

# Biological Psychology

A CYBERNETIC SCIENCE



---

F. J. McGuigan

---

# **Biological Psychology**

## **A Cybernetic Science**

**F. J. McGuigan**

*United States International University*



Prentice Hall  
Englewood Cliffs, New Jersey 07632

*Library of Congress Cataloging-in-Publication Data*

McGuigan, F. J. (Frank J.) (date)

Biological psychology : a cybernetic science / F. J. McGuigan.  
p. cm.

Includes bibliographical references and index.

ISBN 0-13-146655-0

1. Psychobiology. I. Title.

QP360.M3534 1994

152—dc20

93-35572

CIP

*Acquisitions editor: Pete Janzow*

*Editorial assistant: Marilyn Coco*

*Cover design: Anne Ricigliano*

*Production coordinators: Herb Klein and Tricia Kenny*



© 1994 by Prentice-Hall, Inc.

A Paramount Communications Company

Englewood Cliffs, New Jersey 07632

All rights reserved. No part of this book may  
be reproduced, in any form or by any means,  
without permission in writing from the publisher.

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-13-146655-0

Prentice-Hall International (UK) Limited, *London*

Prentice-Hall of Australia Pty. Limited, *Sydney*

Prentice-Hall Canada Inc., *Toronto*

Prentice-Hall Hispanoamericana, S.A., *Mexico*

Prentice-Hall of India Private Limited, *New Delhi*

Prentice-Hall of Japan, Inc., *Tokyo*

Simon & Schuster Asia Pte. Ltd., *Singapore*

Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*

# **Biological Psychology**

***To Betty, Casius, and Tobias***

# Preface

The original and enduring problem of psychology is that of understanding “the mind.” Psychology’s unique contribution has been to scientifically study mental processes as the components of mind. The first scientific approach was a physiological one espoused in 1879 by the father of psychology, Wilhelm Wundt—the title of his book, which has been called the most influential in the history of psychology, was *Principles of Physiological Psychology*. Biological approaches to psychology continued, as in Alexander Bain’s influential work, into the twentieth century. Early American textbooks of psychology especially emphasized neuroanatomy and physiology. Notable among them were John Watson’s (1919) *Psychology from the Standpoint of a Behaviorist* and John Dashiell’s (1928) *Fundamentals of Objective Psychology*. More recently, with the contemporary development of highly sophisticated physiological and psychophysiological instrumentation, the study of biological psychology has been growing at an exponential rate. Interrelated, component fields of biological psychology include neuroscience, physiological psychology, neuropsychology, electropsychology, psychophysiology, neurobiology, and psychobiology.

As these fields have expanded, there has also emerged a growing recognition that we cannot understand behavior of the body if its components are studied only in isolation. Rather, to understand the body and how it functions to generate behavior in all of its complexities, we must study it in its entirety. As an illustration of contemporary recognition of the necessity for studying interactive systems, the following was a description written for an advanced work on behavioral states. It was edited by Richard Bandler and published by Alan R. Liss, Inc.:

Research on brain-behavior relationships has been hampered by the shortcomings of studying specific brain regions as if they were anatomically and functionally discrete systems. These subsystems interact in ways that cannot be described solely in terms of their particular organization: to understand these higher-order functions it is necessary to elucidate the linkages interconnecting the brain’s components. These linkages can be studied by careful correlation of the alterations in sensorimotor activity produced by changes in behavioral states.

Another recent indication of the growing biological and cybernetic *zeitgeist* is pointed out by John Naisbitt and Patricia Aburdene in their best seller *Megatrends 2000*. They hold that the 1990s are the age of biology and that “We are in the process of creating a society that is an elaborate array of information feedback systems, the very structure of the biological organism” (p. 241).

Cybernetics is an excellent model for understanding how the various systems of the body interact. Our effort is to present principles of biological psychology within a cybernetic framework. Cybernetics is a science of control and communication through circuits. As applied in biological psychology, we view numerous circuits functioning within the brain and between the brain and other systems

throughout the body. The primary cybernetic principle by which systems of the body interact is that of negative feedback circuits. Additional control principles of feedforward and adaptive control are also applicable.

