chapter 4

PHYSICAL DEVELOPMENT AND HEALTH

chapter **outline**

1 Body Growth and Change

Learning Goal 1 Discuss developmental changes in the body.

Patterns of Growth
Infancy and Childhood
Adolescence

2 The Brain

Learning Goal 2 Describe how the brain changes.

The Neuroconstructivist View
Brain Physiology
Infancy
Childhood
Adolescence

3 Sleep

Learning Goal 3 Summarize how sleep patterns change as children and adolescents develop.

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Adolescence

4 Health

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Exercise

Angie, an elementary-school-aged girl, provided the following comments about losing weight:

> When I was eight years old, I weighed 125 pounds. My clothes were the size that large teenage girls wear. I hated my body and my classmates teased me all the time. I was so overweight and out of shape that when I took a P.E. class my face would get red and I had trouble breathing. I was jealous of the kids who played sports and weren't overweight like I was.
>
> I'm nine years old now and I've lost 30 pounds. I'm much happier and proud of myself. How did I lose the weight? My mom said she had finally decided enough was enough. She took me to a pediatrician who specializes in helping children lose weight and keep it off. The pediatrician counseled my mom about my eating and exercise habits, then had us join a group that he had created for overweight children and their parents. My mom and I go to the group once a week and we've now been participating in the program for six months. I no longer eat fast food meals and my mom is cooking more healthy meals. Now that I've lost weight, exercise is not as hard for me and I don't get teased by the kids at school. My mom's pretty happy too because she's lost 15 pounds herself since we've been in the counseling program.

Not all overweight children are as successful as Angie at reducing their weight. Indeed, being overweight in childhood has become a major national concern in the United States (Schiff, 2013). Later in the chapter, we will explore the causes and consequences of being overweight in childhood.

preview

Think about how much you changed physically as you grew up. You came into this life as a small being but grew very rapidly in infancy, more slowly in childhood, and once again more rapidly during puberty. In this chapter, we will explore changes in body growth, the brain, and sleep. We also will examine aspects of children's health.

Body Growth and Change

LG1 Discuss developmental changes in the body.

Patterns of Growth | Infancy and Childhood | Adolescence

In the journey of childhood, we go through many bodily changes. Let's begin by studying some basic patterns of growth and then turn to the bodily changes that occur from infancy through adolescence.

PATTERNS OF GROWTH

During prenatal development and early infancy, the head constitutes an extraordinarily large portion of the total body (see Figure 4.1). Gradually, the body's proportions change. Why? Growth is not random. Instead, it generally follows two patterns: the cephalocaudal pattern and the proximodistal pattern.

cephalocaudal pattern The sequence in which the fastest growth occurs at the top of the body—the head—with physical growth in size, weight, and feature differentiation gradually working from top to bottom.

The **cephalocaudal pattern** is the sequence in which the fastest growth always occurs at the top—the head. Physical growth in size, weight, and feature differentiation gradually works its way down from the top to the bottom—for example, from neck to shoulders, to middle trunk, and so on. This same pattern occurs in the head area; the top parts of the head—the eyes and brain—grow faster than the lower parts, such as the jaw.

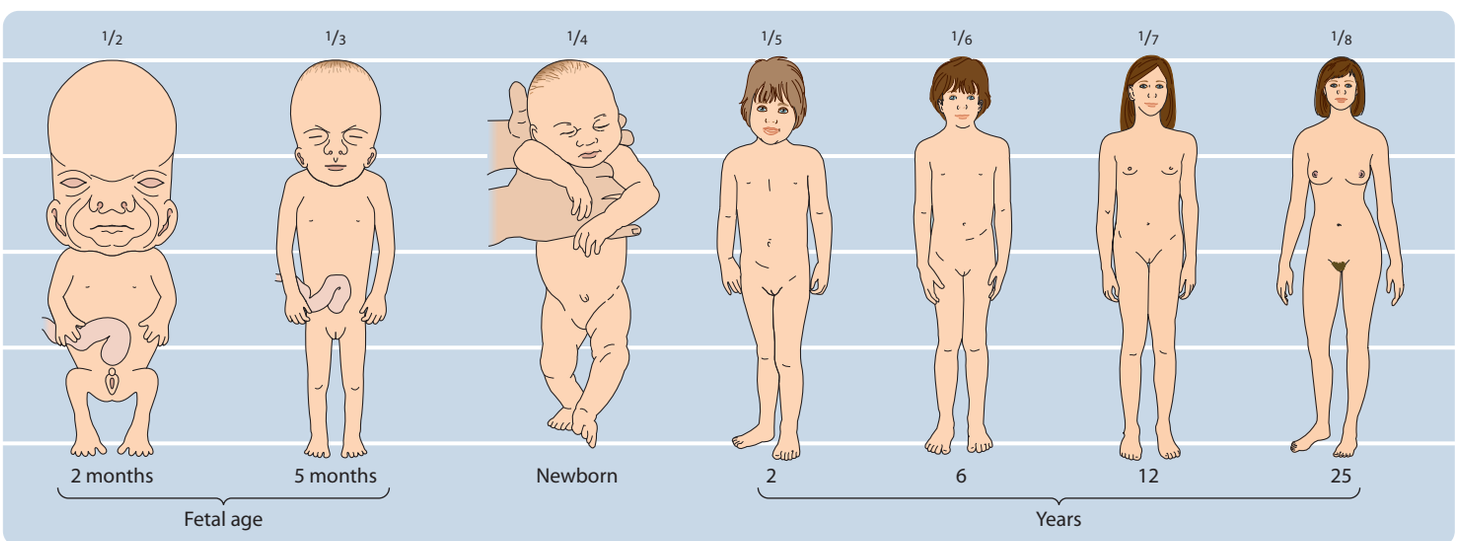


FIGURE **4.1**

CHANGES IN PROPORTIONS OF THE HUMAN BODY DURING GROWTH. As individuals develop from infancy through adulthood, one of the most noticeable physical changes is that the head becomes smaller in relation to the rest of the body. The fractions listed refer to head size as a proportion of total body length at different ages.

Sensory and motor development also generally proceed according to the cephalocaudal principle. For example, infants see objects before they can control their torso, and they can use their hands long before they can crawl or walk. However, one study found that infants reached for toys with their feet prior to using their hands (Galloway & Thelen, 2004). On average, infants first touched the toy with their feet when they were 12 weeks old and with their hands when they were 16 weeks old. We will have much more to say about sensory and motor development in Chapter 5.

The **proximodistal pattern** is the growth sequence that starts at the center of the body and moves toward the extremities. For example, muscle control of the trunk and arms matures before control of the hands and fingers. Further, infants use their whole hand as a unit before they can control several fingers.

developmental **connection**

Dynamic Systems Theory

Sensory and motor development are coupled in many aspects of children's acquisition of skills. Chapter 5, p. 161

INFANCY AND CHILDHOOD

Height and weight increase rapidly in infancy (Lampl, 2008). Growth takes a slower course during the childhood years.

Infancy The average North American newborn is 20 inches long and weighs 7½ pounds. Ninety-five percent of full-term newborns are 18 to 22 inches long and weigh between 5½ and 10 pounds.

In the first several days of life, most newborns lose 5 to 7 percent of their body weight. Once infants adjust to sucking, swallowing, and digesting, they grow rapidly, gaining an average of 5 to 6 ounces per week during the first month. They have doubled their birth weight by the age of 4 months and have nearly tripled it by their first birthday. Infants grow about one inch per month during the first year, reaching approximately 1½ times their birth length by their first birthday.

In the second year of life, infants' rate of growth slows considerably (Burns & others, 2013). By 2 years of age, infants weigh approximately 26 to 32 pounds, having gained a quarter to half a pound per month during the second year; at age 2 they have reached about one-fifth of their adult weight. The average 2-year-old is 32 to 35 inches tall, which is nearly one-half of adult height.

Early Childhood As the preschool child grows older, the percentage of increase in height and weight decreases with each additional year (McMahon & Stryjewski, 2012). Girls are only slightly smaller and lighter than boys during these years. Both boys and girls slim down as the trunks of their bodies lengthen. Although their heads are still somewhat large for their bodies, by the end of the preschool years most children have lost their top-heavy look. Body fat declines slowly but steadily during the preschool years. Girls have more fatty tissue than boys; boys have more muscle tissue.

Growth patterns vary individually (Florin & Ludwig, 2011). Much of the variation is due to heredity, but environmental experiences are involved to some extent. A review of the height and weight of children around the world concluded that two important contributors to height differences are ethnic origin and nutrition (Meredith, 1978). Also, urban, middle-socioeconomic-status, and firstborn children were taller than rural, lower-socioeconomic-status, and later-born children. The children whose mothers smoked during pregnancy were half an inch shorter than the children whose mothers did not smoke during pregnancy. In the United States, African American children are taller than White children.

Why are some children unusually short? The culprits are congenital factors (genetic or prenatal problems), growth hormone deficiency, a physical problem that develops in childhood, or an emotional difficulty (Wit, Kiess, & Mullis, 2011). When congenital growth problems are the cause of unusual shortness, often the child can be treated with hormones (Collett-Solberg, 2011). Usually this treatment is directed at the pituitary, the body's master gland, located at the base of the brain. This gland secretes growth-related hormones. Physical problems during childhood that can stunt growth include malnutrition and chronic infections. However, if the problems are properly treated, normal growth usually is attained.

The bodies of 5-year-olds and 2-year-olds have different proportions. Notice how the 5-year-old not only is taller and weighs more, but also has a longer trunk and legs than the 2-year-old. *What might be some other physical differences between 2- and 5-year-olds?*

proximodistal pattern The sequence in which growth starts at the center of the body and moves toward the extremities.

What characterizes physical growth during middle and late childhood?

Middle and Late Childhood The period of middle and late childhood—from about 6 to 11 years of age—involves slow, consistent growth. This is a period of calm before the rapid growth spurt of adolescence.

During the elementary school years, children grow an average of 2 to 3 inches a year. At the age of 8 the average girl and the average boy are 4 feet 2 inches tall. During the middle and late childhood years, children gain about 5 to 7 pounds a year. The average 8-year-old girl and the average 8-year-old boy weigh 56 pounds (National Center for Health Statistics, 2000). The weight increase is due mainly to increases in the size of the skeletal and muscular systems, as well as the size of some body organs. Muscle mass and strength gradually increase as "baby fat" decreases in middle and late childhood.

The loose movements of early childhood give way to improved muscle tone in middle and late childhood. Children also double their strength capacity during these years. The increase in muscular strength is due to heredity and to exercise. Because they have more muscle cells, boys tend to be stronger than girls.

Changes in proportions are among the most pronounced physical changes in middle and late childhood. Head circumference, waist circumference, and leg length decrease in relation to body height (Burns & others, 2013). A less noticeable physical change is that bones continue to harden during middle and late childhood; still, they yield to pressure and pull more than mature bones.

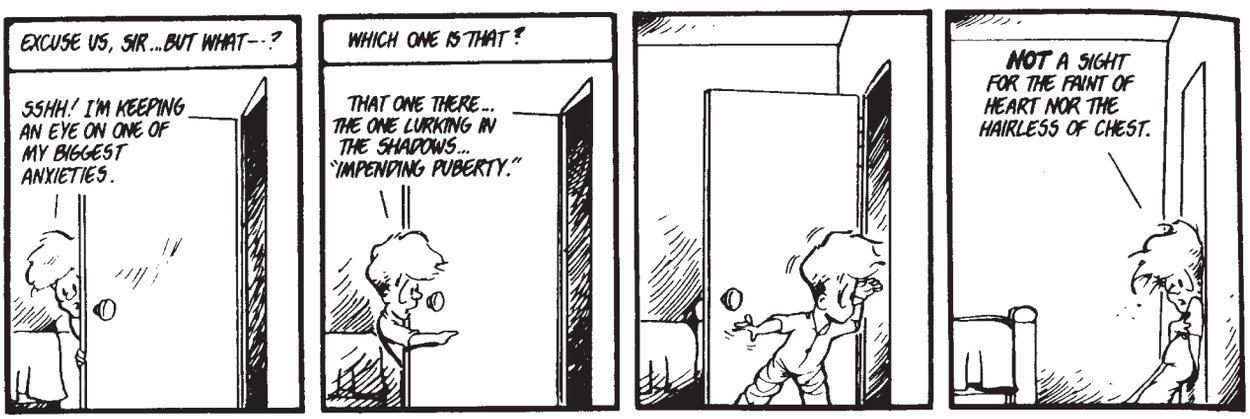
ADOLESCENCE

After slowing through childhood, growth surges during puberty. **Puberty** is a period of rapid physical maturation involving hormonal and bodily changes that occur primarily in early adolescence. The features and proportions of the body change as the individual becomes capable of reproducing. We will begin our exploration of puberty by describing its determinants and then examine important physical changes and psychological accompaniments of puberty.

puberty A period of rapid physical maturation involving hormonal and bodily changes that take place primarily in early adolescence.

Determinants of Puberty Puberty is not the same as adolescence. For virtually everyone, puberty has ended long before adolescence is over. Puberty is often thought of as the most important marker for the beginning of adolescence.

There are wide variations in the onset and progression of puberty (Dorn & Biro, 2011). Puberty might begin as early as 10 years of age or as late as 13½ for boys. It might end as early as 13 years or as late as 17 years.



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In fact, over the years the timing of puberty has changed. Imagine a 3-year-old girl with fully developed breasts or a boy just slightly older with a deep male voice. That is what toddlers would be like by the year 2250 if the age at which puberty arrives were to continue decreasing as it did for much of the twentieth century. For example, in Norway, **menarche**—a girl's first menstruation—now occurs at just over 13 years of age, compared with 17 years of age in the 1840s (Petersen, 1979). In the United States, where children mature up to a year earlier than in European countries, the average age of menarche dropped an average of two to four months per decade for much of the twentieth century, to about 12½ years today. Some researchers have found evidence that the age of puberty is still dropping for American girls; others suggest that the evidence is inconclusive or that the decline in age is slowing down (Herman-Giddens, 2007). A recent study also found that puberty is continuing to occur earlier for boys, although critics say the study sample is skewed toward including more early maturing boys because parents likely brought their sons to see the participating physicians because of health concerns (Herman-Giddens & others, 2012). The earlier onset of puberty is likely the result of improved health and nutrition (Herman-Giddens, 2007; Herman-Giddens & others, 2012).

The normal range for the onset and progression of puberty is wide enough that, given two boys of the same chronological age, one might complete the pubertal sequence before the other one has begun it. For girls, the age range of menarche is even wider. It is considered within a normal range when it occurs between the ages of 9 and 15.

Precocious puberty is the term used to describe the very early onset and rapid progression of puberty. Judith Blakemore and her colleagues (2009) described the following characteristics of precocious puberty. Precocious puberty is usually diagnosed when pubertal onset occurs before 8 years of age in girls and before 9 years of age in boys. Precocious puberty occurs approximately 10 times more often in girls than in boys. When precocious puberty takes place, it typically is treated by reducing gonadotropic secretions, which temporarily stops pubertal change (Sultan & others, 2012). The reasons for this treatment is that children who experience precocious puberty are ultimately likely to have short stature, early sexual capability, and the potential for engaging in age-inappropriate behavior (Blakemore, Berenbaum, & Liben, 2009).

Heredity and Environmental Influences Puberty is not an environmental accident. It does not take place at 2 or 3 years of age, and it does not occur in the twenties. Programmed into the genes of every human being is a timing for the emergence of puberty. Recently, scientists have begun to conduct molecular genetic studies in an attempt to identify specific genes that are linked to the onset and progression of puberty (Dvornyk & Waqar-ul-Haq, 2012).

Environmental factors, such as family influences and stress, can also influence its onset and duration (Arim & others, 2011). Experiences that are linked to earlier pubertal onset include adoption, father absence, low socioeconomic status, family conflict, maternal harshness, child maltreatment, and early substance use (Deardorff & others, 2011; Ellis & others, 2011). In many cases, puberty comes months earlier in these situations, and this earlier onset of puberty is likely explained by high rates of conflict and stress in these social contexts. One study revealed that maternal harshness in early childhood was linked to early maturation as well as sexual risk taking in adolescence (Belsky & others, 2010). Another study found that early onset of menarche was associated with severe child sexual abuse (Boynton-Jarrett & others, 2013).

