

The Endocrine System at a Glance

Third Edition

Ben Greenstein
Diana Wood



 **WILEY-BLACKWELL**

Contents

Preface to the Third Edition

Preface to the First Edition

Part 1 Fundamentals

1 Introduction

Clinical background

The principal endocrine glands

2 Chemical transmission

Classification of endocrine hormones

Basic principles of neurotransmission

Chemical transport

3 Mechanisms of hormone action: I
Membrane receptors

Clinical background

Introduction

Membrane receptors

Second messengers

Receptor antagonists

4 Mechanisms of hormone action: II
Intracellular receptors

Clinical background

Intracellular receptors
Nature of the steroid receptor

5 The hypothalamus and pituitary gland

Clinical scenario
The hypothalamus
The pituitary gland
The nuclei
The neurohormones

6 Gonadotrophin-releasing hormone: a peptide hormone

Clinical background
Introduction
Synthesis and release of peptide hormones
Structure-function studies

7 Principles of feedback control

Clinical scenario
Homeostasis

8 Endocrine function tests

Clinical setting
Insulin tolerance test
Water deprivation test

Part 2 Growth

9 Growth: I Cellular growth factors

Clinical background

Cellular growth and proliferation

10 Growth: II Normal growth

Clinical background

Normal growth

11 Growth: III Growth hormone

Clinical background

Growth hormone (GH)

12 Growth: IV Pathophysiology

Clinical scenario

Regulation of growth hormone secretion

Pathophysiology of growth hormone secretion

Part 3 Thyroid

13 Thyroid: I Thyroid gland and thyroid hormones

Clinical scenario

Thyroid gland: anatomy and structure

Thyroid hormones

14 Thyroid: II Thyroid hormone secretion and action

Clinical scenario

Control of thyroid hormone synthesis and secretion

Actions of thyroid hormone (Fig. 14d)