In this book, we focus on sensory, neural, and muscular systems as they interact to generate the extensive kinds of behavior that psychologists study. Our model is that cognitive (mental) processes are generated when those systems of the body intimately interact in a selective fashion. What follows is a biological explication of the nature of mind. Related phenomena within the province of biological psychology to which we attempt to apply a cybernetic model include those of motivated and emotional behavior, learning and memory, language and laterality of the body, aging, and pathological conditions with clinical applications. In the last chapters efforts are made to assess within a biopsychological framework major problems that society faces (Chapter 14), to present some potential solutions to those problems (Chapter 15), and finally to assess the future of humankind from a biological science point of view. There we consider both pessimistic and optimistic futures. A major hope for this book is that it might help us to more rationally pursue an optimistic future.

While we survey and present a number of data, our primary purpose is to develop an integrative system for incorporating those data into a framework that is both meaningful and interesting to the student. However, while this initial effort to apply cybernetic principles to the major areas of psychology regrettably is uneven, at least a start has been made. It is hoped that others will continue the effort. I would welcome suggestions from students and colleagues both for improving and for extending what is written here.

In order to facilitate the student's progress, I have cited only major references, eliminating a large number of detailed sources.

The main points throughout the book are presented in margin notes where they are discussed. Since these margin notes constitute a summary of the book, independent summaries would be redundant and thus are not presented at the end of the chapters.

Appreciation is given to the following reviewers who critically read earlier drafts of the manuscript: Douglas L. Grimsley, University of North Carolina at Charlotte; Yoshito Kawahara, Mesa College; William F. McDaniel, Georgia College; Matthew Olson, Hamline University; Ellen F. Rosen, College of William and Mary; Cheryl L. Sisk, Michigan State University; Jeffery J. Stern, University of Michigan-Dearborn; and Charlene Wages, Francis Marion College. Special appreciation is expressed to Sirichet Sangkamarn, Deanna Kahn, Ned I. Makaichy, Michelle Mullane, and Paula and Terry Tindall for their excellent help in preparing the manuscript. Thanks too to the students in my classes in Biological Psychology who offered many suggestions and critiques for improving earlier versions of the manuscript. Words are insufficient to indicate my thanks to and esteem for Maria Cristina Isolabella for her help in so many ways that it would be impossible to enumerate them.

FJM  
San Diego, California

# Contents

Preface xv

## Part I A Broad Perspective of Biological Psychology

### CHAPTER 1 A Cybernetic Model for Biological Psychology 1

- What Is Biological Psychology? 1
- Comparative Psychology 2
- The Nature of Systems 3
- Principles of Cybernetics 5
- Cybernetics—A Historical Perspective 14
- Cybernetics of the Body 16
- Cybernetics of the Mind 19
- Emphasis on a Cybernetic Principle—Negative  
Feedback 20
- Key Terms 21
- Study Questions 22
- Further Readings 22

### CHAPTER 2 Origin and Development of Biological Science 23

- The Importance of Historical Perspective 23
- Ancient History of Biology 24
- Greek Conceptions of Soul–Mind 26
- The Dark Ages and Loss of Knowledge 29
- The Nature of “Truth” and the “Truth” of  
Nature 30
- Empiricism and the Probabilistic Nature of  
Knowledge 33
- Galilean Versus Aristotelian Science 34
- Science and Technology 35
- The Scientific Renaissance 36



Theories of Evolution	41
Two Evolutionary Crises	44
Scientific Controversies About Evolution	
Theories	51
Who Is Our Closest Relative?	53
Emphasis on a Major Cybernetic Principle— The Biological and Scientific Values of Feedback	54
Enrichment Material	54
Key Terms	55
Study Questions	57
Further Readings	57

### **CHAPTER 3**

## **The Biology of Mental Processes 58**

The Origin of the Concept of Mind	58
Proposed Solutions to the Mind–Body Problem	59
A Brief History of a Natural Science Approach to Mental Processes	62
Where in the Body Is the Mind?	69
Emphasis on a Cybernetic Principle— Organisms Function as Whole Integrated Units by Circuits Within the Brain and Throughout the Body	77
Key Terms	78
Study Questions	79
Further Readings	80

## **Part II**

# **Systems of the Body and How They Are Studied**

### **CHAPTER 4**

## **An Overview of How the Body Functions 81**

Determinants of Behavior Through Cybernetic Circuits	82
Stimulus Reception from the External Environment	83
Neural Transmission and Responding	83
The Internal Environment	85
Cells—The Building Blocks of the Body and Cybernetic Systems	86
Cells—Their Excitability in Transmitting and Processing Information	101

Some Topographical Terms for Orientation of the Body	110
Emphasis on a Cybernetic Principle—Systems of the Body and Their Interaction	111
Key Terms	114
Study Questions	116
Further Readings	116

