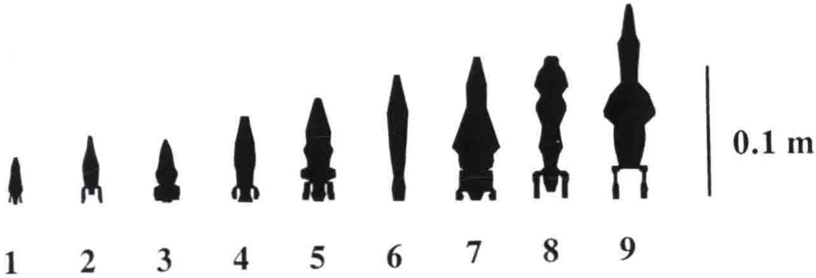
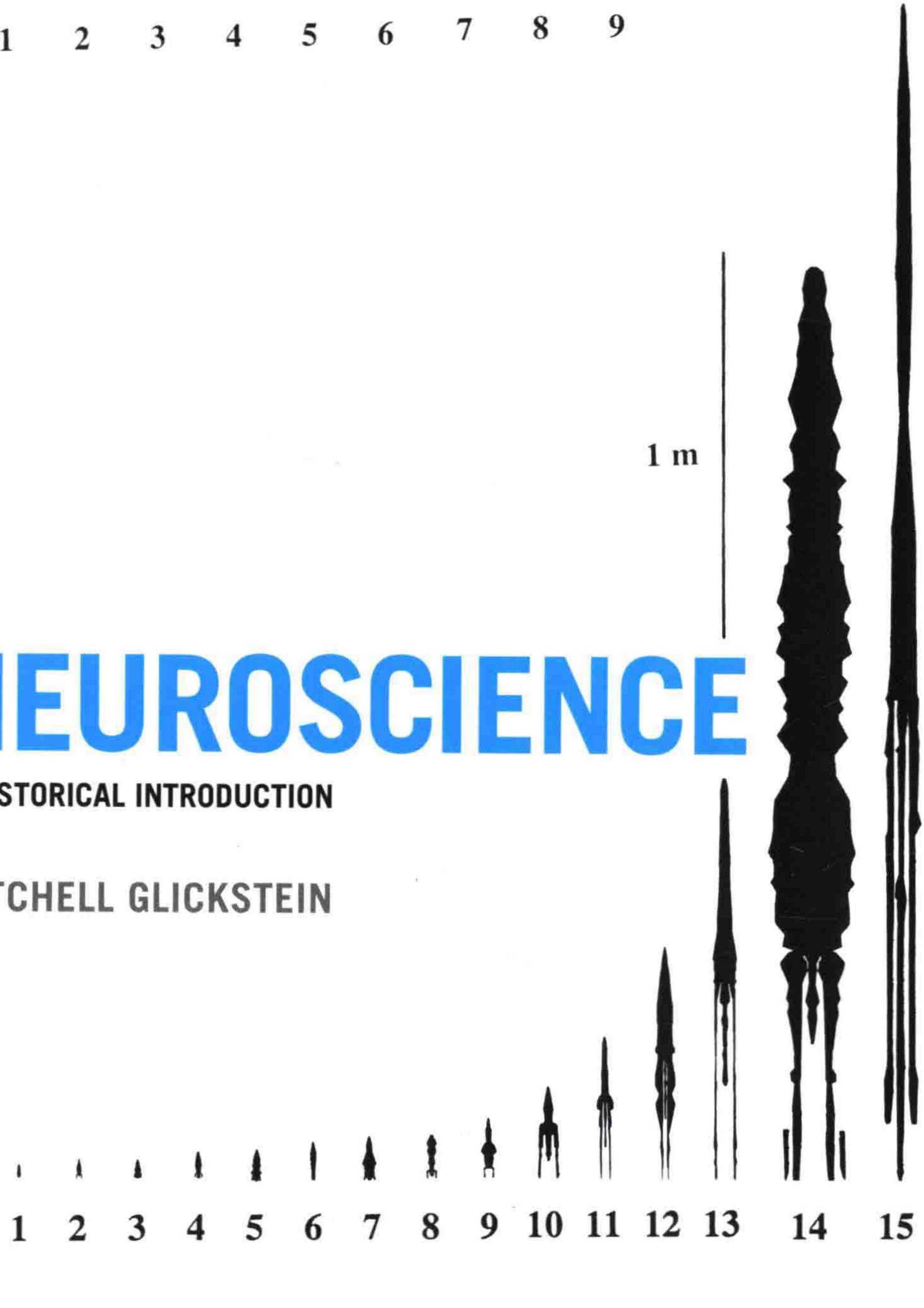


