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Cunningham's Manual of Practical Anatomy

VOLUME ONE
Upper and Lower Limbs

G. J. Romanes

Fourteenth Edition

low-priced edition

CUNNINGHAM'S MANUAL OF PRACTICAL ANATOMY

FOURTEENTH EDITION

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PREFACE TO THE FOURTEENTH EDITION

THIS edition has been rewritten extending further the principles set out in the preface to the thirteenth edition. Because of the increasing difficulty in recruiting trained anatomical teaching staff and the growing pressures on the time of the medical student, which demand more intensive teaching, it is necessary that the Manual should be adequate in itself as a textbook of gross anatomy for the medical curriculum, and that it should retain sufficient dissection instructions to allow this essential activity to be carried out with the minimum of assistance. With this in mind and with the need to make the study of anatomy clearly meaningful in the context of a medical course, the text has again been revised to increase its clarity and to decrease its length even with the introduction of much new material and many new illustrations of immediate clinical importance. Thus brief descriptions of the salient features of the bones have been included for the first time and the surface anatomy sections have been extended to ensure that structures which are visible or palpable can be identified and recognized. The illustrations of the bones and of the muscles attached to them, in addition to appearing in the most appropriate positions in the text, have been brought together as an atlas at the end of the book. This permits ready reference to these essential illustrations and gives the student the opportunity of seeing all the associated features at the same time.

One of the problems which the student faces when dissecting the body is that structures which act together in a particular function cannot always be displayed at the same time. This makes it more difficult to appreciate such functional relationships. To help to overcome this and also to summarise important information for the student, a number of entirely new tables have been produced which deal principally with movements. These tables are of three types. (1) Those which give the attachments and actions of individual muscles which co-operate in the production of movements at one or more joints. (2) Those which show the movements at each joint, the muscles which produce each of these movements, and the nerve supply of each muscle. Together these two tables permit a rapid survey of the complexes of muscles involved in particular joint movements and of those movements which are severely affected by injury to particular nerves. (3) Tables of the motor distribution of every nerve in the limbs. These show the muscles supplied by the nerve in each segment of the limb (*e.g.*, shoulder, arm, forearm, or hand), the effects of paralysis of these muscles when the nerve is injured, and the muscles which are still innervated and thereby maintain the movements often in a weakened form. By means of these tables, the student should be able to see at a glance the degree of disability caused by injury to any nerve at a given position in the limb. To supplement the tables, illustrations are included of the course and major branches of the principal nerves of the upper limb and of the approximate cutaneous distribution both of the nerves in each limb and of the spinal nerves which give rise to them. The tables and illustrations should help the student to synthesise his information from an early stage in his studies and at the same time give him the essential facts on which a diagnosis of injury may be made.

The abbreviation of the text has been achieved partly by the removal of unnecessary detail and partly by placing the less essential elements in the dissection instructions where they are necessary for this activity. To allow this information to be retrieved easily through the page references of the index, the type used in the dissection instructions has been changed so that bold type may be used for special items in these instructions as in the remainder of the text. Nevertheless, the dissection instructions are still clearly marked so that departments wishing to follow one of the many alternative dissection methods can readily do so. Shortening the text has also been achieved by bringing together all the dissection necessary for the full understanding of the functions of a particular system or region (*e.g.*, shoulder girdle movements). In this way it is possible for the text to deal with the functions of muscles and joints in an integrated fashion and avoid unnecessary fractionation of information. It is also possible to give a general account of the distribution of the various arteries and their anastomoses without going into the detailed course of each, except where this is necessary for a full understanding of the region.

References to histological structure and to some essential developmental points are included where these are appropriate and significant. The Manual is not a replacement for standard texts on these two important subjects, but it is hoped that the brief notes will draw the student's attention to the need for further study.

The author is grateful to many members of the Staff of this Department for helpful suggestions, and to Dr. J. C. Gregory of the Oxford University Press for his continuing assistance in all stages of the preparation of this Manual. It is a pleasure to acknowledge the help given by a number of artists, more especially Mrs. McNeill who prepared most of the new drawings.

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G. J. Romanes

CONTENTS

GENERAL INTRODUCTION

For descriptive purposes the Human Body is divided into Head, Neck, Trunk, and Limbs. The Trunk is subdivided into Chest or Thorax and Belly or Abdomen. The Abdomen is further subdivided into Abdomen Proper and the Pelvis. The student acquires first-hand knowledge of the relative positions of the various structures in the body by dissecting it region by region. He requires an anatomical vocabulary which must be adequate to define precisely the relative positions of these structures, and he should have an elementary knowledge of the kinds of structures he will encounter—this is the purpose of the following introduction.

TERMS OF POSITION

The body, or any detached part of it, usually lies horizontally on a table during dissection, but the dissector must remember that terms descriptive of position are always used as though the body was standing upright with the upper limbs hanging by the sides and the palms of the hands directed forwards. This is the **anatomical position. Superior** or **cephalic** therefore refers to the position of a part that is nearer the head of a supposedly upright body, while **inferior** or **caudal** means nearer the feet.

Anterior means nearer the front of the body and **posterior** means nearer the back. **Ventral** and **dorsal** may be used instead of anterior and posterior in the trunk and have the advantage of being appropriate also for four-legged animals (*venter*=belly; *dorsum*=back). *In the hand*, **dorsal** commonly replaces posterior, and **palmar** replaces anterior. *In the foot*, the corresponding surfaces are superior and inferior in the anatomical position, but these terms are usually replaced by **dorsal** (**dorsum** of the foot) and **plantar** (*planta*=the sole).

Median means in the middle. Thus the **median plane** is an imaginary plane that divides the body into two apparently equal halves, right and left. The **anterior** and **posterior median lines** are the edges of that plane on the front and back of the body. A structure is usually said to be median when it is bisected by the median plane. **Medial** means nearer the median plane, and **lateral** means further away from that plane. The presence of two bones, one lateral and the other medial, in the forearm and leg allows the use of the adjectival forms of the names of these bones as synonyms of medial and lateral, *i.e.*, **ulnar** side and **radial** side in the forearm, and **tibial** and **fibular** sides in the leg. The words inner and outer, or their equivalents **internal** and **external**, are used only in the sense of nearer the interior and further away from the interior in any direction; they are not synonymous with medial and lateral, unless applied strictly at right angles to the median plane, and should not be used in place of these terms. **Superficial**, meaning nearer the skin, and **deep**, meaning further from it, are the terms most usually used when direction is of no importance.

A **sagittal plane** may pass through any part of the body but is parallel to the median plane. A **coronal plane** is a vertical plane at right angles to the median plane.

Proximal (nearer to) and **distal** (further from) indicate the relative distances of structures from the root of that structure, *e.g.*, the root of the limb.

Middle, or its Latin equivalent *medius*, is the usual adjective indicating a position between superior and inferior or between anterior and posterior, but **intermediate** is commonly used for a position between lateral and medial.

The terms **superolateral** and **inferomedial**, or **antero-inferior** and **posterosuperior**, or any other combination of the standard terms may be used to show intermediate positions in much the same way as the points of the compass are described.

