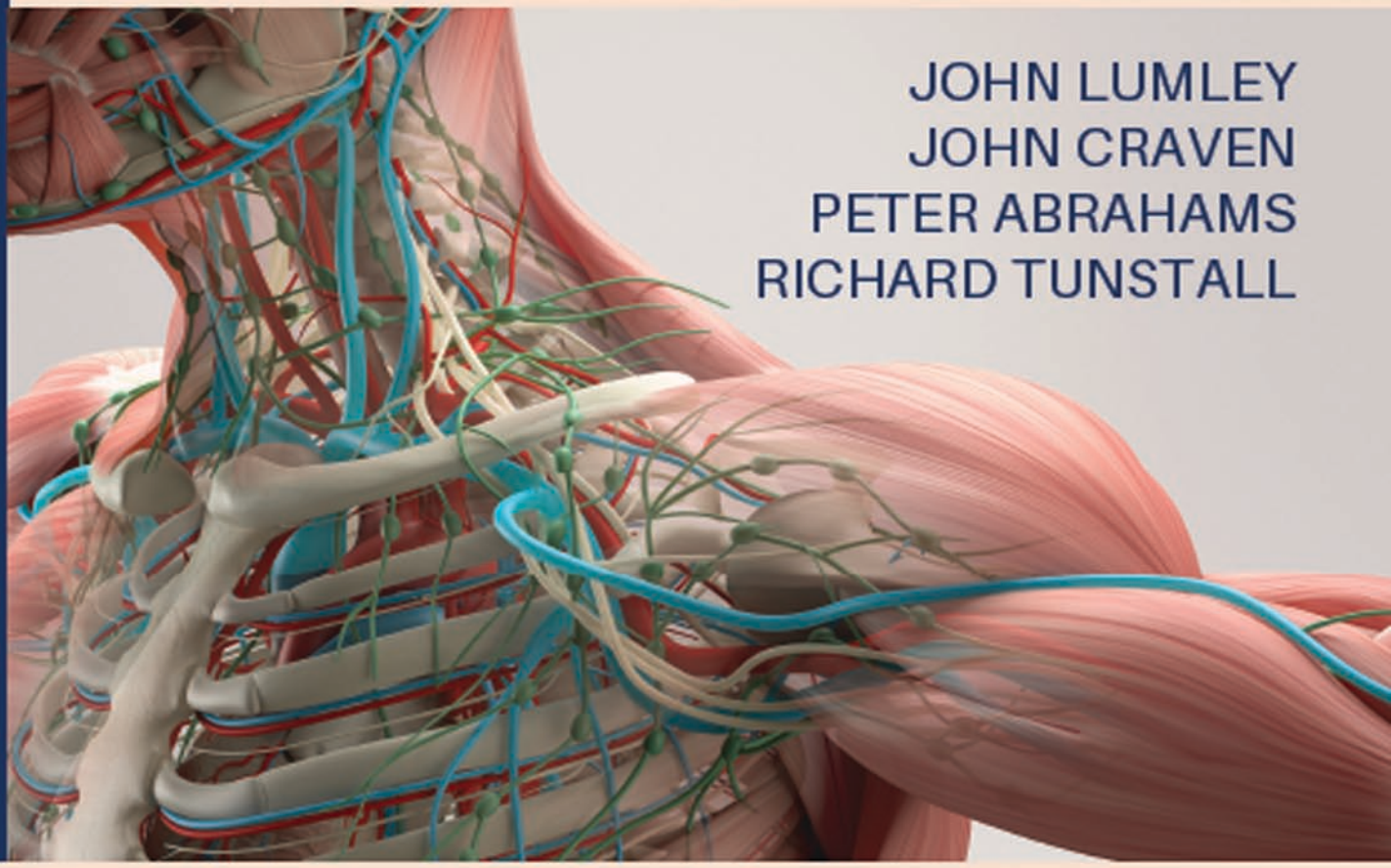
Bailey & Love's

ESSENTIAL CLINICAL ANATOMY



JOHN LUMLEY
JOHN CRAVEN
PETER ABRAHAMS
RICHARD TUNSTALL

CRC Press
Taylor & Francis Group

PRIMAL PICTURES

Bailey & Love's
ESSENTIAL CLINICAL ANATOMY

Bailey & Love's

ESSENTIAL CLINICAL ANATOMY

Edited by

JOHN SP LUMLEY DSc (Hon) MS FRCS FMAA (Hon) FGA
Foundation Dean, University of Bolton School of Medicine, Bolton, UK
Emeritus Professor of Vascular Surgery, University of London, London, UK
Past Council Member and Chairman of the Primary Fellowship Examiners,
Royal College of Surgeons of England, London, UK

JOHN L CRAVEN MD FRCS
Formerly Consultant Surgeon, York District Hospital, York, UK
Past Chairman of the Primary Examiners, Royal College of Surgeons of England, London, UK

PETER H ABRAHAMS MB BS FRCS(Ed) FRCR DO(Hon)
Professor of Clinical Anatomy, Warwick Medical School, University of Warwick, UK
Director or Anatomy, West Midlands Surgical Training Centre, UHCW NHS Trust, Coventry, UK
Extraordinary Professor, Department of Anatomy, University of Pretoria, South Africa
Fellow, Girton College, Cambridge, UK
Professor of Clinical Anatomy, St George's University, Grenada, West Indies
Examiner to the Royal College of Surgeons, London, UK
Family Practitioner, Brent, London, UK

RICHARD G TUNSTALL BMedSci PhD PGCLTHE FHEA
Professor and Head of Clinical Anatomy and Imaging, Warwick Medical School, University of Warwick, UK
MBChB Admissions Lead, Warwick Medical School, University of Warwick, UK
Director of Clinical Anatomy, West Midlands Surgical Training Centre, UHCW NHS Trust, Coventry, UK
Examiner to the Royal College of Surgeons, London, UK

CRC Press
Taylor & Francis Group

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

Printed on acid-free paper

International Standard Book Number-13: 978-1-138-29523-0 (Hardback)
International Standard Book Number-13: 978-1-138-29518-6 (Paperback)

Visit the Taylor & Francis Web site at
http://www.taylorandfrancis.com

and the CRC Press Web site at
http://www.crcpress.com

Contents

Preface vii
Acknowledgements viii

INTRODUCTION

The structure of the body – the systems and organs 2

PART 1: THE THORAX

1 The thoracic wall and diaphragm 22
2 The thoracic cavity 35
3 The mediastinal structures 54
4 The pleura and lungs 63

PART 2: THE ABDOMEN

5 The abdominal wall and peritoneum 80
6 The abdominal alimentary tract 94
7 The liver, spleen and pancreas 113
8 The kidneys and posterior abdominal wall 123
9 The pelvis 136
10 The perineum 153

PART 3: THE BACK

11 The vertebral column and spinal cord 172

PART 4: THE UPPER LIMB

12 The shoulder region 186
13 The elbow and forearm 209
14 The wrist and hand 227

PART 5: THE LOWER LIMB

15 The hip and thigh 242
16 The knee, leg and dorsum of the foot 266
17 The foot 288

PART 5: THE HEAD AND NECK

18 The skull, scalp and face 302
19 The orbit, nose and mouth 315
20 The temporomandibular joint, pharynx and larynx 339
21 The ear, intracranial region and cranial nerves 355
22 The neck 371
23 Vessels, nerves and lymphatic drainage 387
24 Neuroanatomy 400
25 The ventricular system, the meninges and blood supply of the cranial cavity 429

Index 443

Foreword

It goes without saying that anatomical knowledge is the bedrock of clinical surgery and indeed all of medicine. Not only do surgeons in particular need to be fully cognisant of their own specialty requirements but they need to have more far reaching knowledge so as to make thorough clinical examinations, to interpret all modalities of imaging and to deal with trauma and malignancy, which by their very nature know no anatomical barriers. It is therefore a delight to welcome *Essential Clinical Anatomy* as the first publication into the fold of what we envisage will constitute a Bailey and Love compendium of associated titles. As editors of *Bailey and Love's Short Practice of Surgery* we see this anatomy book as very much a companion to the main tome. Although there are snippets of relevant anatomical knowledge in the parent volume, we readily accept that it lacks the detail that is invariably required for a complete understanding of various disease processes and the concomitant therapeutic procedures required to treat them. *Essential Clinical Anatomy* fulfils this need and all undergraduate and postgraduates who are unsure of the relevant anatomy when reading *Short Practice of Surgery* will not put a foot wrong if they keep the former close when perusing the pages of the latter.

Essential Clinical Anatomy covers the modern curricula required by most regulatory medical bodies worldwide and hence provides all that is required for relevant examinations. A constant feature of *Bailey and Love's Short Practice of Surgery* throughout all its editions has been an emphasis on high-quality illustrations and clinical photographs and we are delighted to see this tradition is very much at the fore in this companion volume. The authors are to be congratulated on assembling the information in a most readable and visual format, which will be considerably enhanced by a variety of anatomical teaching videos that can be viewed via the Bailey and Love website.

While we are confident that *Essential Clinical Anatomy* will provide the foundation for all those pursuing a surgical career, we also believe it will be of tremendous benefit for all undergraduate and postgraduate students no matter which branch of medicine they wish to pursue, and we warmly commend this book to you.

Norman S. Williams
Ronan O'Connell
Andrew McCaskie

Preface

The expansion and integration of disciplines within the medical curriculum has reduced time for anatomy teaching, particularly for human dissection, but has not reduced its vital importance. While surgeons need to know the detailed anatomy in their operating field, knowledge of the anatomy that underlies every clinical examination and every radiological/medical image is an essential component of everyday clinical practice.

This text provides a comprehensive cover of most normal and abnormal living anatomy, essential for students across the world. It addresses the knowledge and skills laid down by the General Medical Council (GMC) and the American Association of Clinical Anatomists (AACA; 'A clinical anatomy curriculum for the medical student of the 21st century: gross anatomy', *Clinical Anatomy* 1996;9:71–99; see also Smith *et al.*, 'The Anatomical Society core regional anatomy syllabus for undergraduate medicine', *Journal of Anatomy* 2016;228:15–23).

The regional approach followed corresponds to a typical clinical examination. The nervous system is included, rather than being covered in an additional text; also included is embryology in sufficient detail to explain many common congenital abnormalities. Wherever possible, information, such as muscle attachments, is tabulated and clinical information is highlighted.

The extensive number of illustrations include surface anatomy, coloured labelled diagrams, dissections, a wide range of radiological, laparoscopic and endoscopic images, and clinical pictures of common diseases. A comprehensive index facilitates rapid location of the desired passages. Self-assessment material is included at the end of each chapter; these multiple choice questions (MCQs), single best answer (SBA) questions (used in the USA and also now more widely), extended matching questions (EMQs) and applied questions reflect styles of examination around the world. The answers and explanations can be found in the text, but additional material is included where appropriate.

The authors bring a combined experience of over 150 years of anatomy teaching at all levels, and present this large volume of information in a palatable, interesting and understandable form, emphasizing its relevance to disease and clinical practice.

John Lumley
John Craven
Peter Abrahams
Richard Tunstall

Acknowledgements

We would like to thank Matthew Boissaud-Cooke BMedSc(Hons), MBChB, MRCS, Speciality Trainee in Neurosurgery, University Hospital Plymouth NHS Trust, Plymouth, for contributing the text for Chapter 24.

