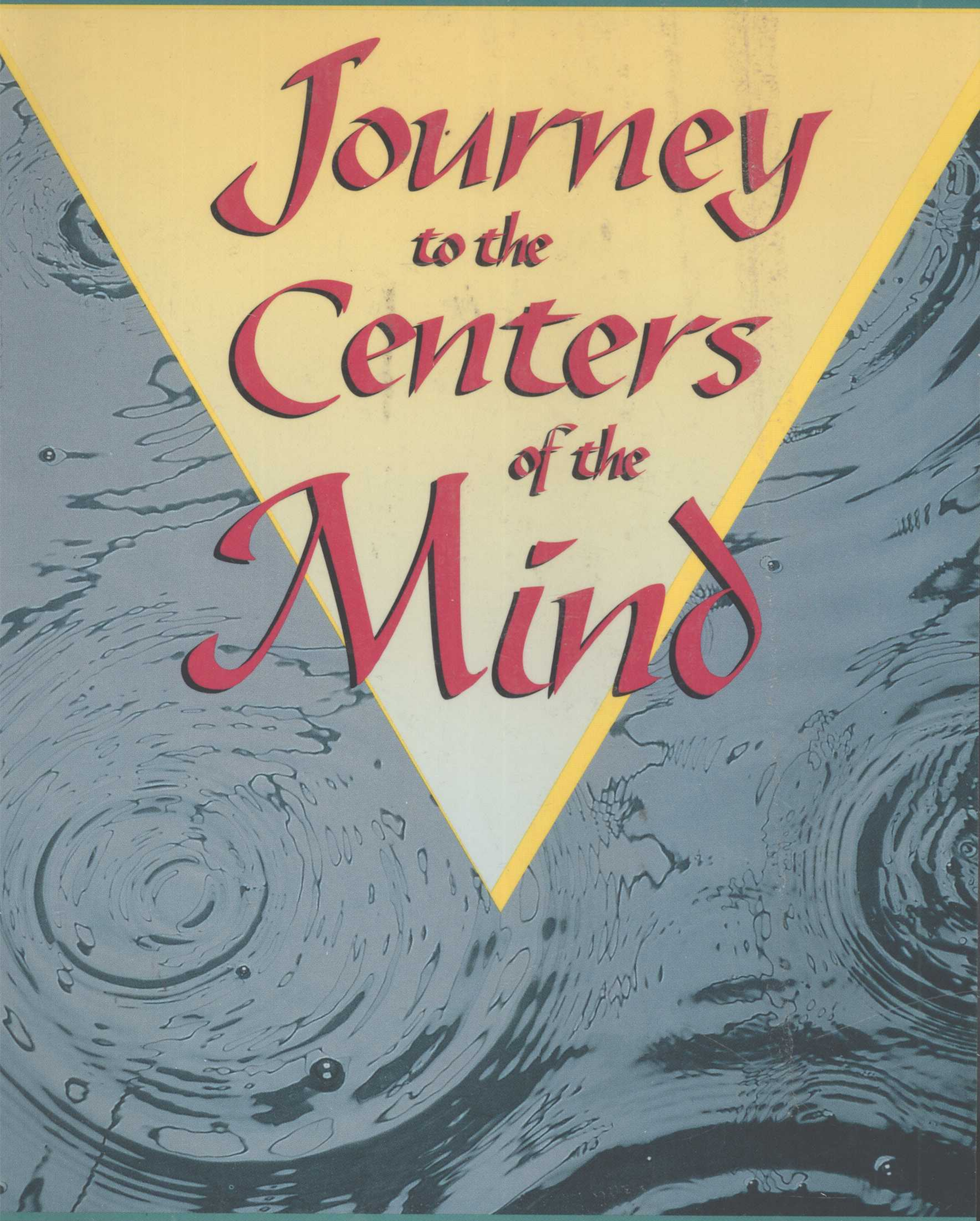
TOWARD A SCIENCE OF CONSCIOUSNESS

Journey to the Centers of the Mind



SUSAN A. GREENFIELD

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Toward a Science of Consciousness

