# CHAPTER ONE
# FROM NEW WAVE REDUCTION TO NEW WAVE METASCIENCE

This book is about contemporary neuroscience. More specifically, it works with detailed examples drawn from current research to express that discipline's reductive aspirations, aims, and potential. This reductionism holds important consequences for some "hot" issues in contemporary philosophy of mind. Even more specifically, this book is about the nature of reduction at work in the mainstream core of the current discipline, cellular and molecular neuroscience.

Questions arise immediately. Why look for philosophical lessons in current cellular and molecular neuroscience? Why does the nature of reduction at work in this area warrant interest, philosophical or scientific? And why try to provide this account by focusing on detailed examples of current research instead of, say, articulating a general account of scientific reduction and applying it to them? These are questions I'll tackle in this introductory chapter.

## 1 WHY CELLULAR AND MOLECULAR NEUROSCIENCE?

Some philosophers (of mind and science) and cognitive scientists regularly keep abreast of developments in contemporary neuroscience. Patricia Churchland's landmark *Neurophilosophy* (1986) provided an explicit defense of this interdisciplinary attention. In the book's "General Introduction," she writes: "In a way, nothing is more obvious than that philosophers of mind could profit from knowing at least something of what there is to know about how the brain works. After all, one might say, how could the empirical facts about the nervous system fail to be relevant to studies in the philosophy of mind?" (1986, 4). Even philosophers who don't share Churchland's exuberance for neuroscience can agree with this much. It only requires that they take discoveries in our current sciences as relevant for some philosophical issues. Of course, there are philosophers who reject even this. They are beyond the pale (of this book).

However, neuroscientifically astute philosophers and cognitive scientists have almost universally ignored the "cellular and molecular wave" that swept through neuroscience over the past two decades. Instead, they've focused on "cognitive neuroscience," the "interdisciplinary melding of studies of the brain, of behavior and cognition, and of computational systems that have properties of the brain and that can produce behavior and cognition" (Kosslyn 1998, 158). Investigative techniques here range from state-of-the-art functional neuroimaging to traditional neuropsychological measures to computational modeling in massively interconnected neural networks. It isn't surprising that philosophers (and cognitive scientists) with neuroscientific proclivities are attracted to this branch of the discipline. First, there is the nearly universal intuition among high-level theorists that "levels" considerations and relations are crucial to understanding the mind-brain. In fact, the mind-brain need not be thought of as special in this regard. Most philosophers of biology assume a similar view about the importance of levels in the study of higher-level biological phenomena; the "philosophy of molecular biology" is hardly a recognized area. In addition to these "levels" intuitions, there is also familiarity. Philosophers are at home with cognitive neuroscience's descriptions of behavior and cognition, and with the types of behavior and cognition these scientists investigate. Grasping the experimental methods isn't even much of a professional stretch. The physics of functional neuroimaging are daunting, but even practicing cognitive neuroscientists who employ these methods tend to leave their physics to physicists and concentrate on the behavioral and control tasks and the functional interpretation of analyzed data. The basic concepts of neurocomputational techniques and their mathematics are readily presented geometrically, making them comprehensible to anyone with some quantitative background (Churchland and Sejnowski 1992). Finally, the relevance of cognitive neuroscientific theories and explanations for philosophical (and cognitive scientific) issues is usually readily apparent. Many philosophers are interested in "naturalizing" intentionality, consciousness, and the like. Cognitive neuroscience appears to be a direct scientific analog of philosophical "naturalizing" projects. In short, the levels of theory and explanation inhabited by contemporary cognitive neuroscience are nearby those of scientifically inspired philosophy of mind. So why search through other branches of current neuroscience for philosophical consequences and implications?

The principal reason is straightforward: neuroscience's "mainstream" currently lies elsewhere. It lies in cellular physiology and molecular biology. This "revolution" began two decades ago and now is in full swing. It is in keeping with the ascendance of molecular techniques and investigations in biology generally and is now reflected clearly in principal neuroscience textbooks. Consider a single example. A decade ago, in the introduction to the

third edition of their monumental *Principles of Neural Science*, Eric Kandel, James Schwartz, and Thomas Jessell asserted the promise of investigating the molecular mechanisms of mind: "The goal of neural science is to understand the mind, how we perceive, move, think, and remember. In the previous editions of this book we stressed that important aspects of behavior could be explained at the level of individual nerve cells. ... Now it is possible to address these questions directly on the molecular level" (1991, xii). Do notice the first sentence. The ultimate *explanandum* of neuroscience is mind, not some behavioral or ersatz laboratory substitute. By 1991, the search was already on for its molecular mechanisms and their experimental verification, to the extent that this focus had already made the discipline's general textbooks.