## **CHAPTER 5**

### **How We Gather and Interpret Information: The Receptor Systems, Our Sense Modalities, and Perceptual Processes 117**

How Do We Perceive Our World?	117
Do Nerves Have Specific Unique Energies?	118
The Principle of Labeled Lines	119
The Receptor Systems	120
Some Unusual Sensory Systems	145
Emphasis on a Cybernetic Principle—Centrifugal Influences from the Brain During Sensory Transmission	149
Key Terms	149
Study Questions	152
Further Readings	152

## **CHAPTER 6**

### **Integrating and Processing Information: Contributions of the Nervous Systems 153**

Defining the Several Nervous Systems	153
The Central Nervous System (CNS)	154
The Peripheral Nervous Systems	172
Brain–Muscle Relations	179
Synapses, Neurons, and the Biochemistry of the Brain	182
Emphasis on a Cybernetic Principle—Neurotransmitters May Function in Positive Feedback Circuits	186
Key Terms	187
Study Questions	188
Further Readings	189

## **CHAPTER 7**

### **Behaving in Our External and Internal Environments—The Effectors 190**

Muscles—Mechanisms for Reacting	190
Glands and Hormones	212

Emphasis on a Cybernetic Principle—The Integrated Use of Feedback and Feedforward in the Control of Behavior	213
Enrichment Material	214
Key Terms	215
Study Questions	217
Further Readings	217

## **CHAPTER 8**

### **Methods of Studying Systems of the Body and Brain 218**

Overview of Biobehavioral Phenomena and Research Techniques	218
Overt and Covert Behavior Contrasted	219
Covert Response Measures	221
Covert Processes	222
Laboratory Techniques for Measuring Covert Processes	223
Electropsychology—Psychophysiological Measures of Covert (and Overt) Processes	228
Methods of Studying the Brain	236
Emphasis on a Cybernetic Principle—Strategy for Measuring Receptor–Neural–Muscular Circuits	249
Enrichment Material	250
Key Terms	251
Study Questions	253
Further Readings	253

## **Part III**

### **Normal Biopsychological Functions**

## **CHAPTER 9**

### **Motivated and Emotional Behaviors 255**

Biologically Motivated Behavior	255
Emotional Behavior	282
Behavior Genetics	288
Species-Specific Behaviors	291
A Summary of Some Important Advances in the Study of Motivated Behavior	291
Emphasis on a Cybernetic Principle—Evolution of a Central-Peripheral Model of Motivated Behavior	292
Enrichment Material	292
Key Terms	293
Study Questions	295
Further Readings	295

## **CHAPTER 10**

### **Learning and Memory 296**

- Principles of Learning and Memory Form the Basis for Scientific and Applied Psychology 297
- The Nature of Learning 297
- Measures of Learning 299
- The Acquisitions of Conditional Responses—Two Procedures 299
- Some Additional Conditioning Phenomena 309
- How Many Kinds of Learning Are There? 313
- Cybernetic Circuits and the Biological Value of Conditioning 314
- Ethological Learning and Species-Specific Constraints 316
- Some Learning Questions with Social Significance 323
- Memory 325
- The Physiological Psychology of Learning and Memory 327
- Emphasis on a Cybernetic Principle—Response Retrieval of an Engram 346
- Key Terms 348
- Study Questions 350
- Further Readings 351

## **CHAPTER 11**

### **The Biology of Language and Lateral Systems 352**

- What Is Language? 352
- Can Other Species Be Taught Human Language? 354
- Evolution of the Speech Systems 358
- Side Preferences of the Head and Body 360
- Emphasis on a Cybernetic Principle—A Review of Interactions of Brain Laterality with Other Head and Body Systems 377
- Key Terms 379
- Study Questions 380
- Further Readings 380

## **CHAPTER 12**

### **The Psychophysiology of Aging 381**

- The Importance of Studying the Aging Process 381
- Life Span Development 382

Normal Aging Changes—Why Do We Grow Old?	383
Quantifying the Aging Process	391
What Keeps Us Young?	393
Treatment of the Enfeebled Elderly	398
Alzheimer's Disease	398
Falls	400
Theories of Aging	400
Emphasis on a Cybernetic Principle— A Beneficial Negative Feedback System in Aging	401
Key Terms	402
Study Questions	402
Further Readings	403

