医学生复习指南丛书

McGraw Hill Education

英文影印版

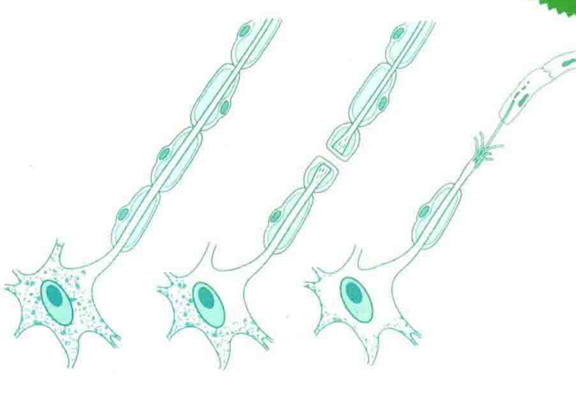
神经科学基本要点

BASIC CONCEPTS IN Neuroscience

A STUDENT'S SURVIVAL GUIDE

Malcolm Slaughter

Great for Course Prep and USMLE



McGraw Hill

北京大学医学出版社

医学生复习指南丛书

英文影印版

神经科学基本要点

BASIC CONCEPTS IN Neuroscience

Editor

MALCOLM SLAUGHTER, PhD

Departm ... sics

State U ... alo

Illustrated by

JOHN NYQUIST, MS, CMI

BARBARA E. EVANS, BFA

Medical Illustrations and Graphics, ASCIT

State University of New York at Buffalo

Buffalo, New York

北京大学医学出版社

Malcolm Slaughter
Basic Concepts in Neuroscience: a student's survival guide
ISBN 0-07-136046-8

图书在版编目(CIP)数据

神经科学基本要点 = Basic Concepts in Neuroscience
/(美)斯洛特主编 .—北京:北京大学医学出版社,
2002.10
(医学生复习指南丛书)
ISBN 7-81071-390-6

Ⅰ.神… Ⅱ.斯… Ⅲ.神经科学-医学院校-
教学参考资料-英文 Ⅳ.R338

中国版本图书馆 CIP 数据核字(2002)第 076125 号

北京大学医学出版社出版
(北京海淀区学院路 38 号北京大学医学部院内 100083)
莱芜市圣龙印务书刊有限责任公司印刷 新华书店经销
* * *
开本:787mm×1092mm 1/16 印张:19.75 字数:424 千字
2002 年 10 月第 1 版 2002 年 10 月山东第 1 次印刷
印数:1-3000 册 定价:32.00 元

神经科学基本要点

BASIC CONCEPTS IN Neuroscience

Notice

Medicine is an ever-changing science. As new research and clinical experience broaden our knowledge, changes in treatment and drug therapy are required. The editor and the publisher of this work have checked with sources believed to be reliable in their efforts to provide information that is complete and generally in accord with the standards accepted at the time of publication. However, in view of the possibility of human error or changes in medical sciences, neither the editor nor the publisher nor any other party who has been involved in the preparation or publication of this work warrants that the information contained herein is in every respect accurate or complete, and they disclaim all responsibility for any errors or omissions or for the results obtained from use of the information contained in this work. Readers are encouraged to confirm the information contained herein with other sources. For example and in particular, readers are advised to check the product information sheet included in the package of each drug they plan to administer to be certain that the information contained in this work is accurate and that changes have not been made in the recommended dose or in the contraindications for administration. This recommendation is of particular importance in connection with new or infrequently used drugs.

Dedicated to Dr. Beverly Bishop, Distinguished Professor of Physiology and Biophysics, for her tireless and timely support of neuroscience at the University of Buffalo

影印出版说明

"医学生复习指南丛书"是美国医学生所用的基础医学阅读参考书系列之一，也是参加"美国医生执照考试"（United States Medical Licensing Examination，USMLE）考前复习的主要参考书。由《生理学基本要点》、《生物化学基本要点》、《免疫学基本要点》、《药理学基本要点》、《病理学基本要点》、《医学遗传学基本要点》、《细胞生物学与组织学基本要点》、《胚胎学基本要点》、《神经科学基本要点》等组成。

本丛书内容主要为基础医学各核心课程中的基本概念及重点内容，涵盖了"美国医生执照考试"（USMLE）的主要考点内容，并用容易理解与掌握的方式对各个学科的难点内容进行了讲解。在编写方式上，作者用简明易懂的文字和大量的图表进行解释，便于学生掌握学科的重点内容，可使学生用最少的时间对学科的内容有一个完整的概念与基本了解。在取材上经过作者的精心取舍，注重知识的系统性和相关知识的联系，加强了临床应用必需的内容，因而在内容的深度和广度上比较适合医学本科教育的需要，也符合医学基础服务于临床的宗旨。例如："细胞生物学与组织学基础教程"中不仅讲述了从细胞膜至细胞核的基本知识，还介绍了各种组织和各个器官的结构和功能；"医学遗传学基础教程"从遗传学的基础概念联系到大量的临床遗传性疾病；"胚胎学基础教程"讲述了许多先天性畸形的发生机制和危险因子……这样的编排不仅使医学基础知识紧扣临床实际，还会增强学生运用知识的能力。当然，在相互联系中更能巩固所学知识的记忆。