Hormones Behind the first whisker in boys and the widening of hips in girls is a flood of hormones. **Hormones** are powerful chemical substances secreted by the endocrine glands and carried through the body by the bloodstream. In the case of puberty, the secretion of key hormones is controlled by the interaction of the hypothalamus, the pituitary gland, and the gonads (sex glands). The *hypothalamus* is a structure in the brain best known for monitoring eating, drinking, and sex. The *pituitary gland* is an important endocrine gland that controls growth and regulates other glands. The *gonads* are the sex glands—the testes in males, the ovaries in females.

The key hormonal changes involve two classes of hormones that have significantly different concentrations in males and females (Susman & Dorn, 2013). **Androgens** are the main class of male sex hormones. **Estrogens** are the main class of female sex hormones.

Testosterone is an androgen that is a key hormone in the development of puberty in boys (Colvin & Abdullatif, 2012). As the testosterone level rises during puberty, external genitals enlarge, height increases, and the voice changes. **Estradiol** is an estrogen that plays

menarche A girl's first menstruation.

precocious puberty Very early onset and rapid progression of puberty.

hormones Powerful chemical substances secreted by the endocrine glands and carried through the body by the bloodstream.

androgens The main class of male sex hormones.

estrogens The main class of female sex hormones.

testosterone An androgen that is a key hormone in boys' pubertal development.

estradiol An estrogen that is a key hormone in girls' pubertal development.

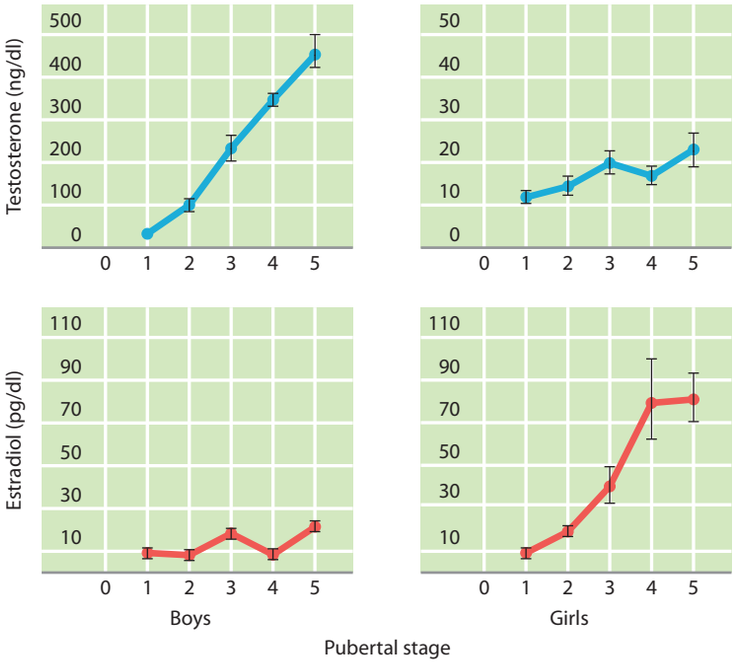


FIGURE 4.2

HORMONE LEVELS BY SEX AND PUBERTAL STAGE FOR TESTOSTERONE AND ESTRADIOL. The five stages range from the early beginning of puberty (stage 1) to the most advanced stage of puberty (stage 5). Notice the significant increase in testosterone in boys and the significant increase in estradiol in girls.

an important role in female pubertal development. As the estradiol level rises, breast development, uterine development, and skeletal changes occur. In one study, testosterone levels increased eighteenfold in boys but only twofold in girls across puberty; estradiol levels increased eightfold in girls but only twofold in boys across puberty (Nottleman & others, 1987) (see Figure 4.2).

Are there links between concentrations of hormones and adolescent behavior? Findings are inconsistent (Vermeersch & others, 2008). In any event, hormonal factors alone are not responsible for adolescent behavior (Graber, 2008). For example, one study found that social factors accounted for two to four times as much variance as hormonal factors in young adolescent girls' depression and anger (Brooks-Gunn & Warren, 1989). Hormones do not act independently; hormonal activity is influenced by many environmental factors, including parent-adolescent relationships. Stress, eating patterns, sexual activity, and depression can also activate or suppress various aspects of the hormone system (Susman & Dorn, 2013).

Growth Spurt Puberty ushers in the most rapid increases in growth since infancy. As indicated in Figure 4.3, the growth spurt associated with puberty occurs approximately two years earlier for girls than for boys. The mean beginning of the growth spurt in the United States today is 9 years of age for girls and 11 years of age for boys. Pubertal change peaks at an average of 11.5 years for girls and 13.5 years for boys. During their growth spurt, girls increase in height about 3.5 inches per year, boys about 4 inches.

Boys and girls who are shorter or taller than their peers before adolescence are likely to remain so during adolescence. At the beginning of adolescence, girls tend to be as tall as or taller than boys their age, but by the end of the middle school years most boys have caught up, or, in many cases, even surpassed girls in height. And although height in elementary school is a good predictor of height later in adolescence, as much as 30 percent of the height of individuals in late adolescence is unexplained by height in the elementary school years.

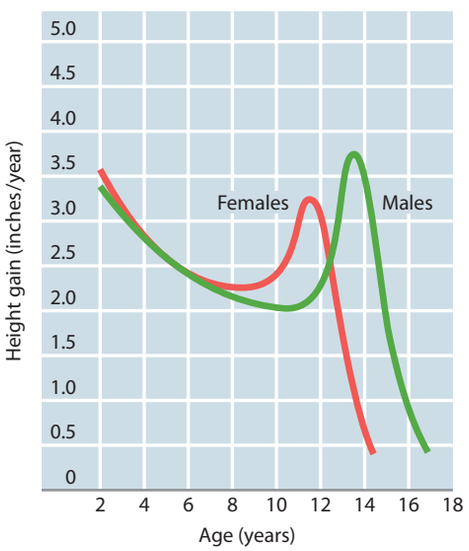
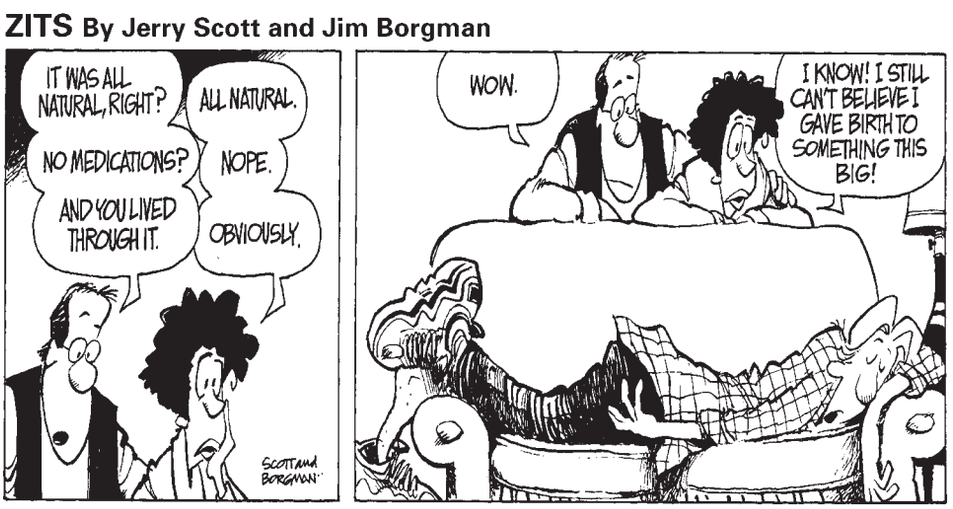


FIGURE 4.3

PUBERTAL GROWTH SPURT. On average, the peak of the growth spurt that characterizes pubertal change occurs two years earlier for girls (11½) than for boys (13½).

Sexual Maturation Think back to the onset of your puberty. Of the striking changes that were taking place in your body, what was the first change that occurred? Researchers have found that male pubertal characteristics develop in this order: increase in penis and testicle size, appearance of straight pubic hair, minor voice change, first ejaculation (which usually



occurs through masturbation or a wet dream), appearance of curly pubic hair, onset of maximum body growth, growth of hair in armpits, more detectable voice changes, and growth of facial hair. Three of the most noticeable areas of sexual maturation in boys are penis elongation, testes development, and growth of facial hair. The normal range and average age of development in boys and girls for these sexual characteristics, along with height spurt, is shown in Figure 4.4.

What is the order of appearance of physical changes in females? First, on average the breasts enlarge and then pubic hair appears. These are two of the most noticeable aspects of female pubertal development. A recent longitudinal study revealed that on average, girls' breast development preceded their pubic hair development by about 2 months (Susman & others, 2010). Later, hair appears in the armpits. As these changes occur, the female grows in height, and her hips become wider than her shoulders. Her first menstruation (menarche) occurs rather late in the pubertal cycle; it is considered normal if it occurs between the ages of 9 and 15. Initially, her menstrual cycles may be highly irregular. For the first several years, she might not ovulate during every menstrual cycle. Some girls do not become fertile until two years after their periods begin. Pubertal females do not experience voice changes comparable to those in pubertal males. By the end of puberty, the female's breasts have become more fully rounded.

Psychological Dimensions of Puberty A host of psychological changes accompany an adolescent's pubertal development. Two of the most pronounced psychological changes involve body image and early and late maturation.

Body Image One psychological aspect of physical change in puberty is certain: Adolescents are preoccupied with their bodies and develop images of what their bodies are like (Park & Epstein, 2013; Williams, Wyatt, & Winters, 2013). Preoccupation with body image is strong throughout adolescence, but it is especially acute during early adolescence, a time when adolescents are more dissatisfied with their bodies than in late adolescence. Nonetheless, when the entirety of adolescence was considered, not just puberty, a recent study found that both boys' and girls' body images became more positive as they moved from the beginning to the end of adolescence (Holsen, Carlson Jones, & Skogbrott Birkeland, 2012).

Gender differences characterize adolescents' perceptions of their bodies. In general, girls are less happy with their bodies and have more negative body images than boys throughout puberty (Benowitz-Fredericks & others, 2012). As pubertal change proceeds, girls often become more dissatisfied with their bodies, probably because their body fat increases. In contrast, boys become more satisfied as they move through puberty, probably because their muscle mass increases.

Although we have described gender differences in the body images of adolescents, emphasizing that girls tend to have more negative body images than boys, keep in mind that there is considerable variation, with many adolescent girls having positive body images and many adolescent boys having negative body images. Further, a recent research review revealed an increase in body satisfaction for non-Latino White adolescent girls but not for African American adolescent girls (Grabe & Hyde, 2006).

Early and Late Maturation Did you enter puberty early, late, or on time? When adolescents mature earlier or later than their peers, they often perceive themselves differently and their maturational timing is linked to their socioemotional development and whether they develop problems (Negriff, Susman, & Trickett, 2011). In the Berkeley Longitudinal Study conducted some years ago, early-maturing boys perceived themselves more positively and had more successful peer relations than did late-maturing boys (Jones, 1965). The findings for early-maturing

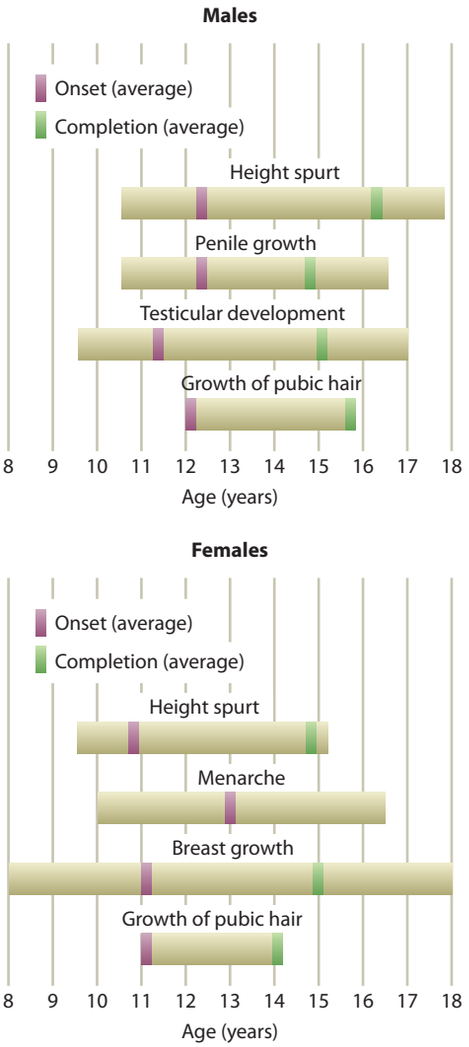


FIGURE **4.4**
NORMAL RANGE AND AVERAGE DEVELOPMENT OF SEXUAL CHARACTERISTICS IN MALES AND FEMALES

What gender differences characterize adolescents' body image? What might explain the differences?

How does early and late maturation influence adolescent development?

girls were similar but not as strong as for boys. When the late-maturing boys were in their thirties, however, they had developed a more positive identity than the early-maturing boys had (Peskin, 1967). Perhaps the late-maturing boys had more time to explore life's options, or perhaps the early-maturing boys continued to focus on their physical status instead of paying attention to career development and achievement.

An increasing number of researchers have found that early maturation increases girls' vulnerability to a number of problems (Sontag-Padilla & others, 2012; Susman & Dorn, 2013; Negriff, Susman, & Trickett, 2011). Early-maturing girls are more likely to smoke, drink, be depressed, have an eating disorder, engage in delinquency, struggle for earlier independence from their parents, and have older friends; and their bodies are likely to elicit responses from males that lead to earlier dating and earlier sexual experiences (de Rose & others, 2011; Negriff, Susman, & Trickett, 2011). And early-maturing girls are more likely to drop out of high school and to cohabit and marry earlier (Cavanagh, 2009). Apparently as a result of their social and cognitive immaturity, combined with early physical development, early-maturing girls are easily lured into problem behaviors, not recognizing the possible long-term effects of these on their development. Two recent studies document the negative outcomes of early pubertal timing in girls:

- Early-maturing girls were more likely to engage in substance abuse and early sexual intercourse (Gaudineau & others, 2010).
- A study of 9- to 13-year-old girls found that early pubertal timing at time 1 was linked to a higher level of sexual activity at time 2, which in turn was related to higher delinquency at time 3 (Negriff, Susman, & Trickett, 2011).

Review *Connect* Reflect

LG1 Discuss developmental changes in the body.

Review

- What are cephalocaudal and proximodistal patterns?
- How do height and weight change in infancy and childhood?
- What changes characterize puberty?

Connect

- Describe the influence of nature and nurture on the relationship between hormones and puberty.

Reflect *Your Own Personal Journey of Life*

- Did you experience puberty early, late, or on time? How do you think this affected your social relationships and development?

The Brain

LG2 Describe how the brain changes.

- The Neuroconstructivist View
- Brain Physiology
- Infancy
- Childhood
- Adolescence

neuroconstructivist view Theory of brain development emphasizing the following points: (a) biological processes and environmental conditions influence the brain's development, (b) the brain has plasticity and is context dependent, and (c) the development of the brain and the child's cognitive development are closely linked.

In every physical change we have described so far, the brain is involved in some way. Structures of the brain help to regulate not only behavior but also metabolism, the release of hormones, and other aspects of the body's physiology.

We described the amazing growth of the brain from conception to birth in Chapter 3. In this section, we initially will explore the neuroconstructivist view, describe basic structures and function of the brain, and then examine developmental changes in the brain from infancy through adolescence.

THE NEUROCONSTRUCTIVIST VIEW

Until recently, little was known for certain about how the brain changes as children develop. Not long ago, scientists thought that our genes determined how our brains were "wired" and that the cells in the brain responsible for processing information just maturationally unfolded with little or no input from environmental experiences. Whatever brain your heredity dealt you, you were essentially stuck with it. This view, however, turned out to be wrong. Instead, the brain has plasticity, and its development depends on context (Diamond, 2013; Nelson, 2012).