## **CHAPTER 13**

### **Cognitive Psychophysiology: The Biology of Higher Mental Processes 404**

Mind and Cognition	404
Illustrative Psychophysiological Events During Some Cognitive Activities	410
Capability of Speech Muscles for Refined Differential Activity	428
An Illustration of Self-Control with a Cybernetic Model—Relaxation and Mental Practice in Sports Psychology	430
Do Animals Think?—Evolution of Cognition and Intelligence	431
Psychochronology	432
Emphasis on a Cybernetic Principle— Conclusions About the Nature of Mental Processes	433
Key Terms	435
Study Questions	436
Further Readings	437

## **Part IV**

### **Pathological Conditions and Clinical Applications**

## **CHAPTER 14**

### **Biology of Pathological Behavior and Disease 439**

Engineering Behavior for a Better Life	440
Nature and Extent of Our Problems	440

The Importance of Biobehavioral Control	441
Kinds of Disorders	441
Some Special Problems of Youth	491
Disorders of Initiating and Maintaining Sleep	493
Dyslexia and Learning Disorders	494
Emphasis on a Cybernetic Principles— Addictive Behaviors Have Some Characteristics of a Positive Feedback Model	495
Key Terms	496
Study Questions	498
Further Readings	498

## **CHAPTER 15**

### **Therapy and Control of Pathological and Normal Behavior 499**

Our Search for Happiness	499
Quackery	501
The Costs of Detrimental Behavior	501
How to Achieve What We Want—Self-Control and the Development of Will Power	502
A Word About Strategies and Models for Research	546
Emphasis on a Cybernetic Principle— Multicausal and Multieffect Models Must Replace Single Cause-Effect Models of Behavior	546
Key Terms	547
Study Questions	548
Further Readings	548

## **Part V**

### **Confronting Society's Problems Through Science and Technology**

## **CHAPTER 16**

### **The Future of Humanity as It Relates to Biological Science 551**

Anticipating and Controlling the Future	552
A Pessimistic Future	552
An Optimistic Future	561
Warfare—An Optimistic Future	571
Bioethics	572
Conclusion	573

Emphasis on a Cybernetic Principle— Intervening into Positive Feedback Systems to Achieve Stable Negative Feedback Systems	573
Key Terms	576
Study Questions	576
Further Readings	577

**References 578**

**Name Index 587**

**Subject Index 591**

Biological psychologists study how interacting bodily systems and the environment influence behavior.

A species is a group of organisms that have certain characteristics in common.

The comparative study of organisms along the phylogenetic scale facilitates the development of general principles of behavior.

**Biological Psychology Defined.** Behavior, whether it be overt or covert, is best understood as a product of *interacting systems of the body*. The major systems of the body are the receptor, nervous, muscular, glandular, and circulatory systems. As we move through our world, our behavior is generated by intricate physiological interactions of these systems. **Biological psychology** is that specialization within psychology for understanding behavior by studying how the systems of the body interact with each other and with the environment.

Biological psychology is **interdisciplinary** in nature. Scientists from the disciplines of psychology, physiology, medicine, biological psychiatry, behavioral medicine, and biomedical engineering work in this interdisciplinary field. Biological psychology is a broad discipline that includes fields with related names such as physiological psychology, psychophysiology, and neuroscience.

The scientist who studies the behavior of organisms from a biological point of view considers salient characteristics of all the various **species** of organisms in the world. The simple one-celled organisms named *amoeba* and *paramecium caudatum* are examples of species. Amoebae have in common the characteristic of being single-celled organisms that lack supporting structures. They thus look somewhat like small pieces of gelatin.

**The Phylogenetic Scale.** Species are classified by common characteristics along the **phylogenetic scale** (Fig. 1.1). The phylogenetic scale starts with the simplest single-celled organisms and progresses through frogs, dogs, and apes to the highest, most complex organisms, the species *Homo sapiens*.

