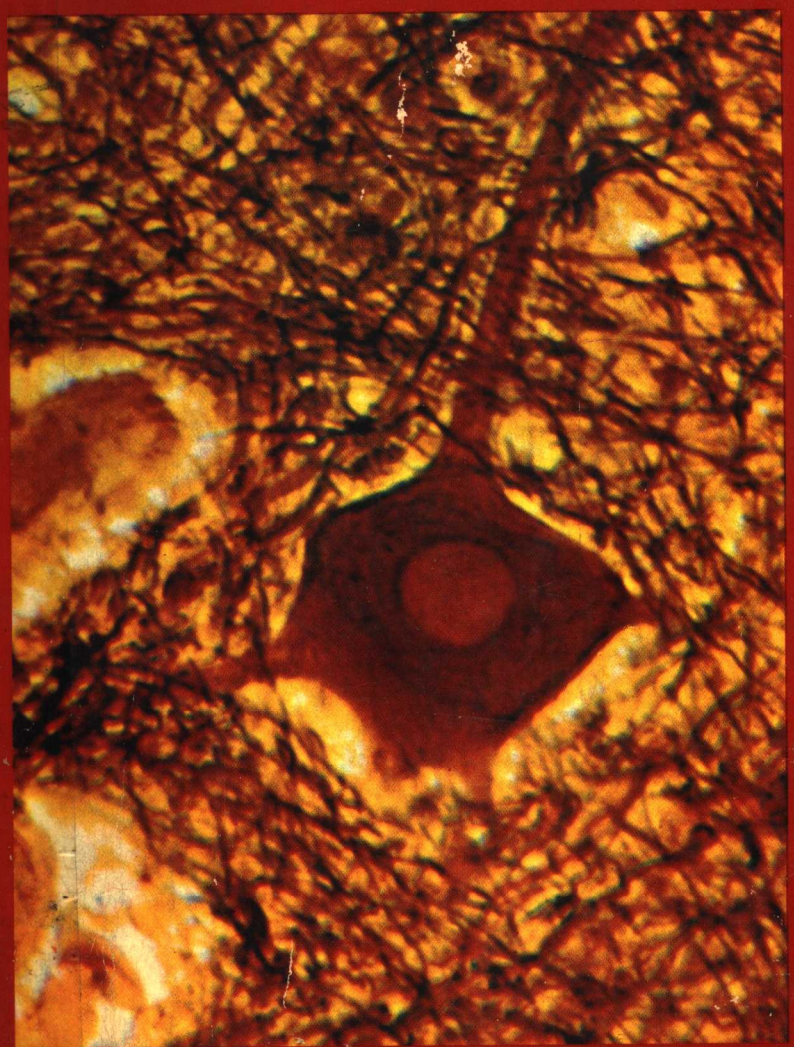
modern cell biology

SECOND EDITION

WILLIAM D. McELROY / CARL P. SWANSON



modern cell biology

SECOND EDITION

WILLIAM D. McELROY

Chancellor
University of California, San Diego

CARL P. SWANSON

Department of Botany
University of Massachusetts

PRENTICE-HALL, INC., Englewood Cliffs, N.J.

Library of Congress Cataloging in Publication Data

McElroy, William David (date)
Modern cell biology.
(Prentice-Hall biological sciences series)
Issued also as pt. 1 of Biology and man in 1975.
Includes bibliographies and index.
1. Cytology. I. Swanson, Carl P., joint author.
II. Title.
QH581.2.M27 1976 574.8'7 75-22218
ISBN 0-13-589614-2