In the increasingly popular **neuroconstructivist view,** (a) biological processes (genes, for example) and environmental conditions (enriched or impoverished, for example) influence the brain's development, (b) the brain has plasticity and is context dependent, and (c) development of the brain is closely linked with the child's cognitive development. These factors constrain or advance the child's construction of cognitive skills (Diamond, 2013; Peltzer-Karpf, 2012; Westermann, Thomas, & Karmiloff-Smith, 2011). The neuroconstructivist view emphasizes the importance of considering interactions between experience and gene expression in the brain's development, much in the same way the epigenetic view proposes (see Chapter 2, "Biological Beginnings").

developmental **connection**

Nature and Nurture

In the epigenetic view, development is an ongoing, bidirectional interchange between heredity and the environment. Chapter 2, p. 69

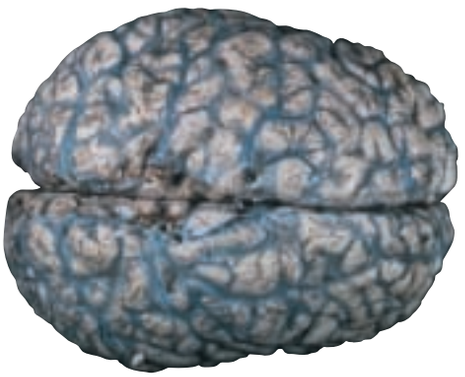


FIGURE **4.5**

THE HUMAN BRAIN'S HEMISPHERES. The two halves (hemispheres) of the human brain are clearly seen in this photograph.

BRAIN PHYSIOLOGY

The brain includes a number of major structures. The key components of these structures are *neurons,* the nerve cells that handle information processing, which we initially described in Chapter 3.

Structure and Function Looked at from above, the brain has two halves, or hemispheres (see Figure 4.5). The top portion of the brain, farthest from the spinal cord, is known as the forebrain. Its outer layer of cells, the cerebral cortex, covers it like a cap. The cerebral cortex is responsible for about 80 percent of the brain's volume and is critically important in perception, thinking, language, and other functions.

Each hemisphere of the cortex has four major areas, called lobes. Although the lobes usually work together, each has a somewhat different primary function (see Figure 4.6):

- *Frontal lobes* are involved in voluntary movement, thinking, personality, and intentionality or purpose.
- *Occipital lobes* function in vision.
- *Temporal lobes* facilitate hearing, language processing, and memory.
- *Parietal lobes* help to register spatial location, direct attention, and maintain motor control.

Deeper in the brain, beneath the cortex, lie other key structures. These include the hypothalamus and the pituitary gland as well as the *amygdala,* which plays an important role in emotions, and the *hippocampus,* which is especially active in memory and emotion.

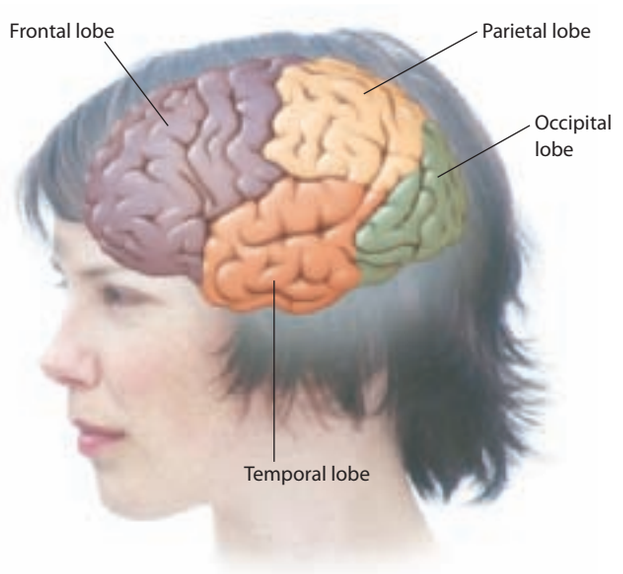


FIGURE **4.6**

THE BRAIN'S FOUR LOBES. Shown here are the locations of the brain's four lobes: frontal, occipital, temporal, and parietal.

Neurons How do neurons work? As we indicated, these nerve cells process information. Figure 4.7 shows some important parts of the neuron, including the *axon* and *dendrites*. Basically, an axon sends electrical signals away from the central part of the neuron. At the end of the axon are terminal buttons, which release chemicals called *neurotransmitters* into *synapses,* which are tiny gaps between neurons' fibers. Chemical interactions in synapses connect axons and dendrites, allowing information to pass from neuron to neuron (Emes & Grant, 2013). Think of the synapse as a river that blocks a road. A grocery truck arrives at one bank of the river, crosses by ferry, and continues its journey to market. Similarly, a message in the brain is "ferried" across the synapse by a neurotransmitter, which pours out information contained in chemicals when it reaches the other side of the river.

developmental **connection**

Intelligence

Are some regions of the brain linked with children's intelligence more than others? Chapter 8, p. 235

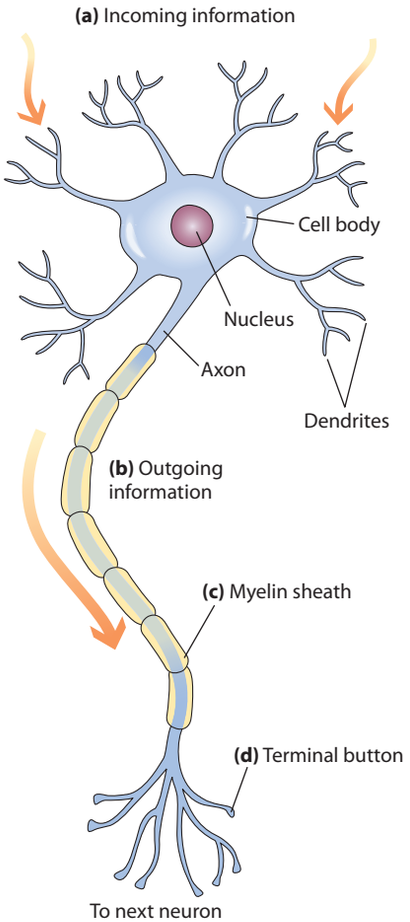


FIGURE 4.7

THE NEURON. (*a*) The dendrites receive information from other neurons, muscles, or glands. (*b*) Axons transmit information away from the cell body. (*c*) A myelin sheath covers most axons and speeds information transmission. (*d*) As the axon ends, it branches out into terminal buttons.

developmental **connection**

Gender

How large are gender differences in the brain? Chapter 12, p. 347

developmental **connection**

Brain Development

How does the brain change from conception to birth? Chapter 3, p. 79

lateralization Specialization of function in one hemisphere of the cerebral cortex or the other.

myelination The process of encasing axons with a myelin sheath that increases the speed of processing information.

Most axons are covered by a myelin sheath, which is a layer of fat cells. The sheath helps impulses travel faster along the axon, increasing the speed with which information travels from neuron to neuron (Buttermore, Thaxton, & Bhat, 2013). The myelin sheath developed as the brain evolved. As brain size increased, it became necessary for information to travel faster over longer distances in the nervous system. We can compare the myelin sheath's development to the evolution of freeways as cities grew. A freeway is a shielded road, and it keeps fast-moving, long-distance traffic from getting snarled by slow local traffic.

Which neurons get which information? Clusters of neurons known as *neural circuits* work together to handle particular types of information (Homae & others, 2011). The brain is organized in many neural circuits (Rueda & Posner, 2013; Short & others, 2013). For example, one neural circuit is important in attention and working memory (the type of memory that holds information for a brief time and serves as a "mental workbench" as we perform a task) (Krimer & Goldman-Rakic, 2001). This neural circuit uses the neurotransmitter dopamine and lies in the prefrontal cortex and midbrain areas of the brain (D'Ardenne & others, 2012).

To some extent, the type of information handled by neurons depends on whether they are in the left or right hemisphere of the cortex (Griffiths & others, 2013). Speech and grammar, for example, depend on activity in the left hemisphere in most people; humor and the use of metaphors depend on activity in the right hemisphere (McGettigan & others, 2012). This specialization of function in one hemisphere of the cerebral cortex or the other is called **lateralization.** However, most neuroscientists agree that complex functions such as reading or performing music involve both hemispheres (Ibrahim & Eviatar, 2013). Labeling people as "left-brained" because they are logical thinkers and "right-brained" because they are creative thinkers does not correspond to the way the brain's hemispheres work. Complex thinking in normal people is the outcome of communication between both hemispheres of the brain (Liegeois & others, 2008). For example, a recent meta-analysis revealed no hemispheric specialization in creative thinking (Mihov, Denzler, & Forster, 2010).

INFANCY

As we saw in Chapter 3, brain development occurs extensively during the prenatal period. The brain's development is also substantial during infancy and later on (Diamond, 2013; Markant & Thomas, 2013; Zelazo, 2013).

Because the brain is still developing so rapidly in infancy, the infant's head should be protected from falls or other injuries and the baby should never be shaken. *Shaken baby syndrome,* which includes brain swelling and hemorrhaging, affects hundreds of babies in the United States each year (Swaiman & others, 2012). A recent analysis found that fathers were the most frequent perpetrators of shaken baby syndrome, followed by child care providers and by a boyfriend of the victim's mother (National Center on Shaken Baby Syndrome, 2011).

Studying the brain's development in infancy is not as easy as it might seem. Even the latest brain-imaging technologies (described in Chapter 1) cannot make out fine details in adult brains and cannot be used with babies (Nelson, 2012). Positron-emission tomography (PET) scans pose a radiation risk to babies, and infants wriggle too much to allow technicians to capture accurate images using magnetic resonance imaging (MRI). However, researchers have been successful in using the electroencephalogram (EEG), a measure of the brain's electrical activity, to learn about the brain's development in infancy (Bell & Cuevas, 2012, 2013). Among the researchers who are making strides in finding out more about the brain's development in infancy are Martha Ann Bell and her colleagues (Bell & Cuevas, 2012, 2013; Bell & Diaz, 2012; Morasch, Raj, & Bell, 2013), Charles Nelson and his colleagues (Nelson, 2007, 2012, 2013a, b; Righi & Nelson, 2013), and John Richards and his colleagues (Richards, 2009, 2010; Richards, Reynolds, & Courage, 2010; Sanchez, Richards, & Almi, 2012) (see Figure 4.8).

As an infant walks, talks, runs, shakes a rattle, smiles, and frowns, changes in its brain are occurring. Consider that the infant began life as a single cell and nine months later was born with a brain and nervous system that contained approximately 100 billion nerve cells, or neurons. What determines how those neurons are connected to communicate with each other?

Early Experience and the Brain Children who grow up in a deprived environment may also have depressed brain activity (Zeanah, Fox, & Nelson, 2012). As shown in Figure 4.9, a child who grew up in the unresponsive and unstimulating environment of a Romanian orphanage showed considerably depressed brain activity compared with a normal child.

Are the effects of deprived environments irreversible? There is reason to think the answer is no (Bryck & Fisher, 2012; Sharma, Classen, & Cohen, 2013). The brain demonstrates both flexibility and resilience. Consider 14-year-old Michael Rehbein. At age 7, he began to experience uncontrollable seizures—as many as 400 a day. Doctors said the only solution was to remove the left hemisphere of his brain where the seizures were occurring. Recovery was slow, but his right hemisphere began to reorganize and take over functions that normally occur in the brain's left hemisphere, including speech (see Figure 4.10). One study of 10 children who had experienced an arterial stroke perinatally (during or around birth) revealed that in 8 of the 10 the right hemisphere was dominant in processing language (Guzzetta & others, 2008).

Neuroscientists believe that what wires the brain—or rewires it, in the case of Michael Rehbein—is repeated experience. Each time a baby tries to touch an attractive object or gazes intently at a face, tiny bursts of electricity shoot through the brain, knitting together neurons into circuits. The results are some of the behavioral milestones we discuss in this chapter.

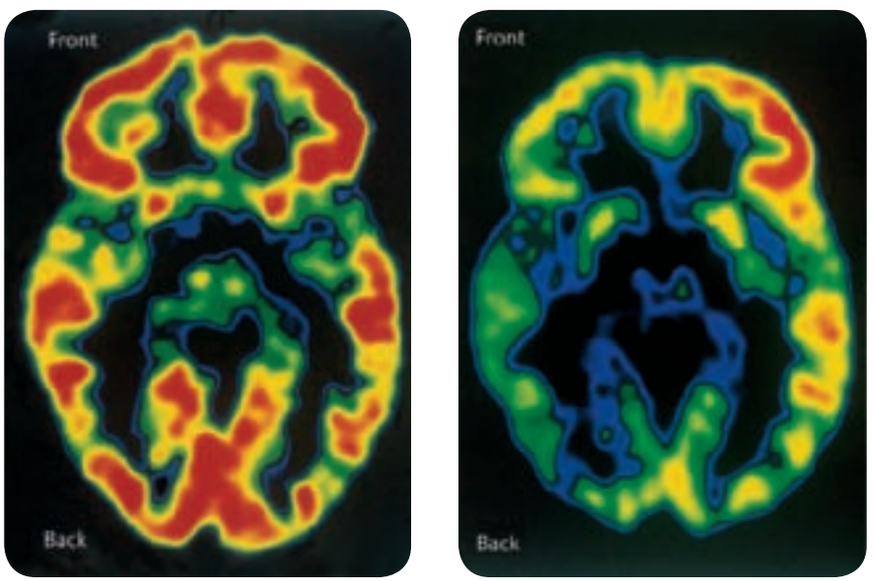
In sum, the infant's brain is waiting for experiences to determine how connections are made (Mai & others, 2012). Before birth, it appears that genes mainly direct basic wiring patterns. Neurons grow and travel to distant places awaiting further instructions (Nelson, 2012). After birth, the inflowing stream of sights, sounds, smells, touches, language, and eye contact help shape the brain's neural connections (Diamond, 2013; Lamb, 2013; Narvaez & others, 2013).

FIGURE **4.8**

MEASURING THE ACTIVITY OF AN INFANT'S BRAIN. By attaching up to 128 electrodes to a baby's scalp to measure the brain's activity, Charles Nelson (2003, 2012) has found that even newborns produce distinctive brain waves that reveal they can distinguish their mother's voice from another woman's, even while they are asleep. *Why is it so difficult to measure infants' brain activity?*

Changing Neurons At birth, the newborn's brain is about 25 percent of its adult weight. By the second birthday, the brain is about 75 percent of its adult weight. Two key developments during these first two years involve the myelin sheath (the layer of fat cells that speeds up the electrical impulse along the axon) and connections between dendrites.

Myelination, the process of encasing axons with a myelin sheath, begins prenatally and continues

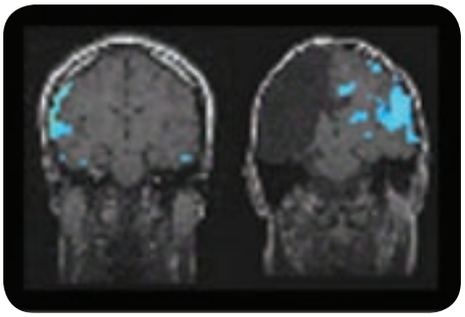


(*a*) (*b*)

FIGURE **4.9**

EARLY DEPRIVATION AND BRAIN ACTIVITY. These two photographs are PET (positron emission tomography) scans (which use radioactive tracers to image and analyze blood flow and metabolic activity in the body's organs) of the brains of (*a*) a normal child and (*b*) an institutionalized Romanian orphan who experienced substantial deprivation since birth. In PET scans, the highest to lowest brain activity is reflected in the colors of red, yellow, green, blue, and black, respectively. As can be seen, red and yellow show up to a much greater degree in the PET scan of the normal child than the deprived Romanian orphan.

(*a*)



(*b*)

FIGURE **4.10**

PLASTICITY IN THE BRAIN'S HEMISPHERES. (*a*) Michael Rehbein at 14 years of age. (*b*) Michael's right hemisphere (*right*) has reorganized to take over the language functions normally carried out by corresponding areas in the left hemisphere of an intact brain (*left*). However, the right hemisphere is not as efficient as the left, and more areas of the brain are recruited to process speech.

FIGURE **4.11**

MYELINATED NERVE FIBER. The myelin sheath, shown in brown, encases the axon (white). This image was produced by an electron microscope that magnified the nerve fiber 12,000 times. *What role does myelination play in the brain's development?*

after birth (see Figure 4.11). The myelin sheath insulates axons and helps electrical signals travel faster down the axon (Markant & Thomas, 2013; Nelson, 2012). As we indicated earlier, myelination increases the speed at which information is processed. It also is involved in providing energy to neurons and in communication (Harris & Attwell, 2012). Myelination for visual pathways occurs rapidly after birth and is completed during the first six months. Auditory myelination is not completed until 4 or 5 years of age. Some aspects of myelination continue even into adolescence. Indeed, the most extensive changes in myelination in the frontal lobes occur during adolescence (Giedd, 2012).

