

Cambridge University Press  
978-1-107-62550-1 - Biological Actions of Sex Hormones  
Harold Burrows  
Frontmatter  
[More information](#)

---

BIOLOGICAL ACTIONS  
OF  
SEX HORMONES

Cambridge University Press  
978-1-107-62550-1 - Biological Actions of Sex Hormones  
Harold Burrows  
Frontmatter  
[More information](#)

---

Cambridge University Press  
978-1-107-62550-1 - Biological Actions of Sex Hormones  
Harold Burrows  
Frontmatter  
[More information](#)

---

# BIOLOGICAL ACTIONS OF SEX HORMONES

BY  
HAROLD BURROWS  
C.B.E., Ph.D., F.R.C.S.



CAMBRIDGE  
AT THE UNIVERSITY PRESS  
1945

Cambridge University Press  
978-1-107-62550-1 - Biological Actions of Sex Hormones  
Harold Burrows  
Frontmatter  
[More information](#)

---

CAMBRIDGE UNIVERSITY PRESS  
Cambridge, New York, Melbourne, Madrid, Cape Town,  
Singapore, São Paulo, Delhi, Mexico City

Cambridge University Press  
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

[www.cambridge.org](http://www.cambridge.org)  
Information on this title: [www.cambridge.org/9781107625501](http://www.cambridge.org/9781107625501)

© Cambridge University Press 1945

This publication is in copyright. Subject to statutory exception  
and to the provisions of relevant collective licensing agreements,  
no reproduction of any part may take place without the written  
permission of Cambridge University Press.

First published 1945  
First paperback edition 2013

*A catalogue record for this publication is available from the British Library*

ISBN 978-1-107-62550-1 Paperback

Cambridge University Press has no responsibility for the persistence or  
accuracy of URLs for external or third-party internet websites referred to in  
this publication, and does not guarantee that any content on such websites is,  
or will remain, accurate or appropriate.

# CONTENTS

## PREFACE

PAGE ix

## PART I. GONADOTROPHINS

### CHAPTER I. The Nature and Functions of Gonadotrophins

Introductory remarks, *p.* 1; Inactivation, excretion, sources and distribution of gonadotrophin, *p.* 4; Are the pituitary and placental gonadotrophins identical? *p.* 10; Are the follicle ripening (FRH) and luteinizing (LH) hormones distinct compounds? *p.* 12; The action of gonadotrophins on the ovary with special reference to hormonal balance, *p.* 17; The action of gonadotrophins on the testis, *p.* 25; The interstitial cell-stimulating hormone (ICSH), *p.* 29; Puberty and the awakening of sexual activity, *p.* 30

### CHAPTER II. Factors which Influence the Gonadotrophic Activity of the Pituitary

Age, *p.* 32; Afferent stimuli acting through the central nervous system, *p.* 34; Changes of external temperature, *p.* 40; Seasons, *p.* 41; Oestrous cycle, *p.* 41; Pregnancy, *p.* 44; Gonadectomy, *p.* 44; Partial gonadectomy, cryptorchidism and sterilization by X-rays, *p.* 46; Gonadal hormones, *p.* 51; Gonadotrophins, *p.* 59; Sex, *p.* 60; Nutrition, including vitamin deficiency and general physical development, *p.* 64

### CHAPTER III. Factors which influence the Reaction of the Gonads to Gonadotrophins

Age, *p.* 70; Season, *p.* 73; The nature and mode of preparation of the gonadotrophin, *p.* 74; Synergism and augmentation, *p.* 74; Delayed absorption, *p.* 74; Divisional dosage, *p.* 75; Site of introduction, *p.* 75; Acquired resistance to the action of gonadotrophin, *p.* 76; Difference in responses by different species, *p.* 83; Temperature, *p.* 84

### CHAPTER IV. Factors which affect the Cytological Structure and Weight of the Anterior Lobe of the Pituitary

Seasonal changes, *p.* 85; The oestrous cycle, *p.* 86; Pregnancy, pseudopregnancy and lactation, *p.* 87; Gonadal hormones, *p.* 88; Gonadotrophin, *p.* 91; Sex, *p.* 92; Castration, and destruction of seminal epithelium, *p.* 93; Nutrition, *p.* 94; Age, *p.* 95

## PART II. GONADAL HORMONES

### CHAPTER V. A General View of the Gonadal Hormones

Experimental investigation of the action of gonadal hormones, *p.* 96; Chemical structure, *p.* 98; Sources, functions and excretion, *p.* 100; So-called bisexual activities of the gonadal hormones, *p.* 102; Co-operation of different gonadal hormones, *p.* 115; Mutual antagonisms between gonadal hormones, *p.* 118; Factors influencing the action of administered gonadal hormones, *p.* 123; The speed of reaction to gonadal hormones, *p.* 140; Gradients of responsiveness to gonadal hormones, *p.* 140; Reversible and irreversible effects of sex hormones, *p.* 142; Actions common to gonadal and adrenal cortical hormones, *p.* 143; The influence of gonadal hormones on behaviour, *p.* 144; Anaesthetic properties of gonadal hormones, *p.* 147; The influence of gonadal hormones on tissue growth, with special reference to cancer, *p.* 147

