Chapter 3

The Biological basis of Behavior
PSY 100

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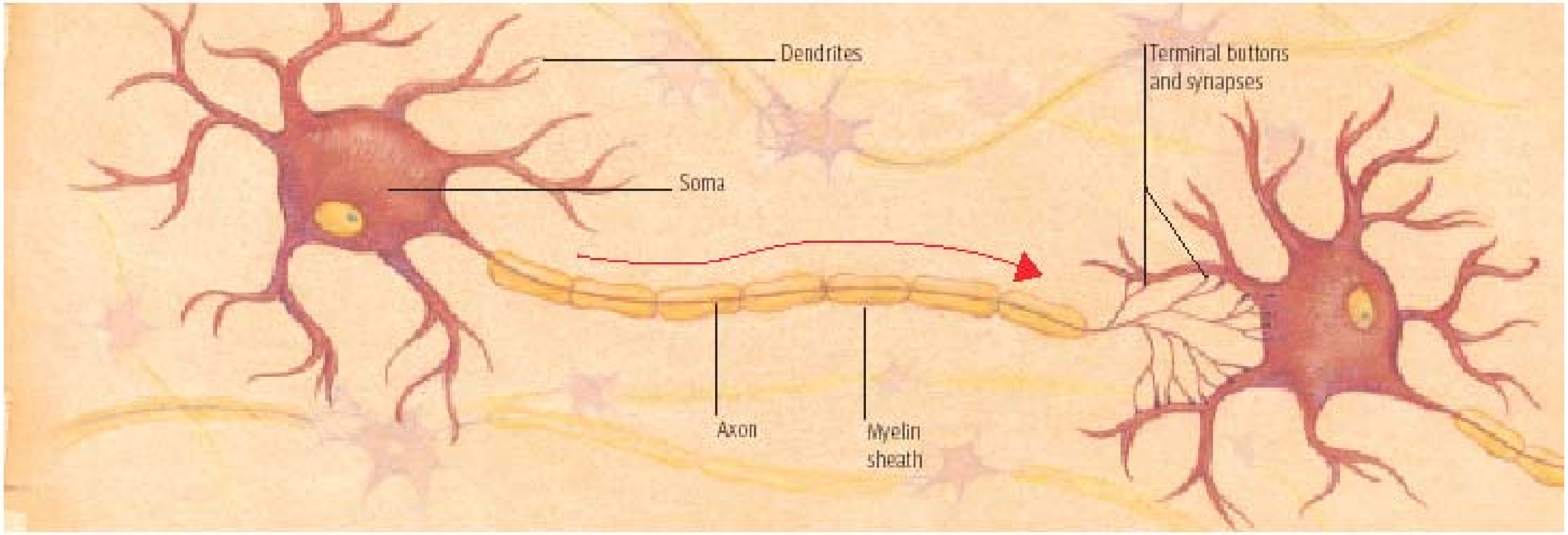
Communication in the Nervous System

- Hardware:
  - **Glia** – structural support and insulation
  - **Neurons** – communication
  - **Soma** – cell body
  - **Dendrites** – receive
  - **Axon** – transmit away


Dendrites
Soma
Axon
Myelin
sheath
Terminal buttons
and synapses

Neural Communication: Insulation and Information Transfer

- **Myelin sheath** – speeds up transmission
- **Terminal Button** – end of axon; secretes neurotransmitters
- **Neurotransmitters** – chemical messengers
- **Synapse** – point at which neurons interconnect

The Neural Impulse: Electrochemical Beginnings

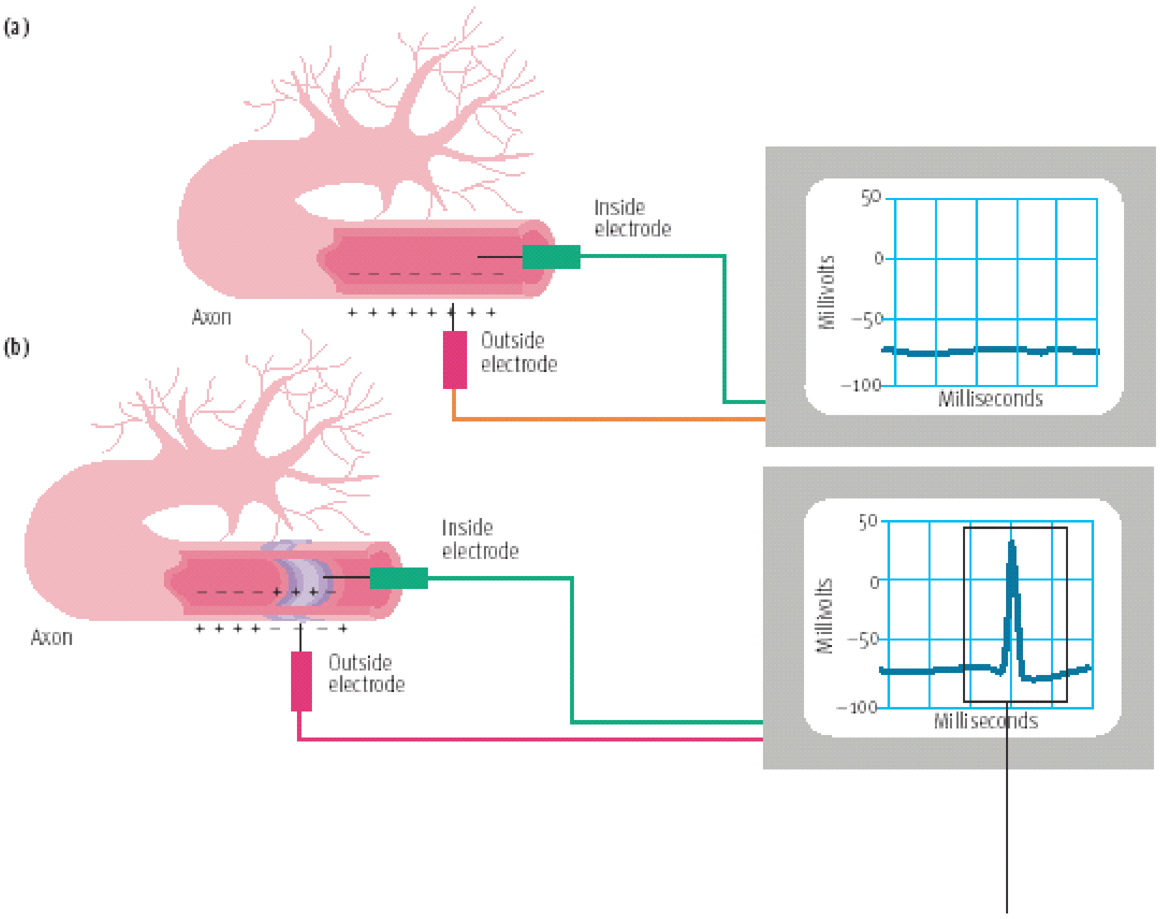
- **Hodgkin & Huxley (1952)** - giant squid
  - Fluids inside and outside neuron
  - Electrically charged particles (ions)
  - Neuron at rest – negative charge on inside compared to outside
  - -70 millivolts – **resting potential**

The Neural Impulse: The Action Potential

- Stimulation causes cell membrane to open briefly
- Positively charged sodium ions flow in
- Shift in electrical charge travels along neuron
- **The Action Potential**
- **All – or – none law**

Figure 3.2

The neural impulse. The electric charge of a neuron can be measured with a pair of electrodes connected to an oscilloscope. **(a)** At rest, the neuron is like a tiny wet battery with a resting potential of about −70 millivolts. **(b)** When a neuron is stimulated, a sharp jump in its electric potential occurs, resulting in a spike on the oscilloscope recording of the neuron's electrical activity. This change in voltage, called an action potential, travels along the axon. **(c)** Biochemical changes propel the action potential along the axon. An action potential begins when sodium gates in the membrane of an axon open, permitting positively charged sodium ions to flow into the axon. **(d)** The potassium gates have opened to let potassium ions flow outward. At the next point along the axon membrane, sodium gates open and the process is repeated, thus allowing the action potential to move along the axon. **(e)** This blowup of the voltage spike associated with an action potential depicts how these biochemical changes relate to the electrical activity of the cell..