Dramatic increases in dendrites and synapses (the tiny gaps between neurons across which neurotransmitters carry information) also characterize the development of the brain in the first two years of life (see Figure 4.12). Nearly twice as many of these connections are made as will ever be used (Huttenlocher & others, 1991; Huttenlocher & Dabholkar, 1997). The connections that are used become strengthened and survive; the unused ones are replaced by other pathways or disappear. That is, connections are "pruned" (Campbell & others, 2012). Figure 4.13 vividly illustrates the growth and later pruning of synapses in the visual, auditory, and prefrontal cortex areas of the brain (Huttenlocher & Dabholkar, 1997).

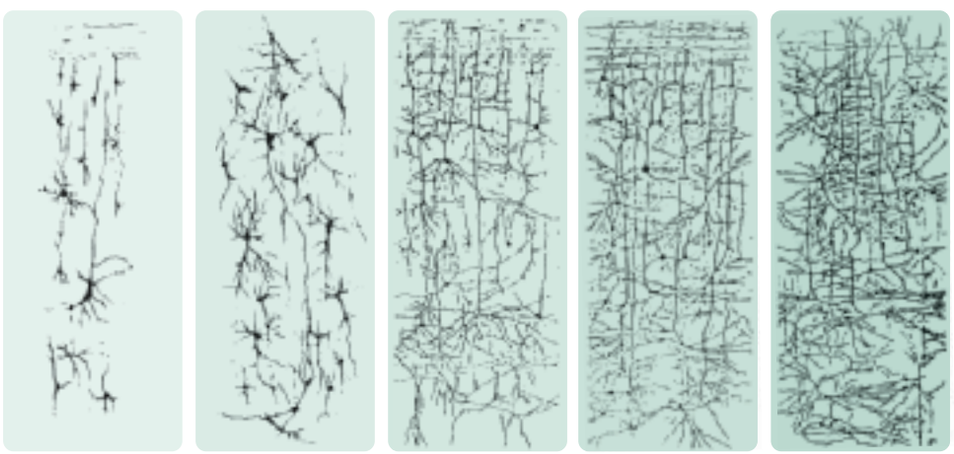


FIGURE **4.12**

THE DEVELOPMENT OF DENDRITIC SPREADING. Note the increase in connectedness between neurons over the course of the first two years of life.

As shown in Figure 4.13, "blooming and pruning" vary considerably by brain region in humans. For example, the peak synaptic overproduction in the area concerned with vision occurs about the fourth postnatal month, followed by a gradual pruning until the middle to end of the preschool years (Huttenlocher & Dabholkar, 1997). In areas of the brain involved in hearing and language, a similar, though somewhat later, course is detected. However, in the prefrontal cortex (the area of the brain where higher-level thinking and self-regulation occur), the peak of overproduction occurs at just after 3 years of age. Both heredity and environment are thought to influence synaptic overproduction and subsequent pruning.

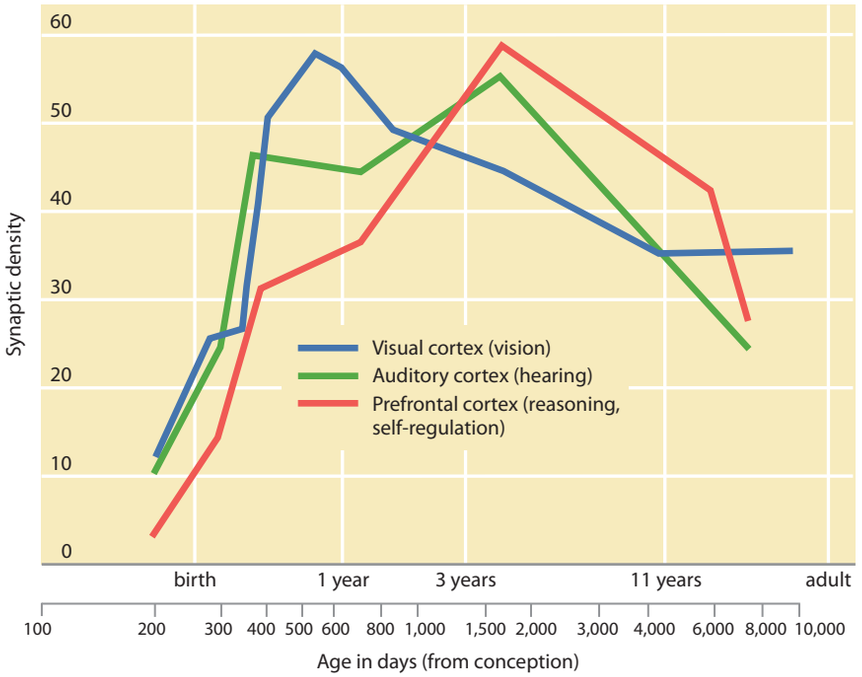


FIGURE 4.13

SYNAPTIC DENSITY IN THE HUMAN BRAIN FROM INFANCY TO ADULTHOOD. The graph shows the dramatic increase and then pruning in synaptic density for three regions of the brain: visual cortex, auditory cortex, and prefrontal cortex. Synaptic density is believed to be an important indication of the extent of connectivity between neurons.

Changing Structures At birth, the hemispheres already have started to specialize: Newborns show greater electrical activity in the left hemisphere than in the right hemisphere when they are making or listening to speech sounds (Imada & others, 2007).

In general, some areas of the brain, such as the primary motor areas, develop earlier than others, such as the primary sensory areas. The frontal lobes are immature in the newborn. However, as neurons in the frontal lobes become myelinated and interconnected during the first year of life, infants develop an ability to regulate their physiological states, such as sleep, and gain more control over their reflexes. Cognitive skills that require deliberate thinking do not emerge until later in the first year (Bell & Cuevas, 2013).

CHILDHOOD

The brain and other parts of the nervous system continue developing through childhood and adolescence. These changes enable children to plan their actions, to attend to stimuli more effectively, and to make considerable strides in language development (Diamond, 2013).

During early childhood, the brain and head grow more rapidly than any other part of the body. Figure 4.14 shows how the growth curve for the head and brain advances more rapidly than the growth curve for height and weight. Some of the brain's increase in size is due to myelination and some is due to an increase in the number and size of dendrites. Some developmentalists conclude that myelination is important in the maturation of a number of abilities in children (Fair & Schlaggar, 2008). For example, myelination in the areas of the brain related to hand-eye coordination is not complete until about 4 years of age. A functional magnetic resonance imaging (fMRI) study of children (mean age, 4 years) found that those who were characterized by developmental delay of motor and cognitive milestones had significantly reduced levels of myelination (Pujol & others, 2004). Myelination in the areas of the brain related to focusing attention is not complete until middle or late childhood.

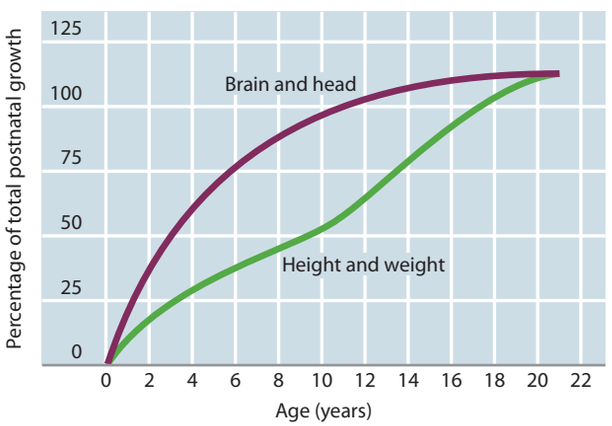


FIGURE 4.14

GROWTH CURVES FOR THE HEAD AND BRAIN AND FOR HEIGHT AND WEIGHT. The more rapid growth of the brain and head can easily be seen. Height and weight advance more gradually over the first two decades of life.

The brain in early childhood is not growing as rapidly as it did in infancy. However, the anatomical changes in the child's brain between the ages of 3 and 15 are dramatic. By repeatedly obtaining brain scans of the same children for up to four years, scientists have found that children's brains experience rapid, distinct bursts of growth (Gogtay & Thompson, 2010; Thompson & others, 2000). The amount of brain material in some areas can nearly double in as little as one year, followed by a drastic loss of tissue as unneeded cells are purged and the brain continues to reorganize itself. The overall size of the brain does not increase dramatically from 3 to 15. What does dramatically change are local patterns within the brain (Gogtay & Thompson, 2010; Thompson & others, 2000). From 3 to 6 years of age, the most rapid growth occurs in the frontal lobe areas involved in planning and organizing new actions and in maintaining attention to tasks (Diamond, 2013). From age 6 through puberty, the most dramatic growth takes place in the temporal and parietal lobes, especially in areas that play major roles in language and spatial relations.

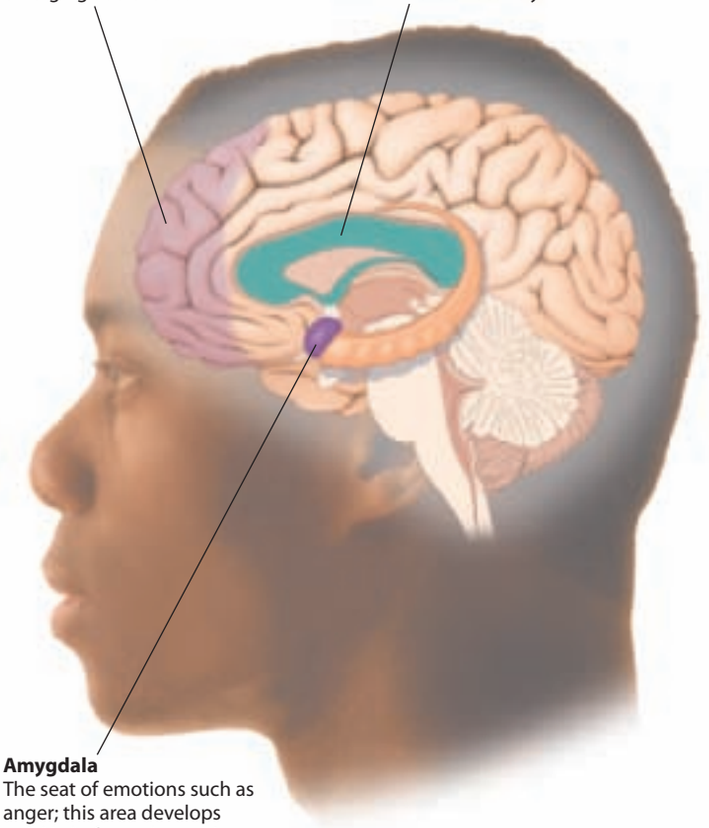


FIGURE **4.15**
CHANGES IN THE ADOLESCENT BRAIN

Developmental neuroscientist Mark Johnson and his colleagues (2009) proposed that the prefrontal cortex likely orchestrates the functions of many other brain regions during development. As part of this neural leadership and organizational role, the prefrontal cortex may provide an advantage to neural connections and networks that include the prefrontal cortex. In the view of these researchers, the prefrontal cortex likely coordinates the best neural connections for solving a problem.

Links between the changing brain and children's cognitive development involve activation of brain areas, with some areas increasing in activation while others decrease. One shift in activation that occurs as children develop in middle and late childhood is from diffuse, larger areas to more focal, smaller areas (Durston & others, 2006). This shift is characterized by synaptic pruning in which areas of the brain not being used lose synaptic connections and those being used show an increase in connections. In a recent study, researchers found less diffusion and more focal activation in the prefrontal cortex (the highest level of the frontal lobes) from 7 to 30 years of age (Durston & others, 2006). The activation change was accompanied by increased efficiency in cognitive performance, especially in *cognitive control,* which involves flexible and effective control in a number of areas. These areas include controlling attention, reducing interfering thoughts, inhibiting motor actions, and being flexible in switching between competing choices (Carlson, Zelazo, & Faja, 2013; Diamond, 2013).

ADOLESCENCE

Along with the rest of the body, the brain is changing during adolescence, but the study of adolescent brain development is in its infancy (Blakemore & Mills, 2014; Giedd & others, 2012). As advances in technology take place, significant strides will also likely be made in charting developmental changes in the adolescent brain. What do we know now?

Earlier we indicated that connections between neurons become "pruned" as children and adolescents develop. The pruning means that the connections which are used strengthen and survive, while the unused ones are replaced by other pathways or disappear. As a result of this pruning, by the end of adolescence individuals have "fewer, more selective, more effective neuronal connections than they did as children" (Kuhn, 2009, p. 153). And this pruning indicates that the activities adolescents choose to engage in and not to engage in influence which neural connections will be strengthened and which will disappear.

Using fMRI brain scans, scientists have recently discovered that adolescents' brains undergo significant structural changes (Chein & others, 2011; Lenroot & Giedd, 2011). The **corpus callosum,** where fibers connect the brain's left and right hemispheres, thickens in adolescence; this improves adolescents' ability to process information. We just described advances in the development of the **prefrontal cortex**—the highest level of the frontal lobes involved in reasoning, decision making, and self-control. The prefrontal cortex doesn't finish maturing until the emerging adult years (approximately 18 to 25 years of age) or later, but the **amygdala**—the seat of emotions such as anger—matures earlier than the prefrontal cortex (Casey, Duhoux, & Malter Cohen, 2010). Figure 4.15 shows the locations of the corpus callosum, prefrontal cortex, and amygdala. A recent study of 137 early adolescents revealed a positive link between the volume of the amygdala and the duration of adolescents' aggressive behavior during interactions with parents (Whittle & others, 2008).

Many of the changes in the adolescent brain that have been described involve the rapidly emerging field of *developmental social neuroscience,* which involves connections between development, the brain, and socioemotional processes (Blakemore & Mills, 2014; Salley, Miller, & Bell, 2013). For example, consider leading researcher Charles Nelson's (2003) view that although adolescents are capable of very strong emotions, their prefrontal cortex hasn't developed to the point at which they can control these passions. It is as if their brain doesn't have the brakes to slow down their emotions. Or consider this interpretation of the development

developmental **connection**

Brain Development

How might developmental changes in the adolescent's brain be linked to adolescents' decision-making skills? Chapter 7, p. 218

corpus callosum Brain area where fibers connect the brain's left and right hemispheres.

prefrontal cortex The highest level of the frontal lobes that is involved in reasoning, decision making, and self-control.

amygdala The seat of emotions in the brain.

of emotion and cognition in adolescents: "early activation of strong 'turbo-charged' feelings with a relatively un-skilled set of 'driving skills' or cognitive abilities to modulate strong emotions and motivations" (Dahl, 2004, p. 18).

Of course, a major issue in adolescent brain development is which comes first: biological changes in the brain or experiences that stimulate these changes (Lerner, Boyd, & Du, 2009). Consider a study in which the prefrontal cortex thickened and more brain connections formed when adolescents resisted peer pressure (Paus & others, 2007). A recent study also found that adolescents from Mexican backgrounds with greater family obligation values showed decreased activation in the brain's regions (ventral striatum) involving reward sensitivity, which was linked to less real-life risk-taking behavior, and increased activation in the brain's regions (prefrontal cortex) involving cognitive control, which was associated with better decision-making skills (Telzer & others, 2013).

Scientists have yet to determine whether the brain changes come first or whether they result from experiences with peers, parents, and others. Once again, we encounter the nature/nurture issue that is so prominent in examining development (Giedd & others, 2012).

developmental **connection**

Brain Development

Developmental social neuroscience is a recently emerging field that focuses on connections between development, socio-emotional factors, and neuroscience. Chapter 1, p. 13

Review *Connect* Reflect

LG2 Describe how the brain changes.

Review

- What are some key features of the neuroconstructivist view?
- What is the nature of brain physiology?
- How does the brain change in infancy?
- What characterizes the development of the brain in childhood?
- How does the brain change in adolescence, and how might this change be linked to adolescents' behavior?

Connect

- Both infancy and adolescence are times of significant change in the brain. Compare and contrast these changes.

