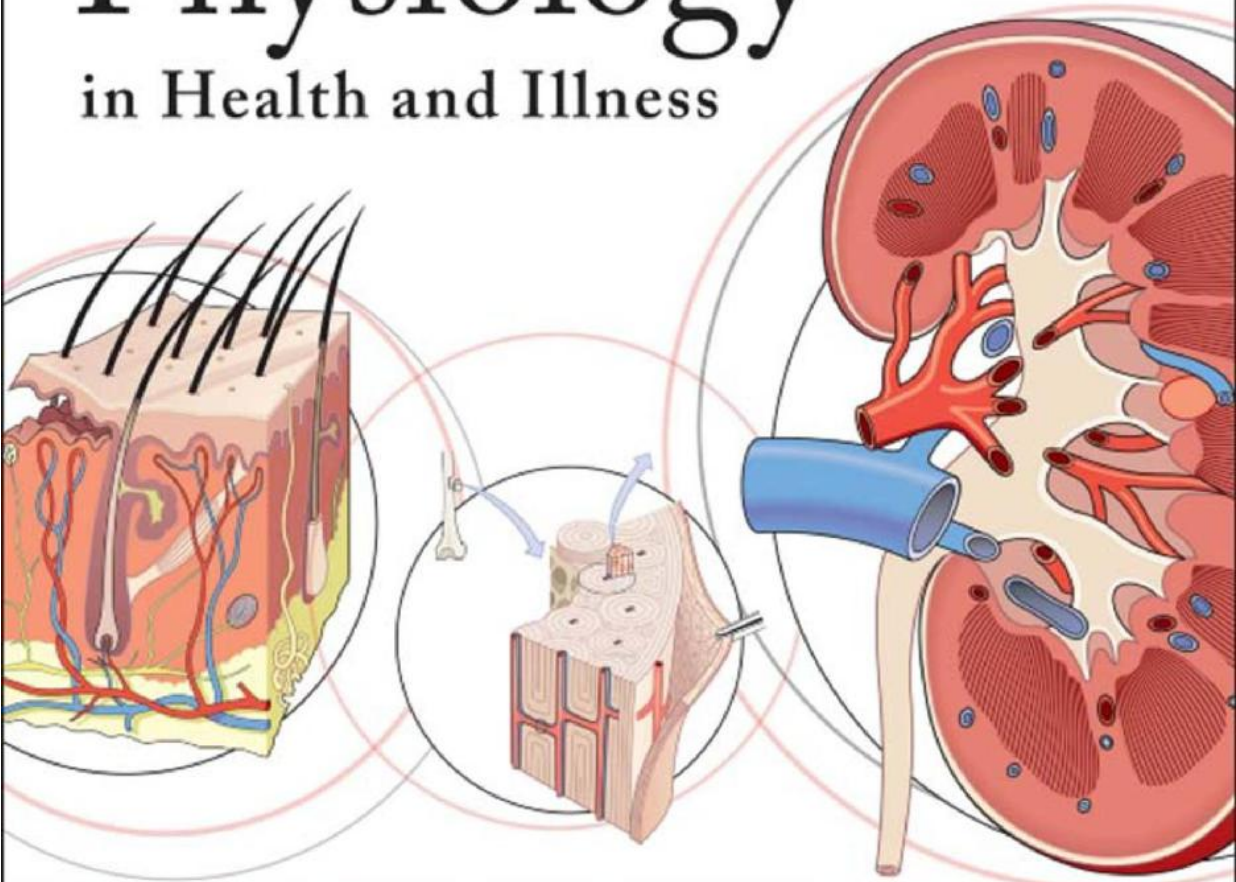


Anne Waugh & Allison Grant

12th Edition

Ross and Wilson
**Anatomy &
Physiology**
in Health and Illness



CHURCHILL
LIVINGSTONE
ELSEVIER

ELSEVIER evolve

- Colouring exercises
- Animations
- Self-assessment questions
- Case studies, illustrations and photographs.