TERMS OF MOVEMENT

All movements take place at joints and may occur in any plane, but are usually described in the sagittal and coronal planes. *Movements of the trunk in the sagittal plane* are known as **flexion** (bending anteriorly) and **extension** (straightening or bending posteriorly). *In the limbs*, flexion is applied to the movement which carries the limb anteriorly and folds it; extension to the movement which carries it posteriorly and straightens it. Movements of the trunk *in the coronal plane* are known as **lateral flexion**, while in the limb they are called **abduction** (movement away from the median plane) and **adduction** (movement towards the median plane). The latter terms apply primarily to the proximal joints of the limbs, shoulder and hip, but are also used *at the wrist* where abduction (**radial deviation**) refers to movement of the hand towards the radial (thumb) side and adduction (**ulnar deviation**) to movement towards the ulnar (little finger) side. *In the fingers and toes*, abduction is applied to the spreading and adduction to the drawing together of these structures. In the hand this movement is away from or towards the line of the middle finger, in the foot it is away from or towards the line of the second toe. These movements occur in the plane of the finger or toe nails and *in the thumb* are in an anteroposterior direction because the thumb is rotated so that its surfaces are at right angles to those of the fingers. Thus abduction of the thumb carries it anteriorly and adduction carries it posteriorly.

Rotation is the term applied to the movement in which a part of the body is turned around its own longitudinal axis.

STRUCTURES MET IN DISSECTION

The **skin** consists of a superficial layer of avascular, stratified squamous epithelium, the **epidermis**, and a deeper, vascular, dense fibrous tissue, the **dermis**, which sends small peg-like protrusions into the epidermis. These protrusions form the minute bleeding points which appear when a thin layer is cut from the surface of the skin and they help to bind the epidermis to the dermis by increasing the area of contact between them. The skin is separated from the deeper structures (muscles and bones) by two layers of fibrous tissue, the superficial and deep fasciae.

THE SUPERFICIAL FASCIA

This fibrous mesh, filled with fat, connects the dermis to the underlying sheet of deep fascia, and is particularly dense in the scalp, the back of the neck, the palms of the hands, and the soles of the feet, thus binding the skin firmly to the deep fascia in these situations. In other parts of the body its looseness and elasticity allow the skin to be moved freely yet return it to its original position.

The thickness of the superficial fascia varies with the amount of fat in its meshes. It is thinnest in the eyelids, the nipples and areolae of the breasts, and in some parts of the external genital organs where there is no fat. In a well-nourished body, the **fat** in the superficial fascia rounds off the contours, but its distribution and amount varies in the sexes. The smoother outline of a woman's figure, due to the greater amount of subcutaneous fat, is a secondary sex-character. The fat is an insulating layer and accounts for the increased resistance of the female to cold in comparison with the male. This insulation is partly overcome in hot conditions by the passage of much venous blood through the large veins of the superficial fascia—veins which are contracted in cold conditions forcing the venous blood to return through the veins deep to the deep fascia. The superficial fascia also contains small arteries, lymph vessels, and nerves of the skin; a few lymph nodes are embedded in it.

VESSELS

The **blood vessels** consist of **arteries**, **capillaries**, and **veins**.

Arteries are tubes which convey blood from the heart to the tissues at high pressure. The largest artery in the body is the elastic aorta which begins at the heart and is approximately 2·5 cm in diameter. It gives rise to a number of branches which vary in size with the volume of tissue each has to supply. These branch and re-branch, often unequally, and becoming successively narrower, have progressively more muscle and less elastic tissue in their walls. The smallest arteries ($<0{\cdot}1$ mm in diameter) are known as **arterioles**. They transmit blood into the capillaries and are entirely muscular.

The large **elastic arteries** resist a high internal pressure and their elastic recoil smooths out the intermittent pumping action of the heart to produce a continuous flow of blood. The contraction and dilatation of the **muscular arteries** controls the volume of blood distributed through each. This is essential for directing blood to the active tissues and for maintaining the blood pressure in a system which has a potential capacity greatly in excess of the circulating blood volume.

In many tissues the smaller arteries unite with one another, forming tubular loops called **anastomoses**. Such anastomoses occur especially around the joints of the limbs, in the gastro-intestinal tract, at the base of the brain, and elsewhere. They are of importance in maintaining the circulation when one of the arteries to the tissue is blocked. In these circumstances the remaining arteries enlarge gradually to produce a **collateral circulation**. In some tissues the degree of anastomosis between adjacent arteries may be so slight that blockage of one cannot be compensated for by its neighbours. As a result, the piece of tissue supplied by the blocked artery dies. Such **end-arteries** are particularly important in the eye, the brain, the lungs, the kidneys, and the spleen.

Blood capillaries are microscopic tubes which form a network through which the arterioles discharge blood into the smallest tributaries of the veins. The capillary walls consist of a single layer of flattened **endothelial cells** through which substances are exchanged between the blood and the tissues. The amount of blood flowing through the capillaries (and its pressure) is determined by the degree of contraction of the arterioles, and this is related to the activity of the tissue which they supply. The capillaries may be short-circuited by **arteriovenous anastomoses**. These contractile vessels form direct communications between the smaller arteries and veins. When they open, they permit a considerable blood flow to occur without involving the capillaries. Such anastomoses occur in many parts of the body, especially in exposed parts of the skin and the walls of some organs. The increased flow which they permit produces greater heat transfer without a consequent rise in the metabolic rate of the tissue which they would supply through the capillaries. Thus they are used to promote heat loss from the skin and to warm air which is being drawn into the lungs through the cavities of the nose.

Veins. The pumping action of the heart forces the blood through the arteries and capillaries, but is mostly spent by the time the blood reaches the veins from the capillaries. The more sluggish flow of blood in the veins is aided (1) by compression from the contracting muscles adjacent to them, and (2) by the fall in pressure in the thorax with each inspiration which draws venous blood into the thorax as well as air. Because of the low pressure in the veins, the flow of blood is easily retarded in them even by light compression, though this is usually overcome because there are multiple venous pathways. The presence of

valves in the veins prevents any tendency to backward flow of the blood. The positions of the valves in the superficial veins of the forearm can be seen as localized swellings when the veins are distended with blood by being compressed at the elbow.

It was the demonstration of valves in the veins by Fabricius that led William Harvey (1578–1657) to discover the circulation of the blood. Whenever possible, the student should slit open the veins in the different parts of the body to see the position and structure of the valves.

Lymph nodes are firm, gland-like structures which vary in size from a pin-head to a large bean. They are one of the two main sources of the lymphocytes of the blood (the other is the bone marrow), and tend to decrease in size with age unless enlarged by inflammation or tumour growth. They are difficult to distinguish from the fat in which they lie unless coloured by particles of foreign material which are carried to them through the lymph vessels in scavenger cells (**phagocytes**), *e.g.*, carbon in the lymph nodes of the lung. In the limbs, the lymph nodes are largest and most numerous in the **armpit** (axilla) and groin. They are usually found in groups which are linked to each other by lymph vessels.

The **lymph vessels** are fine tubes that contain a clear fluid called lymph. **Lymph** passes into the tissues through the walls of the blood capillaries. It permeates all the tissues of the body and provides the mechanism for exchange of substances between the tissues and the blood. Lymph is drained by the lymph vessels and by absorption into the venous ends of the blood capillaries. More lymph is produced in active tissues and in inflamed tissues where the blood capillary endothelium becomes excessively permeable. This excess is usually removed by the lymph vessels but its accumulation in inflammation is one of the causes of swelling. Thus there is a continuous flow of lymph from the alimentary canal, some part of which is nearly always active, but the flow is intermittent from parts which are sometimes at rest, *e.g.*, the limbs.