Reflect *Your Own Personal Journey of Life*

- A parent tells you that his or her child is "left-brained" and that this aspect of the brain explains why the child does well in school. Is the parent likely to be providing an accurate explanation or probably off-base? Explain.

Sleep

LG3 Summarize how sleep patterns change as children and adolescents develop.

Infancy | Childhood | Adolescence

Sleep restores, replenishes, and rebuilds our brains and bodies. Some neuroscientists believe that sleep gives neurons that have been used while we are awake a chance to shut down and repair themselves (National Institute of Neurological Disorders and Stroke, 2013). How do sleeping patterns change during the childhood years?

Sleep that knits up the ravelled sleave of care . . .
Balm of hurt minds,
nature's second course. Chief nourisher in life's feast.

—William Shakespeare
English playwright, 17th century

INFANCY

When we were infants, sleep consumed more of our time than it does now. Newborns sleep 16 to 17 hours a day, although some sleep more and others less—the range is from a low of about 10 hours to a high of about 21 hours per day. A recent research review concluded that infants 0 to 2 years of age slept an average of 12.8 hours out of the 24, within a range of

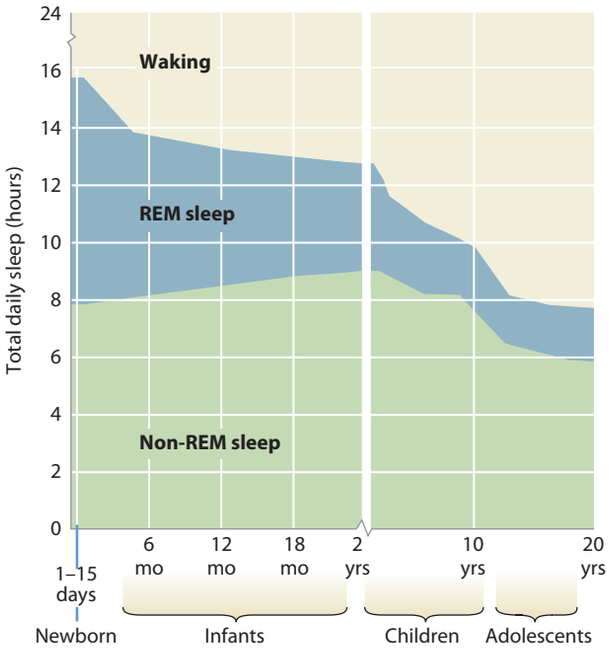


FIGURE **4.16**
DEVELOPMENTAL CHANGES IN REM AND NON-REM SLEEP

9.7 to 15.9 hours (Galland & others, 2012). A recent study also revealed that by 6 months of age the majority of infants slept through the night, awakening their mothers only once or twice a week (Weinraub & others, 2012).

Although total sleep remains somewhat consistent for young infants, their sleep during the day does not always follow a rhythmic pattern. An infant might change from sleeping several long bouts of 7 or 8 hours to three or four shorter sessions only several hours in duration. By about 1 month of age, most infants have begun to sleep longer at night. By 6 months of age, they usually have moved closer to adult-like sleep patterns, spending their longest span of sleep at night and their longest span of waking during the day (Sadeh, 2008).

The most common infant sleep-related problem reported by parents is nighttime waking (The Hospital for Sick Children & others, 2010). Surveys indicate that 20 to 30 percent of infants have difficulty going to sleep at night and staying asleep (Sadeh, 2008). A recent study revealed that the mother's emotional availability at bedtime was linked to fewer infant sleep problems, supporting the premise that parents' emotional availability to infants in sleep contexts increases feelings of safety and security, and consequently promotes better-regulated infant sleep (Teti & others, 2010). Further, a recent study found that a higher involvement of fathers in overall infant care was related to fewer infant sleep problems (Tikotzky, Sadeh, & Glickman-Gavrieli, 2010). However, infant nighttime waking problems have consistently been linked to excessive parental involvement in sleep-related interactions with their infant (Sadeh, 2008). And a recent study revealed that maternal depression during pregnancy, early introduction of solid foods, infant TV viewing, and child care attendance were related to shorter duration of infant sleep (Nevarez & others, 2010). Also, a recent study found that nighttime wakings at 1 year of age predicted lower sleep efficiency at 4 years of age (Tikotzky & Shaashua, 2012).

REM Sleep In REM sleep, the eyes flutter beneath closed lids; in non-REM sleep, this type of eye movement does not occur and sleep is quieter. Figure 4.16 shows developmental changes in the average number of total hours spent in REM and non-REM sleep. By the time they reach adulthood, individuals spend about one-fifth of their night in REM sleep, and REM sleep usually appears about one hour after non-REM sleep. However, about half of an infant's sleep is REM sleep, and infants often begin their sleep cycle with REM sleep rather than non-REM sleep (Sadeh, 2008). A much greater amount of time is taken up by REM sleep in infancy than at any other point in the life span. By the time infants reach 3 months of age, the percentage of time they spend in REM sleep falls to about 40 percent, and REM sleep no longer begins their sleep cycle.

Why do infants spend so much time in REM sleep? Researchers are not certain. The large amount of REM sleep may provide infants with added self-stimulation, since they spend less time awake than do older children. REM sleep also might promote the brain's development in infancy (Graven, 2006).

When adults are awakened during REM sleep, they frequently report that they have been dreaming, but when they are awakened during non-REM sleep they are much less likely to report having been dreaming (Cartwright & others, 2006). Since infants spend more time than adults in REM sleep, can we conclude that they dream a lot? We don't know whether infants dream or not, because they don't have any way of reporting dreams.

Shared Sleeping Some child experts stress that there are benefits to shared sleeping (as when an infant sleeps in the same bed with its mother). They state that it can promote breast feeding, lets the mother respond more quickly to the baby's cries, and allows her to detect breathing pauses in the baby that might be dangerous (Pelayo & others, 2006). Sharing a bed with a mother is common practice in many countries, such as Guatemala and China, whereas in others, such as the United States and Great Britain, most newborns sleep in a crib, either in the same room as the parents or in a separate room.

Shared sleeping remains a controversial issue, with some experts recommending it and others arguing against it, although recently the recommendation trend has been to avoid infant-parent bed sharing, especially until the infant is at least six months of age (Byard, 2012a, b; Weber & others, 2012). The American Academy of Pediatrics Task Force on Infant Positioning

and SIDS (AAPTFIPS) (2000) recommends against shared sleeping. Its members argue that in some instances bed sharing might lead to sudden infant death syndrome (SIDS), as could be the case if a sleeping mother rolls over on her baby. Recent studies have found that bed sharing is linked with a greater incidence of SIDS, especially when parents smoke (Byard 2012a, b). And a recent study of 2-month-old infants revealed that they had more sleep problems such as disordered breathing when they shared the bed with parents (Kelmanson, 2010).

Is this a good sleep position for infants? Why or why not?

SIDS **Sudden infant death syndrome (SIDS)** is a condition that occurs when infants stop breathing, usually during the night, and die suddenly without an apparent cause. SIDS remains the highest cause of infant death in the United States, with nearly 3,000 infant deaths attributed to it annually (Montagna & Chokroverty, 2011). Risk of SIDS is highest at 2 to 4 months of age (National Institute of Child Health and Development, 2013).

Since 1992, The American Academy of Pediatrics (AAP) has recommended that infants be placed to sleep on their backs to reduce the risk of SIDS, and the frequency of prone (on the stomach) sleeping among U.S. infants has dropped dramatically (AAPTFIPS, 2000). Researchers have found that SIDS does indeed decrease when infants sleep on their backs rather than their stomachs or sides (Darrah & Bartlett, 2013). Among the reasons given for prone sleeping being a high-risk factor for SIDS are that it impairs the infant's arousal from sleep and restricts the infant's ability to swallow effectively (Moon & Fu, 2012).

In addition to sleeping in a prone position, researchers have found that the following are risk factors for SIDS:

- SIDS occurs more often in infants with abnormal brain stem functioning involving the neurotransmitter serotonin (Broadbrent & others, 2012; Duncan & others, 2010).
- Heart arrhythmias are estimated to occur in as many as 15 percent of SIDS cases, and two recent studies found that gene mutations were linked to the occurrence of these arrhythmias (Brion & others, 2012; Van Norstrand & others, 2012).
- Six percent of infants with sleep apnea, a temporary cessation of breathing in which the airway is completely blocked, usually for 10 seconds or longer, die of SIDS (Ednick & others, 2010; McNamara & Sullivan, 2000).
- Low birth weight infants are 5 to 10 times more likely to die of SIDS than are their normal-weight counterparts (Horne & others, 2002).
- Infants whose siblings have died of SIDS are two to four times as likely to die of it (Lenoir, Mallet, & Calenda, 2000).
- African American and Eskimo infants are four to six times as likely as all others to die of SIDS (Ige & Shelton, 2004; Kitsantas & Gaffney, 2010).
- SIDS is more common in lower socioeconomic groups (Mitchell & others, 2000).
- Two recent reviews concluded that breast feeding is linked to a lower incidence of SIDS (Hauck & others, 2011; Zotter & Pichler, 2012).
- SIDS is more common in infants who are passively exposed to cigarette smoke (Dietz & others, 2010).
- SIDS is more common when infants and parents share the same bed (Senter & others, 2010).
- SIDS is more common if infants sleep in soft bedding (Moon & Fu, 2012).
- SIDS is more likely to occur in infants who do not use a pacifier when they go to sleep than in those who do use a pacifier (Jenik & Vain, 2010).
- SIDS is less common when infants sleep in a bedroom with a fan. A recent study revealed that sleeping in a bedroom with a fan lowers the risk of SIDS by 70 percent (Coleman-Phox, Odouli, & Li, 2008).

CHILDHOOD

A good night's sleep is an important aspect of a child's development (El-Sheikh, 2013; El-Sheikh & others, 2013). Experts recommend that young children get 11 to 13 hours of sleep each night and that first- to fifth-graders get 10 to 11 hours of sleep each night (National

sudden infant death syndrome (SIDS) A condition that occurs when an infant stops breathing, usually during the night, and suddenly dies without an apparent cause.

What are some links between children's sleep patterns and other aspects of development?

Sleep Foundation, 2013). Most young children sleep through the night and have one daytime nap. Not only is the amount of sleep children get important, but so is uninterrupted sleep (Moore, 2012). However, it sometimes is difficult to get young children to go to sleep as they drag out their bedtime routine.

To improve sleep, Mona El-Sheikh (2013) recommends ensuring that children have a bedroom that is cool, dark, and comfortable; consistent bed times and wake times; and positive family relationships. Also, helping the child slow down before bedtime often contributes to less resistance in going to bed. Reading the child a story, playing quietly with the child in the bath, and letting the child sit on the caregiver's lap while listening to music are quieting activities.

Children can experience a number of sleep problems (El-Sheikh, 2011). One estimate indicates that more than 40 percent of children experience a sleep problem at some point in their development (Boyle & Cropley, 2004). The following research studies indicate links between children's sleep problems and negative developmental outcomes:

- Children who had trouble sleeping in childhood were more likely to have alcohol use problems in adolescence and early adulthood (Wong & others, 2010).
- Sleep problems in early childhood were a subsequent indicator of attention problems that in some cases persisted into early adolescence (O'Callaghan & others, 2010).
- A recent analysis concluded that chronic sleep disorders that deprive children of adequate sleep may result in impaired brain development (Jan & others, 2010).
- Emotional security in parent and marital relationships when children were in the third grade predicted fewer sleep problems when they reached the fifth grade (Keller & El-Sheikh, 2010).

ADOLESCENCE

There has recently been a surge of interest in adolescent sleep patterns (Mak & others, 2012; Short & others, 2012). This interest focuses on the belief that many adolescents are not getting enough sleep, that there are physiological underpinnings to the desire of adolescents, especially older ones, to stay up later at night and sleep longer in the morning, and that these findings have implications for understanding the times of day when adolescents learn most effectively in school (Hansen & others, 2005). For example, a recent national survey found that 8 percent of middle school students and 14 percent of high school students are late for school or miss school because they oversleep (National Sleep Foundation, 2006). Also in this survey, 6 percent of middle school students and 28 percent of high school students fall asleep in U.S. schools on any given day. Studies recently have confirmed that adolescents in other countries also are not getting adequate sleep (Leger & others, 2012; Short & others, 2012). In one recent study, Asian adolescents had later bedtimes and were getting less sleep than U.S. adolescents (Gradisar, Gardner, & Duhnt, 2011).

Getting too little sleep in adolescence is linked to a number of problems, including delinquency (Clinkinbeard & others, 2011), sleep disturbances in emerging and early adulthood (Dregan & Armstrong, 2010), and less effective attention (Beebe, Rose, & Amin, 2010). A longitudinal study in which adolescents completed daily diaries for 14-day periods in ninth, tenth, and twelfth grades found that regardless of how much students studied each day, when the students sacrificed sleep time to study more than usual, they had difficulty understanding what was taught in class and were more likely to struggle with class assignments the next day (Gillen-O'Neel, Huynh, & Fuligni, 2012).

Mary Carskadon (2002, 2004, 2005, 2006, 2011) has conducted a number of research studies on adolescent sleep patterns. She has found that adolescents sleep an average of 9 hours and 25 minutes when given the opportunity to sleep as long as they like. Most adolescents get considerably less sleep than this, especially during the week. This creates a sleep debt, which

adolescents often try to make up on the weekend. Carskadon also found that older adolescents are often more sleepy during the day than are younger adolescents and concluded that this was not because of factors such as academic work and social pressures. Rather, her research suggests that adolescents' biological clocks undergo a hormonal phase shift as they get older. This pushes the time of wakefulness to an hour later than when they were young adolescents. Carskadon found that this shift was caused by a delay in the nightly presence of the hormone *melatonin,* which is produced by the brain's pineal gland in preparing the body for sleep. Melatonin is secreted at about 9:30 p.m. in younger adolescents but is produced approximately an hour later in older adolescents, which delays the onset of sleep.

Carskadon determined that early school starting times can result in grogginess and lack of attention in class and poor performance on tests. Based on this research, some schools are now starting later (Cassoff & others, 2013). For example, school officials in Edina, Minnesota, made the decision to start classes at 8:30 a.m. instead of 7:25 a.m. Discipline problems and the number of students who report an illness or depression have dropped. Test scores in Edina have improved for high school students but not for middle school students, which supports Carskadon's idea that older adolescents are more affected by earlier school start times than younger adolescents are. Also, a recent study found that just a 30-minute delay in school start time was linked to improvements in adolescents' sleep, alertness, mood, and health (Owens, Belon, & Moss, 2010).

In Mary Carskadon's sleep laboratory at Brown University, an adolescent girl's brain activity is being monitored. Carskadon (2005) says that in the morning, sleep-deprived adolescents'"brains are telling them it's nighttime . . . and the rest of the world is saying it's time to go to school" (p. 19).

Review *Connect* Reflect

LG3 Summarize how sleep patterns change as children and adolescents develop.

Review

- How can sleep be characterized in infancy?
- What changes occur in sleep during childhood?
- How does adolescence affect sleep?

Connect

- In this section, you learned that exposure to cigarette smoke can affect an infant's risk for SIDS. In Chapter 3, what did you learn about cigarette smoke's effect on fetal development?

Reflect *Your Own Personal Journey of Life*

- Did your sleep patterns start to change when you became an adolescent? Have they changed since you went through puberty? If so, how?

Health

LG4 Characterize children's health.

