Table 1.1 Nobel prizes specifically related to the nervous system or behavior.

Nobel Winner(s)	Date	Accomplishment
Ivan Pavlov	1904	Research on the physiology of digestion
Camillo Golgi and Santiago Romón y Cajal	1906	Research on the structure of the nervous system
Charles Sherrington and Edgar Adrian	1932	Discoveries about the functions of neurons
Henry Dale and Otto Loewi	1936	Discoveries about the transmission of nerve impulses
Joseph Erlanger and Herbert Gasser	1944	Research on the functions of single nerve fibers
Walter Hess	1949	Research on the role of the brain in behavior
Egas Moniz	1949	Development of the prefrontal lobotomy
Georg von Békésy	1961	Research on the auditory system
John Eccles, Alan Hodgkin, and Andrew Huxley	1963	Research on the ionic basis of neural transmission
Ragnor Granit, Haldan Hartline, and George Wald	1967	Research on the chemistry and physiology of vision
Bernard Katz, Ulf von Euler, and Julius Axelrod	1970	Discoveries related to synaptic transmission
Karl Von Frisch, Konrad Lorenz, and Nikolass Tinbergen	1973	Studies of animal behavior
Roger Guillemin and Andrew Schally	1977	Discoveries related to hormone production by the brain
Herbert Simon	1979	Research on human cognition
Roger Sperry	1981	Research on separation of the cerebral hemispheres
David Hubel and Torsten Wiesel	1981	Research on neurons of the visual system
Rita Levi-Montalcini and Stanley Cohen	1986	Discovery and study of nerve growth factors
Erwin Neher and Bert Sakmann	1991	Research on ion channels
Alfred Gilman and Martin Rodbell	1994	Discovery of G-protein–coupled receptors
Arvid Carlsson, Paul Greengard, and Eric Kandel	2000	Discoveries related to synaptic transmission
Linda Buck and Richard Axel	2004	Research on the olfactory system
John O'Keefe, May-Britt Moser, and Edvard Moser	2014	Research on the brain's system for recognizing locations

understanding are shortsighted. Of course, it is not necessary for a research project to be completely pure or completely applied; many research programs have elements of both approaches. Moreover, pure research often becomes the topic of **translational research**: research that aims to translate the findings of pure research into useful applications for humankind (see Howells, Sena, & Macleod, 2014; Woolf, 2008).

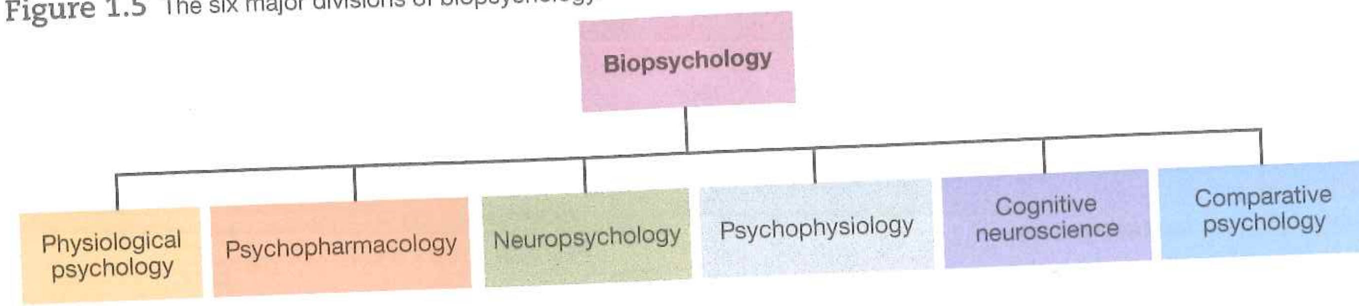
One important difference between pure and applied research is that pure research is more vulnerable to the vagaries of political regulation because politicians and the voting public have difficulty understanding why research of no immediate practical benefit should be supported. If the decision were yours, would you be willing to grant hundreds of thousands of dollars to support the study of squid *motor neurons* (neurons that control muscles), learning in recently hatched geese, the activity of single nerve cells in the visual systems of monkeys, the hormones released by the *hypothalamus* (a small neural structure at the base of the brain) of pigs and sheep, or the function of the *corpus callosum* (the large neural pathway that connects the left and right halves of the brain)? Which, if any, of these projects would you consider worthy of support? Each of these seemingly esoteric projects was supported, and each earned a Nobel Prize.

Table 1.1 provides a timeline of some of the Nobel Prizes awarded for research related to the brain and behavior. The purpose of this table is to give you a general sense of the official recognition that behavioral and brain research has received, not to have you memorize the list. You will learn later in the chapter that, when it comes to evaluating science, the Nobel Committee has not been infallible.