Anato

Ross and Wilson

&

my

Physiology

in Health and Illness

12th Edition

For Elsevier:

***Content Strategist:* Mairi McCubbin**

***Content Development Specialist:* Sheila Black**

***Project Manager:* Caroline Jones**

***Designer:* Christian Bilbow**

***Illustration Manager:* Jennifer Rose**

Ross and Wilson

Anato &

my

Physiology

in Health and Illness

12th Edition

Anne Waugh BSc(Hons) MSc CertEd SRN RNT FHEA

Senior Teaching Fellow and Director of Academic Quality, School of
Nursing, Midwifery and Social Care, Edinburgh Napier University,

Edinburgh, UK

Allison Grant BSc PhD RGN

Lecturer, Division of Biological and Biomedical Sciences, Glasgow
Caledonian University, Glasgow, UK

Illustrations by Graeme Chambers

Edinburgh London New York Oxford Philadelphia St Louis Sydney Toronto
2014

© 2014 Elsevier Ltd. All rights reserved.

Twelfth Edition: 2014

Eleventh Edition: 2010

Tenth Edition: 2006

Ninth Edition: 2002

Eighth Edition: 2001

Seventh Edition: 1998

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. Details on how to seek permission, further information about the Publisher's permissions policies and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency, can be found at our website: www.elsevier.com/permissions.

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

© 1997 Pearson Professional Limited

© 1990, 1987, 1981, 1973 Longman Group Limited

© 1968, 1966, 1963 E & S Livingstone Ltd.

ISBN 978-0-7020-5325-2

International ISBN 978-0-7020-5326-9

E-ISBN 978-0-7020-5321-4

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data

A catalog record for this book is available from the Library of Congress

Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

With respect to any drug or pharmaceutical products identified, readers are advised to check the most current information provided (i) on procedures featured or (ii) by the manufacturer of each product to be administered, to verify the recommended dose or formula, the method and duration of administration, and contraindications.

It is the responsibility of practitioners, relying on their own experience and knowledge of their patients, to make diagnoses, to determine dosages and

the best treatment for each individual patient, and to take all appropriate safety precautions.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

