Chapter 2

Neuroscience and Behavior
Neural Communication

- **Biological Psychology**
  - branch of psychology concerned with the links between biology and behavior
  - some biological psychologists call themselves *behavioral neuroscientists, neuropsychologists, behavior geneticists, physiological psychologist, or biopsychologists*

- **Neuron**
  - a nerve cell
  - the basic building block of the nervous system
Neural Communication

- **Dendrite**
  - the bushy, branching extensions of a neuron that receive messages and conduct impulses toward the cell body

- **Axon**
  - the extension of a neuron, ending in branching terminal fibers, through which messages are sent to other neurons or to muscles or glands

- **Myelin [MY-uh-lin] Sheath**
  - a layer of fatty cells segmentally encasing the fibers of many neurons
  - enables vastly greater transmission speed of neutral impulses
Neural Communication

- **Dendrites**: receive messages from other cells
- **Axon**: passes messages away from the cell body to other neurons, muscles, or glands
- **Myelin sheath**: covers the axon of some neurons and helps speed neural impulses
- **Neural impulse**: electrical signal traveling down the axon
- **Terminal branches of axon**: form junctions with other cells
Neural Communication

- **Action Potential**
  - a neural impulse; a brief electrical charge that travels down an axon
  - generated by the movement of positively charges atoms in and out of channels in the axon’s membrane

- **Threshold**
  - the level of stimulation required to trigger a neural impulse
Neural Communication

- **Synapse [SIN-aps]**
  - junction between the axon tip of the sending neuron and the dendrite or cell body of the receiving neuron
  - tiny gap at this junction is called the *synaptic gap* or *cleft*

- **Neurotransmitters**
  - chemical messengers that traverse the synaptic gaps between neurons
  - when released by the sending neuron, neurotransmitters travel across the synapse and bind to receptor sites on the receiving neuron, thereby influencing whether it will generate a neural impulse
Neural Communication

Diagram showing the process of neural communication, with labels for parts such as sending neuron, receiving neuron, axon, synaptic vesicles, presynaptic membrane, postsynaptic membrane, and binding sites on ion channels.
Neural Communication

Serotonin Pathways

Dopamine Pathways
# Neural Communication

## SOME NEUROTRANSMITTERS AND THEIR FUNCTIONS

<table>
<thead>
<tr>
<th>Neurotransmitter</th>
<th>Function</th>
<th>Examples of Malfunctions</th>
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<tbody>
<tr>
<td>Acetylcholine (ACh)</td>
<td>Enables muscle action, learning, and memory</td>
<td>Undersupply, as ACh-producing neurons deteriorate, marks Alzheimer's disease</td>
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<tr>
<td>Dopamine</td>
<td>Influences movement, learning, attention, and emotion</td>
<td>Excess dopamine receptor activity linked to schizophrenia; starved of dopamine, the brain produces the tremors and decreased mobility of Parkinson's disease</td>
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<tr>
<td>Serotonin</td>
<td>Affects mood, hunger, sleep, and arousal</td>
<td>Undersupply linked to depression; Prozac and some other antidepressant drugs raise serotonin levels</td>
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<tr>
<td>Norepinephrine</td>
<td>Helps control alertness and arousal</td>
<td>Undersupply can depress mood</td>
</tr>
<tr>
<td>GABA (gamma-aminobutyric acid)</td>
<td>A major inhibitory neurotransmitter</td>
<td>Undersupply linked to seizures, tremors, and insomnia</td>
</tr>
<tr>
<td>Glutamate</td>
<td>A major excitatory neurotransmitter; involved in memory</td>
<td>Oversupply can overstimulate brain, producing migraines or seizures (which is why some people avoid MSG, monosodium glutamate, in food)</td>
</tr>
</tbody>
</table>
Neural Communication

- **Acetylcholine** [ah-seat-el-KO-leen]
  - a neurotransmitter that, in addition to its role in learning and memory, triggers muscle contraction

- **Endorphins** [en-DOR-fins]
  - “morphine within”
  - natural, opiatelike neurotransmitters
  - linked to pain control and to pleasure
Neural Communication

- Neurotransmitter molecule
- Receiving cell membrane
- Receptor site on receiving neuron
- Agonist mimics neurotransmitter
- Antagonist blocks neurotransmitter
The Nervous System