Mechanism of action of thyroid hormone

15 Thyroid: III Thyroid pathophysiology

Clinical scenario

Introduction

Thyroid function tests

Thyroid cancer

Part 4 Adrenals and autoimmunity

16 Adrenal gland: I Adrenal medulla

Clinical scenario

The adrenal glands

Actions of epinephrine

17 Adrenal gland: II Adrenocortical hormones

Clinical background

Adrenocortical hormones

Biosynthesis of glucocorticoids

Synthesis of adrenal androgens

Synthesis of adrenal estrogens

Mechanism of action of cortisol

18 Adrenal gland: III
Adrenocorticotrophic hormone (ACTH)

Clinical scenario

Adrenocorticotrophic hormone

19 Adrenal gland: IV Cortisol and
androgens

Clinical background

Physiological actions of Cortisol

20 Adrenal gland: V Aldosterone

Clinical scenario

Aldosterone

21 Adrenal gland: VI Pathophysiology

Clinical scenario

Adrenal hypofunction

22 Endocrine autoimmunity

Clinical scenario

Autoimmunity

Part 5 Sexual differentiation and
development

23 Sexual differentiation and
development: I Introduction

Clinical scenario

Genetic sex

Gonadal sex

Phenotypic sex: secondary sexual characteristics

24 Sexual differentiation and development: II Puberty

Clinical background

Puberty

Endocrine regulation of puberty

Gonadal development in childhood and puberty

Part 6 Female reproduction

25 Female reproduction: I Menstrual cycle

Clinical background

Female reproductive organs

The menstrual cycle

26 Female reproduction: II Ovarian steroids

Clinical scenario

Physiological actions of estrogens

Mechanism of action of estrogens

Ovarian androgens

27 Female reproduction: III
Pregnancy

Fertilization and i mplantation
Steroidogenesis

28 Female reproduction: IV
Parturition and lactation

Parturition and lactation
Lactation and the suckling reflex

29 Female reproduction: V
Pathophysiology

Clinical scenario
Reproductive pathophysiology

30 Female reproduction: VI
Contraception

Clinical background
Oral contraceptives
Other uses of estrogens

Part 7 Male reproduction

31 Male reproduction: I The testis

Clinical background
The testis

32 Male reproduction: II Actions of androgens

Clinical scenario

Actions of testosterone

Peripheral actions of testosterone

33 Male reproduction: III Pathophysiology

Clinical background

Male reproductive pathophysiology

Prostatic pathophysiology

Part 8 Posterior pituitary hormones, salt and water balance and hypertension

34 Oxytocin

Biosynthesis

Secretion

Actions

35 Vasopressin

Clinical scenario

Biosynthesis

Mechanism of action of vasopressin

Physiological actions of vasopressin

36 Renin-angiotensin-aldosterone system

Clinical background

Renin

Angiotensin II

37 Endocrine hypertension

Clinical background

Hormonal causes of hypertension and treatments

Part 9 Metabolic endocrinology: Pancreas and gastrointestinal tract

38 Insulin: I The pancreas and insulin secretion

Clinical scenario

Introduction

Insulin

39 Insulin: II Insulin action

Clinical scenario

Mechanism of action of insulin

Insulin effects

40 Insulin: III Type 1 diabetes mellitus

Clinical scenario

Insulin lack

Type 1 diabetes mellitus (IDDM)
Poor diabetic control - microvascular complications

41 Insulin: IV Type 2 diabetes mellitus

Clinical background
Type 2 diabetes mellitus
Treatment of Type 2 diabetes
The diabetic foot

42 Glucagon

Clinical background
Biosynthesis, storage and secretion
Mechanism of action
Effects of glucagon
Glucagon receptor mutations

43 Gastrointestinal hormones

Clinical background
Introduction
Biosynthesis, chemistry and release

Part 10 Metabolic endocrinology: Energy homoeostasis and obesity

44 Energy homoeostasis: I Summary

Clinical background
Endocrine hormones and energy metabolism

Energy stores

Endocrine control of food intake

45 Energy homoeostasis: II Central control

Clinical scenario

Introduction

Central regulation of feeding behaviour

46 Obesity: I Causes of obesity

Clinical background

Introduction

Possible causes of obesity

47 Obesity: II Cardiovascular and respiratory complications

Clinical background

Cardiovascular complications of obesity

Respiratory complications of obesity

48 Obesity: III Insulin resistance and endocrine complications

Clinical background

Other endocrine causes and implications of obesity

Treatment of obesity

Part 11 Calcium and metabolic bone disease

49 Calcium: I Parathyroid hormone

Clinical scenario

Role of calcium

Regulation of calcium metabolism

Synthesis and secretion of PTH

Physiological actions of PTH

Pathophysiology of PTH

50 Calcium: II Calcitonin

Clinical background

Calcitonin

51 Calcium: III Vitamin D

Clinical scenario

Vitamin D

Synthesis of vitamin D

Regulation of metabolism

Mechanism of action

Physiological actions of vitamin D

52 Bone remodeling

Introduction

Cellular structure of bone

Cell types in bone

Bone remodelling

53 Metabolic bone disease: I Paget's disease

Clinical background
Paget's disease of bone

54 Metabolic bone disease: II Primary osteoporosis

Clinical background

Aetiology

Estrogen and osteoporosis

Imaging studies and laboratory findings

Laboratory parameters

55 Metabolic bone disease: III Secondary osteoporosis

Introduction

Glucocorticoids and osteoporosis

Other endocrine disorders

Heritable disorders

Immobilization and osteoporosis

Prevention and treatment of osteoporosis

Part 12 Self assessment

MCQ_s

Chapter 1: Introduction

Chapter 2: Chemical transmission

Chapter 3: Mechanisms of hormone action: I

Membrane receptors

Chapter 4: Mechanisms of hormone action:

II Intracellular receptors

Chapter 5: The hypothalamus and pituitary gland

Chapter 6: Gonadotrophin - releasing hormone: a peptide hormone

Chapter 7: Principles of feedback control

Chapter 8: Endocrine function tests

Chapter 9: Growth: I Cellular growth factors

Chapter 10: Growth: II Normal growth

Chapter 11: Growth: III Growth hormone

Chapter 12: Growth: IV Pathophysiology

Chapter 13: Thyroid: I Thyroid gland and thyroid hormones

Chapter 14: Thyroid: II Thyroid hormone secretion and action

Chapter 15: Thyroid: III Thyroid pathophysiology

Chapter 16: Adrenal gland: I Adrenal medulla

Chapter 17: Adrenal gland: II Adrenocortical hormones

Chapter 18: Adrenal gland: III Adrenocorticotrophic hormone (ACTH)

