



# AN INTRODUCTION TO FUNCTIONAL ANATOMY

BY

DAVID SINCLAIR

M.A. (Oxford), M.D. (St. Andrews)

*Professor of Anatomy, University of Western Australia  
Late University Demonstrator in Anatomy, University of Oxford  
Late Lecturer in Anatomy and Physiology,  
Dorset House School of Occupational Therapy, Oxford*

BLACKWELL  
SCIENTIFIC PUBLICATIONS  
OXFORD

*This book is copyright. It may not be reproduced by any means in whole or in part without permission. Application with regard to copyright should be addressed to the publishers.*

*Published simultaneously in the United States by Charles C. Thomas, Publisher, 301-327 East Lawrence Avenue, Springfield, Illinois.*

*Published simultaneously in Canada by The Ryerson Press, Queen Street West, Toronto 2*

First printed May 1957

Printed in Holland for BLACKWELL SCIENTIFIC PUBLICATIONS, LTD.  
by THE YSEL PRESS, Deventer  
and bound at THE KEMP HALL BINDERY

## CONTENTS

INTRODUCTION .....	15
--------------------	----

### PART ONE TISSUES AND SYSTEMS

1. PROTOPLASM AND THE CELL .....	25
2. EPITHELIA .....	30
3. CONNECTIVE TISSUE .....	33
4. CARTILAGE .....	36
5. BONE .....	38
FUNCTIONS AND DESCRIPTION .....	38
STRUCTURE OF BONES .....	39
OSSIFICATION AND GROWTH OF BONE .....	41
REPAIR OF FRACTURES .....	46
6. JOINTS .....	48
DESCRIPTION AND CLASSIFICATION .....	48
MOVEMENTS PERMITTED AT SYNOVIAL JOINTS .....	51
STABILITY OF JOINTS .....	52
LIMITATION OF MOVEMENT .....	54
7. MUSCLE .....	56
VISCERAL MUSCLE .....	56
CARDIAC MUSCLE .....	57
SOMATIC MUSCLE .....	59
Attachments of somatic muscle .....	60
Arrangement of fasciculi .....	61
Contraction of somatic muscle .....	63
Work and energy .....	65
Actions of somatic muscles .....	66
8. THE NERVOUS SYSTEM .....	72
PLAN OF CONSTRUCTION .....	72

ANATOMY OF THE NEURONE .....	73
The neurone theory .....	76
Intercalated neurones .....	76
Sensory neurones .....	77
Motor neurones .....	79
TRANSMISSION OF MESSAGES .....	80
The nerve impulse .....	80
Sensory transmission .....	81
The synapse .....	82
Motor transmission .....	83
Reactions and reflexes .....	84
<i>Tendon reflexes</i> .....	86
<i>Muscle tone</i> .....	87
<i>Superficial reflexes</i> .....	88
<i>Other types of reflex action</i> .....	88
THE PERIPHERAL NERVOUS SYSTEM .....	89
The spinal nerves .....	89
<i>Plexuses</i> .....	92
The cranial nerves .....	95
The autonomic system .....	97
<i>Sympathetic system</i> .....	97
<i>Parasympathetic system</i> .....	100
Structure of a peripheral nerve .....	102
Effects of nerve injuries .....	103
<i>Lesions of peripheral nerves</i> .....	103
<i>Motor paralysis</i> .....	104
<i>Sensory paralysis</i> .....	105
<i>Trophic paralysis</i> .....	105
<i>Disability</i> .....	106
<i>Lesions of nerve roots</i> .....	106
<i>Degeneration and regeneration</i> .....	106
Nerve blocks .....	108
Referred pain .....	109
THE SPINAL CORD .....	110
Structure and function .....	110
Spinal meninges .....	116
Lumbar puncture .....	118
THE BRAIN .....	118
The hind-brain .....	119

