PART I: HISTORICAL BACKGROUND

CHAPTER 1

SUPERNATURAL, MATERIALISTIC, AND BIOLOGICAL THEORIES OF THE MIND

1.1. Prologue: The Problem of Mind and Matter

1.1.1. Everyday Concepts of the Mind. The term *mind* is used by everybody in daily discourse, although with different meanings. To some, the word refers to certain overt (public) manifestations of intelligent beings. A person has a "keen mind" if he can answer difficult questions or solve complex problems, he is "out of his mind" if his behavior becomes bizarre or irrational, and his "mind is failing" if he can no longer behave rationally. To others, the term refers to the covert (private) experiences they themselves have or attribute to other people. Examples are memories that pop up unbidden or are laboriously reconstructed in the inner theater of our consciousness, daydreams or fantasies, and thinking and reasoning that we engage in before making a decision. The two meanings are not mutually exclusive and they are often used interchangeably because the human ability to behave intelligently presupposes such subjective processes as remembering, thinking, judging, deliberating and consciously monitoring what one is doing. But once we admit that "mind" refers to subjective experiences, we are confronted with the dilemma whether inner states that are not of the rational kind also belong to these categories. Feeling pain or pleasure, being happy or sad, savoring the flavor of some delicacy or being disgusted by the foul taste of a rotting substance, being overcome by a sublime feeling upon watching a beautiful sunset, are all subjective experiences but they are of an affective rather than a cognitive kind. And once we accept that feelings and emotions are mental phenomena, we then have to entertain the proposition that animals that cannot solve problems by thinking and deliberating are also mental beings. These animals are attracted or repelled by different substances, approach or avoid certain situations, make complex perceptual discriminations, and learn from experience. This proposition runs counter to the widespread belief that only human beings have a mind. Those who deny that animals have minds attribute their adaptive behavior to a mysterious force, called instinct, or grant animals only a primitive form of mental ability, one that is drastically different from the human "soul."

1.1.2. The Idea of Two Domains of Nature. Since ancient times, sages have concerned themselves with the vexing problem of the relationship between what they thought of as visible matter and invisible spirits, and two facets of human nature, body and soul. More recently, philosophers, psychologists, and neurobiologists have reformulated the latter problem by investigating the more specific relationship between brain and mind, i.e., the interaction between functions of the nervous system and psychological and behavioral processes.

MIND AND MATTER. The philosophical meaning of "matter" is quite clear: it is any perceptible object, body or "stuff" that has definable boundaries and is located somewhere in space (what Descartes called *res extensa*). Typically, matter is visible and tangible, and can be lifted, pushed, carried about, and manipulated. Matter also has force, potential or actual energy; for instance, heavy bodies resist being moved or, if in motion, they resist being stopped. Many objects in our environment seem to be composed of nothing else but matter and energy, and we can exhaustively characterize objects by describing their shape, texture, and size, and their static or dynamic properties, such as liquid or solid, soft or hard, light or heavy, cold or hot. Although the modern scientific concept of matter is no longer anchored to these sensation-based categories, it has retained its reference to anything that can be either directly perceived or indirectly demonstrated. Atoms and molecules may not be visible to the

naked eye, but they can be visualized, measured, and manipulated with the aid of appropriate scientific instruments. (Only in the world of subatomic particles dealt with by nuclear physics and quantum mechanics does the nature of matter become problematic.) In sharp contrast, there is considerable ambiguity and disagreement about the meaning of "mind" and "spirit." Many philosophers, like Plato in ancient Greece and Descartes in modern Europe, held that the individual soul (mind) is an emanation or fragment of the cosmic "spirit" (*nous* and *res cogitans*, respectively), a sublime entity that is as real as physical matter and energy but fundamentally different from it. This view remains influential to this day in the religious traditions of the West, the Near East and the Far East. Opposing this view, some philosophers held that mind is part of the material world, perhaps finer and flimsier than physical matter but still part of the same universe. In the West this took the form of the materialistic theory of a "mind stuff," first formulated in ancient Greece by Leucippus and Democritus, and later popularized in Rome by Lucretius. Quite a different idea, to which we shall return later, is that mind is not a stuff at all but an organic process and force characterized by the subjective experiences (feelings and sensations, sensations and perceptions, memories and thoughts) of all animals.

MIND AND BODY. Most of us with a scientific education accept the belief that natural things like rocks and mountains, lakes and clouds, and artifacts like chairs or automobiles, lack mental attributes, that is, they have no feelings or desires, do not see, hear or think. Most people also accept the scientific view that atoms and molecules or stars and galaxies are, likewise, mindless constituents of the universe. In sharp contrast, most of us take it for granted (and we shall deal later with those who do not) that at least some living bodies, like ours, have minds. But if bodies can have a mind, how are the two related and how can they interact when they are so different? The body is perceptible and exists in the public domain, accessible to all. The mind, in contrast, is imperceptible and exists only in the private domain, hovering somewhere inside the experiencing subject. While others may infer that I am in pain by the way I am behaving, they cannot *feel* my suffering. They may assume that I am preoccupied with some thought but they do not *know* what I am thinking. If the two are so different, how do they, and how can they, interact? How can my immaterial mind have material effects, as when my fingers moves by my *willing* it, and how can the material body have mental effects, as when air vibrations affecting my ear makes me hear what is said? We cannot answer this enigma because the mind-body interaction violates two of the fundamental canons of natural science, the principle of physical determinism and the law of energy conservation. Determinism rules out the participation of nonmaterial agencies in natural phenomena because each physical *effect* in a chain of events must have an antecedent physical *cause*. My "will" to move my finger, a mental phenomenon, should not be able to initiate the chain of material events that results in my finger moving. The physical stimuli acting on my sense organs should not be able to produce the mental processes of sensing and perceiving. Similarly, the law of the conservation of energy does not permit any gain in the energy state of a material system by nonmaterial (mental) contributions, nor does it allow energy loss by a physical system through its conversion into a nonmaterial (mental) event. However, while the problem remains incomprehensible at the metaphysical level of *causality*, it can be satisfactorily studied at the empirical level through demonstrable *correlations*. Without being able to explain how the two interact, we can ask, and we can now give satisfactory answers to, what sort of mental states give rise to what kind of physical events, and what kind of physical events give rise to what sort of mental states.

MIND AND BRAIN. The modern version of ancient speculations about the metaphysical problem of mind-body interaction is the scientific investigation of the contingent relationship between mental processes and brain activity. Some ancient philosophers either denied that the brain plays any role in mental activity (Aristotle assigned that function to the heart) or else thought of the brain as one of several body organs through which the soul exerted its physical effects (Plato thought of the chest and the belly as the other organs). And while the ancient physicians, like Hippocrates and Galen, did proclaim that the brain was the "seat of the soul," they invoked quasi-materialistic explanations of how the two communicated, such as "humors" that diffused through the brain's porous substance or the "animal spirit" flowing through its hollow ventricles. Fanciful theories of mind-brain relationship were popular well into modern times—such as the localization of different faculties, imagination, understanding and memory, in different brain structures or ventricles—but there was no consensus on the brain's pivotal role. Shakespeare voiced that uncertainty when he posed the question:

> Tell me where is Fancy bred
> Or in the heart or in the head.
>
> (*Merchant of Venice*, Act III, Scene 2)

It was not until the early decades of the nineteenth century, that the brain was accepted by practically all scientists as the "organ" of mental faculties (although in popular parlance the heart remains the spring of emotions). And by the nineteenth century, and more particularly during the twentieth century, the intricate organization of the central nervous system was sufficiently understood to allow the formulation of reasonable hypotheses of how the brain controls behavior and how its components and networks "mediate" different mental states. Thanks to the extensive work of neuroanatomists, neurophysiologists, neurochemists we now possess a workable knowledge of how the sense organs convey information to the brain, how its different components are involved in the transduction, encoding, transmission, processing, and storing of the gathered information, and the mechanisms underlying the patterning and execution of motor activities. And thanks to the work of experimental and clinical neuropsychologists and behavioral biologists, we have a considerable corpus of data that link behavioral functions and mental processes to the operation of specific brain structures. Although the metaphysical problem of the interaction between the subjective domain of the mind and the objective domain of the brain has not been resolved, the interaction between the two may be considered an established fact. Therefore, no scientific or philosophical discussion of the nature of mental states or processes can proceed without due reference to the implicated neural mechanisms, brain regions and networks.

MIND AND BEHAVIOR. Although the empirical problem of mind-brain relationship is of great interest to scientists, philosophers and intellectuals, it is of no direct concern to the layman going about his daily life. Not so, however, the related problem of how mind and behavior are interconnected. Any time a person interacts with another, the first thing he is trying to do is infer what goes on in the other's mind. What is she trying to do or accomplish, what are her motives or intentions? Is she pretending to be angry or is she truly annoyed? Is he telling the truth or is he lying? What are his convictions, preconceptions, or prejudices? We cannot adequately assess the behavior of another person without considering his or her presumed

feelings, emotions, beliefs, breadth of knowledge or style of reasoning. Because of this practical necessity, the mind's role in human conduct was among the first subjects dealt with by the ancient philosophers. Socrates stressed the importance not only of an understanding of what goes on in the mind of others but also in one's own mind ("know thyself"). Plato (1953a, 1953b) distinguished between reason, courage and passion as the different mental powers that guide human behavior, and advocated the subjugation of passion to reason as the guiding principle of moral behavior. Likewise, Aristotle (1968) argued that only the person whose conduct is guided by reason and makes free choices, is a moral agent; the man ruled by passion is a slave to his desires, cravings, and lust. The Stoics, like Cicero (1951) discussed the roles played by different emotions—anger, hatred, love, compassion, jealousy, grief, pride, honor, and so forth—in the conduct of life. The physicians, like Rufus of Alexandria (Clarke and O'Malley, 1968) and Galen (Siegel, 1968), made a distinction between voluntary acts performed freely by conscious choice and involuntary acts made automatically without consciousness.

1.1.3. Traditional Theories of the Mind. The mind's nature and properties has been the subject of speculation and theorizing for a long time and, more recently, of some scientific research. We may distinguish three such theories, the supernatural, materialistic, and the biological. Oldest and most widespread are the various types of spiritualistic theories, all of which assume that there are two realities: the visible and tangible, material domain of the natural world, and the invisible and intangible supernatural realm of the spiritual world. These dualistic theories usually postulate some linkage between the external physical world and the person's material body, and the world of spirits and the soul that dwells within the person.

SUPERNATURAL THEORIES. Animism, spiritualism and vitalism must be the oldest of the three theories of the mind, as there is indirect archeological evidence of prehistoric man's belief in the soul, and in spirits and ghosts, and direct ethnological evidence of the prevalence of a supernatural belief system in all preliterate cultures. In its modern form, supernaturalism endures as the widespread belief in the soul's separate existence from the body—its origination before the body commences to develop and its persistence after the body has disintegrated. Among the presumed contribution of the supernatural to the individual and his conduct is the theory that a mysterious life force drives and guides embryonic development (vitalism), that the soul endows human beings with conscious awareness (animism), and that a divinely-inspired conscience is the source of our moral behavior (spiritualism).

MATERIALISTIC THEORIES. In contrast to the dualism of supernatural theories, materialistic theories are typically monistic. Radical materialists assume that there is only one domain in nature, the physical (positivism). What is called mind or soul is nothing more than matter, more refined and ethereal than the matter of coarse bodies and, therefore invisible and intangible, but not drastically different from it. In a less radical form, the mind's existence is not altogether denied but it is conceived to be an epiphenomenon (behaviorism). In the materialist view, behavior is not governed by the mind but by physiological operations of the brain that are analogous to how machines and computers work.

BIOLOGICAL THEORIES. Biological theories tend to be quasi-dualistic. They do not assume the existence of two separate domains in nature, the physical and the spiritual, but posit that the

mind is an organic process mediated by sensory, central nervous, and motor mechanisms and its function is to motivate, guide and monitor animal and human behavior. In its evolutionary formulation, the theory postulates that the mind has emerged as inner or subjective experience in lower animals as a simple mechanism of sentience (selectively responding to beneficial and harmful stimuli). The mind has become ever more complex and efficacious as sensory, integrative, and brain mechanisms have evolved in the vertebrate line that led to humans.

1.1.4. A Proposed Evolutionary Biological Theory. We shall develop the idea in this book that subjective experience in any of its manifestations—inchoate feelings of pain and pleasure (sentience); seeing, touching, smelling, tasting and hearing (sensation); recognizing and discriminating objects, beings and events in the external world (perception); storing and recollecting these experiences (memory); judging, thinking and reasoning (cognition); and conscious awareness of the world and of oneself (reflection and introspection)—are all mental phenomena, and they are all of organic origin, i.e., functions of the brain. These experiences may differ drastically in their qualitative properties and functions but share the distinctive property of being *inner states* of behaving subjects that *motivate* them to pursue goals and *guides* them in making choices. Hunger and thirst, pain and pleasure, relish and disgust, fear and anger, sensations and perceptions, memories and beliefs, illusions and fantasies, ideas and aspirations, inferences and judgments, and so forth, are very different in their contents and functions but they are all mental phenomena because they motivate, initiate and guide behavior by virtue of their *experiential* properties. Moreover, while granting that there is a profound difference between the animal mind and the human mind, we shall marshal support for the Darwinian notion of an evolutionary continuity between the two. Although we have no direct access to the subjective states of animals, we shall argue that many of our mental experiences—feelings and emotions, sensations and perceptions, and mnemonic and cognitive abilities—are an animal heritage. It is an established fact that mental functions depend on neural activity, and we also know about many shared properties of the sensory and motor systems of animals, and man. What animals lack is not subjective experience per se but the ability to *introspect* and *reflect* upon their experiences. Therefore, we shall distinguish between direct or tacit experiences that we share with our animal ancestors and higher order mental functions, such as reflection- and introspection-based explicit experiences, that are lacking in animals. The latter are higher-order mental functions mediated by language use and cultural traditions.

Our ability to introspect and reflect upon what we sense, perceive, remember, dream and think about is, of course, the reason that we can entertain such abstract concepts as “mind” and “mental.” Introspection and self-reflection are our only direct acquaintance with the subjective properties of the mind. It is natural therefore that the early philosophical speculations and later psychological investigations of mental phenomena focused more on the “higher” *cognitive* processes than the “lower” *affective* processes. However, we must supplement that direct, introspection-based anthropomorphic (top-down) approach to the study of the mind with an indirect, inferential phylogenetic (bottom-up) approach if we are to understand not only how the mind works but how it has originated. We will make the case that in order to understand the dynamic organization and great complexity of the human mind, we must consider its evolutionary history: how the mind has emerged in the animal world in the form of protopathic sentience (a feeling state without any reference to what transpires in the external world), and

how it has evolved along a tortuous phylogenetic path that climaxed in the evolution of sensory and perceptual acquaintance with the world, the recollection of past experiences, imagination, thinking and reasoning power, the use of language to communicate our wishes and thoughts, and, finally, the ability to introspect and reflect upon what transpires in the external world and within ourselves.

1.2. Mind as a Supernatural Force: Animism, Spiritualism, and Vitalism

Many people throughout the world believe that there is some mysterious link between their own mind or soul and an external, supernatural world of spirit or spirits. Anthropologists call this belief of ancient origin, *animism*. Psychologists use this term to explain the tendency of young children to attribute inanimate motion to teleological forces. *Cosmic spiritualism* is a more advanced form of animism advocated by some philosophers, and by clerics and theologians, who insist that the soul is of supernatural origin and immortal. *Personal spiritualism* is a philosophy that conceives of the human reason and morality as a supernatural endowment. *Vitalism* is a doctrine that invokes the operation of a supernatural force to explain the teleological facets of organic development.

1.2.1. Animism as an Ancient Cultural Tradition. The concept of animism was introduced into anthropology by Tylor (1871) to designate the pervasive belief of ancient, preliterate humans in a spiritual domain, one that hovers over things or is immanent in them, and to which the mind belongs. Tylor traced the origin of animism to two related psychological sources: the experience of dreams and hallucinations, and speculations about life and death. While dreaming, one's soul seems to leave the body behind, moving backward or forward in time, traveling long distances, and engaging in various adventures. In hallucinations and trance states, other people long deceased reappear as ghosts, pleading, arguing and threatening, or otherwise meddling in one's affairs. Body and soul are apparently separable. Moreover, the idea that one's spirit is separable from the body, offers a reasonable explanation of life, loss of consciousness when asleep, and death. For instance, the Negritos of the Andaman Islands in the Bay of Bengal have believed that each person has a soul in the form of a shadow, and that double may leave the body during sleep, but then returns before awakening (Lowie, 1924). But when the person dies the double departs and becomes a spirit in the jungle or the ocean. These spirits are usually invisible, but some natives claimed to have seen them as grotesque creatures with small bodies, long arms and legs, and the like. Since the most obvious sign if a man is alive or dead is whether or not he breathes, the term applied to both spirit and soul in many languages is derived from the word for breathing; the English term "spirit" comes from the Latin *spirare*, to breathe, and the alternate Latin term *anima*, from "wind" (Spearman, 1937). Because people in preliterate societies saw less of a difference between beasts and man than we do, animals were considered to be *animated* by spirits much like ourselves. Moreover, the idea of animation was often extended to explain such dramatic physical events as storms, floods, earthquakes, and such cosmic phenomena as the movement of the moon, the sun and the stars. That is, not only living things but also objects and events—anything displaying power and motion—were perceived as animated entities driven by some benevolent or malevolent spiritual force.

