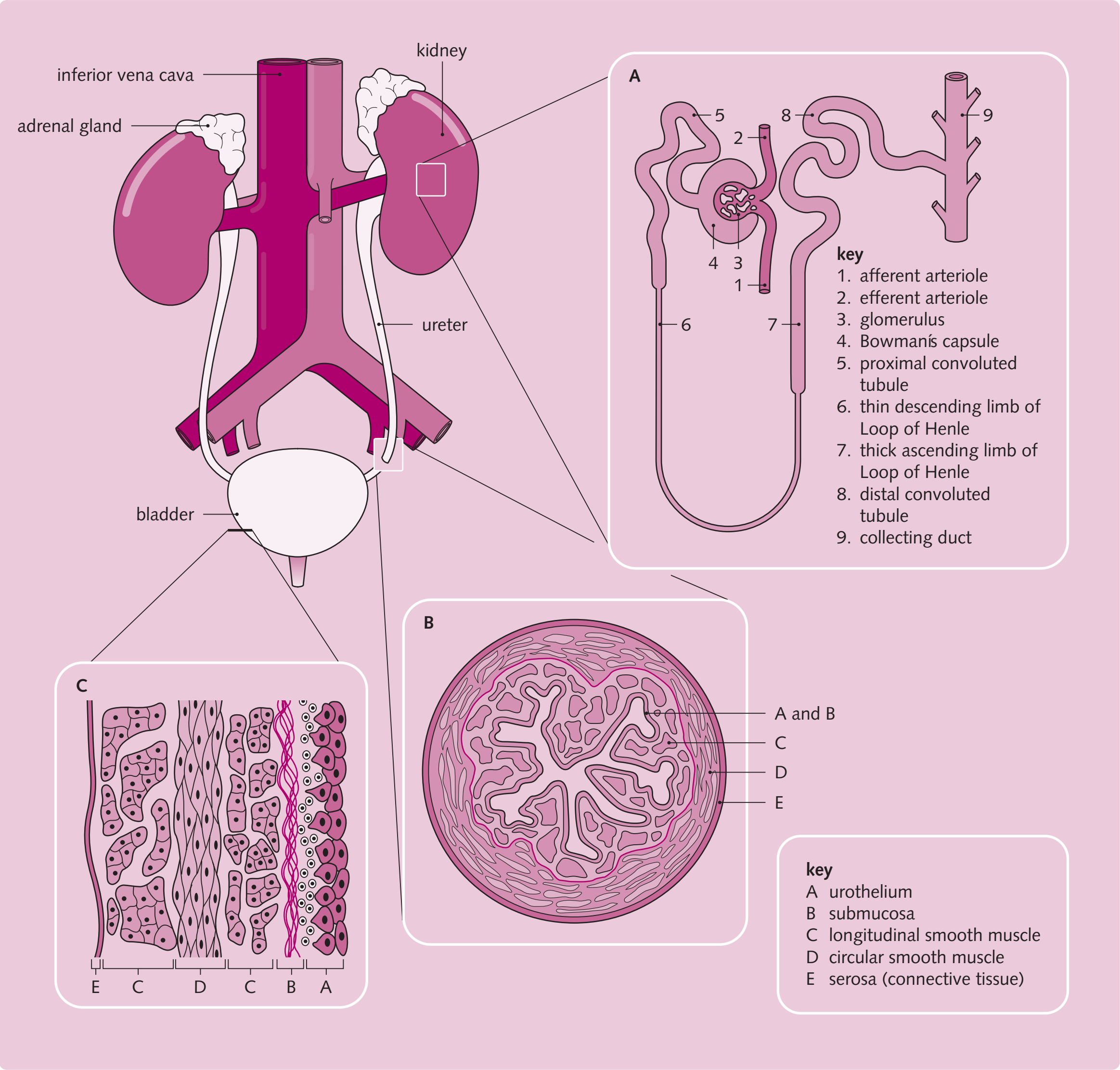


Fig. 1.14 Components of the urinary tract. Inset A shows the structure of a nephron, inset B shows the structure of the ureter and inset C shows the structure of the bladder wall.

(when only barium is used) or double when both barium and air are introduced into the intestines.

Angiography is a procedure in which a contrast medium is injected into an artery or vein via a percutaneous catheter. It is used to assess vascular disease such as atherosclerosis (fatty plaques) in the coronary arteries or an aneurysm (a balloon-like swelling) in the abdominal aorta.

The following chapters will introduce normal radiographic anatomical structures and give a method for reading X-rays because they will be presented to you not only in your anatomy studies but also in the clinical years. The pre-registration house officer will usually be expected to perform the initial interpretation of an X-ray.