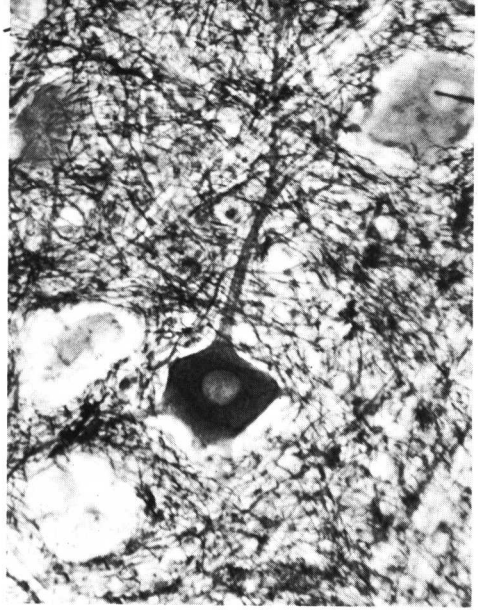
modern cell biology

second edition

William D. McElroy and Carl P. Swanson

10 9 8 7 6 5 4 3

Printed in the United States of America

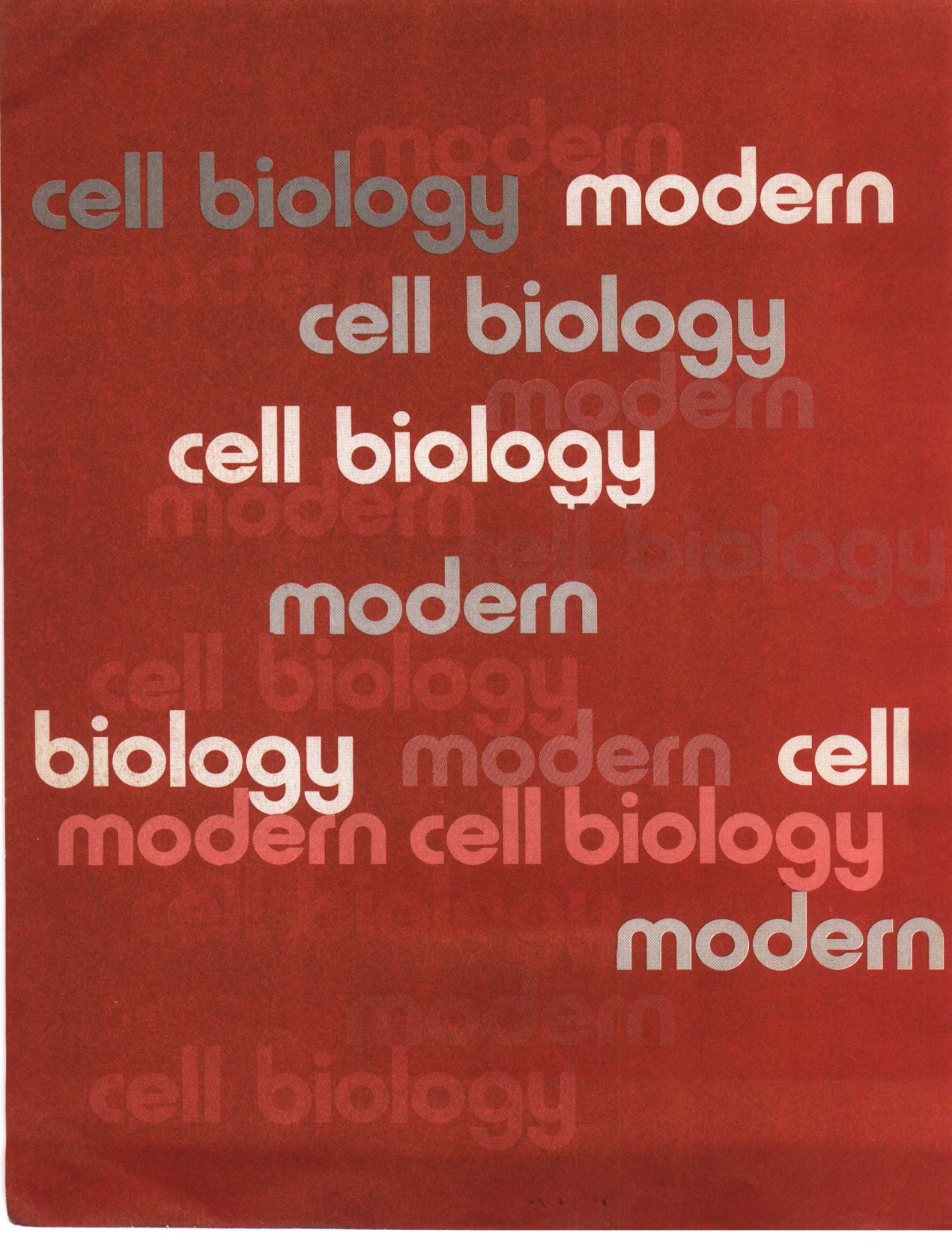


Section by E. Evans; Photo by A. Blaker

ABOUT THE COVER PHOTOGRAPH Section through spinal cord (yellow-red-brown). This section shows a large ventral horn cell of the spinal cord. The cell body is clearly seen with an axon extending from it. This axon leaves the spinal cord and carries impulses to muscles. The field is interlaced with great numbers of branches and twigs from other nerve axons.

PRENTICE-HALL BIOLOGICAL SCIENCES SERIES

William D. McElroy
and
Carl P. Swanson
editors


cell biology modern
cell biology
cell biology
modern
biology modern cell
modern cell biology
modern

preface

Our readers may think that the title of this volume, *Modern Cell Biology,* does not strictly describe the contents. That is, they may feel that the title suggests a narrower coverage than the contents, and particularly the last four chapters, would imply. This, we readily admit, is a matter of judgment, but we feel comfortable with our choice of title.

As cell biologists, we are dealing with the structure, function, and biochemistry of cells, topics which have been enormously enriched in recent decades as new instruments, new techniques, and new methods of approach have made cells more readily accessible to study at more and more refined levels of investigation and understanding. But we are concerned not only with cells as such, but also with their relation to the larger problems of inheritance, development, evolution, and the origin of life. In addition, to help the reader visualize cells in the total scheme of time and place and change, we range in subject from atoms to galaxies, and from viruses and bacteria to humans and redwoods.

The cell doctrine, one of the central concepts in biology, was made possible by the development of the microscope, which enabled us to see smaller objects than the naked eye would permit. The cell, therefore, becomes the middle ground for our study

of life. In the domain of smaller structures, cells are the objects wherein the chemistry of life is being enacted, where atoms aggregate into molecules, and molecules into organelles; in multicellular form, the cell is the object that enables us to see and describe the visible world of life that is so much more familiar to us.