The Synapse: Chemicals as Signal Couriers

- **Synaptic cleft**
- **Presynaptic neuron**
  - Synaptic vesicles
  - Neurotransmitters
- **Postsynaptic neuron**
  - Receptor sites

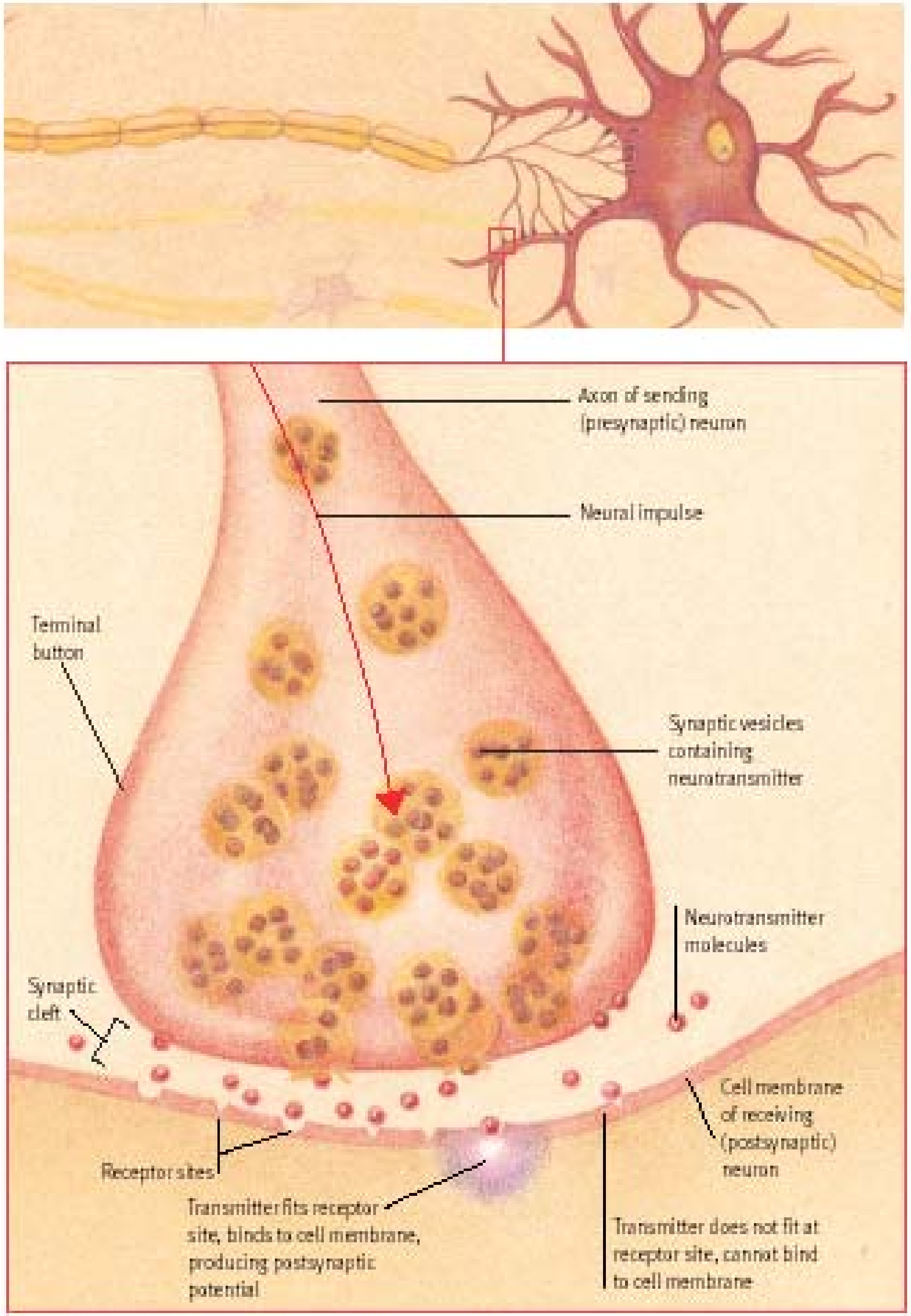


Figure 3.3

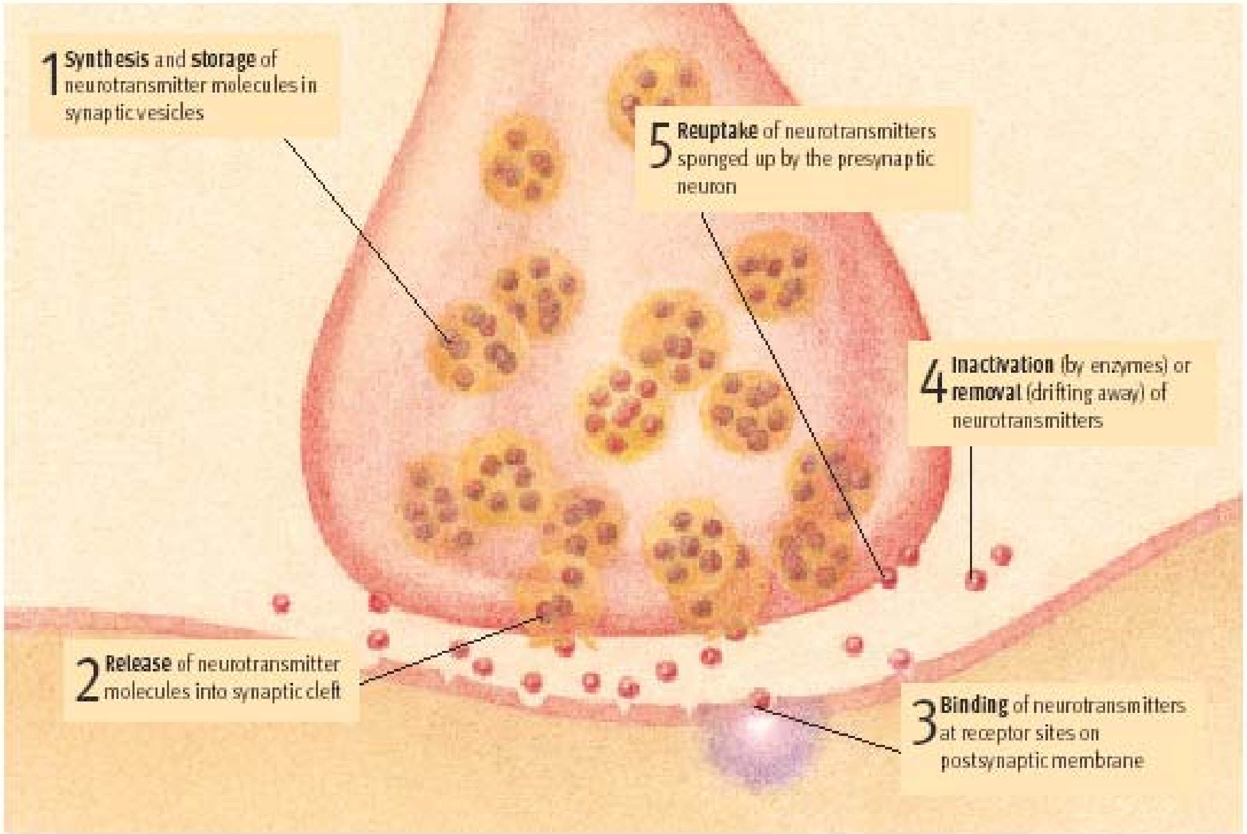
The synapse. When a neural impulse reaches an axon's terminal buttons, it triggers the release of chemical messengers called neurotransmitters. The neurotransmitter molecules diffuse across the synaptic cleft and bind to receptor sites on the postsynaptic neuron. A specific neurotransmitter can bind only to receptor sites that its molecular structure will fit into, much like a key must fit a lock..