NEUROSCIENCE

A HISTORICAL INTRODUCTION

MITCHELL GLICKSTEIN



neuroscience

NEUROSCIENCE

A HISTORICAL INTRODUCTION

MITCHELL GLICKSTEIN

This introduction to neuroscience is unique in its emphasis on how we know what we know about the structure and function of the nervous system. The book traces our current neuroscientific knowledge to its many and varied sources. It discusses, among other topics, the structure of nerve cells; electrical transmission in the nervous system; chemical transmission and the mechanism of drug action; sensation; vision; hearing; movement; learning and memory; language and the brain; neurological disease; personality and emotion; the treatment of mental illness; and consciousness. It explains the sometimes baffling Latin names for brain subdivisions; discusses the role of technology in the field, from microscopes to EEGs; and describes the many varieties of scientific discovery. The book's novel perspective offers a particularly effective way for students to learn about neuroscience. It also makes it clear that past contributions offer a valuable guide for thinking about the puzzles that remain.

The late Mitchell Glickstein was Emeritus Professor of Neuroscience at University College London. He held research and teaching positions at Caltech, University of Washington, Brown University, and Dartmouth College.

"Authoritative, highly readable, wonderfully illustrated, and just plain interesting. ... Only Glickstein could have achieved all of this."

Michael Gazzaniga

"This book is a must for anyone interested in the historical antecedents of the concepts and ideas that preoccupy today's neuroscientists."

Leo M. Chalupa, George Washington University

"Generalists, and even specialists, looking for a good overview of neuroscience will find that Glickstein's contribution is solid."

Amy Ione, *Leonardo Reviews*

Cover art: In life the cerebellum is deeply folded. The true dimensions of its surface are revealed if it is unrolled. The figure, from a study by Fahad Sultan and Valentino Braitenberg, shows the unrolled dimensions of several mammalian species. The human brain is number 14. Number 15 shows the unrolled cerebellum of a cow.

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A Historical Introduction

Mitchell Glickstein

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Neuroscience

To Ben and Hannah

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Contents

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Introduction

We are our brains: we see, we feel, we hear by way of messages sent from the sense organs to the brain. We move by commands from the brain to our muscles, relayed by way of the spinal cord. Over two thousand years ago the Greek physician Hippocrates wrote:

> Men ought to know that from nothing else but thence [from the brain] come joys, delights, laughter and sports, and sorrows, grief, despondency, and lamentations. And by this, in a special manner, we acquire wisdom and knowledge, and see and hear, and know what are foul and what are fair, what are bad and what are good, what are sweet and what unsavory. Some we discriminate by habit, and some we perceive by their utility. By this we distinguish objects of relish and disrelish, according to the seasons; and the same things do not always please us. And by the same organ we become mad and delirious, and fears and terrors assail us, some by night, and some by day, and dreams and untimely wanderings, and cares that are not suitable, and ignorance of present circumstances, desuetude, and unskilfulness. All these things we endure from the brain, when it is not healthy. . . .[1]

This book is about the brain and the spinal cord and their connections to the sense organs and the muscles of the body. The aim of this book is to discuss how we know about these processes. What were the observations and experiments that help to understand the structure and function of the brain and spinal cord? One unifying theme is that of localization. Are there parts of the brain and spinal cord that do different things? What do the different parts of the brain and spinal cord look like? How are they constructed and interconnected? If we consider any specific region of the brain or spinal cord, we can ask: What is known about what that particular region does?

Our knowledge of neuroscience comes from many sources. Some of the earliest clues came from observing the effect of injuries to the brain and spinal cord in humans and animals. An ancient observation relates to the role of the spinal cord in movement and posture. In the sixth

Figure 1.1
From the British Museum Assyrian collection ca. 600 BC. The figure is from a wall panel showing the effect of a spinal cord lesion. The lioness has been pierced by a spear, interrupting the spinal cord at a midthoracic level. Note the flaccid paralysis of the lower limbs and the normal posture in the upper limbs.

century BC, Assyria occupied a region of the Middle East between the Tigris and Euphrates rivers, now mostly inside Iraq. At the time of the Assyrian empire there were wild lions in the region that posed a danger to humans and livestock. One of the functions of the Assyrian kings was to protect their people and their flocks by hunting these Mesopotamian lions. Figure 1.1 is from a sculpture on the walls of a sixth century Assyrian temple showing a lion whose spinal cord had been severed.