The

publisher's

policy is to use

paper manufactured

from sustainable forests

Printed in China

Contents

Evolve online resources: <https://evolve.elsevier.com/Waugh/anatomy/>

Evolve online resources

vi

Preface

vii

Acknowledgements

viii

Common prefixes, suffixes and roots

ix

Key

xi

Section 1 **The body and its constituents**

1

1 Introduction to the human body

3

2 Introduction to the chemistry of life

21

3 The cells, tissues and organisation of the body

31

Section 2 **Communication**

59

4 The blood

61

5 The cardiovascular system

81

6 The lymphatic system

133

7 The nervous system

143

8 The special senses

191

9 The endocrine system

215

Section 3 Intake of raw materials and elimination of waste

239

10 The respiratory system

241

11 Introduction to nutrition

273

12 The digestive system

285

13 The urinary system

337

Section 4 Protection and survival

359

14 The skin

361

15 Resistance and immunity

375

16 The musculoskeletal system

389

17 Introduction to genetics

437

18 The reproductive systems

449

Glossary

471

Normal values

479

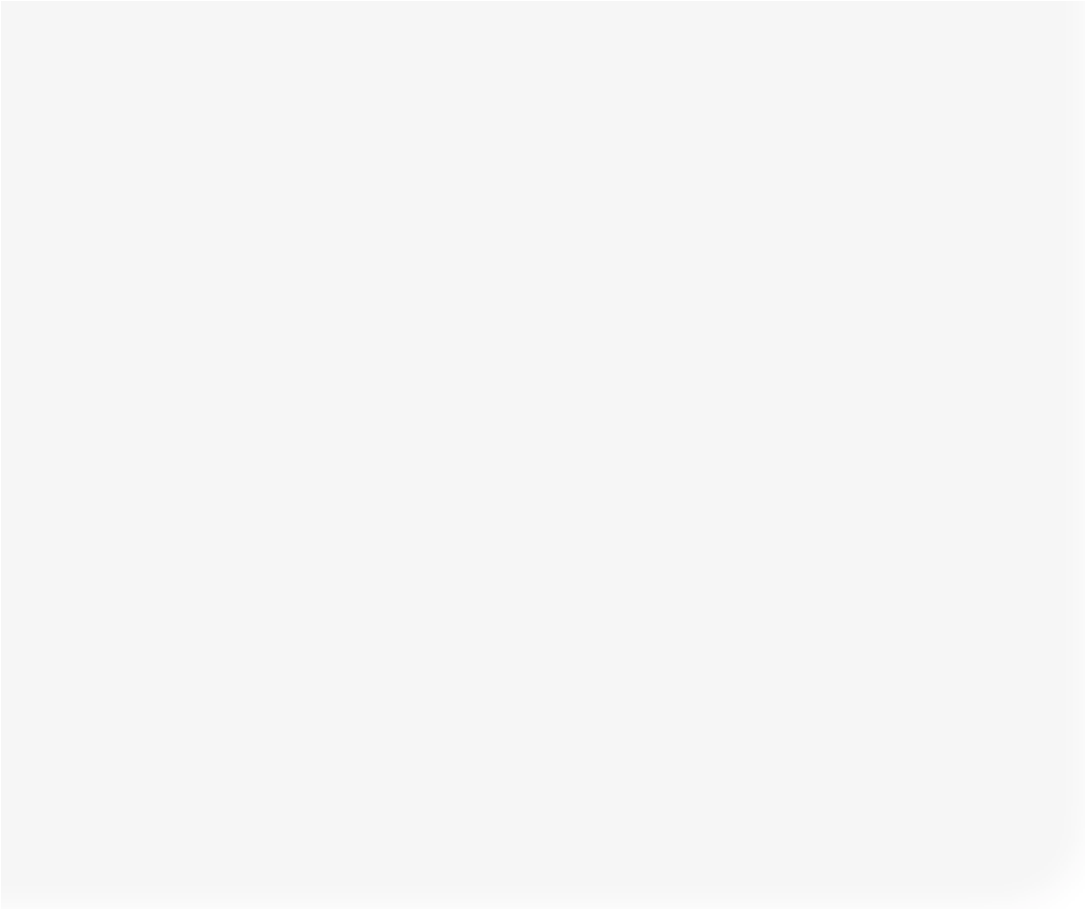
Bibliography

481

Index

483

v



Preface

Ross and Wilson has been a core text for students of anatomy and physiology for over 50 years. This latest edition continues to be aimed at healthcare professionals including nurses, students of nursing, the allied health

micrographs and photographs have been included to provide detailed and enlightening views of many anatomical features.

This edition is accompanied by a companion

professions and complementary therapies, paramedics website (<https://evolve.elsevier.com/Waugh/anatomy/>) and ambulance technicians, many of whom have found with over 100 animations and an extensive range of previous editions invaluable. It retains the straightforward online self-test activities that reflect the content of each ward approach to the description of body systems and chapter. The material in this textbook is also supported how they work. The anatomy and physiology of health is by the new 4th edition of the accompanying study guide, supplemented by new sections describing common which gives students who prefer paper-based activities age-related changes to structure and function, before the opportunity to test their learning and improve their considering the pathology and pathophysiology of some knowledge.

important disorders and diseases.

The features from the previous edition have been

The human body is presented system by system. The retained and revised, including learning outcomes, a list

reader must, however, remember that physiology is an of common prefixes, suffixes and roots, and extensive integrated subject and that, although the systems are con- in-text chapter cross-references. The comprehensive glos- sidered in separate chapters, all function cooperatively to sary has been extended. New sections outlining the impli- maintain health. The first three chapters provide an over- cations of normal ageing on the structure and function of view of the body and describe its main structures.

body systems have been prepared for this edition. Some The later chapters are organised into three further sec- biological values, extracted from the text, are presented tions, reflecting those areas essential for normal body as an appendix for easy reference. In some cases, slight function: communication; intake of raw materials and variations in 'normals' may be found in other texts and elimination of waste; and protection and survival. Much used in clinical practice.

of the material for this edition has been revised and rewritten. Many of the diagrams have been revised and,

Anne Waugh

based on reader feedback, more new coloured electron

Allison Grant

vii

Acknowledgements

Authors' Acknowledgements

We are indebted to the many readers of the eleventh edition for

The twelfth edition of this textbook would not have been possible
their feedback and constructive comments, many of which have
without the efforts of many people. In preparing this edition, we
influenced the current revision.

have continued to build on the foundations established by Kathleen

We are also grateful to the staff of Elsevier, particularly Mairi

Wilson and we would like to acknowledge her immense contribu-

McCubbin, Sheila Black, Caroline Jones for their continuing support.
tion to the success of this title.

Thanks are also due to our families, Andy, Michael, Seona and

Thanks are due once again to Graeme Chambers for his patience

Struan, for their continued patience, support and acceptance of lost
in the preparation of the new and revised artwork.

evenings and weekends.