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PREFACE

I first performed a dissection on the human brain more than twenty years ago. At the time I was tantalized by the thought that a scrap of brain tissue might readily disintegrate from the apparently solid mass and, were it not for protective gloves, lodge beneath my fingernails. It is perhaps macabre, but nonetheless intriguing, to wonder what that particular scrap of brain was actually for: Did it generate a love of Beethoven? Was it a memory of a particular summer day? Would it have caused the person to fidget while speaking? In short, how do our very personalities and mental processes, our "states of consciousness," derive from a slurry of tissue with the consistency of a soft-boiled egg? The brain is a tangible physical organ constituted from molecules; but that collection of molecules seems mockingly remote from the insubstantial, complex, transient thoughts that combine to endow us with conscious awareness. Even then, while floundering in the tangle of Latin names labeling every nook and cranny of tissue, the stark truth was that I held in one hand the pickled essence of what had once been someone's individuality.

Since that time I have been plagued by our apparent inability to formulate even the dimmest vision of the physical basis of our "state of mind." Perhaps my awe and frustration would have remained unfocused and undeveloped had it not been for a chance turn in conversation one night over dinner in a Chinese restaurant with the philosopher Susan Hurley. We started discussing the physical basis of consciousness from our respective and widely different standpoints. Rapidly it became clear that a debate between philosophers and neuroscientists would be enormously

revealing and valuable, not only in clarifying areas of formerly esoteric mystery but also perhaps in enabling us to make more progress together than we could ever achieve in isolation. I approached Colin Blakemore, then the head of my department (the Laboratory of Physiology), and together we organized a series of debates, each between a philosopher and a neuroscientist on a particular theme. These sessions took place on cold and dark autumn and winter evenings in Oxford, with minimal publicity, and even that confined to the university. Nonetheless more than a hundred people consistently turned out each time, and frequently stayed in heated discussion until after midnight. Such was our success, and the demand for an increased understanding of the mind-brain, that we were persuaded to take a step we had never originally envisaged and publish the presentations.

Listening to the debates, and subsequently editing (with Colin Blakemore) *Mindwaves*, sharpened my interest further in the type of contribution that neuroscience could make to the question. The more I heard, read, and thought about it, the more it seemed incredible that mere molecules could in some way constitute an inner vision, idea, or emotion, or—even more astounding—that they could generate the subjectivity of an emotion. Yet how else could we explain why, in cases of brain death where there is no brain activity, there is never any consciousness? Consciousness is continuous with the brain's activity and must emerge from it.

Despite the seemingly obvious truth that the brain generates consciousness, there are those who think that it is premature to use the rigors of science to explore a topic that cannot be defined satisfactorily. The psychologist Stuart Sutherland is widely quoted as claiming, "Consciousness is a fascinating phenomenon; it is impossible to specify what it is, what it does or why it evolved. Nothing worth reading has been written on it." Perhaps it is the utter subjectivity of the concept that makes it so alarming and unpalatable. After all, the clarion call of all scientists is "objectivity." Even the accepted writing style in research papers is to abjure any use of "I" or "we" in favor of insipid and often clumsy phrases such as "a stock solution was made up." If neutrality is the key to good science and if good science is indeed founded on the making of objective measurements, then how are scientists to tackle something that is above all so subjective, so confined to the individual?

To date there have been various ways of coping with this dilemma. Some scientists opt out altogether, waiting for someone else to convert consciousness obligingly and miraculously into a nonsubjective phenomenon. Once this transformation has taken place, objective measurements can be made, with an operational definition of consciousness akin to declaring that we know when a solution is hot because we can measure the rising temperature. Others have already capitulated and claim that there is, after all, no subjectivity, no self in consciousness, and that consciousness can be studied as a series of sequential snapshots of ongoing brain states, and hence even modeled on a computer. Still another group, the physicalists, believe that although consciousness is generated by the brain, it is such a special property that it currently defies scientific understanding.

