Chapter 2
The Role of Biology in Psychology
2.1 How Do Our Nervous Systems Affect Thinking and Behavior? (1)

• **Nervous system**
  – A network of billions of cells in the brain and the body, responsible for all aspects of what we feel, think, and do

• The nervous system has three basic functions
  1. Receive sensory input from the world through vision, hearing, touch, taste, and smell
  2. Process the information in the brain by paying attention to it, perceiving it, and remembering it
  3. Respond to the information by acting on it
2.1 How Do Our Nervous Systems Affect Thinking and Behavior? (2)

- **Central nervous system**
  - The part of the nervous system that consists of the brain and the spinal cord

- **Peripheral nervous system**
  - The part of the nervous system that enables nerves to connect the central nervous system to the muscles, organs, and glands
Neurons Are the Basic Units of Our Nervous Systems (1)

• Neurons
  – The basic units of the nervous system: Cells that receive, integrate, and transmit information in the nervous system.
  – Neurons operate through electrical impulses, communicate with other neurons through chemical signals, and form neural networks.
Neurons: the Basic Units

• Structure of neurons
  – **Dendrites**: Branchlike extensions of the neuron with receptors that detect information from other neurons
  – **Cell body**: The part of the neuron where information from thousands of other neurons is collected and integrated
  – **Axon**: The long, narrow outgrowth of a neuron that enables it to transmit information to other neurons
  – **Synapse**: The site of communication between neurons through neurotransmitters
Neurons Are the Basic Units of Our Nervous Systems (5)
Neurons Are the Basic Units of Our Nervous Systems (6)

- Electrical properties of neurons
  - Parts of the neuron are covered with a membrane, which is semipermeable
    - Ions, such as sodium and potassium, may move from outside the neuron to the inside or from inside the neuron to the outside
    - The movement of these ions across the membrane enables neurons to communicate
Neurons Are the Basic Units of Our Nervous Systems (7)

- The neuron begins in a resting state when the electrical charge inside the neuron is slightly more negative than the electrical charge outside.

- **Action potential**: The neural impulse that travels along the axon and then causes the release of neurotransmitters into the synapse.
  - During an action potential, sodium ions continue to enter the neuron and potassium ions leave the neuron.
Action Potentials Allow Neurons to Communicate With Each Other (1)

- Neurons communicate with other neurons in three phases
  1. Neurons pass signals to receiving neurons
  2. Neurons receive signals from neighboring neurons
  3. Neurons assess the incoming signals
Action Potentials Allow Neurons to Communicate With Each Other (3)

• Action potentials
  – Myelin sheath
    • Fatty layer that insulates the axon
  – To communicate, a neuron fires an action potential
    • A neuron cannot fire just a little bit: It either fires or it does not
Action Potentials Allow Neurons to Communicate With Each Other (4)

• Neurotransmitters in the synapse
  – Neurons do not touch one another; instead, they communicate chemically at the synapse
  – **Neurotransmitters**: Chemical substances that carry signals from one neuron to another
  – Receptors are specialized sites that specifically respond to certain types of neurotransmitters
  – Two major ways in which neurotransmitters are removed from the synapse
    • Reuptake
    • Enzyme degradation
Action Potentials Allow Neurons to Communicate With Each Other (6)
Action Potentials Allow Neurons to Communicate With Each Other (7)

• Excitatory and inhibitory signals
  – Postsynaptic neurons can produce signals of two types
    • Excitatory—they increase the likelihood that it will fire
    • Inhibitory signals inhibit the neuron—they decrease the likelihood that it will fire
Neurotransmitters Influence Our Mental Activity and Behavior (1)

• Drugs that enhance the actions of neurotransmitters are known as agonists
• Drugs that inhibit the actions of neurotransmitters are known as antagonists
Neurotransmitters Influence Our Mental Activity and Behavior (3)

• Acetylcholine
  – Motor control over muscles
  – Attention, memory, learning, and sleeping

• Epinephrine
  – Energy
  – Formerly called adrenaline

• Norepinephrine
  – Arousal and alertness

• Serotonin
  – Emotional states, impulse control, and dreaming
Neurotransmitters Influence Our Mental Activity and Behavior (4)

• Dopamine
  – Reward and motivation
  – Motor control over voluntary movement

• GABA (gamma-aminobutyric acid)
  – Inhibition of action potentials
  – Anxiety reduction: and Intoxication (through alcohol)

• Glutamate
  – Enhancement of action potentials
  – Learning and memory

• Endorphins
  – Pain reduction: and Reward
2.2 How Do the Parts of Our Brains Function?