ANIMISM AS A COMPREHENSIVE WORLDVIEW. Man's dreams, hallucinations, and visions, on the one hand, and speculations, on the other hand, led to and old and pervasive animistic belief of the existence of two separate but interacting domains in the universe, a realm of matter and spirit in the external world, and a realm of body and soul within oneself. Spiritual forces were invoked as powerful agencies not only in speculations about beneficial and harmful events in the environment (rain, rich harvest, flood, fire, earthquake) but also about fortunate and unfortunate personal events (pleasant family affairs, good health, disease, death). In an attempt to deal with presumed benevolent and malevolent spirits (angels, ghosts, demons)—either to propitiate or to intimidate them—primitive people carried out daily routines with as much attention paid to rituals and magic as to practical and technical considerations (Boas, 1911; Malinowski, 1932, 1935; Murdock, 1934). In most preliterate societies, animism became a comprehensive world view: spirits were invoked to explain terrestrial and celestial events (animistic physics), how inert bodies came to life, why living beings remained healthy or became ill, and why they died (animistic biology and medicine). And, above all, animism became a psychological theory that accounted for differences not only between comatose and conscious states but also explained such abnormal conditions as delirium, madness, epileptic fit and trance—states in which one became "possessed" or "seized" by spirits or became "inspired" by them.

1.2.2. Animism as a Stage in Mental Development. This predisposition to attribute actions and events to mental motives rather than physical causes is manifest also in children who think that not only living beings, like men and animals, but also inanimate objects are animated. Children are inquisitive by nature; according to old surveys, questions constitute 10-15% of kindergarten-age children's utterances (Rugg et al., 1929; Fisher, 1934). The answer adults usually give to the child's question, *why?*, is either causal (deterministic) or purposive (teleological). When a young child looks out of the window and asks his mother, "why does it rain," she may answer that it rains "in order" to provide the soil with needed water and allow the plants to grow for our benefit (a teleological explanation). Alternatively, she may say that it rains "because" the cooling temperature made the moisture in the air condense into clouds and form large water droplets (a causal explanation). The young child is likely to find the causal explanation incomprehensible but will be satisfied with the teleological explanation. Piaget (1930, 1937), who studied children's concept of "life" and "living," postulated that childhood animism is a stage in mental development. When a child about eight years of age was asked if the sun is alive, he answered affirmatively because "it gives light." A watch is alive "because it goes." However, the bench is not alive because "it's only for sitting on" (quoted from Munn, 1965, p. 358). The child, at this stage of development, endows all active and moving objects with life. Piaget's observations were confirmed in a series of older investigations of children of various cultures (Russell, 1940a; Dennis and Russell, 1940; Dennis, 1943). Moreover, Russell (1940b) found that a child who said that something was alive was also likely to regard it to have mental traits, such as feeling and knowing. In a more recent study of children's conception of "mind," Broughton (1980) reported that a girl about seven years of age stated that "everyone has a mind except dolls and tables … If you have no mind then you can't be alive. Because your mind helps you." Another girl about the same age, asked about the sun, said the sun has a mind "Because it just can't do something. It has to think about it first." Asked if a tree has a mind, she answered, "When it's a baby, a seed, it thinks whether it's going to grow up" (Broughton, 1980; p. 192).

FROM PURPOSIVE TO CAUSAL EXPLANATION. Suppose that a child looking out of the window sees a cat chasing a mouse. When he inquires why the cat is so mean, the response could take the form of a causal, neurological explanation in terms of nerve impulses reaching a region of the amygdala and the hypothalamus implicated in predatory behavior. However, it is more likely that not only the child but also most adults would find a purposive explanation far more satisfactory, i.e., that the cat chases the mouse because it is a carnivore, and carnivores are motivated to hunt and kill prey to feed themselves. When we try to comprehend the behavior of others, or even ourselves, we tend to look for mental motives, such as: "He ran fast because he was determined to get there first;" "He stammered because he became embarrassed;" "I insulted my friend because he made me mad." In all these instances a casual (neurological) explanation might be construed about the transpiring events but during a social encounter those would be irrelevant as our interest is not in the mechanisms of behavior but in their motive or purpose. When someone slaps my back, I have to make an instant decision about his motives: "is it a friendly gesture?" and accept it graciously as a rough form of greeting, or "is it a hostile act ?" and adopt an offensive or defensive posture.

Modern children growing up in an environment filled with electrical and electronic toys and machines, and getting an early scientific and technical education, do better in distinguishing between inert objects, moving artifacts, and behaving organisms but they still display a preference for teleological (animistic) explanations over causal explanations (Kelemen, 1999, 2003). Childhood animism, which appears to be a natural disposition, may originate in the child's implicit understanding of the role played by mental states and motives in his own actions (desires and wants) and the actions of parents and peers (anger, jealousy). The child then simply extends this mode of explanation to other things that are active, particularly if he is not familiar with their mechanisms. As the child matures, this generalized animistic explanation of movements and events is gradually abandoned, perhaps as the result of a widely accepted modern distinction between inanimate causation in the physical world and the purposive motivation of animated beings. While most modern children, when questioned, will reveal that they know that their toys are mechanisms energized by batteries and moved by motors and gears, nonetheless their behavior reveals that they perceive their toys as live beings. Animistic explanations of inanimate movements are not abandoned by many educated adults (Dennis, 1953). People often explain a variety of emotionally disturbing phenomena such as earthquakes, floods, diseases, and death, as divine punishment.

1.2.3. Cosmic Spiritualism: Mind as a Rational Agency of Extrinsic Origin. Animistic thinking was still a powerful belief system in ancient Greece during the sixth century BCE when some philosophers, like Pythagoras, were beginning to advocate an admixture of animistic and rationalist worldview (Huffman, 2009). The details of Pythagoras' philosophy are not known except that he taught two interrelated doctrines. First, that the universe obeys the rules of mathematics, implying that natural phenomena are governed by rational principles. Second, that the soul is a divine force that temporarily inhabits the body but persists after death through transmigration to another body. Pythagoreanism, which later turned into a religious sect and then disappeared, is historically important because it influenced Plato's teachings. Plato distinguished between the individual soul (*psyche*) and its cosmic source, the spirit (*nous*). He

argued that since the universe is rational, it must be governed by an agent that resembles the human soul but is superior to it. In one of his dialogues, Plato has Socrates ask a disciple,

> And whence comes that soul, my dear Protarchus, unless the body of the universe, which contains elements like those in our bodies but in every way fairer ... Can there be another source?
>
> (Plato, 1953b, p. 583 [Philebus, 30a])

Plato did not clarify how the individual's soul emanates from the cosmic soul, but he insisted that the soul exists before it inhabits a particular body and does not perish when that dies. Plato added to this belief in the soul's immortality, the doctrine of reminiscence. He argued that being a rational force of spiritual origin, our mind must be furnished at birth with innate ideas and knowledge of the world. The role of sensory impressions and experience is merely to retrieve and recollect them.

> The soul ... being immortal and having been born again many times, and having seen all things that exist, whether in this world or in the world below, has knowledge of them all, and it is no wonder that she should be able to call to remembrance all that she ever knew about virtue, and about everything ... There is no difficulty in a man eliciting out of a single recollection all the rest, the process generally called 'learning,' if he is strenuous and does not faint; for all inquiry and all learning is but recollection.
>
> (Plato, 1953a, p. 278 [Meno, 81d])

Mind-body dualism, and the added belief that the mind is an immortal spiritual entity, and the body merely its temporary vessel, has become the established doctrine of most world religions. However, the doctrine of the preexistence of the soul that Plato taught never became popular in the West. A widely held belief of Western religions is that the individual's body and soul are jointly created at conception, and after the body perishes the soul of the individual, which takes up abode in Heaven or Hell, persists. In contrast, in several less individualistically oriented Eastern religions, like Hinduism, there is a belief in the transmigration of the soul. When the soul parts from one particular body it is sooner or later reincarnated in another. Indeed, it is the belief of the Hindu faithful that through good deeds his soul may end the travail of transmigrations, and upon being released from the body's bondage (*moksha*) it is reunited with the cosmic soul, *Atman* (Zaehner, 1962). A common psychological source of all these religious beliefs is the exaltation of the mind as a spiritual essence.

1.2.4. Personal Spiritualism: The Immortal Soul as Subjective Experience. Unlike Plato, who conceived of the soul as an ethereal substance of external origin, Descartes proposed that the mind is something very personal or private, the experience of the thinking and knowing individual. While Descartes partially followed tradition when he defined the soul as a kind of substance—*res cogitans* in contrast to *res extensa* of ordinary matter—but he stressed its subjective quality when he defined the soul as

> a substance the whole essence or nature of which is to think ... this 'me,' that is to say the soul by which I am what I am.
>
> (Descartes, 1955a; p. 101)

And while in most of his writings Descartes did not consider feelings and emotions to be mental phenomena, which he should have done if inner experience is the criterion of the mental, he was aware of this inconsistency when he wrote in his Principles of Philosophy:

> By the word thought, I understand all that of which we are conscious as operating in us. And that is why not alone understanding, willing, imagining, but also feeling, are here the same thing as thought.
>
> (Descartes, 1955b, p. 222)

Descartes believed that only humans are conscious beings (animals are automatons) and that the human soul is of divine origin.

A more consistent identification of the mind with personal experience is due to the *empiricist* philosophers, Locke (1690) and Hume (1739). Contrary to Plato's nativism, according to which the soul is an emanation of the cosmic spirit, and thus comes furnished with knowledge and understanding at birth, the major tenet of empiricism is that, the mind is more like an empty slate (*tabula rasa*) at birth, and it comes to be filled with knowledge after it is exposed to sensations and perceptions from the external world.

> He that attentively considers the state of the child, at his first coming into the world, will have little reason to think him stored with plenty of ideas, that are to be the matter of his future knowledge. It is by degrees he comes furnished with them.
>
> (Locke, 1965, vol. 1, p. 79 [Book II, chapter I, 6])

Locke made sensation and perception the basic elements of the mind. He argued that these elements become compounded into ideas by the process of *association* (contiguity, similarity, etc.). As Hume wrote, the mind is

> nothing but a bundle or collection of different perceptions, which succeed each other with an inconceivable rapidity … The mind is a kind of theatre, where several perceptions successively make their appearances; pass, re-pass, glide away, and mingle in an infinite variety of postures and situations.
>
> (Hume, 1946, pp. 252-253 [Book I, part IV, section VI])

However, both Locke and Hume admitted that to proceed from sensations and perceptions to the formation of ideas, it was also necessary to think, judge, and reflect upon what one experiences. As Locke wrote,

> external material things as the objects of SENSATIONS, and the operations of our minds within as objects of REFLECTION are the only originals from whence all our ideas take their beginnings.
>
> (Locke, 1965, vol. 1, p. 78 [Book II, chapter I, 4]

The role of reflection as a creative process was not stressed by the associatonists, and that became the center of Leibniz's criticism of emipricism. As he wrote:

> Experience is necessary, I admit, if the soul is to be given such and such thoughts … But how could the senses provide the ideas? … [S]omeone will confront me with this accepted philosophical axiom, that there is nothing in the soul which does not come from the senses. But an exception must be made of the soul itself and its states. *Nihil est in intellectu quod non fuerit in sensu, excipe: nisi ipse intellectus.*
>
> (Leibniz, 1981, p. 110 [Book II, chapter i])

Leibniz maintained that the intellect is a distinctive innate human faculty that transforms the externally elicited sensations and perceptions into concepts and ideas. He called this process *apperception*. He defined apperception as an active mental process that brings indistinct percepts into the center of consciousness, making them vivid and clear and enriching them with the mind's store of relevant information. Moreover, Leibniz was emphatically opposed to a mechanistic explanation of mental phenomena, sensing and perceiving as much as thinking and reflection:

> One is obliged to admit that perception and what depends upon it is inexplicable on mechanical principles, that is, by figures and motions. In imagining that there is a machine whose construction would enable it to think, to sense, and to have perception ... one should, when visiting within it, find only parts pushing one another, and never anything by which to explain a perception. Thus, it is in the simple substance, and not in the composite or in the machine, that one must look for perception.
>
> ... by means of the soul or form, there is a true unity which corresponds to what is called the I in us; such a thing could not occur in artificial machines, nor in the simple mass of matter, however organized it may be.
>
> (Quoted from Kulstad and Carlin, 2007)

The empiricism of Locke and Hume, and the rationalism of Descartes and Leibniz were partially reconciled by Kant (1929). In his *Critique of Pure Reason* (the German edition published in 1781), Kant made a distinction between the experience-based (*a posteriori*) origin of what we know about the world and the innate (*a priori*) framework of rational categories, that aids us in conceptualizing and comprehending what we experience. The principal rational categories that Kant distinguished are space, time, causality, quantity, quality, possibility,

necessity, and reciprocity. These *a priori* categories are analytic and synthetic tools that the human intellect uses for processing sensory information, with the latter being the source of our acquaintance of what exists and transpires in the external world or within ourselves. For instance, when we experience some event, the intellect that we are born with analyzes that in terms of its spatial attributes (its shape, location in space, whether it is moving or stationary, etc.), its temporal characteristics (its duration, speed, time of the day, etc.), and its causal relations to other events.

1.2.5. Aristotle's Vitalism: Mind as a Life Force. Aristotle stated in the opening lines of his *De Anima* that the "soul is as it were the first principle of animal life" (Aristotle, 1968, p. 1). To understand what Aristotle meant by this we must begin with his theory that the soul, as an energizing, formative, and guiding force, is responsible for the actualization of the potential for life and living that is inherent in certain "natural bodies." Aristotle did not clearly define what he meant by natural bodies but his examples indicate that he thought of such dormant organic entities as seeds and eggs. He maintained that the growth of a tree and the development of a chick—i.e., the actualization of the potential inherent in the seed or the egg—are products of the teleological force of the soul. In his view, the soul is not only the developmental force that transforms dormant seeds into living beings but also the motivational force that instigates and guides the life processes of mature organisms. As he stated:

> The soul is the cause and first principle of the living body ... three ways distinguished; for the soul is the cause as being that from which the movement is itself derived, as that for the sake of which it occurs, and as the essence of bodies which are ensouled.
>
> (Aristotle, 1968, p. 18 [415b])

That is, the soul is, first, an organic driving (motivating) force. Second, it is an organic teleological (purposive) agency. And clarifying the third criterion, "the essence of bodies which are ensouled," Aristotle says:

> if an instrument, e.g. an axe, were a natural body, then its substance would be what it is to be an axe, and this would be its soul ... if the eye were an animal, sight would be its soul ... The eye is matter for sight, and if this fails it is no longer an eye, except homonymously, just like an eye in stone or a painted eye.
>
> (Aristotle, 1968, pp. 9-10 [412b])

That is, the soul is the essence of all life functions. Aristotle rejects the presocratic and Platonic idea of the *extrinsic* origin and independent existence of the soul. He proposes instead that the soul is an *intrinsic* property of living matter: it is dormant in the seed before embryonic development commences; it then grows and differentiates; and, finally, disappears when life ends. And importantly, the soul is not a generic life force but an individual one. As he wrote:

> those have the right conception who believe that the soul does not exist without a body and yet is not itself a kind of body. For it is not a body, but something which belongs to a body…and in a body of such and such a kind. Not as our predecessors

> supposed, when they fitted it to a body without any further determination of what body and of what kind ...
>
> (Aristotle, 1968, p. 14 [414a])

Aristotle has not been consistent in his claim of the strictly organic origin of the soul. He distinguished between three grades or stages—the vegetative, the animal, and the rational soul—and argued for the organic origin of the first two, but considered reason (*nous*) to be of divine origin and immortal. Moreover, while he maintained that the soul is an inherent organic force, he also described it as a mysterious entity, what he called *entelechy*. He could not see how goal-directed and purposive behavior could arise from matter devoid of that supernatural guiding force and, thus, he moved from the dualism of mind and matter to an unexplained dichotomy between soulless or inanimate matter and soulful or *animate* matter (Aristotle, 1968). Our current knowledge of the role played by nuclear DNA as the genetic blueprint, and by RNA and a host of cytoplasmic proteins and other molecules as translational, synthesizing and signaling factors, was unknown in his days. Hence, he could not formulate a naturalistic account of how embryonic "potentials" might be "actualized" during embryonic and fetal development. And not knowing anything about the brain—its neurons furnished with dendrites, axons and synapses, and its complex system of sensory, motor and integrative pathways and circuits—indeed, denying that the brain had any role in mental functions, he could not conceive of mind as strictly an organic process.