Publisher's Acknowledgements

Figure 5.54 Zephyr/Science Photo Library

The following figures are reproduced with kind permission.

Figure 5.56A Alex Barte/Science Photo Library

Figures 1.1, 1.16, 3.15C, 3.19B, 6.6, 8.2, 10.12B, 12.5B, 13.6, 14.1, 14.5,

Figure 5.56B David M Martin MD/Science Photo Library

16.55, 18.18A Steve G Schmeissner/Science Photo Library

Figure 7.4 CMEABG – UCBL1, ISM/Science Photo Library

Figure 1.6 National Cancer Institute/Science Photo Library

Figures 7.11, 17.1 Standring S et al (2004) *Gray's anatomy: the anatomi-*

Figure 1.19 Thierry Berrod, Mona Lisa Production/Science Photo

cal basis of clinical practice 39th edn Churchill Livingstone:

Library

Edinburgh

Figure 1.21 United Nations (2012) *Population Ageing and Development*

Figure 7.22 Penfield W, Rasmussen T (1950) The cerebral cortex of

2012, wall chart. Department for Economic and Social Affairs,

man. Macmillan, New York. © 1950 Macmillan Publishing Co.,

Population Division, New York.

renewed 1978 Theodore Rasmussen.

Figure 3.2B Hermann Schillers, Prof. Dr H Oberleithner, University

Figure 7.37 Thibodeau GA, Patton KT (2007) *Anthony's Textbook*

Hospital of Muenster/Science Photo Library

of anatomy and Physiology 18th edn Mosby: St Louis

Figure 3.3 Bill Longcore/Science Photo Library

Figure 8.27 Martini, Nath & Bartholomew 2012 *Fundamentals of*

Figure 3.4 Science Photo Library

Anatomy and Physiology 9th edn Pearson (Fig. 17.13, p. 566)

Figure 3.5 Dr Torsten Wittmann/Science Photo Library

Figures 8.11C, 8.12 Paul Parker/Science Photo Library

Figure 3.6 Eye of Science/Science Photo Library

Figure 8.25 Sue Ford/Science Photo Library. Reproduced with

Figure 3.9 Dr Gopal Murti/Science Photo Library

permission.

Figures 3.14, 4.4A, 5.3, 12.21 Telser B, Young AG, Baldwin KM (2007)

Figures 8.26, 9.20, 10.27 Dr P Marazzi/Science Photo Library. Repro-

Elsevier's integrated histology Mosby: Edinburgh

duced with permission

Figure 3.17 Medimage/Science Photo Library

Figure 9.14 George Bernard/Science Photo Library

Figures 3.18B, 4.2, 5.46A, 16.68 Biophoto Associates/Science Photo

Figure 9.15 John Radcliffe Hospital/Science Photo Library

Library

Figures 9.16, 9.17 Science Photo Library

Figure 3.23B Professors PM Motta, PM Andrews, KR Porter &

Figure 10.19 Hossler, Custom Medical Stock Photo/Science Photo

J Vial/Science Photo Library

Library

Figure 3.24B R Bick, B Poindexter, UT Medical School/Science Photo

Figure 10.29 Dr Tony Brain/Science Photo Library

Library

Figure 11.3 Tony McConnell/Science Photo Library

Figures 3.27, 7.10, 13.18 Young B, Lowe JS, Stevens A et al (2006)

Figure 13.5 Susumu Nishinaga/Science Photo Library

Wheater's functional histology: a text and colour atlas Edinburgh:

Figure 13.8 Christopher Riethmuller, Prof. Dr H Oberleithner,

Churchill Livingstone

University Hospital of Muenster/Science Photo Library

Figure 3.41 Cross SS Ed. 2013 *Underwood's Pathology: a Clinical*

Figure 14.3 Anatomical Travelogue/Science Photo Library

Approach 6th edn, Churchill Livingstone: Edinburgh

Figure 14.14 James Stevenson/Science Photo Library

Figure 4.3 Telser AG, Young JK, Baldwin KM (2007) *Elsevier's inte-*

Figure 15.1 Biology Media/Science Photo Library

grated histology Mosby: Edinburgh ; Young B, Lowe JS, Stevens A

Figure 16.4 Jean-Claude Révy, ISM/Science Photo Library

et al (2006) *Wheater's functional histology: a text and colour atlas*

Figures 16.5B, 16.67 Prof. P Motta/Dept of Anatomy/University

Edinburgh: Churchill Livingstone

'la Sapienza', Rome/Science Photo Library

Figure 4.4D Professors PM Motta & S Correr/Science Photo

Figure 16.7 Innerspace Imaging/Science Photo Library

Library

Figure 16.57 Kent Wood/Science Photo Library

Figures 4.15, 10.8A, 12.47 CNRI/Science Photo Library

Figure 16.69 Alain Power and SYRED/Science Photo Library

Figures 4.16, 12.26B Eye of Science/Science Photo Library

Figure 18.8 Professors PM Motta & J Van Blerkom/Science Photo

Figure 5.11C Thomas Deerinck, NCMIR/Science Photo Library

Library

Figure 5.13C Philippe Plailly/Science Photo Library

Figure 18.8B Susumu Nishinaga/Science Photo Library

viii

Common prefixes, suffixes and roots

Prefix/suffix/root

To do with

Examples in the text

a-/an-

lack of

anuria, agranulocyte, asystole, anaemia

ab-

away from

abduct

ad-

towards

adduct

-aemia

of the blood

anaemia, hypoxaemia, uraemia, hypovolaemia

angio-

vessel

angiotensin, haemangioma

ante-

before, in front of

anterior

anti-

against

antidiuretic, anticoagulant, antigen, antimicrobial

baro-

pressure

baroreceptor

-blast

germ, bud

reticuloblast, osteoblast

brady-

slow

bradycardia

broncho-

bronchus

bronchiole, bronchitis, bronchus

card-

heart

cardiac, myocardium, tachycardia

chole-

bile

cholecystokinin, cholecystitis, cholangitis

circum-

around

circumduction

cyto-/-cyte

cell

erythrocyte, cytosol, cytoplasm, cytotoxic

derm-

skin

dermatitis, dermatome, dermis

di-

two

disaccharide, diencephalon

dys-

difficult

dysuria, dyspnoea, dysmenorrhoea, dysplasia

-ema

swelling

oedema, emphysema, lymphoedema

endo-

inner

endocrine, endocytosis, endothelium

enter-

intestine

enterokinase, gastroenteritis

epi-

upon

epimysium, epicardium

erythro-

red

erythrocyte, erythropoietin, erythropoiesis

exo-

outside

exocytosis, exophthalmos

extra-

outside

extracellular, extrapyramidal

-fferent

carry

afferent, efferent

gast-

stomach

gastric, gastrin, gastritis, gastrointestinal

-gen-

origin/production

gene, genome, genetic, antigen, pathogen, allergen

-globin

protein

myoglobin, haemoglobin

haem-

blood

haemostasis, haemorrhage, haemolytic

hetero-

different

heterozygous

homo-

the same, steady

homozygous, homologous

ix

COMMON PREFIXES, SUFFIXES AND ROOTS

Prefix/suffix/root

To do with

Examples in the text

-hydr-

water

dehydration, hydrostatic, hydrocephalus

hepat-

liver

hepatic, hepatitis, hepatomegaly, hepatocyte

hyper-

excess/above

hypertension, hypertrophy, hypercapnia

hypo-

below/under

hypoglycaemia, hypotension, hypovolaemia

intra-

within

intracellular, intracranial, intraocular

-ism

condition

hyperthyroidism, dwarfism, rheumatism

-itis

inflammation

appendicitis, hepatitis, cystitis, gastritis

lact-

milk

lactation, lactic, lacteal

lymph-

lymph tissue

lymphocyte, lymphatic, lymphoedema

lyso-/-lysis

breaking down

