

Chapter in Review

1. The human nervous system is a complex biological system designed for nearly instantaneous communication among billions of neurons throughout the body. The nervous system is composed of specialized cells, principally neurons: motor neurons, sensory neurons, and interneurons. Neurons allow communication to take place among the various structures of the body. The nervous system also contains cells known as glia that assist neurons in their work of communication.
2. Neurons have an anatomy. Most neurons share a similar anatomy composed of dendrites, cell body, axon, and terminal. Dendrites “branch out” from the neuron cell body, and are covered with synaptic receptors that receive information from other neurons. The cell body contains the cell nucleus where most genetic information is stored. The axon is a narrow extension of a neuron that conveys information from the cell body as electrical impulses initiated by the firing of an action potential. The axon ends in the small, bulb-like structure called the terminal. The terminal releases neurotransmitters that transmit information in chemical form from one neuron (presynaptic neuron) to specialized receptor cells on another neuron (postsynaptic neuron).
3. Neurotransmitters affect many aspects of mental life. For example, serotonin has many kinds of effects depending on the receptor to which it binds. Dopamine is involved in learning, memory, attention, and problem-solving, and also is an important component of reward systems. GABA generally acts to inhibit brain neurons from firing and thus tends to quiet brain activity. Some drugs (agonists) may increase the effects of neurotransmitters, while others (antagonists) may decrease neurotransmitter effects.
4. The nervous system is organized into two distinct but interdependent divisions: central nervous system and peripheral nervous system. The central nervous system (CNS) consists of the brain and spinal cord. It receives information from the peripheral nervous system, organizes and interprets the information, and sends “instructions” back to the peripheral nervous system to take actions or make adjustments to bodily functions.
5. The spinal cord is a bundle of nerve tracts organized into segments that act as a communication pathway between the brain and the rest of the body. The spinal cord is composed of two types of tissue mass: grey matter, made up of cell bodies, unmyelinated axons, dendrites, and glia; and white matter, axons with myelin sheaths that allow for swifter communication. The spinal cord also controls spinal reflexes and is responsible for central pattern generators.
6. The peripheral nervous system makes communication possible between brain and body. It consists of cranial nerves that enter and leave the underside of the brain, and spinal nerves that branch out from the spinal cord. The peripheral nervous system is organized into somatic and autonomic nervous systems. The somatic nervous system is in charge of regulating voluntary motor actions. The autonomic nervous system oversees primarily involuntary activities of muscles, glands, and organs. The autonomic nervous system is subdivided in turn into the sympathetic and parasympathetic nervous systems. The sympathetic nervous system mobilizes the organs and muscles for arousal, often in response to a threat. The

- parasympathetic nervous system restores and conserves energy by returning the body to resting state following arousal.
7. The brain is a network of organs made up of astonishingly complex, integrated clusters of neurons that form neural circuits. The organization of the brain may be described in different ways, but on a basic level the brain can be divided into three parts: hindbrain (base of the brain), midbrain (small area above the hindbrain), and forebrain (the largest region).
 8. The hindbrain consists of the cerebellum, medulla, pons, and reticular formation. The cerebellum coordinates the various sensory inputs we experience during waking consciousness, allowing for accurate visual-spatial perception. The primary function of the medulla is to control various autonomic functions including regulation of breathing and heart functioning. The pons plays vital roles in regulation of the body during sleep and relaying information from the hindbrain to the forebrain. The reticular formation is a net-like web of neurons that begins at the medulla and threads upward toward the midbrain and downward toward the cerebellum and spinal cord. It plays a crucial role in variations in consciousness and attention. Inferior and superior coliculi are essential in conveying auditory and visual information to the forebrain to be interpreted as sounds and sights.
 9. The massive human forebrain is the seat of thought, emotion, personality, memory, intelligence, language, and consciousness. The forebrain is divided into two nearly symmetrical cerebral hemispheres, each with systems and structures that correspond almost exactly. The hemispheres are connected by a bundle of over 200 million axons known as the corpus callosum.
 10. The major structures of each cerebral hemisphere of the forebrain are the limbic system, the thalamus, and the cerebral cortex. The limbic system regulates emotion and motivation, plays a part in memory, regulates the sleep/wake cycle, and is the seat of basic drives such as hunger and thirst. The limbic system is composed of the hypothalamus, the hippocampus, the amygdale, and clusters of nerves called nuclei—including the basal ganglia and nucleus accumbens. The thalamus regulates our sensory experience by relaying sensory information to the cerebral cortex and instructions from the cerebral cortex about the type of sensory input that should be allowed “passage.” The cerebral cortex—the outer layer of the cerebrum, that makes up the bulk of the brain—is the center of higher cognitive processes, such as problem solving, planning, learning, memory, and language. It also allows us to interpret the raw information we receive from our senses and initiates voluntary movement.
 11. The areas of the cerebral cortex can be grouped into four large regions known as lobes. Each lobe contains neurons primarily devoted to certain sorts of tasks. The occipital lobe processes visual information through the primary visual cortex and associated visual areas. The parietal lobe—via the somatosensory cortex and somatosensory areas—processes sensations of heat, cold, pain, and touch, and helps to orient the placement of our limbs and bodies in space. The temporal lobe interprets neural messages from the ears as sound via the auditory cortex and auditory association area. Wernicke’s area sits at the border of left temporal lobe and the frontal lobe, and is critical for allowing speech comprehension (and possibly the processing of music as well). The frontal lobe makes up the bulk of