1.2.6. Schopenhauer's Philosophy of "Will." Aristotle's rationalism received far more attention in the Middle Ages (as represented by Avicenna and Averroes in Muslim philosophy, and by Aquinas in Scholastic philosophy) than did his vitalism. In radical opposition to that rationalist tradition, Schopenhauer argued in his *Die Welt als Wille und Vorstellung* (originally published in 1819), that in its origin and essence the mind is not an intellectual or cognitive faculty but an irrational, vital (conative) force dedicated to support organic survival and self-preservation. Schopenhauer did not deny the role of the intellect in behavior but insisted that it was little more than the maidservant of the "will," conceived of as a mysterious, all-powerful life force. As he wrote:

> in all animal natures, the *will* is what is primary and substantial, the *intellect* again is secondary, adventitious, indeed a mere tool for the service of the former, and is more or less complete and complicated, according to the demands of this service.
>
> (Schopenhauer, 1928; p. 252)

And in reference to humans, he wrote,

> The will…constitutes the inner, true, and indestructible nature of man…the intellect is a mere accident of our being…a parasite of the rest of the organism; for it does not directly enter into its constitution, but merely serves the end of self-preservation by regulating the relations of the organism to the external world.
>
> (Schopenhauer, 1928, p. 249)

And even though he did not clearly subscribe to the theory of organic evolution, he claimed that the "will" is ubiquitous in the entire animal kingdom while the intellect has only emerged gradually in higher species.

> If we run through the series of grades of animals downwards, we see the intellect always becoming weaker and less perfect, but we by no means observe a corresponding degradation of the will. Rather it retains everywhere its identical nature and shows itself in the form of great attachment to life, care for the individual and the species, egoism and regardlessness of all others, together with the emotions that spring from these.
>
> (Schopenhauer, 1928; p. 254)

Schopenhauer listed a host of arguments in support of his belief that the organic "will," manifested mentally as an irrational, instinctual force, dominates reason. Anticipating Freud, he also looked upon the intellect as a rationalizing force:

> Nothing is more provoking, when we are arguing against a man with reasons and explanation, and taking all pains to convince him, under the impression that we have only to do with his *understanding*, than to discover at last that he *will* not understand ... Then he is certainly not to be got at, for reasons and proofs applied against the will are like blows of a phantom produced by mirrors against a solid body.
>
> (Schopenhauer, 1928; pp. 275-276)

Schopenhauer's philosophy of the "will" as the instinctual bedrock and governor of cognitive processes, has contributed greatly to Freud's conception of personality as a hierarchically organized dynamic system of unconscious and conscious elements.

1.2.7. Freud's Theory of the "Id." Freud (1933, 1947) proposed that human personality consists of three mental components, the *id*, the *ego* and the *superego*. The id is

> a cauldron of seething excitement…[I]t is somewhere in direct contact with somatic processes, and takes over from them instinctual needs and gives them mental expression…in accordance with the pleasure-principle.
>
> (Freud, 1933, pp. 103-104)

The unrestrained operation of the id, governed by primal emotions, is manifest in infant behavior. When deprived, frustrated or hurt, the infant expresses its distress by crying and screaming, demanding instant relief and gratification. As it matures, the child learns that emotional gratification must often be delayed. This is the beginning of the development of a secondary mental mechanism, the ego.

> The ego is that part of the id which has been modified by direct influence of the external world…[It] has the task of bringing the influence of the external world to bear upon the id and its tendencies, and endeavors to substitute the reality-principle

> for the pleasure-principle which reigns supreme in the id…The ego represents what we call reason and sanity, in contrast to the id which contains the passions.
>
> (Freud, 1947, pp. 29-30)

Reminiscent of Plato's famous metaphor about the role of reason in the control of passions, Freud says that the ego, is

> in its relation to the id…like a man on horseback, who has to hold in check the superior strength of the horse; with this difference, that the rider seeks to do so with his own strength while the ego uses borrowed forces.
>
> (Freud, 1947, p. 30)

The third mental component of personality is the superego. The superego transcends the pleasure principle and the reality principle and is value-oriented, that is, it is governed by moral ideals of right and wrong. All psychic energy is of emotional origin and, one-sidedly, Freud stressed the importance of the sex drive, the *libido*, as a the principal instinctual force. The libido energizes all mental operations but its targets and manifestations can be modified by the ego and the superego and by life's vicissitudes. For instance, the libido that is normally directed towards another person can be redirected to oneself (as in narcissism) or to an inanimate object (as in fetishism), and it can repressed or sublimated (as in religious enthusiasm).

1.2.8. Biological and Psychological Instinct Theories. The term "*instinct*" was first used by ancient Stoic philosophers attempting to explain the difference between the mindless adaptive behavior of animals and the intelligent behavior of humans. The Stoics conceived of instinct as a mysterious force implanted by God into the hearts of animals so that they may take care of their survival needs without any insight into what they are doing, and may pursue future goals without any foresight (Cicero, 1951). In contrast to instinctive animals, rational humans make free choices and foresee the consequences of their actions. Man is, therefore, morally responsible for what he does. Carried to extremes in the Middle Ages, it was argued by some that as a rational and conscious agent, man has no instincts, and unconscious animals lack intelligence. In line with his theory of a continuity in both somatic and mental evolution in animals and man, Darwin (1871) argued that man had instincts and some animals were intelligent. In time, the conceptualization of instinct as a mysterious force, and the strict dichotomy between instinctive animals and intelligent humans, was gradually abandoned and replaced by biological theories of innately organized behaviors as species-specific organic adaptations.

Are instincts associated with or based on mental activities? Craig (1918) distinguished between the initiating appetitive and aversive components of instincts and their consummation. He conceived of appetite and aversion as *affects* that motivate the organism to acquire desired objectives (food, water, mate) and evade undesirable situations (danger, injury, predators), respectively. Eating, drinking, mating, fighting, or fleeing are motivated *emotional* reactions that are instrumental in gratifying wants and relieving stress. The ethologists, Lorenz (1950) and Tinbergen (1942, 1951), abandoned the mental constructs of appetite and aversion and distinguished three quasi-physiological components in all instincts: an innate releasing

mechanism, a reservoir of action-specific energy, and a fixed action pattern. The "innate releasing mechanism," the input (sensory) arm of the instinct, is the specific stimulus configuration that serves as a code to allow access to the brain mechanism that coordinates a particular instinct. Examples of releasers are the sight of the gaping mouth of a fledgling bird that induces the parent to regurgitate food, the posture of an aggressor that induces fighting or fleeing, or the sexual ornament displayed by a potential mate during the breeding season that induces courtship behavior. The "reservoir of specific energy" is the built-up driving force, which becomes exhausted during the performance of the instinctive act and terminates it. Evidence for such an energy reservoir comes from the observation of "vacuum" activities, such as the display of an instinctive act in the absence of an appropriate goal object, and "displacement" activities, such as pecking at nothing in particular, preening, grooming, digging, kicking, or yawning when the execution of the instinctive reaction is prevented. The "fixed action pattern" is the output (motor) arm of the instinct, a stereotyped or ritualized sequence of movements that allows the consummation of the instinctive act. It may be chewing and swallowing, a flight response, or copulation.

McDougall (1928) advocated that instincts are closely associated with feelings and emotions that play a major role in human behavior. According to McDougall, human behavior is the product of a finite number of instincts, and each of them is linked to positive emotions (pleasure, desire, craving) or negative emotions (pain, suffering, frustration). Among affect-based instincts in man, McDougall identifies flight, repulsion, curiosity, sex, maternal tenderness, pugnacity, self-abasement, self-assertion, gregariousness, and acquisitiveness. In McDougall's view, different situations evoke different affects and they, in turn, trigger specific instinctive reactions. Facing an aggressor or predator produces fear or terror and that drives the subject to flee. Meeting a potential sexual mate produces desire or lust and that induces courtship behavior and the attempt to copulate. Hearing her child cry, evokes tenderness and compassion in the mother and that induces her to nurse and cuddle the child. As an instinctive act is carried out, pleasure and pain assess the individual's success or failure and sustains the ongoing behavior. In McDougall's "conative" or "hormic" psychology, which has a strong flavor of vitalism, we may discern an amalgamation of Schopenhauer's metaphysical speculations and Freud's dynamic psychology.

1.2.9. From Instincts to the Experimental Study of Motivation and Emotion. Aristotle's entelechy, Schopenhauer's will, Freud's libido, McDougall's horme, and Tinbergen and Lorenz's energy reservoir are all hypothetical vital forces invoked to explain the driven and end-seeking character of behavior; they are not empirically based or experimentally demonstrated organic processes or brain functions. Aristotle's concept of entelechy was based on his belief that the heart was the seat of the soul, which starts to beat early during embryonic development and keeps doing that unceasingly until death. That attribution that the "seat of the soul" is the heart was obviously wrong. Schopenhauer's concept of the will as a mysterious cosmic force that uses the body as its material instrument, much as a musician uses the piano to create music, is not based on scientific evidence. Tinbergen and Lorenz's hydraulic model of energy reservoir is just a metaphor because such a mechanism cannot be reconciled with the known physiology of the nervous system. And while Freud and McDougall did link instincts to affects that we

are familiar with from personal experience, they did not link them to the somatic and neural foundations of feelings and emotions.

Physiologists and physiological psychologists in the early 20th century initiated experimental investigations of the organic foundations of motivation and emotions. Using physiological techniques, Cannon (1915, 1929) demonstrated that affective states triggered by metabolic needs and organic stress—hunger, thirst, pain, fear, and rage—are linked with changes in the activity of the autonomic nervous system and the secretion of hormones that alter respiration, blood circulation, levels of blood glucose concentration, and so forth. Following Claude Bernard's earlier demonstrations and theorizing, Cannon interpreted these changes as emergency responses (arousal and energy mobilization) that promote the restoration of the homeostasis of the body's internal milieu, safeguard the organism's corporal integrity, and foster its welfare. With regard to behavioral manifestations, Richter (1922, 1927) showed that food deprivation in rats leads to increases in levels of locomotor activity in proportion to the duration of that deprivation. Likewise, Richter found that the locomotor activity of female rats increases several-fold during puberty and cycles thereafter in synchrony with their estrous periods. Removal of the ovaries in female rats, or castration of males, reduces these hormonally triggered high activity levels; these can be restored by the administration of estrogen or androgen, respectively, as shown by others (reviewed by Hall, 1961). The visceral changes that trigger heightened locomotor activity trigger not only generalized behavioral arousal but also specific activities aimed at finding food, water or a mating partner. Furthermore, learning studies in rats and other animals have established that hunger, thirst or sexual deprivation can serve as incentives to acquire sensory discriminations and master skills that aid the gratification of particular needs (reviewed by Cofer and Appley, 1964). Not only metabolic needs but also cognitive needs may be associated with behavioral motivation. For instance, rats placed in a novel environment engage in exploratory behavior, as if motivated by curiosity (Berlyne, 1950). Rats also work for hedonic rewards, such as a drop of saccharine solution that has no nutrient value but apparently provides a pleasurable sensation (Young, 1961). Finally, rats will self-stimulate their brain when electrodes are implanted at sites that produce a rewarding experience (Olds, 1956). Due to these types of experimental investigations, motivation (replacing the supernatural instincts) could be tied, on the one hand, to affects and, on the other hand, to visceral, somatic and neural processes.

1.3. The Mind Ignored or Denied: Materialism, Behaviorism, and Positivism

1.3.1. Early Materialistic Conceptions of the Mind. The ancient Greek philosophers, Leucippus and Democritus (5th century BCE), developed the idea that all matter is composed of indivisible elements, what they called *atoms*. This idea was also applied to the soul, which was considered to be made of finer, smoother and rounder atoms than inanimate matter. This idea was further developed by Epicurus (3rd century BCE) and popularized in the poem, *De Rerum Natura* by Lucretius (1st century BCE) in Rome (Lucretius, 1910). With reference to perception, the materialists argued that replicas (*simulacra*) emanating from physical objects reach, by way of the sense organs, the soul atoms and induce in the latter corresponding movements or resonance to produce sense impressions. Because the soul atoms were believed

to be distributed throughout the body, the contact between the outside world and the soul was a direct one through pores. Beyond such generalities, the ancient atomic theory furnished no details how the soul atoms might be responsible for other mental activities, such as feelings, memories, ideas or thoughts. This early atomic theory did not deal with the subjectivity of mental phenomena, and only sought to counter the widespread "superstition" that there are two discrete domains in the universe, the natural and the supernatural.

An indirect contact between the material atoms of the external world and the presumed soul atoms of the body, rather than a direct one, was suggested by the early observations of the Alexandrian physicians, Herophilus and Erasistratus (Clarke and O'Malley, 1968). Dissecting animals and humans, they found that some of sense organs, such as eyes, were connected by nerve fascicles to the brain, which lent support to the Hippocratic doctrine that the brain is the organ of the soul. The brain was thought to be suffused by different humors and the admixture of these were held responsible for the emotional disposition (temperament) of individuals. In the 2nd century CE, Galen postulated the existence of a fine substance in the brain, the "animal spirit," which was thought to be responsible for the coordination of behavior (Siegel, 1968). It was hypothesized that the animal spirit flows from the sense organs, by way of the tubular nerves, to the fluid-filled ventricles of the brain, and thence to the muscles, producing both involuntary and voluntary movements. This was perhaps the earliest version of the idea that the central nervous system is composed of reflex circuits of a mechanical kind. However, Galen did not deny the existence of the soul and left unclear how the fine substance of the animal spirit and the immortal soul interacted within the brain ventricles. Because Galen's dualism could be reconciled with the spiritualist philosophies of the Middle Ages, his ventricular theory of brain function remained popular until the 18th century.

1.3.2. Mechanistic Theories of the Mind. Descartes, among others, elaborated on Galen's ideas and developed the hypothesis that bodily functions in animals and man are mechanical processes controlled by the brain with a hydraulic apparatus (Descartes, 1972). The involuntary reflexes of animals and man are controlled by the different sense organs that propel the animal spirit through hollow nerves to components of the ventricular system supplied by valves, and from there to the different muscles. Descartes insisted, however, that the voluntary movements of humans was different, being controlled by the unitary soul (the *I*) that acted upon the pineal gland, a unitary structure of the brain. Few of Descartes' contemporaries accepted this fanciful hypothesis. Julien de la Mettrie went further and, in his *L'Homme Machine*, published in 1747, argued that voluntary behavior was also a mechanical process (Vartanian, 1960). Mettrie denied the existence of a soul and proposed that sensation, affect, memory, imagination, thought, and will are all material manifestations of brain activity. Some of the philosophers of the Enlightenment, of whom Cabanis may have been the most radical, shared Mettrie's views. Cabanis claimed that the role of the brain in thinking is not unlike the role of the stomach in secreting digestive juices (Vartanian, 1960). In contrast to Descartes hydraulic model, Mettrie's and Cabanis's behavioral mechanism was modeled on the latest mechanical devices, clocks driven by springs. All this was fanciful speculation rather than scientific hypotheses based on empirical evidence. These materialists neglected the emerging new physiological evidence regarding the excitable nature of nerve-muscle interaction that

was being demonstrated experimentally by Jan Swammerdam, Albrecht Haller, and others (Brazier, 1959, 1984).

Due the steady advances made in the anatomy and physiology of the sense organs, the nervous system and the muscular system, the clockwork model of the human machine was soon abandoned in favor of a more realistic physiological model based on the discovery of the electrical nature of nerve conduction and muscle contraction. Galvani discovered in 1791 that if a spark from an electrostatic machine or other source was applied to the spinal cord of a frog, its leg muscles contracted (Brazier, 1959, 1984). The same could be achieved by direct electrical stimulation of muscle. Using a galvanometer, duBois Reymond demonstrated in 1848 that electric current flows along a nerve whenever its stimulation produces muscle contraction. A few years later Helmholtz was able to measure the speed of nerve conduction. Concurrent with these scientific advances, Charles Bell and François Magendie provided experimental evidence that the postulated mechanical reflex arc is composed of three parts, the afferent nerves that connect the sense organs with the spinal cord by way of the dorsal root, the spinal cord, and the efferent nerves that leave the ventral root to connect with the muscles to produce movement (Clarke and O'Malley, 1968). By the end of the 19th century, Ivan Pavlov showed that reflexes can be modified by learning (conditioned reflexes) making it possible to extend the mechanical reflex model of *involuntary* activities to those that are commonly considered to be mentally-mediated *voluntary* activities.

1.3.3. Behaviorism: The Mind Viewed as an Epiphenomenon. Pavlov's research gave rise to the behaviorist movement in the early 20th century. Two kinds of behaviorism have been distinguished, methodological and theoretical. Methodological behaviorism advocates the study of psychological problems with objective techniques, using primarily laboratory animals as model organisms. One of the pioneers of methodological behaviorism was Thorndike (1911) who demonstrated the feasibility of analyzing the principles of memory and learning in animals. Theoretical behaviorism is a program that eschews all reference to mental phenomena (Watson 1914, 1919; Hull, 1943). However, neither Watson nor Hull denied the existence of inner experience, rather they considered mental processes to be subjective epiphenomena of behavior that an objective (scientific) psychology could ignore. In the introduction to his popular textbook, Watson wrote:

> the reader will find no discussion of consciousness and no reference to such terms as sensation, perception, attention, image, will and the like ... I frankly do not know what they mean, nor do I believe that any one can use them consistently.
>
> (Watson, 1919; p. viii)

Hull later made a concerted effort to develop a rigorous theory of behaviorism. In reference to Hume and Kant's epistemology, Hull noted in his diary, written in 1930:

> Every time I start reading writers of the classic theories of knowledge I am at once struck with the extreme subjectivity of their point of departure…All have started from introspective experience as the more primary and more basic, and attempted to derive a system with which to explain action and human nature as well…The

> moral of the whole thing is that innumerable attempts to derive a satisfactory (i.e., scientific) theory of knowledge and of thought and reason from conscious experience as such have failed. In the place of this I propose to develop a system which starts from exactly the opposite end. I shall invert the whole historical system. I shall start with action—habit—and proceed to deduce all the rest, including conscious experience, from action, i.e., habit.