本丛书写作文字流畅，可读性强；条理清晰，方便查阅。对于中国的医学生来说，使用本丛书不仅能使他们掌握各学科的专业基础知识和基本概念，同时，在学习过程中，还能学到更加地道的英语表达方式，提高其专业外语水平。本丛书可作为医学基础课双语教学的英语教学参考书，也是参加美国"医生执照考试"（USMLE）的中国医学生和医生考前复习的必备参考书。

· P R E F A C E ·

Basic Concepts in Neuroscience: A Student's Survival Guide is designed to provide a quick reference to the key topics in neuroscience. It is oriented toward the needs of medical, graduate, and advanced undergraduate students. Each chapter highlights the basic principles of the field, coupled with a description of experimental protocols that clarifies and amplifies the subject. Although interrelated, each chapter is intended to be self-explanatory so the student can focus on areas of interest.

This book is designed to be easily read and to quickly guide students through the fundamentals of neuroscience. The format of each chapter includes highlighted summary statements. The authors made a special effort to include many flowcharts and figures in each chapter that can serve as study guides. We recommend that students review these statements and figures to obtain an overview of the chapter. In striving for clarity, we emphasized essential principles and made brevity a virtue. We hope the reader values this approach; however, we recommend that this book be used in combination with a more extensive neuroscience textbook.

A group of faculty at the University at Buffalo wrote this book based on a graduate level course: Introduction to Neuroscience. Each chapter was written by a faculty researcher who is a specialist on the chapter topic, ensuring that the content is not only factual but also current. The goal has been to make the descriptions readable and interesting, yet to convey the excitement of the evolving science of the brain. The faculty's commitment to exposing students to research-based learning is clearly shown in the numerous examples of information imparted within an experimental framework.

I want to thank all of the faculty members who contributed to this book. It was one more obligation in an overburdened schedule, but each one contributed magnificently. Special thanks go to John Nyquist and Barbara Evans, whose drawings enliven every chapter. I am very grateful for the guidance, patience, and expertise of the editors at McGraw-Hill: Janet Foltin, Harriet Lebowitz, Lester A. Sheinis, and Arline Keithe.

BASIC CONCEPTS IN Neuroscience

· C O N T E N T S ·

CHAPTER 4 SYNAPTIC TRANSMISSION 65

Edward Koenig

CHAPTER 5 NEUROTRANSMITTERS 86

Jerome Roth

CHAPTER 6 SENSORY SYSTEMS 117

Malcolm Slaughter

CONTRIBUTORS

John M. Aletta, PhD
Clinical Assistant Professor of Pharmacology and Toxicology
Department of Pharmacology and Toxicology
State University of New York at Buffalo
Buffalo, New York
Chapter 2

Beverly P. Bishop, PhD
Professor of Physiology and Biophysics
Department of Physiology and Biophysics
University at Buffalo
State University of New York
Buffalo, New York
Chapters 7, 8, 9

Kathleen M.K. Boje, PhD
Associate Professor of Pharmaceutics
Department of Pharmaceutics, School of Pharmacy
State University of New York at Buffalo
Buffalo, New York
Chapter 12

Arlene R. Collins, MA, PhD
Professor of Microbiology
Department of Microbiology, School of Medicine and Biomedical Sciences
State University of New York at Buffalo
Buffalo, New York
Chapter 13

Dennis M. Higgins, PhD
Professor of Pharmacology and Toxicology
Department of Pharmacology and Toxicology
State University of New York at Buffalo
Buffalo, New York
Chapter 1

Elaine M. Hull, PhD
Professor of Psychology
Department of Psychology
State University of New York at Buffalo
Buffalo, New York
Chapter 10

Edward Koenig, PhD
Professor of Physiology and Biophysics
Department of Physiology and Biophysics
State University of New York at Buffalo
Buffalo, New York
Chapter 4

Jerome Roth, PhD
Professor of Pharmacology and Toxicology
Department of Pharmacology and Toxicology
State University of New York at Buffalo
Buffalo, New York
Chapter 5

Malcolm Slaughter, PhD
Professor of Physiology and Biophysics
Department of Physiology and Biophysics
State University of New York at Buffalo
Buffalo, New York
Chapters 3, 6

Susan B. Udin, PhD
Professor of Physiology and Biophysics
Department of Physiology and Biophysics
State University of New York at Buffalo
Buffalo, New York
Chapter 11

· C H A P T E R · 1 ·

CELL BIOLOGY OF THE NERVOUS SYSTEM

•

Dennis M. Higgins

The two most important types of cells within the nervous system are *neurons* and *glia*. These cells are specialized to perform three basic functions: to receive information from the five senses, to integrate these data, and to generate motor behaviors that ensure the survival of the organism.