Lymph is collected from the tissues by a closed network of fine **lymph capillaries** which have a similar structure to blood capillaries but are wider and less regular in shape. They are more permeable to particulate matter and cells than blood capillaries. Small lymph vessels drain this capillary plexus. These unite to form larger lymph vessels many of which converge on each primary lymph node. The lymph passes through this node and leaves it in a vessel which usually converges on a secondary and, through it, on a tertiary lymph node as one of many similar vessels. Thus the lymph drains through a number of lymph nodes and is gathered into larger and larger lymph vessels before returning to the blood stream by entering the great veins at the root of the neck. The vessels which carry lymph to a node are called **afferent vessels**; those that carry it away from a node are **efferent lymph vessels** (*ad*=to; *ex*=from; *fero*=carry).

The flow of lymph through the lymph vessels depends on the movements of the body aided by the low pressure in the great veins at the root of the neck and the presence of multiple **valves** in the lymph vessels though not in the capillary plexuses. These valves are so closely set that a distended lymph vessel has a beaded appearance.

The lymph vessels in the superficial fascia drain the capillary plexuses of the skin. They converge directly on the important groups of lymph nodes situated mainly in the axilla [FIG. 34], the groin [FIG. 152], and the neck. Most lymph nodes are situated close to the deep veins along which the deep lymph vessels run.

Only the largest lymph vessels can be demonstrated by dissection, *but the great importance of this system in the reaction to infection and in the spread of disease —either bacterial infection or cancerous tumours— make it necessary for the student to know the main routes of lymph drainage and particularly the positions of the primary lymph nodes which drain lymph from the various parts of the body*. This information makes it possible for the clinician to determine the position in the body of a pathological condition which is causing enlargement of a particular group of primary lymph nodes and to gauge the extent of the spread of the disease by the involvement of secondary or tertiary lymph nodes.

NERVES

These are whitish cords consisting of large numbers of exceedingly fine filaments (**nerve fibres**) of variable diameter, bound together in bundles by fibrous tissue. Nerves have considerable tensile strength and are capable of being stretched to a moderate degree without damage. The fibrous tissue which confers this strength forms a delicate sheath (**endoneurium**) around each nerve fibre, encloses the individual bundles of nerve fibres in a cellular and fibrous sheath (**perineurium**), and binds the bundles together with a dense fibrous layer (**epineurium**).

Each nerve fibre consists of the process of a nerve cell enclosed in a series of **sheath cells** arranged end to end. Each of these sheath cells which surrounds a nerve cell process of larger diameter, forms one segment of a discontinuous, laminated, fatty sheath, the **myelin sheath**. Such fibres are white in colour and are called **myelinated nerve fibres**. The thinner nerve cell processes, simply enclosed in the sheath cells, are grey in colour, and are called **non-myelinated nerve fibres**.

Nerve fibres transmit messages (**nerve impulses**) either from the central nervous system to the various structures of the body or from these structures to the central nervous system. The fibres which carry impulses from the central nervous system are called **efferent**. Many of these pass to the muscles to make them contract and are therefore often called **motor nerve fibres**. Those which carry impulses to the central nervous system are known as **afferent** fibres. The information which they transmit from the skin

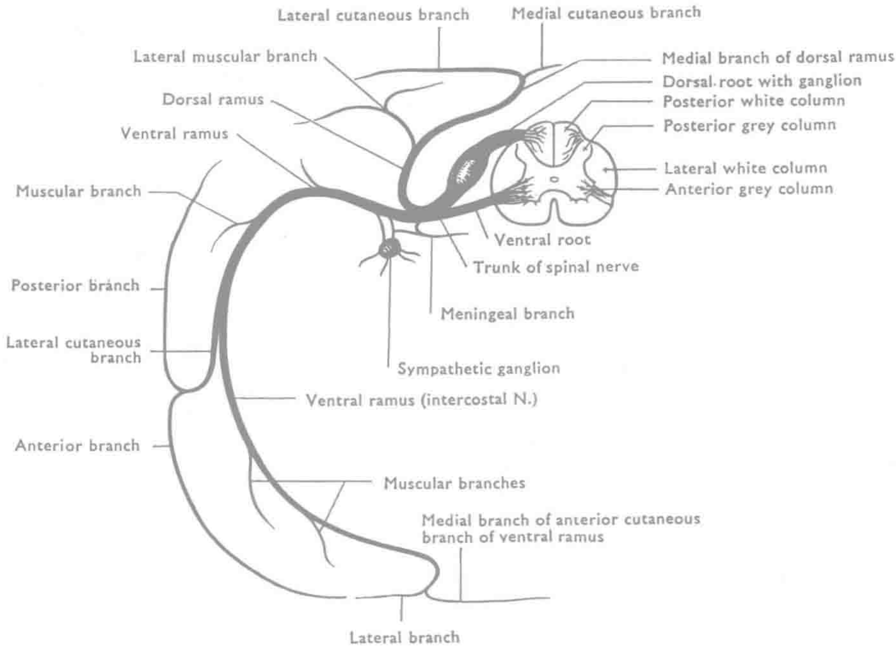

FIG. 1 Diagram of a typical spinal nerve. Note that the medial branch of the dorsal ramus is represented as distributed to skin, whilst the lateral branch terminates at a deeper level in muscle. Both branches, however, supply muscles; and in the lower half of the body it is the lateral branch that supplies skin.

and deeper tissues often evokes subjective sensations within the central nervous system, hence they are often called **sensory nerve fibres**. In addition to the impulses which they carry, nerve fibres also transmit substances in both directions in the nerve cell process. Thus there is a flow of materials to and from the nerve cells which give rise to these processes.

Nerves may branch or unite with one another, usually at acute angles. When they do so there is usually no division and never any fusion of individual nerve fibres, but only the passage of some of the nerve fibres into a separate bundle or the entry of two or more bundles into a single sheath. A similar process of rearrangement of fibres between the bundles occurs throughout the length of all nerves. Nerve fibres frequently branch extensively near their termination, though they may give off such branches (**collaterals**) at any point between adjacent sheath cells and their segments of myelin in myelinated nerve fibres. The gaps between the segments of myelin are known as **nodes**.

Nerves may be classified as: (1) **cranial nerves** which are attached to the brain and emerge from the skull or cranium. (2) **Spinal nerves** which are attached to the spinal medulla and escape from the vertebral column through the intervertebral foramina.

Spinal Nerves

There are 31 pairs of these, named after the groups of vertebrae between which they emerge—8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal. All these nerves emerge caudal to the corresponding vertebrae except the cervical. The first seven cervical emerge cranial to the corresponding vertebrae while the eighth emerges between the seventh cervical and first thoracic vertebrae.

Spinal nerves are attached to the spinal medulla by two roots—ventral and dorsal [FIG. 1].

The **ventral root** consists of bundles of efferent fibres which arise from nerve cells in the spinal medulla. The **dorsal roots** consist of bundles of afferent fibres. These arise from a cluster of nerve cells which forms a swelling (the **spinal ganglion**) on each dorsal root. Each of these ganglion cells sends one process into the spinal nerve and another into the spinal medulla through the dorsal root.