What Are the Divisions of Biopsychology?

As you have just learned, biopsychologists conduct their research in a variety of fundamentally different ways. Biopsychologists who take the same approaches to their research tend to publish their research in the same journals, attend the same scientific meetings, and belong to the same professional societies. The particular approaches to biopsychology that have flourished and grown have gained wide recognition as separate divisions of biopsychological research. The purpose of this module of the chapter is to give you a clearer sense of biopsychology and its diversity by describing six of its major divisions (see Figure 1.5): (1) physiological psychology, (2) psychopharmacology, (3) neuropsychology, (4) psychophysiology, (5) cognitive neuroscience, and (6) comparative psychology. For simplicity,

Figure 1.5 The six major divisions of biopsychology.



they are presented as distinct approaches, but there is much overlap among them, and many biopsychologists regularly follow more than one approach.

Physiological Psychology

LO 1.7 Describe the division of biopsychology known as physiological psychology.

Physiological psychology is the division of biopsychology that studies the neural mechanisms of behavior through the direct manipulation and recording of the brain in controlled experiments—surgical and electrical methods are most common. The subjects of physiological psychology research are almost always laboratory animals because the focus on direct brain manipulation and controlled experiments precludes the use of human participants in most instances. There is also a tradition of pure research in physiological psychology; the emphasis is usually on research that contributes to the development of theories of the neural control of behavior rather than on research of immediate practical benefit.

Psychopharmacology

LO 1.8 Describe the division of biopsychology known as psychopharmacology.

Psychopharmacology is similar to physiological psychology except that it focuses on the manipulation of neural activity and behavior with drugs. In fact, many of the early psychopharmacologists were simply physiological psychologists who moved into drug research, and many of today's biopsychologists identify closely with both approaches. However, the study of the effects of drugs on the brain and behavior has become so specialized that psychopharmacology is regarded as a separate discipline. A substantial portion of psychopharmacological research is applied. Although drugs are sometimes used by psychopharmacologists to study the basic principles of brain–behavior interaction, the purpose of many psychopharmacological experiments is to develop therapeutic drugs (see Chapter 18) or to reduce drug abuse (see Chapter 15). Psychopharmacologists study the effects of drugs on laboratory species—and on humans, if the ethics of the situation permits it.

Clinical Implications

Neuropsychology

LO 1.9 Describe the division of biopsychology known as neuropsychology.

Neuropsychology is the study of the psychological effects of brain damage in human patients. Because human volunteers cannot ethically be exposed to experimental treatments that endanger normal brain function, neuropsychology deals almost exclusively with case studies and quasiexperimental studies of patients with brain damage resulting from disease, accident, or neurosurgery. The outer layer of the cerebral hemispheres—the **cerebral cortex**—is most likely to be damaged by accident or surgery; this is one reason why neuropsychology has focused on this important part of the human brain.

Neuropsychology is the most applied of the biopsychological subdisciplines; the neuropsychological assessment of human patients, even when part of a program of pure research, is always done with an eye toward benefiting them in some way. Neuropsychological tests facilitate diagnosis and thus help the attending physician prescribe effective treatment (see Benton, 1994). They can also be an important basis for patient care and counseling; Kolb and Whishaw (1990) described such an application.

Clinical Implications

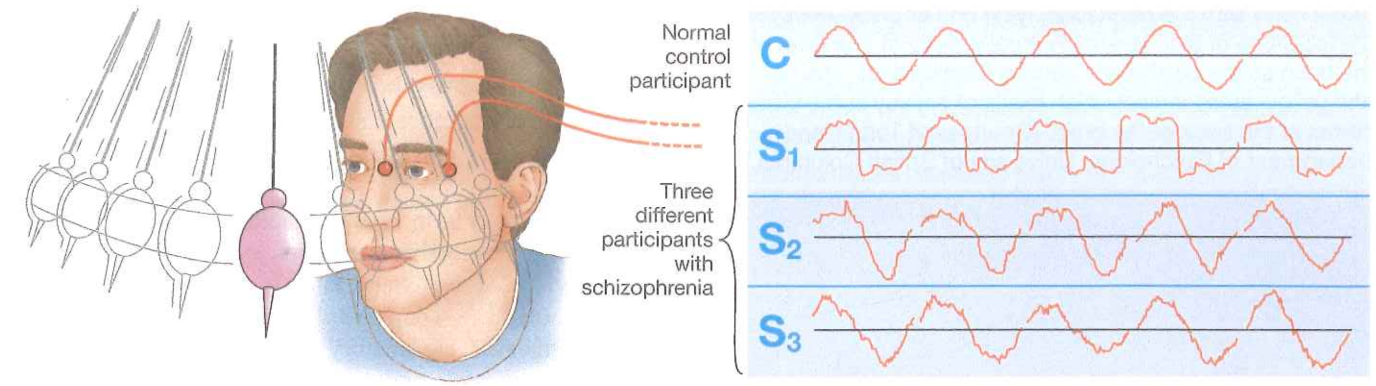
The Case of Mr. R., the Brain-Damaged Student Who Switched to Architecture