Those going along with these sorts of premises may well find themselves intellectually becalmed. There appears to be no obvious strategy for exploring the physical basis of consciousness while at the same time preserving its quintessential subjective phenomenology. What I have tried to do in this book, however, is to present a possible way forward. The most sensible and obvious place to start seemed to be with a survey of what has been said already. The relevant disciplines are now so widely disparate that it is easy for scientists and philosophers to polarize, and for scientists themselves to get blinkered by one particular approach or technique. It was for me a valuable and urgently needed exercise to compare ideas gleaned from philosophy, cognitive psychology, basic neuroscience, computation, brain damage studies, animal behavior, and developmental psychology before introducing any pet theories of consciousness of my own. It was also important to strip away any subject-related jargon and see if there were any common themes that could act as clues for how to proceed. Hence the first five chapters are, I hope, no mere rehashing; rather, they play an integral part in the development of the theory presented in the later chapters.

Even though I am a neuroscientist, writing unequivocally from a neuroscientist's perspective, the theory itself is not inspired by a purely scientific contemplation of the brain. Many scientists, from both physical and biological backgrounds, have tackled the question of consciousness by starting with the properties of the physical brain, and then trying to see how consciousness might be

tacked on post hoc as an all-or-none entity. Here I present a reverse strategy. The theory starts as just that, a theory, prompted by examining consciousness itself. From there we are then able to see how any or all of the possible features of consciousness can be accommodated in the brain.

One of the most basic features of consciousness emphasized here is that consciousness grows as the brain does. Consciousness is not all-or-none but increases and deepens as the brain becomes more sophisticated and as one progresses from fetus to neonate to child. In addition, it is possible to imagine that even as adults our consciousness will also be variable in depth, momentarily shrinking and expanding in accordance with our interaction with the outside world as we live out our lives. Charged with these ideas, the advantage of then turning to neuroscience is that it offers us an opportunity to see how such shifting degrees of consciousness might really match up with shifting, ever changing combinations of neurons.

In this spirit, the aim of writing this book was to harness what we know about brain chemistry and brain electricity to help see how we might, one day, formulate the physical basis of the phenomenological sensation of consciousness. At this particular moment, however, there are no instant answers, no magic bullets, and no trendy catchphrases that sum it all up. Surely we need first to be able to correlate purported mental events with actual events in the brain that are free of metaphor and grounded firmly in current scientific knowledge. As this correlation becomes tighter and more detailed, the nearer we will come to an understanding of how consciousness can be generated by populations of neurons. I have tried to focus on this issue: how to come to terms with the generation of consciousness by the brain. This book offers a tentative step forward to strengthening the connection between the phenomenology and the physiology of consciousness, of offering a framework for explaining one in terms of the other. As such, I hope the book will contribute as one of the voices for neuroscience in the current, ever burgeoning debate. Above all, I hope that it will be easily understandable to the non-neuroscientist. I have made it one of my highest priorities to explain any facts, phenomena, or concepts in terms readily accessible to the general reader.

Many people have knowingly and unknowingly helped me write this book. Among those who never realized they were

making any contribution are the medical students at Lincoln College, who, over the last decade, have put me through my paces and have helped me work out ideas on brain function during tutorials on neuroscience. In this regard I would also like to thank my friend and colleague John Stein, who has time and again acted as a wily and uncompromising critic during wide-ranging discussions. In addition I am grateful to my research group for their continued support while this project was under way, and most of all to my parents for a lifetime of encouragement. Of those who have had a more immediate role, I am indebted to Elizabeth Clark not only for her excellent secretarial services but also for her unflagging cheerfulness and interest. Several distinguished authorities have also provided invaluable contributions by reading the manuscript and making extremely helpful comments; accordingly, I am indebted to Gary Aston-Jones, Patricia Churchland, Gordon Claridge, Marianne Fillenz, George Graham, Jeffrey A. Gray, Richard L. Gregory, J. Allan Hobson, Ron Hoy, Bryan Kolb, Steven Rose, and Christine A. Skarda. Finally, there are two people without whom this book would truly not have been possible and to whom any expressions of thanks would always be insufficient: one is my husband, Peter, and the other my editor, Jonathan Cobb.

