CHAPTER 5

Brain, Motor Skill, and Physical Development

Key Themes in Brain, Motor Skill, and Physical Development

- **Nature/Nurture** What roles do nature and nurture play in brain, motor skill, and physical development?
- **Sociocultural Influence** How does the sociocultural context influence brain, motor skill, and physical development?
- **Child's Active Role** How does the child play an active role in the process of brain, motor skill, and physical development?
- **Continuity/Discontinuity** Are brain, motor skill, and physical development continuous or discontinuous?
- **Individual Differences** How prominent are individual differences in brain, motor skill, and physical development?
- **Interaction Among Domains** How do brain, motor skill, and physical development interact with other domains of development?

She stared intently at the thirteen-year-old who had just finished her routine. Danielle couldn't believe what she had just seen. How could any girl her own age do that? Danielle's words expressed admiration and awe, but her voice was tinged with envy as she confided to her best friend, "We've been in gymnastics ever since we were five. If we tried that, we'd probably break our necks!"

Even as a toddler, Danielle seemed captivated by leaping and tumbling. Her parents took great pride in their daughter's graceful athleticism and precocious motor skills. Danielle enrolled in ballet and gymnastics at an early age. Both activities had been fun. As Danielle became older and more skilled, however, she especially seemed to thrive on the competition that permeated the gymnastics meets. She liked being good at what she did; she preferred being the best. However, she couldn't imagine anyone at her age with the dexterity and endurance to carry out that kind of routine. Through the applause, her friend had no difficulty hearing Danielle mutter, "I'll bet I can do that. I don't care if I do break my neck."

Physical growth and advances in motor skills are among the most readily apparent signs of development as it progresses from infancy through childhood and into adolescence. Few children become Olympic gymnasts, but virtually all acquire a sophisticated set of motor skills and physical abilities. The transformation is accompanied by less obvious, but no less revolutionary, changes in the brain.

Development of the brain, the acquisition of physical skills, and the growth of the body from infancy to adolescence affect virtually every behavior displayed by the child and are, in turn, influenced by the social, emotional, and cognitive demands in which their growth occurs. Consider how newfound motor coordinations may, for example, dramatically awaken cognition. The six-month-old who begins to reach for and grasp objects acquires a fresh and powerful means of gaining information and, at the same time, a new way to control and influence her environment. So, too, the child who just learned to ride his bike opens up broader vistas to explore and, at the same time, must learn to avoid new dangers that may accompany this feat.

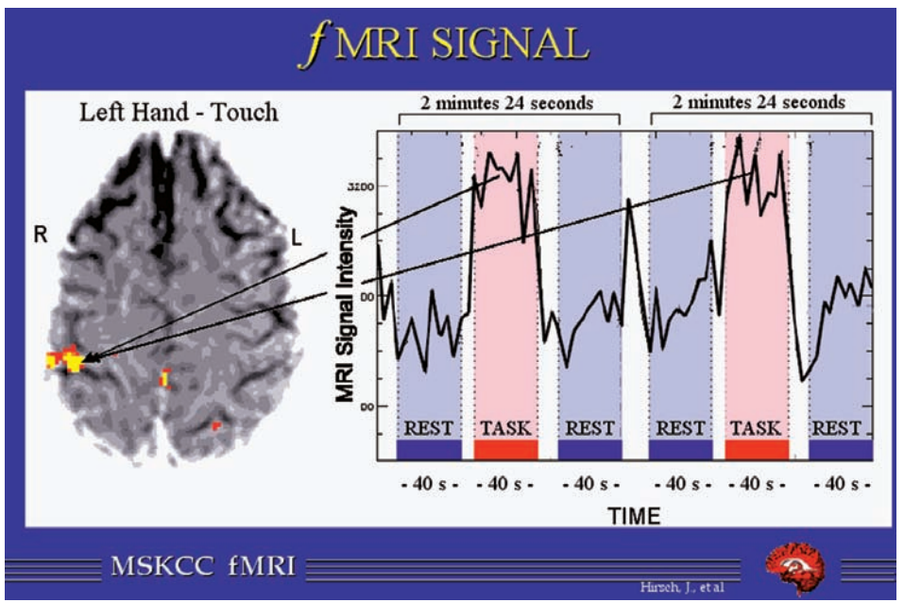
The reactions of others to changing stature and accomplishments can arouse a child's pride and promote renewed efforts, or they can lead to discouragement and apprehension. For example, when children begin to crawl, they may confront new barriers and repeated choruses of "no, don't do that." How these freshly imposed limits, inspired by burgeoning physical and mental capacities, are faced and resolved can affect many other aspects of solving problems or building relationships with others. Danielle, who is physically poised and skilled, displays confidence in the demands of learning a new and difficult gymnastic routine. That self-assurance very easily could extend to her social interactions and to her academic challenges. In contrast, the

child who fails to display certain competencies or lacks physical attributes valued in a society—for example, is shorter, less coordinated, or otherwise physically distinctive—may receive strikingly different treatment compared with the child who is tall, strong, or athletic. Interpreting and orchestrating all these changes is the increasingly sophisticated and complex brain.