Chapter 19: Adrenal gland: IV Cortisol and androgens

Chapter 20: Adrenal gland: V Aldosterone

Chapter 21: Adrenal gland: VI Pathophysiology

Chapter 22: Endocrine autoimmunity

Chapter 23: Sexual differentiation and development: I Introduction

Chapter 24: Sexual differentiation and development: II Puberty

Chapter 25: Female reproduction: I Menstrual cycle

Chapter 26: Female reproduction: II Ovarian steroids

Chapter 27: Female reproduction: III Pregnancy

Chapter 28: Female reproduction: IV Parturition and lactation

Chapter 29: Female reproduction: V Pathophysiology

Chapter 30: Female reproduction: VI Contraception

Chapter 31: Male reproduction: I The testis

Chapter 32: Male reproduction: II Actions of androgens

Chapter 33: Male reproduction: III Pathophysiology

Chapter 34: Oxytocin

Chapter 35: Vasopressin

Chapter 36: Renin - angiotensin - aldosterone system

Chapter 37: Endocrine hypertension

Chapter 38: Insulin: I The pancreas and insulin secretion

Chapter 39: Insulin: II Insulin action

Chapter 40: Insulin: III Type 1 diabetes mellitus

[Chapter 41: Insulin: IV Type 2 diabetes mellitus](#)

[Chapter 42: Glucagon](#)

[Chapter 43: Gastrointestinal hormones](#)

[Chapter 44: Energy homeostasis: I Summary](#)

[Chapter 45: Energy homeostasis: II Central control](#)

[Chapter 46: Obesity: I Causes of obesity](#)

[Chapter 47: Obesity: II Cardiovascular and respiratory complications](#)

[Chapter 48: Obesity: III Insulin resistance and endocrine complications](#)

[Chapter 49: Calcium: I Parathyroid hormone](#)

[Chapter 50: Calcium: II Calcitonin](#)

[Chapter 51: Calcium: III Vitamin D](#)

[Chapter 52: Bone remodelling](#)

[Chapter 53: Metabolic bone disease: I Paget's disease](#)

[Chapter 54: Metabolic bone disease: II Primary osteoporosis](#)

[Chapter 55: Metabolic bone disease: III Secondary osteoporosis](#)

[Answers](#)

[Appendix Normal Values](#)

[Glossary](#)

Index

The Endocrine System at a Glance

Ben Greenstein

BA (Hons) PhD
Senior Visiting Research Fellow
Pain Management Unit
Royal Free School of Medicine
London
UK

Diana Wood

MA MD FRCP
Director of Medical Education and Clinical Dean
University of Cambridge School of Clinical Medicine
Clinical School
Addenbrooke's Hospital
Cambridge
UK

Third edition

 **WILEY-BLONDEL**

A John Wiley & Sons, Ltd., Publication

This edition first published 2011 © 2011 by Ben Greenstein
and Diana Wood

First edition 1994

Second edition 2006

Wiley-Blackwell is an imprint of John Wiley & Sons, formed
by the merger of Wiley's global Scientific, Technical and
Medical business with Blackwell Publishing.

Registered office: John Wiley & Sons, Ltd, The Atrium,
Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial offices: 9600 Garsington Road, Oxford, OX4 2DQ,
UK

The Atrium, Southern Gate, Chichester, West Sussex, PO19
8SQ, UK 111 River Street, Hoboken, NJ 07030-5774, USA

For details of our global editorial offices, for customer
services and for information about how to apply for
permission to reuse the copyright material in this book
please see our website at www.wiley.com/wiley-blackwell.

The right of the author to be identified as the author of this
work has been asserted in accordance with the UK
Copyright, Designs and Patents Act 1988.

All rights reserved. No part of this publication may be
reproduced, stored in a retrieval system, or transmitted, in
any form or by any means, electronic, mechanical,
photocopying, recording or otherwise, except as permitted
by the UK Copyright, Designs and Patents Act 1988, without
the prior permission of the publisher.

Designations used by companies to distinguish their
products are often claimed as trademarks. All brand names
and product names used in this book are trade names,
service marks, trademarks or registered trademarks of their
respective owners. The publisher is not associated with any
product or vendor mentioned in this book. This publication is

designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold on the understanding that the publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

Library of Congress Cataloging-in-Publication Data

Greenstein, Ben, 1941-

The endocrine system at a glance/Ben Greenstein, Diana Wood. - 3rd ed.

p.; cm. - (At a glance series)

Includes index.