Susan A. Greenfield
Oxford, England
March 1995

CONTENTS

chapter one

THE PROBLEMS OF CONSCIOUSNESS

Locked away in our brains is an absolute and inviolate individuality, a personal inner privacy of cascades of thoughts and feelings to which no one else has automatic access. As long as you can avoid any severe cranial trauma or anesthetist's ministrations, and as long as you can evade sleep, you can peer from this inner world, perhaps reacting to and interacting with the outside world of objective time and space, but all the time remaining distinct from it. This inner world of your particular consciousness arises from a kaleidoscope of memories, prejudices, hopes, habits, and emotions which are constantly expanding and enriching your life as you develop. It is a world that respects neither conventional space nor time: It is composed of incessantly shifting scenes, some hazy and some almost real, some rooted in history, fear, or fantasy, and others a seemingly faithful reproduction of the immediate outside. Inside our heads is a world contemptuous of clocks where we live out the slow-motion scene of an accident or, immersed in a thriller, remain unaware that a whole morning has flown. For most of us, consciousness is at the root of the purpose of modern life: After all, we spend most of our existence striving to heighten, broaden, divert, or simply indulge it.

But how is the trick of deincarnation achieved? What special property is actually built into the brain to generate

this inner world of consciousness? There is no little creature in the deepest recesses between your ears to appreciate all that is going on: There is no brain within the brain. There is a morass of a hundred billion brain cells that generate electricity and release minute quantities of chemicals. Nothing is translated back again from nervous impulses, decoded into colors, shapes, or smells. Brain electricity and brain chemistry are ultimately all there is to your mind.

Our secret inner world, our consciousness, is the ultimate enigma of the brain and the most baffling problem that that same brain will ever ask itself about itself. We are about to embark on a journey, a journey into neuroscience, to try to resolve this enigma. As you stare at this page, what might be going on at this very moment in the tangible mass of tissue behind your eyes to create a private, subjective experience? Immediately, of course, we run into problems.

The Problem of Definition

"Experience is never limited, and it is never complete; it is an immense sensibility, a kind of huge spiderweb of the finest silken threads suspended in the chamber of consciousness, and catching every airborne particle in its tissue." So Henry James (1888) captured the essence of states of awareness without any attempt at a definition. Few would deny that we experience consciousness most of the time we are not asleep; yet it is like clutching at air when it comes to explaining what we actually mean by the concept. So what is the problem?

We can practice first with some straightforward definitions and see how we normally go about things. A mouse is a small rodent; a table is a piece of furniture; love is an emotion; the retina is a sense organ. It is easy to see from these examples that when we make a stab at defining something, we usually start by referring to a larger group or set, such as rodents, furniture, emotions, or organs. We could even categorize tricky entities such as unicorns and Santa Claus by referring to the set of mythical concepts.

But what about an entity that is so all-embracing that it cannot fit into any category, however large? The largest and most

embracing entity would seem to be the universe. Of course we could always seize on the very uniqueness and all-inclusive nature of the universe to define it as "all there is." But then someone could argue back that unicorns and Santa Claus do not exist in actuality, although they are both far from being mere nonsense words. Hence in a sense these mythical entities *exist*. Our mental world, our consciousness, stretches beyond the physical world and everything observable that it contains to embrace imaginary concepts and events such as a green sky, humanoid Martians, time travel, and so on. Moreover, the individual inner state of consciousness really is a consistent, complete, and autonomous world. Toward the end of Shakespeare's *Richard II,* the king, alone in a dungeon in Pomfret Castle with presumably little to stimulate his senses, muses:

> *My brain I'll prove the female to my soul,*
> *My soul the father; and these two beget*
> *A generation of still-breeding thoughts,*
> *And these same thoughts people this little world*
> *In humours like the people of this world.*
>
> Act v, Scene v

Our imagination seems boundless: Consciousness is more encompassing than the universe. It is the ultimate superset; no wonder it is hard to define. On the other hand, some might argue that we could relegate consciousness to a lesser status, make it merely part of a larger set by dismissing it simply as "a property of the brain," on a level with many other humdrum features such as the peculiar grayish color or soft-boiled egg consistency. Although this might serve as a definition of sorts, it is not adequate: Consciousness is far from humdrum. Such a definition would have ignored the quintessential subjectivity of consciousness that prevents it from being lined up with other properties of the brain. *There are simply no terms of reference, no framework for capturing an objective description of the subjective.*