How do brain, motor skills, and body develop? To what extent do parenting, culture, or other environmental events influence their course? How important are appearance, early maturity, and physical prowess to achievements in other domains of development? In this chapter we explore these kinds of questions. First, we turn to the developing brain, the structure that plays a central role in controlling and integrating the many changes in all aspects of behavior, including physical development.

The Brain and Nervous System

In no other decade before the 1990s has the brain and its influence on the development of human behavior received more attention. Major advances in the field of *cognitive neuroscience*, the study of neural and other structures and systems of the brain associated with behavior, have produced insights and generated widespread interest among neuroscientists, child psychologists, parents, and the public about the relationship between the brain and behavior. In large part, much of this enthusiasm has been spurred by the emergence of fascinating new technologies for studying the brain (Thompson & Nelson, 2001). Among these innovative procedures are *positron emission tomography* (PET scans), *functional magnetic resonance imaging* (fMRI), and the recording of *event-related potentials* (ERP). These techniques measure metabolic activity, blood flow, and electrical events and provide clues about which areas of the brain are functioning when an individual is engaged in motor, sensory, linguistic, emotional, and other information processing. At the present time, PET scans have limited utility for studying normal infants and children because they require injection of a radioactive substance. However, fMRI (which measures cerebral blood flow) and ERP (which is a measure of electrical activity generated by the synchronous firing of neurons) are among the more widely available noninvasive procedures that hold considerable promise for investigating normal and abnormal brain development (Casey, Thomas, & McCandless, 2001; Nelson & Monk, 2001).



Cognitive neuroscientists employ many newer methods to understand how the brain functions as it processes information. One procedure involves functional magnetic resource imaging (fMRI). In this procedure information about blood flow and the availability of oxygen to various regions of the brain, an indicator of neural activation, is measured. Here, while the left hand is receiving tactile stimulation, one section of the brain (the right post central gyrus) shows activation, as indicated by the bright yellow and red coloration in that region. When the hand was not being touched (rest periods), the intensity of the fMRI signal was much less. This and other emerging technologies hold great promise for learning which specific areas of the brain are involved in various kinds of cognitive processing.

Theoretical and practical questions about the importance of early experience, the possibility of critical periods for receiving certain kinds of stimulation, and whether neural growth continues during later childhood, adolescence, and even well into adulthood have further fueled enthusiasm for studying the brain (Bruer, 1999). Much remains to be learned about these issues, and we continue to address some of them in other chapters. However, we summarize here a few of the major developmental changes that take place in the brain.

The Developing Brain

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Early Brain Development

Even before birth, brain growth is rapid. As Figure 5.1 shows, the size of the brain swiftly increases, from about 4 percent of its adult weight at five months after conception to about 25 percent at birth and about 80 percent by four years of age (Spreen et al., 1994). However, the total volume of the brain does not change very much after about the age of five. Such a statement is a bit misleading, because the volume of the white matter increases throughout childhood and into adulthood largely because of continuing myelination of neurons. In contrast, the volume of gray matter, usually associated with the neurons, decreases largely as a result of pruning and perhaps cell death (Durston et al., 2001).

The *brainstem* and *midbrain* (see Figure 5.2), which are involved in basic reflexes and sensory processing, as well as such essential biological functions as digestion, elimination, and respiration, are fairly well established at birth (Joseph, 2000). In con-