Then Hull went a step farther:

> It may well be that, when I have thoroughly worked out the problems of ordinary action, learning of various sorts, symbolism, and so on, I will so far have undermined the matter of conscious experience that it will be relatively easy to attack, there being little left.
>
> (Hull, 1962; pp. 836-838)

1.3.4. Positivism: The Mind's Existence Denied. Independently of the behaviorists, a group of philosophers, known as logical positivists (Carnap, Neurath, and others), argued in the 1930s that private experience could not be the subject of any scientific discourse. They did not wish to banish mental phenomena completely from the domain of philosophical inquiry. They argued that the only valid mentalistic concepts have observable consequences that are publicly accessible for verification or refutation. Going much beyond the logical positivists, Ryle (1949) proposed later that any reference to the mind was a logical error, the false notion of "a ghost in the machine." To avoid this error, he argued, we ought to replace mental terms with objective terms, such as behavioral dispositions, faculties, and operations. As he stated:

> in describing the workings of a person's mind we are not describing a second set of shadowy operations. We are describing certain phases of his one career; namely, we are describing the ways in which parts of his conduct are managed.
>
> (Ryle, 1949; p. 50)

Ryle maintained that there is no "second theatre" where the mind dwells and acts; any talk about feelings, perception and thinking are only descriptions of what one is disposed to do or is in the process of doing. However, as Ryle's critics have pointed out, whereas talking of behavioral motives and performance is a useful way to describe what "other minds" are doing and, may perhaps even predict their behavior, it fails to deal with the problem of subjective experience. An excruciating pain is something more than an inclination to take a pill, have a shot of whiskey, or visit a doctor.

While Ryle insisted that what we call a mental process in everyday language is an erroneous description of a behavioral disposition or action, other materialistic philosophers went further by maintaining that mentalistic terms are nothing more than references to brain activities. This is the mind-brain identity theory. Recent advances in neurobiology have conclusively established that certain types of mental processes are inseparably associated with the activity of specific brain regions. Most neurobiologists have interpreted this in a dualistic framework as an indication that mental functions are "correlated" with, "dependent" upon, or "mediated"

by neural mechanisms and processes. But identity theorists favor a radical reductionism. They deny the mind's existence altogether, and maintain that when we speak of mental states or processes we merely talk about brain states or brain processes. As Smart has expressed this view:

> When I say that a sensation is a brain process or that lightning is an electric discharge I do not mean just that the sensation is somehow spatially or temporally continuous with the process or that the lightning is just spatially or temporally continuous with the discharge ... the brain-process doctrine asserts identity in the strict sense.
>
> (Smart, 1959; p. 145)

According to Smart, it is wrong to say that a mental experience is correlated with a brain process or that it is a report of a felt brain state. He asserted, instead, that brain activity and mental activity are the same:

> in so far as a sensation statement is a report of something, that something is in fact a brain process.
>
> (Smart, 1959; p. 145)

To use Ryle's phrase, however, the mind-brain identity theorists are committing a "category error." Neurobiologists can demonstrate that a particular sort of subjective experience is consistently correlated with enhanced activity in a particular brain circuit, and that the occurrence of one predicts the presence of the other. A tooth ache is correlated with and dependent upon the electrical discharge of a set of nociceptive fibers in the trigeminal nerve, and the excitation of a set of neurons in the spinal cord, and activation of specific brainstem and midbrain structures. Similarly, the red hue of the setting sun may be correlated with a particular discharge pattern of certain types of retinal cells (cones and ganglion cells) and of a set of neurons in the lateral geniculate body and the striate cortex. However, that does not mean that the *agony* of the pain or the *sight* of a color is nothing else than the electrical discharge of those particular sets of neurons. Try to tell the person suffering from an excruciating tooth ache that he should not be moaning and groaning because he does not *suffer*, all that is wrong with him is an increased rate of neuron discharge in some regions of his central nervous system. The felt experience (*qualia*) of pain and the electric firing of neurons belong to two different domains of reality. The inseparability of specific brain events and specific subjective experiences does not indicate identity but only interdependence. Mental processes are *subjective*, covert events that transpire in the *private theater* of the individual; they are directly accessible to nobody else but the sentient individual. In contrast, brain processes are *objective*, overt events taking place in the *public theater* to which anyone equipped with sophisticated electronic recording devices can gain access. While subjective experience cannot arise in the absence of brain activity, that does not mean that the two—the brain's physiological processes and its psychological processes—are the same phenomena. Although inseparable, the two could not be more dissimilar.

1.3.5. Teleology Without a Mind: The Genetic Blueprint. One of the traditional arguments in support of the operation of a supernatural agency in the guidance of life processes is their teleology and purpose. Current events in the physical world are determined by past

events, i.e., antecedent causes. But in the living world, some current activities are future-directed, aimed at achieving certain end-states or reaching some goals. What else may guide the goal-directed development of an embryo or the purposive behavior of a mature animal but a psychic agent—spirit or soul—endowed with foresight? Two modern developments have weakened this argument by demonstrating that physical entities or mechanisms may function as teleological systems. The first of these is the discovery of the molecular substrates of heredity and morphogenesis, the second is the invention of programmable electronic computers displaying artificial intelligence.

The question how a tiny germ cell can metamorphose during embryonic development into a large and complex organism—without the mediation of some mysterious guiding agent—has been partially answered by the discovery of the role of self-replicating macromolecules in that process. It was established by the mid-20th century that the chromosomes of proliferating cells are composed of strands of replicating DNA molecules (genes) that store in coded form the blueprint of the inherited traits of a species, and that the cell contains complementary RNA molecules and associated proteins that can copy and transcribe that coded information. These self-replicating macromolecules are the material substrate of Aristotle's "potential" for development. In turn, the "actualization" of that potential during development is due to the synthesis of proteins, lipids, carbohydrates and other organic substances that form the developing cells, organelles, tissues organs, and organ systems. But how could DNA and RNA templates and the cells' transcription mechanisms have formed to guide embryonic development without supernatural support? The theory of *evolution* has been invoked to explain that. Evolution theory is based on several well-established assumptions. (i) Organisms compete with one another for favorable habitats and scarce essential resources. (ii) Random genetic drift, mutation, and physiological and behavioral segregation produce organisms (phenotypes) with modified genes and gene pools (genotypes). (iii) The chances of species survival, the propagation of one's own kind over successive generations, is higher for those species that have gene pools that adapt more to their environment than other less well adapted species. (iv) As environmental conditions change, the survival of a species requires either a modification in its genotype and phenotype or else the species becomes extinct. The discovery of these evolutionary mechanisms has demystified the teleological nature of embryonic development, the inheritance of species-specific somatic traits and innate behavioral adaptations. But could the conscious behavior of animals and man, those that we usually associate with intelligence, be mediated by such mindless mechanisms?

1.3.6. Artificial Intelligence and Animal Intelligence. Electronic computers can do a host of things that until recently were thought of as the hallmark of intelligence. They can store and retrieve immense amounts of information, perform complex calculations with an accuracy and speed that humans cannot match, and solve difficult theoretical and practical problems by carrying out long trains of logic-based operations. Metaphorically, computers have a "memory," "understand" written or spoken instructions, and solve problems "rationally." Indeed, some people have argued that a computer that solves logical problems has a mind. Making that claim, they have turned the table around and, instead of denying that living creatures have a mind, grant machines the same ability. Most people, of course, will agree that computers are mindless electromechanical machines designed, manufactured and operated

by intelligent human beings to carry out *rule-based* logical operations (algorithms) to solve specific problems. But if machines can carry out goal-directed activities intelligently, could animals, unlike humans, that display purposive and intelligent behavior also be mindless? And if mental participation is not a prerequisite of intelligent behavior what criteria can we use to determine who (or what) has or does not have a mind?

Most people will agree that a computer performing a goal-directed operation is not driven or motivated by feelings and emotions, such as a *desire* to achieve a certain end or the *hope* that the operation will succeed. It is inconceivable that a computer might suffer *pain* when damaged, feels *frustrated* when it cannot solve a problem, or experiences *joy* when it successfully finishes a job. Accepting that a computer lacks feelings and emotions, might it, as a machine performing logical operations, be *aware* or *conscious* of what it is doing? The Turing test (Turing, 1950), or any similar procedure, which tests whether an observer can tell whether the answer to a question is produced by a computer or a human being, does not really address the question whether the machine is conscious or not, only how well it has been programmed. Computers can solve logical problems mindlessly because conscious people have designed, assembled and programmed them, and conscious people operate them. Electronic engineers design the circuit boards that can perform rule-based, logical operations and store that information; technicians assemble the various components of the computers; software designers write the programs that make the computer carry out specific assignments; and the owner of the computer selects and prompts the programs that he or she wants to use for some particular purpose.

But if logical operations can be performed by mindless machines, why do we have be conscious to think and reason? After all, electronic computers perform logical operations faster, more economically and more reliably than we do mentally. In the next chapter, we shall develop the idea that we depend on consciousness when we think and reason because the organ we use for that purpose—our brain—is unlike a mechanical computer. In contrast to a computer that is built of physical parts by intelligent agents to perform logical operations, our brain is the product of a very long phylogenetic history, and a lengthy process of ontogenetic development. Unlike computers, that are assembled, energized, employed, and repaired by *extrinsic* agents, the growth and differentiation of the brain is driven by *intrinsic* morphogenetic forces. And once it is mature, the brain's primordial function is to aid the organism's life-sustaining, life-protecting and life-enhancing activities. Unlike machines constructed of enduring physical components, organisms are composed of transient organic components that have to be constantly turned over, replaced and regenerated. Our brain is composed of cells that, with some significant differences, are very similar to other cells of the body. The original function of neurons and the nervous system (and in protozoans and primitive animals lacking a nervous system of its neuroid precursors) was, and remains, not to carry out logical operations but to serve the survival needs of the individual organism by initiating, coordinating and sustaining commerce with the environment. Mentation began to evolve 2-3 billion years ago, much before *knowing* creatures existed on this planet. Members of the animal kingdom engage in self-motivated and self-guided activities to procure essential nutrients, protect themselves from damage, regenerate themselves when injured, and ensure the survival of their kind. Irrespective whether primitive or advanced, animals are *autonomous individual agents* by virtue of being subjective agents.

At the primordial and fundamental level, animal behavior is motivated by *hunger* when food deprived, *suffering* when injured, *fear* when endangered, and *pleasure* when gratified. At a more advanced level, animals *sense and perceive* what transpires in the external world. At a still more advanced level, animals enhance their behavioral autonomy by *comprehending* what transpires in the external world.

1.4. Mind as an Organic Process: Biological and Evolutionary Theories

1.4.1. Structural and Functional Psychology. As psychology gradually became divorced from philosophy in the 19th century and sought to become an experimental science, two schools developed, what became known as structuralism and functionalism (Murphy, 1949). Structuralism was a static approach. The principal concern of its adherents was the analysis and description of the features and properties of human subjective experience. Relying mostly on personal introspection and the verbal testimony of trained subjects, the structuralists analyzed the attributes of such experiences as sensing, perceiving, memory, imagination, judgment, and thinking. The use of objective methods to measure mental functions began with Weber and Fechner's quantitative psychophysical studies of the relationship between physical stimuli and sensation and perception (Boring, 1942). This was followed by Ebbinghaus' work on verbal learning and recall, and Galton's inquiries into individual differences in mental aptitudes (Murphy, 1949). The most influential structural psychologists at the turn of the century were Wundt (1896) and Titchener (1909). Functionalism was a more dynamic psychological approach. The principal concern of its proponents was the role played by mental processes in behavioral functions. The earliest functionalists, like James (1890), still worked in the anthropomorphic framework, with a primary interest in the role of sensation, perception, cognition and consciousness in human conduct. But inspired by Darwin's evolutionary theory, and his advocacy of a mental continuity between animals and man, the functionalists soon came to realize that many of the psychological problems studied in humans can be profitably investigated in animals. Their studies used more rigorous quantitative methods and a better control of the different variables involved.

The systematic and widespread use of animals in the experimental study of psychological issues began in the first decades of the 20th century. Among its pioneers were Pavlov (1906, 1929) who studied conditioning in dogs; Thorndike (1911) who dealt with problem solving in cats; Hunter (1913) who used the delayed reaction test to study short-term memory in several animal species; Köhler (1925) who observed the role of intelligence in chimpanzee behavior; Lashley (1930, 1938) who investigated visual pattern discrimination in rats; and Tolman (1932) who studied spatial learning in rats. The additional advantage of using animals as experimental subjects was that it allowed psychologists to use invasive techniques to study the role of different parts of the brain in specific behavioral or mental functions. This is exemplified by Lashley's (1929, 1935) studies of maze learning and visual discrimination following cortical lesions in rats; Jacobsen's (1935) investigations of deficits in delayed reaction tasks following frontal lobe lesions in monkeys; and Klüver and Bucy's (1938) studies of the role of the temporal cortex of monkeys in "psychic" functions. The pioneering investigations of Hess (1928), using stimulating electrodes implanted in the brainstem to investigate the emotional reactions of cats, was followed by Olds' (Olds and Milner, 1954; Olds, 1956) studies of self-stimulation in

rats with electrodes implanted in different brain regions. Regrettably, the focus on animals as experimental subjects in psychology, particularly rats, lent support to the behaviorist doctrine that the mind is not a causative factor in behavior (Watson, 1919; Skinner, 1938; Hull, 1943). The behaviorists rejected mentalistic terms as appropriate in the scientific study of behavior and used instead such concepts in their theorizing as "drive," "reinforcement," and "habit strength," or such veiled subjective terms as "engram" for memory trace, "vicarious trial and error" for thinking, "cognitive map" for spatial learning, and "brain reinforcement" for affective motivation in self-stimulation. However, with the decline of radical behaviorism's influence in psychology by the second half of the 20th century, the Darwinian theory of mental continuity between animals and man became acceptable again. Comparative psychologists and physiological psychologists began to treat their animal subjects as sensing, perceiving, feeling, remembering and, to some extent, reasoning beings.

1.4.2. Early Speculations about the Evolution of Mind and Brain. The hypothesis of mental evolution is as old as that of somatic evolution, and it was linked by the mid-19th century to the emerging evidence of brain evolution. Antedating by a few years the publication of Darwin's *The Origin of Species* (1859), Herbert Spencer argued in his *Principles of Psychology* (1855):

> If the doctrine of Evolution is true, the inevitable implication is that Mind can be understood only by observing how Mind is evolved. If creatures of the most elevated kinds have reached those highly integrated, very definite and extremely heterogeneous organizations they possess, through modification upon modification accumulated during an immeasurable past; if the developed nervous systems of such creatures have gained their complex structure and functions little by little; then, necessarily, the involved forms of consciousness, which are the correlates of these complex structures and functions, must also have arisen by degrees.

Spencer postulated that sentience emerged in the form of

> a nascent Mind, possessed by low types in which nerve centers are not yet clearly differentiated from one another ... [This was coupled with a] confused sentiency formed of recurrent pulses of feeling having but little variety or combination. At a stage above this, while yet the organs of the higher senses are rudimentary, Mind is present probably under the form of a few sensations which, like those yielded by our own viscera, are simple, vague and incoherent. From this upwards, mental evolution exhibits a differentiation of these simple feelings into the more numerous kinds which the special senses yield; an ever increasing integration of such more varied feelings, an ever increasing distinctness of structure in such aggregates; that is to say…a change from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity.
>
> (Quoted from Magoun, 1960; p. 191)

In a similar vein, Laycock (1859) wrote in his *Mind and Brain*:

> As we ascend the scale, the differentiation of tissue takes place and instincts of plants or animals appear. As we ascend still higher in animal life, the instincts gradually lose their unknowing character and the mental faculties emerge with their appropriate organic basis in the encephalon. Finally, with the highest evolution, we find man evincing in art and science the results of the operation of mental powers which in the lower animals are purely instinctive and in the lowest organism simply vital processes.
>
> (Quoted from Magoun, 1960; p. 190)

1.4.3. Evolution Theory and the Problem of Mental Evolution. As we noted earlier, Darwin entertained the idea that, like our somatic traits, so also our mental faculties have an evolutionary history. Darwin bequeathed his unpublished notes on the subject of animal and human behavior to Romanes. Romanes (1883, 1888) distinguished between mindless behavioral functions (instincts), and mental functions (reasoning ability, aesthetic and moral sense, and consciousness). Relying mostly on anectodal reports, he argued for the absence of intelligence in lower animals, and its emergence in such higher animals as cats and dogs. However, this conclusion was rejected as unwarranted by Lloyd Morgan (1899). Morgan stated as his "canon of parsimony" that when attributing mental functions to animals we must avoid the trap of anthropomorphism.

> In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty if it can be interpreted as the outcome of one which stands lower in the psychological scale.

By applying this strict criterion, he denied that animals can reason. As he wrote:

> in denying to animals the perception of relations and faculty of reason, I do so in no dogmatic spirit, and not in support of any preconceived theory or opinion, but because the evidence before us is not…sufficient to justify the hypothesis that any animals have reached that stage of mental evolution at which they are even incipiently rational.