The mid-brain .....	122
The fore-brain .....	123
<i>The cerebral cortex</i> .....	125
<i>The basal ganglia</i> .....	128
<i>The electroencephalogram</i> .....	130
Summary of main fibre pathways .....	132
<i>The motor pathways</i> .....	132
<i>The exteroceptive sensory pathways</i> .....	133
<i>The proprioceptive sensory pathways</i> .....	133
The cranial meninges .....	135
The circulation of the cerebrospinal fluid .....	136
Blood supply of the central nervous system ..	137
THE SPECIAL SENSES .....	138
The eye .....	138
<i>Structure and function</i> .....	138
<i>Optical defects</i> .....	143
<i>Movements of the eyeball</i> .....	144
<i>The tears</i> .....	146
The ear .....	147
The vestibular apparatus .....	152
Smell and taste .....	153
OUTLINE OF THE CLINICAL EXAMINATION OF THE NERVOUS SYSTEM .....	154
Intellectual functions .....	154
Exteroceptive functions .....	154
Proprioceptive functions .....	155
Motor functions .....	156
Reflexes .....	156
9. THE CIRCULATORY SYSTEM .....	158
THE BLOOD VESSELS .....	158
THE HEART .....	162
The cardiac cycle .....	166
THE BLOOD PRESSURE AND THE CONTROL OF THE CIRCULATION .....	168
TISSUE FLUID AND THE LYMPHATIC SYSTEM .....	170
OUTLINE OF THE CLINICAL EXAMINATION OF THE CIRCULATORY SYSTEM .....	173

10. THE BLOOD .....	174
THE PLASMA .....	174
THE SOLID ELEMENTS .....	175
11. THE RESPIRATORY SYSTEM .....	179
TRANSPORT OF GASES IN THE BLOOD .....	179
THE RESPIRATORY PASSAGES .....	180
THE LUNGS AND PLEURAL CAVITIES .....	185
THE CONTROL OF RESPIRATION .....	187
THE RESPIRATORY QUOTIENT .....	189
OUTLINE OF THE CLINICAL EXAMINATION OF THE RESPIRATORY SYSTEM .....	189
12. THE DIGESTIVE SYSTEM .....	191
13. THE GENITO-URINARY SYSTEM .....	201
14. THE ENDOCRINE SYSTEM .....	206

## PART TWO

### THE BODY AS A WHOLE

15. METABOLISM .....	213
THE FATE OF THE ABSORBED FOOD .....	213
ENERGY REQUIREMENTS .....	216
THE VITAMINS .....	218
EXCRETION .....	219
FLUID BALANCE .....	219
SALT BALANCE .....	221
TEMPERATURE REGULATION .....	222
16. POSTURE .....	225
MECHANISMS OF POSTURE .....	225
VARIETIES OF POSTURE .....	227
17. MUSCULAR ACTIVITY .....	229
EFFECTS OF MUSCULAR EXERCISE .....	229
TRAINING .....	233
THE ENERGY COST OF EXERCISE .....	233
METHODS OF ASSESSING MUSCULAR FUNCTION .....	234
TREATMENT OF PARALYSED MUSCLES .....	235
DEVELOPMENT OF CO-ORDINATED MOVEMENTS .....	236



## PART THREE

## TOPOGRAPHICAL ANATOMY

18. THE VERTEBRAL COLUMN .....	241
DESCRIPTION .....	241
REGIONAL DIFFERENCES .....	244
LIGAMENTS .....	246
CURVATURES .....	247
JOINTS AND MOVEMENTS .....	248
MUSCLES .....	249
19. THE HEAD AND NECK .....	252
THE SKULL .....	252
THE HYOID BONE .....	258
THE TEMPORO-MANDIBULAR JOINT .....	258
IMPORTANT MUSCLES .....	259
IMPORTANT NERVES .....	262
IMPORTANT VESSELS .....	264
IMPORTANT VISCERA .....	265
20. THE THORAX .....	266
THE THORACIC CAGE .....	266
THE MECHANICS OF THE RIBS .....	268
RESPIRATORY MOVEMENTS .....	268
IMPORTANT NERVES .....	270
IMPORTANT VESSELS .....	272
IMPORTANT VISCERA .....	273
21. THE ABDOMEN AND PELVIS .....	275
THE BONY PELVIS .....	275
THE JOINTS .....	277
IMPORTANT MUSCLES .....	278
IMPORTANT NERVES .....	283
IMPORTANT VESSELS .....	285
IMPORTANT VISCERA .....	286
22. THE UPPER LIMB .....	287
INTRODUCTION .....	287
THE SKELETON .....	287
JOINTS AND MOVEMENTS .....	296
TRANSMISSION OF FORCE IN THE UPPER LIMB .....	306
THE MUSCLES .....	308