By the text's recent fourth edition, and after another decade of cellular and molecular research, these same authors were ready to announce mind-to-molecules "linkages" not just as research promises, but rather as accomplished results:

> This book ... describes how neural science is attempting to link molecules to mind—how proteins responsible for the activities of individual nerve cells are related to the complexity of neural processes. Today it is possible to link the molecular dynamics of individual nerve cells to representations of perceptual and motor acts in the brain and to relate these internal mechanisms to observable behavior. (2000, 3-4)

The chain of explanations envisioned by these authors is nothing less than a *reduction* of mind to molecules, through interposed "cognitive" and cellular levels. It should be noted explicitly that *Principles of Neural Science* remains the standard comprehensive textbook in the field.

Two lessons from these passages—and from similar passages that occur in introductory chapters in most of neuroscience's current texts—are crucial. First, according to these prominent neuroscientists speaking with the authority of textbook authors, some observable behaviors have already been explained at the level of molecular mechanisms. Second, the guiding aim of "mainstream" neuroscience is the discovery of these mind-to-molecules "linkages." So by limiting attention to cognitive neuroscience only, by ignoring the cellular and molecular core, philosophers and cognitive scientists are getting off the neuroscience train before the current end of its explanatory line. Throughout this book I will argue explicitly that techniques of cognitive neuroscience are an essential part of discovering mind-to-molecules "linkages." But some of what these techniques reveal has already been carried

"further down" to cellular, synaptic, and ultimately molecular biological mechanisms; these existing reductions reveal an essentially heuristic role for higher-level scientific investigations; and there is genuine empirical promise that more "ruthless reductions" will be coming forth. Defending these assertions is this book's principal goal.

When one limits his or her attention to cognitive neuroscience, one not only misses some of neuroscience's most celebrated recent results. One also misses the core of the current discipline: the problems, methods, and results that occupy the day-to-day work of the greatest percentage of the 28,000+ scientists who belong to the Society for Neuroscience and thereby identify themselves professionally as neuroscientists. The Society is "the largest professional society dedicated to the study of the nervous system." Regular membership is open to "any scientist ... who has done meritorious research relating to the nervous system" (www.sfn.org/memb/fact_sheet.html). Its web site offers a searchable database of the abstracts from the 13,000+ slide talks and posters presented at the most recent annual meeting (at this writing, of the 2001 annual meeting, November 4-11, in San Diego, CA) (http://sfn.scholarone.com/, available as a link from www.sfn.org). This resource is a gold mine for surveying "hot" areas in current neuroscience. What is hot now? Searching for cellular and molecular mechanisms and attempting to relate these mechanisms directly to observable behavior. For example, if one conducts a standard search of this database on the two themes most dominated by cellular physiological and molecular biological experimental techniques, namely "Development" and "Synaptic Transmission and Excitability," searching for "Any subtheme," one receives 4698 abstracts (respectively, 1818 and 2880). On the other hand, if one searches the theme most closely associated with cognitive neuroscientific techniques, namely "Cognition and Behavior," one receives 1873 abstracts. But when one further limits this last category to the subtheme, "Human cognition and behavior," the number drops to 476 abstracts; and many of these are purely behavioral studies that don't purport to offer "cognitive" explanations for the data revealed. This is anecdotal evidence, of course, but the upshot is clear. When it comes to basic scientific, not-purely-clinical, research, the search for cellular and molecular mechanisms dominates among bench neuroscientists.

Amateur sociology aside, there is another way that philosophers and cognitive scientists become misinformed when they limit their attention to cognitive neuroscience. Searching for mind-brain connections at the level of regional neural activation patterns, neuropsychological measures, or activation vectors across neural networks isn't as "ruthlessly reductionistic" as attempting to explain behavior—and manipulate it experimentally in animal preparations—at the level of intracellular signaling pathways within and between the individual neurons constituting the network. The "parts" are

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