Chapter 3
Biological Processes
What’s It For? Biological Solutions

- Communicating internally
- Initiating and coordinating behavior
- Regulating growth and other internal functions
- Adapting and transmitting the genetic code
Communicating Internally: Learning Goals

1. Describe the structure, type, and function of neurons.
2. Explain how neurons transmit information.
3. Discuss how neurons work together to communicate.
Cells in the Nervous System

• Neurons -- receive, transmit, integrate information
  – Sensory: messages to spinal cord, brain
  – Interneurons: connect sensory, motor neurons
  – Motor neurons: messages from spinal cord, brain
• Glial cells -- “support” cells
• Reflexes
  – Processed in spinal cord, not brain
Anatomy of a Neuron: Overview

- Dendrites
- Soma
- Axon
- Terminal buttons
Dendrites

- Receive information
- 1000s of branches
  - Enable receiving information from many sources
Soma

• Main “body” of the cell
• Metabolic center
• Genetic material stored here
• Information is processed here
Axon

• Transmits information
• Action potential travels down the axon to other neurons
• Terminal buttons on end
  – These release chemicals
Main Parts of the Neuron: A Review

- The three main parts of a neuron are highlighted in this video. Other parts described include the nucleus, nucleolus, and axon hillock.
Neural Transmission

• Synapse: Tiny gap between the terminal buttons of one neuron and the dendrite of the next one
• Chemicals flow into the synapse from the terminal buttons
• Neural transmission:
  – Dendrites->Soma->Axon->Terminal Buttons
Resting Potential

• Tiny charge between inside, outside of neuron
• Created by electrically charged particles (ions)
  – Some (sodium, chloride) concentrated outside cell
  – Some concentrated (potassium) inside cell
• Maintained by sodium-potassium pump and selectively permeable cell membrane
The Action Potential

• Change in potential, primarily because of messages from other neurons

• Excitatory messages:
  – Cell loses the negative charge
    • Depolarization

• Inhibitory messages:
  – Cell becomes more negatively charged
    • Hyperpolarization
About The Action Potential

• “All or none”
  – Do not vary in strength or intensity
• Travel down the axon between 2 and 200 m.p.h.
• Speed increased if neuron is myelinated
  – Nodes of Ranvier
  – Saltatory conduction
Neurotransmitters

• When action potential reaches the end of the axon, it triggers vesicles (sacs) in the terminal buttons to release chemicals called neurotransmitters
• These activate receptors in the postsynaptic membrane
• May be excitatory or inhibitory, depending on the receptor
Example Neurotransmitters

- Acetylcholine
  - Involved in triggering muscles to contract
- Dopamine
  - Inhibitory effects
  - Involved in schizophrenia, Parkinson’s disease
- Serotonin
  - Involved in sleep and dreaming
- Gamma-amino-butyric acid (GABA)
  - Involved in regulating anxiety
Psychology, Fifth Edition, James S. Nairne
Chapter 3

Neural impulse
Myelin sheath
Presynaptic neuron
Terminal button
Synapse
Vesicles containing neurotransmitters
Neurotransmitter molecules diffuse throughout the synapse
Postsynaptic dendrite
Postsynaptic membrane
Sodium ion
Neurotransmitter binding site (receptor)
Membrane
Ion channel
Synapse
Sodium ion channel open
Inside postsynaptic cell
Sodium ion channel closed

Neurotransmitters bind to receptor, opening the ion channel and allowing sodium ions to flow into the postsynaptic cell.
Drugs and the Brain

• Agonists
  – Mimic the action of neurotransmitters
  – Example: Nicotine mimics acetylcholine

• Antagonists
  – Block the action of neurotransmitters
  – Example: Curare blocks acetylcholine

• Neuromodulators
  – Increase or decrease effectiveness of other neurotransmitters
  – Example: Endorphins
The Communication Network

• Behaviors, thoughts, feelings, arise from pattern of activation across many neurons, not from just one neuron

• Firing rate also communicates information
  – Number of action potentials generated per unit of time
  – Refractory period limits firing rate

• Artificial neural networks can be used to simulate brain’s neural systems
Initiating Behavior: Learning Goals

1. Describe the basic organization of the nervous system.
2. Explain the techniques researchers use to study the brain.
3. Describe the major structures of the brain and their functions.
4. Discuss how the two hemispheres coordinate brain functions.
Organization of the Nervous System

• Central
  – Brain and spinal cord
• Peripheral
  – Somatic
  – Autonomic
    • Sympathetic
      – Prepares body for emergencies
    • Parasympathetic
      – Calms the body down
Techniques for Studying the Brain