lysosome, glycolysis, lysozyme

-mega-

large

megaloblast, acromegaly, splenomegaly, hepatomegaly

micro-

small

microbe, microtubules, microvilli

myo-

muscle

myocardium, myoglobin, myopathy, myosin

neo-

new

neoplasm, gluconeogenesis, neonate

nephro-

kidney

nephron, nephrotic, nephroblastoma, nephrosis

neuro-

nerve

neurone, neuralgia, neuropathy

-oid

resembling

myeloid, sesamoid, sigmoid

olig-

small

oliguria

-ology

study of

cardiology, neurology, physiology

-oma

tumour

carcinoma, melanoma, fibroma

-ophth-

eye

xerophthalmia, ophthalmic, exophthalmos

-ory

referring to

secretory, sensory, auditory, gustatory

os-, osteo-

bone

osteocyte, osteoarthritis, osteoporosis

-path-

disease

pathogenesis, neuropathy, nephropathy

-penia

deficiency of

leukopenia, thrombocytopenia

phag(o)-

eating

phagocyte, phagocytic

-plasm

substance

cytoplasm, neoplasm

pneumo-

lung/air

pneumothorax, pneumonia, pneumotoxic

poly-

many

polypeptide, polyuria, polycythaemia

-rrhagia

excessive flow

menorrhagia

-rrhoea

discharge

dysmenorrhoea, diarrhoea, rhinorrhoea

sarco-

muscle

sarcomere, sarcoplasm

-scler

hard

arteriosclerosis, scleroderma

sub-

under

subphrenic, subarachnoid, sublingual

tachy-

excessively fast

tachycardia, tachypnoea

thrombo-

clot

thrombocyte, thrombosis, thrombin, thrombus

-tox-

poison

toxin, cytotoxic, hepatotoxic

tri-

three

tripeptide, trisaccharide, trigeminal

-uria

urine

anuria, polyuria, haematuria, nocturia, oliguria

vas, vaso-

vessel

vasoconstriction, vas deferens, vascular

x

Key

Orientation compasses are used beside many of the figures, with paired directional terms above and below and on each side of the compass.

A

A/P: anterior/posterior. This indicates that the figure

S

S/I: superior/inferior. This indicates that the figure has
has been drawn from above or below using a transverse

L

R

been drawn from the front, side or the back using either

P

A

section, and shows the relationship of the structures to
a sagittal or frontal section, and shows the relationship of

P

the front/back of the body.

I

the structures to the top/bottom of the body.

L/R: left/right.

P/A: posterior/anterior.

e.g. Figure 16.20

e.g. Figure 7.42

S

P

A

A

I

L

R

Vagus nerve

Common

P

carotid

artery

Oesophagus

Anterior aspect

Trachea

Cardiac

Vertebral

Body

plexus

Arch of

foramen

aorta

Right

Pedicle

Pulmonary

bronchus

trunk

Transverse

Vertebral

Heart

process

Right

arch

pulmonary

artery

Stomach

Lamina

Diaphragm

Superior articular

Spinous

process

process

S

S/I: superior/inferior.

P

P/D: proximal/distal. This indicates the relationship of

M/L: medial/lateral. This indicates that the figure has

M

L

the structures to their point of attachment to the body.

L

M

been drawn using a sagittal section, and shows the

L/M: Lateral/medial.

I

relationship of the structures to the midline of the body.

D

e.g. Figure 16.35

e.g. Figure 7.35 (posterior view)

Scaphoid

S

S

Capitate

Lunate

Trapezium

Triquetrum

L

M

M

L

Trapezoid

Pisiform

I

I

Axillary

Hamate

1st

Radial nerve

(circumflex)

metacarpal

nerve

5th

Radial nerve

Radial

metacarpal

behind

Proximal

nerve

humerus

phalanx

Distal

Median nerve

Proximal

Ulnar nerve

phalanx

phalanges

Radial

Ulnar

nerve

nerve

Branch

Median

of radial

nerve

Middle

nerve

phalanges

Ulnar

Radial

nerve

nerve

P

L

M

Distal

Anterior view

Posterior view

D

phalanges

xi

KEY

To help you locate bones of the skeleton, some artwork has either a skull or skeleton orientation icon beside it with the bone(s) under discussion clearly coloured.