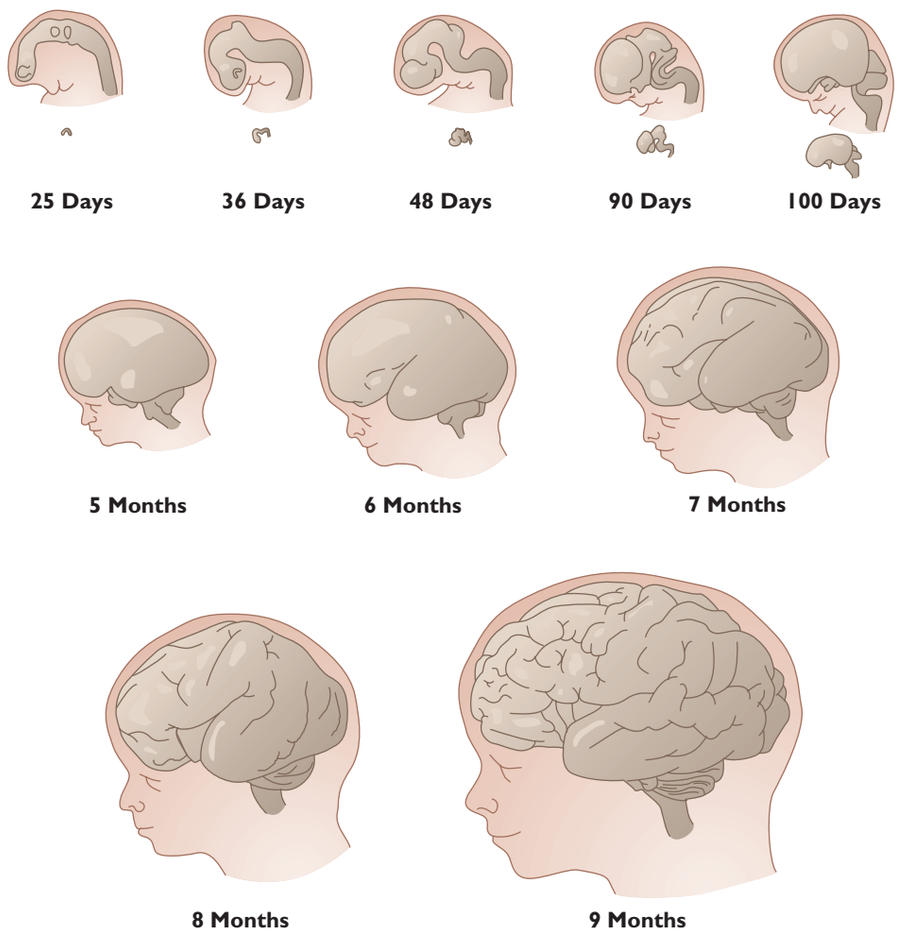


FIGURE 5.1
The Developing Human Brain

During prenatal development, the human brain shows dramatic increases in size, and the cerebral cortex takes on a convoluted pattern to increase surface area. During the last trimester of prenatal development, the brain takes on an adultlike shape, and by birth most of the neurons have formed. The brain's weight increases most dramatically from about the fifth prenatal month until the infant is about two-and-a-half years of age. The drawings have been made to a common scale; however, the first five have been enlarged to a common size to show details.

Source: Adapted from Cowan, 1979.

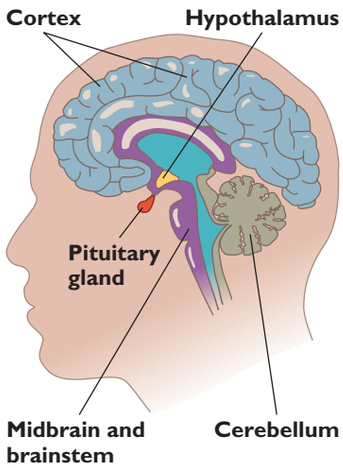


FIGURE 5.2
Cross-Section of the Human Brain

Certain regions of the brain are closely associated with specific functions. The overarching cortex is essential for most of behavior and includes regions associated with processing sensory and motor information, as well as areas heavily involved in thinking, planning, and problem solving. The early-developing midbrain and brain stem are important to basic biological functioning. The cerebellum is centrally involved in coordination and control of voluntary movements. Both the hypothalamus and pituitary glands are believed to play a major role in the regulation of physical growth.

trast, neural changes in the cortex, the part of the brain most closely linked to sensation, motor responses, thinking, planning, and problem solving, continue to take place well after birth. Within the cortex, regions associated with sensory and motor functions tend to be among the earliest to mature. The frontal cortex, the region of the brain most directly involved in higher levels of cognition, tends to be among the latest.

With development, **neurons,** cells that carry electrochemical messages as neural impulses, *proliferate,* that is, increase in number. Neurons also *migrate*—move to various regions of the brain—and *differentiate*—increase in size, complexity, and functioning. One notable aspect of differentiation is the increased number and kinds of *synapses,* the space-filled junctures associated with the branches or dendrites of the neuron that permit it to communicate with other neurons. Parts of many neurons also become surrounded by **myelin,** a sheath of fatty material that serves to insulate and speed neural impulses by about tenfold. An estimated ten times more **glial cells** (from the Greek word for *glue*) than neurons also form within the brain (Blinkov & Glezer, 1968). Glial cells establish a scaffolding for neuron migration, provide the material from which myelin develops, facilitate the transfer of nutrients to neurons, and instruct the neurons to form synapses with other neurons (Ullian et al., 2001).