• Brain damage
  – Case study approach
• Activating the brain electrically or chemically
• Monitoring the brain
  – Electroencephalograph (EEG)
  – Computerized tomography (CT)
  – Positron emission tomography (PET)
  – Magnetic resonance imaging (MRI)
Major Structures of the Brain

- Hindbrain
- Midbrain
- Forebrain
Hindbrain

- Main function: “Life support”
  - Substructures:
    - Medulla and Pons -- reflexes, heart rate, respiration, blood pressure
    - Reticular formation -- sleep, arousal
    - Cerebellum -- complex movements
Midbrain

• Main function: “Relay stations”
  – Coordinates sensory information

• Substructures:
  – Tectum
    • Superior colliculus
    • Inferior colliculus
  – Substantia nigra
Forebrain

• Main function: “Higher” mental processes
• Substructures:
  – Cerebral cortex -- outer covering
  – Thalamus -- sensory relay
  – Hypothalamus -- motivated behavior
  – Limbic system -- motivation, emotion, memory
    • amygdala (emotion), hippocampus (memory)
Cerebral cortex

Thalamus

Hypothalamus

Pituitary gland

Amygdala

Hippocampus
Cerebral Cortex

• Left/right hemispheres
• Divided into lobes:
  – Frontal: planning, decision making, memory, personality
  – Parietal: processing sensations of touch, temperature, pain
  – Temporal: auditory processing, speech, language comprehension (left hemisphere)
  – Occipital: vision
The Case of Phineas Gage

• Illustrates effects of damage to the cerebral cortex
• Railroad construction accident, 1848
• Iron rod driven through skull
  – Frontal lobe damage
• Gage survived
• Personality changes:
  – Unpredictable
  – Crude
The Divided Brain

• In general, left side of cortex handles information from the right side of body/space, and vice versa

• Information does eventually go to both hemispheres
  – Corpus callosum transfers information across hemispheres

• Studies of split-brain patients have told us a great deal about divisions in the brain
Hemispheric Specialization

• Right hemisphere: Spatial tasks, emotions
• Left hemisphere: Verbal tasks
• Is there any such thing as being “left brained” or “right brained?”
  – Not according to well-designed studies
  – Hemispheres normally share information, work together
Regulating Growth and Internal Functions: Learning Goals

• Explain how the endocrine system controls long-term and widespread communication needs.

• Discuss the role hormones play in gender-specific behaviors.
The Endocrine System

- Communication system that uses the bloodstream rather than neurons
- Hormones
  - Chemicals released by endocrine glands
  - Unlike nervous system, relatively slow, longer lasting messages
  - Coordinates with nervous system
How the Endocrine System Works

• Hypothalamus controls pituitary gland
• Pituitary controls secretion of hormones from sites in the body
• Examples
  – Testes: Testosterone
  – Ovaries: Estrogen
  – Adrenal glands: Norepinephrine and epinephrine
Hypothalamus
Stimulates adrenal glands.

Adrenal Glands
Secrete norepinephrine and epinephrine into bloodstream.

Norepinephrine and Epinephrine
Cause energy surge and heart rate increase; blood is shunted away from the stomach and intestine to areas that require it; glucose is made available to the muscles.
Are There Gender Effects?

- Hormones determine whether male or female sex organs develop prenatally
- Possible effect on brain development as well
- Some gender effects on task performance
  - Men outperform women on spatial tasks; reverse is true for verbal tasks
- Prenatal hormone exposure has some effect on behavior in childhood
- However: Many gender differences are small
Adapting and Transmitting the Genetic Code: Learning Goals

• Review natural selection and adaptation.
• Describe the basic principles of genetic transmission.
• Explain how psychologists study genetic influences on behavior.
Natural Selection and Adaptations

• Traits are inherited via genes
• Traits can be psychological as well as physical
  – More likely to be passed to offspring if they aid in finding a mate, increase chance of survival
• Natural selection
  – Adaptations: Features selected by nature because they increase odds of survival
Genetic Principles

• Chromosomes: Strips of DNA
  – Half come from mother, half from father
• Genes: Segments of chromosomes that influence particular characteristics
  – Examples: height, hair color
• Dominant genes may mask recessive ones
• Genes may mutate (spontaneously change)
How Genes Translate Into Traits

• Phenotype: What you can observe about the trait
  – Example: A person’s weight

• Phenotype influenced by:
  – Genotype (genes)
  – Environment

• So: “Final product” usually influenced by heredity AND environment
Studying the Gene-Behavior Link

• Family studies
  – Similarities/differences among blood relatives
  – But: Shared environment may also play a role

• Twin studies
  – Degree of similarity between identical twins vs. fraternal (nonidentical) twins