## PART III. ANDROGENS

## CHAPTER VI. Androgens

Introductory remarks, *p.* 152; General review of the biological action of androgens, *p.* 152;  
 The sources of androgen within the body, *p.* 157; Inactivation and excretion of androgen,  
*p.* 165

CHAPTER VII. The Action of Androgen on the Reproductive Organs before  
their Complete Differentiation

Ovary, testis. Freemartins, *p.* 176; Accessory generative organs, *p.* 184

CHAPTER VIII. The Action of Androgen on the Reproductive Organs after  
their Complete Differentiation

The gonads: I. The ovary, *p.* 191; II. The testis, *p.* 196

## CHAPTER IX. The Action of Androgen on the Accessory Generative Organs

The uterus, *p.* 207; The vagina, *p.* 212; The oviducts, *p.* 215; The prostate and coagulating  
 gland, *p.* 215; The seminal vesicle, *p.* 218; The vas deferens and epididymis, *p.* 219;  
 The epoöphoron, *p.* 220; Cowper's gland, *p.* 220; The preputial gland, *p.* 221; External  
 genitalia: (i) Scrotum and perineum, *p.* 222; (ii) Penis and clitoris, *p.* 223; Action of  
 androgen on the nipple and mamma, *p.* 229

CHAPTER X. The Action of Androgen on Tissues and Organs other than those  
already dealt with

The adrenal, *p.* 232; The kidney, *p.* 235; The liver, *p.* 236; The pancreas, *p.* 237; The  
 thyroid, *p.* 237; The parathyroid, *p.* 238; The thymus, *p.* 238; The submaxillary salivary  
 gland, *p.* 239; The skin, *p.* 239; The skeleton, bodyweight and muscular system, *p.* 241;  
 The effect of androgen on the deposition and the distribution of fat, *p.* 249; The production  
 of sarcoma by androgen, *p.* 250

## PART IV. OESTROGENS

## CHAPTER XI. Oestrogens

General considerations, *p.* 251; Sources, metabolism and excretion of oestrogen, *p.* 252;  
 Gradients of responsiveness, *p.* 267; Reversibility of the effects, *p.* 268

CHAPTER XII. The Action of Oestrogen on the Embryonic Gonads. and  
Müllerian and Wolffian Systems

The embryonic gonads, *p.* 271; The embryonic Müllerian and Wolffian systems, *p.* 275

CHAPTER XIII. The Action of Oestrogen on the Anterior Lobe of the Pituitary,  
and on the Gonads after their Differentiation

The pituitary, *p.* 277; The ovary, *p.* 280; The testis, *p.* 283

CHAPTER XIV. The Action of Oestrogen on the Accessory Genital Organs  
after their Differentiation, with a special reference to inguinal hernia

External genitalia, *p.* 289; Inguinal hernia, *p.* 291

CONTENTS vii

CHAPTER XV. The Action of Oestrogen on the Accessory Genital Organs  
(continued)

The coagulating gland, *p.* 296; The seminal vesicle, *p.* 296; The prostate, *p.* 297; The uterus masculinus, *p.* 299; The vas deferens and epididymis, *p.* 300; The ampullary glands, *p.* 300; Cowper's glands, *p.* 300; The preputial glands, *p.* 301

CHAPTER XVI. The Action of Oestrogen on the Accessory Genital Organs  
(continued)

The vagina, *p.* 302; The uterus, *p.* 310

CHAPTER XVII. The Effects of Oestrogen on the Mamma

The stroma and nipple, *p.* 326; The mammary gland, *p.* 328; The mammary ducts and acini, *p.* 329; The roles of the pituitary and placenta in the mammary response to oestrogen, *p.* 334; Lactation, *p.* 338

CHAPTER XVIII. Factors in the Causation of Mammary Cancer

The role of oestrogen in mammary cancer, *p.* 348; Hereditary factors in the etiology of mammary cancer: (a) Nongenetic, *p.* 352; (b) Genetic, *p.* 360; Subsidiary factors in mammary carcinogenesis, *p.* 365; Attempts to prevent mammary cancer, *p.* 367

CHAPTER XIX. The Effects of Oestrogen on Connective Tissues and Skin

General growth and bodyweight, *p.* 368; Skeleton, *p.* 370; Adipose tissue, *p.* 375; Voluntary muscle, *p.* 375; Skin, *p.* 376; Sarcomata induced by oestrogen, *p.* 376