- Nervous System
  - the body’s speedy, electrochemical communication system
  - consists of all the nerve cells of the peripheral and central nervous systems

- Central Nervous System (CNS)
  - the brain and spinal cord

- Peripheral Nervous System (PNS)
  - the sensory and motor neurons that connect the central nervous system (CNS) to the rest of the body
The Nervous System

Nervous system

Peripheral
  - Autonomic (controls self-regulated action of internal organs and glands)
    - Sympathetic (arousing)
    - Parasympathetic (calming)
  - Skeletal (controls voluntary movements of skeletal muscles)

Central (brain and spinal cord)
The Nervous System

- **Nerves**
  - neural “cables” containing many axons
  - part of the peripheral nervous system
  - connect the central nervous system with muscles, glands, and sense organs

- **Sensory Neurons**
  - neurons that carry incoming information from the sense receptors to the central nervous system
The Nervous System

- **Interneurons**
  - CNS neurons that internally communicate and intervene between the sensory inputs and motor outputs

- **Motor Neurons**
  - carry outgoing information from the CNS to muscles and glands

- **Somatic Nervous System**
  - the division of the peripheral nervous system that controls the body's skeletal muscles
The Nervous System

- **Autonomic Nervous System**
  - the part of the peripheral nervous system that controls the glands and the muscles of the internal organs (such as the heart)

- **Sympathetic Nervous System**
  - division of the autonomic nervous system that arouses the body, mobilizing its energy in stressful situations

- **Parasympathetic Nervous System**
  - division of the autonomic nervous system that calms the body, conserving its energy
The Nervous System
The Nervous System

CENTRAL NERVOUS SYSTEM

Brain

PARASYMPATHETIC

Contracts pupil
Stimulates salivation (strongly)

Spinal cord

Constricts bronchi

Slows heartbeat

Stimulates activity

Stimulates gallbladder

Contracts bladder

Stimulates erection of sex organs

Gallbladder
The Nervous System

Reflex

- a simple, automatic, inborn response to a sensory stimulus
The Brain

- **Brainstem**
  - the oldest part and central core of the brain, beginning where the spinal cord swells as it enters the skull
  - responsible for automatic survival functions
- **Medulla [muh-DUL-uh]**
  - base of the brainstem
  - controls heartbeat and breathing
The Brain

- **Reticular Formation**
  - a nerve network in the brainstem that plays an important role in controlling arousal

- **Thalamus [THAL-uh-muss]**
  - the brain’s sensory switchboard, located on top of the brainstem
  - it directs messages to the sensory receiving areas in the cortex and transmits replies to the cerebellum and medulla
The Brain
The Brain

- **Cerebellum** [sehr-uh-BELL-um]
  - the “little brain” attached to the rear of the brainstem
  - it helps coordinate voluntary movement and balance
Lesion

- tissue destruction
- a brain lesion is a naturally or experimentally caused destruction of brain tissue
Electroencephalogram (EEG)

- an amplified recording of the waves of electrical activity that sweep across the brain’s surface
- these waves are measured by electrodes placed on the scalp
The Brain

- **Computed Tomography (CT) Scan**
  - a series of x-ray photographs taken from different angles and combined by computer into a composite representation of a slice through the body. Also called *CAT scan*

- **Positron Emission Tomography (PET) Scan**
  - a visual display of brain activity that detects where a radioactive form of glucose goes while the brain performs a given task

- **Magnetic Resonance Imaging (MRI)**
  - a technique that uses magnetic fields and radio waves to produce computer-generated images that distinguish among different types of soft tissue; allows us to see structures within the brain
PET Scan
The Brain

- **Limbic System**
  - a doughnut-shaped system of neural structures at the border of the brainstem and cerebral hemispheres
  - associated with emotions such as fear and aggression and drives such as those for food and sex
  - includes the hippocampus, amygdala, and hypothalamus.