• To truly understand how we see, hear, remember, interact with others, and sometimes experience psychological disorders, we need to understand the main structures of the brain
Understanding of Our Brains Has Developed Over Time (1)

• Early studies of the brain
  – Franz Gall
    • **Phrenology**: Analysis of personality based on the location and size of skull bumps
  – Paul Broca
    • **Broca’s area**: A small portion of the left frontal region of the brain, which is crucial for producing speech
Understanding of Our Brains Has Developed Over Time (4)

- Contemporary brain research
  - Electroencephalograph (EEG): This measurement is useful because different behavioral states produce different and predictable EEG patterns
  - Functional magnetic resonance imaging (fMRI): This technique measures changes in the blood’s oxygen level
  - Transcranial magnetic stimulation (TMS): This technique uses a very fast and powerful magnetic field to momentarily disrupt activity in a specific brain region
Understanding of Our Brains Has Developed Over Time (7)
The Hindbrain and Midbrain House

Basic Programs for Our Survival (1)

• The lower part of the brain contains structures that are essential for survival
  – Hindbrain
  – Midbrain
  – Forebrain

• The spinal cord’s most important job is communication between the brain and the rest of the body
  – Gray matter
  – White matter
The Hindbrain and Midbrain House
Basic Programs for Our Survival (2)

• Hindbrain
  – **Medulla**: A hindbrain structure at the top of the spinal cord; it controls survival functions such as breathing and heart rate
  – **Pons**: A hindbrain structure above the medulla; it regulates sleep and arousal and coordinates movements of the left and right sides of the body
  – **Cerebellum**: A hindbrain structure at the back of the brain stem; it is essential for coordinated movement and balance
The Hindbrain and Midbrain House
Basic Programs for Our Survival (3)

• Midbrain
  – Involved in reflexive movement of the eyes and body
  – Substantia nigra: Initiation of voluntary motor activity
    • This region is critical for the production of dopamine
    • Parkinson’s disease is caused by the death of substantia nigra cells and the resulting loss of dopamine produced by those cells
The Hindbrain and Midbrain House
Basic Programs for Our Survival (4)
Forebrain Subcortical Structures Control Our Motivations and Emotions (1)

• The forebrain includes two main areas: The cerebral cortex and the five subcortical structures

1. **Thalamus:** A subcortical forebrain structure; the gateway to the brain for almost all incoming sensory information before that information reaches the cortex

2. **Hypothalamus:** A subcortical forebrain structure involved in regulating bodily functions. The hypothalamus also influences our basic motivated behaviors
Forebrain Subcortical Structures Control Our Motivations and Emotions (2)

3. **Hippocampus**: A subcortical forebrain structure that is associated with the formation of memories

4. **Amygdala**: A subcortical forebrain structure that serves a vital role in our learning to associate things with emotional responses and in processing emotional information

5. **Basal ganglia**: Motor planning and movement, reward

– Some of these structures belong to the limbic system
Forebrain Subcortical Structures Control Our Motivations and Emotions (4)

- Cerebral cortex (thought, planning)
- Basal ganglia (motor planning and movement, reward)
- Thalamus (sensory gateway for seeing, hearing, etc.)
- Hypothalamus (regulates body functions and motivates behaviors)
- Hippocampus (formation of memories)
- Amygdala (associates emotions with experiences)
Forebrain Subcortical Structures Control Our Motivations and Emotions (5)

• The outer layer of the forebrain is called the cerebral cortex
  – The cortex is divided into two halves. These halves are called the left hemisphere and the right hemisphere
  – Each cerebral hemisphere has four areas, which are called lobes
    • Occipital
    • Parietal
    • Temporal
    • Frontal
Forebrain Subcortical Structures Control Our Motivations and Emotions (6)
The Cerebral Cortex of the Forebrain Processes Our Complex Mental Activity (1)

• The outer layer of the forebrain is called the cerebral cortex
  – The hemispheres are connected by a structure called the corpus callosum, which is a massive bridge consisting of millions of axons
  • Studying split-brain patients has revealed important insights into how the two hemispheres are specialized for certain functions
The Cerebral Cortex of the Forebrain Processes Our Complex Mental Activity (3)