But he added presciently,

> If good reason can be shown for the rejection of that canon, the logical foundation of my argument will be destroyed.
>
> Quoted from Gottlieb, 1979, p. 151

Regrettably, Morgan's strictures did turn into a dogma, and early proponents of behavior theory (e.g., Thorndike, 1911; Watson, 1914) rejected such commonsense terms as perception and reasoning as appropriate explanations of animal behavior. As we shall try to demonstrate, there is ample experimental evidence available now that, indeed, higher animals possess advanced perceptual powers, and some can solve novel problems by a process that can be described as intelligence. But can we go beyond such operational terms as perceptual discrimination and

problem solving and attribute conscious perception and understanding to an animal? How do we proceed from studying the advanced behavioral capacities of animals to a scientifically defensible attribution of mental functions to them?

1.4.4. Can the Animal Mind be Studied Scientifically? Following the Scholastic and Cartesian tradition, psychologists had great difficulty in accepting the idea that animals have a mind. They believed that the ability to communicate ideas verbally, entertain abstract thoughts, and being self-conscious are the criteria of the mind; therefore, animals lacking linguistic skills and self-consciousness must be mindless. However, if we take overt manifestations of subjective experience as the criteria of the mind, irrespective whether manifested by man or animal, it becomes difficult to deny that advanced animals have minds.

ATTRIBUTION OF MIND TO ADVANCED ANIMALS. Animals like dogs, cats, monkeys and apes express a variety of emotions, make perceptual discriminations, learn and remember, and solve some problems that require at least the rudiments of reasoning ability. The excited dog inviting us to play, running after the ball, catching it, bringing it back and dropping it, and waiting until the ball is thrown again, obviously perceives the properties of the toy and knows the rules of the game. The dog behaves much like the human child does in a similar situation, with the only difference that the child expresses its joy by laughing and talking excitedly while the dog by wagging its tail and barking. How can we deny feelings to the dog whose behavior manifests a rich repertoire of functionally appropriate emotional expressions? How can we deny subjective awareness to the dog that moves about the house it has been reared in knowingly and interacts with members of our household discriminately? Indeed, experimental studies have shown that even "lower" mammals, such as rats, display clear evidence of satisfaction, frustration, remembering, and anticipation. For instance, if a rat masters a maze problem for a favored food reward but later finds a less appetizing bait it has been trained on, its behavior instantly deteriorates (Crespi, 1942), suggesting that the rat had certain expectations, perhaps it uses a search image of the reward, to navigate through the maze.

ATTRIBUTION OF MIND TO PRIMITIVE ANIMALS. We are less sure about the mental abilities of lower vertebrates whose emotional expressions and behavioral aptitudes we are less familiar with. Does a fish have feelings and emotions? As we shall see later, when a fish is isolated or captured, defends its territory, or competes for mates during the breeding season, it manifests hormonal and physiological changes, and displays species-specific emotional expressions that can be unmistakably identified as manifestations of fear, anger or sexual lust. On what basis can we deny that fish have feelings when they display the full complement of biochemical, physiological and behavioral indices of emotional behavior in higher animals and man? Can a fish perceive some of the things present in its environment and recollect past events? We shall review both observational and experimental evidence that fish make sensory and perceptual discriminations and can acquire new habits and skills. Why, then, deny fish some awareness of the world it lives in and the ability to remember past events? The next question is: are we justified in attributing mental functions to primitive invertebrates and protozoa that do not have a brain like ours and with which we share fewer physiological and behavioral similarities? And if so, what sort of subjective experience may we attribute to them?

DISTINCTION BETWEEN IMPLICIT AND EXPLICIT AWARENESS. To deal with the question whether animals have a mind, and whether or not they are conscious beings like we are, we begin with a distinction between two types of subjective experience, the simpler form of *implicit* or *tacit* awareness, what Bertrand Russell (1912) called "knowledge by acquaintance," and the more complex form of explicit or verbalized awareness, what he called "knowledge by description." Implicit awareness—the non-reflective, immediate experience of seeing and hearing something—may be considered an elementary form of perceiving of what exists and transpires in the outside world. It is this awareness that, while awake, allows us to find our way about in our environment and carry out our daily routines. Reaching for the spoon rather than the fork next to the bowl as I start consuming my soup while concurrently engaged in a conversation, I am explicitly (full-consciously) aware of the conversation I am having but only implicitly (quasi-consciously) aware of selecting the right utensil. Were I so distracted by the discussion that I reached for a fork to ladle my soup, I would soon become explicitly aware that I made the wrong choice and, putting back the fork, I grab the spoon. This action may be accompanied by consciously saying to myself: "How could you do that, stupid; you can't eat soup with a fork." The dog eating solid food from a bowl for a while, and then turning to the water dish to have some fluid, is obviously aware of what it is doing. Dogs, like ourselves, constantly make choices what to eat to satisfy their hunger, how to get from the house to the yard to relieve themselves, and then return to the house and find a comfortable place to rest. But that awareness could be an implicit one, the ability to feel what they need and know how to satisfy their needs.

Can we attribute explicit awareness to an animal, like a dog, that lacks language skills and, hence, is unable to reflect upon what it perceives, what has happened in the past, and what may happen in the future? We propose that only verbally competent beings can treat their experiences as a matter for contemplation and introspection, and thus proceed from quasi-conscious implicit awareness to fully conscious explicit awareness. Only implicit awareness may apply to preverbal infants. The young infant that first reaches for objects and later crawls towards them displays direct perception, or implicit awareness. But the infant cannot be explicitly aware of what it is doing because it lacks the verbal skills to reflect upon its actions. Once a child acquires language, he (or she) becomes empowered to communicate with others what it wishes to obtain or do. With language skills, children can rehearse, contemplate and think of what they want to do to and how to go about it. In time, the child learns to distinguish between perceiving, imagining or thinking about something; wishing for something, and how to go about acquiring it. The child becomes explicitly aware of what goes on inside oneself and what transpires in the outside world. The child discovers that not seeing something when he covers his eyes with his hands (the peekaboo game) does not mean that that the object has ceased to exist but only that it has temporarily become invisible because of his action. There is experimental evidence for the development of object permanence early in infancy (Kramer et al., 1975; Baillargeon and DeVos, 1991). The verbalized realization that "I can see only if my eyes are open" is the beginning of the development of explicit awareness.

ARE PROTOZOANS SENTIENT BEINGS? If we cannot deny implicit awareness to animals that have nostrils, eyes, and ears like we have, that sniff about, look around and listen intently when aroused, and can be trained to make perceptual discriminations, learn and unlearn tasks, and

solve problems, what about animals that have no sense organs that resemble ours? Indeed, what about animals that lack specialized sense organs and a brain to process the sensory information they might receive? Can we attribute awareness to them? We shall argue that any organism that displays physiological and behavioral signs of affective arousal or mood—hungry when food deprived, suffering when injured, gratified when relieved, fearful when threatened, and enraged when challenged or frustrated, fleeing from toxic sites, and so forth—may be considered a sentient being. As Jennings (1906) has demonstrated over a century ago, protozoans, like an amoeba, will doggedly pursue its prey when food-deprived and becomes quiescent after it has engulfed and ingested the prey. Since this primitive animal lacks modality-specific sensory organelles, it cannot possibly perceive or be aware what transpires in its environment. But why deny that its goal-directed behavior is goaded by something like hunger and the lure of some nutrient? Similarly, when an amoeba encounters an inhospitable milieu, be it excessive heat or cold or some chemical irritant, it withdraws and does not become quiescent until it finds a more hospitable environment. Because the amoeba lacks modality-specific sensory mechanisms, it cannot discriminate among the stimuli that cause its suffering or discomfort. But is it possible that it experiences some inchoate subjective feeling of comfort or discomfort when it reacts adaptively? Or is it more parsimonious to assume that the irritated amoeba does not feel anything but merely displays a physiological reaction, what is called tropism? How are we to distinguish between putative affects and mindless physiological reactions in lowly organisms that do not display emotional expressions that we can recognize?

1.4.5. Objective Criteria of Sentience in Animals. Our attribution of subjective experience to others like ourselves, covert mental states that we have no direct access to, is based on introspection. Introspection reveals that we can experience a plethora of mental states in correlation with changes in the environment or within ourselves. We experience a variety of feelings and emotions (affects), sensations and perceptions (awareness), images and recollections (memories), dreams and hopes (fantasies), ideas and thoughts (consciousness). Among these subjective experiences, some are elemental, others compounded. Pain, pleasure, fear or anger are elemental affects (*sui generis* that cannot be reduced to others); envy, shame, guilt, wonder or awe are complex affects. There are basic sensations, such as a sweet or a bitter taste, a fragrant or putrid odor, a red or a green hue, a high or low tone; and there are complex perceptions, such as the image of an apple or a pear, a spoon or a fork, this or that person, and so forth. There are different categories of memories, such as recognizing something familiar and recollecting some past episode. We may entertain imaginary events that we have never witnessed before, construct scenes in our minds that we anticipate to happen in the future, and contemplate what goes on in the outside world or inside ourselves. Accepting the proposition that all animals are sentient beings, the question then becomes what kind of mental states can we attribute to animals that are more or less like ourselves and those that are very different from us? It seems justified to attribute pain to the dog that whimpers when it touches an electrified fence and displays an array of autonomic responses similar to what we do when shocked. We may also attribute perception and memory to the dog when, after a few punishments, it stops in its tracks whenever it gets close to that fence. But it would be unwarranted to assume that the dog has any *understanding* that it has been shocked by electric current or, indeed, what electricity is? And what about animals with far simpler sensory systems and brain mechanisms than a dog? What does a hydra devoid of differentiated sense organs and a central nervous

system experience when it detects the proximity of prey, extends its tentacles, reaches for the prey, and captures it? It cannot possibly perceive the prey as an object of a particular shape and size, moving at a particular speed but, judged by its goal-directed behavior, it must somehow sense the prey's presence and its location. What criteria must we rely on when observing the behavior of such an animal and avoid either the error of attributing to it mental processes that it cannot possibly possess or the error of denying that its behavior is guided by some kind of sentient process?

THE THREE CRITERIA OF MENTATION. We propose that three criteria must be satisfied before we can state with some justification that a particular behavior exhibited by an animal involves mental processes of any sort. (i) *The motivational criterion*. We must have evidence that the observed behavior is goal-seeking, goal-guided, and goal-sustained. This criterion must be satisfied because of our assumption that mind has emerged and evolved in the animal world because of its biological utility as a teleological driving and guiding force. (ii) *The behavioral specificity criterion.* We cannot attribute anger to an animal that displays no sign of arousal or does not show signs of its readiness to fight; lust to an animal that shows no indication of sexual maturation and inclination to pursue a mate; parental love to an animal that does not care for its young; or intelligence to an animal that, when challenged with a problem, does not try to solve it. (iii) *The substrate criterion.* We cannot attribute sight to an animal that lacks photosensitive transducers; visual form perception to an animal that lacks a topographically organized retina and a retinotopically organized brain processing mechanism; or vision-based concept formation to an animal that lacks the prerequisite brain mechanisms (such as a visual cortex) for higher-level information processing. We propose that all three of these criteria have to be satisfied to justify the attribution of a specific kind of mental ability to an animal.

(i) *The motivational criterion*. Since we conceive of mental processes as causative agencies of behavior, we must have evidence that the postulated mental process plays a role in the triggering and guidance of a behavior. If I shine my flashlight on a rock, yell at it, or otherwise insult it but it does not flee or fight me back, I conclude that it is an insentient or inanimate material. Of course, some people believe that a rock (or, more likely, a particular rock) has an indwelling spirit. But that is an unscientific assumption because the rock's overt inertia makes that attribution objectively unjustified. In contrast, if I shine my flashlight on a crawling amoeba and it reverses its direction and crawls away from the light, I get a hint that that slimy blob might be an animate organism. But the amoeba's negative response to the optic stimulus is not, by itself, sufficient evidence that it is a sentient being. Its withdrawal from the light could be the outcome of a physiological reaction devoid of sentience, such as negative phototropism (the kind manifested by the growing rootlet of a plant), a reflex action (as seen in the contraction of the pupil of the eye), or the product of a physical mechanism, like the photocell that triggers the opening of the door as I enter a public building. But an examination of the amoeba's reaction to the light reveals that its behavior is unlike the action of a machine. Consider a sophisticated toy automobile. As I press the start button of its remote control, it begins to move forward, and without my aid it avoids obstacles along its path, and reverses its direction of motion upon reaching the edge of the table. It behaves much like an animate being except that it did not start to move to achieve some goal, and it gradually slows down and stops moving altogether as its battery loses its charge. This is different from the behavior

of the hungry amoeba that increases its search activity as it gets hungrier (Jennings, 1906). Evidently, the amoeba's behavior is motivated to achieve a certain end-state, i.e., replenish its exhausted nutrient reserves and thus satisfy its metabolic needs. Moreover, once the amoeba has detected prey, it displays great tenacity in pursuit of the prey. But this evidence of goal-seeking behavior is not, by itself, sufficient to postulate mental guidance. There are mindless mechanical devices that can be programmed to pursue a particular end-state or track a target. Computers can be programmed to perform a set of calculations, and guided missiles can be set to follow a moving target, such as a plane or a helicopter, and make corrections if the latter takes evasive action. However, unlike programmable machines, animals are not externally programmed to carry out this or that course of action but self-motivated to pursue specific end-states, depending on their changing internal conditions and external circumstances.

(ii) *The behavioral specificity criterion.* Animals behave differently when food-, water- or air-deprived, when cold or hot, when threatened or frustrated, when tired or exhausted, when sexually aroused or protecting their young. If I neglect to feed my dog for some time, it begins to run around restlessly, licks its empty food dish, and starts to whine or bark. I assume that, like myself when food deprived, the dog feels hungry. When I place food in its dish, the dog's behavior changes: it wags its tail, begins to eat and continues to do so until its ration is consumed or it gets sated. It is reasonable to assume that the displeasure of hunger served as a psychobiological goading force to make the food-deprived animal seek food (in the wild it may go hunting), and the pleasure of obtaining food and consuming it serves as a luring force to ensure that it persists feeding until sated. Having consumed the chow placed in its dish, the dog may display a new behavior. If so trained, it may move to the table as I eat and wait there while I have my dinner. Its behavior indicates that it anticipates to be rewarded with a bone to gnaw on after I have finished my meal. Why doubt that the dog, based on past experience, anticipates the reward? We are justified to attribute different mental states to animals on the basis of their overt behavior. We may attribute hunger to a food-deprived animal when it displays food-seeking behavior; anger when, being frustrated, it displays fighting behavior; fear when, upon being threatened, it withdraws or hides; amorousness when it is seeking a mate and engages in courtship behavior, and so forth. But how far back can we go in the phylogenetic scale and postulate with some confidence the operation of such mental processes as perception, recollection, and anticipation as causative forces of goal-directed behavior?

(iii) *The substrate criterion.* It is well established that, in higher animals and man, particular behavioral functions depend on specific sensory, brain and motor mechanisms, and that genetic defects, pathological disorders, and experimental interference with these mechanisms result in predictable behavioral abnormalities or deficits. Vision in both animals and man depends on the photochemical reactions of retinal receptors and the operation of central visual pathways and circuits, and both will display predictable visual field deficits (scotoma) following localized retinal damage. Both will fail to learn complex visual discrimination tasks if the visual area of their neocortex is destroyed. If it can be demonstrated that in both animals and man there is a similar linkage between specific sensory and neural substrates and behavioral performance, the inference is justified that they have comparable subjective experiences. But if neocortical mediation is a prerequisite of sight, what might the visual experience of a fish that has a retina

similar to ours but lacks a visual cortex? And what about the vision of an animal that has some photoreceptor cells but no eyes and brain? Do they lack vision altogether, or is their vision different from ours and, then, in what way? We will argue that the attribution of particular mental states to an animal must satisfy substrate criteria. An amoeba without photosensitive transducer compounds (rhodopsin) cannot be said to have vision. A protozoan with a small eyespot, like Euglena, may have some elementary form of vision, such as the direction of a light source. A cnidarian (like a jellyfish) furnished with scattered photosensitive visual cells (ocelli) around its body may be able to distinguish bright and dark visual fields. A planarian (flatworm) that has a lateral pair of primitive eyes may be able to behold a simple image of an approaching or receding object, and the pattern vision of a fish with complex, moving eye and a topographically organized and intricate optic lobe must have superior vision. However, the vision-based perceptual experience of a fish without hands and fingers must be different from that of a squirrel, monkey, ape or human who routinely combine looking at objects with palpating and manipulating them. Since mind is a product of organic substrates, the attribution of specific mental functions must be based on the properties of those substrates.

1.4.6. The Distinction Between Vegetative Processes and Animative Activities. The terms "biological psychology" and "physiological psychology" are sometimes used as synonyms. But we favor a distinction. Physiological psychology is research and method oriented; it focuses on the experimental investigation of the biophysical and biochemical properties of the sensory, neural and motor mechanisms of behavior. Biological psychology, in contrast, is a theoretical branch of psychology that stresses the importance of considering organic functions in explaining mind and behavior. Following an old idea by Bichat (1771-1802), we distinguished some time ago between two classes of organic functions: (a) vegetative processes that are shared by all living things, plants and animals, and (b) animative activities that are the unique property of all animals but are absent in plants (Altman, 1966). The ubiquitous vegetative processes consist of three basic life functions: (i) metabolism, (ii) growth and reproduction, and (iii) accommodative and regenerative processes. The animative activities, which are unique to animals, serve the vegetative functions by producing a variety of behavioral actions and reactions, such as browsing, grazing or hunting, avoiding insult or injury, pursuing a mate, caring for offspring, and the like, to support the basic life processes. As displayed by multicellular animals, animative activities are mediated by a triad of behavioral mechanisms that are absent in plants: (iv) sensory transducers for information gathering, (v) a nervous system to process that information and select appropriate responses, and (vi) a contractile muscular system to produce swift movements. We also proposed that the vegetative processes proceed in both plants and animals without mental mediation, whereas many (but not all) animative activities are dependent on mental functions.