- the cerebral cortex. Within it are the primary motor cortex, where deliberate body movements are planned, and the prefrontal cortex, which appears to receive and integrate information from all bodily systems and brain regions to assist in decision-making, organizing information, and planning actions. At the border of the frontal and temporal lobes sits Broca's area, which allows a person to produce structured, grammatical speech.
12. Experiments among patients who have experienced split-brain surgery have shown that each cerebral hemisphere is specialized to a certain extent. The left hemisphere is specialized primarily for tasks involving linear processing of information, including language, logical reasoning, and mathematics. The right hemisphere is specialized for integrative processing including recognizing emotion in others, facial recognition, music and art, and visual-spatial tasks. Although the hemispheres are specialized in this way, they are also at least to some degree plastic. Regions of the brain (e.g., lobes of the forebrain) may also show plasticity under certain circumstances.
 13. The endocrine system consists of glands and the hormones they synthesize. The endocrine system partially overlaps the nervous system to some degree.
 14. Neuroscience is the multidisciplinary study of the central and peripheral nervous systems. Neuroscience can be divided into subdisciplines. Two of these subdisciplines central to psychology are behavioral neuroscience—the study of the neural basis of behavior—and cognitive neuroscience, the study of the neural basis of cognition and emotion. Neuroscience has advanced dramatically through the use of contemporary imaging technologies such as MRI and fMRI. However, neuroscience has limits as to the questions it can answer about psychology.

Section Summaries

Where is the mind?

1. Dualism, the view developed by René Descartes and his followers, holds that the body is material, but the mind is immaterial and not physically unified with the brain/body. Materialism holds that the mind is a physical, material product of the human brain.
2. Modern science has by and large rejected dualism as a description of mind. Several facts argue against dualism. First, when brain chemistry is altered, mental states are also often altered. Second, neuroscientific evidence suggests that specific kinds of thoughts and actions are connected to activity at specific brain regions, and these brain regions may begin to become active prior to the making of decisions to act. Third, there is a logical problem in proposing that an immaterial structure can affect and communicate with one that is material.

How is the nervous system built?

1. Neurons and glia are cells that allow communication to occur throughout the nervous system and the rest of the body. Neurons receive and transmit information. Glia assist neurons in their work by building myelin sheaths and developing and maintaining synapses.
2. Nerves are communication channels made up of chains of neurons. Three types of neurons make up these chains: motor neurons, sensory neurons, and interneurons.
3. In general, neurons are constructed of the following components: dendrites, cell body, axon, and terminal.
4. Neural communication is electrochemical. It begins when a neuron fires an action potential. The action potential conveys information in electrical form to the terminal of the presynaptic neuron. This stimulates the release of neurotransmitters from the neuron's vesicles. The neurotransmitters spill into the synapse, some crossing the synaptic gap and binding to receptor sites in the postsynaptic neuron. The "message" received by the postsynaptic neuron may be excitatory or inhibitory, depending on the type of receptor and the placement of the neuron within the nervous system. If the "message" received is excitatory, the postsynaptic neuron will fire an action potential. Otherwise, it will remain at resting potential.
5. Neurotransmitter agonists increase the effectiveness of neurotransmitters, while antagonists decrease their effectiveness.
6. Neurotransmitters are important regulators of psychological life.

How is the nervous system organized?