The two roots unite at the distal end of the ganglion to form the trunk of the spinal nerve in the intervertebral foramen. This short trunk, which thus consists of a mixture of efferent and afferent fibres, divides into a **ventral ramus** and a **dorsal ramus** as it emerges from the intervertebral foramen. *Do not confuse the rami (branches) into which the nerve divides with the roots by which it is formed*, for every ramus contains both efferent and afferent fibres.

The small **dorsal ramus** passes backwards into the muscle on the back of the vertebral column (erector spinae). Here it divides into lateral and medial branches which supply that muscle, and one of them sends a branch to the overlying skin. These cutaneous branches of the dorsal rami form a row of nerves on each side of the midline of the back [FIG. 20].

The large **ventral rami** run laterally. The *thoracic* ventral rami run along the lower border of the corresponding ribs. They form the intercostal (upper eleven) and subcostal (twelfth) nerves (*costa*=a rib). Each of these ventral rami supplies the strip of muscle in which it lies and gives off lateral and anterior cutaneous branches. These, together with the cutaneous branch of the dorsal ramus, supply a strip of skin from the posterior median line to the anterior median line. This strip of skin supplied by a single spinal nerve is known as a **dermatome**. The total mass of muscle supplied by a single spinal nerve is a **myotome**.

The ventral rami of the *cervical, lumbar, sacral, and coccygeal nerves* are more or less plaited together to form **nerve plexuses**. The cervical (with part of the first thoracic) form the cervical and brachial plexuses, the latter supplying most of the nerves to the upper limb. The lumbar, sacral, and coccygeal ventral rami cooperate to form plexuses of the same name. The first two are mainly concerned with the nerve supply of the lower limb.

Soon after its formation, each ventral ramus receives a slender bundle of non-myelinated nerve fibres (the **grey ramus communicans**) from the corresponding ganglion of the **sympathetic trunk**. This trunk is formed by a row of ganglia (groups of nerve cells) united by nerve fibres. It extends from the base of the skull to the coccyx, one on each side of the vertebral column. The nerve fibres in each grey ramus arise from the cells in a sympathetic trunk ganglion. The fibres which enter each ventral ramus are distributed through all its branches. They also enter every branch of each dorsal ramus by coursing back in the corresponding ventral ramus to enter the dorsal ramus. These **sympathetic nerve fibres** supply the muscles of the blood vessels and of the hairs (arrectores pilorum) and the sweat glands. Thus each spinal nerve carries efferent fibres to these involuntary structures in addition to those which it transmits to the muscles which are under the control of the will (voluntary).

The thoracic and upper two or three lumbar ventral roots and rami contain an additional group of fine, myelinated fibres. These leave the ventral ramus as a slender branch (**white ramus communicans**) which enters the sympathetic trunk. Within the trunk, the fibres of the white ramus communicans run longitudinally. They end on the nerve cells in the ganglia throughout the length of the sympathetic trunk. Through these nerve fibres the central nervous system controls the activity of all the nerve cells in the sympathetic trunk. Thus it can alter the secretion of sweat, the amount of blood flowing through the various tissues, and the erection of hairs (goose-flesh) throughout the body by way of the processes of the sympathetic nerve cells that are distributed through the spinal (and cranial) nerves. It is important to note that the nerve fibres which connect the central nervous system to the sympathetic nervous system run only in the first thoracic to second or third lumbar spinal nerves. If all these nerves or the white rami communicantes arising from them were cut, the sympathetic nervous system would be separated from the control of the central nervous system. This would result in the loss of a number of responses, *e.g.*, the sweating and dilatation of skin vessels on exposure to heat, and the contraction of skin vessels with goose-flesh in response to cold or fear.

Since fibres of the white rami communicantes end in the ganglia of the sympathetic trunk, they are known as **preganglionic nerve fibres**, while those of the grey rami communicantes are known as **postganglionic nerve fibres** because they arise from the cells of the ganglia. Postganglionic fibres are present in every branch of all the nerves.

From the information given above, it should be clear that branches of nerves to skin (cutaneous branches) are not entirely sensory but also contain sympathetic efferents. Similarly, branches to muscles are not entirely efferent but also contain sensory fibres and sympathetic fibres. Thus the signs of nerve injury are not simply paralysis of muscle and loss of sensation, but also loss of sweating, blood vessel control, and goose-flesh.

DEEP FASCIA

Deep fascia is the dense, inelastic membrane which separates the superficial fascia from the underlying structures. It is continuous with the fibres of the superficial fascia, and sends wide partitions or **septa** between the muscles from its deep surface. Thus it ensheathes the muscles and the vessels and nerves which lie between them. These sheaths form a major part of the attachment of many muscles for they pass deeply to become continuous with the fascia which surrounds and is tightly adherent to the bones (**periosteum**). The sheaths also form tunnels within which the muscles slide independently of the adjacent muscles; hence such **intermuscular septa** are well developed between adjacent muscles of different function. Such tunnels are frequently thickened to form restraining bands or **retinacula** that hold the tendons in position and form pulleys within which the tendons slide where they change direction, *e.g.*, at wrist and ankle. When muscles contract they tighten within their sheaths and compress the veins within and between them. Thus they form effective pumps for the return of venous blood; the dense deep fascia and septa in the legs playing a major role in the return of blood from these dependent extremities. It follows that severe wasting of the muscles of the legs or extensive damage to the deep fascia which surrounds them leads to a poor venous return with the accumulation of blood and fluid in the legs (**oedema**).

Fascia reacts readily by laying down collagen fibres parallel to any forces applied to it. Thus it becomes thickened to form (1) glistening **aponeuroses** where muscles are attached to it; (2) **retinacula** where it is stretched by tendons curving round it; (3) **ligaments** where there are forces tending to separate bones which meet at a joint.

Ligaments are strong bands of inelastic, white, fibrous tissue which connect bones, more especially at joints. Their basic structure is the same as that of tendons, but their margins are usually less well defined since they are thickenings in the general mass of fascia and are not called upon to slide on adjacent tissues as tendons do.

MUSCLES

The muscles are the red flesh of the body and form nearly half of its weight. They produce movements for they can be shortened (contracted) at will so as to approximate the structures to which they are attached. Each muscle has at least two attachments, one at each end, and its actions can readily be predicted from a knowledge of these attachments. However, muscles are most often used in complex groupings even in apparently simple movements, so that paralysis of a single muscle may scarcely be noticed except for a degree of weakness of the movements in which it plays a part. Most muscles, nevertheless, play a key role in some movement and a knowledge of this is of considerable importance in the diagnosis of muscle paralysis—an essential element in determining the presence, site, and degree of injury to nerves.

Muscles are used in a number of different ways. They may shorten and thus produce a movement (**concentric action**). If the tension developed by a muscle is equal to the load against which it is acting, then it helps to fix a part of the body (**isometric contraction**) as in holding the arm outstretched. If the tension developed in a muscle is less than the load acting against it, the muscle will lengthen while active, thus paying out gradually (**excentric action**) to control the speed and force of a movement in the direction opposite to that normally produced by the muscle when it is shortening, *e.g.*, in lowering the arm to the side or a heavy weight to the floor. To test this, place your left hand on the skin over your right deltoid muscle, *i.e.*, on the lateral surface of the shoulder below its tip. Now abduct the arm till it is horizontal and feel the deltoid muscle hardening as it contracts (concentric action). Note that as long as you hold the arm in this position the deltoid remains contracted and hard (isometric contraction). Now slowly lower the arm towards the side and note that the deltoid remains contracted throughout the action (excentric action) but at once becomes soft (*i.e.*, stops contracting) if the hand is pressed down against an obstruction while the arm is being lowered.