The authors and publisher also thank the following individuals and institutions for kindly supplying figures for this book. Dr Tania Abrahams for tropical pathology. Dr Rosalind Ambrose for tropical radiology. Dr Ray Armstrong and ARC for musculoskeletal cases. Professor JM Boon for dissections from 'The Virtual Procedures Clinic' CD-ROM (www.primalpictures.com 2003). Section of Clinical Anatomy University of Pretoria, Dr L Van Heerden and the following students: Van Jaarsveld M; Joubert AT; Van Schoor AN; Phetla MV; Mbandlwa L; Mahlomoje ID; Deetlefs MEC; Schoonraad B; Van Blerk EM; Gichangi C; Smith AB; Van der Colff FJ; Connell A; Sitholimela SC for their beautiful dissections 2002/3. Mr S Dexter for laparoscopic shots. Professor R Ger for photos from *Essentials of Clinical Anatomy*, Parthenon, 1986. R Hutchings, freelance photographer. Professor Kubrick for lymphatic dissections. Dr Lahiri and the Wellington Hospital Cardiac Imaging and Research Centre for EBCT scans of one of the authors. Miss Gilli Vafidis for ophthalmoscopy views. Dr Alan Hunter for a bronchoscopic view. Professor J Weir and team for images from *Imaging Atlas of Human Anatomy*, 4th edition, Elsevier, 2010. Mr T Welch for tropical pathology. University of Warwick and the West Midlands Surgical Training Centre (UK) for images of their plastinated prosection collection, funded by the West Midlands Strategic Health Authority and produced in Guben (Germany) by von Hagens Plastinations. Professor T Wright for auriscopic views.

The following figures are reproduced with kind permission of Bart's Medical Illustration Collection, previously published in *Hamilton Bailey's: Demonstrations of Physical Signs in Clinical Surgery*, 19th edition. (eds. JSP Lumley, AK D'Cruz, JJ Hoballah, CEH Scott-Conner) CRC Press, 2016:

1.3, 1.6a, 1.12, 1.18, 1.20a, 2.20, 4.3a, 4.3b, 4.18, 5.8, 5.12, 5.14, 5.15, 6.8, 6.14, 7.8, 10.6, 12.5a, 12.5c, 12.5d, 12.6, 12.19a, 12.21, 14.4b, 14.8. 14.11, 15.6c, 15.7, 15.12c, 15.12d, 15.12e, 15.13, 15.18, 15.26a, 15.26b, 15.32b, 16.3a, 16.3b, 16.3c, 16.3d, 16.11a, 16.11b, 16.11c, 16.12, 17.6a, 17.6b, 17.6c, 17.6d, 17.10, 17.16, 19.6, 19.7b, 19.11, 19.26, 20.8, 20.17, 21.3, 22.12.

Introduction

The structure of the body – the systems and organs 2

The structure of the body – the systems and organs

- Epithelial tissue 2
- Connective tissue 3
- Supporting tissue 4
- Joints 7
- Muscular tissue 9
- Nervous tissue 11
- The cardiovascular system 13
- The lymphatic system 14
- Orientation 15
- Imaging – the essentials 16
- EMQs 20

The systems and organs of the body are composed of epithelial, connective, muscular and nervous tissues.

EPITHELIAL TISSUE

Epithelium forms a protective covering over the internal and external surfaces of the body. It is derived from all three primitive embryonic layers. The ectoderm forms the skin; the mesoderm forms the pleura, pericardium and peritoneum; and the endoderm forms the endothelial lining of the blood vessels and gut.

Most glands are epithelial in origin, as they are formed by invagination of an epithelial surface. Epithelium is resistant to physical and chemical damage and the effects of dehydration. It can serve as a selective barrier and can be resistant to harmful metabolites, chemicals and bacteria. It is characterized by a minimal amount of intercellular substance and a tendency to form sheets of cells of one or more layers, having a capability of continuous replacement. It may be simple, transitional or stratified.

Simple epithelium

This consists of a single layer of cells on a basement membrane (**Figs. 0.1a–e**). It is described as squamous (pavement), cuboidal or columnar, depending on the shape of its cells. Squamous cells are found lining the alveoli of the lungs, the blood vessels (endothelium) and the serous cavities (mesothelium). Cuboidal cells line the ducts of many glands. Columnar cells are often ciliated and may be modified as mucus-forming goblet cells; they line much of the alimentary, respiratory and reproductive tracts. Mucus, a glycoprotein, accumulates in the cell and is discharged from its free (luminal) surface.

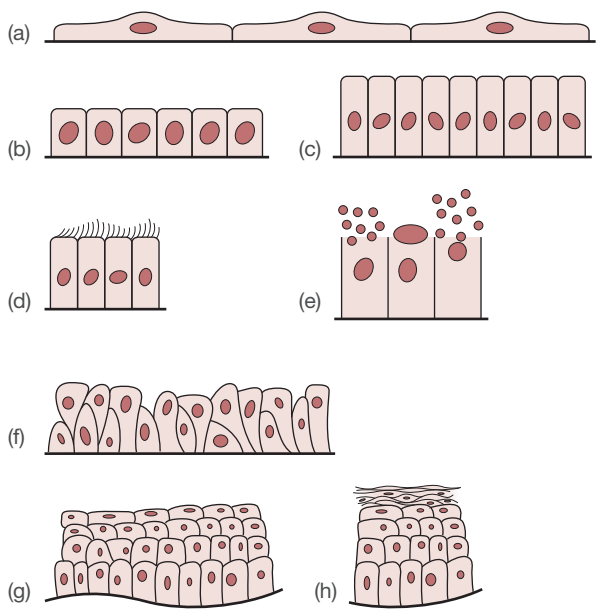


Figure 0.1 Epithelial tissue: (a) squamous; (b) cuboidal; (c) columnar; (d) columnar ciliated; (e) columnar with goblet cells; (f) transitional; (g) stratified epithelium; (h) stratified squamous epithelium

Transitional epithelium

This contains two or three layers of cells, most of which are attached to the basement membrane and are nucleated (**Fig. 0.1f**). It lines most of the urinary tract, is stretchable and does not desquamate. It contains few glands.

Stratified squamous epithelium

This also has two or more layers of cells (**Figs. 0.1g,h**). Cells in contact with the basement membrane are columnar cells.

The more superficial cells are flattened, and the surface cells have no nuclei (enucleate) and are continually being rubbed away (desquamated). This form of epithelium covers the exterior of the body, lines both ends of the alimentary tract and is particularly suited to areas exposed to wear and tear. In the upper respiratory tract the differing lengths of the columnar cells gives the appearance of a double layer, and this is known as pseudostratified columnar epithelium; it contains numerous mucous cells.

Skin

This consists of two layers, an outer **epidermis** and an inner **dermis** (corium) (Fig. 0.2). The epidermis is composed of keratinized stratified squamous epithelium. **Hair follicles**, **sweat and sebaceous glands** and **nails** are modifications of the epidermis. The colour of the skin is determined by blood flow and melanocytes, the pigment-producing cells that lie in the basal layer of the epidermis. The scales on the surface of the skin consist mainly of **keratin**, a sulphur-containing fibrous protein largely responsible for the skin's protective and barrier properties.

The dermis is a layer of vascular connective tissue moulded tightly to the epidermis and merging in its deeper part with the subcutaneous tissues. Lying in the dermis are the coiled tubular sweat glands opening on to the skin surface and hair follicles, to each of which is attached an arrector pili muscle. The roots of the hairs and the sweat glands extend into the subcutaneous tissue.

Mucous and serous membranes

These line the wet internal surfaces of the body and consist of two layers, an epithelium and a corium. The epithelium of mucous membranes is usually of a simple variety with many mucous or serous cells, but the urinary tract is lined by transitional epithelium, and the respiratory tract by pseudostratified columnar ciliated epithelium with mucous cells. The serous membranes line most of the closed body cavities. The corium underlies the epithelium and is composed of connective tissue. In the alimentary tract it contains a thin sheet of smooth muscle – the **muscularis mucosa**.

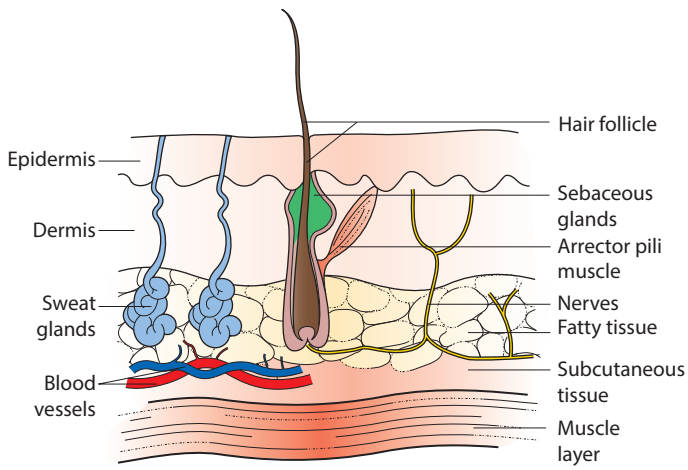


Figure 0.2 Diagram of a cross-section through the skin

Glands

These are epithelial ingrowths modified to produce secretions. These secretions may pass on to the epithelial surface (**exocrine** glands) or into the bloodstream (**endocrine** glands). Exocrine glands may be unicellular (goblet) or multicellular. The latter may be simple (containing one duct) or compound (branched) where numerous, small ducts open into a single main duct. The secretory part of the gland may be long and thin (tubular), globular (acinar), oval (alveolar) or intermediate, e.g. tubuloalveolar. The secretions of the exocrine glands may be formed by disintegration of the whole cell (holocrine, e.g. sebaceous glands), disintegration of the free end of the cell (**apocrine**, e.g. mammary glands), or without cellular damage (merocrine or **epicrine**, e.g. most other glands). Most endocrine glands are of the last type.

If the duct of an exocrine gland becomes blocked and the gland continues to secrete, the fluid accumulates and a cyst is formed. A generalized enlargement of glands is termed adenopathy.

CONNECTIVE TISSUE

This is characterized by having a large amount of intercellular substance. It forms areolar tissue, the packing material of the body, the supporting tissues (cartilage, bone) and blood (Fig. 0.3). Embryonic connective tissue is called mesenchyme.

Areolar tissue

The intercellular substance is semisolid and composed of proteins and mucopolysaccharides. Three types of fibres are found: coarse **collagen** fibres, which are white (in bulk), flexible, inelastic and arranged in bundles; **elastic** fibres, which are yellowish (in bulk), less frequent and branching; and **reticular** fibres, which form a very fine silver-staining network throughout the tissues.