## COMPARATIVE PSYCHOLOGY

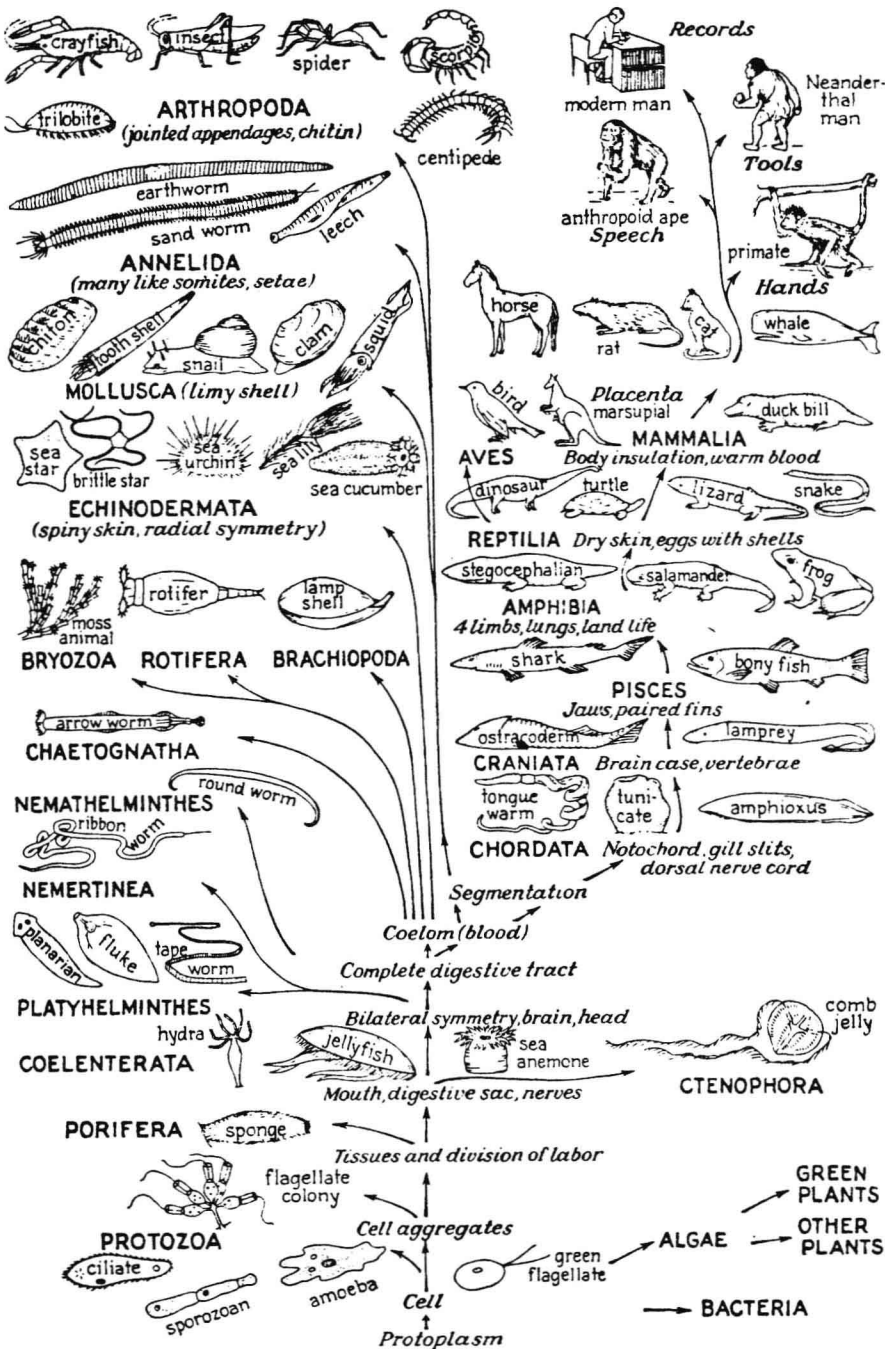
As a consequence of the effort to understand behavior throughout the phylogenetic scale, biological psychologists focus on the similarities and differences among species. A classic field of psychology devoted to such comparisons is known as **comparative psychology**. Comparative psychologists study abilities and behaviors of different species. For example, they have found that although the visual acuity of humans is excellent, their sense of smell is quite inferior to that of dogs.

In this book we will concentrate on **vertebrates**—those organisms that, like humans, have a spinal cord. As species, they are high in the phylogenetic scale. However, it is important to emphasize the great value of the comparative study of all species. This value, in part, results from our being able to conduct research on lower animals to discover how simpler forms of behavior occur. On the basis of fundamental findings from animal research, we can often generalize more effectively to the complex behavior of humans. Throughout this book we will note the importance of information gained from research on lower animals.

## THE NATURE OF SYSTEMS

Our task of understanding behavior in all its complexity throughout the phylogenetic scale is extensive indeed. To accomplish this task, we need to develop a theoretical framework or model with which to organize our thoughts and research findings. The major organizing principles that we will use center around the *interac-*





**FIGURE 1.1** The phylogenetic scale represents the animal kingdom in the form of a genealogical tree. The major groups are identified in boldface type. Characteristics are stated in italics such that all groups above a given characteristic possess that trait. (From Storer, 1943)