When a muscle shortens, either or both ends may move, but it is usual to consider one end (**the origin**) as fixed while the other (**the insertion**) moves. Which attachment moves is determined by other forces in action at the time and is not an intrinsic property of the individual muscle. Thus muscles passing from the leg into the foot will move the foot when it is off the ground, but will move the leg on the foot when the foot is on the ground. Similarly, muscles which are used to pull downwards on a rope can also be used to climb up it.

The fleshy part of a muscle (the **muscle belly**) is composed of bundles of **muscle fibres** held together by fibrous tissue within which they slide during contraction. The ends of the muscle fibres are attached through the medium of fibrous tissue but there may be so little of this that the belly appears to be attached directly to bone. More usually the fibrous tissue forms long, inelastic cords (tendons or sinews) or a thin, wide sheet (**aponeurosis**: *neuron* and *nervus* originally meant sinew) depending on the arrangement of the muscle fibres. **Tendons** usually extend over the surface or into the substance of the muscle and thus increase the surface area for its attachment. Tendons also enable a muscle (a) to act at a distance (*e.g.*, muscles of the forearm that act on the fingers) and (b) to change the direction of its pull by passing round a fibrous or bony pulley (*e.g.*, the tendons in a flexed finger). Tendons which are compressed against a bony surface (*e.g.*, the ball of the big toe) are frequently protected by the development in their substance of a small, cartilage-covered, **sesamoid bone** for articulation with that surface.

The *power of a muscle* depends on the number and diameter of its fibres. The number may be increased by arranging the fibres obliquely to the line of the tendon and thus packing more but shorter fibres into the same space. Thus **bipennate muscles** (*e.g.*, dorsal interossei of the hand [FIG. 88]) have fibres which converge on a central tendon like barbs of a feather, and **multipennate muscles** (*e.g.*, deltoid and subscapularis) have a series of such intramuscular tendinous sheets. The obliquity of the fibres reduces the power of each but not proportionately to the increase in number of fibres. The diameter and power of individual muscle fibres is increased by exercise because of an increase in the number of contractile elements (myofibrils) in each fibre.

Muscle fibres can only contract to 40 per cent of their fully stretched length. Thus the short fibres of pennate muscles are more suitable where power rather than range of contaction is required. This limitation in the *range of contraction* affects all muscles and those which act over several joints may be unable to shorten sufficiently to produce the full range of movement at all of them simultaneously (**active insufficiency**: *e.g.*, the fingers cannot be fully flexed when the wrist is also flexed). Likewise, the opposing muscles may be unable to stretch sufficiently to allow such movement to take place (**passive insufficiency**). For both these reasons it is often essential to use other muscles (called fixators or **synergists** in this type of action) to fix certain of the joints so that the others can be moved effectively (*e.g.*, fixation of the wrist during full flexion of the fingers in clenching the fist).

Most muscles are attached to the bones close to the joints on which they act. Thus they lose mechanical advantage over the fulcrum (joint) but gain in speed and range of movement through the levers (bones) on which they act. In many cases, muscles which are clustered round a joint are less concerned with the movement of that joint than with maintaining its stability in any position. Thus they act as ligaments of variable length and tension in place of the usual ligaments which would inevitably restrict movement (*e.g.*, at the shoulder joint).

The manner in which a muscle acts on a joint depends on its position relative to the joint. It should be remembered, however, that any muscle may act concentrically, isometrically, or excentrically [p. 6].

In addition to the main artery and nerve which enter most limb muscles at distinct **neurovascular hila**, numerous small arteries enter elsewhere. The vessels of muscles with fleshy attachments anastomose with those of the bone and may be of importance in the repair of fractures at these sites.

Nerves which enter muscles carry impulses which cause the muscle to contract, but they also transmit sensory impulses from the muscle and tendon to the central nervous system whereby the tension and degree of contraction may be measured. Such nerves also transmit sympathetic nerve fibres to the blood vessels in the muscle. It is possible to stimulate contraction in individual muscles by the application of appropriate electrical impulses to the skin overlying the neurovascular hilus. Such 'motor points' may be used to diagnose the state of innervation of a muscle.

Muscles are often classified in groups by the principal action which they have on a particular joint, *e.g.*, flexors, extensors, abductors, adductors etc. [see p. 1]. This is not a satisfactory classification because the different parts of one muscle may have very different functions (*e.g.*, the anterior fibres of deltoid [p. 44] are flexors of the shoulder while the posterior fibres are extensors) and a single muscle may be a flexor of one joint and an extensor of another (*e.g.*, rectus femoris [p. 114]). Unfortunately the terms flexor and extensor are also used to designate the groups of muscles in the limbs which develop respectively from the ventral and dorsal sheets of muscle irrespective of the actual functions of the individual muscles. These 'flexor' groups of muscles are supplied by the anterior divisions of the ventral rami of the spinal nerves entering the limb and are thus differentiated from the 'extensors' which are supplied by the posterior divisions.

Bursae and Synovial Sheaths

Where two structures slide freely over each other, *e.g.*, muscle, tendon, or skin over bone or fascia, the friction between them is reduced by the presence of a **bursa**. This is a closed sac lined with a smooth synovial membrane which normally secretes a small amount of glutinous fluid into the sac. When there is irritation or infection of the bursa, the secretion is increased and the bursa becomes swollen, tight, and tender, as in a bunion. Similar **synovial sheaths** enclose tendons where the range of movement is considerable, *e.g.*, the tendons sliding in the fingers [FIG. 66].

JOINTS

A joint is present where two bones come together whether there is movement between them or not. *Joints without movement* are those where the adjacent bones have either fused or are united by a thin layer of dense fibrous tissue or cartilage. The first of these is usually a late stage in the development of one of the other two [FIG. 2, A and B]. *Joints with a small amount of movement* are those where the bones are held together with a thick layer of fibrous tissue or fibrocartilage, *e.g.*, the discs between the bodies of the vertebrae. *Joints with the maximum amount of movement* are **synovial joints**. Here the bearing surfaces of the bones are covered with firm, slippery, **articular cartilage** and slide on each other in a narrow cavity containing lubricant **synovial fluid**. Outside the cavity, the bones are held together by a tubular sheath of fibrous tissue (the **fibrous capsule** or **fibrous membrane**) which is a continuation of the periosteum between the two bones and is sufficiently loose to permit movement. It may be strengthened in certain situations where it will not interfere with movement or where it is required to limit such movement. Such strengthenings form some of the **ligaments of the joint** and are usually named from their position, *e.g.*, radial and ulnar collateral ligaments of the elbow joint. Thus in the hinge-like elbow joint, the anterior and posterior parts of the capsule are lax, while the collateral ligaments lie approximately as radii of the arc of movement and thus remain tight in all positions, effectively holding the bones together.

All the structures which immediately surround the joint cavity, except the articular cartilage, are separated from that cavity by **synovial membrane**.