THE UBIQUITOUS LIFE-SUSTAINING VEGETATIVE PROCESSES. The vegetative processes are shared functions of all living things, whether sessile plants or mobile animals. Life is not possible without metabolism; no organism can come into existence without growth and reproduction; and no organism can complete its life cycle without the ability to make adjustments to changing conditions in its milieu and repair itself when worn or injured.

(i) *Metabolism* is a prerequisite of organic survival. All living organisms are encapsulated dynamic systems that retain their structural and functional integrity, grow and repair themselves because their metabolism furnishes them with the needed energy and other essential resources. Metabolism consists of two complementary processes, energy-demanding anabolism and energy-supplying catabolism. The function of anabolism is to synthesize complex organic molecules from simpler ones, such as proteins from amino acids. The function of catabolism is to break down energy-rich organic molecules, such as carbohydrates, and use the liberated energy to support the organism's anabolic processes. The maintenance of the metabolic process requires the procurement of nutrients from outside sources. In the case of *autotrophic* plants, the nutrients are principally inorganic substances (carbon dioxide, nitrogen, phosphorus, water, and trace elements) which they synthesize into energy-rich carbohydrates by capturing the sun's energy, and then burning the carbohydrates to sustain their life processes. The extensive distribution of inorganic nutrients required by plants explains why they can lead a sessile existence and prosper without active behavioral transactions with the environment. In contrast, animals are *heterotrophic* organisms; they require organic nutrients, such as carbohydrates, lipids, and proteins, to satisfy their metabolic needs. Because of the patchy distribution of organic nutrients, animals have to actively interact with their environment to feed themselves. They have to find grazing, browsing or scavenging sites, pursue and overpower prey, and ingest the obtained nutrients.

(ii) *Reproduction* and *growth* are coupled organic functions that make possible the propagation of one's own kind from one generation to the next. While metabolism is sufficient to sustain the dynamic integrity of an individual organism through its own life cycle, all living beings perish and, therefore, the survival of the species requires that at least some of its members engage in reproduction. Reproduction starts in most organisms with sexual union of germ cells (sperm and ova) containing the gene pool of the species. The genes are an assembly of self-replicating DNA macromolecular templates that, based on the sequence of a four-letter nucleotide code—A(denine), T(hymine), G(uanine), and C(ytosine)—provide the blueprints that preserve the genetic heritage of the species. The DNA genetic codes are copied to complementary RNA templates which, in turn, select the amino acids (from a total of 20 varieties) and assemble them to form myriads of species-specific peptides and proteins. Structural and functional proteins, and protein complexes associated with one another and with other substances, are the building blocks of the cell and the controlling mechanisms of its functions. In unicellular organisms cell duplication has basically only one function, that of species propagation. In multicellular organisms cell duplication has two functions, propagation and morphogenetic growth. Proliferating totipotent germ cells produce multicellular offspring endowed with species-specific traits. In the course of embryonic development, the genetic potency of most proliferating cells becomes restricted and different cell lines become committed to produce different kind of tissues, organs and organ systems. The basic mechanisms of sexual reproduction are alike in both plants and animals. But because plants are sessile organisms, fertilization requires that they foster the aid of some active outside agency (inanimate or animate) to bring their sperms and ova together and permit their union. Among inanimate agents are air or water currents; familiar animate agents are insects and birds that, attracted by the secretions or fruits produced by plants, transport pollen and seed from one site to another. This passive mode of sexual propagation contrasts with the sexual behavior of animals, in

which males and females actively search for one another, engage in courtship behavior, mate and, in higher forms, nourish, protect and rear their young.

(iii) *Accommodation* and *regeneration* are another set of vegetative functions displayed by all organisms. Because environmental conditions vary in different places and over time, the individual cannot survive without making appropriate adjustments to those changes. Unlike the swift behavioral adjustments carried out by animals, the adjustments of plants are more sluggish. When a seed lands on the ground, its budding shoot starts to grow slowly upward to capture sunlight, while its root grows downward to penetrate the wet soil and gather water and nutrients. This oriented growth toward two different stimulus sources is known as heliotropism and geotropism, respectively. Another example of environmental accommodation in plants, one that looks more like a behavioral response, is the closure of some flowers at sunset or in the rain, and the capturing of insects by carnivorous plants. Significantly, these adjustments by plants are not mediated by differentiated sense organs, nerves and muscles, as are the behavioral responses of animals. Rather they are regulated by hormones (auxins) that affect metabolic and growth processes. The bending of a root or a shoot in a particular direction is produced by the unilateral elongation of multiplying plant cells, and the closure or opening of petals or leaves are produced by the reversible swelling and shrinkage of specialized cells at their base. The vegetative regeneration of tissues and organs are shared life processes of both plants and animals.

THE ANIMATIVE OR BEHAVIORAL ACTION SYSTEM OF ANIMALS. In addition to sharing the life-sustaining vegetative processes with sessile plants, animals are active, behaving organisms that respond swiftly to external stimuli and engage in effective transactions with their environment. Animal behavior is a product of the animative action system: *sensors*, *nerves*, and *muscle*. The transducer-equipped sensors gather information about prevailing or changing external and internal conditions; impulse-propagating nerve cells convey bioelectric messages from the sensors to different components of the nervous system, and from the nervous system to muscles; the contractile muscles produce fast body movements. Specialized sensors, nerves and muscles are also responsible for certain internal and visceral functions. Examples are the pumping of blood through the circulatory system by the muscles of the heart, the involvement of the chest muscles in breathing, the transporting of nutrients through the gastrointestinal system by peristaltic smooth muscle movements, and the expulsion of urine by the contractile bladder.

(i) *Sensors* in animals and man range in complexity from the relatively simple irritable cells embedded in the skin that trigger sensations of pain, pressure, warmth and cold, to the complex sense organs, such as the eyes, nostrils, ears and mobile tentacles or fingers that enable them to actively inspect, smell, taste, listen to, and examine by touch what goes on in their environment. The principal constituents of sensory cells and sense organs are transducer molecules that convert physical energy (mechanical, optical, and thermal stimuli) and chemical stimuli (the molecular action of certain gases, solutes, and pheromones) into bioelectrical signals (receptor potentials). In the case of complex sense organs, various accessory structures (such as the cornea, lens, iris, and the extraocular muscles of the eyes) make possible active information gathering and selective attention to different stimuli, as when focusing the eye

on an object and tracking its movements. The visceral sensors are typically simpler than the sense organs of the behavioral system, responding to such specific chemical stimuli as the concentration of oxygen, carbon dioxide, or glucose in the blood, and such mechanical stimuli as blood pressure or bladder distention.

(ii) The *nervous system* is typically composed of a smaller or larger set of differentiated nerve cells, or neurons. Neurons are specialized impulse-conducting cells that convey coded messages from peripheral sensors by way of sensory (afferent) nerves to the central nervous system (CNS) that contains the brain and spinal cord. Afferent neurons receive analog signals (graded receptor potentials) produced by the transducers (photosensitive rods and cones in the retina of the eye, mechanosensitive hair cells in the cochlea of the ear, etc.) and translate them into digitally coded messages (action potentials) that are transmitted by way of their axons to the CNS. Axons from different sensors and different body regions form modality- and site-specific transmission lines (topographically organized in spinal and cranial nerves and tracts) that convey messages directly to or through relay stations to specific brain regions, where the sensory information received undergoes complex processing. Within the CNS, aggregates of neurons form discrete structures (ganglia, nuclei, cortices) with distinctive local circuits, and selective short- and long-distance interconnections with other aggregates. Sensory processing stations are connected with integrative and motor centers in the brain and spinal cord that generate appropriate action programs that finally issue commands to motor neurons that reach muscles via their efferent nerve axons in cranial and spinal nerves. The CNS also monitors ongoing events within the body interior and regulates visceral functions by way of sensory input from proprioceptors and visceroceptors and motor output via the sympathetic and parasympathetic components of autonomic nervous system.

(iii) *Muscles* are composed of specialized cells with macromolecular proteins (principally actin and myosin) that contract to produce either static mechanical force or dynamic motion. The contractile elements in *voluntary* muscles form visible microscopic *striations*. Striated muscle is dependent on motor nerve impulses for contraction. Most of these muscles are attached to jointed skeletal elements of the head, neck, trunk, and limbs. They produce bending movements (flexing), straightening movements (extending), and twisting movements (rotating) by the coordinated action of agonist and antagonist muscles. Some specialized muscles produce quick movements (isotonic contraction), others maintain body posture or resist displacement (isometric contraction). This orchestration results in patterned locomotor movements, such as swimming, walking, or running. Striated muscles can be directed to perform specific exploratory movements, such as, raising or turning of the head to look in a particular direction, and finger movements that enable advanced animals to palpate, grasp and manipulate objects. Other striated muscles are attached to specialized organs, like the jaws, the tongue, the vocal apparatus, and the pharynx, and mediate such behavioral acts as biting, chewing, swallowing or vocalizing. The contractile elements are regularly arranged to form striations in *cardiac muscle* that is distinguished from all other types because it can initiate its own contractions without instructions from the nervous system. The contractile elements in *smooth muscle* are irregularly arranged and do not form striations. Smooth muscle lines the walls of arteries, veins, and organs of the viscera, such as the esophagus, stomach, large and

small intestines. It contracts when instructed by the autonomic nervous system, which is the involuntary motor part of the nervous system.

1.4.7. The Behavioral Action System and Mentation in Animals and Man. The animative behavioral system differs fundamentally from the vegetative system. Whereas all our vegetative processes (and by implication, all the life functions of plants) proceed without conscious mental activity, some behavioral activities, but not others, are dependent upon mental awareness. For example, we are not aware of the metabolic processes of our tissues and internal organs (e.g., the secretion of digestive juices and hormones) and cannot exercise control over them. These vegetative processes, and the supporting visceral functions (like the peristaltic movements of our alimentary system) proceed autonomously, independent of our volition and awareness. Likewise, the pumping of our heart and the blood flow of our circulatory system, which carries oxygen, nutrients, minerals, hormones, and other blood-borne substances to various needy sites throughout our body, proceed largely involuntarily and without our awareness. In sharp contrast, we have voluntary control over at least some facets of our behavioral transactions with the environment and are, to various degrees, aware of the movements of different members of our body. For instance, we voluntarily look and sniff the food we select to consume, and engage our tongue and palate before swallowing. Mental processes aid us in behaving adaptively in relation to our changing needs and wants and in relation to variable environmental conditions and circumstances. Sensations of hunger and appetite guarantee that we supply our body with sufficient nutrients; sight, smell and taste enable us to choose what, when, and how much food we consume; satiety sensations make us stop eating after awhile so that we do not become obese. And ever more complex mental functions enable us to procure nutrients or, what we call, earn a living. That is, the primordial function of mentation is to aid us in gratifying our basic needs through transactions with the environment.

REACTIVE AND PROACTIVE MENTAL PROCESSES. Some mental processes are reactive (exogenous, bottom-up) phenomena—the brain's response to peripheral stimulation; others are proactive (endogenous, top-down)—the brain's initiation of some peripheral action. Light rays falling on the retina, chemicals affecting the olfactory epithelium, and sound waves reaching the cochlea, produce subjective experiences in the form of seeing, smelling, and hearing. These inner states makes us become aware of objects present in our environment and of events transpiring there. Similarly, sensations arising from our internal organs make us become aware of what goes on within our body. We feel hungry when our stomach is empty, thirsty when dehydrated, feel tired after a long exertion, and have the urge to urinate when our bladder is full. It is well established that these peripherally evoked mental states are associated with the activation of different components of our central nervous system; that is, they have objective corollaries. Bypassing the sense organs, stimulation of the sensory projection areas of the cerebral cortex triggers sensations; stimulating other areas like the temporal cortex, trigger higher-level subjective experiences, such as memories, insights, ideas and thoughts (Penfield and Rasmussen, 1950). Differing from these reactive mental processes, others are centrally initiated, or proactive, such as expectations, hopes, fears, fantasies, day-dreams, and deliberate schemes and plans. These subjective states lead to the top-down activation of different brain regions—from the motor cortex to subcortical structures and the spinal cord to produce volitional actions. We may eat not only because of peripherally-triggered hunger

sensations but also because we anticipate the pleasure of doing so. Upon awaking in the morning, our desire to enjoy a good breakfast may lead us to carry out a series of deliberately planned sets of actions, such as getting some eggs and butter out of the refrigerator, lighting the stove, breaking the eggs and scrambling them, setting the table, toasting some bread, and so forth. These sorts of centrally evoked volitional acts involve such mental processes as having an idea what we want to achieve, recollecting what items we need and where they are stored, and how to proceed in proper order to achieve the anticipated end.

WHAT MENTAL STATES MAY WE ATTRIBUTE TO DIFFERENT ANIMALS? If we accept that reactive sensation, perception and memory, and proactive desiring, deliberating and planning are causally linked to the control of human behavior, can we make similar attributions to animals? And if we can accept the idea that the behavior of higher animals is dependent on at least some of these complex mental processes, can we attribute the same to lower animals? Justified attribution of a particular mental state to an animal has to be based on a comparability of its physiological reactions and overt behavior to actions that we carry out with mental support. The attribution of a particular feeling state to an animal—pain, pleasure, fear or anger—must be based on comparable autonomic reactions and emotional expressions manifested in similar situations by humans. The attribution of a particular sensory experience to an animal—whether it treats a substance as palatable or distasteful, whether it can perceive the color, shape, softness or hardness of an object—must be based on comparable behavioral performance in man. The attribution of insight and reasoning to an animal must be based on analogous ways that the two solve difficult or novel problems.

Among justified mental attributions to vertebrates that share comparable sensory, neural and motor mechanisms with humans are some of the following. In the realm of affects, *pain* is inferred when tissue damage or injury trigger physiological and endocrine manifestations of stress as well as writhing, wailing and vocalization. *Pleasure* is inferred when the gratification of a need or a reward produces physiological, endocrine, and behavioral signs of relief or relaxation. *Like* is indicated when a particular stimulus consistently serves as a lure and leads to approach or to preference in a choice situation. *Dislike* is indicated when a stimulus consistently produces aversion, rejection or withdrawal. *Fear* may be inferred when a stimulus predictably triggers a defensive reaction, such as fleeing, hiding or freezing. *Anger* is indicated when offensive reactions, such as growling or hissing, and biting or fighting, are exhibited. *Affection* is indicated when there is evidence for benevolent or altruistic behavior, such as caring, grooming, or defending an infant or a companion. *Hatred* is inferred when a stranger, intruder or competitor triggers aggression. In the realm of cognition, *sensation* is indicated when a simple stimulus consistently evokes a particular behavioral response, and *perception* is indicated when a sensory discrimination is made on the basis of the size, shape, texture or the spatial features of an object. *Curiosity* is indicated when some novel object or situation triggers exploratory behavior, and *attention* when an object of interest is tracked, inspected or examined. *Memory* is indicated when previously encountered objects, events or scenes are treated with familiarity, and *imagery* when an animal searches for an object or moves toward a target that is not perceptually available to it. *Thinking* is suggested when an animal pauses before it makes a choice and deliberately looks back and forth rather than acting impulsively or stereotypically. Finally, in the realm of volition, *desire* or *craving* is indicated

when a particular object is doggedly pursued, *intention*, when a behavior manifests antecedent purposive planning and preparation, and *insight*, when a difficult problem is solved in a novel or creative way.

1.4.8. The Conjoint Evolution of the Behavioral Apparatus and Mentation. We proposed earlier that mental processes are products of the animative action system—the triad of sense organs, the nervous system, and the muscular system. But that applies only to multicellular animals. At the lowest evolutionary level, in bacteria, behavior may proceed without mentation and, at the next level, in unicellular protozoa, mentation may exist without awareness. We will argue that prokaryotic bacteria, such as the flagellated *Escherichia coli*, are mindless organisms because they do not display goal-seeking behavior. They display both sensitivity and motility, and tend to move from unfavorable to favorable regions of their medium, but they accomplish that with the aid of a random (stochastic) response mechanism, running or tumbling, rather than displaying goal-seeking (teleological) behavior. In contrast, we consider eukaryotic protozoans—such as amoebas, flagellates and ciliates that lack a differentiated animative action system—to be sentient beings because they do display goal-seeking behavior. Unlike most of the molecular mechanisms of sensitivity and motility employed by prokaryotes, the behavioral system of protozoans consists of molecular complexes and subcellular organelles with properties similar to those displayed by multicellular animals that have sensors, nerves and muscles. Indeed, we shall argue that some of those mechanisms are part of our protozoan legacy.