ISBN-13: 978-1-4443-3215-5 (pbk.: alk. paper)

ISBN-10: 1-4443-3215-5

1. Endocrinology. I. Wood, Diana F. II. Title. III. Series: At a glance series (Oxford, England) [DNLM: 1. Endocrine Glands-physiology. 2. Endocrine Glands-physiopathology. 3. Endocrine System Diseases. 4. Hormones-secretion. WK 100] QP187.G834 2011 612.4-dc22

2011007204

Preface to the Third Edition

The third edition of this book is again co-authored by Ben Greenstein and Diana Wood, a clinical endocrinologist. The book aims to relate basic endocrine sciences to the clinical background and presentations of disease and in keeping with the overall philosophy of the *At a Glance* series, and strives to present data in a varied way that facilitates rapid assimilation of the information. The book is aimed at undergraduate medical students, primarily in the early part of their course, although as a handy and accessible reference book and revision tool it should also be a useful source of information for clinical medical students and junior doctors. *The Endocrine System at a Glance*, as the name implies, does not claim to replace comprehensive textbooks; rather it serves as a concise guide and revision aid to this fascinating branch of clinical science and medicine. A new addition to the third edition is the presentation of revision questions relating to each chapter.

The authors have striven to present the data clearly and accurately, and every effort has been made to include information that is up-to-date at the time of going to press. We make no claim to infallibility, however, and if readers spot ambiguities, factual inaccuracies or typographical errors, we should be most grateful for feedback and for suggestions which will improve the book and the presentation of the information.

It remains for us to thank the many students and colleagues who have read and commented on the book while in draft form. It has been a pleasure to work with the staff at Wiley-Blackwell, and in particular Karen Moore and Beth Bishop, whose patience and guidance is much appreciated.

Ben Greenstein

Diana Wood

London and Cambridge

Preface to the First Edition

***Endocrinology at a Glance* published 1994**

Endocrinology at a Glance is intended to be just that. It has been designed and written so that the diagrams and text complement each other, and both are to be consulted. The emphasis has been on the diagrams, and words have been kept to a minimum.

The book has been produced to provide as comprehensive an overview of the subject as any medical or science undergraduate student will need in order to pass and pass well an examination in basic endocrinology. In addition, it is hoped that *Endocrinology at a Glance* will be useful to students of clinical endocrinology who need to refer rapidly to the mechanisms underlying the subject. The book is not presented as an alternative to the several excellent textbooks of endocrinology, which serve as useful reference texts, and some of which have been used during the writing of this book.

Every attempt has been made to present the data accurately and to provide the most up-to-date and reliable information available. When speculative data are given, their fragility has been indicated. Nevertheless, every writer, especially this one, is human and if the reader spots errors or a lack of clarity, or has any suggestions to improve or add to the presentation, this feedback will be gratefully appreciated and acknowledged.

I should like to thank the many undergraduate, medical, dental and science students who have scrutinized and used the diagrams, or similar ones, over the years, and whose criticisms have helped to make them more useful. I should like to thank Elizabeth Bridges, Kay Chan, Yacoub Dhaher, Munther Khamashta and Adam Greenstein for commentating on some of the work. It has been a pleasure working with the staff of Blackwell Science Ltd, and

particularly Dr Stuart Taylor and Emma Lynch, whose friendly encouragement and advice cheered me on.