1. The nervous system is divided into two major systems: the central nervous system (CNS) and the peripheral nervous system (PNS).
2. The CNS is "command central," receiving, organizing, and interpreting information from the PNS and sending instructions to the PNS to take actions or make adjustments to bodily functions. The PNS transmits information to and from the brain via the spinal cord.
3. The PNS consists of autonomic and somatic nervous systems. The somatic nervous system controls voluntary motor actions and also conveys information to

- the brain from the sense organs. The autonomic nervous system controls activities in the muscles, glands, and organs that are primarily involuntary.
4. The autonomic nervous system has two subsystems: the sympathetic nervous system, which mobilizes the organs and muscles for arousal, and the parasympathetic nervous system, which returns the body to resting state following arousal.

How is the brain organized?

1. The brain is an integrated system of organ-like clusters of neurons that operate as a network of connections. The brain can be divided geographically into the forebrain, midbrain, and hindbrain.
2. Important structures of the hindbrain include the cerebellum, medulla, pons, and reticular formation. Important structures of the midbrain include superior and inferior colliculi. The hindbrain and midbrain control bodily functions vital to maintaining life.
3. The forebrain is the largest region of the brain. It is the seat of cognition, emotion, personality, memory, intelligence, language, and consciousness. It is divided into two symmetrical cerebral hemispheres connected by the corpus callosum. For the most part, each hemisphere contains the same structures.
4. The forebrain includes the limbic system, the thalamus, and the cerebral cortex. The limbic system is a series of substructures (including hypothalamus, amygdala, hippocampus, basal ganglia, and nucleus accumbens) that regulate mood, emotion, memory, and basic drives including hunger, thirst, and sex. The thalamus relays sensory information to the cerebral cortex, and conveys instructions back from the cortex regarding the extent to which certain types of sensory messages should be conveyed. The cerebral cortex, which makes up the bulk of the forebrain, interprets sensory information, controls voluntary movement, and is the home of higher thinking processes.
5. The cerebral cortex can be divided into four regions called lobes. The occipital lobe, which processes visual information, contains the primary visual cortex and visual association areas. The parietal lobe processes sensations of heat, cold, pain, and touch via the somatosensory cortex and somatosensory association areas. The temporal lobe processes auditory information via the auditory cortex and auditory association areas. The frontal lobe includes the primary motor cortex, where deliberate body movements are planned and executed; and the prefrontal cortex—a decision-maker, organizer of information, emotion-monitor, and planner of action in the service of obtaining goals.
6. Although each cerebral hemisphere has structures that “mirror” the other, each is also specialized to accomplish certain tasks. The left hemisphere is specialized primarily for tasks involving sequential processing—language, logical reasoning, and numerical skills. The right hemisphere is specialized for integrative processing—reading nonverbal emotional expressions, facial recognition, music and art, and visual-spatial tasks. Experiments with split-brain people underscore the specialization of each hemisphere.
7. Although the brain is specialized, it is also to some degree plastic.

What is the endocrine system?

1. The endocrine system consists of glands and the hormones they release.
2. The endocrine system is distinct from the nervous system, but the two also overlap. For example, the pituitary and pineal glands and the hypothalamus are all brain structures critical to the functioning of the endocrine system; and many hormones lead “double lives” as neurotransmitters.

What is neuroscience?

1. Behavioral neuroscientists study the anatomy, physiology, and molecular structure of the entire nervous systems of humans and other animals. Cognitive neuroscientists focus on the brain and the neural basis of cognition and emotion in human beings.
2. The early history of behavioral neuroscience includes the pseudoscientific work of phrenologists and the more science-minded but nonetheless equally incorrect views of the equipotentialists.
3. Two classic early neuroscientific findings are the discovery of personality change due to traumatic brain injury (the Phineas Gage case) and the discovery of Broca’s area by Paul Broca.
4. Magnetic resonance imaging (MRI) uses radio wave pulses within a magnetic field to momentarily alter the alignment of protons in the brain. When the protons return to their ordinary state, an image is generated. In functional magnetic resonance imaging (fMRI), series of images are produced as a person engages in various tasks and activities.
5. Other brain imaging systems include computerized tomography (CT or “CAT scan”), positron emission tomography (PET), and electroencephalography (EEG).
6. The mind and brain are not identical, even though the mind emerges from the brain. However, there is a danger that in stressing the ways in which the mind and brain differ, one may fall back on dualism.
7. The debate between those who stress innate biology in understanding human psychology and those who stress experience and the environment is known as the nature-nurture dichotomy. Those taking the “nature” side are known as *nativists*, and those taking the “nurture” side are known as *empiricists*.