When a Neurotransmitter Binds: The Postsynaptic Potential

- Voltage change at receptor site – **postsynaptic potential (PSP)**
  - Not all-or-none
  - Changes the probability of the postsynaptic neuron firing
- Positive voltage shift – **excitatory PSP**
- Negative voltage shift – **inhibitory PSP**

Figure 3.4

Overview of synaptic transmission. The main elements in synaptic transmission are summarized here, superimposed on a blowup of the synapse seen in Figure 3.3. The five key processes involved in communication at synapses are (1) synthesis and storage, (2) release, (3) binding, (4) inactivation or removal, and (5) reuptake of neurotransmitters. As you'll see in this chapter and the remainder of the book, the effects of many phenomena—such as pain, drug use, and some diseases—can be explained in terms of how they alter one or more of these processes (usually at synapses releasing a specific neurotransmitter)..



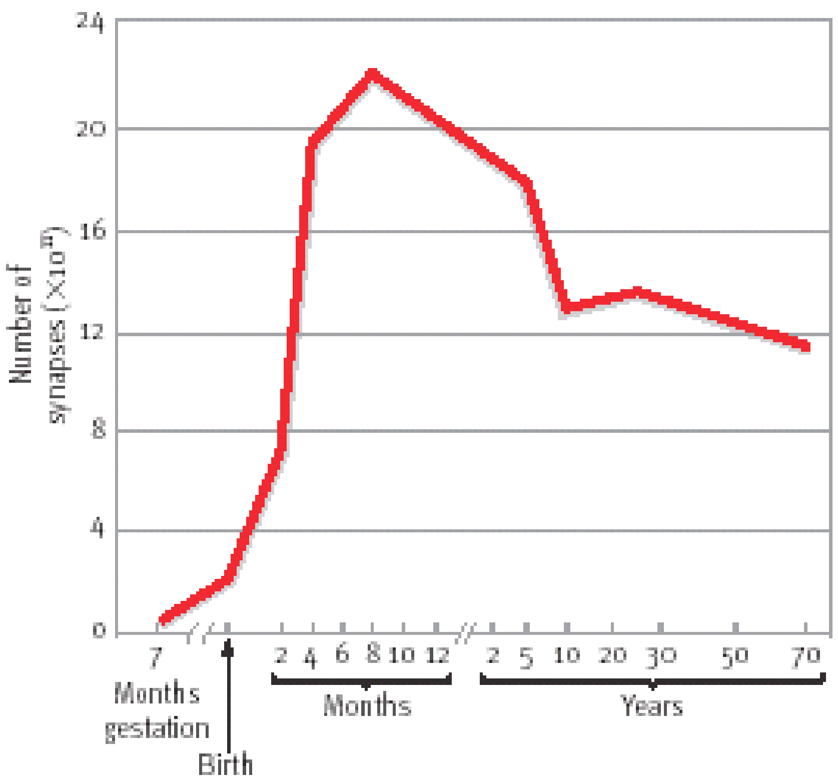
Signals: From Postsynaptic Potentials to Neural Networks

- One neuron, signals from thousands of other neurons
- Requires integration of signals
  - PSPs add up, balance out
  - Balance between IPSPs and EPSPs
- Neural networks
  - Patterns of neural activity
  - Interconnected neurons that fire together or sequentially
- Synaptic connections
  - Elimination and creation
  - Synaptic pruning

Figure 3.5

Synaptic pruning. This graph summarizes data on the estimated number of synapses in the human visual cortex as a function of age (Huttenlocher, 1994). As you can see, the number of synapses in this area of the brain peaks around age 1 and then mostly declines over the course of the life span. This decline reflects the process of *synaptic pruning*, which involves the gradual elimination of less active synapses.

SOURCE: Data based on Huttenlocher, P. R. (1994). Synaptogenesis in human cerebral cortex. In G. Dawson & K. W. Fischer (Eds.), *Human behavior and the developing brain.* New York: Guilford Press. Graphic adapted from Kolb, B. & Whishaw, I. Q. (2001). *An introduction to brain and behavior.* New York: Worth Publishers.



Neurotransmitters

- Specific neurotransmitters work at specific synapses
  - Lock and key mechanism
- **Agonist** – mimics neurotransmitter action
- **Antagonist** – opposes action of a neurotransmitter
- 15 – 20 neurotransmitters known at present
- Interactions between neurotransmitter circuits

Table 3.1 Common Neurotransmitters and Some of Their Functions

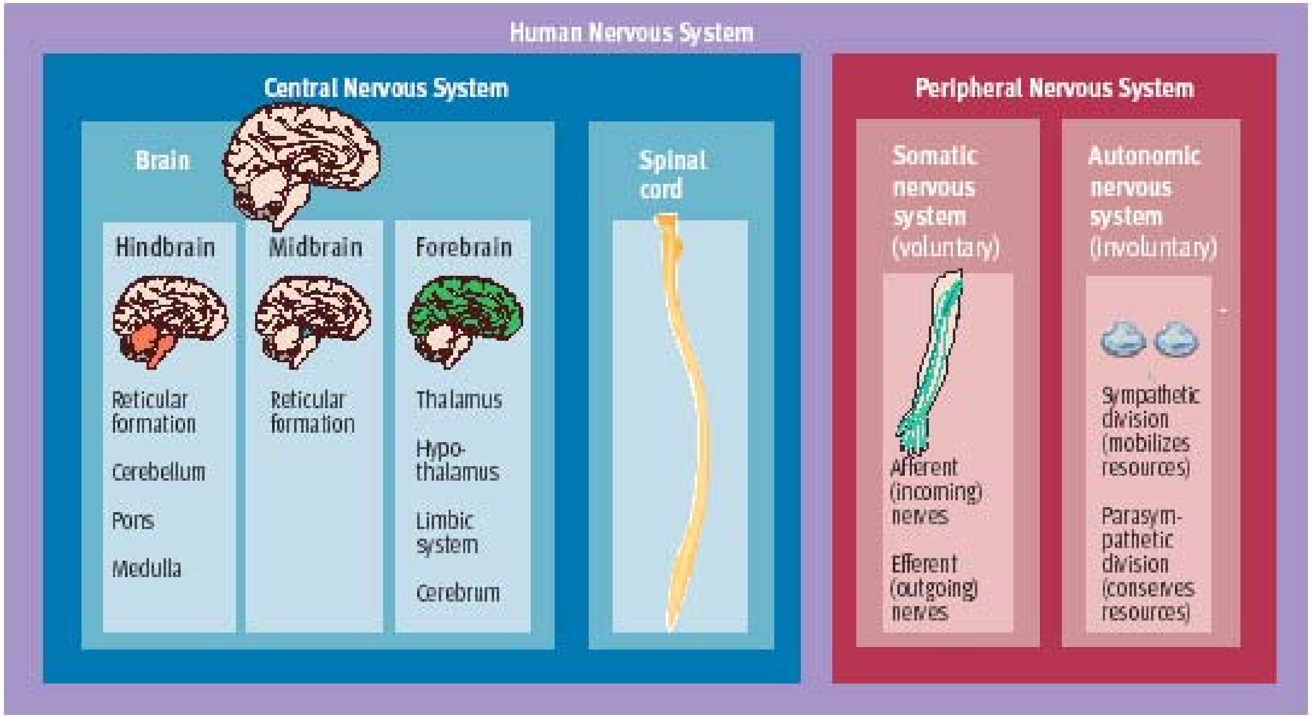
Neurotransmitter	Functions and Characteristics
Acetylcholine (ACh)	Activates motor neurons controlling skeletal muscles Contributes to the regulation of attention, arousal, and memory Some ACh receptors stimulated by nicotine
Dopamine (DA)	Contributes to control of voluntary movement, pleasurable emotions Decreased levels associated with Parkinson's disease Overactivity at DA synapses associated with schizophrenia Cocaine and amphetamines elevate activity at DA synapses
Norepinephrine (NE)	Contributes to modulation of mood and arousal Cocaine and amphetamines elevate activity at NE synapses
Serotonin	Involved in regulation of sleep and wakefulness, eating, aggression Abnormal levels may contribute to depression and obsessive-compulsive disorder Prozac and similar antidepressant drugs affect serotonin circuits
GABA	Serves as widely distributed inhibitory transmitter Valium and similar antianxiety drugs work at GABA synapses
Endorphins	Resemble opiate drugs in structure and effects Contribute to pain relief and perhaps to some pleasurable emotions

Organization of the Nervous System

- **Central nervous system (CNS)** – brain and spinal cord
  - **Afferent** = toward the CNS/ **Efferent** = away from the CNS
- **Peripheral nervous system** – nerves that lie outside the central nervous system
  - **Somatic nervous system**– voluntary muscles and sensory receptors
  - **Autonomic nervous system (ANS)** – controls automatic, involuntary functions
    - **Sympathetic** – Go (fight-or-flight)
    - **Parasympathetic** – Stop

Figure 3.6

Organization of the human nervous system. This overview of the human nervous system shows the relationships of its various parts and systems. The brain is traditionally divided into three regions: the hindbrain, the midbrain, and the forebrain. The reticular formation runs through both the midbrain and the hindbrain on its way up and down the brainstem. These and other parts of the brain are discussed in detail later in the chapter. The peripheral nervous system is made up of the somatic nervous system, which controls voluntary muscles and sensory receptors, and the autonomic nervous system, which controls the involuntary activities of smooth muscles, blood vessels, and glands.