Muscles acting on the shoulder girdle .....	308
Muscles acting on the shoulder joint .....	311
Muscles acting on the elbow joint .....	314
Muscles acting on the radio-ulnar joints .....	316
Muscles acting on the radio-carpal and mid-carpal joints .....	317
Muscles acting on the fingers .....	320
Muscles acting on the thumb .....	325
FASCIAL ARRANGEMENTS IN THE WRIST AND HAND .....	327
THE USE OF THE HAND .....	330
THE NERVES .....	331
The brachial plexus .....	331
The median nerve .....	333
The ulnar nerve .....	336
The radial nerve .....	338
The musculo-cutaneous nerve .....	341
The axillary nerve .....	341
Injury to the brachial plexus .....	341
Nerve territories of the upper limb .....	342
Motor points .....	342
THE VESSELS .....	342
The arteries .....	342
The veins .....	345
The lymphatics .....	346
<b>23. THE LOWER LIMB .....</b>	<b>347</b>
INTRODUCTION .....	347
THE SKELETON .....	348
JOINTS AND MOVEMENTS .....	357
TRANSFERENCE OF WEIGHT .....	364
THE MUSCLES .....	366
Muscles acting on the hip joint .....	366
Muscles acting on the knee joint .....	371
Muscles acting on the ankle joint .....	373
Muscles acting on the tarsal joints .....	376
Muscles acting on the toes .....	377
FASCIAL ARRANGEMENTS AT THE ANKLE AND IN THE SOLE ..	381
MECHANISM OF STANDING .....	382
MECHANISM OF WALKING .....	382
THE NERVES .....	383

The lumbar plexus .....	383
The sacral plexus .....	385
Nerve territories in the lower limb .....	390
Motor points .....	391
THE BLOOD VESSELS AND LYMPHATICS .....	391
GLOSSARY .....	395

# AN INTRODUCTION TO FUNCTIONAL ANATOMY



# AN INTRODUCTION TO FUNCTIONAL ANATOMY

BY

DAVID SINCLAIR

M.A. (Oxford), M.D. (St. Andrews)

*Professor of Anatomy, University of Western Australia  
Late University Demonstrator in Anatomy, University of Oxford  
Late Lecturer in Anatomy and Physiology,  
Dorset House School of Occupational Therapy, Oxford*

BLACKWELL  
SCIENTIFIC PUBLICATIONS  
OXFORD

*This book is copyright. It may not be reproduced by any means in whole or in part without permission. Application with regard to copyright should be addressed to the publishers.*

*Published simultaneously in the United States by Charles C. Thomas, Publisher, 301-327 East Lawrence Avenue, Springfield, Illinois.*

*Published simultaneously in Canada by The Ryerson Press, Queen Street West, Toronto 2*

First printed May 1957

Printed in Holland for BLACKWELL SCIENTIFIC PUBLICATIONS, LTD.  
by THE YSEL PRESS, Deventer  
and bound at THE KEMP HALL BINDERY

## PREFACE

Many different groups of people study human anatomy and physiology. A knowledge of these subjects has for a long time been regarded as essential for the medical and nursing professions, and both are well catered for by numerous textbooks. Nowadays, however, the medical staff of a general hospital is fortified by the presence of physiotherapists, occupational therapists, radiographers, orthoptists, speech therapists and others, and it is generally accepted that all these ancillary specialists should have some instruction in the form and functioning of the human body.