e.g. Figures 16.17 and 16.39

Coronoid

S

Facet for articulation

process

with acetabulum of pelvis

L

M

Condylar

Neck

process

Articular

I

surface for

temporo-

Greater

Head

mandibular

trochanter

joint

Ramus

Intertrochanteric

Lesser

line

trochanter

Body

Angle

S

A

P

Alveolar ridge

I

Figure 16.17

Linea aspera

Popliteal

surface

Lateral

Medial

condyle

condyle

Facets for articulation

with tibia

Figure 16.39

xii

N

IOTCE

11

The body and its

S

constituents

Introduction to the human body

3

Introduction to the chemistry of life

21

The cells, tissues and organisation of the body

31

This page intentionally left blank

R ETP

1

Introduction to

AH

the human body

C

Levels of structural complexity

4

Introduction to the study of illness

18

The internal environment and homeostasis

5

Aetiology

18

Homeostasis

6

Pathogenesis

18

Homeostatic imbalance

7

Survival needs of the body

8

ANIMATIONS

Communication

8

1.1

Anatomy turntable

4

Intake of raw materials and elimination

1.2

Cardiovascular (circulatory) system

9

of waste

11

1.3

Airflow through the lungs

11

Protection and survival

13

1.4

The alimentary canal

12

Introduction to ageing

15

1.5

Urine flow

13



SECTION 1 The body and its constituents

The human body is rather like a highly technical and

sophisticated machine. It operates as a single entity, but is made up of a number of systems that work inter-dependently. Each system is associated with a specific function that is normally essential for the well-being of the individual. Should one system fail, the consequences can extend to others, and may greatly reduce the ability of the body to function normally. Integrated working of the body systems ensures survival. The human body is therefore complex in both structure and function, and this book uses a systems approach to explain the fundamental structures and processes involved.

Anatomy is the study of the structure of the body and the physical relationships between its constituent parts.

Physiology is the study of how the body systems work, and the ways in which their integrated activities maintain life and health of the individual. *Pathology* is the study of abnormalities and *pathophysiology* considers how they affect body functions, often causing illness.

Most body systems become less efficient with age.

Physiological decline is a normal part of ageing and

should not be confused with illness or disease although some conditions do become more common in older life.

Maintaining a healthy lifestyle can not only slow the effects of ageing but also protect against illness in later

Figure 1.1 Coloured scanning electron micrograph of some nerve cells (neurones).

life. The general impact of ageing is outlined in this chapter and the effects on body function are explored in more detail in later chapters.

The final section of this chapter provides a framework distinguished by their size, shape and the dyes they for studying diseases, an outline of mechanisms that absorb when stained in the laboratory. Each cell type has cause disease and some common disease processes. Build-become *specialised*, enabling it to carry out a particular ing on the normal anatomy and physiology, a systems function that contributes to body needs. Figure 1.1 shows approach is adopted to consider common illnesses at the some highly magnified nerve cells. The specialised func-end of the later chapters.

tion of nerve cells is to transmit electrical signals (nerve impulses); these are integrated and co-ordinated allowing the millions of nerve cells in the body to provide a rapid and sophisticated communication system. In complex

Levels of structural complexity

organisms such as the human body, cells with similar structures and functions are found together, forming

Learning outcome

tissues. The structure and functions of cells and tissues are

After studying this section, you should be able to:

explored in Chapter 3.

Organs are made up of a number of different types of

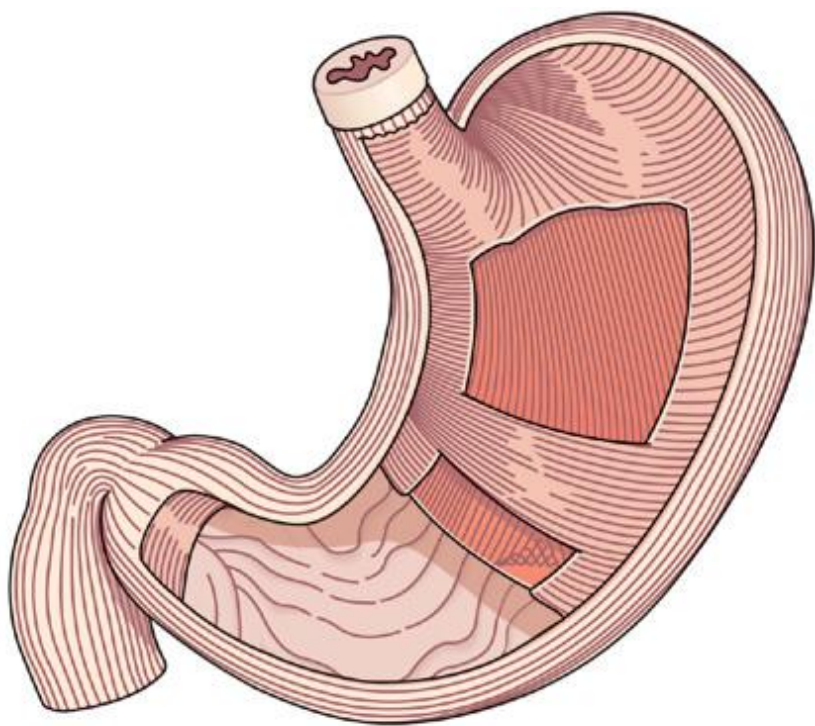
- describe the levels of structural complexity within tissue and have evolved to carry out a specific function. the body.