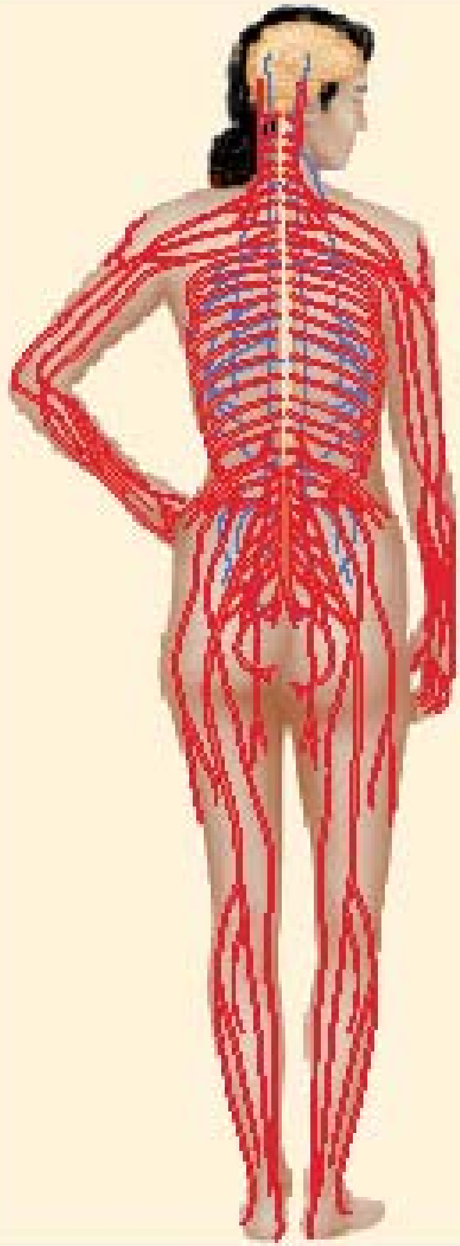
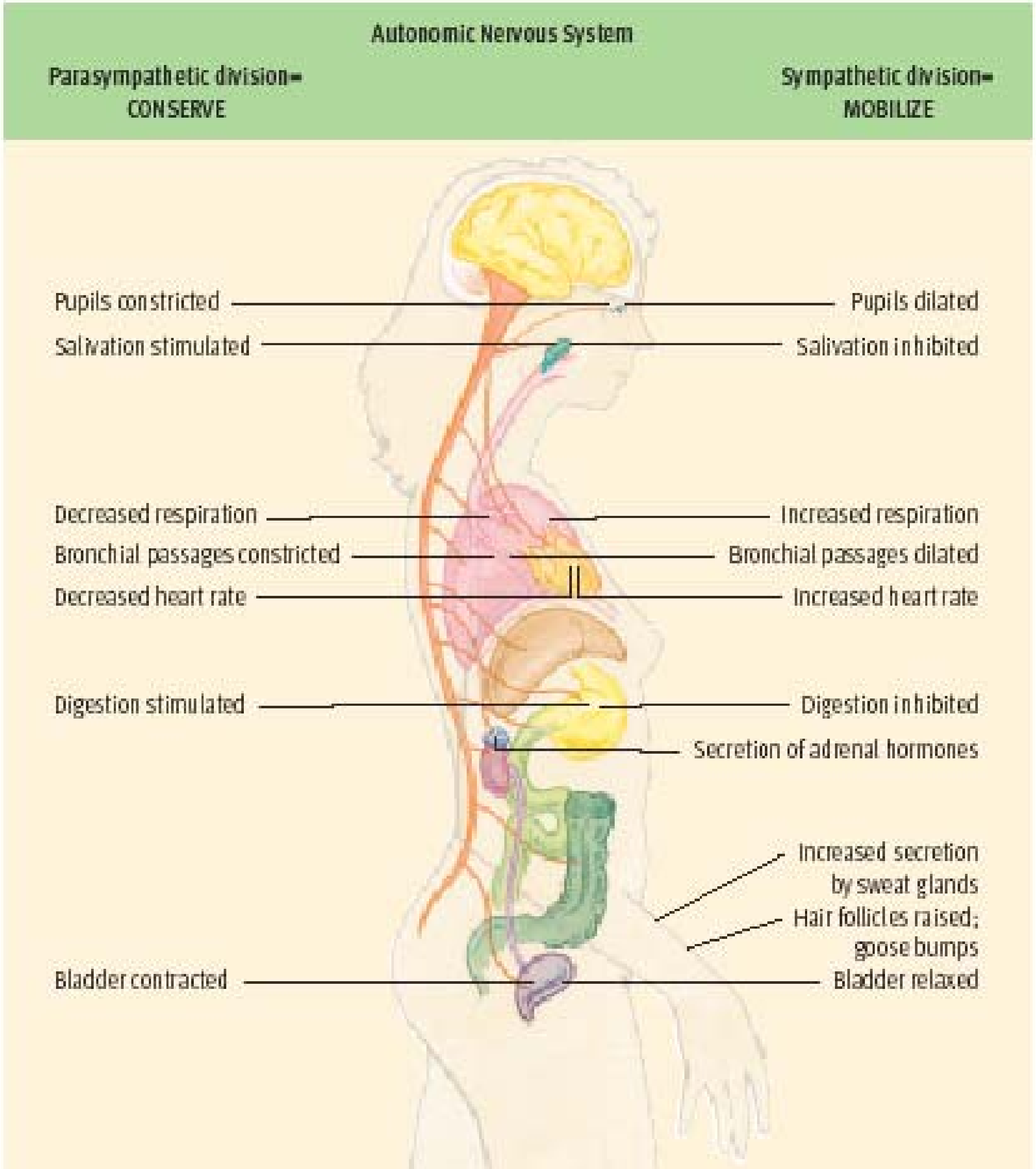


Figure 3.7

The central and peripheral nervous systems. The central nervous system consists of the brain and the spinal cord. The peripheral nervous system consists of the remaining nerves that fan out throughout the body. The peripheral nervous system is divided into the somatic nervous system, which is shown in red, and the autonomic nervous system, which is shown in blue.

SOURCE: Graphic from Haime, J. (2000). *Psychology: The adaptive mind.* Belmont, CA: Wadsworth. © 2000 Wadsworth Publishing. Reprinted by permission.



Autonomic Nervous System
Parasympathetic division=
CONSERVE
Sympathetic division=
MOBILIZE
Pupils constricted
Pupils dilated
Salivation stimulated
Salivation inhibited
Decreased respiration
Increased respiration
Bronchial passages constricted
Bronchial passages dilated
Decreased heart rate
Increased heart rate
Digestion stimulated
Digestion inhibited
Secretion of adrenal hormones
Increased secretion
by sweat glands
Hair follicles raised;
goose bumps
Bladder contracted
Bladder relaxed

Studying the Brain: Research Methods

- Electroencephalography (EEG)
- Damage studies/lesioning
- Electrical stimulation (ESB)
- Brain imaging –
  - computerized tomography
  - positron emission tomography
  - magnetic resonance imaging

Brain Regions and Functions

- **Hindbrain** – vital functions – medulla, pons, and cerebellum
- **Midbrain** – sensory functions – dopaminergic projections, reticular activating system
- **Forebrain** – emotion, complex thought – thalamus, hypothalamus, limbic system, cerebrum, cerebral cortex

(a) The patient's head is positioned in a large cylinder, as shown here.