Mr. R. was a 21-year-old honor student at a university. One day he was involved in a car accident in which he struck his head against the dashboard. Following the accident, Mr. R's grades began to decline; his once exceptional academic performance was now only average. He seemed to have particular trouble completing his term papers. Finally, after a year of struggling academically, he went for a neuropsychological assessment. The findings were striking.

Mr. R. turned out to be one of roughly one-third of left-handers whose language functions are represented in the right hemisphere of their brain, rather than in their left hemisphere. Furthermore, although Mr. R. had a superior IQ score, his verbal memory and reading speed were low-average—something that is quite unusual for a person with such a good education and of such high intelligence.

The neuropsychologists concluded that he may have suffered some damage to his right temporal lobe during the car accident, which would help explain his diminished language skills. The neuropsychologists also recommended that Mr. R pursue a field that didn't require superior verbal memory skills. Following his exam and based on the recommendation of his neuropsychologists, Mr. R. switched majors and began studying architecture.

Figure 1.6 Visual tracking of a pendulum by a normal control participant (top) and people with schizophrenia (adapted from Iacono & Koenig, 1983.)



Psychophysiology

LO 1.10 Describe the division of biopsychology known as psychophysiology.

Psychophysiology is the division of biopsychology that studies the relation between physiological activity and psychological processes in human subjects. Because the subjects of psychophysiological research are human, psychophysiological recording procedures are typically noninvasive; that is, the physiological activity is recorded from the surface of the body. The usual measure of brain activity is the scalp **electroencephalogram (EEG)** (see Chapter 5). Other common psychophysiological measures are muscle tension, eye movement, and several indicators of autonomic nervous system activity (e.g., heart rate, blood pressure, pupil dilation, and electrical conductance of the skin). The **autonomic nervous system (ANS)** is the division of the nervous system that regulates the body's inner environment (see Chapter 3).

Most psychophysiological research focuses on understanding the physiology of psychological processes, such as attention, emotion, and information processing, but there have been some interesting clinical applications of the psychophysiological method. For example, psychophysiological experiments have indicated that persons with schizophrenia have difficulty smoothly tracking a moving object such as a pendulum (see Meyhöfer et al., 2014)—see Figure 1.6.

Clinical Implications

> **Clinical Implications** If people with schizophrenia have difficulty smoothly tracking moving objects, what clinical implications do you think this might have? (For a description of the symptoms of schizophrenia, see Chapter 18.)

Cognitive Neuroscience

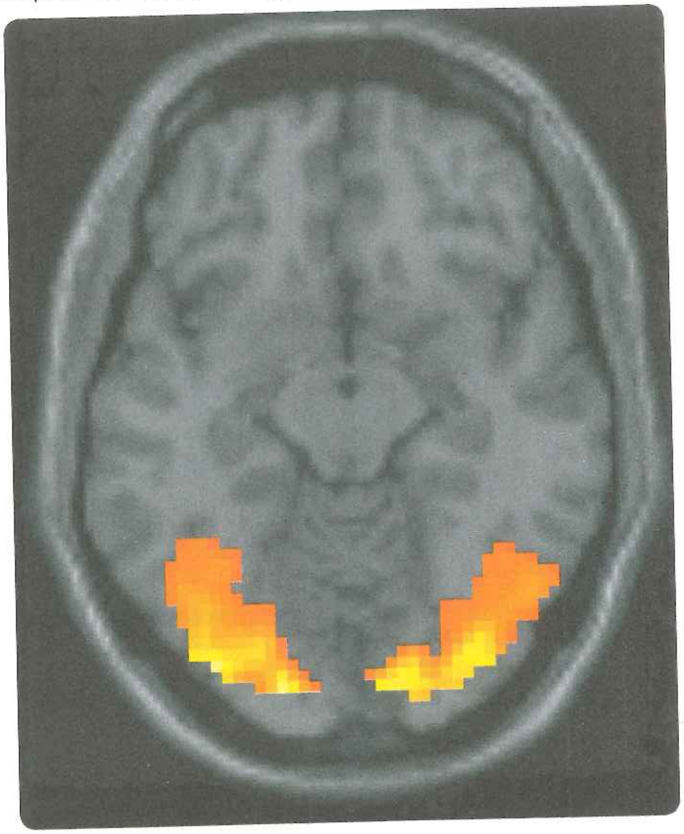
LO 1.11 Describe the division of biopsychology known as cognitive neuroscience.