1.4.9. Proposed Grades and Stages in Mental Evolution: A Preview. Although we assume that sentience is a ubiquitous phenomenon in all prokaryotic animals, that does not imply that they all have similar mental aptitudes. The ability of the most primitive animals, those with simple sensory organelles, to sense a dim or bright light source is not the same as the ability of more advanced animals with differentiated eyes to perceive the distinctive shape, color and texture of objects. And that perceptual ability is not the same as using the eyes to scrutinize an object while simultaneously palpating it with fingers to examine the substantive properties of objects such as their strength, pliability, and durability. At still higher and higher levels of perception, objects are characterized as familiar or unfamiliar, based on memory; as members of this or that class of objects with comparable properties, based on concept formation; and how they are causally related to one another, based on language-mediated reflection.

We offer an evolutionary theory in this book, according to which mentation arose in single-celled eukaryotic protozoans, such as amoebas and ciliates, during the Archean era several billion years ago in the form of *protopathic sentience*. Protozoans are heterotrophic, that is, they require particular organic nutrients for their survival and, therefore, have to move about in their environment to search for food. However, protozoans lack differentiated sensory cells and tissues and, therefore, cannot see, touch or hear, that is, have sensations, to provide them with information as to what transpires in their environment. We shall argue that protozoans must have *inchoate feelings*, something akin to hunger when food deprived, appetite when detecting some nutrient source, and pleasure when engulfing a prey. Similarly, they may feel something like pain or displeasure when they encounter toxic sites or objects that threaten their survival. This primordial form of subjective experience—inchoate affects devoid of sensory and

perceptual content—may have been the only form of subjective experience in the animal world for several billion years. Then, as multicellular animals, like cnidarians (hydra and jellyfish), emerged during the Proterozoic era (about 900 million years ago) with differentiated sensory tissues and a primitive nervous system, a new kind of subjective experience began to evolve, the experiencing of *elementary sensations*. Being endowed with primitive photoreceptors, mechanoreceptors and chemoreceptors, cnidaria could now subjectively discriminate environmental objects in terms of elementary qualia, such as sight, smell, taste, or touch, and perhaps as dark or bright, appetizing and distasteful, soft or hard, and so forth. Then, during the Paleozoic era (about 400 million years ago), fish evolved with highly differentiated sense organs, such as bilateral eyes furnished with complex ocular mechanisms and topographically organized retinae, and enlarged brains with dedicated centers for sensory processing, such as the optic lobe. These early vertebrates became endowed with *phenomenal perception*, the ability to distinguish objects by such surface features as size, shape, texture and ornamentation; by such spatial features as approaching or withdrawing; and by relational features such as friend or foe, kin or stranger. These vertebrates also evolved some ability to modify their behavior through learning by experience.

The subsequent advances in vertebrate mental evolution were the result of the emergence and elaboration of new brain structures (such as the neocortex of mammals) which enabled mammals to use subjective *memory* processes to modify their inborn dispositions on the basis of their individual experience and learning. For instance, the mnemonic ability to recall memory images where different nutrients are located, recollect routes to those sites, and use search images to keep in sight what is being sought or pursued, has greatly enhanced the success of the individual when embarking on a foraging or hunting expedition. Another advance in some mammals, such as primates, was the evolution of hands in conjunction with the focusing frontal eyes to serve as dexterous manipulatory organs. Hand-eye coordination led to the recognition of the multifaceted properties of objects in the environment, with *substantive* features being added to their phenomenal appearance, such as their consistency, strength, durability, malleability, composition, and so forth. The final step in the evolution of the mental powers of animals, which culminated in humans endowed with linguistic skills, was the advance from perception to the use of *concepts* and *ideas* that could be named. Named objects and ideas allowed for vicarous thinking and reasoning. Language use led to culture, the transmission of tradition and knowledge from one generation to the next by means of instruction and education, and thus to the enhancement of the mental abilities of the individual.

The following is a list of some of the proposed grades and stages of mental evolution, starting with putative sentience of protozoans and culminating in the reflective consciousness of modern humans. (The supporting evidence, with extensive documentation, will be provided in subsequent chapters.) We assume that the genetic mechanisms underlying each phylogenetic stage is, to various degrees, part of our evolutionary legacy.

PROTOPATHIC SENTIENCE: BEFORE AWARENESS. Protopathic *sentience* is the hypothetical mental endowment of protozoans that display goal-seeking behavior and the ability to discriminate and selectively respond to some environmental stimuli. Jennings (1906) described over a century ago how a food deprived amoeba tenaciously pursues a moving prey, much like

any other hungry animal might do, and reaching it, engulfs the prey with its pseudopods. If presented with different substances, the amoeba ingests some and rejects others. However, because they lack modality-specific sensory mechanisms, there is no reason to postulate that amoebas are *aware* of the existence of an external world—sees the fleeing prey, smells its trail, or senses the vibrations it produces as it moves. But when they display goal-seeking pursuit and selectivity in their behavior, it is reasonable to assume that they experience some inchoate feelings, perhaps hunger and appetite, like and dislike, and pain and pleasure. Hunger would goad the protozoan to seek nutrients; appetite to pursue a potential food source; like and dislike to select among available nutrients; pain to leave toxic sites, and pleasure to relax when finding a hospitable milieu. From an epistemological perspective, a protozoan is a mental agent in the limited sense that it has inchoate feelings of its internal state but, lacking modality-specific sensory mechanisms, it cannot be aware of what transpires in the external world.

AMORPHOUS QUALEOUS SENSATION: THE DAWN OF AWARENESS. With the evolution in cnidarians (hydra, jellyfish) of a triad of specialized behavioral mechanisms—sensory cells, a peripheral nerve net (but no head or brain), and primitive muscle cells—a new mental faculty may have emerged in the animal world, that of *sensation*. A jellyfish furnished with primitive eyes (ocelli) has the mechanisms to discriminate an expanding shadow (a possible threat from a predator) from a receding shadow (an innocuous body passing by) and respond accordingly. It might also be able to discriminate a bright visual expanse (the sea surface) from a dark expanse (the depth of the sea), which would account for its alternating movement to these sites when feeding or resting. Cnidarians also possess other sensors that selectively respond to chemicals, vibration, and gravity. Since each of these sensory elements can provide distinct qualities—the sensory *qualia* of vision, olfaction, touch and pressure—a cnidarian may have some awareness of what transpires in its environment. But since the primitive sense organs of cnidarians are not topographically organized, as are for instance the eyes of vertebrates furnished with a retinal surface, and they do not have a central nervous system, cnidarians lack the organic apparatus to construct a configural representation (model or image) of what is out there. The sensations they have may provide them with some *amorphous* form of awareness that there is a world out there but that world must lack form or structure.

ISOMORPHOUS PERCEPTUAL REPRESENTATION: PHENOMENAL AWARENESS. Animals furnished with topographically organized (retinotopic, somatotopic, cochleotopic) sensory and neural mechanisms, are endowed with organic substrates for pattern recognition, i.e., the construction of a representation—sketch, model or image—of the shape, texture, size, and location of different objects in the external world. A mechanism for elementary configural representation is present in planarians (flatworms), bilateral invertebrates with some vertebrate affinities. They posses a primitive head, a pair of anterior eyes, and a primitive brain. However, composed only of a small number of photoreceptors, the flatworm eye has limited resolving power; it cannot furnish a clear image of what an object looks like and what transformations the object undergoes as it moves. That ability emerged in higher metazoans, such as in fish in the phylum of vertebrates with their paired eyes. Fish are endowed with complex oculomotor mechanisms, a fine-grained retinal surface, and a topographically-organized neural processing mechanism, the optic lobe. It has been amply demonstrated that fish can discriminate the shape, size, and texture of objects, their direction of movement, and some other features. It is

this *representational perception* that allows fish to recognize their own kind by their distinctive body markings and movements; distinguish different external objects by their shape; and form a topographic map of their environment in which they can locate feeding sites, shelters, resting areas, and their home base. We call this ability *isomorphous* because what is perceived mentally is a workable rendering, or portrait, of what the external world is like. However, because fish lack a mobile tongue and limbs with sensitive flexible digits to actively palpate, grasp and manipulate objects, their visual perception provides them with information only about the surface features of objects—their appearance—rather than with their material composition and structural properties. Accordingly, we call this *phenomenal awareness*. To use an older philosophical terminology, qualeous sensation provides lower vertebrates with "secondary qualities," subjective experiences that do not portray things the way they really are; whereas, isomorphous perception provides higher animals with "primary qualities," the realistic portrayal of the objective features (shape, size, distance, speed and direction of movement) of the different things that exist in the external world.

MULTIMODAL PERCEPTUAL INTEGRATION: SUBSTANTIVE AWARENESS. We assume that, by virtue of their mental faculties, the perceptual world of fish consists of objects, beings landmarks, and scenes in the form of visible *images* rather than as tangible and manipulable *substances*. Without palpation and manipulation (licking, chewing, grasping, pulling, lifting, squeezing, tearing apart, etc.), the visual information that a fish receives lacks information about the structural properties of things, such as their weight, hardiness, pliability, composition, durability, and so on. To perceive something as a solid object with multifarious properties rather than just a picture, requires the concurrent amalgamation of visual, tactile and kinesthetic information. Most mammals achieve this *multimodal integration* by using their highly mobile tongue and their forelimbs to obtain supplementary information about what vision provides. Mammals are inquisitive and playful creatures that explore every nook and cranny of their environment, pounce on things, climb over them, chew on them, shove them, and try to tear them apart. Through these transactions, they become aware of the distinctive *substantive* properties of the different objects they examine. The palpation and manipulation of objects under visual guidance is particularly well developed in arboreal primates with long and dexterous fingers and medially placed eyes for hand-eye coordination. The current evidence indicates that this concurrent multimodal integration is mediated by higher-order brain structures, particularly the neocortical projection and association areas, which are absent in lower vertebrates but are particularly well developed in primates.

AFFECTIVE ADVANCES: FROM BASIC EMOTIONS TO ADVANCED EMOTIONS AND SENTIMENTS. Feelings and emotions are mental processes serving organic imperatives, goading and/or luring animals to gratify their needs and wants. We will provide indirect evidence that the following basic affects motivate the behavior of lower vertebrates: (i) ecological affects, the selection of habitats on the basis of *likes* and *dislikes*; (ii) prophylactic affects that protect tissues from injury—*hurt* and *pain*; (iii) agonistic affects that aid the individual's chances of survival—*fear* and *anger*; (iv) dietary affects that regulate feeding behavior—*hunger* and *appetite*, *relish* and *disgust*; and (v) affects that foster sexual reproduction—*libido* and *orgasm*. In lower vertebrates that also display parental behavior, and more particularly in birds and mammals, caring for the young is promoted (vi) by parental and filial *love* and *affection*. We will then argue that as new

behavioral functions have emerged in vertebrate phylogeny, new sets of affects evolved with them to ensure their employment. In mammals with advanced learning abilities, getting to know the properties of objects in their habitat is promoted by *exuberance* and *curiosity*, affects that promote exploratory and investigative behavior. In mammals with a social organization, bonding among the individuals and the establishment of a hierarchic order is promoted by the affects of *amicability* and *hostility*. And finally, the human linguistic ability to use words to name things and to consolidate and communicate the ideas they form about the world and themselves is coupled with new affects. These supportive affects are partly responsible for motivating childhood questions like: "what's that?" "when?" "who?" "why?" "why not?" and so forth. The disposition to ask for the names of things to expand one's vocabulary, and to master the rules of grammar to speak effectively, satisfies our thirst for knowledge through an *affectively-supported cognitive* process. And so is the parallel human disposition to build and manufacture things, as manifested in children's delight in playful *constructiveness*, using blocks to erect make-believe buildings or sand to build castles. Finally, the amalgamation of affective and cognitive processes is responsible for various complex human emotions and sentiments, such as *envy* and *jealousy*, *shame* and *guilt*, *gratitude* and *resentment*, *sympathy*, *empathy* and *antipathy*.

MNEMONIC ADVANCES: FROM ASSOCIATIVE LEARNING TO CONSCIOUS MEMORY. Pattern perception provides animals with the potential to distinguish different objects, beings, scenes, and events encountered in their environment. But to actually recognize the significance of environmental change, what is encountered must also be *remembered*. The ability to store information and learn from experience, enables animals to distinguish among the great variety of edible and inedible things; recognize parent, kin, friend, and foe; get to know the layout of their environment and the location of what they need or want; distinguish safe and dangerous situations, and so forth. Much of that learning is an associative process in primitive animals: the repeated pairing of environmental stimuli and behavioral responses with rewarding or frustrating consequences—called appetitive, aversive and avoidance conditioning. Associative learning is a slow process that typically forms by trial-and-error with little or no awareness and may be mediated by lower-level brain mechanisms. A more advanced, and much faster form of learning is based on mental imagery, the conscious *recognition* and *recollection* of past encounters in the form of quasi-perceptual experiences. Mental imagery appears to be well developed in birds and mammals with differentiated forebrains, allowing them to visualize objects and events that are not perceptually available, plan ahead what to do, and look around before acting. These conscious memories may serve the individual in a variety of ways: as guide images—visualizing the route to reach a particular destination; as search images — keep in mind what one is pursuing; as warning images—abstain from doing things that are risky or hazardous; or as anticipatory images—recollect where and when something desirable will become available or has been stored, and how to go about reaching and obtaining it. Unlike the slower associative learning, conscious recollection may be based on a single exposure or trial. Perhaps that is so because the animal can rehearse mentally what a single experience provides and thus consolidate it.

COGNITIVE ADVANCES: LANGUAGE USE, CONCEPT FORMATION, AND IDEATION. An important mental advance in mammals, most evident in monkeys and apes, has been the ability to

categorize things and events in terms of their shared features and properties. This cognitive ability allows advanced animals to conceive of the same object as *different* to achieve diverse ends, and different things as *similar* to achieve the same end. A stick lying nearby may be of no interest to a monkey while picking fruit on the ground. However, with the cognitive ability of categorization, the monkey may treat the stick as a "hammer" when nuts are available that have to be cracked to get to their kernel; as a "probe" when the stick can be used to push a raisin out of a tube; or as a "spoon" when the monkey wants to extract honey from a container with a narrow neck. Similarly, an ape can use or assemble different objects to reach for a banana suspended from the ceiling in its cage, a long bamboo pole, join two shorter poles together, pile boxes and climb on the top of them. That ability promotes increased behavioral flexibility. Monkeys and apes can treat pictures of objects as representations of real things; sort photographs into different piles, such as animals, vehicles and furniture; discriminate portraits of their own species from other monkey species, or distinguish between monkeys of any species as belonging to one category and people to another. Do these animals form concepts in the sense of thinking in terms of ideas? We shall argue it is more likely that the categorization of subhuman primates is a perceptual *prototype* rather than a thought-based *idea*. Ideation requires language, the ability to consolidate and store fleeting ideas by linking them to referential symbols, words. Subhuman primates do not have naturally-acquired language, although intense training can teach them some "words."

1.4.10. From the Animal to the Human Mind: Language, Reflective Consciousness, and Culture. Human children are innately endowed with the aptitude to learn and use the language of a particular culture. Correlated with the postnatal maturation of the neocortex, such as its myelination, infants begin to babble spontaneously, and rapidly learn to utter generic speech sounds, called phonemes. Then they start to imitate the syllables used by their caregivers and learn to form words. Children first use single words to express their wishes and to refer to everyday objects and actions. Then they learn to combine more and more words into phrases that obey the rules of syntax and grammar. They finally learn to speak in complete sentences. That enables them, first, to request or demand what they need or want and, gradually, to engage in conversations to describe what they experience.

THE ORIGINS OF LANGUAGE. Clues about the possible evolutionary progression of true language comes from the fossil record of human evolution. Archeological studies of hominids have shown progressive advances in tool manufacture, social organization, the emergence of religion, art, and science. While the prehistory of language use is unknown, we have no reason to attribute a true language to *Australopithecus*, the earliest hominid, that evolved in Africa about 4 million years ago and became extinct about 2-2.5 million years ago. Australopithecenes had only an ape-sized brain, but they differed from apes in a major respect, upright posture. Walking on the hindlimbs frees the forelimbs from a locomotor function, and allows the hand to manipulate and palpate objects. While early Australopithecenes probably lacked the ability to make stone tools, later populations (2.5 million years old) may have produced simple ones. *Homo habilis*, commonly thought to be a descendant of *Australopithecus*, also evolved in Africa, had a slightly larger brain than an ape, and may have had a primitive language. This species produced simple flaked stone tools in the Oldowan period (early Paleolithic, 2.0-1.5 million years ago). *Homo erectus* is the first hominid species to have a large brain case with

a forehead to accommodate an enlarged neocortex. This species has a fossil record from approximately 2 million years ago to 500,000 years ago, and displayed advanced technical skills by producing finely-wrought Acheulean tools (lower Paleolithic, 1.65 million to 100,000 years ago). In addition, populations of these hominids were able to leave tropical and subtropical Africa to colonize Eurasia, presumably because they knew how to make fire and prepare clothing to keep warm during cold nights and through the long winters. To feed themselves in winter, they killed large game, butchered them, and carried the quarry to their home base. That sort of behavior required training to produce standardized tools and weapons, group discussion how to proceed, and rapid tactical decisions as the hunt progressed. Such behavior is inconceivable without improved verbal means of communication. Language must have further developed, and the neocortices of brains grew larger during the middle Paleolithic period in *Homo heidelbergensis*, and *Homo neanderthalis*. In addition, there is evidence for the progressive growth in the mental ability of these humans as, beyond being concerned with their survival needs, they began to contemplate the meaning of life and death. They began to bury their dead, provide them with offerings, and produced works of art. Archsic *Homo sapiens* appeared in the middle Paleolithic with a greatly expanded neocortex and eventually became the only human species. Modern *Homo sapiens* produces a great variety of tools and weapons and has a complex language that allows continual growth of knowledge and the emergence of new technologies that expand our sensory limitations, lead to an increased mastery of environmental resources, and fosters a better understanding of himself in his universe.