The hind paws appear to be paralyzed; they no longer support the animal's hindquarters. Cutting the spinal cord produced paralysis in the parts of the body below the level of the cut. Paralysis as well as lack of sensation below the injury occurs in people with similar injury to the spinal cord.

Some of what we know about the brain and its functions comes from such chance observations and clinical descriptions of the effects of lesions in humans. But most of what we know came from experiments.

The field of neuroscience arose from many parent disciplines. The aim of this text is to introduce neuroscience from a historical perspective. I believe that a science can often be best understood by studying the work of its pioneers, those people whose work has led to our current understanding.

Here are some of the key questions that have been asked in arriving at our present knowledge:

- How were neurons—the nerve cells that are the basic building blocks of the nervous system—and their processes first identified?
- How do axons—the long fiber processes that carry sensory information and motor commands—interconnect nerve cells and activate muscles?
- How are pain, temperature, smell, and taste received and coded by the brain?
- How does a person or animal recognize objects by seeing them, hearing them, or touching them?
- What is the mechanism whereby an image that is formed by the eye is analyzed to yield the percept of an object?
- How is movement organized by the brain?
- How do we manage to avoid bumping into other people when we walk on a crowded street?
- How is it that we reach accurately for a glass of water or catch a moving ball?
- Are improvements in skills and perception as we grow from infancy to adulthood determined innately, or must they be learned?
- What sorts of complex behavior are innate, requiring no learning, and how is such behavior elicited?
- What is sleep; how is a relaxed state different from an alert state of mind?
- Why does a person eat or drink; what makes us hungry or thirsty?
- At a given moment why do we select one particular goal over all of the other goals that we might choose?
- If we have had no food or water for a day, which are we likely to seek first? What are the factors that determine such a choice?
- What is thought; what happens in the brain when we think?
- How do motives and feelings arise from activity of the brain?

There are many more questions we could ask, but this list gives an idea of the range of the questions we can ask. Some remain unanswered, and some have been answered only in part. Neuroscience attempts to answer these questions from the biological point of view: How are these functions controlled by the brain and spinal cord?

Study of the brain has an ancient history and derives from several branches of medicine and science. Neuroanatomy is one of these core sciences. Anatomy's task is to describe biological structure from its grossest features such as the large muscles and bones of the leg down to the level of a single cell and its smallest constituent parts. Neuroanatomy became recognizable as a distinct branch of anatomy several hundred years ago. From the neuroanatomists of previous centuries we learned about the basic parts of the brain; about the cell groups and fiber tracts that make it up. The nineteenth-century neuroanatomists first described the nature of nerve cells and how they connect with one another. The neuroanatomists of the twentieth century continued to teach us about the structure of nerve cells, their constituent parts, and how they are interconnected.

Just as neuroanatomy became distinct from general anatomy because of the special nature of brain, for the same reasons neurophysiology represents a highly specialized area of physiology. Neurophysiologists have demonstrated that nerves function electrically, and from their work we have understood the physical basis of that electrical activity. Neurophysiology has helped to understand the mechanism of reflexes—stereotyped, predictable, and unlearned responses to certain sensory stimuli. Absent or altered reflexes can be related to damage to the brain or spinal cord.

Allied to neurophysiology are neurochemistry and neuropharmacology. Nerve cells activate or inhibit one another by releasing a small amount of a chemical substance at nerve terminals that is called a neurotransmitter. How many such substances are there, and how do they work? Neurochemistry and neuropharmacology are directed toward study of how nerve cells communicate with one another by way of these chemical transmitter substances. Their work forms the basis for the analysis of how drugs affect the brain.

An important source of input into our thinking about the brain and its functions comes from the work of physicians who have attempted to correlate the site or nature of a brain injury with the symptoms that are caused by such injury. We know something about brain localization for speech and language from the writings of nineteenth-century physicians who studied the location of brain injuries in patients who lost the power to produce speech or understand language following damage to the brain. We know the location and organization of the visual area of the