Illness and Injuries Among Children

Nutrition and Eating Behavior

Exercise

What are the major threats to children's health today? We will look first at the major illnesses and injuries experienced by children and adolescents before turning to less obvious threats to healthy development: poor nutrition and eating habits, and lack of exercise. The formation of healthy habits in childhood, such as eating foods low in fat and cholesterol and engaging in regular exercise, not only has immediate benefits but also contributes to the delay or prevention of premature

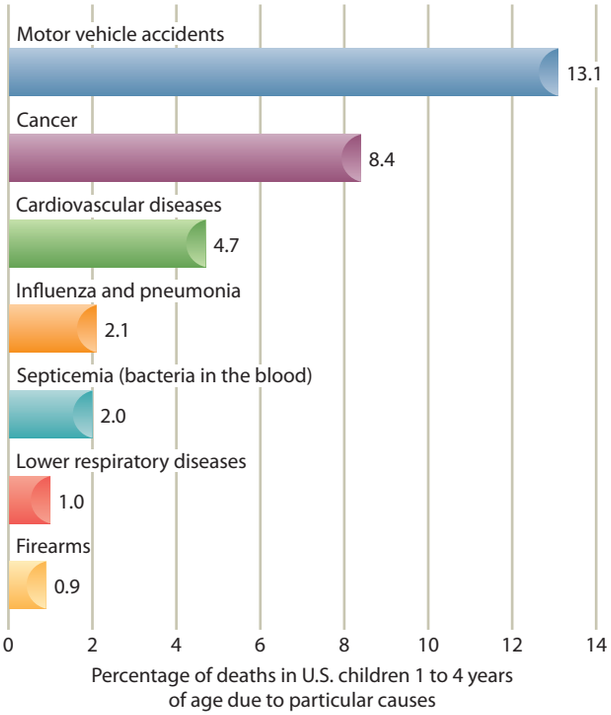


FIGURE **4.17**

MAIN CAUSES OF DEATH IN CHILDREN 1 THROUGH 4 YEARS OF AGE. These figures show the percentage of deaths in U.S. children 1 to 4 years of age due to particular causes in 2002 (National Vital Statistics Reports, 2004).

disability and mortality in adulthood from heart disease, stroke, diabetes, and cancer. And adolescence is a critical juncture in the adoption of many health-enhancing behaviors, such as regular exercise, and health-compromising behaviors, such as smoking (Catalano & others, 2012; Phillips & Edwards, 2013).

ILLNESS AND INJURIES AMONG CHILDREN

In this section, we first examine broad patterns in the causes of illness and death among children and adolescents. Then we turn to the difficulties faced by poor children in the United States and around the world.

Early Childhood Young children's active and exploratory nature, coupled with being unaware of danger in many instances, often puts them in situations in which they are at risk for injuries. Most of the cuts, bumps, and bruises sustained by young children are minor, but some accidental injuries can produce serious impairment or even death. In the United States, motor vehicle accidents are the leading cause of death in young children, followed by cancer and cardiovascular disease (National Vital Statistics Report, 2004) (see Figure 4.17). In addition to motor vehicle accidents, other accidental deaths in children involve drowning, falls, burns, and poisoning (Conde, 2012; Gielen & others, 2012).

An increasing number of studies reach the conclusion that children are at risk for health problems when they live in homes in which a parent smokes (Been & others, 2013; Hwang & others, 2012). Children exposed to tobacco smoke in the home are more likely to develop wheezing symptoms and asthma than children in nonsmoking homes (Yi & others, 2012). A recent study found that parental smoking was a risk factor for higher blood pressure in children (Simonetti & others, 2011). And another recent study revealed that exposure to secondhand smoke was related to young children's sleep problems, including sleep-disordered breathing (Yolton & others, 2010).

An estimated 3 million U.S. children under 6 years of age are thought to be at risk for lead poisoning (Moya, Bearer, & Etzel, 2004). The negative effects of high lead levels in children's blood include lower intelligence, lower achievement, attention deficit hyperactivity disorder, and elevated blood pressure (Burke & Miller, 2011). Children in poverty face a higher risk for lead poisoning than children living in higher socioeconomic conditions (Vivier & others, 2011).

Middle and Late Childhood For the most part, middle and late childhood is a time of excellent health (Van Dyck, 2007). Disease and death are less prevalent in this period than in early childhood and adolescence.

The most common cause of severe injury and death in middle and late childhood is motor vehicle accidents, either as a pedestrian or as a passenger (Frisbie, Hummer, & McKinnon, 2009). Using safety-belt restraints is important in reducing the severity of motor vehicle injuries.

Most accidents occur in or near the child's home or school. The most effective strategy for preventing injury is to educate the child about the hazards of risk taking and improper use of equipment (Snowdon & others, 2008). Appropriate safety helmets, protective eye and mouth shields, and protective padding are recommended for children who engage in active sports.

Cancer Children not only are vulnerable to injuries, they also may develop life-threatening diseases. Cancer is the second leading cause of death in children 5 to 14 years of age. Three percent of all children's deaths in this age period are due to cancer. Currently, 1 in every 330 children in the United States develops cancer before the age of 19. Moreover, the incidence of cancer in children is increasing (National Cancer Institute, 2011).

Childhood cancers have a different profile from adult cancers. Cancers in adults attack mainly the lungs, colon, breast, prostate, and pancreas. In children, cancers mainly attack the white blood cells (leukemia), brain, bone, lymphatic system, muscles, kidneys, and nervous system. Researchers are intensely searching for possible genetic links to childhood cancers (Crespi, 2011; Spector & others, 2013).

The most common cancer in children is leukemia, a cancer of the tissues that make blood cells (Kelly & others, 2013). In leukemia, the bone marrow makes an abundance of white blood cells that don't function properly. They crowd out normal cells, making the child susceptible to bruising and infection.

Because of advancements in cancer treatment, children with cancer are surviving longer (Sung & others, 2013). Approximately 80 percent of children with acute lymphoblastic leukemia are cured with current chemotherapy treatment (Wayne, 2011).

Cardiovascular Disease Cardiovascular disease is uncommon in children. Nonetheless, environmental experiences and behavior in the childhood years can sow the seeds for cardiovascular disease in adulthood. Many elementary-school-aged children already possess one or more of the risk factors for cardiovascular disease, such as hypertension and obesity (Malatesta-Muncher & Mitsnefes, 2012; Peters & others, 2012). A national study found that an increasing percentage of U.S. children and adolescents had elevated blood pressure from 1988 to 2006 (Ostchega & others, 2009). In this study, children who were obese were more likely to have elevated blood pressure. Further, one study revealed that high blood pressure goes undiagnosed in 75 percent of children with the disease (Hansen, Gunn, & Kaelber, 2007).

Health, Illness, and Poverty Among the World's Children An estimated 7 percent of U.S. children receive no health care, and the vast majority of these children live in poverty. One approach to children's health aims to treat not only medical problems of the individual child but also the conditions of the entire family. In fact, some programs seek to identify children who are at risk for problems and then try to alter the risk factors in an effort to prevent illness and disease.

Poverty in the United States is dwarfed by poverty in developing countries around the world. Each year UNICEF produces a report entitled *The State of the World's Children*. In recent years, the following factors that are especially influenced by poverty are linked to the under-5 mortality rate: the nutritional health and health knowledge of mothers, levels of immunization, dehydration, availability of maternal and child health services, income and food availability in the family, availability of clean water and safe sanitation, and the overall safety of the child's environment.

Devastating effects on the health of young children occur in countries where poverty rates are high (UNICEF, 2012). The poor are the majority in nearly one of every five nations in the world (UNICEF, 2012). They often experience hunger, malnutrition, illness, inadequate access to health care, unsafe water, and a lack of protection from harm (Horton, 2006).

What are some of the main causes of death in young children around the world?

In the last decade, there has been a dramatic increase in the number of young children who have died because HIV/AIDS was transmitted to them by their parents (UNICEF, 2012). Deaths in young children due to HIV/AIDS occur most frequently in countries with high rates of poverty and low levels of education. For example, uneducated people are four times more likely to believe that there is no way to avoid AIDS and three times more likely to be unaware that the virus can be transmitted from mother to child (UNICEF, 2006).

Many of the deaths of young children around the world can be prevented by a reduction in poverty and improvements in nutrition, sanitation, education, and health services (UNICEF, 2012).

NUTRITION AND EATING BEHAVIOR

Poverty influences health in part through its effects on nutrition. However, it is not just children living in low-income families who have health-related nutrition problems; across the spectrum of income levels, recent decades have seen a dramatic increase in the percent of U.S. children who are overweight.

Infancy

From birth to 1 year of age, human infants nearly triple their weight and increase their length by 50 percent. What do they need to sustain this growth?

Nutritional Needs and Eating Behavior

Individual differences among infants in terms of their nutrient reserves, body composition, growth rates, and activity patterns make it difficult to define actual nutrient needs (Schiff, 2013). However, because parents need guidelines, nutritionists recommend that infants consume approximately 50 calories per day for each pound they weigh—more than twice an adult's requirement per pound.

A national study of more than 3,000 randomly selected 4- to 24-month-olds documented that many U.S. parents aren't feeding their babies enough fruits and vegetables, but are feeding them too much junk food (Fox & others, 2004). Up to one-third of the babies ate no vegetables and fruit but frequently ate French fries, and almost half of the 7- to 8-month-old babies were fed desserts, sweets, or sweetened drinks. By 15 months, French fries were the most common vegetable the babies ate.

Such poor dietary patterns early in development can result in more infants being overweight (Black & others, 2009; Thorisdottir, Gunnarsdottir, & Thorisdottir, 2013). The Centers for Disease Control and Prevention (2013) has a category of obesity for adults but does not have an obesity category for infants, children, and adolescents because of the stigma the label may bring. Rather, they have categories for being overweight or at risk for being overweight in childhood and adolescence. Children are considered overweight if they are above the 95th percentile in weight for their age and gender; they are labeled at risk for being overweight if they are between the 85th and 95th percentiles.

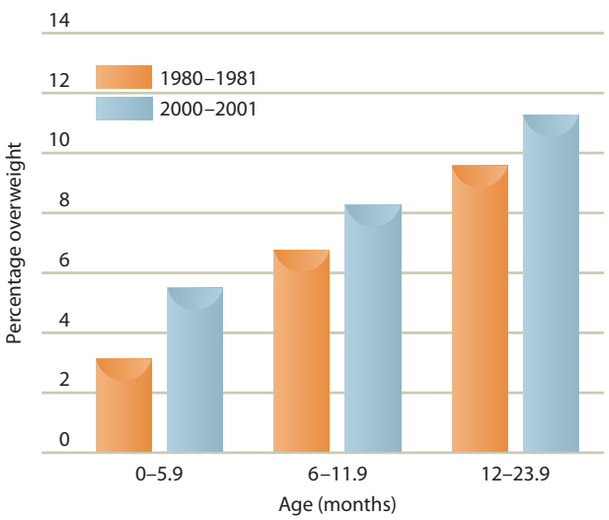


FIGURE **4.18**

PERCENTAGE OF OVERWEIGHT U.S. INFANTS IN 1980–1981 AND 2000–2001. *Note:* Infants above the 95th percentile for their age and gender on a weight-for-height index were categorized as overweight.

One analysis revealed that in 1980, 3.4 percent of U.S. babies less than 6 months old were overweight, a percentage that increased to 5.9 percent in 2001 (Kim & others, 2006). As shown in Figure 4.18, as younger infants become older infants, an even greater percentage are overweight. Also in this study, in addition to the 5.9 percent of infants less than 6 months old who were overweight in 2001, another 11 percent were categorized as at risk for being overweight.

In addition to consuming too many French fries, sweetened drinks, and desserts, are there other factors that might explain this increase in overweight U.S. infants? A mother's weight gain during pregnancy and a mother's own high weight before pregnancy may be factors (Rios-Castillo & others, 2013). One important factor seems to be whether an infant is breast-fed or bottle-fed. Breast-fed infants have lower rates of weight gain than bottle-fed infants by school age, and it is estimated that breast feeding reduces the risk of obesity by approximately 20 percent (Li & others, 2007).

Breast Versus Bottle Feeding

For the first four to six months of life, human milk or an alternative formula is the baby's source of nutrients and energy. For years, debate has focused on whether breast feeding is better for the infant than bottle feeding. The growing consensus is that breast feeding is better for the baby's

health (McKinney & Murray, 2013; Vasquez & Berg, 2012). Since the 1970s, breast feeding by U.S. mothers has soared (see Figure 4.19) (Centers for Disease Control and Prevention, 2012). In 2009, 77 percent of U.S. mothers breast-fed their newborns and 44 percent breast-fed their 6-month-olds. The American Academy of Pediatrics Section on Breastfeeding (2012) recently reconfirmed its recommendation of exclusive breast feeding in the first six months followed by continued breast feeding as complementary foods are introduced, and further breast feeding for one year or longer as mutually desired by the mother and infant.

What are some of the benefits of breast feeding? The following conclusions are based on the current status of research:

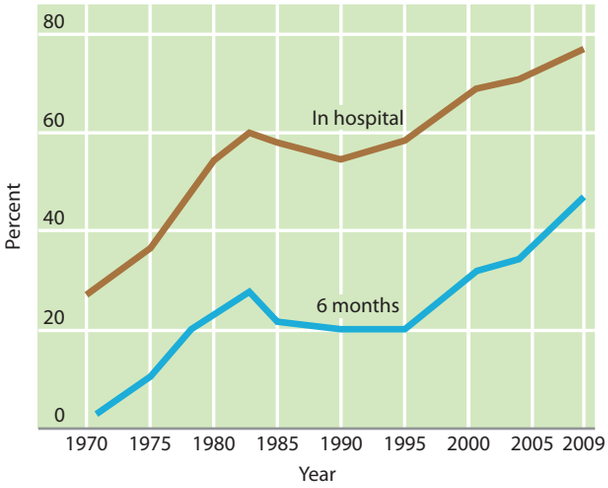


FIGURE **4.19**

TRENDS IN BREAST FEEDING IN THE UNITED STATES, 1970–2009

Evaluation of Outcomes for Child

- *Gastrointestinal infections.* Breast-fed infants have fewer gastrointestinal infections (Garofalo, 2010).
- *Lower respiratory tract infections.* Breast-fed infants have fewer infections of the lower respiratory tract (Prameela, 2012).
- *Allergies.* A recent research review by the American Academy of Pediatrics indicated that there is no evidence that breast feeding reduces the risk of allergies in children (Greer & others, 2008). The research review also concluded that modest evidence exists for feeding hyperallergenic formulas to susceptible babies if they are not solely breast-fed.
- *Asthma.* The recent research review by the American Academy of Pediatrics concluded that exclusive breast feeding for three months protects against wheezing in babies, but whether it prevents asthma in older children is unclear (Greer & others, 2008).
- *Otitis media.* Breast-fed infants are less likely to develop this middle ear infection (Rovers, de Kok, & Schilder, 2006).
- *Atopic dermatitis.* Breast-fed babies are less likely to have this chronic inflammation of the skin (Snijders & others, 2007). The recent research review by the American Academy of Pediatrics also concluded that for infants with a family history of allergies, breast feeding exclusively for at least four months is linked to a lower risk of skin rashes (Greer & others, 2008).
- *Overweight and obesity.* Research indicates that breast-fed infants are less likely to become overweight or obese in childhood, adolescence, and adulthood (Khuc & others, 2013; Scott, Ng, & Cobiac, 2012).
- *Diabetes.* Breast-fed infants are less likely to develop type 1 diabetes in childhood (Ping & Hagopian, 2006) and type 2 diabetes in adulthood (Villegas & others, 2008).
- *SIDS.* Breast-fed infants are less likely to experience SIDS (Zotter & Pichler, 2012).

In recent large-scale research reviews, no conclusive evidence for the benefits of breast feeding was found for children's cognitive development and cardiovascular health (Agency for Healthcare Research and Quality, 2007; Ip & others, 2009).

Evaluation of Outcomes for Mother

- *Breast cancer.* Consistent evidence indicates a lower incidence of breast cancer in women who breast feed their infants (Akbari & others, 2011; Shema & others, 2007).
- *Ovarian cancer.* Evidence also reveals a reduction in ovarian cancer in women who breast feed their infants (Jordan & others, 2008; Stuebe & Schwartz, 2010).
- *Type 2 diabetes.* Some evidence suggests a small reduction in type 2 diabetes in women who breast feed their infants (Ip & others, 2009; Stuebe & Schwartz, 2010).

Human milk or an alternative formula is a baby's source of nutrients for the first four to six months. The growing consensus is that breast feeding is better for the baby's health, although controversy still swirls about the issue of breast feeding versus bottle feeding. *Why is breast feeding strongly recommended by pediatricians?*

In recent large-scale research reviews, no conclusive evidence could be found for maternal benefits of breast feeding with regard to return to prepregnancy weight, osteoporosis, and postpartum depression (Agency for Healthcare Research and Quality, 2007; Ip & others, 2009). However, a recent study revealed that women who breast-fed their infants had a lower incidence of metabolic syndrome (a disorder characterized by obesity, hypertension, and insulin resistance) in midlife (Ram & others, 2008).