(b) An X-ray beam and X-ray detector rotate around the patient's head, taking multiple X rays of a horizontal slice of the patient's brain.

(c) A computer combines X rays to create an image of a horizontal slice of the brain. This scan shows a tumor (in red) on the right.

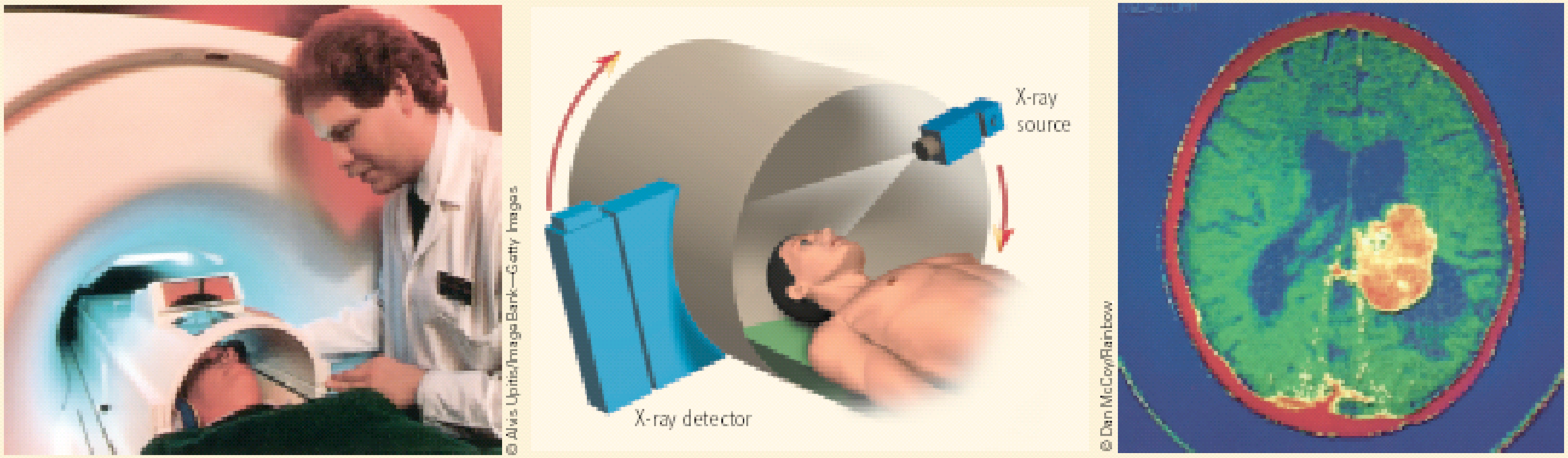
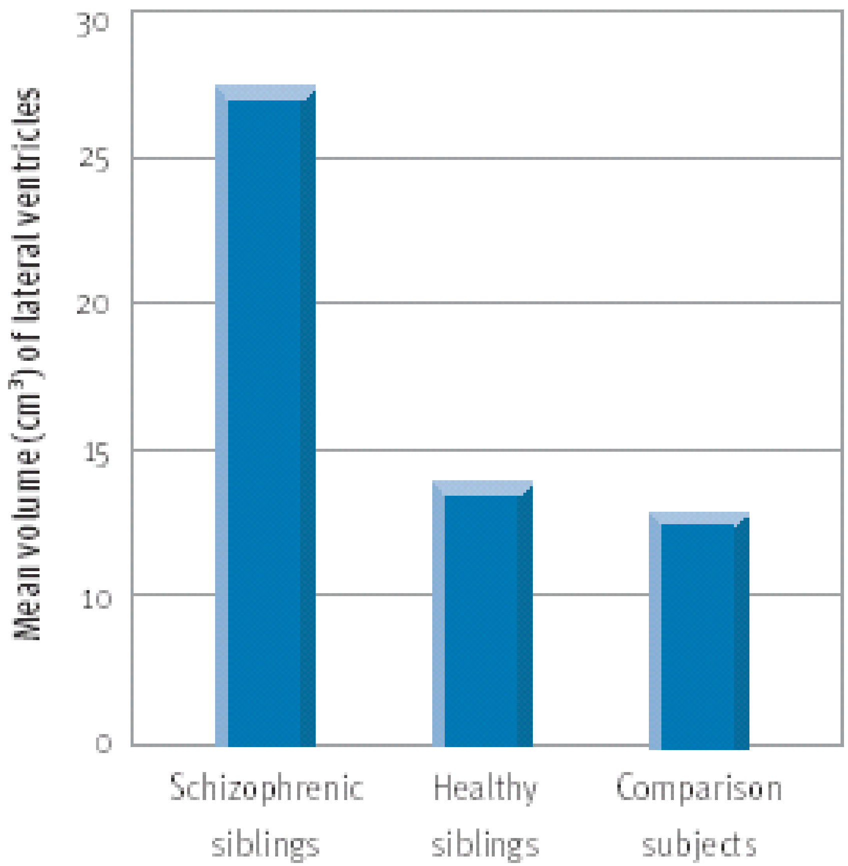


Figure 3.12

CT technology. CT scans can be used in research to examine aspects of brain structure. They provide computer-enhanced X rays of horizontal slices of the brain.

Figure 3.15

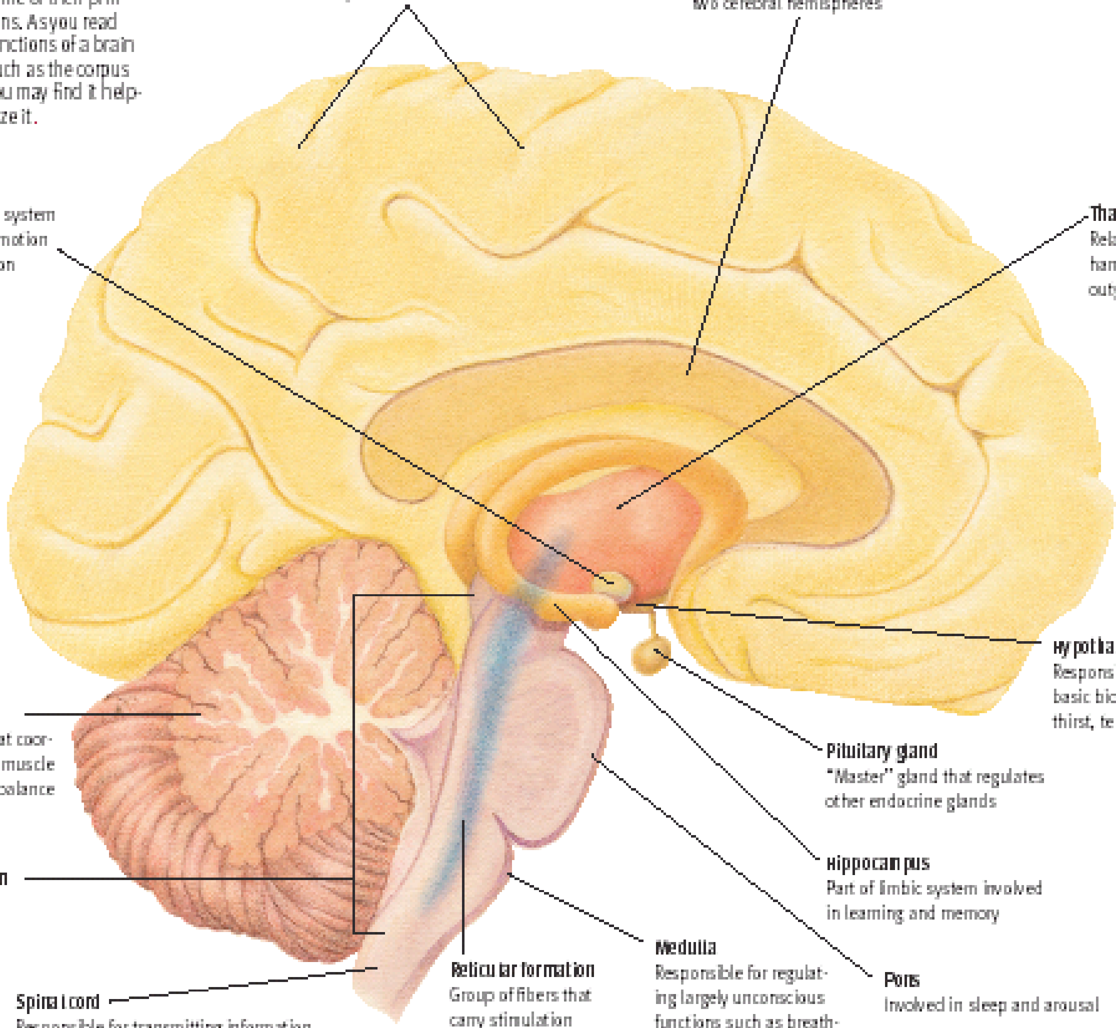
Enlarged brain ventricles in a schizophrenic patient. As in other studies, Staal et al. (2000) found that schizophrenic subjects tend to have enlarged brain ventricles. The data for the lateral ventricles are shown here. As you can see, the lateral ventricles of the schizophrenic subjects were about twice as large as those seen in their healthy siblings or control subjects..