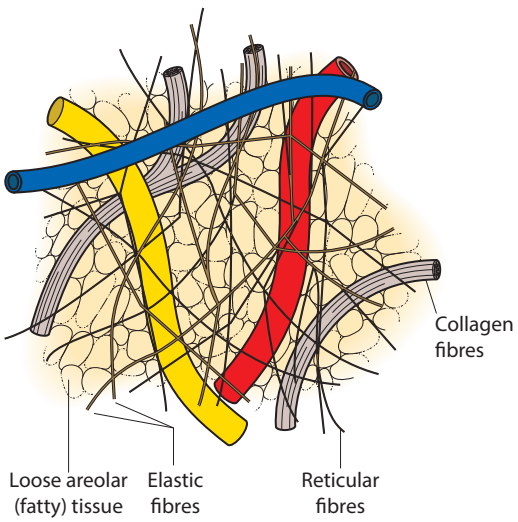


Figure 0.3 Connective tissue

The cells are of five main varieties: large, slender poorly staining fibroblasts, closely concerned with the production of the three types of tissue fibre; tissue macrophages, which are phagocytic and can engulf particulate matter; oval plasma cells with their cartwheel-like staining nucleus, concerned with antibody production; granular basophilic mast cells, concerned with histamine and heparin production; and the cyst-like fat-containing cells.

The relative amounts of cellular and intercellular substance vary throughout the body. Subcutaneous tissue contains a variable amount of fat and loose fibrous tissue. Superficially, fat is usually predominant, but more deeply the fibrous tissue forms a well-defined superficial fascial sheet connecting it to the deep fascia that invests the limbs and trunk. In other places condensations of non-elastic fibrous tissue form **ligaments**, **tendons** and **aponeuroses**, and **retinacula**. Ligaments are usually attached to the bones on each side of a joint, maintaining its stability; tendons join the muscles to the bones by blending with the periosteum; aponeuroses are thin flattened tendinous sheets through which muscles gain wider attachments. Retinacula are usually thickenings of the deep fascia related to joints.

SUPPORTING TISSUE

Cartilage

This is an avascular, firm tissue composed of cells (chondrocytes) in an abundant intercellular substance (matrix) (Fig. 0.4). It is formed from an overlying fibrous layer, the perichondrium, and classified, according to its predominant fibres, into hyaline cartilage, fibrocartilage and yellow elastic cartilage.

- **Hyaline cartilage** contains many cells and a few fine collagen-like fibres, and is found in the rib cartilages and over most articular surfaces. It also forms the precursor in cartilaginous ossification.
- **Fibrocartilage** contains many dense fibrous bundles and fewer cells, and is present in the intervertebral discs, over the articular surface of bones that ossify in membranes, e.g. the mandible, and in intra-articular cartilages, e.g. the menisci of the knee.
- **Yellow elastic cartilage** contains elastic fibres and is found in the auricular, epiglottic and the apices of the arytenoid cartilages of the head.

Bone

This is a hard supporting tissue composed mainly of inorganic calcium salts impregnating a network of collagen fibres (Fig. 0.5). The basic unit, composed of concentric layers around a central vessel, is known as a **Haversian system**. The bone cells (osteocytes) lie within spaces (lacunae) between the layers and their processes pass into canaliculi in the bone. **Compact bone** is dense and strong and forms the outer part of most bones. The **cancellous** (spongy) bone within consists of a network of thin partitions (trabeculae) around intercommunicating spaces; the osteocytes lie within lacunae in the trabeculae. The outer surface of a bone is covered by a thick fibrous layer, the **periosteum**, many of the cells of which are the granular, bone-forming **osteoblasts**. These cells, when enclosed in the hard intercellular substance, become osteocytes. The blood supply of bone is from the periosteum and muscular vessels and, in the case of long bones, from one or two nutrient arteries that enter the shaft.

The shape of the bones of the body, the proportion of compact to cancellous tissue and the architecture of the trabeculae are arranged to give maximum strength along with economy of material. Both genetic and local factors influence the shape and size of a bone. Adjacent muscles or organs (e.g. the brain) mould the bone to some extent.

Many of these factors can be investigated in the living person by means of X-rays.

Bones are classified as long, short, flat, sesamoid or irregular (Fig. 0.6).

Long bones are present in the limbs. The body (shaft) is a cylinder of compact bone surrounding a medullary cavity

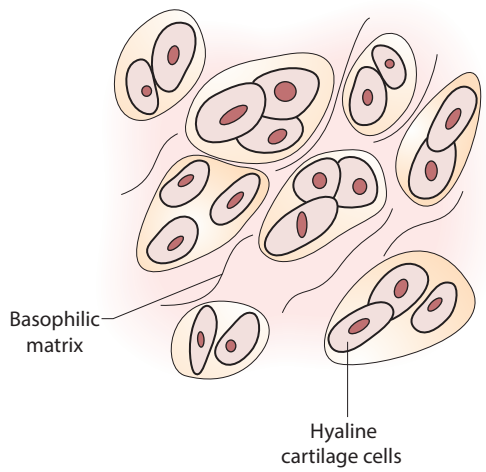


Figure 0.4 Hyaline cartilage

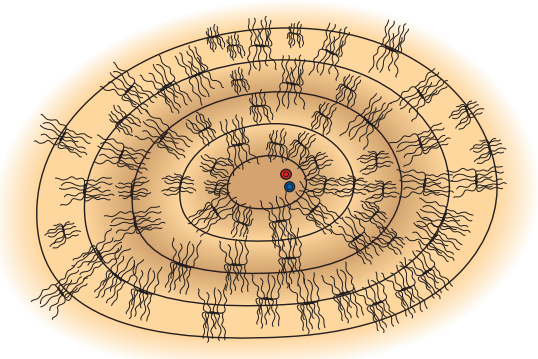


Figure 0.5 Haversian bony systems with osteoblasts in circular layers with central canals carrying nutrient vessels

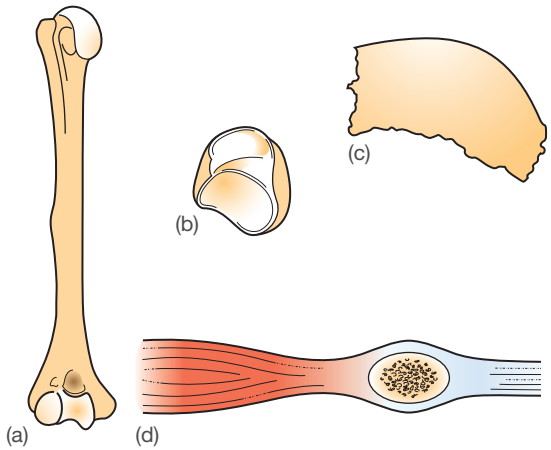


Figure 0.6 Bone types: (a) long bone (humerus); (b) irregular bone (lunate); (c) flat bone (from vault of skull); (d) sesamoid bone, a small pebble-like bone within a tendon, e.g. in the tendon of flexor hallucis longus beneath the head of the first metatarsal

that is filled with some cancellous bone and a large amount of yellow fatty marrow. The two ends are formed of spongy bone with a thin outer shell of compact bone. The trabeculae in the cancellous bone are laid down along the lines of force. In the developing long bone of a child but not normally in the adult, blood-forming tissue is found in the marrow.

The **short bones** are found in the carpus and tarsus. They consist of spongy bone covered with a thin layer of compact bone.

The **flat bones**, e.g. the scapula, give attachment to muscles and form a protective covering (the bones of the skull vault). They consist of two layers of compact bone with a thin intervening spongy layer (the diplöe in the skull).

Sesamoid bones are formed within tendons and serve to relieve friction and to alter the line of pull of a muscle. The largest sesamoid bone is the patella.

The remaining **irregular bones** may contain red, blood-forming marrow (the vertebrae), or air spaces (sinuses) (Fig. 0.7).

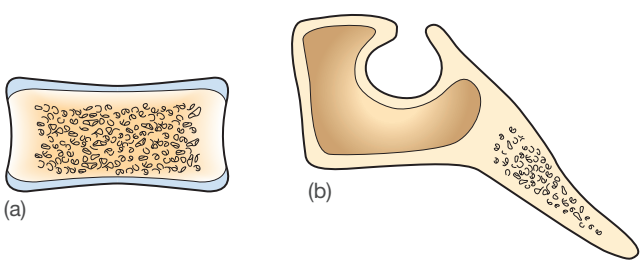


Figure 0.7 (a) Cancellous bone, e.g. within the centre of a vertebral body, surrounded by a layer of compact bone. (b) Pneumatized bone, e.g. the skull sinuses around the nasal cavity

Excessive force applied to a bone may cause it to break (fracture), and in such injuries the adjacent soft tissues may be damaged both by the force and by the broken ends of the bone. Knowledge of the anatomical relations of the bone enables the clinician to predict the likely association of nerve, artery and muscle injury with a fracture. A break in the overlying skin is a serious complication of fractures, as it permits the entry of infecting organisms. In these circumstances the fracture is said to be compound (Fig. 0.8).

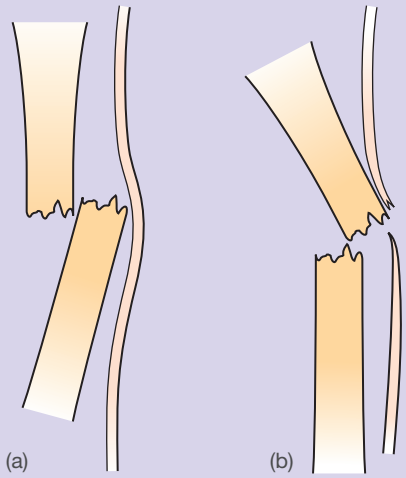


Figure 0.8 Fracture: (a) simple; (b) compound. In the latter the overlying skin has been lacerated. This is much more serious because bacterial infection can enter the bone, with possible long-term sequelae

Ossification

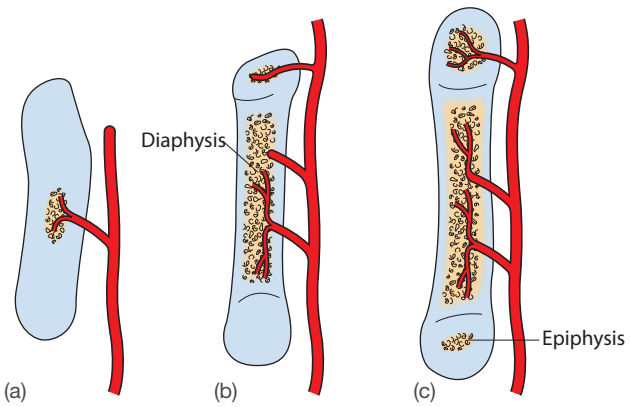
Bone may develop either (i) in a condensed fibrous tissue model, when the process is called **membranous** (mesenchymal) ossification, or (ii) in a cartilage model that has replaced the mesenchyme, when the process is called **cartilaginous** (endochondral) ossification.

Mesenchymal ossification usually starts in the 5th to 6th weeks of intrauterine life and is found in the bones of the skull vault, the bones of the face and part of the clavicle.

Cartilaginous ossification occurs in all long bones except the clavicle. A primary centre appears for the body of a long bone in about the 8th week of intrauterine life, and secondary centres for each end appear between birth and puberty. Fusion of the body and these centres occurs in about the 18th year in males. Secondary centres appear and fuse up to a year earlier in females. Further ossification centres may develop at puberty in areas of major muscle attachment, e.g. the processes of the vertebrae and the crests of the scapula and the hip. They fuse with the rest of the bone by about the 25th year.

Development of a long bone

A long bone develops from a cartilaginous model possessing an outer perichondrium and an irregular cartilaginous matrix; the deep layers of the perichondrium have bone-forming properties (Fig. 0.9).