CHAPTER XX. The Actions of Oestrogen on organs other than those considered in earlier chapters

The liver, *p.* 377; The pancreas, *p.* 378; Blood and vascular system, *p.* 379; The adrenals, *p.* 384; Excretion of water and electrolytes, *p.* 386; The thymus, *p.* 388

PART V. PROGESTINS

CHAPTER XXI. Progestins

Sources of progestin, *p.* 390; The corpus luteum, *p.* 394

CHAPTER XXII. Progestins (continued). The Biological actions of Progestin

The pituitary, *p.* 406; Embryological development, *p.* 406; Male reproductive organs, *p.* 406; The ovary and the oestrous cycle, *p.* 408; Accessory reproductive organs of the adult female, *p.* 413; Co-operation and antagonism between progesterone and other gonadal hormones, *p.* 426; Actions common to progesterone and adrenal cortical hormones, *p.* 435; Miscellaneous actions of progesterone, *p.* 438

PART VI. SEX HORMONES OF THE ADRENAL CORTEX

CHAPTER XXIII. Sex Hormones of the Adrenal Cortex

General considerations, *p.* 440; The pituitary-adrenal relationship, *p.* 441; Adrenal-gonad relationship, *p.* 444; Adrenal virilism and feminism, *p.* 453; Inactivation of deoxycorticosterone by the liver, *p.* 456

APPENDIX: Abbreviations	457
Synonyms	457
REFERENCES	460
GLOSSARY	485
INDEX	487

Cambridge University Press  
978-1-107-62550-1 - Biological Actions of Sex Hormones  
Harold Burrows  
Frontmatter  
[More information](#)

---



## P R E F A C E

In the last few years our comprehension of vital phenomena has been rapidly extending. The nature of the sex hormones, and the reactions of living tissues toward them, have been prominent in this advance, and it is now generally understood that compounds formed in the pituitary, gonads and adrenals radically affect the structure and functions of the body and the workings of the mind. To-day our knowledge of these matters is growing so fast that to keep abreast of it is not easy for those who are occupied with many other affairs. The author felt, therefore, that a co-ordinated summary of experimental inquiries in this field might be useful. In pursuing the idea attention has been confined almost entirely to biological work performed in the laboratory; the ultimate possibility of applying the experience so gained for the benefit of man has been the leading motive.

The essay can hardly be offered to the scientific world without an apology. Biological work is still largely confined to qualitative observation. Life is a changing process and in solving its problems we are often deprived of fixed and measurable data; moreover, the adaptability of living tissue to circumstance involves so many and such complex reactions that an exact prediction of the outcome of any extraneous influence cannot, as a rule, be stated in precise quantitative terms; nor can experimental results in this field be described adequately without specifying the conditions in which they were obtained. The presentation of the subject demanded by the latter drawback may, it is feared, be tedious to the reader, especially as the narrative contains many references to the literature. Sir James Paget complained of the difficulty of composing a readable scientific review, and the present writer is too modest to suppose that he has overcome the difficulty. It is hoped, however, that the matter contained in these pages may supply a trustworthy, though limited, foundation for further progress in both sex-hormone research and clinical practice.

The author would like to regard his book as a tribute to the pioneers of sex-hormone physiology, with special regard to John Hunter (1728–93), the first and greatest of them. More than a hundred years before the term hormone had been invented, Hunter showed that the accessory reproductive organs are largely dependent for their development and even for their existence on some influence derived from the gonads.

The writer regrets that much good work done in foreign lands has been given inadequate consideration, but it may be unnecessary or impossible to insert every detail into a picture; for general portrayal it is perhaps enough to draw the salient features as far as possible with fidelity of outline and correct emphasis.

My own experimental work on the sex hormones has been done, under the auspices of the British Empire Cancer Campaign, at the Chester Beatty Research Institute of the Royal Cancer Hospital (Free). To the authorities of these institutions, to Professor Kennaway the director, and to my other colleagues

## PREFACE

I should like to express gratitude for their interest and encouragement. I have also to thank, most cordially, several donors for generous gifts of chemical material; among these donors are Dr Girard of Paris, Dr Laqueur of Amsterdam, Dr Macbeth of Organon, Limited, Mr Smart and Dr Miescher of the Ciba Company. To Dr Macbeth I am greatly indebted for extensive references to relevant literature. I should like also to acknowledge valuable advice from Dr F. H. A. Marshall. To Dr J. N. Goldsmith I am especially grateful; not only has he prepared an exceptionally helpful index but he has given great help with proof-reading and advice on various details. Lastly, I must mention the unremitting help which I have received from my wife, without whose aid this book could not have been written.

H.B.

*London, 1944*