An alternative approach for coming to grips with the problem of definition is to resort to a grapeshot approach and attempt to convey a sense of the concept through a range of particular and personalized examples. "Bliss was it that dawn to be alive, / But

to be young was very heaven"; "As soon as she saw him she felt traces of the old flame creep beneath her limbs"; "Do I dare / Disturb the universe?" From these diverse examples, we could compile a list of some of the facets or effects of consciousness. Such a list might read something like this: a feeling of being special, perhaps the most important person alive; a cohesiveness of values and attitudes over time, amounting to a unified concept of self; a blurring of past, present, and future so that any ongoing experience is colored by what we hope, fear, and remember; a sense of spontaneity and proactivity that elevates us above mere machines responding robotically to instructions from outside forces.

We all "know" what consciousness is, but find it impossible to articulate using an objective frame of reference. Hence the fascination and frustration of the subject. Whichever way we might characterize it phenomenologically, consciousness is ultimately the very essence of ourselves. But there are those who might argue that soul and mind also capture our individuality. So how might consciousness be distinguished from these two terms?

Soul, Mind, and Consciousness

For some, such as Plato (c. 428–c. 348 B.C.) and René Descartes (1596–1650), the term soul had clear theological associations that rendered it immune from study. At the end of the eighteenth century, the same wariness was apparent, for different reasons, in the attitudes of Immanuel Kant (1724–1804) and Charles Bonnet (1720–1793), who both shrank from ever being able to attempt to explain "the great phenomenon of the union between body and soul." Soul was simply not physical in the sense that the brain was. Others, such as Thomas Willis (1621–1675) and Robert Whytt (1714–1766), argued that the soul was virtually indistinguishable from mind, effectively a mortal entity that was an integral part of the brain, toward the front end and "equipped with dioptric mirrors" (see Mazzolini 1991).

The crucial difference as to whether or not soul and mind are interchangeable hinges on whether or not we are speaking of immortality. For those who believe in the existence of a soul that has the chief characteristic of being immortal, such an entity would be, by definition, independent of the physical and mortal

basis of mind. But it is this physical basis of mind, not the immortal qualities of soul, that is my only concern in this book. However, in cases where soul is used as a term for the mental properties of the brain, we shall consider it interchangeable with mind, in that use of one or the other simply reflects the preoccupations and tastes of a particular era.

What about distinguishing consciousness from mind? When we fall asleep, we would probably admit to a loss of consciousness, but we would probably not regard ourselves as having relinquished our minds. Mind, then, has a more inclusive, permanent, and enduring connotation that survives the fleeting moment and is somehow tied up with our integral and continuing personalities. Consciousness, on the other hand, is suggestive of more transient states in the here and now.

Moments of Consciousness and Arousal

If consciousness is only some fleeting state of our highly individual minds, perhaps there is not so looming a problem after all. Let's consider another transient state, arousal. In everyday language we think of it as underscoring extreme emotions such as anger or love. Indeed, in evolutionary terms an aroused state serves to prepare us for action of some kind, whether it is to save, propagate, or maintain life. The changes that occur when the body is highly aroused are often dubbed the "fight or flight" response. They consist of sweating, an increase in heart rate and blood pressure, a cessation of digestion of food, and removal of blood from the skin in order to divert it to meet the more urgent demands of the vital organs for oxygen. This response is frequently elicited in situations where life is not literally threatened but is interpreted as such, as in a heated argument. Could this background tone to our experiences be the same as consciousness?