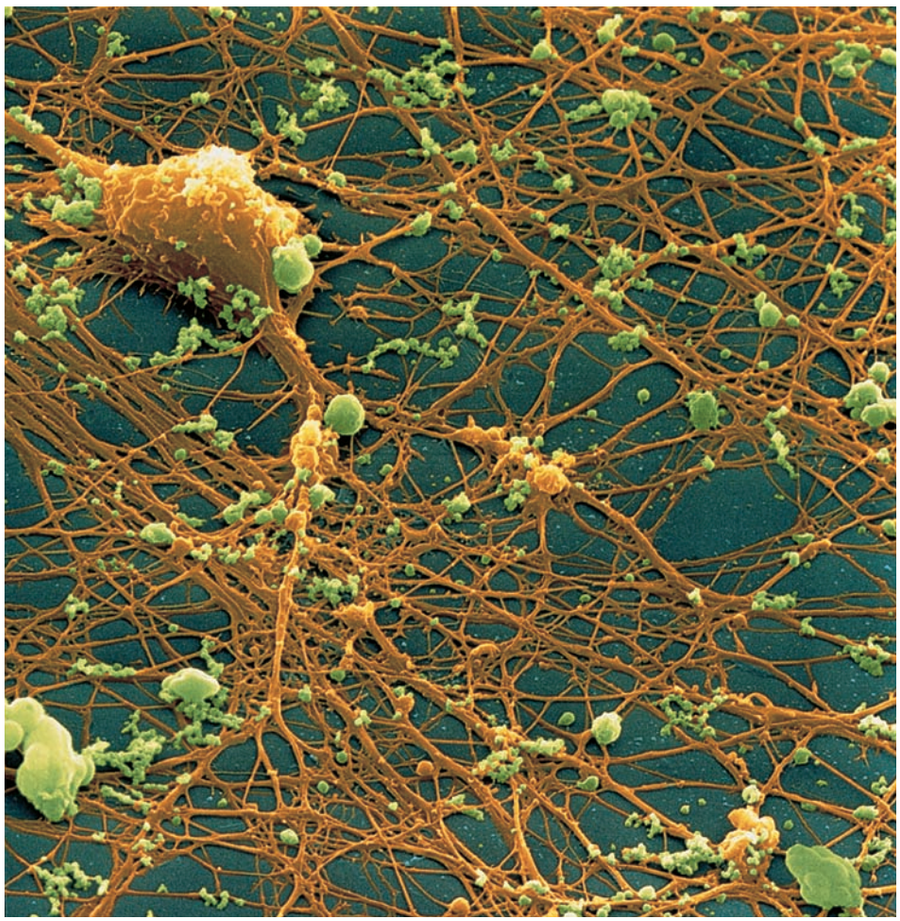
● **Neuron Proliferation** The production of new nerve cells is known as *neuron proliferation.* Neuron production in humans begins near the end of the first month of prenatal development, shortly after the neural tube closes, and much of it, at least in the cerebral cortex, is completed by the sixth month of prenatal development (Nelson, 1999). Thus, at a very early age, a finite but very large number—certainly well over 100 billion—of young neurons have formed (Shatz, 1992).

● **Neuron Migration** Shortly after their formation, neurons move from the neural tube, where they were produced, to other locations. In some regions of the brain this movement occurs passively, so that as additional neurons are born, older neurons are pushed further to the outside of that portion of the brain. This type of growth takes place, for example, in the hypothalamus, the brain stem, and the cerebellum. However, for many other regions of the brain such as the cerebral cortex, the neurons may migrate a great distance, passing through levels of older neurons that already have reached their final destination. These regions of the brain are formed by an *inside-out pattern* of development in which layers of nerve cells nearer the outer surface are younger than layers deeper in the cortex (Rakic, 1981). Under these circumstances, how do neurons know where to migrate and when to stop migrating? Both neurochemical and mechanical information probably play a role. Young neurons attach to and maneuver along the surfaces of fibers of glial cells radiating to the region of their destination, detaching from their guide, as shown in Figure 5.3, at programmed locations. Both the production and migration of large numbers of neurons

neuron Nerve cell within the central nervous system that is electrochemically designed to transmit messages between cells.

myelin Sheath of fatty cells that insulates and speeds neural impulses by about tenfold.

glial cells Brain cells that provide the material from which myelin is created, nourish neurons, and provide a scaffolding for neuron migration.