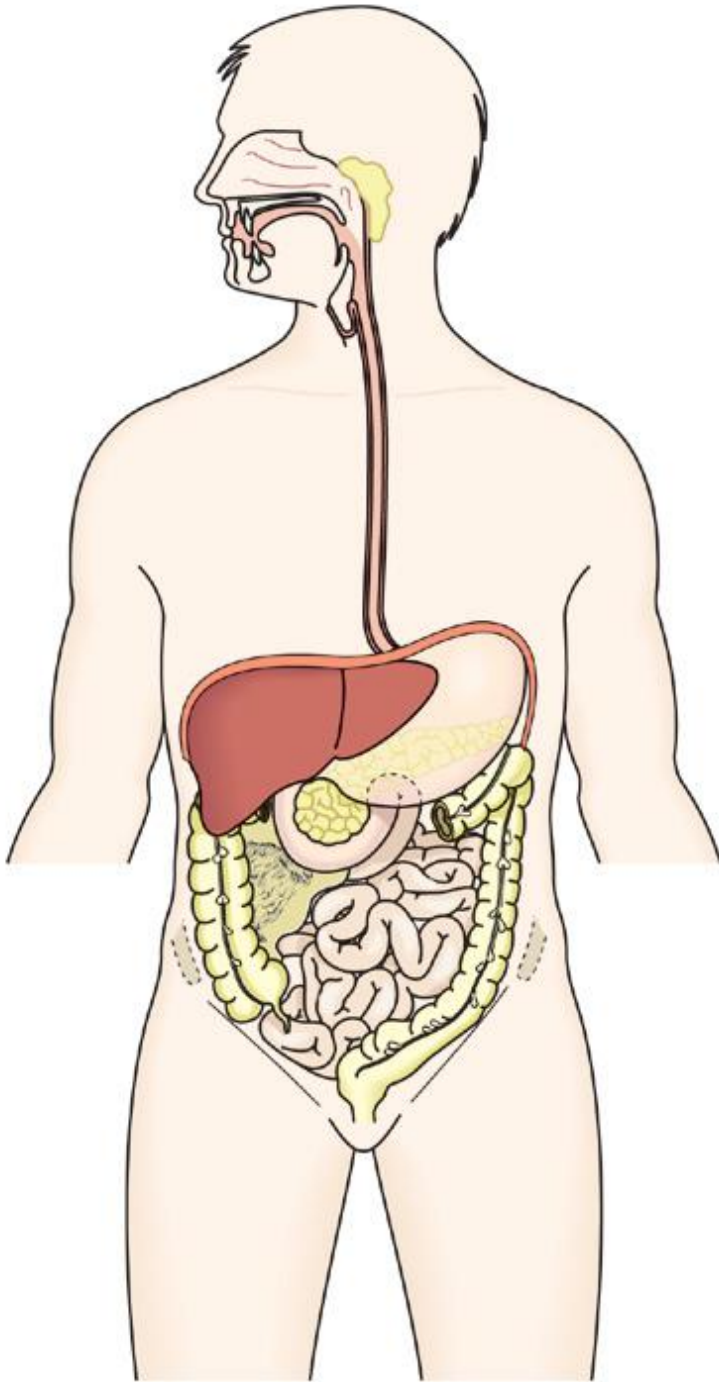
Figure 1.2 shows that the stomach is lined by a layer of epithelial tissue and that its wall contains layers of smooth muscle tissue. Both tissues contribute to the functions of Within the body are different levels of structural organi- the stomach, but in different ways.

sation and complexity. The most fundamental of these is *Systems* consist of a number of organs and tissues chemical. *Atoms* combine to form *molecules*, of which there that together contribute to one or more survival needs is a vast range in the body. The structures, properties and of the body. For example the stomach is one of several functions of important biological molecules are considered organs of the digestive system, which has its own specialised in Chapter 2.

cific function. The human body has several systems, *Cells* are the smallest independent units of living matter which work interdependently carrying out specific and there are trillions of them within the body. They functions. All are required for health. The structure are too small to be seen with the naked eye, but when and functions of the body systems are considered in magnified using a microscope different types can be later chapters.

1.1





Introduction to the human body CHAPTER 1

Atoms

Molecules