The Cerebrum: Two Hemispheres, Four Lobes

- **Cerebral Hemispheres** – two specialized halves connected by the **corpus collosum**
  - **Left hemisphere** – verbal processing: language, speech, reading, writing
  - **Right hemisphere** – nonverbal processing: spatial, musical, visual recognition
- **Four Lobes**:
  - **Occipital** – vision
  - **Parietal** - somatosensory
  - **Temporal** - auditory
  - **Frontal** – movement, executive control systems

hindbrain and midbrain aren't trivial; they control such vital functions as breathing, waking, and maintaining balance. (Bottom) This cross section of the brain highlights key structures and some of their principal functions. As you read about the functions of a brain structure, such as the corpus callosum, you may find it helpful to visualize it.



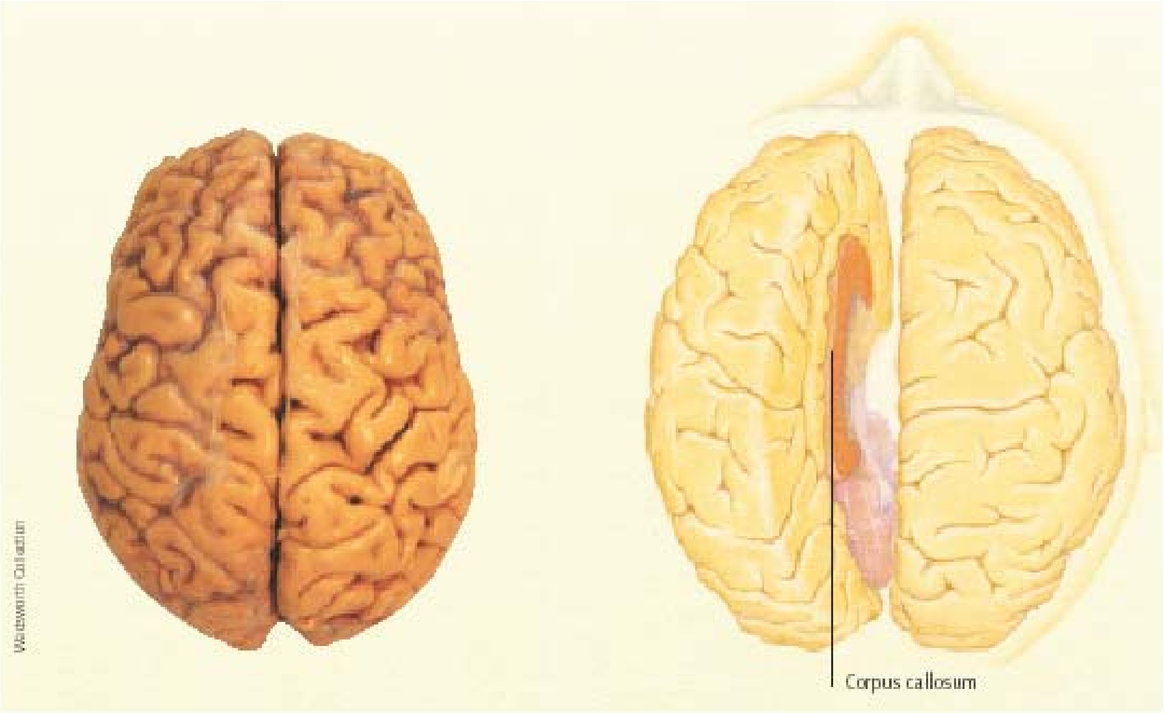
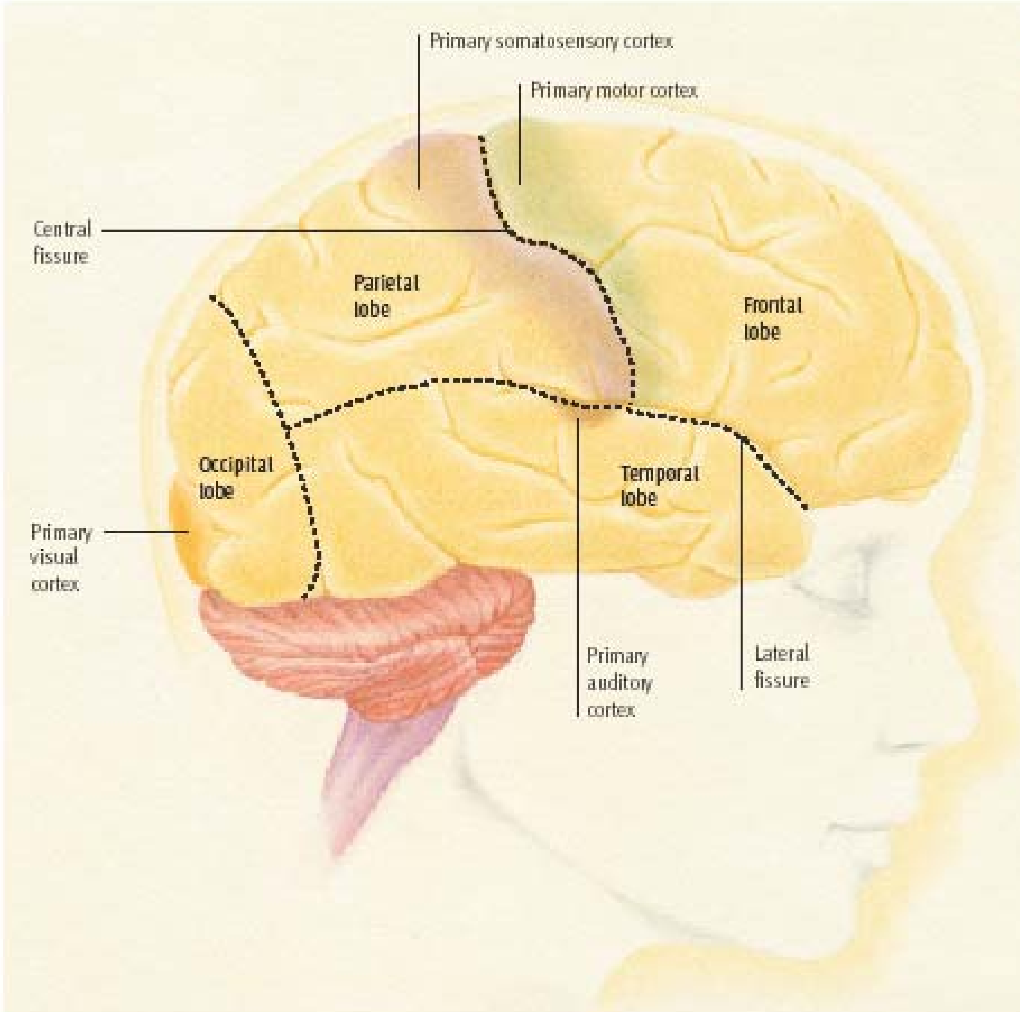


Figure 9.18

The cerebral hemispheres and the corpus callosum. (Left) As this photo shows, the longitudinal fissure running down the middle of the brain (viewed from above) separates the left and right halves of the cerebral cortex. (Right) In this drawing the cerebral hemispheres have been "pulled apart" to reveal the corpus callosum. This band of fibers is the communication bridge between the right and left halves of the human brain..