To accomplish these tasks, neurons and glia have acquired specialized properties that facilitate the processing of information. The unique cellular characteristics of neurons are the most obvious and most important.

Confusing terminology. *Neuron* and *nerve cell* are synonyms that refer to the major information-conveying cells in the nervous system. *Neural cell,* however, refers to all of the cells in the nervous system, including both neurons and glia. *Nerve* refers to long projections that emanate from the central nervous system. Typically nerves contain axons and glia but not the cell bodies of nerve cells.

SPECIALIZED ADAPTATIONS OF NEURONS

What happens when you step on a sharp object? First a signal must be conveyed from the foot to the spinal cord and higher brain centers (Figure 1–1) indicating the presence of a painful stimulus; the motor neurons must then stimulate

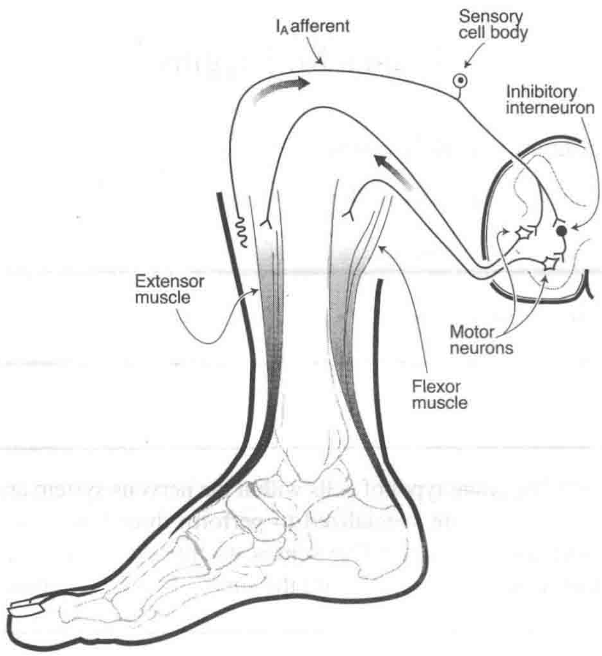


Figure 1–1
A simple reflex. Painful stimuli are detected by nerve terminals in the skin and parenchyma. Pain and pressure are converted by the nerve into electrical signals that are propagated along the sensory nerve toward the spinal cord. These impulses are then transmitted across synaptic junctions to cause excitation of motor neurons, which in turn causes the contraction of distal muscles.

the muscles, causing the foot to be lifted. To accomplish this seemingly simple task, information must be conducted over a distance of ~1 m, the distance from the foot to the spinal cord. One meter is equivalent to 1,000,000 μm. Because human cells rarely exceed 50 μm in diameter, transmission of information over this distance represents a formidable cellular challenge.

> The evolutionary solution for this problem has been for neurons to acquire the ability to form long, thin processes that can bridge the entire distance from the foot to the spinal cord. These processes are called *axons*.

Axons represent only a partial solution to the problem of information transfer over long distances; for the system to function properly other specializations are needed. To allow the organism to respond to environmental changes in a timely manner, information has to be conveyed rapidly from one end of the axon to the other. This requirement is met by the electrical propagation of signals along the axon (see Chapter 3). In addition, information must be conveyed in a polarized manner, that is, it must proceed from the sensory neuron to the spinal cord and then to the motor neuron.

> The specialized cellular junctions that direct this information flow are called *synapses*.

These are described in more detail in Chapter 4.

Although the axon represents an elegant solution to the problem of conveying information over long distances, this cellular adaptation comes with a significant cost. Axons typically have diameters ranging from 0.2 to 10 μm, and the cell body of neurons is typically ~20 μm in diameter. To obtain some idea of what this means in terms of asymmetry, consider Figure 1–2, which shows the neuronal cell body with a 20-mm diameter, that is, at a 1000-fold magnification of a neuron that is 20 μm in diameter, and the axon's diameter at 1000-fold magnification. However, at this scale only a small fragment of the axon's initial length is shown, because to show the 1,000,000-μm length of the axon the figure would have to be 1,000,000 mm long. This is equivalent to 1 km. Thus, if the axon terminal was drawn to scale, it would require a piece of paper about 0.6 miles long.

How does this extreme asymmetry affect the nerve cell? Imagine what would happen if you tried to extend a piece of steel wire for a half mile between two high buildings. It would sag under its own weight and then break.