• Lobes of the cerebral cortex
  – **Occipital lobes**: Regions of the cerebral cortex at the back of the brain; these regions are important for vision
  – **Parietal lobes**: Regions of the cerebral cortex in front of the occipital lobes and behind the frontal lobes; these regions are important for the sense of touch and for picturing the layout of spaces in an environment
    • “Homunculus”
The Cerebral Cortex of the Forebrain Processes Our Complex Mental Activity (4)
The Cerebral Cortex of the Forebrain Processes Our Complex Mental Activity (6)

- **Temporal lobes**: Regions of the cerebral cortex below the parietal lobes and in front of the occipital lobes; these regions are important for processing auditory information and for perceiving objects and faces.

- **Frontal lobes**: Regions of the cerebral cortex at the front of the brain; these regions are important for movement and complex processes (rational thought, attention, and social processes).
The Cerebral Cortex of the Forebrain Processes Our Complex Mental Activity (7)

• Prefrontal cortex
  – 30 percent of the brain
    • The difference between the human brain and the brains of other animals lies in the complexity and organization of neural circuits
  – Phineas Gage
    • Studying damaged brains
  – A lobotomy is a deliberate damaging of the prefrontal cortex to control behavior
2.3 How Do Our Brains Communicate With Our Bodies?

• The peripheral nervous system has two primary components
  – The somatic nervous system
  – The autonomic nervous system

• **Somatic nervous system**
  – A part of the peripheral nervous system; this part transmits sensory signals and motor signals between the central nervous system and the skin, muscles, and joints
Our Autonomic Nervous System Regulates the Body Automatically (1)

- **Autonomic nervous system**
  - A part of the peripheral nervous system; this part transmits sensory signals and motor signals between the central nervous system and the body’s glands and internal organs
  - The autonomic nervous system has two divisions
    - The sympathetic nervous system and the parasympathetic nervous system
      - Both divisions control the activity of organs and glands
The Endocrine System Affects Our Behavior Through Hormones (1)

• **Endocrine system**
  – A communication system that uses hormones to influence thoughts and actions

• **Hormones**
  – Chemical substances, released from endocrine glands, that travel through the bloodstream to targeted tissues; the tissues are later influenced by the hormones
The Endocrine System Affects Our Behavior Through Hormones (2)
The Endocrine System Affects Our Behavior Through Hormones (3)

• Hormones, sexual development, and behavior
  – Gonads: The testes in males and the ovaries in females
    • Androgens, such as testosterone, are more prevalent in males
    • Estrogens, such as estradiol, are more prevalent in females

• Hormones and physical growth
  – Growth hormone (GH) prompts bone, cartilage, and muscle tissue to grow and helps them regenerate after injury
2.4 How Do Nature and Nurture Affect Our Brains?

- **Genes**
  - The units of heredity, which partially determine an organism’s characteristics

- **Huntington’s Disease**
  - A disorder that affects the nervous system and damages specific parts of the brain

- Your genetic makeup is called your genotype

- Your observable physical and psychological characteristics are called your phenotype
Genes Interact With Environment to Influence Us

• The study of how genes and environment interact to influence psychological factors is known as behavioral genetics
  – **Monozygotic twins**: Identical twins; these siblings result from one zygote splitting in two, so they share the same genes
  – **Dizygotic twins**: Fraternal twins; these siblings result from two separately fertilized eggs, so they are no more similar genetically than non-twin siblings
The Endocrine System Affects Our Behavior Through Hormones

(a) Monozygotic (identical) twins

One sperm fertilizes one egg ...  ... and the zygote splits in two.

(b) Dizygotic (fraternal) twins

Two sperm fertilize two eggs ...  ... which become two zygotes.

Figure 2.26
Environment Changes Our Brains (1)

• **Plasticity**
  – A property of the brain that causes it to change through experience, drugs, or injury
  • Plasticity reflects the interactive nature of biological and environmental influences
Environment Changes Our Brains (3)

- Strengthening existing connections
  - Neurons that fire together, wire together
- Brain reorganization
  - Entirely new connections develop between neurons. This new growth is a major factor in recovery from brain injury
    - Brain reorganization is much more common in children than in adults