In the matter of textbooks the needs of these professions differ quite markedly from the needs of medical students and nurses. The physiotherapist, for example, requires no more than a nodding acquaintance with the alimentary and genito-urinary systems, but must have a knowledge of the locomotor system much in excess of what is required by the vast majority of nurses. A textbook suitable for nurses is therefore often unsatisfactory for their para-medical colleagues. Instruction in anatomy and physiology should be an integral part of a planned curriculum, and not merely provide a standardized parcel of knowledge to be picked up and carried by everyone without regard to his or her future requirements.

The needs of the various groups of ancillary workers also differ, though perhaps to a lesser extent, for they are all concerned chiefly with derangements of the locomotor and nervous systems: it has indeed been suggested that much of the instruction in anatomy and physiology for ancillary specialists could be made common ground. This book has been written round the syllabus of the Association of Occupational Therapists, and is based on several years' experience in teaching anatomy and physiology to the Dorset House School of Occupational Therapy at Oxford, but I hope that it may prove useful not only to occupational therapists but also to other ancillary specialists whose needs are similar.

It is impossible to understand the functions of the body without an adequate knowledge of its structure, and, conversely, a good grounding in structure involves an appreciation of function. Of recent years the artificial barrier between the two "subjects" of

anatomy and physiology has begun to break down: I have attempted to present them as an integrated pattern of study. The first part of the book is concerned with the structure and activities of the various tissues and systems, and is introduced by a brief description of the general features of living cells. The second part deals in outline with some aspects of the functioning of the body as a whole. Such situations as the response to physical exercise involve the interaction of many systems, and may help the student to think of each system as part of a smoothly running whole. In the third section the descriptive topography of the body is taken up. The approach is systematic rather than regional, and from the mass of anatomical information I have tried to select only material which has a functional importance. I have not hesitated to simplify somewhat the attachments of the muscles and the details of their nerve supply and only the main blood vessels of each region are mentioned. The terminology used is that adopted at the 6th International Anatomical Congress at Paris in 1955, but where familiar terms are hallowed by usage I have given them as equivalents.

I hope that this book may be of help to all those in the early stages of a career in the para-medical services, and that it will encourage them to regard anatomy and physiology, not as mere examination material, but as a vital, (and even, perhaps, an interesting) part of their education.

PERTH March 1957

DAVID SINCLAIR



## ACKNOWLEDGMENTS

I should like to thank Dr. Howard Darcus, at whose suggestion this book was written, and also to acknowledge gratefully the helpful advice of Miss M.H. Kidston and Miss Joan Kennedy of the Dorset House School of Occupational Therapy. The illustrations are the work of Miss Christine Court and Miss Marjorie Beck, and I should like to express my appreciation of the care with which they have executed their drawings. Some of the illustrations have been re-drawn or adapted from other books. Thus, Figs. 54, 57, 97, 98, 106, 122, 123, 154, 155 and 157 have their sources in "*Cunningham's Text Book of Anatomy*", edited by Professor J. C. Brash and published by the Oxford University Press. Figs. 109, 110, 120, 121, 126 and 150 are from "*Gray's Anatomy*", edited by Professors T. B. Johnston and J. Whillis, and published by Longmans, Green. Figs. 6, 25, 63 and 64 derive from "*The Tissues of the Body*", by Professor Sir Wilfrid Le Gros Clark, published by the Oxford University Press, and Figs. 45, 46 and 91 come from "*Basic Anatomy*", by Professor G. A. G. Mitchell and Dr. E. L. Patterson, published by E. & S. Livingstone Ltd. To all these authors, publishers and editors I extend my grateful thanks. Finally, I must record my debt to the staff of Blackwell Scientific Publications. Writing a book can never become a wholly painless activity, but thanks to them my troubles have been minimal.