The bones which articulate at synovial joints are of many different shapes to permit particular movements while preventing others. Thus the surfaces of the bones may be flat (**plane joint**) permitting only slight gliding movements (*e.g.*, in some of the joints between the bones of the hand and foot) and giving some resilience to an otherwise rigid structure. More usually the surfaces of the articulating bones are curved. The greatest number of different movements is obtained from the **ball-and-socket** type of joint (*e.g.*, shoulder and hip joints) in which the spheroidal end of one bone fits into a cup-shaped recess in the other. Where the cup is shallow (*e.g.*, the shoulder joint) the range of each movement is great but the intrinsic strength and stability is decreased in comparison with joints having a deep cup (*e.g.*, the hip joint). Three types of joints allow movements in only two directions at right angles to each other—usually flexion/extension and abduction/adduction—but permit little or no rotation. (1) **Condyloid joints** (*e.g.*, the joints of the knuckles where the fingers meet the hand) have a bony configuration similar to

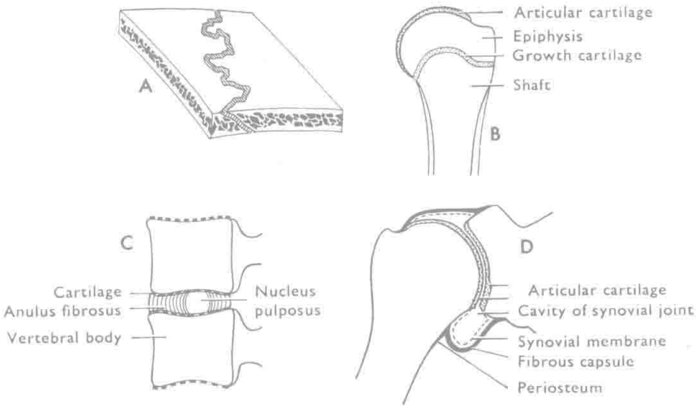

FIG. 2 Diagrams to show four types of joints.

A. A suture between two skull bones. In this the bones are firmly bound together by a thin layer of dense fibrous tissue which does not allow movement, but permits the addition of new bone to the adjacent surfaces, thus assisting in growth of the bones.

B. Section through the proximal end of the growing humerus; the two parts of the bone, epiphysis and body, are joined by a layer of firm, growing cartilage. No movement is possible, the joint is a temporary one concerned with the growth in length of the body, and is called a synchondrosis. When growth ceases this joint is replaced by bone, forming a synostosis, a fate which also overtakes sutures.

C. Section through an intervertebral disc joining two vertebral bodies. A thick laminated fibrous sheath (anulus fibrosus) of great strength encloses a pulpy central mass (nucleus pulposus). The flexibility of the disc allows limited movement between the vertebrae, the range increasing with the thickness of the disc.

D. Section through the shoulder joint to show the parts of a synovial joint. Such joints have a cavity which extends between the ends of the bones which are covered with slippery, hyaline cartilage, and the whole is enclosed in a fibrous sheath or capsule lined with synovial membrane. This type of joint allows the maximum freedom of movement which is limited only by the shape of the articular surfaces, and the length and strength of the fibrous capsule and ligaments.

the ball-and-socket type of joint but rotation is limited by the liagments. (2) The **ellipsoid joint** (*e.g.*, the wrist joint) is also like a ball-and-socket joint, but the radius of curvature of the surfaces is long in one direction and short at right angles to this—like a sausage fitted into a curved trough. (3) In the **saddle** type of joint (*e.g.*, the carpometacarpal joint at the base of the thumb) the articular surface of the bone is concave in one direction and convex at right angles to this—the convex surface of one bone fitting the concave surface of the other.

Two types of joints give movement around only one axis. (1) In **hinge joints** (*e.g.*, the interphalangeal joints of the fingers and the ankle joint) the configuration of the bones and the arrangement of the ligaments prevent movements except those of flexion and extension. (2) In the **pivot joint** (*e.g.*, the proximal radio-ulnar joint) a cylindrical bone lies in a ring formed by bone and ligament, the one element rotating on the other much as a door swings on the pin of a hinge. At such a joint only rotation is possible.

It should be remembered that many joints are used to achieve most movements and that their combined actions are necessary for normal activity. It follows that damage to one joint may interfere with many movements.

In joints where considerable movement is required in many directions (*e.g.*, the shoulder) the fibrous capsule is thin and lax throughout, being supported by muscles which closely surround the joint and are able to be stretched to the required degree, but can be tightened to support the joint in any position. Where extreme mobility in one direction is required (*e.g.*, at the knuckles or knee) the appropriate part of the fibrous capsule is entirely replaced by the tendon of a muscle.

The stability and complexity of movement at a joint are sometimes increased by placing a **disc** of fibrous tissue between the bones. This may have different curvatures on its two surfaces and thus convert a single joint into two, each having a different type of movement. It may also act as a shock absorber within the joint, or assist with the spreading of the synovial fluid between the bearing surfaces of joints which are under considerable pressure (*e.g.*, the knee joint).

BONES

Bone is a living, vascular form of connective tissue in which the intercellular substance consists of dense, white fibrous tissue embedded in a hard calcium phosphate complex. The fibrous tissue imparts resilience to the bone, while the calcium salts resist compression forces.

Bone occurs in two forms. (1) **Compact bone** is dense and forms the tubular bodies of the long bones filled with yellow (fatty) bone marrow. (2) **Cancellous bone** is a lattice of bone spicules. It occurs in the ends of long bones and fills the flat and irregular bones. The spaces between the spicules are filled with bone marrow which is often of the red variety (blood cell forming).

The **periosteum** is a dense layer of fibrous tissue which covers the external surfaces of all bones, except where they articulate in synovial joints. It is continuous through the substance of the bone with the connective tissue of the marrow spaces, the **endosteum**. Periosteum is also continuous with muscles, tendons, ligaments, and the fibrous capsules of joints which are attached to bones. It is also continuous with the deep fascia where a bone becomes subcutaneous and elsewhere through the intermuscular fibrous septa.

Dried bones show a number of tell-tale marks which allow the student to learn much about the structures in contact with the bone. Bone is smooth (a) where it is covered in life by articular cartilage;

(b) where it gives a fleshy attachment to muscles; and (c) where it is subcutaneous. It is often roughened where ligaments, aponeuroses, and tendons are attached, and has grooves lodging blood vessels, and holes (foramina) where arteries enter and veins leave the bone. Many of these features are more readily felt than seen, and they are of importance for they show the exact point of attachment of structures to the bone and so clarify their functions.

It is important for the student to determine the position of each bone in the body, to be able to identify the parts of the bones which are readily visible or palpable, and to check these findings by the use of radiographs.

Bones are usually classified according to their shape. (1) The **long bones** of the limbs vary in length from finger to thigh bones, but all tend to have enlarged, articular ends (composed of cancellous bone with a thin shell of compact bone) and a narrower, tubular **body** (shaft) of compact bone. Of the remainder (2) the **short bones**, *e.g.*, of the wrist and foot, (3) the **flat bones**, *e.g.*, the sternum and vault of the skull, and (4) the **irregular bones**, *e.g.*, the vertebral column, all consist of cancellous bone enclosed in compact bone of varying thickness, while (5) the **pneumatic bones** of the skull have the marrow cavity replaced by air spaces which are extensions of the nasal cavity.