Our emphasis, as a consequence, remains cellular even though our immediate topic may be molecules or humans. Where there are no cells, life is absent; the cell is the smallest unit of organized matter exhibiting all of those activities that, collectively, distinguish the living from the nonliving. The cell, through its informational content and its behavior in division, fertilization, and reproduction, provides the physical basis for the transmittal of characteristics from one individual to another, and from one generation to the next. These characteristics express themselves through the medium of cells; it is the multiplication, movement, and differentiation of cells that lead to the development and maturation of an individual, whether that individual be a single cell or a multicellular organism. If we think of cells functioning through time, displaying the heritable changes that occur continuously but randomly, seeing these changes gain expression in individuals, and visualizing their spread through populations, we are then dealing with the evolution of living systems. It is through these processes that we gain an understanding of the diversity as well as the continuity and unity of life.

Cells can also be viewed as the entities through which energy is continuously being manipulated; that is, the cells are so constructed that energy is trapped, converted to more usable forms, stored, and eventually utilized, after which it is returned to the external world as chemical or heat energy. This is all accomplished in an organized and orderly fashion, and it is the organization and structure of cells that permit this to take place.

As humans we are the most important living species because we live in an anthropomorphic world of our own creation. Like all other organisms, we are a collection of cells, organized as to type, number, and location in such a way as to bring about the appearances, and display the behaviors, of a human being. To emphasize the human race as the principal species for focus in the cellular world that we are describing is merely to provide additional relevance to our examination of cells and their structure and function. No other justification is needed.