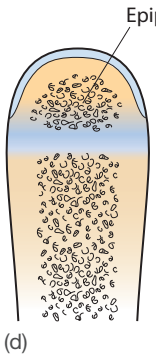


Figure 0.9 (a)–(d) Ossification of a long bone. The ossification starts in the shaft of the bone, usually during uterine life. Secondary centres start in the epiphysis, one end often preceding the other, and appear after puberty. (e) Staining techniques show ossification in the fetal long bones and skull. The shafts are already ossified but the secondary epiphyseal centres are not visible as they only appear after birth. Note that the wrist, elbow, shoulder, knee and hip joints are still cartilaginous

The first changes occur in the cartilage cells of the middle of the body (the **diaphysis**). They become greatly enlarged and the matrix is correspondingly reduced and calcified. The cells die and undergo shrinkage, leaving spaces known as primary alveoli. The deeper layer of **perichondrium** around the middle of the body starts to produce bone, and is then known as the **periosteum**. Blood vessels and bone cells (the bone-forming osteoblasts and the bone-removing osteoclasts) pass inwards from the periosteum to the calcified zone. The cartilage is not converted into bone but is replaced by it after its removal by the osteoclasts. The multinucleated osteoclasts initiate absorption of the calcified material, producing larger spaces, the secondary alveoli. Osteoblasts come to line the secondary alveoli and layers of bone are deposited. Some osteoblasts are incorporated into the bone, becoming the bone cells (**osteocytes**). Ossification extends up and down the body from this primary centre. The cells of the adjacent cartilage come to lie in parallel longitudinal rows and are subsequently replaced in the manner already described. This form of ossification is known as endochondral (cartilaginous).

Secondary centres of ossification (the **epiphyses**) appear later in life. Osteogenic cells invade the calcified cartilage after the cells have undergone hypertrophy, death and shrinkage. The layer of cartilage left between the epiphysis and the diaphysis is known as the **epiphyseal plate**. The part of the diaphysis bordering the plate is known as the **metaphysis**; the cartilage adjacent to the metaphysis is continually being ossified. New cartilage cells are formed in the epiphyseal plate. Growth in length of the bone continues until the cartilage cells stop multiplying, and fusion of the diaphysis and epiphysis then occurs. The internal architecture of the bone is remodelled by osteoclastic and osteoblastic activity. Simultaneous laying down of layers of bone around the body by the periosteum increases the girth of the bone and is known as **subperiosteal ossification**; it is a form of mesenchymal ossification. Growth and remodelling of the bone continues until adulthood through continuous destruction by osteoclasts and replacement by osteoblasts.

Epiphyses may be classified into three types: **pressure** epiphyses, seen at the ends of weight-bearing bones; **traction** epiphyses occurring at the site of muscle attachments; and '**atavistic**' epiphyses, which are functionless skeletal remnants that may show on an X-ray and be mistaken for disease or injury.

Injury in a young person can dislodge the epiphysis from the metaphysis; e.g. a fall on the outstretched arm may produce a slipped epiphysis of the lower end of the radius. This injury may interfere with further growth at that end of the bone.

In summary, most primary ossification centres of long bones appear by the end of the second month of intrauterine life, and most epiphyseal centres before puberty. The epiphyses at the knee joint appear just before birth and are an indication of the age of the fetus. Most long bones cease to grow in length between the 18th and 20th years in men, and a year or so earlier in women.

The skeleton

The skeleton is divisible into an **axial** part (the bones of the head and trunk) and an **appendicular** part (the bones of the limbs). The upper limb is joined to the trunk by the mobile muscular pectoral girdle, and the lower limb by the stable bony pelvic girdle.

JOINTS

These are unions between two or more bones and may be of four types: bony, fibrous, cartilaginous or synovial.

Bony

The three elements of the hip bone are joined by bony union, as are the occipital and the sphenoid in the skull after completion of the second dentition (Fig. 0.10).

Fibrous

The bony surfaces are united by fibrous tissue. These joints comprise the skull sutures, the articulations of the roots of the teeth and the inferior tibiofibular joint (Fig. 0.11).

Cartilaginous

These may be primary or secondary. In the primary cartilaginous joints the bony surfaces are united by hyaline cartilage, as seen in the union of the body and the ends in a developing long bone (Fig. 0.12).

In the secondary cartilaginous joints, the symphyses (Fig. 0.13), the bony surfaces are covered with hyaline cartilage and united by a fibrocartilaginous disc. These joints all lie in the midline and comprise the intervertebral discs, the symphysis pubis and the manubriosternal and xiphisternal junctions.

Synovial

The bony articular surfaces (facets) are covered with **hyaline cartilage** (with the exception of the temporomandibular and sternoclavicular joints, where they are covered with fibrocartilage) (Fig. 0.14). A fibrous **capsule** is attached near to the articular margins of the bones. The surfaces of the interior of the joint, except those covered by cartilage, are lined by a delicate vascular **synovial membrane**, which secretes a lubricating **synovial fluid** into the joint cavity.

The capsule may possess **ligamentous thickenings**, and accessory extracapsular and intracapsular **ligaments** may pass across the joint. Fibrous intra-articular **discs** are present in some joints, occasionally completely dividing their cavity (e.g. temporomandibular joint). **Tendons** occasionally enter the joint cavity by piercing the capsule (biceps brachii), and

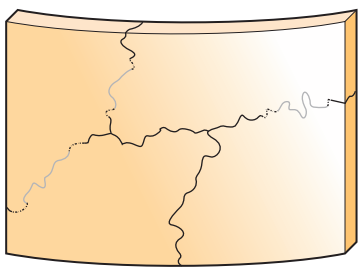


Figure 0.10 Bony joints between the skull bones. These ossify and disappear later in life

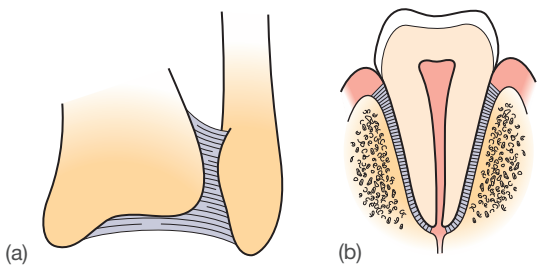


Figure 0.11 Fibrous joints where two bones are attached by fibrous tissue: (a) inferior tibiofibular joint; (b) tooth socket, where the enamel is attached to the surrounding bone by fibres of the periodontal ligament

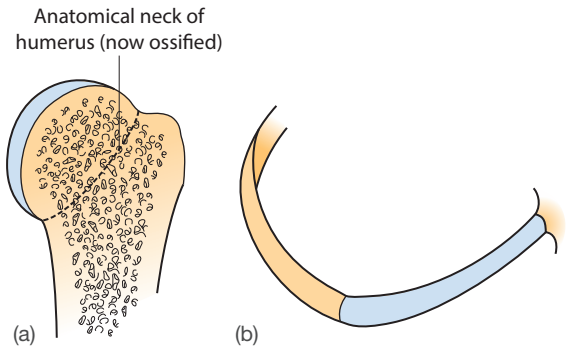


Figure 0.12 Primary cartilaginous joints: (a) union of epiphysis and metaphysis (dotted line); originally hyaline cartilage, now ossified; (b) union between rib and costal cartilage

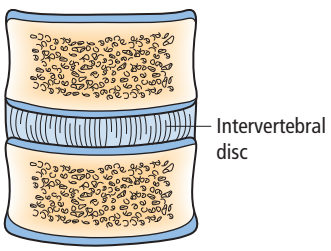


Figure 0.13 Secondary cartilaginous joint where the bone is covered by hyaline cartilage and the two surfaces are joined by a fibrocartilaginous disc. These occur in the midline and include the intervertebral, symphysis pubis and manubriosternal joints

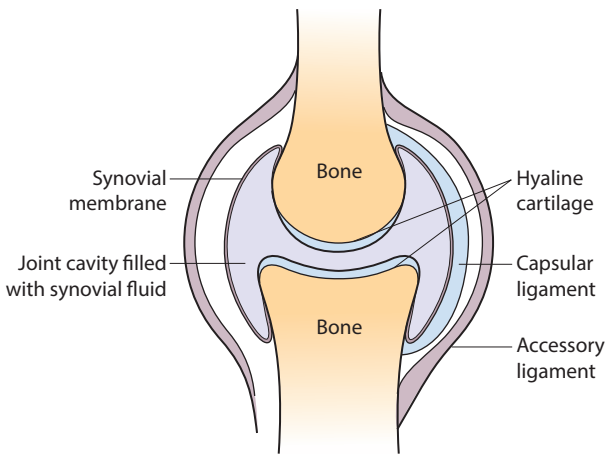


Figure 0.14 Synovial joint

fat pads may be present between the capsule and the synovial lining (knee joint).

Muscles or tendons crossing superficial to the joint may be protected by a synovial sheath or sac whose fluid prevents excessive friction. The sacs are known as **bursae**, and the cavity may communicate with that of the joint.

Functional aspects of joints

Movement

Bony, fibrous and primary cartilaginous joints are immobile, secondary cartilaginous joints are slightly mobile and synovial joints are freely mobile.

Synovial joints are subdivided into a number of varieties according to the movements possible at the joint. These varieties are listed below and the movements are best understood by examining the examples given.

- **Hinge** – elbow, ankle and interphalangeal joints; the knee and temporomandibular joints are modified hinge joints (**Fig. 0.15**)
- **Pivot** – the proximal radioulnar joint and the dens articulation of the atlantoaxial joint (**Fig. 0.16**)
- **Condyloid** – metacarpophalangeal joint (**Fig. 0.17a**)
- **Ellipsoid** – radiocarpal (wrist) joint (**Fig. 0.17b**)
- **Saddle** – carpometacarpal joint of the thumb (**Fig. 0.18**)
- **Ball and socket** – hip and shoulder joints (**Fig. 0.19**)
- **Plane** – intercarpal joints and joints between the articular processes of adjacent vertebrae (**Fig. 0.20**).