Bones are formed during *development* in two ways. 1. The majority of bones are preformed in cartilage (**cartilage bone**) by the production of a cartilage model.

The cartilage model consists of cartilage cells buried in an apparently homogeneous matrix. This grows by the proliferation of its cells and the production of matrix by each of these. The model is then replaced by bone (ossification). This process begins in one of two ways.

A. In long bones, a supporting shell of bone is laid down by the periosteum on the external surface of the body of the model. The matrix of the cartilage internal to this calcifies and its contained cells die leaving spaces throughout the calcified cartilage. This is then invaded by phagocytic cells (**osteoclasts**) and blood vessels from the surrounding shell in such a manner that the spaces coalesce leaving spicules of calcified cartilage between them. These spicules, mainly longitudinal, are then strengthened by the action of bone-forming cells (**osteoblasts**) which lay down bone on the spicules to increase the strength of this temporary scaffolding. This process begins at the centre of the body and then spreads towards the ends which remain cartilaginous. Each cartilaginous end is continuous with the ossifying body through a zone of growing cartilage (**growth cartilage**) which adds new cartilage to the body at the same rate as the processes of calcification and ossification spread towards it. Thus the cartilaginous ends move away from the centre of the body, followed by a zone of active ossification (**metaphysis**) in calcified cartilage which produces cancellous bone. The external shell of bone increases in length at the same rate, so that its extremities always lie at the metaphysis. This process increases the length of the body of the bone, while its diameter is increased partly by the growth of the cartilage ends and partly by the addition of bone to the external surface of the enclosing shell. This bone is produced by a highly cellular (osteogenic) layer which is characteristic of the **periosteum** of developing bones. As the shell increases in thickness, the need for the internal scaffolding of cancellous bone disappears and it is removed leaving a continuous marrow cavity. Thereafter, this cavity increases in transverse diameter at a slightly slower rate than bone is added to the external surface of the shell. These processes of bone removal are carried out by osteoclasts.

B. In short and irregular bones and in the ends of long bones, the same process occurs in the centre of the cartilage model without the production of an external shell of bone. Thus a centre of ossification begins and spreads outwards as the surrounding cartilage continues to grow until the adult size is reached. By this time, the ossification has replaced all of the cartilage except that which persists on the articular surfaces. At about the same time, the growth cartilages in the long bones stop growing and ossification from the body spreads into them. Thus fusion occurs between the ossification in the body and that in the cartilaginous ends. This brings growth in length to a halt. After this has happened in all the bones, there can be no further growth in length and the height of the individual is fixed.

The ossifications in the ends of the long bones (**epiphyses**) appear much later (at or after birth) than those in the bodies (**primary centres**, at approximately 8 weeks of intra-uterine life) and hence are often known as **secondary centres**. In short and irregular bones they form the primary centres many of which do not appear till after birth. In all cases the ossification in cartilage forms cancellous bone, while that formed by the periosteum is compact bone, though cancellous bone can be turned into compact bone by continuation of the process of ossification.

The majority of long bones have epiphyses (secondary centres) at each end, but the growth in length occurs mainly at one end. At this '**growing end**' the epiphysis usually appears earlier and fuses with the body later than that at the non-growing end where union of the body and epiphysis may occur considerably before growth ceases. The presence of such 'growing ends' in long bones makes the injury to these ends in children much more serious than damage to the non-growing end. Since epiphyses are visible in radiographs and are separated from the body of the bone by a clear region of growing cartilage during growth, they have to be differentiated from fractures. It is useful, therefore, to know where epiphyses appear and when they are present. The student should not try to memorize all of these but should have a general indication of their times of appearance and fusion, realizing that there are marked individual variations.

2. Bone may also be formed in connective tissue without the intervention of cartilage (**membranous ossification**). Here osteoblasts are produced which form many separate spicules of bone. These fuse to form a lattice around the capillaries of the connective tissue. This may persist as cancellous bone, or continued deposition of bone in the cavities of the lattice can turn it into compact bone. In either case, the formation of periosteum with a cellular, **osteogenic layer** on the external surfaces of a membrane bone permits the continued growth of the bone by deposition. Continuous periosteal deposition of bone ceases at the end of growth. Then the cellular, osteogenic layer of the periosteum disappears, its outer, **fibrous layer** persisting and fusing with the surface of the bone. Osteogenesis from the periosteum can begin again when increased strength of a bone is required (*e.g.*, when the weight or muscularity of the individual increases). It is also responsible for the surface irregularities of the bone where tendons and ligaments are attached and for much of the formation of new bone at the sites of fractures.

Absorption of unnecessary bone plays an important part in bone development. In addition to increasing the size of the marrow cavity and lightening the bone, it also maintains the normal external shape of the bone throughout its growth.

GENERAL INSTRUCTIONS FOR DISSECTION

Instruments

The dissector requires one scalpel with a solid blade; two pair of forceps, preferably with rounded points; a strong blunt hook or seeker; and a hand lens. The lens is especially useful as an aid to bridging the gap between gross and microscopic anatomy and can also help to throw light on the functions of many tissues.

Deep to the skin, the body consists of a number of organs embedded in a matrix of fibrous connective tissue (**fascia**) which varies in density from a loose mesh to tough sheets or bundles of fibres. Dissection is the process of freeing the organs from this tissue and demonstrating the variations in its density. This can best be done by blunt dissection with a hook or forceps by pulling these through the loose layers of connective tissue. In this way it is possible to free organs without damaging blood vessels or nerves, the knife being reserved for cutting the skin and the dense layers of deep fascia which enclose many organs and partly conceal them.

Removal of the Skin

One method is to remove the skin from the superficial fascia in a series of flaps which can be replaced to obviate drying of the part. It is probably better to cut through both skin and superficial fascia and remove both of them in one layer from the underlying deep fascia by blunt dissection. The blood vessels and nerves entering the superficial fascia through the deep fascia are easily found in this way and can be traced for some distance. The alternative of searching for their minute branches in the superficial fascia is a tedious and often unrewarding process. The student should be aware that the distribution of cutaneous nerves is of considerable clinical importance, but this is best learnt by reference to diagrams except in the case of the larger branches which are easily followed. In the superficial fascia, the nerves are almost always accompanied by a small artery and one or more minute veins. Larger veins are also found in the superficial fascia. They run a solitary course to pierce the deep fascia and drain into the deep veins. At such junctions, these superficial veins contain valves which prevent the reflux of blood from the deep veins.

Deep Dissection

When the deep fascia has been uncovered and examined, proceed to remove it. This is made more difficult because it sends sheets between the various muscles enclosing each in a separate tunnel. Where a number of muscles arise together, the walls of these tunnels also give origin to muscle fibres and thus they form a tendinous sheet which appears to bind together adjacent muscles. Elsewhere it is relatively easy to strip the deep fascia from muscles for only delicate strands pass between the individual bundles of muscle fibres. *It is important to follow each muscle to its attachments and to define these accurately, for it is only in this way that the functions of a muscle can be determined.*

As each muscle is exposed and lifted from its bed, look for the neurovascular bundle entering its surface. Follow the structures in the neurovascular bundle back to the main nerve trunk and vessels from which they arise. Once these have been identified, it is relatively easy to follow them by blunt dissection and determine their other branches. In many situations it will be found that the arteries are accompanied by tributaries of the main vein which often obscure the artery and nerve. In these cases it is usually advisable to remove the veins so that a clearer view of the other structures can be obtained. In any case it will be found that there are usually multiple venous channels and that their arrangement is much less standard than that of the arteries. The arteries are less constant in their arrangement than the nerves.