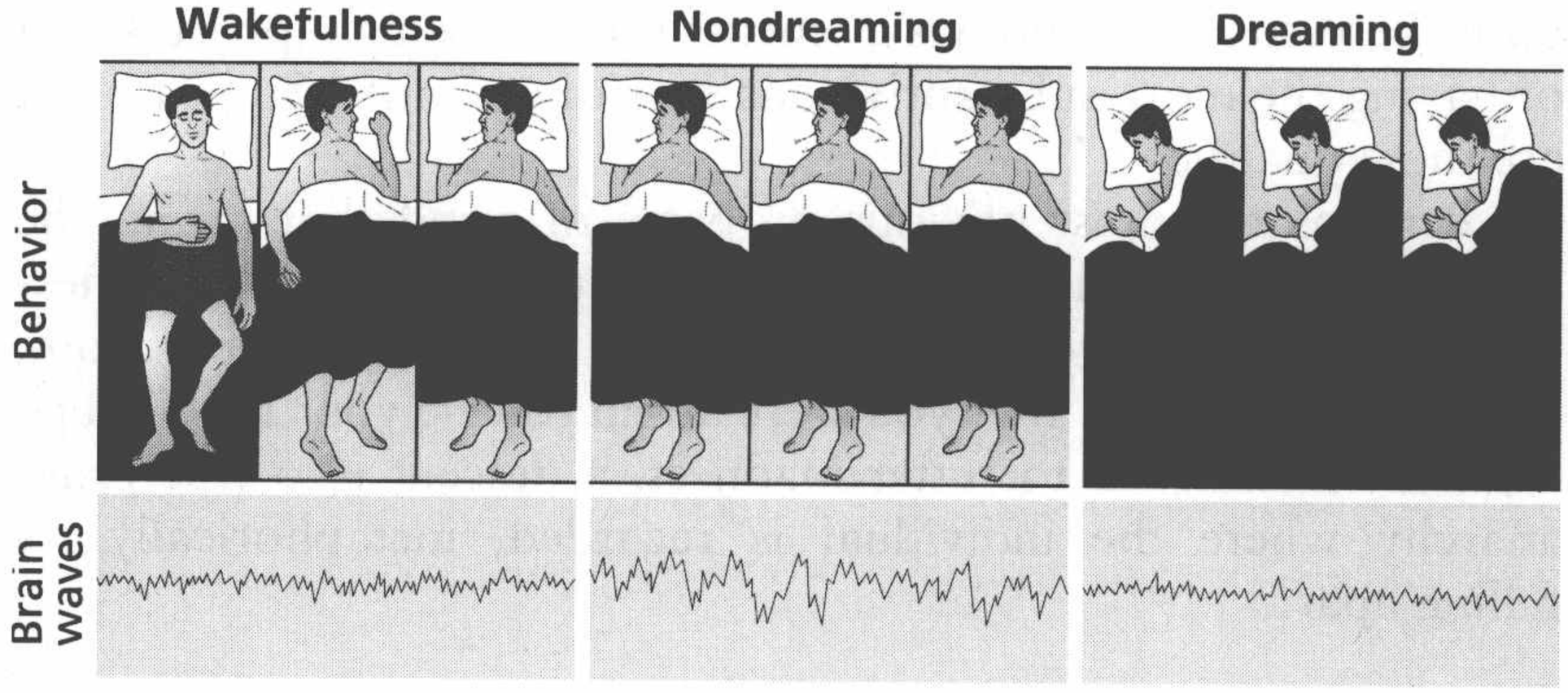
Fighting and fleeing are extreme examples of arousal. It is less obvious perhaps that arousal, in physiological terms, is not just the fight or flight response. In a less obtrusive fashion it is constantly with us: We can think of it for the moment as an energizing power permeating the brain as well as the body. Arousal is best thought of, physiologically, as some type of generalized activation of brain cells caused by certain chemicals pulsing

through the brain (Steriade and Buzsaki 1990). Another way of looking at it is as the most basic behavior we have. It is not an independent, optional course of action but to greater or lesser extents pervades all we do. In extreme examples, arousal can be conspicuous by its low levels (sedation) as well as by its high levels (hyperactivity and distraction).

But now it seems that the features of arousal, as described here, are starting to have an uncanny resemblance to some of the features of consciousness. Both are always with us while we are awake and both are dramatically reduced when we are asleep. How, then, might arousal differ, if at all, from consciousness? In terms of the brain, a state of high arousal is registered as intense activity of brain cells recorded from electrodes on the scalp. When arousal is measured, it is not an all-or-none phenomenon but, rather, is graded, a sort of continuum. At one end of the continuum of arousal, we are in nondreaming stages of sleep, we are unconscious. Interestingly enough, it is when we are unconscious in this way that it is *easier* to be awakened than when we are dreaming (Rechtshaffen et al. 1966). It is when we are dreaming, however, and we are in rapid eye movement (REM) sleep that, according to recordings from electrodes placed on the scalp, the brain is relatively more aroused than in dreamless stages of non-REM sleep.