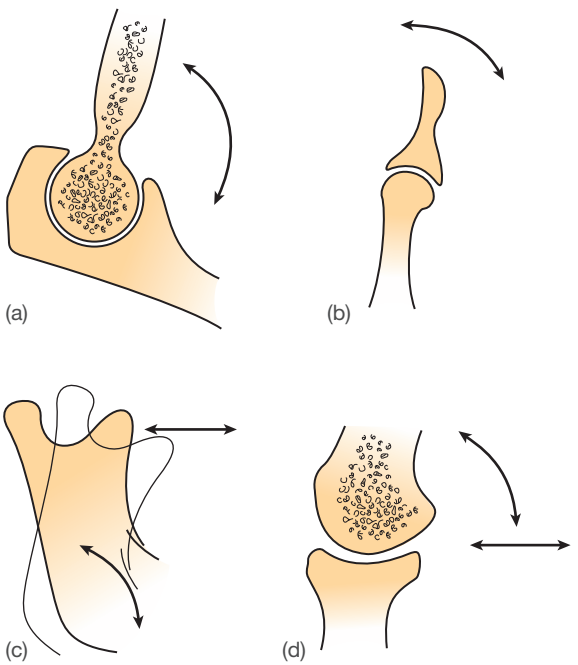


Figure 0.15 Hinge joints: (a) elbow and (b) interphalangeal joints, allowing flexion–extension in a single plane. The temporomandibular joint (c) and knee joint (d) are modified hinge joints with flexion and extension in a single plane but with a little rotation or gliding in the lax position of the capsules

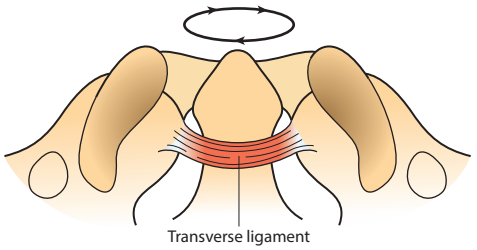


Figure 0.16 Pivot joint: horizontal view of the atlantoaxial joint. The odontoid process of the axis rotates with the anterior articular facet of the atlas anteriorly and transverse ligament posteriorly

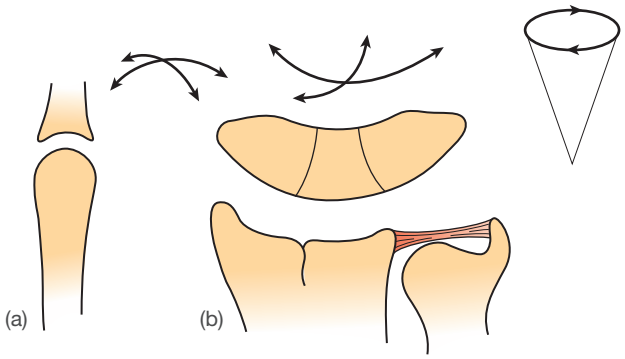


Figure 0.17 (a) Condyloid joint, e.g. metacarpophalangeal joint. (b) Ellipsoid joint of the wrist (radiocarpal) joint. These joints move in two planes: flexion–extension and abduction–adduction. Circumduction is a combination of all of these movements where the distal part of the limb can rotate around the pivot point or the centre of the joint

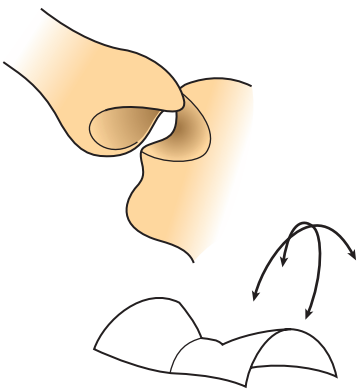


Figure 0.18 Saddle joint. The carpometacarpal joint of the thumb is shaped like the saddle of a horse where the rider can slide off from side to side as well as move backwards and forwards

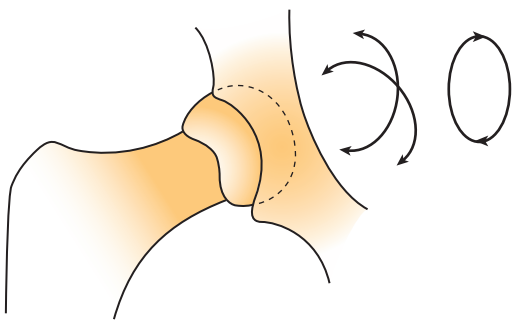


Figure 0.19 Ball and socket joint, e.g. the hip. The hip joint has all the movements of the condyloid joint and in addition the head can rotate within the socket, i.e. there is additional medial and lateral rotation

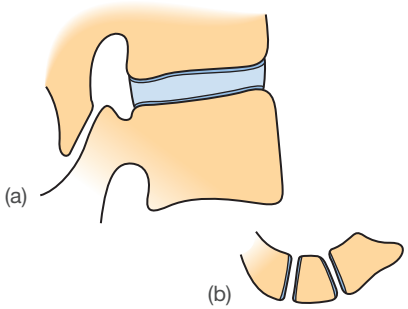


Figure 0.20 Joint movements. (a) In a secondary cartilaginous joint, e.g. in the symphysis pubis or an intervertebral joint, there is the possibility of slight stretching and movement. The symphysis softens in pregnancy and allows slight adaptation of the pelvic form during parturition. (b) Plane joints allow a little gliding of the adjacent joints, e.g. in the carpus

Stability

Stability depends on bony, ligamentous or muscular factors. It is usually inversely related to the mobility of the joint.

Many of these functional aspects of joints may be assessed by radiology. Displacement of the articulating surfaces of a joint is known as dislocation. Partial displacement of the articulating surfaces is known as subluxation. Dislocation of a joint may follow severe injury and is always associated with damage to the capsular and accessory ligaments. There may also be fractures of the bony structures of the joint, and occasionally damage to closely related nerves and vessels. Chronic inflammatory processes are prone to affect the bone ends (osteoarthritis) and synovial membrane (rheumatoid arthritis), and joints thus affected may be deformed and painful (**Figs. 0.21a,b**), with marked limitation of movement.

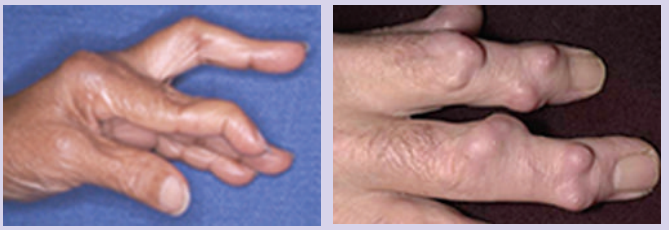


Figure 0.21 (a) Rheumatoid arthritis producing marked deformity. (b) Osteoarthritic disease is less marked in the hand but may be accompanied by skin nodules called Osler's disease

Nerve supply

The capsule and ligaments of a joint contain pain, proprioceptive and stretch fibres: these provide information on the position of the joint and any abnormal forces. The nerve supply of a joint is from the nerves supplying the muscles acting on the joint.

MUSCULAR TISSUE

This is a contractile tissue. There are skeletal, smooth and cardiac varieties.

Skeletal (striated, voluntary) muscle

This acts mainly on the bony skeleton or as a diaphragm, but it is also found around the pharynx and larynx, and forms some sphincters (**Fig. 0.22**). It is composed of unbranched fibres of sarcoplasm limited by a membrane, the sarcolemma, and contains many nuclei. Each fibre has a motor endplate and contains many contractile units, the myofibrils, which have

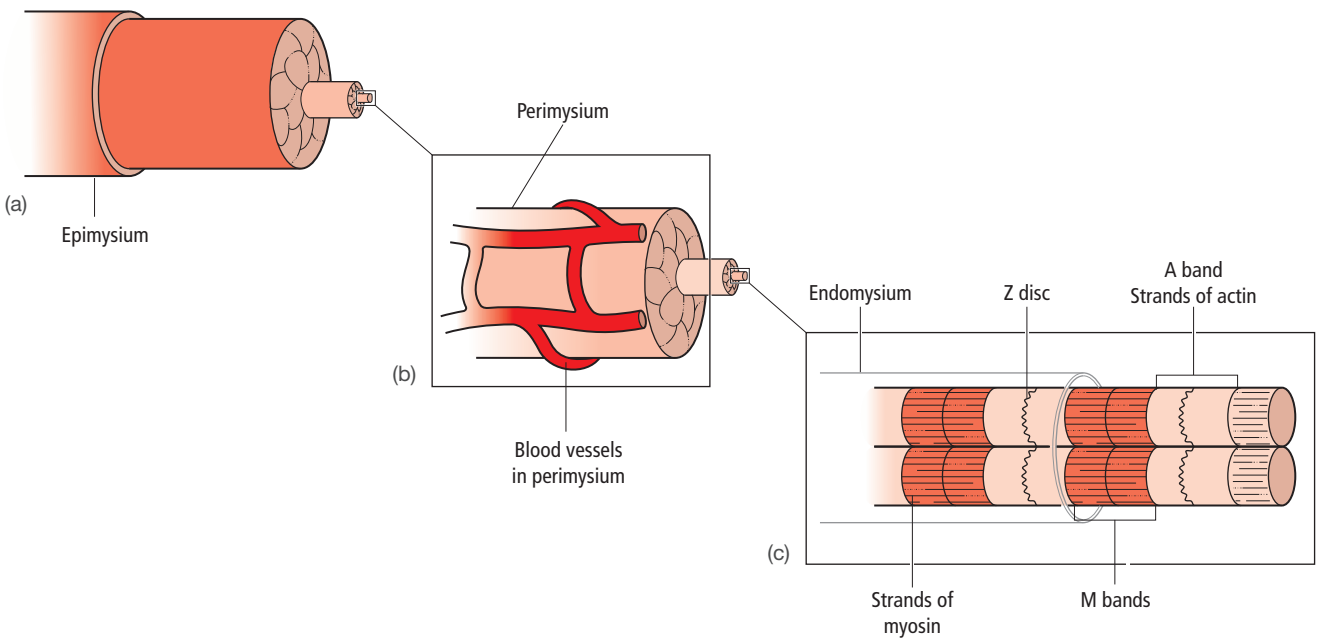


Figure 0.22 Muscle fibres of striated muscle [(a), (b) and (c) showing increasing magnification]: (a) epimysium surrounding muscle bundles; (b) muscle bundles surrounded by perimysium containing nutrient blood vessels and nerves; (c) muscle fibres contained within endomysium. The strands of myosin and actin interlock during muscle contraction in a similar fashion to Velcro

alternating dark (A) and light (I) bands. A dark line (the Z disc) crosses the middle of the I band. The bands of adjacent myofibrils coincide, giving the muscle fibre its striated appearance. Each fibre is enveloped and attached to its neighbour by a fibrous endomysium, and bundles of fibres are enclosed by a fibrous perimysium. A muscle composed of many bundles is surrounded by an epimysium.

The motor nerve supply of the muscle comes from the anterior horn cells of the spinal cord and the motor nuclei of the brainstem. The sensory supply arises in the more specialized spindles and tendon organs as well as the simpler touch and pain endings. Impulses from the sensory endings pass into the posterior horn of the spinal cord.

Skeletal muscles are formed by voluntary fibres. The muscles are usually attached at each end to bone, by the periosteum, either directly or through **tendons** and **aponeuroses**, and cross one or more joints. Occasionally two muscles meet at a common stretchable union known as a **raphé**, e.g. the mylohyoid muscles (**Fig. 0.23g**). Muscles have a very rich blood supply.

Muscle fibres are arranged either **parallel** (**Fig 0.23a**) to the direction of the action (sartorius), or **obliquely** to it (known as **pennate** muscles). **Unipennate** muscles (extensor digitorum longus) have oblique fibres inserted into one side of a side tendon (**Fig. 0.23c**). In **bipennate** muscles (rectus femoris) oblique fibres are inserted into each side of the tendon (**Fig. 0.23d**). A **multipennate** muscle has a number of parallel bipennate tendons (deltoid) or is a circular muscle with a central tendon (tibialis anterior). In muscles of equal volume, a parallel arrangement of fibres gives greater movement but less power than an oblique arrangement. The least mobile attachment of a muscle is often called its **origin**, and the more mobile attachment its **insertion**. However, this is an arbitrary distinction, so reference in the text here is made to muscle **attachments**, rather than to origin or insertion. An **aponeurosis** (**Fig. 0.23f**) is a flat, thin tendinous expansion providing a wide attachment, as seen in the abdominal wall muscles.

When a movement occurs at a joint, the muscles concerned in producing it are known as the prime movers or agonists and those opposing it as antagonists. Muscles contracting to steady the joint across which movement is occurring are known as synergists. A further type of action is known as the action of paradox, in which a muscle gradually relaxes against the pull of gravity, e.g. bending forwards produced by relaxing the back muscles.