Many health professionals have argued that breast feeding facilitates the development of an attachment bond between the mother and infant (Britton, Britton, & Gronwaldt, 2006; Wittig & Spatz, 2008). However, a research review found that the positive role of breast feeding on the mother-infant relationship is not supported by research (Jansen, de Weerth, & Riksen-Walraven, 2008). The review concluded that recommending breast feeding should not be based on its role in improving the mother-infant relationship but rather on its positive effects on infant and maternal health.

The AAP Work Group on Breastfeeding strongly endorses breast feeding throughout the first year of life (AAPWGB, 1997). Are there circumstances when mothers should not breast feed? Yes, a mother should not breast feed (1) when she is infected with HIV or some other infectious disease that can be transmitted through her milk, (2) if she has active tuberculosis, or (3) if she is taking any drug that may not be safe for the infant (Goga & others, 2012).

Some women cannot breast feed their infants because of physical difficulties; others feel guilty if they terminate breast feeding early. Mothers may also worry that they are depriving their infants of important emotional and psychological benefits if they bottle feed rather than breast feed. Some researchers have found, however, that there are no psychological differences between breast-fed and bottle-fed infants (Ferguson, Harwood, & Shannon, 1987; Young, 1990).

A further issue in interpreting the benefits of breast feeding was underscored in recent large-scale research reviews (Agency for Healthcare Research and Quality, 2007; Ip & others, 2009). While highlighting a number of breast feeding benefits for children and mothers, the report issued a caution about breast feeding research: None of the findings imply causality. Breast versus bottle feeding studies are correlational rather than experimental, and women who breast feed are wealthier, older, more educated, and likely more health-conscious than their bottle-feeding counterparts, which could explain why breast-fed children are healthier.

Malnutrition in Infancy Early weaning of infants from breast milk to inadequate sources of nutrients, such as unsuitable and unsanitary cow's milk formula, can cause protein deficiency and malnutrition in infants (UNICEF, 2012). Something that looks like milk but is not, usually a form of tapioca or rice, is also often substituted for breast milk. In many of the world's developing countries, mothers used to breast feed their infants for at least two years. To become more modern, they stopped breast feeding much earlier and replaced it with bottle feeding. Comparisons of breast-fed and bottle-fed infants in countries such as Afghanistan, Haiti, Ghana, and Chile document that the mortality rate of bottle-fed infants is as much as five times that of breast-fed infants (Grant, 1997). However, in the *Connecting with Diversity* interlude, you can read about a recent concern regarding breast feeding.

Two life-threatening conditions that can result from malnutrition are marasmus and kwashiorkor. **Marasmus** is caused by a severe protein-calorie deficiency and results in a wasting away of body tissues in the infant's first year. The infant becomes grossly underweight and his or her muscles atrophy. **Kwashiorkor,** caused by severe protein deficiency, usually appears between 1 and 3 years of age. Children with kwashiorkor sometimes appear to be well fed even though they are not because the disease can cause the child's abdomen and feet to swell with water. Kwashiorkor causes a child's vital organs to collect the nutrients that are present and deprive other parts of the body of them. The child's hair becomes thin, brittle, and colorless, and the child's behavior often becomes listless.

Even if it is not fatal, severe and lengthy malnutrition is detrimental to physical, cognitive, and socioemotional development (Schiff, 2013). A study of Indian children documented the negative influence of chronic malnutrition on children's cognitive development. Children who

developmental **connection**

Research Methods

How does a correlational study differ from an experimental study? Chapter 1, p. 32

This Honduran child has kwashiorkor. Notice the telltale sign of kwashiorkor—a greatly expanded abdomen. *What are some other characteristics of kwashiorkor?*

marasmus Severe malnutrition caused by an insufficient protein-calorie intake, resulting in a shrunken, elderly appearance.

kwashiorkor Severe malnutrition caused by a protein-deficient diet, causing the feet and abdomen to swell with water.

connecting with diversity

The Stories of Latonya and Ramona: Breast and Bottle Feeding in Africa

Latonya is a newborn baby in Ghana. During her first days of life, she has been kept apart from her mother and bottle-fed. Manufacturers of infant formula provide free or subsidized milk powder to the hospital where she was born. Her mother has been persuaded to bottle feed rather than breast feed Latonya. When her mother bottle feeds Latonya, she overdilutes the milk formula with unclean water. Latonya's feeding bottles have not been sterilized. Latonya becomes very sick, and she dies before her first birthday.

Ramona was born in Nigeria, where her family takes part in a "baby-friendly" program. In this program, babies are not separated from their mothers when they are born, and the mothers are encouraged to breast feed them. The mothers are told of the perils that bottle feeding can bring because of unsafe water and unsterilized bottles. They also are informed about the advantages of breast milk, which include its nutritious and hygienic qualities, its ability to immunize babies against common illnesses, and its role in reducing the mother's risk of breast and ovarian cancer. Ramona's mother is breast feeding her. At 1 year of age, Ramona is very healthy.

For many years, maternity units in hospitals favored bottle feeding and did not give mothers adequate information about the benefits of breast feeding. In recent years, the World Health Organization and UNICEF have tried to reverse the trend toward bottle feeding of infants in many impoverished countries. They instituted the "baby-friendly" program in many countries. They also persuaded the International Association of Infant Formula Manufacturers to stop marketing their baby formulas to hospitals in countries where the governments support the baby-friendly initiatives (Grant, 1997). For the hospitals themselves, costs actually were reduced as infant formula, feeding bottles, and separate nurseries became unnecessary. For example, baby-friendly Jose Fabella Memorial Hospital in the Philippines reported saving 8 percent of its annual budget.

The advantages of breast feeding in impoverished countries are substantial. However, these advantages must be balanced against the risk of passing HIV to babies through breast milk if the mothers have the virus; the majority of mothers don't know that they are infected (Goga & others, 2012). In some areas of Africa, more than 30 percent of mothers have the human immunodeficiency virus (HIV).

In what ways does education play a role in the health decisions discussed in this interlude?

(*Top*) An HIV-infected mother breast feeding her baby in Nairobi, Africa. (*Bottom*) A Rwandan mother bottle feeding her baby. *What are some concerns about breast versus bottle feeding in impoverished African countries?*

caring *connections*

Improving the Nutrition of Infants and Young Children Living in Low-Income Families

Poor nutrition is a special concern in the lives of infants from low-income families. To address this problem in the United States, the WIC (Women, Infants, and Children) program provides federal grants to states for healthy supplemental foods, health care referrals, and nutrition education for women from low-income families beginning in pregnancy, and to infants and young children up to 5 years of age who are at nutritional risk (Hillier & others, 2012; Kong & others, 2013; Marshall & others, 2013; Whaley & others, 2012; WIC New York, 2011). WIC serves approximately 7,500,000 participants in the United States.

Positive influences on infants' and young children's nutrition and health have been found for participants in WIC (Black & others, 2012; Davis, Lazariu, & Sekhobo, 2010; Sekhobo & others, 2010). A recent study revealed that a WIC program that introduced peer counseling services for pregnant women increased breast feeding initiation by 27 percent (Olson & others, 2010a, b). Another recent study found that entry during the first trimester of pregnancy to the WIC program in Rhode Island reduced maternal cigarette smoking (Brodsky, Viner-Brown, & Handler, 2009). And a recent multiple-year literacy intervention with Spanish-speaking families in the WIC program in Los Angeles increased literacy resources and activities at home, which in turn led to a higher level of school readiness in children (Whaley & others, 2011).

Participants in the WIC program. *What characterizes the WIC program?*

Why would the WIC program provide lactation counseling as part of its services?

had a history of chronic malnutrition performed more poorly on tests of attention and memory than their counterparts who were not malnourished (Kar, Rao, & Chandramouli, 2008).

Another study linked the diets of rural Guatemalan infants with their social development at the time they entered elementary school (Barrett, Radke-Yarrow, & Klein, 1982). Children whose mothers had been given nutritional supplements during pregnancy, and who themselves had been given more nutritious, high-calorie foods in their first two years of life, were more active, more involved, more helpful with their peers, less anxious, and happier than their counterparts who had not been given nutritional supplements. Also, a recent study found that two food-assisted maternal and child health nutrition programs (both emphasizing food provision, communication about behavior change, and preventive health services) helped to reduce the impact of economic hardship on stunting of children's growth in Haiti (Donegan & others, 2010). To read further about improving infants' and young children's nutrition, as well as other aspects of their lives, see *Caring Connections*.

Adequate early nutrition is an important aspect of healthy development (Hurley & others, 2013; Schiff, 2013). In addition to sound nutrition, children need a nurturing, supportive environment (Lumeng & others, 2012). Caregivers who are not sensitive to developmental changes in infants' nutritional needs, neglectful caregivers, and conditions of poverty can contribute to the development of eating problems in infants (Black & Lozoff, 2008). A recent study found that low maternal sensitivity when infants were 15 and 24 months of age was linked to a higher risk of obesity in adolescence (Anderson & others, 2012).

One individual who has stood out as an advocate of caring for children is T. Berry Brazelton, who is featured in the *Connecting with Careers* profile.

connecting with careers

T. Berry Brazelton, Pediatrician

T. Berry Brazelton is America's best-known pediatrician as a result of his numerous books, television appearances, and newspaper and magazine articles about parenting and children's health. He takes a family-centered approach to child development issues and communicates with parents in easy-to-understand ways.

Dr. Brazelton founded the Child Development Unit at Boston Children's Hospital and created the Brazelton Neonatal Behavioral Assessment Scale, a widely used measure of the newborn's health and well-being (described in Chapter 3). He also has conducted a number of research studies on infants and children and has been president of the Society for Research in Child Development, a leading research organization.

For more information about what pediatricians do, see page 44 in the Careers in Child Development appendix following Chapter 1.

T. Berry Brazelton, pediatrician, with a young child.

Childhood Poor nutrition in childhood can lead to a number of problems and occurs more frequently in low-income than in higher-income families. A special concern is the increasing epidemic of overweight children.

Eating Behavior and Parental Feeding Styles For most children in the United States, insufficient food is not the key problem. Instead, unhealthy eating habits and being overweight threaten their present and future health. A recent study of 2- and 3-year-olds found that French fries and other fried potatoes were the vegetable they were most likely to consume (Fox, Levitt, & Nelson, 2010).

Children's eating behavior is strongly influenced by their caregivers' behavior (Black & Hurley, 2007; Hurley & others, 2013; Mitchell & others, 2013). Children's eating behavior improves when caregivers eat with children on a predictable schedule, model eating healthy food, make mealtimes pleasant occasions, and engage in certain feeding styles. Distractions from television, family arguments, and competing activities should be minimized so children can focus on eating. A sensitive/responsive caregiver feeding style is recommended, in which the caregiver is nurturant, provides clear information about what is expected, and responds appropriately to children's cues (Black & Hurley, 2007). Forceful and restrictive caregiver behaviors are not recommended. For example, a restrictive feeding style is linked to children being overweight (Black & Lozoff, 2008).

Overweight Children Being overweight has become a serious health problem in early childhood (Thompson, Manore, & Vaughan, 2013). A national study revealed that 45 percent of children's meals exceed recommendations for saturated and trans fat, which can raise cholesterol levels and increase the risk of heart disease (Center for Science in the Public Interest, 2008). This study also found that one-third of children's daily caloric intake comes from restaurants, twice the percentage consumed away from home in the 1980s. Further, 93 percent of almost 1,500 possible choices at 13 major fast food chains exceeded 430 calories—one-third of what the National Institute of Medicine recommends that 4- to 8-year-old children consume in a day. Nearly every combination of children's meals at KFC, Taco Bell, Sonic, Jack in the Box, and Chick-fil-A were too high in calories.

The percentages of young children who are overweight or at risk of becoming overweight in the United States have increased dramatically in recent decades, and these percentages are likely to grow unless changes occur in children's lifestyles (Summerbell & others, 2012). In 2009–2010, 12.1 percent of U.S. 2- to 5-year-olds were classified as obese compared with 5 percent in 1976–1980 and 10.4 percent in 2007–2008 (Ogden & others, 2012). That figure is significantly higher for 6- to 11-year-old U.S. children—in 2009–2010, 18 percent of U.S. 6- to 11-year-olds were classified as obese (Ogden & others, 2012).

Girls are more likely than boys to be overweight, and this gender difference occurs in many countries (Sweeting, 2008). In a large-scale U.S. study, African American and Latino children were more likely to be overweight or obese than non-Latino White children (Benson, Baer, & Kaelber, 2009).

It is not just in the United States that children are becoming more overweight. For example, a study found that general and abdominal obesity in Chinese children increased significantly from 1993 to 2009 (Liang & others, 2012).

The risk that overweight young children will continue to be overweight when they are older was documented in a study in which 80 percent of the children who were at risk for being overweight at age 3 were also at risk for being overweight or were overweight at age 12 (Nader & others, 2006). A recent study revealed that preschool children who were overweight were at significant risk for being overweight/obese at age 12 (Shankaran & others, 2011).

Being overweight in childhood also is linked to being overweight in adulthood. One study revealed that girls who were overweight in childhood were 11 to 30 times more likely to be obese in adulthood than girls who were not overweight in childhood (Thompson & others, 2007).

The increase in overweight children in recent decades is cause for great concern because being overweight raises the risk for many medical and psychological problems (Anspaugh & Ezell, 2013). Diabetes, hypertension (high blood pressure), and elevated blood cholesterol levels are common in children who are overweight (Pulgaron, 2013; Riley & Bluhm, 2012). Once considered rare, hypertension in children has become increasingly common in overweight children (Lytle, 2012). Social and psychological consequences of being overweight in childhood include low self-esteem, depression, and some exclusion of obese children from peer groups (Gomes & others, 2011). In one study, obese children were perceived as less attractive, more tired, and more socially withdrawn than non-obese peers (Zeller, Reiter-Purtill, & Ramey, 2008). In a recent study, overweight children reported being teased more by their peers and family members than did normal weight children (McCormack & others, 2011).

Both heredity and environment influence whether children will become overweight. Genetic analysis indicates that heredity is an important factor in children becoming overweight (Morandi & others, 2012; Xia & Grant, 2013). Overweight parents tend to have overweight children, even if they are not living in the same household (Schiff, 2013). One study found that the greatest risk factor for being overweight at 9 years of age was having a parent who was overweight (Agras & others, 2004). And a recent study revealed that having two overweight/obese parents significantly increased the likelihood of a child being overweight/obese (Xu & others, 2011).

Environmental factors that influence whether children become overweight or not include the greater availability of food (especially food high in fat content), energy-saving devices, declining physical activity, parents' eating habits and monitoring of children's eating habits, the context in which a child eats, and heavy screen time (watching TV, playing video games, texting, and so on) (Costigan & others, 2013; Mitchell & others, 2013; Mitchell, Pate, & Blair, 2012). A recent behavior modification study of overweight and obese children made watching TV contingent on their engagement in exercise (Goldfield, 2011). The intervention markedly increased their exercise and reduced their TV viewing time.

Parents play an important role in preventing children from becoming overweight (Barr-Anderson & others, 2013; Rodenburg & others, 2012). Recent research studies indicate intervention programs that emphasize getting parents to engage in healthier lifestyles themselves, as well as feeding their children healthier food and getting them to exercise more, can produce weight reduction in overweight and obese children (Brotman & others, 2012).

connecting with careers

Barbara Deloin, Pediatric Nurse

Barbara Deloin is a pediatric nurse in Denver, Colorado. She practices nursing in the Pediatric Oral Feeding Clinic and is involved in research as part of an irritable infant study for the Children's Hospital in Denver. She also is on the faculty of nursing at the Colorado Health Sciences Center. Deloin previously worked in San Diego where she was coordinator of the Child Health Program for the County of San Diego.

Her research interests focus on children with special health-care needs, especially high-risk infants and children, and promoting positive parent-child experiences. Deloin was elected president of the National Association of Pediatric Nurse Associates and Practitioners for the 2000–2001 term.

For more information about what pediatric nurses do, see page 44 in the Careers in Child Development appendix following Chapter 1.

Barbara Deloin working with a child with special health care needs.