If arousal were the single factor responsible for consciousness, indeed, if it were synonymous with consciousness, then it would be hard to explain why the high arousal accompanying conscious dreams is transformed *less* readily into wakening consciousness than the total lack of consciousness of deep sleep, where arousal is lower. If consciousness were simply arousal, then we would expect that the more aroused we were, the easier it would be to be affected by the ring of an alarm clock or the shaking of a shoulder. There must, therefore, be an additional factor relevant to dreams, and thus consciousness, that is not directly related to arousal. We shall attempt to discover what this additional factor might be later in the book. For the time being, the important point to establish is that arousal and consciousness are *not* synonymous; rather, arousal is most likely to be a contributing factor.

Given that they can be distinguished from each other, how do mind and arousal relate to consciousness? Mind, in our everyday understanding, is long lasting in that it endures as long as the



The three major stages involved in sleep, as shown by changes in body movement and brain waves. In the first stage, wakefulness, there is continuous voluntary movement, and low-amplitude, high-frequency brain waves can be recorded on the electroencephalogram. However, once a person is asleep, brain waves become slower and develop a characteristic large amplitude. Body movement, tossing and turning, still occurs occasionally. When dreaming, however, there is far less movement than in nondreaming sleep—almost as if the sleeper were paralyzed. Brain waves, though, once again resemble those of the awake state. (After J. Carey, ed., *Brain Concepts: Sleep and Dreaming* [Washington, D.C.: Society for Neuroscience, 1991].)

brain does. Consciousness, however, is relinquished every night. In a folklore psychology use of the term, it is a phenomenon with some continuity throughout each day that transcends our moment-to-moment existence in an unbroken stream. Almost seventy years ago the pioneering neurologist Henry Head described the seamless continuity of consciousness as "a march of events with a definite temporal relation; the response obtained from any one point, at a particular moment, depends on what has happened before" (1926). After all, few would confess to a series of ruptures in consciousness during a day at the office, as though our brains were governed by a system operating like traffic lights, where we were forever in a stop-go situation.

By contrast, arousal is far more fickle. It can fluctuate appreciably over shorter time periods and *contribute* to our experiences of awareness throughout the day without being the pivot of consciousness. Arousal is clearly a process, whereas mind is generally regarded as an entity. Consciousness spans the bridge between

both these concepts and has elements both of being a process and of having the more substantive qualities of an entity. So just what are these qualities?

Perhaps the most obvious property of mind that cannot be attributed to arousal is a continuity of individuality. As the anesthetist looms over you on the threshold of the operating room, you would not claim that you were about to lose your mind. Such a phrase is reserved for utter madness, a descent into true brain anarchy where the individual is regarded, metaphorically, as falling apart.

The Problem of Self

Although it might seem like quibbling to stress the difference in permanence between mind and consciousness, such a distinction proves critical when it comes to deciding if we have any enduring individuality. In considering consciousness, philosophers such as Derek Parfit and Daniel Dennett concentrate on whatever mental state prevails and disregard any enduring self that might be independent of that current conscious experience. To explain the subjective feel of consciousness, Parfit (1989) proposes the Buddhist bundle theory, which suggests that different streams of potential consciousness exist. Whichever one dominates at any one time gives you a sense not only of a certain conscious view of the world but also a sense of identity. In a similar vein, Dennett (1991) envisages the brain processing incoming information in a continuing sequence that can be sampled at different stages, so that there are multiple drafts of any one event; whichever draft is dominating amounts to your current consciousness.

It is easy to see that these scenarios, where the fleeting moment dictates your mental state, are better described as a *process* consciousness at work rather than reflecting the static presence of an *entity,* the mind. But the philosopher Thomas Nagel suggests that this is not enough; a fleeting snapshot type of consciousness does not encapsulate the idea of a highly subjective, personalized view of the world. Nagel (1986) argues that individual beliefs, desires, traits, and so forth that make up a person *should* survive the radical break in consciousness that occurs in the total oblivion of sleep or anesthesia, that there is something more to being a person than a snatched moment of consciousness.