Smooth (unstriated, involuntary) muscle

This is present in the walls of most vessels and hollow organs of the body. It is composed of unbranched spindle-shaped cells with a single central nucleus and containing many unstriated myofibrils (**Fig. 0.24**). The fibres are arranged in interlacing bundles and are supplied by the autonomic nervous system.

Cardiac muscle

This is found in the heart. It consists of short, branched cylindrical fibres joined end to end (**Fig. 0.25**). The adherent ends of adjacent fibres form dark intercalated discs. Each fibre contains a single central nucleus and striated myofibrils resembling those of voluntary muscle. It is supplied by the

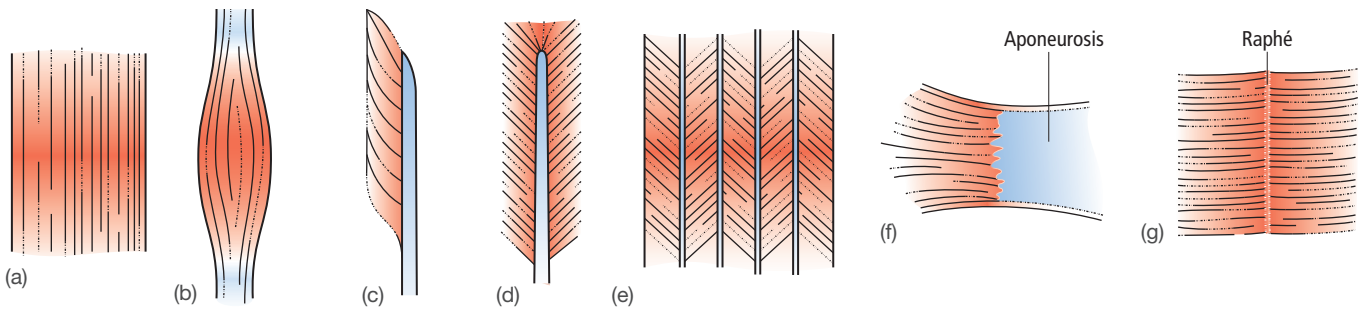


Figure 0.23 Types of striated muscle: (a) parallel (quadrate); (b) fusiform; (c) unipennate; (d) bipennate; (e) multipennate; (f) flat muscle inserted into a tendinous sheet (aponeurosis); (g) two muscles attached to each other along a raphé

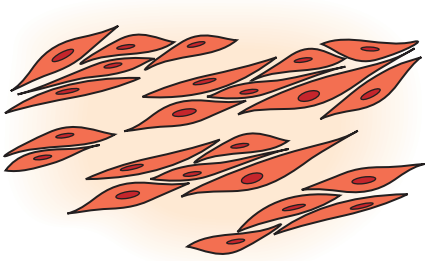


Figure 0.24 Smooth muscle fibres contained within a loose muscle bundle

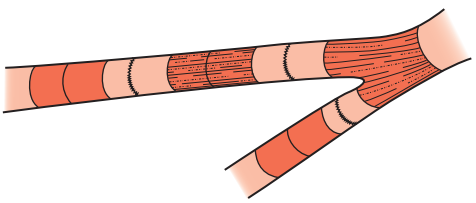


Figure 0.25 Cardiac muscle showing the striations of striated muscle and branching, producing a continuous network of muscle

autonomic nervous system, but heart muscle also has the properties of spontaneous and rhythmic activity. The conducting system of the heart is made up of modified cardiac muscle cells.

NERVOUS TISSUE

This is capable of excitability and conductivity. It consists of excitable cells (**neurons**) (Fig. 0.26) and supporting cells, which in the central nervous system are the **neuroglial cells** and in the peripheral nervous system are the **Schwann cells**.

The neuron is the functional unit of the nervous system and consists of a cell body and processes, usually an **axon** and one or more **dendrites**. The cell bodies are situated in the central nervous system or in peripheral ganglia. They possess a large nucleus and well-marked cellular inclusions. The axon (fibre) begins at a small axon hillock on the cell body and carries impulses away from the cell body. This often long, slender process ends by dividing into many branches that have small terminal knobs, **boutons**, related to the cell bodies or branches of other neurons. The relationship is known as a **synapse** and may be either facilitatory or inhibitory, depending on the neuron of origin, and possibly on the receptor area of the second neuron. A rather specialized synapse is formed when a nerve ends on a muscle fibre at a **motor endplate**.

Axons may give off one or more short collateral branches. They are myelinated or unmyelinated. The myelin is interrupted about every millimetre or so by a constriction called the **node of Ranvier**. In the peripheral nervous system each internodal segment of sheath is produced by a **Schwann cell**, the nucleus of which is seen on its surface. These cells play an important role in peripheral nerve regeneration. Fibres of the peripheral nervous system are also covered by a thin fibrous membrane, the **neurilemma**. In the central nervous system oligodendroglia take the place of the Schwann cells. Dendrites are usually short unmyelinated processes carrying membrane depolarizations to the cell body. The volume over which the dendrites of a single cell extend is known as the dendritic field.

Afferent neurons carry information towards the central nervous system, and efferent neurons carry instructions away from it. Within the central nervous system afferent and efferent neurons are often connected by many intercalated (internuncial or intermediate) neurons.

The neurons are organized to form the central and peripheral nervous systems. The former comprises the brain and spinal cord (Fig. 0.27) and the latter the cranial nerves, spinal nerves and autonomic nervous system (see below). A group of neurons in the central nervous system is called a **nucleus**, and outside the central nervous system (CNS) such a group is known as a **ganglion**. Within the CNS are neuroglial cells, variously known as **astrocytes**, **oligodendroglia** and **microglia**, and these make up almost half of the brain substance.

Astrocytes are stellate cells with large nuclei and numerous processes, which may be of the thick protoplasmic variety, as found mainly in the grey matter, or the thin fibrous variety found mainly in the white matter. Some of the processes end on blood vessels, and the astrocytes are thought to be concerned with fluid balance in the central nervous system and with the nutrition of the neurons. Oligodendroglia are oval dark-staining cells possessing few processes. They produce the myelin of the central nervous system. Microglia are small mobile phagocytic cells and form part of the macrophage system.

Ependymal cells are columnar in shape and line the cavities of the brain and spinal cord. In certain regions the ependyma is modified to form the choroid plexuses of the brain, which produce the cerebrospinal fluid.

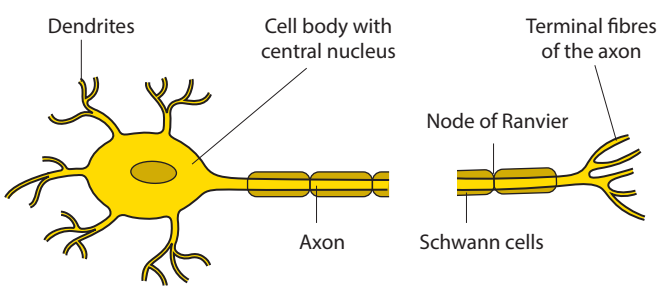


Figure 0.26 Neuron

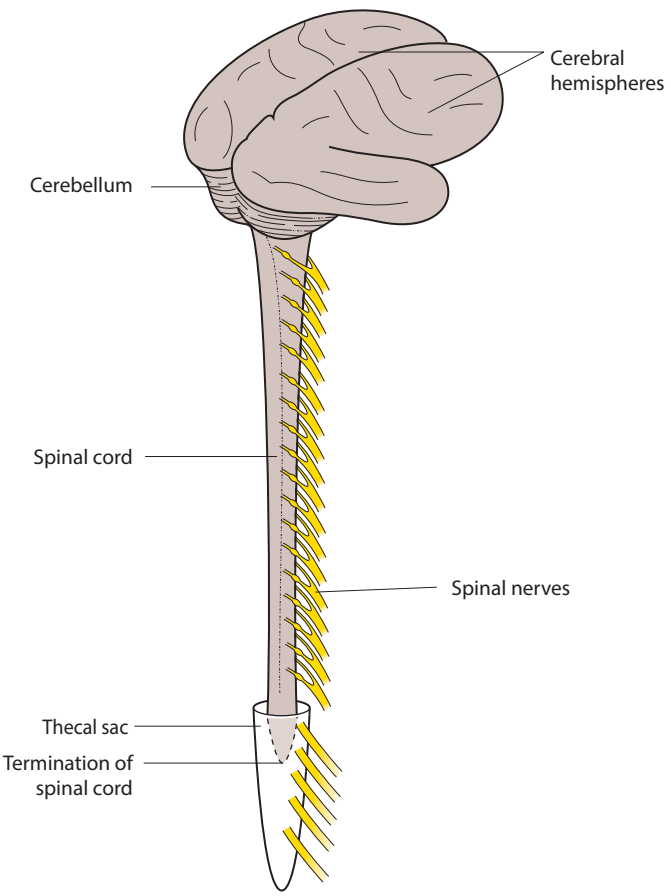


Figure 0.27 Brain and spinal cord

Cranial nerves

Twelve pairs of nerves are attached to the brain (p. 360). Some are mainly sensory, some mainly motor, and others are mixed sensory and motor.

Spinal nerves

The 31 paired spinal nerves (8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal) (**Fig. 0.27**) are formed within the vertebral canal, each by the union of a ventral and a dorsal root. The roots are formed from a number of rootlets that emerge from the anterolateral and posterolateral sulci of the spinal cord. The **ventral root** carries efferent (motor) fibres *from* the cord and the **dorsal root** carries afferent (sensory) fibres *to* the cord. The cell bodies of the sensory fibres are situated in a **ganglion** on the dorsal root (**Fig. 0.28**). The spinal nerves are therefore a mixture of motor and sensory fibres. Each nerve leaves the vertebral canal through an intervertebral foramen and soon divides into a large **ventral** and a smaller **dorsal ramus** (branch).

The adjacent ventral rami of most regions communicate to form **plexuses** (cervical, brachial and lumbosacral), whereas those of the thoracic region become the intercostal and subcostal nerves. The dorsal rami pass backwards into the postvertebral muscles and divide into medial and lateral branches. These rami supply the muscles and skin over the posterior aspect of the body, but give no branches to the limbs.

Tumours within the vertebral canal or a protrusion from a degenerate intervertebral disc may compress a spinal nerve and, occasionally, the spinal cord to produce segmental sensory and motor dysfunction. Knowledge of the anatomical distribution of the individual nerves enables the site of the disease to be identified.

Local anaesthetic agents produce reversible regional loss of sensation, reduce pain and thus facilitate surgical procedures. Infiltrative local anaesthetics permit biopsy of skin lesions and excision of skin and subcutaneous lesions. The anaesthetic agent is injected into the skin, which has been sterilized with alcohol or a povidone–iodine solution, over and around the lesion to be biopsied or excised and into the subcutaneous tissue surrounding it. This will allow, after 2 minutes, the procedure to be carried out painlessly. Sensation will return within 2 hours.