For example, a recent study found that combining a child-centered activity program with a parent-centered dietary modification program was successful in helping overweight children lose pounds over a two-year period (Collins & others, 2011). Some intervention programs with overweight children are conducted through schools and often focus on teaching children and parents about developing a healthy diet, exercising more, and reducing screen time (Summerbell & others, 2012; Zask & others, 2012). A promising strategy is to provide students with healthier foods to eat at school. Several states now have laws that require healthier foods to be sold in vending machines at schools. In one intervention, reducing soft drink consumption at schools was linked with a subsequent reduction in the number of 7- to 11-year-old children who were overweight (James & others, 2004).

What are some concerns about overweight children?

In sum, healthy eating and an active rather than sedentary lifestyle play important roles in children's development (Kotte, Winkler, & Takken, 2013; Wang & others, 2013). Pediatric nurses can influence the health of children by providing advice to parents about ways to improve their children's eating habits and activity levels. To read about the work of one pediatric nurse, see the *Connecting with Careers* profile of Barbara Deloin.

EXERCISE

Exercise can make significant contributions to not only children's physical development but also their cognitive development (Wuest & Fisette, 2012; Davis & others, 2011). We explore developmental aspects of children's exercise and the roles of parents, schools, and screen-based activity.

Early Childhood Routine physical activity should be a daily occurrence for young children. Guidelines recommend that preschool children engage in two hours of physical activity per day, divided into one hour of structured activity and one hour of unstructured free play (National Association for Sport and Physical Education, 2002). The child's life should be centered around activities, not meals.

Following are descriptions of three recent research studies that examine young children's exercise and activities:

- Observations of 3- to 5-year-old children during outdoor play at preschools revealed that the preschool children were mainly sedentary even when participating in outdoor play (Brown & others, 2009). In this study, throughout the day the preschoolers were sedentary 89 percent of the time, engaged in light activity 8 percent of the time, and participated in moderate to vigorous physical activity only 3 percent of the time.
- Preschool children's physical activity was enhanced by family members engaging in sports together and by parents' perception that it was safe for their children to play outside (Beets & Foley, 2008).
- Incorporation of a "move and learn" physical activity curriculum increased the activity level of 3- to 5-year-old children in a half-day preschool program (Trost, Fees, & Dzewaltowski, 2008).
- A recent research review concluded that a higher level of screen time (watching TV, using a computer) at 4 to 6 years of age was linked to a lower activity level and being overweight from preschool through adolescence (te Velde & others, 2012).

To find out how much activity most preschool students are currently getting, see *Connecting Through Research*.

Middle and Late Childhood An increasing number of studies document the importance of exercise in children's physical development (Morano & others, 2012). One study found that 45 minutes of moderate physical activity and 15 minutes of vigorous physical activity daily were related to decreased odds that the children were overweight (Wittmeier, Mollard, & Kriellaars, 2008). And a recent study of 9-year-olds revealed that a higher level of physical activity was linked to a lower level of metabolic disease risk based on measures such as cholesterol, waist circumference, and insulin (Parrett & others, 2011). Also, a recent experimental study found that 13 weeks of aerobic training had significant benefits for insulin resistance and body fat levels of overweight/obese elementary children, regardless of gender or ethnicity (Davis & others, 2012).

A recent research review concluded that aerobic exercise also increasingly is linked to children's cognitive skills (Best, 2010). Researchers have found that aerobic exercise benefits

What are some positive outcomes when young children exercise regularly?

connecting through research

Are Preschool Children Getting Enough Physical Activity?

One study examined the activity level of 281 3- to 5-year-olds in nine preschools (Pate & others, 2004). Each child wore an accelerometer (a small activity monitor) for four to five hours a day. Height and weight assessments of the children were made to calculate each child's body mass index (BMI).

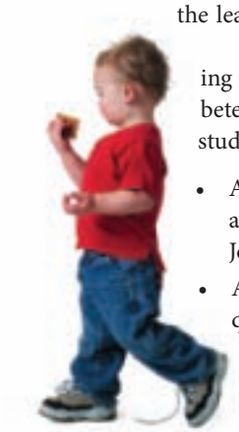
Recently developed guidelines recommend that preschool children engage in two hours of physical activity per day, divided into one hour of structured activity and one hour of unstructured free play (National Association for Sport and Physical Education, 2002). In this study, the young children participated in an average of 7.7 minutes per hour of moderate to vigorous activity, usually in a block of time when they were outside. Over the course of eight hours of a preschool day, these children would get approximately one hour of moderate and vigorous physical activity, only about 50 percent of the amount recommended. The researchers concluded that young children are unlikely to engage in another hour per day of moderate and vigorous physical activity outside their eight hours spent in preschool and thus are not getting adequate opportunities for physical activity.

Gender and age differences characterized the preschool children's physical activity. Boys were more likely to engage in moderate or vigorous physical activity than girls. Children who were 4 or 5 years old were more likely to be sedentary than 3-year-old children.

The young children's physical activity also varied according to the particular preschool they attended. The extent to which they participated in moderate and vigorous physical activity ranged from 4.4 to 10.2 minutes per hour across the nine preschools. Thus, the policies and practices of particular preschools influence the extent to which children engage in physical activity. The researchers concluded that young children need more vigorous play and organized activities. Unfortunately, there is a trend toward reducing time for physical activity, especially eliminating recess, in U.S. elementary schools that is trickling down to kindergarten and preschool programs. This decrease is part of a larger trend that involves narrowing early childhood programs to focus on academic learning and moving away from more comprehensive programs that focus on the whole child (Hyson, Copple, & Jones, 2006).

children's attention, memory, effortful and goal-directed thinking and behavior, and creativity (Davis & Cooper, 2011; Davis & others, 2007, 2011; Monti, Hillman, & Cohen, 2012).

Adolescence Gender and ethnic differences in exercise participation rates are noteworthy, and they reflect the trend of decreasing exercise from early through late adolescence. One study revealed that 40 percent of female and 57 percent of male adolescents met U.S. guidelines for physical activity (Butcher & others, 2008). A recent national study also found that adolescent boys were much more likely to engage in 60 minutes or more of vigorous exercise per day than were girls (Eaton & others, 2012). Also, as indicated in Figure 4.20, in the National Youth Risk Survey, non-Latino White boys exercised the most, African American girls the least (Eaton & others, 2012).



Exercise is linked to a number of positive outcomes in adolescence, including weight regulation as well as lower levels of blood pressure and type 2 diabetes (Goldfield & others, 2012; So & others, 2013). Consider also these recent studies that found positive effects of exercise on a range of adolescent outcomes:

- Adolescents who engaged in higher levels of exercise had lower levels of alcohol, cigarette, and marijuana use (Teery-McElrath, O'Malley, & Johnston, 2011).
- A daily morning running program for three weeks improved the sleep quality, mood, and concentration of adolescents (Kalak & others, 2012).
- Engaging in a 12-week exercise intervention lowered the depression of adolescents who were depressed and not regular exercisers (Dopp & others, 2012).

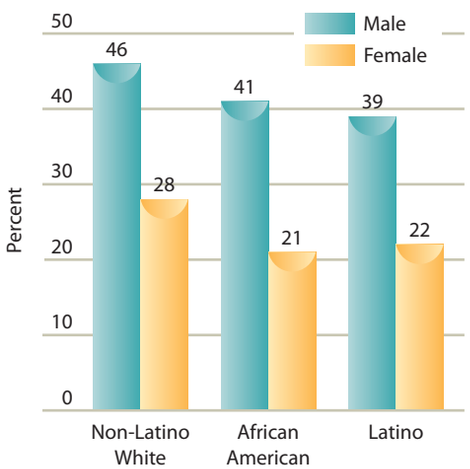


FIGURE **4.20**

EXERCISE RATES OF U.S. HIGH SCHOOL STUDENTS IN 2011: GENDER AND ETHNICITY.

Note: Data are for high school students who were physically active doing any kind of physical activity that increased their heart rate and made them breathe hard some of the time for a total of at least 60 minutes a day on five or more of the seven days preceding the survey. (Source: After Eaton & others, 2012, Table 91).

In 2007, Texas became the first state to test students' physical fitness. The student shown here is performing the trunk lift. Other assessments include aerobic exercise, muscle strength, and body fat. Assessments will be done annually.

- Participating in regular exercise was associated with higher academic achievement in young adolescents (Hashim, Freddy, & Rosmatunisah, 2012).

Parents, Peers, Schools, and the Media Parents play important roles in children's and adolescents' exercise habits (Davis & others, 2013; Loprinzi & others, 2012). Growing up with parents who regularly exercise provides positive models of exercise for children and adolescents.

A recent research review concluded that peers play an important role in children's and adolescents' physical activity (Fitzgerald, Fitzgerald, & Aherne, 2012). In this review, peer/friend support of exercise, better friendship quality and acceptance, and not having experienced peer victimization were linked to adolescents' physical activity.

Some of the blame for inactivity also falls on the nation's schools, many of which fail to provide daily physical education classes (Fung & others, 2012). A recent national survey revealed that only about 50 percent of U.S. ninth- through twelfth-graders participated in physical education classes on one or more days in an average school week and only 31.5 percent did so on five days (Eaton & others, 2012).

Screen-based activity (watching television, using computers, talking on the phone, texting, and instant messaging for long hours) is linked to lower levels of physical fitness in children and adolescents (Mitchell, Pate, & Blair, 2012). A recent study revealed that children and adolescents who engaged in the highest amount of daily screen-based activity (TV/video/video games in this study) were less likely to exercise daily (Sisson & others, 2010). In this study, children and adolescents who engaged in low physical activity and high screen-based activity were almost twice as likely to be overweight as their more active, less sedentary counterparts (Sisson & others, 2010). A recent research review concluded that screen-based activity is linked to a number of adolescent health problems (Costigan & others, 2013). In this review, screen-based sedentary behavior was associated with being overweight, sleep problems, lower levels of physical activity/fitness and well-being, and a higher level of depression.

Here are some ways to get children and adolescents to exercise more:

- Improve physical fitness classes in schools.
- Offer more physical activity programs run by volunteers at school facilities.
- Have children plan community and school exercise activities that interest them.
- Encourage families to focus on physical activity, and challenge parents to exercise more.

Review *Connect* Reflect

LG4 Characterize children's health

Review

- What are the key health problems facing children?
- What are some important aspects of children's nutrition and eating behavior?
- What role does exercise play in children's development?

Connect

- Nutrition was discussed earlier in the chapter as well. What did you learn about nutrition's effect on growth?

Reflect *Your Own Personal Journey of Life*

- What were your eating habits like as a child? In what ways are they similar to or different from your current eating habits? Do you think your early eating habits predicted whether you would have weight problems in adulthood?

Physical Development and Health

Body Growth and Change

LG1 Discuss developmental changes in the body.

Patterns of Growth

- Human growth follows cephalocaudal and proximodistal patterns. In a cephalocaudal pattern, the fastest growth occurs at the top—the head. Physical growth in size, weight, and feature differentiation occurs gradually and moves from the top to the bottom. In a proximodistal pattern, growth begins at the center of the body and then moves toward the extremities.

Infancy and Childhood

- Height and weight increase rapidly in infancy and then take a slower course during childhood. The average North American newborn is 20 inches long and weighs 7½ pounds. Infants grow about 1 inch per month during their first year. In early childhood, girls are only slightly smaller and lighter than boys. Growth is slow and consistent in middle and late childhood, and head circumference, waist circumference, and leg length decrease in relation to body height.

Adolescence

- Puberty is a rapid maturation involving hormonal and body changes that occur primarily in early adolescence. Puberty began to occur at younger ages during the twentieth century. There are wide individual variations in the age at which puberty begins. Heredity plays an important role in determining the onset of puberty. Key hormones involved in puberty are testosterone and estradiol. Rising testosterone levels in boys cause voice changes, enlargement of external genitals, and increased height. In girls, increased levels of estradiol influence breast and uterine development and skeletal change. Key physical changes of puberty include a growth spurt as well as sexual maturation. The growth spurt occurs an average of two years earlier for girls than for boys. Adolescents are preoccupied with their bodies and develop images of their bodies. Adolescent girls have more negative body images than adolescent boys. Early maturation favors boys during adolescence, but in adulthood late-maturing boys have a more successful identity. Early-maturing girls are vulnerable to a number of problems including eating disorders, smoking, and depression.

The Brain

LG2 Describe how the brain changes.

The Neuroconstructivist View

- The old view was that genes determined how a child's brain is wired and that environmental experiences play little or no role in the brain's development. However, in the neuroconstructivist view, (a) biological processes and environmental conditions influence the brain's development, (b) the brain has plasticity and is context dependent, and (c) the development of the brain and the child's cognitive development are closely linked,

Brain Physiology

- Each hemisphere of the brain's cerebral cortex has four lobes (frontal, occipital, temporal, and parietal) with somewhat different primary functions. Neurons are nerve cells in the brain that process information. Communication between neurons occurs through the release of neurotransmitters at gaps called synapses. Communication is speeded by the myelin sheath that covers most axons. Clusters of neurons, known as neural circuits, work together to handle particular types of information. Specialization of functioning occurs in the brain's hemispheres, as in speech and grammar, but for the most part both hemispheres are involved in most complex functions, such as reading or performing music.

Infancy

- Researchers have found that experience influences the brain's development. Early experiences are very important in brain development, and growing up in deprived environments can harm the brain. Myelination continues throughout the childhood years and even into adolescence for some brain areas such as the frontal lobes. Dramatic increases in dendritic and synaptic connections occur in infancy. These connections are overproduced and later pruned.

Childhood

- During early childhood, the brain and head grow more rapidly than any other part of the body. Rapid, distinct bursts of growth occur in different areas of the brain between 3 and 15 years of age. One shift in brain activation in middle and late childhood is from diffuse, larger areas to more focal, smaller areas, especially in cognitive control.

Adolescence

- In adolescence, the corpus callosum thickens, and this improves information processing. Also, the amygdala, which is involved in emotions such as anger, develops earlier than the prefrontal cortex, which functions in reasoning and self-regulation. This gap in development may help to explain the increase in risk-taking behavior that characterizes adolescence.

Sleep

LG3 Summarize how sleep patterns change as children and adolescents develop.

Infancy

- The typical newborn sleeps 16 to 17 hours a day. By 6 months of age, most infants have sleep patterns similar to those of adults. REM sleep occurs more in infancy than in childhood and adulthood. Sleeping arrangements vary across cultures, and there is controversy about shared sleeping. SIDS is a special concern in early infancy.

Childhood

- Most young children sleep through the night and have one daytime nap. It is recommended that preschool children sleep 11 to 13 hours each night and 5- to 12-year-old children 10 to 12 hours each night. Among sleep problems that may develop are narcolepsy, insomnia, and nightmares. Sleep problems in childhood are linked to negative outcomes in other areas of children's development.

Adolescence

- Many adolescents stay up later than when they were children and are getting less sleep than they need. Research suggests that as adolescents get older, the hormone melatonin is released later at night, shifting the adolescent's biological clock. Inadequate sleep is linked to an unhealthy diet, low exercise level, depression, and ineffective stress management.

Health

LG4 Characterize children's health.

Illness and Injuries Among Children

- Motor vehicle accidents are the number one cause of death in childhood. Parental smoking is a major danger for young children. For the most part, middle and late childhood is a time of excellent health. Caregivers play an important role in preventing childhood injuries. Two diseases of special concern in childhood are cancer and cardiovascular disease. A special concern also is the health of children living in poverty here and abroad. Improvements are needed in sanitation, nutrition, education, and health services in addition to a reduction in poverty. In low-income countries, there has been a dramatic increase in the number of children who have died from HIV/AIDS that was transmitted to them by their parents.

Nutrition and Eating Behavior

- The importance of adequate energy intake consumed in a loving and supportive environment during infancy cannot be overstated. Breast feeding is increasingly recommended over bottle feeding. Marasmus and kwashiorkor are diseases caused by severe malnutrition. Concerns about nutrition in childhood focus especially focus on content in diet and overweight/obese children. The percentage of overweight/obese children has increased dramatically in recent decades but has begun to level off. Being overweight increases a child's risk of developing many medical and psychological problems. Parents play an important role in helping children avoid weight problems.

Exercise

- Most children and adolescents are not getting nearly enough exercise. Boys and girls become less active as they reach and progress through adolescence. Parents, schools, and screen-based activity play important roles in whether children and adolescents are physically fit or unfit.

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