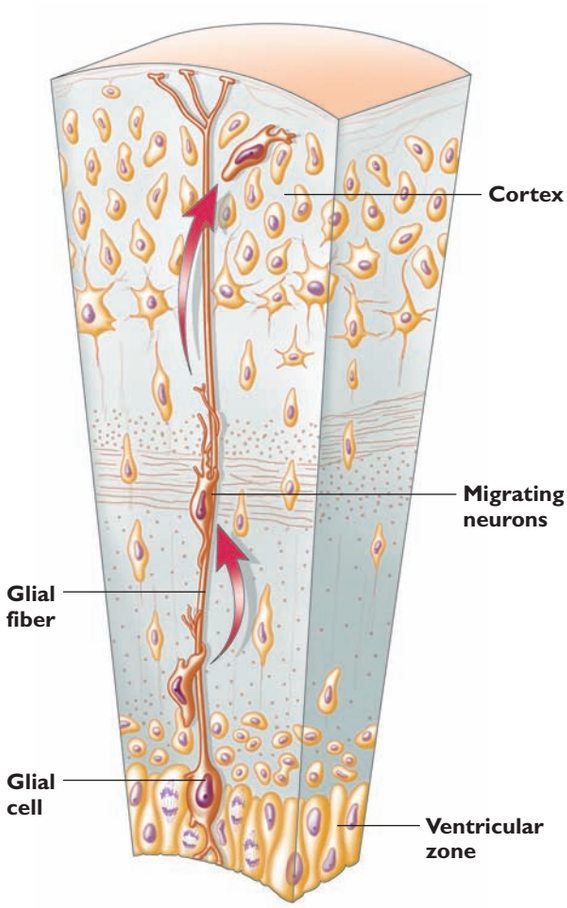
This color-enhanced photo, taken with a scanning electron microscope, shows a neuron. Neurons carry the electrochemical messages that are the basis for behavior. Even before birth, massive numbers of neurons are manufactured and migrate to various regions of the brain, where they begin to establish connections with other neurons.

KEY THEME
Nature/Nurture

in the cortex occur in waves, especially during the seventh and eleventh weeks of gestational age (Spreen et al., 1984). However, some teratogens, including mercury and alcohol, are known to interfere with the onset and path of neuron migration. In fact, developmental defects ranging from mental retardation to behavioral disorders have been linked to interference in the migratory patterns of nerve cells (Gressens, 2000).

● **Neuron Differentiation** Whereas neuron proliferation and migration take place prenatally for the most part, neuron differentiation—the process of enlarging, forming synapses with other neurons, and beginning to function—flourishes postnatally. Neural differentiation, along with the growth of glial cells and other supportive tissues, including myelin, contributes to the substantial postnatal increase in the size of the brain. Moreover, growing evidence exists to indicate that at least in some regions remodeling of the brain, in the form of neuron differentiation and even neuron production, continues well into adulthood (Spear, 2000; Tanapat, Hastings, & Gould, 2001).

Some aspects of neuron differentiation proceed without external stimulation. Experience, however, plays a major role in the selection, maintenance, and strengthening of connections among many neurons (Nelson, 2000). Work investigating the effects of vision on brain development in cats illustrates the complex relationship (Hubel & Wiesel, 1979). By the time a kitten's eyes open, neurons in the visual receptor areas of the cerebral cortex have already established some connections and can respond, for example, to sensory information from either eye or to visual patterns with a broad range of characteristics. But the neurons become far more selective and tuned to particular kinds of sensory information as the kitten experiences specific forms of visual stimulation. Some neurons may, for example, begin to respond to



Source: Adapted from Kunzig, 1998.

FIGURE 5.3
The Migration of Neurons via Glial Fiber

Wrapping themselves around glial fibers, neurons climb in spiral fashion to a particular layer in the cortex of the brain. Because the cortex of the brain develops in an inside-out pattern, earlier waves of neurons need to progress across shorter distances, and their migration may be completed within a day. However, later waves of neurons pass through earlier layers of the cortex and migrate across a greater distance, so that their journey may require several weeks. Some teratogens can interfere with this migratory pattern and, if the disruption is severe, result in a variety of developmental defects.

input arising from one or the other eye only and to transitions in dark-light patterns in the visual field that are vertical or horizontal or at some other spatial orientation.