Autonomic nervous system

The motor part of this system innervates glands and smooth and cardiac muscle. Its fibres form a fine network on the blood vessels and in the nerves. All its fibres arise from neurons of the visceral columns of the brain and spinal cord and synapse with **peripheral ganglion** cells before reaching the organs they supply. This fine network is divisible into two complementary parts, **sympathetic** and **parasympathetic**, which leave the central nervous system at different sites. They usually have opposing effects on the structure they supply through endings, which are mainly adrenergic or cholinergic.

Sympathetic system

Each ventral ramus from the 1st thoracic to the 2nd lumbar nerve gives a bundle of myelinated (preganglionic) fibres to the **sympathetic chain or trunk** (**Fig. 0.28**). The bundles arise near the formation of a ramus and are called **white rami communicantes**; they form the sympathetic outflow of the central nervous system. Each ventral ramus later receives a bundle of unmyelinated (postganglionic) fibres from the sympathetic trunk – a **grey ramus** communicans. (The myelinated and unmyelinated fibres are also termed the white and grey rami communicantes, respectively.)

The peripheral ganglia of the system lie within the two parallel sympathetic trunks alongside the vertebral column. The trunks extend from the base of the skull to the coccyx and have 3 cervical, 12 thoracic, 4 lumbar and 5 sacral ganglia. The preganglionic fibres from the thoracolumbar outflow

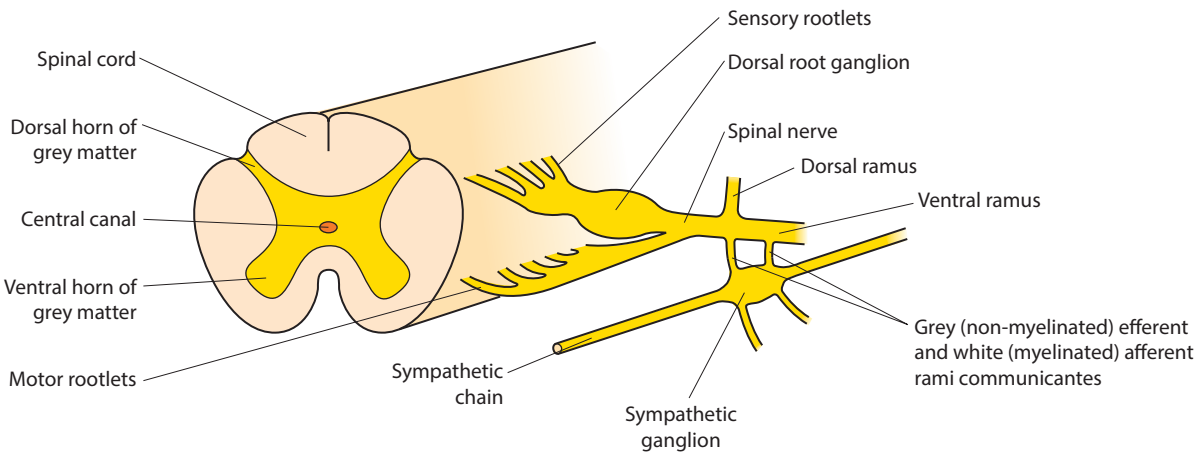


Figure 0.28 Typical spinal nerve formation and connections to the sympathetic ganglia and chain. The ventral motor rootlets unite to form a ventral motor root, joining with the dorsal sensory root, which comes from the sensory rootlets and dorsal root ganglion of each spinal segment. The 'mixed' spinal nerve then divides into a dorsal and a ventral primary ramus. The dorsal rami supply the back whereas the larger ventral rami supply all the limbs and trunk. The sympathetic ganglia are connected to the ventral rami via white (presynaptic) rami communicantes and grey (postsynaptic) rami

may synapse (i) in the adjacent ganglion, (ii) in other ganglia higher or lower in the chain, or (iii) in the collateral ganglia situated in the plexuses around the aorta (e.g. coeliac plexus). Each preganglionic fibre may synapse with 15 or more ganglionic cells, thus giving rise to widespread activity. A number of preganglionic fibres end in the medulla of the suprarenal gland.

Postganglionic (unmyelinated) fibres may (i) return to a spinal nerve in a grey ramus communicans to be distributed to peripheral smooth muscle, e.g. arterial walls, (ii) pass along the major arteries and their branches to be distributed to the organs these supply, or (iii) form named nerves, e.g. cardiac, running to the viscus concerned.

The cell bodies of the sympathetic fibres supplying the upper and lower limbs are situated in ganglia in the cervicothoracic and lumbosacral regions, respectively.

Chemical destruction or surgical removal of these ganglia may be undertaken to improve the cutaneous blood supply of the limb or to reduce excessive sweating.

The visceral branches supply the smooth circular muscle, including the sphincters of the viscera.

Parasympathetic system

This system receives preganglionic fibres from four cranial nerves (oculomotor, facial, glossopharyngeal and vagus) and the 2nd, 3rd and 4th sacral spinal nerves (**craniosacral outflow**). The peripheral ganglia of this system are near the organs they supply, usually in its walls. There are, however, four well-defined, isolated, parasympathetic ganglia associated with the cranial nerves. The postganglionic fibres are usually short and unmyelinated. The visceral branches usually supply the smooth muscle responsible for emptying the organ, and also produce dilatation of the blood vessels. There is little evidence of parasympathetic supply to the limbs.

Afferent (e.g. pain) fibres from the viscera are present in both sympathetic and parasympathetic systems and pass to the central nervous system without synapsing. Their subsequent paths are similar to those of somatic pain. Afferent (reflex) fibres, e.g. from the lungs, heart and bladder, and visceral sensations of nausea, hunger and rectal distension, also reach the central nervous system, probably along parasympathetic pathways.

Most transmitter chemicals can be classified as adrenergic (for the sympathetic system) or cholinergic (for the parasympathetic system).

THE CARDIOVASCULAR SYSTEM

The cardiovascular system comprises the heart and blood vessels, **arteries**, **veins**, **capillaries** and **sinusoids**. The arteries and veins passing to organs and muscles are usually accompanied by the nerves, and together form a compact **neurovascular bundle**.

The walls of the arteries possess three coats (Fig. 0.29a): the intima, composed of an **endothelial** lining and a small amount of connective tissue; the **media**, which is composed mainly of elastic tissue in the larger arteries and almost entirely of smooth muscle in the small **arterioles** and medium-sized

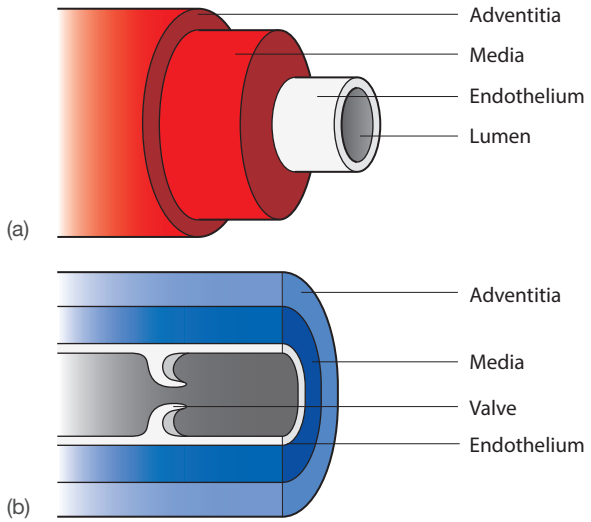


Figure 0.29 Structure of (a) an artery, and (b) a vein

arteries; and the outer fibrous **adventitia**. The coats of the veins correspond to those of the arteries (Fig. 0.29b), but the media contains less smooth muscle and fewer elastic fibres. In the larger veins the adventitia is thicker than the media. In most veins, **valves** are present. These are formed of paired folds of endothelium and help to determine the direction of flow. Medium and smaller arteries are often accompanied by two veins, the **venae comitantes**, rather than one. The smallest, postcapillary veins are termed **venules**. The **capillaries**, which unite the arteries and veins, have walls formed of a single endothelial layer of large angular flattened cells.

The direct union between two vessels is called an anastomosis. **Arteriovenous anastomoses** occur around the nail beds and are an important mechanism in controlling digital blood flow.

They may also exist as congenital abnormalities of the vascular system and can be created surgically when a large vein with an arterialized circulation is required for regular access to the circulation.

Sinusoids are thin-walled, dilated channels uniting arteries and veins and are found in the bone marrow, liver, spleen and suprarenal glands.

In some situations blood passes through two capillary beds before returning to the heart: this constitutes a **portal circulation**. The passage of blood from the stomach, intestine, pancreas and spleen through the liver exemplifies such a system. Short vessels passing through foramina in the skull and joining venous channels (**sinuses**) inside and veins outside are called **emissary** veins.

Reduction of the blood supply to a region is known as ischaemia, and this is of clinical importance in the heart and brain. One important degenerative arterial disease that can affect the vessels is arteriosclerosis, and this is very prevalent in developed countries. The arterial narrowing produced by the disease may cause local intravascular clotting (thrombosis) to occur. A **thrombus** may become detached and flushed into the bloodstream, forming an **embolus** and blocking distal smaller vessels. Local death of an area of tissue or organ owing

to reduction of its blood supply is known as an infarction. In situations where bacteria infect the infarcted area it undergoes putrefaction, a condition known as **gangrene**. In some instances it is possible surgically to bypass arterial blockages, thus re-establishing the distal blood supply and preventing infarction and gangrene.

The body responds to an injury, e.g. invading bacteria, by the process known as **inflammation**. The capillaries dilate and white blood cells pass out of the circulation to phagocytose the offending organisms. The area becomes red and hot because of the increased blood supply, and swollen with increased tissue fluid; it is also painful. A collection of dead tissue and dead white blood cells is called an **abscess**.

THE LYMPHATIC SYSTEM

Lymph consists of cells, mainly lymphocytes, and plasma.

The lymphatic system collects tissue fluid and conveys it to the bloodstream. It comprises the **lymph capillaries** and **vessels**, the lymph nodes, and aggregations of lymph tissue in the spleen and thymus and around the alimentary tract. The system forms an extensive network over the body, although its fine vessels are not easily identified (**Figs. 0.30a,b**).

The lymph capillaries are larger than those of the blood; they are composed of a single layer of **endothelial** cells. The lymph vessels resemble veins and possess many paired valves. The larger collecting vessels open into the venous system near the formation of the brachiocephalic veins.

A **lymph node** (**Fig. 0.30c**) is an aggregation of lymph tissue along the course of a lymph vessel. It is bean-shaped, with a number of afferent vessels (conveying lymph to the node) entering its convex surface and an efferent vessel (carrying lymph away from the node) leaving its hilus (opening). It is surrounded by a fibrous capsule from which fibrous trabeculae pass inwards. It is filled with a reticular network of fine collagen fibres, and the cells are either primitive (lymphocyte precursors) or fixed macrophages. Numerous lymphocytes and a few monocytes lie freely within the meshwork, but they are absent peripherally, leaving a subcapsular lymph space. The cells of the outer part of the node (cortex) are densely packed and known as germinal centres. The centre of the follicle and the hilar (medullary) regions of the node contain loosely packed lymphocytes.

Lymph aggregations elsewhere in the body consist of a mixture of follicles and loosely packed lymphocytes.