VARIATION

It is obvious even to the casual observer that there are wide variations between persons. The same type of variation exists in the size, position, and shape of the various organs of the body in different individuals, just as the fingerprints and even the proteins of the body are unique to each individual. Therefore, no single account of the structure of the body exactly fits every individual, so the student must expect to find variations from the descriptions given in this book. For this reason, he should take every opportunity to look at the other bodies being dissected at the same time. Some of the variations are of considerable clinical importance (*e.g.*, differences in the anastomotic arrangement between the arteries at the base of the brain) while others have no such significance (*e.g.*, an extra belly to a particular muscle, or the marked difference in the arrangement of the superficial veins even on the two sides of the body). One type of variation, not commonly seen in the dissecting room, is the **congenital abnormality** which arises from some defect in development. Many of these are so severe that they lead to death before or immediately after birth, while others, compatible with life outside the uterus, may cause considerable disability and early death (*e.g.*, congenital defects of the heart). Other congenital defects may be present throughout life without any overt sign, and may only come to light at operation or as a result of investigation for some other condition (*e.g.*, at X-ray examination). The student should understand, therefore, the main processes of development and the effects of its abnormalities on the structure and function of the various systems, even though there is insufficient space in this book to do more than draw attention to some of the major points.

ANATOMY OF THE LIVING BODY

It is unfortunate that the study of anatomy has to be carried out on the dead, preserved body in which the texture and appearance of the organs of the body has been altered. The student should remember that the purpose of such studies is to allow him to visualize the living body in action so that he can appreciate the effects of injury or disease, and can recognize an abnormality from his knowledge of the normal. To achieve this kind of information there is no substitute for the personal process of looking at the body by dissection while thinking of the functions of its various parts and checking these points by observation and palpation of the living body. Dissection is only a means to the end of a fuller understanding of function. It deals, for example, with simple concepts such as the arrangement of the valves in the veins, and the more complex structure of the heart without which the normal and abnormal circulation of the blood cannot be understood properly. Similarly, a knowledge of the movements at joints, the muscles which move them, and the nerves which supply these structures is essential if the effects of injury or disease in any of these systems is to be understood and rational corrective measures undertaken. Moreover it forms the basis on which a patient can be advised that he will require to change his occupation and be retrained for some different activity which is compatible with a permanent disability.

As in any other study, dissection can become a meaningless chore unless the student approaches it with an enquiring mind and avoids the temptation of assuming that it is simply a method of learning a number of dead facts.

In this book there are paragraphs describing one method of dissection. These are only for the guidance of the student and need not be followed slavishly. Any method which the student may wish to follow to investigate the body in his own way will prove at least as effective for him.

THE UPPER LIMB

INTRODUCTION

The parts of the upper limb are the shoulder, the arm or brachium, the forearm or antebrachium, and the hand.

The **shoulder** region includes the axilla or armpit, the scapular region or parts around the shoulder blade, and the pectoral or breast region on the front of the chest. The scapula or shoulder blade and the clavicle or collar bone [FIGS. 5, 24, 40] are the bones of the upper limb girdle. They articulate with each other at the acromioclavicular joint, but their only articulation with the rest of the skeleton is where the clavicle articulates with the upper end of the sternum at the sternoclavicular joint. The mobile scapula is otherwise held in position entirely by muscles.

The **arm** is the part between the shoulder and the elbow or cubitus. Its bone is the humerus which articulates with the scapula at the shoulder joint.

The **forearm** extends from the elbow to the wrist. Its bones, the radius and ulna, articulate with the humerus at the elbow joint and with each other proximally and distally at the corresponding radio-ulnar joints. In the anatomical position (supine position of the forearm) the bones are parallel with the radius lateral to the ulna. When the palm of the hand faces posteriorly (prone position of the forearm) the distal end of the radius has rotated around the ulna so that the radius lies obliquely across the ulna. The movement producing this is called **pronation**, the reverse movement is **supination**.

The **hand** consists of the wrist or carpus, the hand proper or metacarpus, and the digits (thumb and fingers). The small wrist or carpal bones are in two rows (proximal and distal) each consisting of four bones. They articulate (a) with one another at the intercarpal joints, (b) proximally, with the radius at the radiocarpal joint, so that they move with the radius in pronation and supination, and (c) distally, with the metacarpal bones at the carpometacarpal joints. The small movements that occur at each of these joints summate to allow a considerable range of movement. Posteriorly the carpal bones are close to the skin, but anteriorly they are covered by muscles of the ball of the thumb (**thenar eminence**), the ball of the little finger (**hypothenar eminence**), and between these by the long tendons entering the hand from the forearm.

The hand proper has five metacarpal bones numbered 1 to 5, beginning with the thumb. Proximally their bases articulate with the distal row of carpal bones, and the 2nd to 5th articulate with each other (intermetacarpal joints [FIG. 98]). Distally each articulates with the proximal phalanx of the corresponding digit.

The **digits** are: the thumb or pollex, the fore-finger or index, the middle finger or digitus medius, the ring finger or annularis, and the little finger or minimus. Each finger has three phalanges though the thumb has only two, the proximal phalanx articulating with the corresponding metacarpal head at the metacarpophalangeal joint. The phalanges articulate with one another at the proximal and distal interphalangeal joints.

THE PECTORAL REGION AND AXILLA

In Man the walls of the thorax form a conical structure which is flattened anteroposteriorly and has its apex truncated obliquely to form the **superior aperture of the thorax**. This is continuous above with the root of the neck and has as its margins the first thoracic vertebra, the first ribs, and the upper part of the sternum (manubrium). The upper limb is attached to the thorax by muscles and bones which diverge from the proximal part of the limb to the anterior and posterior surfaces of the thorax, thus leaving a 3-sided pyramidal space (the **axilla**) between these two groups of muscles and bones and the lateral wall of the thorax. When the arm is by the side, the axilla is a narrow space. When the arm is abducted the volume of the axilla increases and its floor (base) rises, forming a definite 'armpit' and causing the muscular inferior margins of its anterior and posterior walls to stand out as the anterior and posterior **axillary folds**. The superior part of the axilla (apex) lies lateral to the first rib and is continuous over its superior surface with the superior aperture of the thorax below and the root of the neck above. This continuity permits blood vessels and nerves from the thorax and neck to enter the axilla on their way to the upper limb. They pass over the superior surface of the first rib behind the middle of the clavicle [FIG. 17].

The clavicle extends medially from its articulation with the scapula (acromio-clavicular joint) on the superior surface of the shoulder to its articulation with the superolateral surface of the sternum (sterno-clavicular joint)—the only articulation of an upper limb bone with a bone of the trunk. Thus the clavicle acts as a strut which prevents the scapula, and hence the shoulder, from sagging downwards and medially under the weight of the limb as it does when the clavicle is broken. The scapula lies posterior to the axilla and is almost entirely covered with muscles. These either attach the scapula to the humerus or