Without stimulation and the opportunity to function, neurons are unlikely to establish or maintain many connections with other neurons; their synaptic density becomes substantially reduced. For example, in the visual cortex the total number of synapses rises meteorically in the first few months after birth; but then the connections show a small decline from about eight months of age to the late preschool years followed by a more substantial decline between about four and ten years. These dramatic changes in the visual cortex can be seen in Figure 5.4. Neurons may even die if no synapses are formed with other neurons. In fact, one theory holds that massive cell death, perhaps as great as 50 to 75 percent of neurons, occurs during normal development in the brains of some animals and perhaps in some regions of the human brain, although probably not in the cerebral cortex (Huttenlocher, 1994). Thus, the typical infant is genetically equipped with the capacity for neurons to generate many synaptic connections, perhaps far more than a person will ever need. That surplus provides the opportunity for a rich variety of experiences to affect development; it also means that if damage or destruction occurs to some synapses early in life, others may replace them.

KEY THEME
Nature/Nurture

Plasticity in Brain Development

Because of the unspecialized nature of young neurons, the immature brain displays substantial **plasticity,** or the ability, within limits, of alternate regions of the cerebral cortex to take on specialized sensory, linguistic, and other information-processing requirements (Johnson, 2000). Infants or children who suffer damage to regions of the cerebral cortex that process speech, for example, are often able to recover, because

plasticity Capacity of immature systems, including regions of the brain and the individual neurons within those regions, to take on different functions as a result of experience.

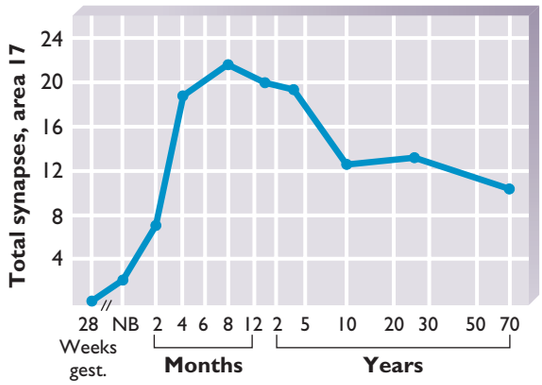


FIGURE 5.4
Estimated Number of Synapses for Neurons in the Human Visual Cortex as a Function of Age

Differentiation of the neurons in the human visual cortex proceeds rapidly shortly after birth and reaches a peak before the end of the first year. The number of synapses ($\times 10^{11}$), connections of dendrites to other neurons, then declines to about half of the original peak number over the lifespan. The rapid increment is associated with visual stimulation after birth and accompanies significant improvements in visual abilities before a year of age, as is discussed in the chapter titled "Basic Learning and Perception." The number of synapses reflects an initial overproduction; those that become functional are then likely to be maintained over the remaining years. Other regions of the cortex may show a similar pattern of rapid increase and then decline in number of synapses, although perhaps at different periods in development.

Source: Adapted from Huttenlocher, 1994.

neurons in other parts of the cortex take on this function. On the other hand, although considerable plasticity is retained by some regions of the mature adult brain (Thompson & Nelson, 2001), the prognosis for recovery of language in adults after an accident or a stroke is usually much poorer, because the remaining neurons in various regions of the brain have become dedicated to processing certain kinds of experiences.

William Greenough and his colleagues contend that neurons in human and other mammalian brains exhibit two different kinds of plasticity (Greenough, Black, & Wallace, 1987). Some neurons are sensitive to *experience-expectant information.* As a result of a long evolutionary process, these neurons begin to grow and differentiate rapidly about the time they can be expected to receive the kinds of stimulation important to their functioning. In many mammals, for example, parts of the visual cortex involved in depth or pattern perception develop quite rapidly shortly before and after the eyes open or, in the case of humans, shortly before and after birth. Research with lower animals indicates that visual deprivation during these periods—being reared in the dark or without patterned light, for example—results in the permanent loss of some kinds of depth and pattern vision, losses that do not occur when equivalent lengths of deprivation occur during other periods.

Other neurons are sensitive to *experience-dependent information.* Many opportunities for learning occur at unpredictable times during development. Each person learns different and unique things, even into old age. The distinctive perceptual features forming the image of a neighbor or the attributes defining the concept of democracy are unique representations registered within an individual's neural system. Here, then, is a form of plasticity that implicates neural differentiation as a critical aspect of brain functioning throughout a person's lifetime.

Brain Lateralization

One of the brain's most obvious physical characteristics is its two mirrorlike structures, a *left* and *right* hemisphere. By and large, sensory information and motor responses on the left side of the body in humans are processed by the right hemisphere and those on the right side of the body are processed by the left hemisphere. In addition, in most adults the left hemisphere is especially involved in language functioning, whereas the right hemisphere is more typically engaged in processing certain types of spatial, emotional, or other nonverbal information (Kosslyn et al., 1999). But these differences are by no means absolute. For example, speech is controlled primarily by the left hemisphere in about 95 percent of right-handed adults but in only about 70 percent of left-handed adults (Kinsbourne & Hiscock, 1983).

lateralization Process by which one hemisphere of the brain comes to dominate the other, for example, processing of language in the left hemisphere or of spatial information in the right hemisphere.