Bacterial infections produce inflammatory responses in the regional lymph nodes. In many malignant diseases neoplastic cells spread via the lymph vessels to the regional lymph nodes, and there develop to such an extent as to completely replace the normal tissue of the lymph node and occlude lymph flow. The stagnation of lymph within the tissues due to obstruction of flow produces a swelling of the tissues known as lymphoedema (**Fig. 1.20b**, p. 29). Lymphoedema may also occur in subjects who are born with a defective lymphatic system, this being termed primary lymphoedema; acquired obstruction is called secondary lymphoedema. The term lymphadenopathy is used to describe a generalized enlargement of the lymph nodes, although they are not glands in the strict definition of the term.

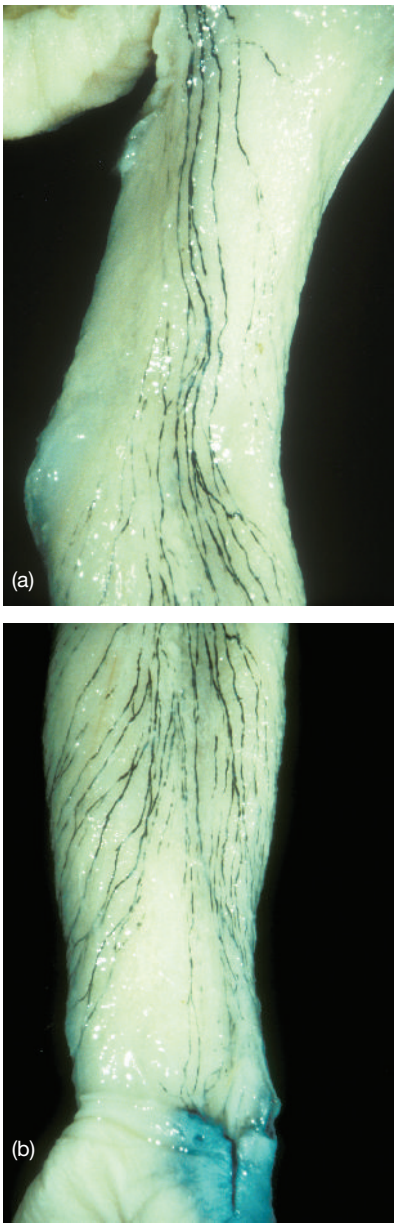


Figure 0.30 (a) and (b) Injection with Indian ink into the palmar skin to show lymphatics of the arm. (c) Lymph node structure

ORIENTATION

The **anatomical position** is that to which all anatomical descriptions refer. It is one in which the person stands upright with feet together, eyes looking forward and arms straight down the side of the body, with the palms facing forward (Fig. 0.31).

Structures in front are termed **anterior** (ventral) and those behind are termed **posterior** (dorsal). In the hands and feet the surfaces are referred to as **palmar** and dorsal and **plantar** and dorsal, respectively. Structures above are **superior** (cranial, rostral) and those below are **inferior** (caudal). Structures may be nearer to (**medial**) or further from (**lateral**) the midline, and those in the midline are called **median**. **Paramedian** means alongside and parallel to the midline. **Superficial** and **deep** denote the position of structures in relation to the surface of the body. A **sagittal** plane passes vertically anteroposteriorly through the body and a **coronal** plane passes vertically at right angles to a sagittal plane. **Transverse** (horizontal) planes pass horizontally through the body and are known radiologically as axial planes.

Proximal and **distal** are terms used to indicate the relation of a structure to the centre of the body. The ankle is distal to the knee joint; the shoulder is proximal to the elbow joint. Blood flows distally (peripherally) in the arteries and proximally (centrally) in the veins.

Movements

Forward movement in a sagittal plane is usually known as **flexion** (Fig. 0.32) and backward movement as **extension** (Fig. 0.33). Owing to rotation of the lower limb during development, backward movement of the leg extends the hip and flexes the knee; downward movement of the toes is flexion. Upward movement at the ankle joint is dorsiflexion (extension) and downward movement is plantar flexion (flexion) (Fig. 0.34). Movement away from the midline in the coronal plane is **abduction** and movement towards the midline is **adduction** (Fig. 0.35). Abduction and adduction of the fingers and toes is taken in relation to the middle finger and second toe. During development of the thumb its axis is rotated in relation to the fingers, therefore movement is described in relation to the plane of the thumbnail. Side-to-side movement of the neck and trunk is termed **lateral flexion**. **Circumduction** (Fig. 0.35) is the movement when the distal end of a bone describes the base of a cone whose apex is at the proximal end. **Rotation** occurs in the long axis of a bone; in the limbs it may be **medial**, towards the midline, or **lateral**, away from it (Fig. 0.36). Medial and lateral rotation of the forearm occurs through the axis drawn through the heads of the radius and ulna, and is termed **pronation** and **supination**, respectively (Fig. 0.37). Rotation of the thumb and little finger so that their pulps meet is termed **opposition** of the two digits, the movement being particularly marked in the thumb. **Rotation** of the forefoot is termed **inversion** when the sole faces the midline and **eversion** when it is turned away from the midline (Fig. 0.38).

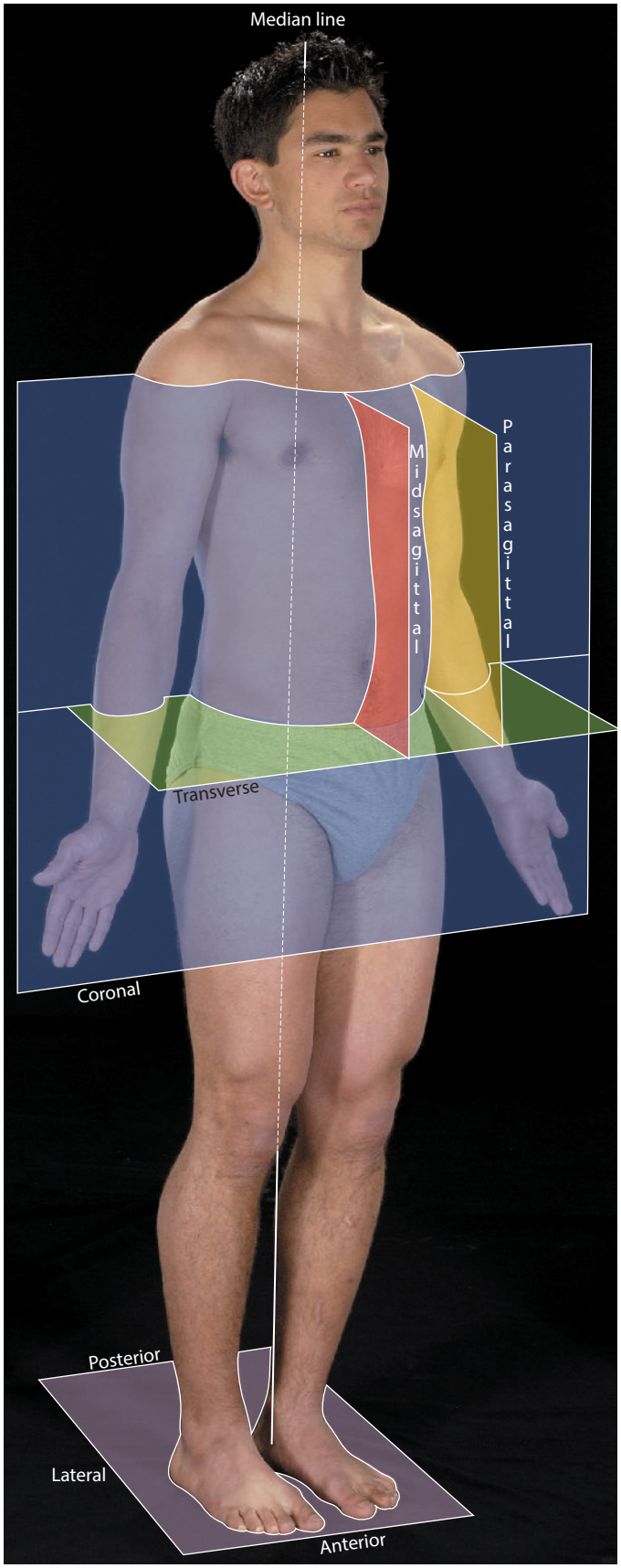
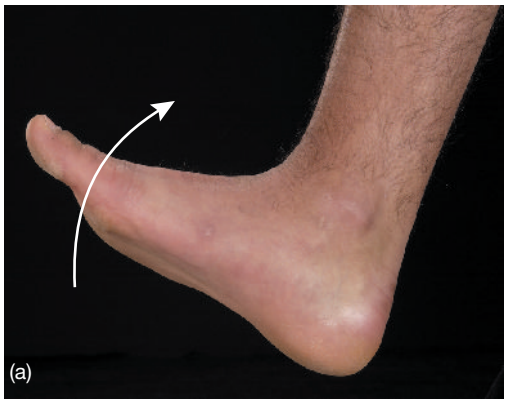


Figure 0.31 Anatomical position. The median line passes from the top of the head to between the ankles

Figure 0.32 Flexion

Figure 0.33 Extension



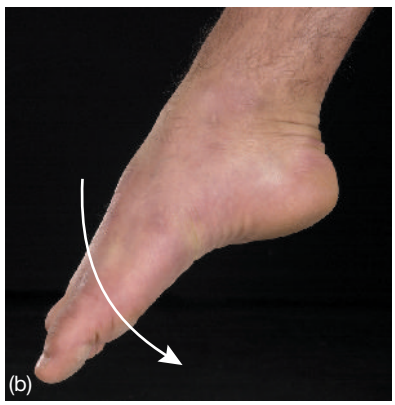


Figure 0.34 (a) Dorsiflexion (true extension). (b) Plantar flexion (true flexion)

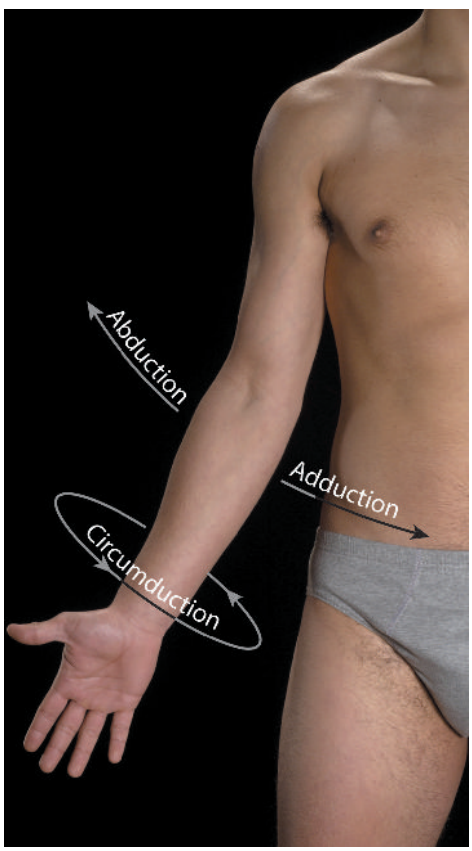


Figure 0.35 Abduction, adduction and circumduction

IMAGING – THE ESSENTIALS

Since the discovery of X-rays over 120 years ago, the study of the normal and diseased human body has become one of the most rapidly expanding fields in medicine. In the 21st century, we now have ultrasound (US), computed tomography (CT), contrast studies and radionuclide scans, and, the last 30 years have provided huge advances in magnetic resonance imaging and angiography (MRI and MRA, respectively) and, more recently, electron beam CT (EBCT).