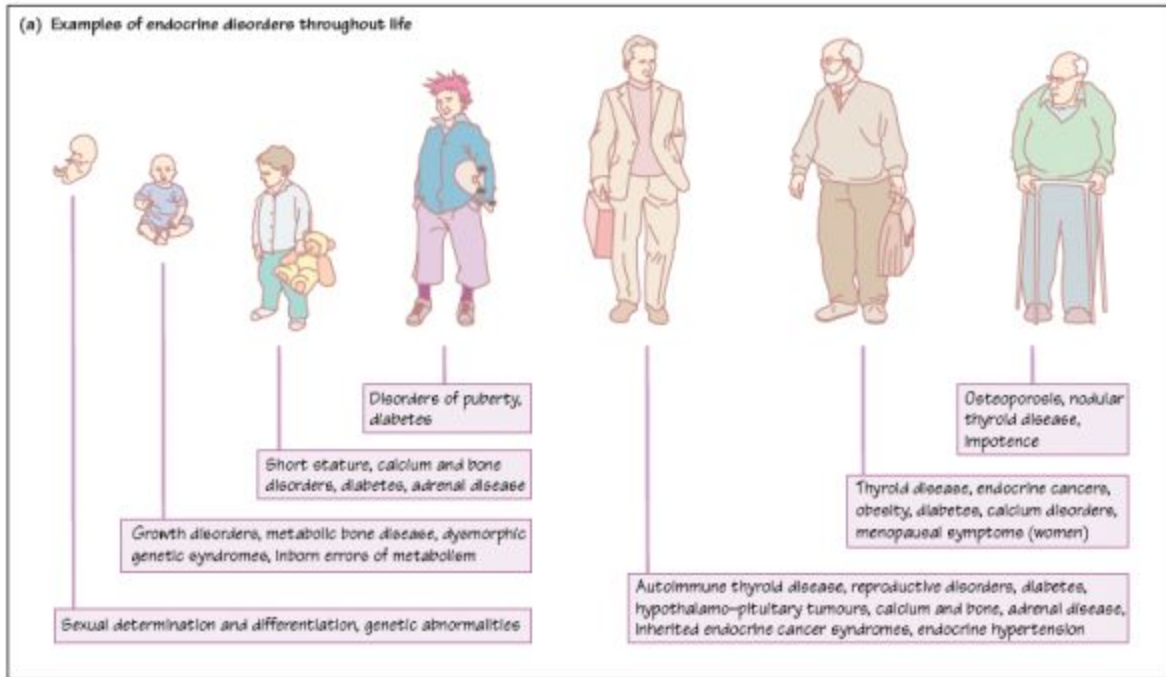
Ben Greenstein

London 1994

Part 1
Fundamentals

1

Introduction



Clinical background

Endocrinology is the study of endocrine hormones and of the organs involved in endocrine hormone release. Classically, hormones have been described as chemical messengers, released and having their actions at distant sites. It is now clear, however, that there is a close relationship between hormones and other factors such as neurotransmitters and growth factors acting in a paracrine or autocrine fashion. Hormones are essential for the maintenance of normal physiological function and hormonal disorders occur at all stages of human life. Clinical

endocrinologists thus look after patients of all ages and with a very wide range of disorders ([Fig. 1a](#)).

The principal endocrine glands

The brain is the controller of the nervous system, but it is also one of the most important endocrine glands. Specialized nerve cells, notably in the hypothalamus, synthesize hormones which are transported along the axon to the nerve terminal. Here they are released into the portal blood system, which carries them to the pituitary gland. In some cases, the axon of the neuroendocrine cell projects down to the pituitary cell itself. The principal hypothalamic neurohormones are:

- 1. corticotrophin-releasing hormone** (CRH), controls the release of ACTH;
- 2. dopamine** inhibits prolactin release;
- 3. growth-hormone-releasing hormone** (GHRH) causes growth hormone release;
- 4. somatostatin** inhibits growth hormone release;
- 5. gonadotrophin-releasing hormone** (GnRH) causes luteinizing hormone (LH) and follicle-stimulating hormone (FSH) release;
- 6. thyrotrophin-releasing hormone** (TRH) causes thyroid-stimulating hormone (TSH) release;
- 7. oxytocin** causes milk ejection and contraction of the uterus in labour - it is synthesized in the hypothalamus and is stored in and released from the posterior pituitary gland;
- 8. vasopressin** (antidiuretic hormone, ADH) promotes water reabsorption from the kidney tubules - it is synthesized in the hypothalamus, and stored in and released from the posterior pituitary gland.

The pituitary gland is composed of two lobes, anterior and posterior, which arise from different embryological

origins - the anterior originates from the embryonic oral cavity and the posterior from the base of the brain (i.e. a neural origin). The two lobes become closely apposed to each other to form the pituitary gland. Humans have a non-functional **intermediate lobe**, which is much larger in some other animals. The principal hormones of the pituitary are:

1 anterior:

(a) corticotrophin (adrenocorticotrophic hormone; ACTH) releases glucocorticoids and other steroids from the adrenal cortex;

(b) follicle-stimulating hormone (FSH) promotes spermatogenesis in males and ovarian follicular maturation in females;

(c) luteinizing hormone (LH) promotes testosterone synthesis in males and causes ovarian follicular rupture and ovulation in females;

(d) prolactin (PRL) promotes lactation and may have an immunomodulatory role in non-lactating females and males;

(e) thyrotrophin (thyroid-stimulating hormone; TSH) promotes thyroid hormone production and release from the thyroid gland;

(f) growth hormone (also called somatotrophin; GH) promotes muscle and skeletal growth.

2 posterior:

(a) oxytocin causes milk ejection and contraction of the uterus in labour;

(b) vasopressin (antidiuretic hormone, ADH) promotes water reabsorption from the renal tubules.

The thyroid gland is situated just in front of the trachea in humans. The thyroid-hormone-producing cells are arranged in follicles, and concentrate iodine which is used for the synthesis of the thyroid hormone. The circulating