Does hemispheric specialization exist already at birth, or does the brain show progressive **lateralization,** the process by which one hemisphere comes to dominate the other in terms of a particular function? Based on research on left-hemisphere damage in children, Eric Lenneberg (1967) proposed that at least until age two, both

hemispheres are capable of carrying out language functions equally well and that lateralization increases only gradually until adolescence. Other researchers, however, suggest that lateralization begins much earlier (Kinsbourne & Hiscock, 1983), perhaps as a consequence of exposure to fetal testosterone (Geschwind & Galaburda, 1987; McManus & Bryden, 1991). For example, some physical differences in the two hemispheres exist already at birth (Kosslyn et al., 1999). Perhaps such brain asymmetries contribute to the observation that most infants lie with the head oriented to the right rather than to the left, an orientation that later predicts hand preference (Michel, 1988). Even before three months of age, most babies more actively use and hold objects longer in the right hand than in the left (Hawn & Harris, 1983). They also turn to stimulation coming from the right side more frequently (Siqueland & Lipsitt, 1966). Furthermore, infants are able to better identify changes in speech sounds heard in their right ear and to detect shifts in the timbre of musical notes better in their left ear (Best, Hoffman, & Glanville, 1982).

FOR YOUR REVIEW

- What are the major methodological procedures that have permitted advances in the study of the developing brain?
- Which regions of the brain develop earliest and latest? To what functions do those regions contribute?
- What developmental changes occur in neurons? How do myelin and glial cells contribute to neuronal development?
- When does the plasticity of the brain decline? What is the difference between experience-expectant and experience-dependent information?
- What evidence exists for brain lateralization in infancy and early childhood?

Motor Skill Development

During postnatal development, cartilage continues to be transformed into bone, and bones elongate and increase in number to become scaffolding to support the body in new physical orientations. As the brain and nervous system mature, neural commands begin to coordinate thickened and enlarged muscles, permitting more powerful and refined motor activities. Two complementary patterns are evident in the emergence of motor activity: *differentiation,* the enrichment of global and relatively diffuse actions with more refined and skilled ones, and *integration,* the increasingly coordinated actions of muscles and sensory systems. Throughout infancy and childhood, motor skills become more efficient, coordinated, and deliberate or automatic as the task requires. Toward the end of childhood, many skills become highly specialized talents: youngsters such as Danielle are already accomplished athletes; others her age are concert musicians.

For Piaget, sensorimotor activity served as the prototype and first stage in the construction of knowledge. Thus, the acquisition, coordination, and integration of basic motor skills is not only an interesting topic of study in itself but also can give us important insights into early cognitive and perceptual development.

KEY THEME
Interaction Among Domains

The First Actions: Reflexes

At first glance, newborns seem helpless and incompetent. Babies eat, sleep, and cry; their diapers always seem to need changing. Yet a more careful look reveals that infants enter their new world with surprisingly adept sensory abilities (see the chapter titled "Basic Learning and Perception"), along with **reflexes,** involuntary reactions to touch, light, sound, and other kinds of stimulation, some of which are exhibited even prenatally.

reflex Involuntary movement in response to touch, light, sound, or other form of stimulation; controlled by subcortical neural mechanisms.

Among the reflexes that babies display is the swimming reflex. When young infants are placed in water, breathing is suspended, and they engage in swim-like movements with their arms and legs.

TABLE 5.1 Typical Reflexes Observed in Newborns and Infants

Considerable variability exists among infants in their reflexes and the ages at which they can be elicited (Touwen, 1974). The presence or absence of any single reflex provides only one among many indicators of healthy or atypical development.