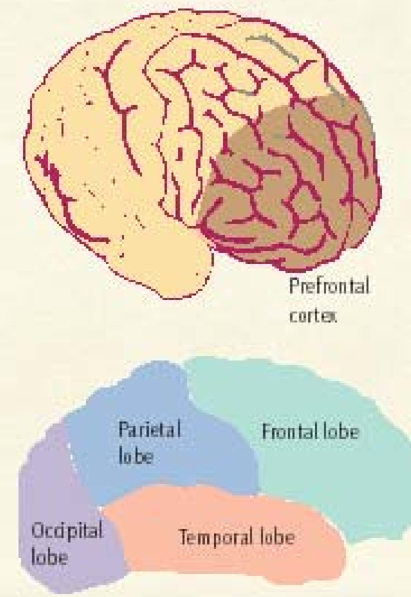
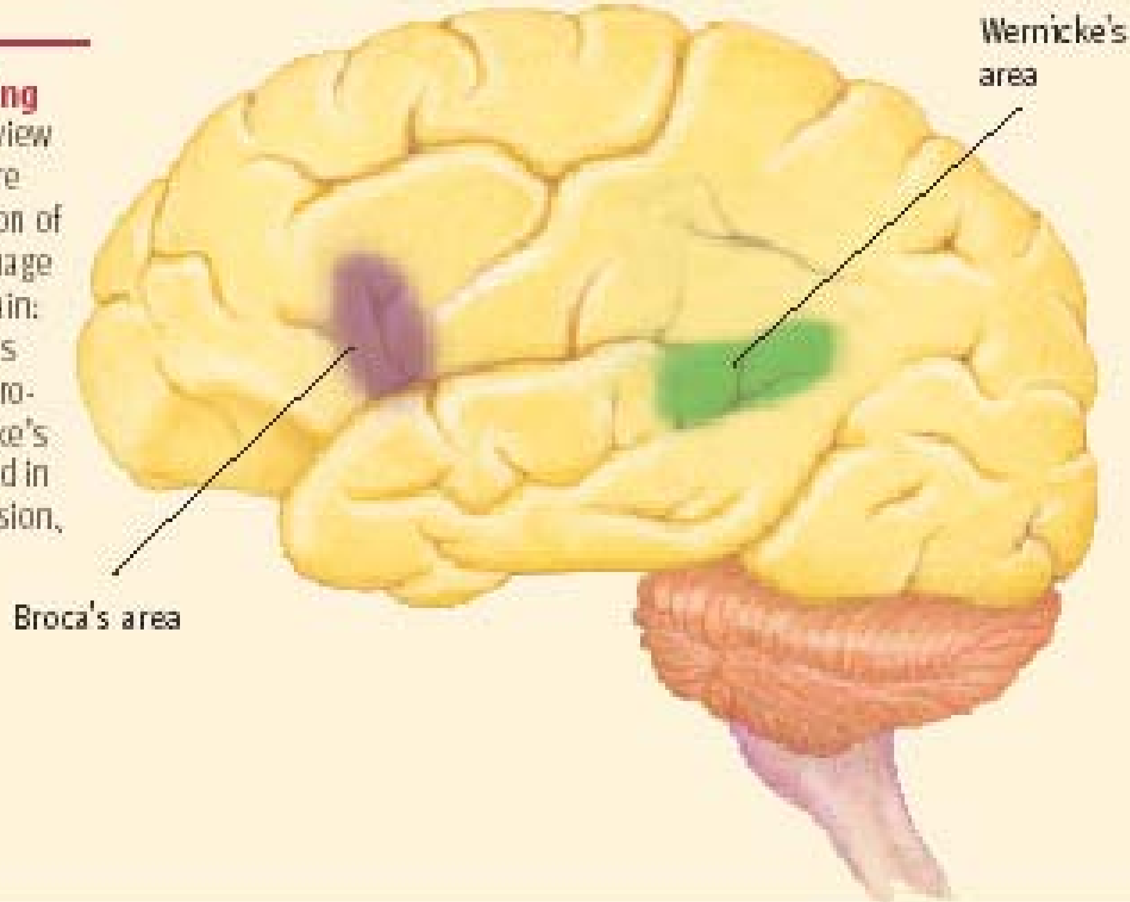


Figure 3.19

The cerebral cortex in humans. The cerebral cortex is divided into right and left halves, called cerebral hemispheres. This diagram provides a view of the right hemisphere. Each cerebral hemisphere can be divided into four lobes (which are highlighted in the bottom inset): the occipital lobe, the parietal lobe, the temporal lobe, and the frontal lobe. Each lobe has areas that handle particular functions, such as visual processing. The functions of the prefrontal cortex are something of a mystery, but they appear to include working memory and relational reasoning..

Figure 3.21

Language processing in the brain. This view of the left hemisphere highlights the location of two centers for language processing in the brain: Broca's area, which is involved in speech production, and Wernicke's area, which is involved in language comprehension.



The Endocrine System: Glands and Hormones

- **Hormones** – chemical messengers in the bloodstream
  - **Pulsatile** release by **endocrine glands**
  - **Negative feedback system**
- **Endocrine glands**
  - **Pituitary** – “master gland,” growth hormone
  - **Thyroid** - metabolic rate
  - **Adrenal** - salt and carbohydrate metabolism
  - **Pancreas** - sugar metabolism
  - **Gonads** - sex hormones

Genes and Behavior: The Interdisciplinary Field of Behavioral Genetics

- **Behavioral genetics** = the study of the influence of genetic factors on behavioral traits
- Basic terminology:
- **Chromosomes** – strands of **DNA** carrying genetic information
  - Human cells contain **46 chromosomes** in pairs (sex-cells – 23 single)
  - Each chromosome – thousands of genes, also in pairs
- **Dominant, recessive**
- **Homozygous, heterozygous**
- **Genotype/Phenotype** and **Polygenic Inheritance**