Cognitive neuroscience is the youngest division of biopsychology. Cognitive neuroscientists study the neural bases of **cognition**, a term that generally refers to higher intellectual processes such as thought, memory, attention, and complex perceptual processes (see Gutchess, 2014; Raichle, 2008). Because of its focus on cognition, most cognitive neuroscience research involves human participants, and because of its focus on human participants, its methods tend to be noninvasive, rather than involving penetration or direct manipulation of the brain.

The major method of cognitive neuroscience is *functional brain imaging*: recording images of the activity of the living human brain (see Chapter 5) while a participant is engaged in a particular cognitive activity. For example, Figure 1.7 shows that the visual areas of the left and right cerebral cortex at the back of the brain became active when the participant viewed a flashing light.

Because the theory and methods of cognitive neuroscience are so complex and pertinent to so many fields, most cognitive neuroscientific publications result from interdisciplinary collaboration among many individuals with

Figure 1.7 Functional brain imaging is the major method of cognitive neuroscience. This image—taken from the top of the head with the participant lying on her back—reveals the locations of high levels of neural activity at one level of the brain as the participant views a flashing light. The red and yellow areas indicate high levels of activity in the visual cortex at the back of the brain. (Courtesy of Todd Handy, Department of Psychology, University of British Columbia.)



different types of training. For example, biopsychologists, cognitive psychologists, social psychologists, economists, computing and mathematics experts, and various types of neuroscientists commonly contribute to the field. Cognitive neuroscience research sometimes involves noninvasive electrophysiological recording, and it sometimes focuses on patients with brain pathology; in these cases, the boundaries between cognitive neuroscience and psychophysiology and neuropsychology, respectively, are blurred.

Comparative Psychology

LO 1.12 Describe the division of biopsychology known as comparative psychology.

Although most biopsychologists study the neural mechanisms of behavior, there is more to biopsychology than this. As Dewsbury (1991) asserted:

> The "biology" in "psychobiology" should include the whole-animal approaches of ethology, ecology, evolution... as well as the latest in physiological methods and thought.... The "compleat psychobiologist" should use whatever explanatory power can be found with modern physiological techniques, but never lose sight of the problems that got us going in the first place: the integrated behavior of whole, functioning, adapted organisms. (p. 122)

The division of biopsychology that deals generally with the biology of behavior, rather than specifically with the neural mechanisms of behavior, is **comparative psychology**. Comparative psychologists compare the behavior of different species in order to understand the evolution, genetics, and adaptiveness of behavior. Some comparative psychologists study behavior in the laboratory; others engage in **ethological research**—the study of animal behavior in its natural environment.

Because two important areas of biopsychological research often employ comparative analysis, we have included them as part of comparative psychology. One of these is *evolutionary psychology* (a subfield that focuses on understanding behavior by considering its likely evolutionary origins)—see Burke (2014), Caporael, (2001), Duchaine, Cosmides, and Tooby (2001), Kenrick (2001). The other is *behavioral genetics* (the study of genetic influences on behavior)—see Carson and Rothstein (1999), Jaffee, Price and Reyes (2013), Plomin et al. (2002).

In case you have forgotten, the purpose of this module has been to demonstrate the diversity of biopsychology by describing six of its major divisions; these are summarized for you in Table 1.2. You will learn much about these divisions in subsequent chapters.

Table 1.2 The six major divisions of biopsychology with examples of how they have approached the study of memory

The Six Divisions of Biopsychology	Examples of How the Six Approaches Have Pursued the Study of Memory
Physiological psychology: study of the neural mechanisms of behavior by manipulating the nervous systems of nonhuman animals in controlled experiments	Physiological psychologists have studied the contributions of the hippocampus to memory by surgically removing the hippocampus in rats and assessing their ability to perform various memory tasks.
Psychopharmacology: study of the effects of drugs on the brain and behavior	Psychopharmacologists have tried to improve the memory of Alzheimer's patients by administering drugs that increase the levels of the neurotransmitter acetylcholine.
Neuropsychology: study of the psychological effects of brain damage in human patients	Neuropsychologists have shown that patients with alcohol-produced brain damage have particular difficulty in remembering recent events.