This volume, like the first edition, is a portion of a larger volume. The first edition was derived from the *Foundations of Biology,* authored by McElroy, Swanson, Galston, Buffaloe, and Macey (Prentice-Hall, 1969). When the *Foundations of Biology* was

revised, its title and authorship was altered (*Biology and Man,* McElroy, Swanson, and Macey) as was its contents. This edition of *Modern Cell Biology* has already appeared as part I of BIOLOGY AND MAN. It reflects many of the changes that have occurred since the first edition, and we like to think that it is also an improved version.

THE AUTHORS

contents

modern cell biology

introduction chapter 1

Each of us, whatever our training, whatever our interests, is an observer of the many worlds about us. Through sight, sound, taste, odor, and touch we are in some way, consciously or unconsciously, constantly responding to our environment and what goes on within that environment: a Cape Cod saltwater marsh, or the grandeur of snow-capped mountain peaks; the night sky sequined with thousands of stars, or the play of light filtering through a forest canopy; a tumbling mountain, the awesomeness of a raging sea, or a puddle left by a recent rain; the tranquility of a rural scene, or the bustle, noise, and excitement of a modern city; an athletic contest, or the tragedy and horror of contending armies; the individuals, groups, and communities that exist around us. As we look and see, listen and hear, with varying degrees of responsiveness, we perceive a universe abounding in diversity of form and action. And as there is diversity in what we perceive, so, too, is there diversity in our individual abilities to perceive. Each of us, because of inheritance and experience, time and circumstance, has a different image of himself and the world about him.

The universe is an enormously varied complex of matter and energy. There is nothing else. But the diversity around us stems from the manner in which matter and energy are organized,

managed, manipulated, and expressed. At one extreme are the largest units of matter of which we are aware and can comprehend, the galaxies and supergalaxies. The bowl of the Big Dipper in the northern skies appears featureless and empty to the unaided eye, but this is due to our limits of resolution. Through a large telescope, nearly half a million galaxies, each containing billions of stars, can be seen to lie framed within the bowl. Like the individual stars that form them—some red, some blue, some giants, and some dwarfs—the galaxies vary in size, structure, shape, age, and in the amount of energy they emit, some of which reaches our earth as electromagnetic waves: visible light, x-rays, or cosmic rays (Fig. 1.1). The great number of galaxies visible in only one small patch of sky gives us an idea of the immensity of the universe. By comparison, our own galaxy, which has a diameter of about 100,000 light-years, is dwarfed.

Figure 1.1 We live in many environments. Our stellar environment, a galaxy similar to Andromeda (see artist's rendering above), consists of many billions of stars. One of those stars, the Sun, supports the only life we are aware of in the Universe, the life that we know on our own planet.

At the other extreme is one of the smallest units of matter, the hydrogen atom, with a diameter of about one angstrom unit. Halfway along this cosmic yardstick, measured on a log scale, stands man the observer—curious, wondering, experimenting, and asking questions. His ability to ask questions is one aspect of his behavior that sets him apart from the other animals. He can also turn his sights inward and ask questions about himself. On the basis of his answers he can then alter his behavior and consider the consequences of doing so. He can also alter his environment to suit his present or future needs and wishes. Man can transform a barren desert into a lush tropical garden. Any other species, plant or animal, would have to adapt or become extinct.

Man is also a user and maker of tools. His mastery in technology has enabled him to construct artificial microenvironments such as bathyspheres and space probes, in which he can journey to the deepest trenches of the sea floor or into interplanetary space (Fig. 1.2). In the process of molding his environment and making replicas of it to meet his own ends, as no other animal has ever done, man at the present time is the most successful animal on the face of the earth. Yet an animal he is, as much a product of evolution as the other species he observes. It is as biological for man to dream, build, paint, and sing as it is for a muskrat to build a shelter of mud, sticks, and grass.

Despite his capabilities and his uniqueness, man, too, is an organized expression of matter and energy. His environment consists of three zones: the *lithosphere,* the *hydrosphere,* and the *atmosphere.* Man partakes of each, for his body, like that of all living things, consists of minerals, water, and gases, through which energy in various forms is accepted, transformed, stored, or used. It is the manner of organization of matter and of energy manipulation that led to the emergence of new qualities, that of life and of the biosphere, with all their varied manifestations.