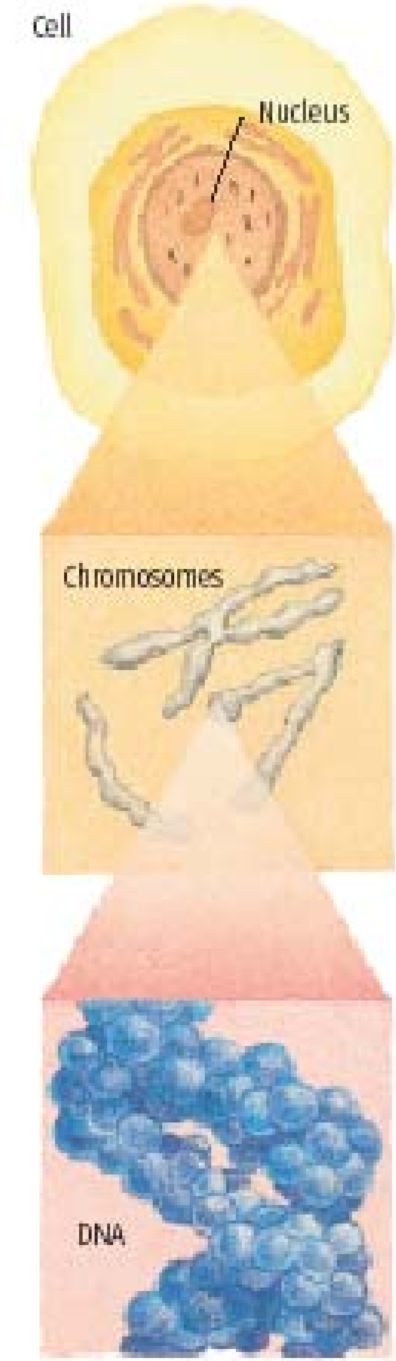


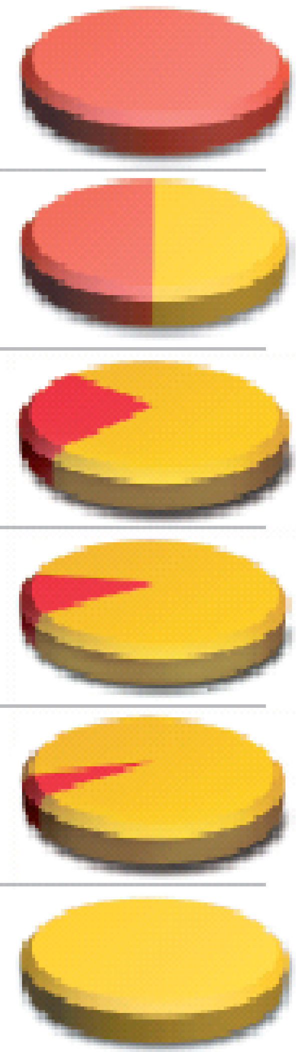
Figure 3.25

Genetic material. This series of enlargements shows the main components of genetic material. (Top) In the nucleus of every cell are chromosomes, which carry the information needed to construct new human beings. (Center) Chromosomes are thread-like strands of DNA that carry thousands of genes, the functional units of hereditary transmission. (Bottom) DNA is a spiraled double chain of molecules that can copy itself to reproduce.

Research Methods in Behavioral Genetics

- **Family studies** – does it run in the family?
- **Twin studies** – compare resemblance of identical (monozygotic) and fraternal (dizygotic) twins on a **trait**
- **Adoption** studies – examine resemblance between adopted children and their biological and adoptive parents

Relationship	Degree of relatedness	
Identical twins		100%
Fraternal twins Brother or sister Parent or child	First degree relatives	50%
Grandparent or grandchild Uncle, aunt, nephew, or niece Half-bother or half-sister	Second degree relatives	25%
First cousin	Third degree relatives	12.5%
Second cousin	Fourth degree relatives	6.25%
Unrelated		0%



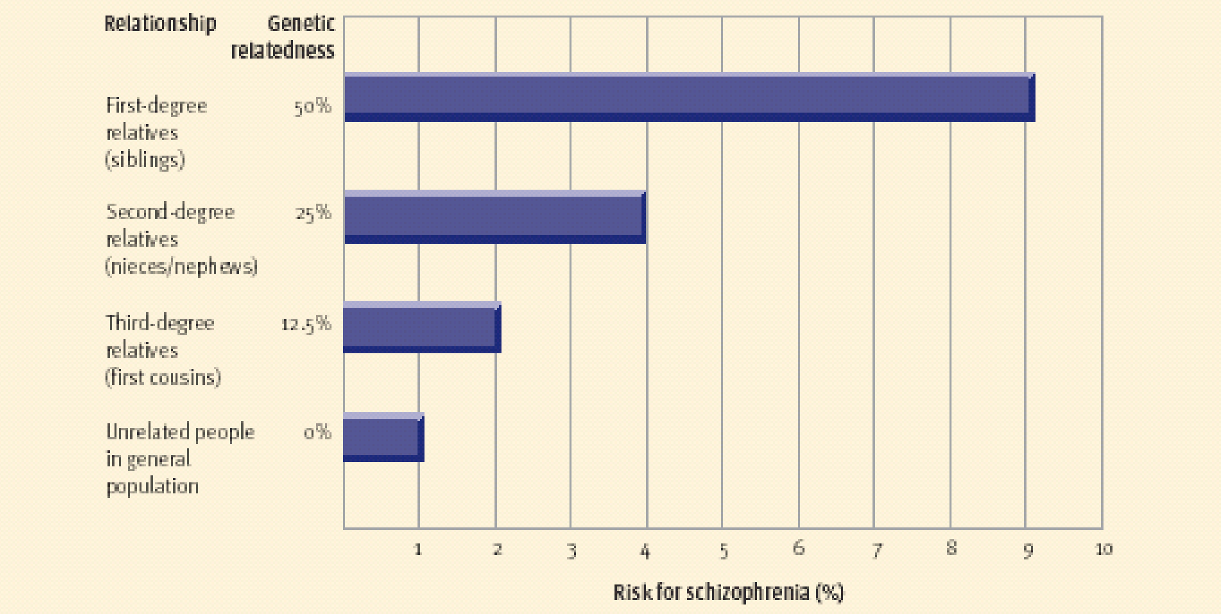


Figure 3.28

Family studies of risk for schizophrenic disorders. First-degree relatives of schizophrenic patients have an elevated risk of developing a schizophrenic disorder (Gottesman, 1991). For instance, the risk for siblings of schizophrenic patients is about 9% instead of the baseline 1% for unrelated people. Second- and third-degree relatives have progressively smaller elevations in risk for this disorder. Although these patterns of risk do not prove that schizophrenia is partly inherited, they are consistent with this hypothesis.

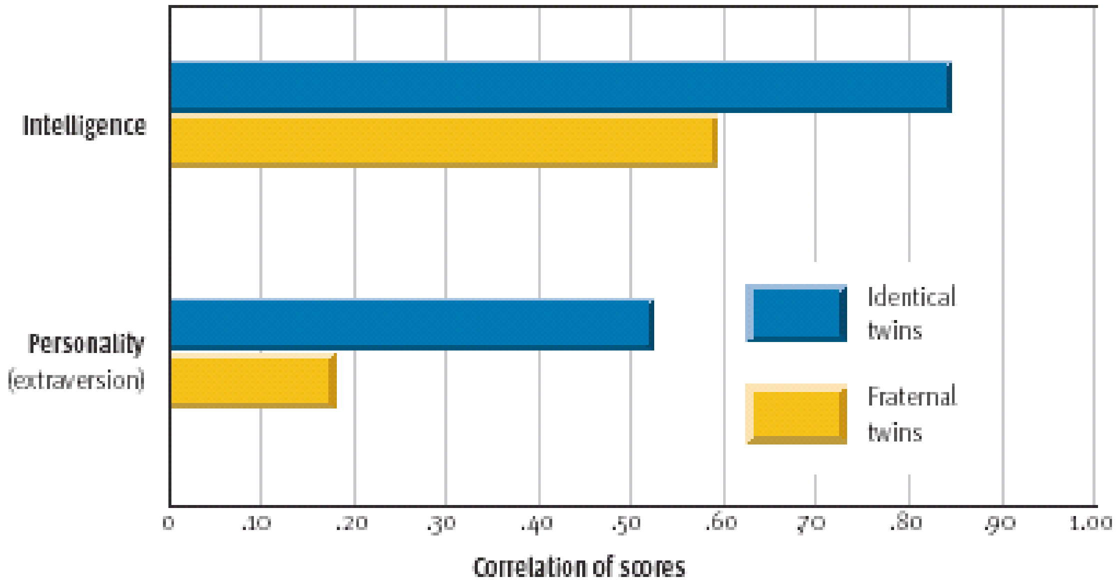


Figure 3.30

Twin studies of intelligence and personality. Identical twins tend to be more similar than fraternal twins (as reflected in higher correlations) with regard to intelligence and specific personality traits, such as extraversion. These findings suggest that intelligence and personality are influenced by heredity. (Intelligence data from McGue et al., 1993; extraversion data based on Loehlin, 1992).

Modern Approaches to the Nature vs. Nurture Debate

- **Molecular Genetics** = the study of the biochemical bases of genetic inheritance
  - **Genetic mapping** – locating specific genes - **The Human Genome Project**
- **Behavioral Genetics**
  - The **interactionist** model
  - Richard Rose (1995) – "We inherit dispositions, not destinies."

Evolutionary Psychology: Behavior in Terms of Adaptive Significance

- Based on Darwin's ideas of **natural selection**
  - **Reproductive success** key
- **Adaptations** – behavioral as well as physical
  - Fight-or-flight response
  - Taste preferences
  - Parental investment and mating

References

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