- **Amygdala** [ah-MIG-dah-la]
  - two almond-shaped neural clusters that are components of the limbic system and are linked to emotion
The Brain

- **Hypothalamus**
  - neural structure lying below (hypo) the thalamus; directs several maintenance activities
    - eating
    - drinking
    - body temperature
  - helps govern the endocrine system via the pituitary gland
  - is linked to emotion
The Limbic System

- Hypothalamus
- Pituitary gland
- Amygdala
- Hippocampus
The Limbic System

- Electrode implanted in reward center
The Cerebral Cortex

- **Cerebral Cortex**
  - the intricate fabric of interconnected neural cells that covers the cerebral hemispheres
  - the body’s ultimate control and information processing center

- **Glial Cells**
  - cells in the nervous system that support, nourish, and protect neurons
The Cerebral Cortex

- **Frontal Lobes**
  - involved in speaking and muscle movements and in making plans and judgments

- **Parietal Lobes**
  - include the sensory cortex

- **Occipital Lobes**
  - include the visual areas, which receive visual information from the opposite visual field

- **Temporal Lobes**
  - include the auditory areas
The Cerebral Cortex

Frontal lobe

Parietal lobe

Occipital lobe

Temporal lobe
The Cerebral Cortex

- **Motor Cortex**
  - area at the rear of the frontal lobes that controls voluntary movements

- **Sensory Cortex**
  - area at the front of the parietal lobes that registers and processes body sensations
The Cerebral Cortex

Output: Motor cortex
(Left hemisphere section controls the body’s right side)

Input: Sensory cortex
(Left hemisphere section receives input from the body’s right side)
The Cerebral Cortex

- Functional MRI scan shows the visual cortex activated as the subject looks at faces.
Visual and Auditory Cortex
Association Areas

- More intelligent animals have increased “uncommitted” or association areas of the cortex
Aphasia
- impairment of language, usually caused by left hemisphere damage either to Broca’s area (impairing speaking) or to Wernicke’s area (impairing understanding)

Broca’s Area
- an area of the left frontal lobe that directs the muscle movements involved in speech

Wernicke’s Area
- an area of the left temporal lobe involved in language comprehension and expression
Specialization and Integration

1. Visual cortex
   (receives written words as visual stimulation)

2. Angular gyrus
   (transforms visual representations into an auditory code)

3. Wernicke’s area
   (interprets auditory code)

4. Broca’s area
   (controls speech muscles via the motor cortex)

5. Motor cortex
   (word is pronounced)
Specialization and Integration

- Brain activity when hearing, seeing, and speaking words

(a) Hearing  
(b) Seeing  
(c) Speaking
Brain Structures and their Functions

- **Corpus callosum:** axon fibers connecting two cerebral hemispheres
- **Thalamus:** relays messages between lower brain centers and cerebral cortex
- **Hypothalamus:** controls maintenance functions such as eating; helps govern endocrine system; linked to emotion and reward
- **Pituitary:** master endocrine gland
- **Reticular formation:** helps control arousal
- **Medulla:** controls heartbeat and breathing
- **Spinal cord:** pathway for neural fibers traveling to and from brain; controls simple reflexes
- **Cerebellum:** coordinates voluntary movement and balance

- **Amygdala:** neural centers in the limbic system linked to emotion
- **Hippocampus:** a structure in the limbic system linked to memory

- **Cerebral cortex:** ultimate control and information-processing center
Brain Reorganization

- Plasticity
  - the brain’s capacity for modification, as evident in brain reorganization following damage (especially in children) and in experiments on the effects of experience on brain development
Our Divided Brain

- Corpus Callosum
  - large band of neural fibers
  - connects the two brain hemispheres
  - carries messages between the hemispheres
Our Divided Brain

- The information highway from the eye to the brain
Split Brain

- a condition in which the two hemispheres of the brain are isolated by cutting the connecting fibers (mainly those of the corpus callosum) between them
Split Brain

“Look at the dot.”

Two words separated by a dot are momentarily projected.

“What word did you see?”

or

“Point with your left hand to the word you saw.”

“Art”
The Endocrine System

- Endocrine System
  - the body’s “slow” chemical communication system
  - a set of glands that secrete hormones into the bloodstream
Neural and Hormonal Systems

- **Hormones**
  - chemical messengers, mostly those manufactured by the endocrine glands, that are produced in one tissue and affect another

- **Adrenal [ah-DREEN-el] Glands**
  - a pair of endocrine glands just above the kidneys
  - secrete the hormones epinephrine (adrenaline) and norepinephrine (noradrenaline), which help to arouse the body in times of stress

- **Pituitary Gland**
  - under the influence of the hypothalamus, the pituitary regulates growth and controls other endocrine glands