FROM KNOWING TO INTERPRETING. Subhuman primates may categorize hairy beings that use four legs to walk as "animals," metallic objects that move on wheels as "vehicles," and stationary household items as "furniture." But this ability to categorize things and actions in terms of their *perceptible* similarities and differences is not the same as the ability to generate ideas about the role of *imperceptible* and non-portrayable variables in an attempt to comprehend what they are and what they do. To advance from *knowing*, familiarity with visible things and their properties, to *interpreting* how imperceptible factors affect their relationships requires the ability to form *abstract ideas*. These non-portrayable ideas may refer to temporal relations, such as "yesterday and tomorrow;" spatial relations such as "inside and outside;" and logical and causal qualifications, specifications and interpretations, such as "if-then," "and-or," "possibly," "likely," or "certainly." Even more difficult is the conceptualization of evaluative ideas, such as "honest and dishonest," "just and unjust," "beautiful and ugly." To entertain such ideas and share them with others requires the use of words or other symbols. Using words to form ideas and describe them requires *thinking*. Ideas without the use of words to encapsulate and consolidate them are difficult to work with while one thinks, and they are impossible to share with others. Words that designate an idea bear no resemblance to the idea; they are arbitrary in their origin but fixed by social convention and cultural tradition.

REFLECTIVE CONSCIOUSNESS: THE ROLE OF IDEATION, EDUCATION, AND CULTURE. Language use has made three monumental contributions to the evolution and distinctiveness of the human mind. First, it made possible the cognitive advance from tacit (implicit) awareness to reflective (explicit) consciousness. Second, it allows the direct sharing of knowledge among individuals. Third, it is the principal vehicle of cultural growth by allowing the transmission of knowledge from one generation to the next.

(i) Without the use of words we cannot *reflect* upon what we feel, perceive, remember and do, hence we are only *implicitly* aware of what transpires within us and in the outside world. We are *explicitly* conscious only of those experiences that we reflect upon by verbalizing them. Using words to describe fleeting ideas is essential for thinking and reasoning about our experiences. This contrasts with subhuman animals with recollection memory that may reminisce or dream about the past but cannot analyze their experiences because that requires verbally-mediated abstract ideas that provide a temporal, spatial and causal framework for those experiences. (ii) Without words, we cannot share our experiences with others, and others cannot share their experiences with us. What we feel, remember and think remains private. Parents may guide their young by what they do or refrain from doing without words, but they cannot explicitly instruct and train them. The basis of intentional education, whether informal or formal, is linguistic communication. (iii) Culture is created and sustained through the transmission of beliefs, knowledge and values from one generation to the next. The primary means of doing that is by oral communication. Lacking language, animals may have practical traditions but not an ideation-based culture.

THE ROLE OF CULTURAL EVOLUTION IN MENTAL DEVELOPMENT. Once children acquire the ability to exchange information with their elders, the direction of their mental development comes increasingly under cultural influence. Raised in scientifically, technologically and socially advanced cultures, the young get an education that provides them with a realistic understanding of the physical and social world they live in and are given the opportunity to acquire the necessary skills to succeed in society as adults and enjoy a high living standard. Well-organized modern societies provide us with access to healthy nutrients that are produced, prepared, conserved and distributed by novel techniques. We can take advantage of a transportation system to travel far and wide without the strain of walking and carrying our belongings. We can use cell phones and computers to communicate with one another instantly irrespective where we are. And we can turn to modern hospitals when we feel ill, get injured or suffer a life-endangering disease. Unfortunately, this cultural advance is not available to all and large populations enjoy none of these benefits. The reasons are manifold. Parents and children in the underdeveloped world lack access to adequate nutrition and health care, they do not receive a modern education, and their social order and political system does not enable them to develop their natural potentials.

Depending on the region and culture in which they are reared, children assimilate the ideas of their elders and teachers, and learn to interpret what they themselves experience within that conceptual framework. Whether our culture is primitive or advanced, traditional or modern, the spoken and written words of authorities are the major source of what we know and believe in, and we treat what we learn by oral or written transmission to be as real as what we learn by direct experience. By natural disposition, children tend to interpret all events in animistic terms. Whatever happens is by design and for some purpose—much like their own actions and that of their parents. That animistic tendency is stoked in traditional, faith-based cultures that fill the minds of the young with ancient myths and legends, old grievances, and distorted interpretations of what transpires in the world. This is in contrast to children reared in advanced secular cultures who are taught to believe only in assertions that are based on empirical evidence that can be verified or refuted. Importantly, much of what is culturally

transmitted is not about *facts* but about *values*, moral values of what is right and wrong, social values of what is proper and improper, aesthetic values of what is nice and ugly. Whereas the animal mind is almost entirely devoted to servicing *organic needs*—satisfy hunger and thirst, keep warm and avoid cold, maximize safety and welfare—the human mind also endeavors to live by acquired *cultural values*. Depending on the value system of our culture, and what we assimilate as personally suiting us, we expend great effort to become and be perceived as upright and decent, pious and charitable, rich and famous, strong and brave, knowledgeable and articulate, attractive and beautiful, and so forth. However, the necessary adoption of a cultural value system has also created several problems. One of these is the difficulty that some individuals experience in adapting to and living by the value system of their culture. The other is that the assimilation of different cultural value systems has erected barriers and often outright conflicts among people raised in different cultures. We illustrate this by reference to the personal and social quandaries and struggles that we witness in the contemporary world.

CULTURE AND THE QUANDARY OF THE INDIVIDUAL. The quandary of the individual is that the new scientific world view may be in sharp conflict with what he or she has been brought up to believe in. Moreover, the faith-based, traditional world view is often easier to assimilate and is personally more gratifying and reassuring than the scientific world view. For instance, the traditional Western belief that our earth is the center of the universe and was created by *design* for our use to pursue a divine *destiny*, is easier to comprehend than the scientific account that depicts our abode, which appears to be so large, as a speck in a vast universe that is composed of trillions of suns and billions of galaxies situated at inconceivable distances from us. It is difficult to accept that our planet is rotating around its axis and revolving around the sun at great speed, when our senses tell us that it is stationary. Or that life, manifestly a purposive phenomenon, is something that has come about by some meaningless accident. Or that the biosphere was for billion of years but a messy soup composed of rapidly procreating slimy creatures. Or that mind emerged at some point in time and remained for hundreds of million years little more than a brutal force aiding ferocious and nasty beasts to outwit and exterminate one another. Or that, finally, man appeared on the scene several millions years ago and passed through a series of stages that led from savagery and barbarism to civilization. Is it not more sensible and comforting to continue to believe that our earth was *created* by a caring God for our benefit; that God implanted a *soul* into our heart to tell us what is right and what is wrong; that God keeps track of what we are doing, and if we are virtuous we get rewarded by going to Heaven, and if we are sinners by landing in Hell? On the other hand, where are these two sites located. The old idea that Heaven is situated "above" our planet, and Hell "below" it, turns out to be a fiction in light of what astronomers have revealed with their sensitive instruments about the structure of the universe. And what exactly is the "soul" that is said to proceed to these fictional sites? If feelings, memory and knowledge are products of our working brain, what could the soul be consisting of after the brain has disintegrated? In what sense could that disembodied entity *enjoy* itself by going to Heaven or *suffer* if it lands in Hell?

Notwithstanding these logical arguments, most people continue to believe in the existence of a supernatural world, and that their immortal soul is somehow part of it. There are many reasons for the persistence of this animistic belief but two of them stand out. First, our mind is not a pure rational mechanism. Feelings and emotions play as much a role in what we

think, and in the guidance of our daily life, as do reason and logic. When confronted by life's vicissitudes, our emotions—fear and anxiety, despair and misery, wish and hope—influence our thinking as much as do our rational reckonings. The person who is told by his physician that he has a tumor growing in his body will be stricken by anxiety, alternating with hope, as he awaits the diagnosis whether the tumor is benign or malignant. Upon learning that he is victim of an incurable cancer, his anxiety turns into horror. What is he to do? Since time immemorial, sick people have turned to witch doctors and priests, fervently hoping that through the performance of some ritual or magic, a miracle will occur and they will be healed. And in many cases people do recover, confirming their faith in the efficacy of the supernatural intervention.

CULTURE AND SOCIAL AND POLITICAL PROBLEMS. The social and political problems posed by cultural evolution are even more troublesome. Whereas science and technology are gradually becoming unifying global influences in the modern world, authoritarian and dogmatic religions remain a divisive force. Scientific facts are accepted by most people who have received a secular education, regardless of their ethnic or religious background. The disputes about scientific theories and hypotheses concern not cultural tradition or personal preference but the validity and reliability of the marshaled evidence. Similarly, technological and applied-science advances are welcomed by all reasonable people since they make their life more comfortable, keep them healthier, and prolong their life. In contrast, some of the fundamentalist religions impede social harmony and world peace as they promote intolerance and global discord. Most world religions have ancient texts that spell out in detail what is right or wrong, proper or improper, virtuous or sinful, true or false. Because true believers read these texts as God's instructions, they cannot question or doubt their validity. Hence, those who do not faithfully follow every commandment of their scripture to the letter, or give the words a different interpretation of what they do, are considered by fundamentalists as sinners or renegades, and those who adhere to other faiths as pagans or infidels. However, judged by objective standards of modern scholarship, these sacred texts are the work of ancient people who had no understanding of the forces of the physical world and the laws they obey, no knowledge of man's evolutionary past, and limited understanding of human nature. Fundamentalists reject the findings of modern science and discourage their study by their followers. To ensure the survival of their religion in its traditional form, they have schools attached to their houses of worship whose mission is to indoctrinate the young in the tenets of their faith at the expense of becoming enlightened by modern scholarship and science.

MATTERS OF VALUE AND MATTERS OF FACT. In assessing the merits in personal convictions and cultural traditions, we have to make a distinction between claims concerning facts and those concerning values. Factual claims are based on observation, exploration and experiment, and they are valid only, and to the extent, that they have been verified by others than the claimants. If the claim is such that it cannot be confirmed or refuted, it does not belong to the domain of facts. From an epistemological perspective, most "facts" are only theories and hypotheses. They advance toward being considered facts, from a pragmatic perspective, to the extent that continuing observations and experiments confirm their validity. Examples of well-substantiated theories that, for all practical purposes, may be considered facts are the atomic theory, and the laws of gravitation and electromagnetism in physics, and the laws of genetic

inheritance and the theory of evolution in biology. It requires expert knowledge to assess the validity of a hypothesis or theory and only empirical evidence can be marshaled to support or reject them. Some details of scientific theories may remain unresolved or disputed by experts, and in light of new discoveries, they are subject to emendations and corrections. However, those who are not qualified to assess the validity of these theories but reject it on other grounds than rival or new evidence are meddling in matters they do not understand. An example is the rejection of evolution theory on the ground that it differs from the biblical account. Family tradition, tribal myths and legends, the claim of preachers, political propaganda, or personal preference are irrelevant when it comes to judging matters of fact.

Not so, however, with values. The values held by a person or a group *are* based on tradition, tribal myths and legends, the teachings of religious and political authorities, and on personal preferences. Someone's values can only be objected to if they lead to harm—to themselves, others or society—but not because they violate some scientific fact. Children do not create their own religion but assimilate the creed of their parents and the culture (or subculture) in which they are reared. As they become more independent and begin to think for themselves, that cultural inheritance may be modified to various degrees. Religious doctrines tend to be rigid and indiscriminate ("one size fits all") and they suit some better than others. Therefore, there are individual differences in the faith and piety of those belonging to the same religion. The faith of the pessimist is different from the optimist, and so is the faith of the fearful and the brave, the compassionate and the callous, the rich and the poor, the docile and the rebellious. People tend to adhere to their religion because it is helpful and congenial, it gives a framework and structure to their daily life, and many people continue to hold supernatural beliefs because it gives them strength to face uncertainties and adversities, and cope with what they fear and cannot understand.

CAN THE CONFLICT BETWEEN SCIENCE AND RELIGION BE RESOLVED? The adherence to one's tradition does not pose any personal and social problems unless the believer comes under the influence of dogmatic fundamentalists, or lives in a theocratic society, that insist that he must adhere to the dogmas of his religion to the letter, and that the he will defend the integrity and survival of their creed by all means available, to the point of fighting renegades and infidels. Although there is an undeniable conflict between faith-based creeds and empirically-based science, thoughtful individuals have been able to reconcile, one way or another, their religious heritage with their scientific knowledge. Moreover, modern theologians have come up with syntheses of faith and science by reinterpreting the teachings of their sacred texts as guidelines of conduct rather than as dictates that have to be strictly followed. Leaders of reformed religions have a useful personal and social service to perform. Parochial houses of worship can provide individuals and families with a place to meditate and socialize. Religious institutions in larger towns and cities can promote cooperation and harmony among individuals and groups with different economic and personal interests, social status, and ethnic backgrounds. And in states and empires, religious institutions can facilitate coexistence among populations of heterogeneous tribal and ethnic backgrounds. Historically, the adoption of Buddhism helped the unification of multi-ethnic China, Hinduism that of India, Islam that of the Near East, and Christianity that of Europe. Praying helps many individuals to gain strength in facing difficulties and calamities. Problems can arise when worshipping is considered a substitute

for realistic efforts to improve the condition of the individual and society, and when ancient political ideas are held to be adequate to solve modern problems. For example, many religions support the privileges of the rich and the powerful (often their benefactors) at the expense of the poor, and instead of seeking to reform the social order, advocate charitable assistance to the poor as a remedy or promising them justice and recompense in an imaginary netherworld. Following ancient views, some religions consider females inferior to males, not deserving an education, and obligate them to subordinate themselves to male dominance. Although our planet is threatened by overpopulation, some traditional religions oppose population control because their sacred texts command their adherents to multiply in number, (presumably to gain in strength relative to their adversaries). Most religions consider homosexuality a sin and thereby interfere with the life of a significant minority of the human population. And, in the worst cases, there are the fanatics who, while preaching peace and love as the pillar of their religion, teach their young to hate the infidels, fight them and, if need be, sacrifice themselves to their divine cause.

THE FUTURE OF CONTINUING MENTAL AND CULTURAL EVOLUTION. According to an ancient Hebrew myth, God created the first man, Adam, in His own image (the first woman, Eve, was a byproduct), and Adam lived happily in Paradise. But, having succumbed to evil influence, Adam disobeyed God's command and consumed the forbidden food. God expelled Adam from Paradise, and ever since his progeny roam the lands as born sinners. Since that calamity, Man's only salvation is to atone for that original sin, worship God, and pray for his forgiveness. The modern biological story of man's origin and his confounded nature is different. Human origins is traced to a long line of ancestral animals, and his unfortunate nature, the admixture of benevolence and malevolence, is attributed to his evolutionary history. Our animal ancestors sought to survive and prosper by using, as circumstances demanded, cunning and brute force, and goodwill and cooperation. This conflicting legacy is evident in the organization of our brain, which contains structures, neural circuits, and humoral factors that incline us to be selfish, hateful and aggressive in some situations, and selfless, loving and cooperative in others. These two origin scenarios counsel different remedies as how to improve the human condition. The ancient story is fatalistic: we have to resign ourselves to the given that we are sinners and our only hope for salvation is the grace of God. The modern story is inspiring: yes, our beginning was brutish but we have been able, at least partially, to overcome that legacy and there is hope that we may be able to continue to try to improve our condition. But in light of all the evil that we are witnessing around us day after day, how can we improve the human condition? Will human nature change or is it culture that will have to be improved?

There is no reason to believe that our brain as an organ, the "hardware," will undergo evolutionary changes so that we will become less greedy, aggressive and destructive, and more generous, peaceful and constructive. The structural organization of our brain has probably not changed since about 40 millennia ago, the time when a species of anatomically modern humans colonized a large portion of our globe. However, our maturing brain is highly malleable with tremendous functional potential. To foster that potential, our brain has to be properly nurtured from childhood onward and throughout life, that is, furnished with optimal "software." The way our brain functions depends greatly on how it is "programmed" and used, on the cultural values we assimilate, the knowledge we acquire, and the social conditions under which we

live. We are burdened by our emotional heritage, the legacy of animal ancestors that used brute force to survive, and the legacy of our hominin ancestors who came to dominate the globe by using their barbaric disposition to ensnare and kill game, and may have had done the same to their own kind as they competed with and fought each other. This bestial and barbaric legacy is evident in the way we treat our fellowmen to this day, the rich with their financial manipulations exploiting the poor, the strong with their weapons subduing the defenseless. But we also have another legacy, the simian mother's love of her young and group members seeking amicable relations with one another. These prosocial emotional traits combined with our growing understanding of human nature, and the gradual improvement of our culture and social order, offer hope that the human condition may be improved.