Name of Reflex	Testing Procedure	Response	Developmental Course	Significance
Primitive Reflexes				
Palmar or Hand Grasp	Place finger in hand.	Hand grasps object.	Birth to about 4 months.	Absence may signal neurological defects; persistence could interfere with voluntary grasping.
Rooting	Stroke corner of mouth lightly.	Head and tongue move toward stimulus.	Birth to about 5 months.	Mouth is brought to stimulus to permit sucking.
Sucking	Place finger in mouth or on lips.	Sucking begins.	Birth to about 6 months.	Ensures intake of potential nutrients.
Moro	(1) Sit child up, allow head to drop about 20 degrees backward, or (2) make a loud noise, or (3) lower baby rapidly.	Baby extends arms outward, hands open; then brings hands to midline, hands clenched, spine straightened.	Birth to about 5–7 months.	Absence may signal neurological defects; persistence could interfere with acquisition of sitting.
Babinski	Stroke bottom of foot.	Toes fan and then curl.	Birth to about 1 year.	Absence may signal neurological defects.
Asymmetric Tonic Neck Reflex	Place baby on back, arms and legs extended, and rotate head 90 degrees.	Arm on face side extends, arm on back side of head flexes.	About 1 month to 4 months.	Absence may signal neurological defects; persistence could prevent rolling over, coordination.

TABLE 5.1 Typical Reflexes Observed in Newborns and Infants *(continued)*

Name of Reflex	Testing Procedure	Response	Developmental Course	Significance
Postural Reflexes				
Stepping	Hold baby under arms, upright, leaning forward.	Makes walk-like stepping movements.	Birth to about 3 months.	Absence may signal neurological defects.
Labyrinthine	(1) Place baby on back. (2) Place baby on stomach.	Extends arms and legs. Flexes arms and legs.	Birth to about 4 months.	Absence may signal neurological defects.
Swimming	Place baby in water.	Holds breath involuntarily; arms and legs move as if trying to swim.	Birth to about 4–6 months.	Absence may signal neurological defects.
Placing	Hold baby under arms, upright, top of foot touching bottom edge of table.	Lifts foot and places on top of table.	Birth through 12 months.	Absence may signal neurological defects.
Landau Reaction	Place baby on stomach, hold under chest.	Lifts head, eventually other parts of body, above chest.	Head at 2 months, other parts of body later.	Absence may signal neurological defects; inadequate muscle tone for motor development.
Body Righting	Rotate hips or shoulder.	Rotates remainder of body.	4 months to more than 12 months.	Absence may signal neurological defects; difficulty in gaining postural control and walking.

Reflexes are among the building blocks that soon give rise to voluntary movements and the acquisition of developmental milestones or significant achievements in motor skills. Along with breathing and swallowing, *primitive reflexes* such as rooting and sucking (see Table 5.1) provide nourishment for survival of the infant. Among our evolutionary ancestors, other reflexes, such as the Moro and palmar reflexes, helped to protect newborns from danger. *Postural reflexes,* including stepping, swimming, and body righting (which are surprisingly similar to later voluntary movements), appear to be designed to maintain a specific orientation to the environment. If primitive or postural reflexes are absent, are too strong or too weak, display unequal strength when normally elicited from either side of the body, or continue to be exhibited beyond certain ages, a pediatrician may begin to suspect cerebral palsy or some other neurological impairment and developmental difficulties for the baby (Blasco, 1994).

Research Applied to Parenting

Reducing Sudden Infant Death Syndrome

Danielle's parents faithfully attended her gymnastics meets and were ardent supporters of her efforts. Danielle wasn't always pleased by the watchful presence they exhibited toward her, their only daughter. But she was beginning to more fully understand it. When Danielle was four, her parents introduced her to a baby brother. Danielle remembered how proud she had been to hold him and to "help her mother." But all that changed a few months later. On that tragic morning, she had been awakened by the

frantic voices of her parents and strangers—emergency medical technicians, she learned later—in her baby brother's room. She suspected something terrible had happened, and it had: her brother had died. She was frightened then and for a long time thereafter. Her fears subsided only gradually as her parents picked up the pieces of their lives.

To survive in the postnatal environment, the infant must synchronize rooting and sucking with swallowing and breathing. In fact, the inability to coordinate these reflexes often makes nursing difficult for premature infants (Rosenblith & Sims-Knight, 1985). But organizing and controlling breathing can be a problem for a small number of older infants as well. The abrupt, unexplained death of an infant less than one year of age who stops breathing during sleep is known as **sudden infant death syndrome (SIDS).** The deaths, most frequently reported in babies about two to four months of age, are particularly tragic because they occur with no identifiable warnings. The highest incidence appears to occur at a time when basic automatic respiratory reflexes governed by the brain stem begin to be supplemented by voluntary, cortex-regulated breathing essential for vocalization and the emergence of speech.

SIDS, once known as *crib death* or *cot death,* claimed the lives of between one and two of every one thousand babies born in the United States in recent decades. Much higher rates had been reported in some other countries such as New Zealand (Mitchell et al., 1997). It continues to be the third leading cause of infant mortality in the United States and in most Western countries. Only congenital malformations and low birth weight or prematurity contribute to more deaths among infants (Hoyert et al., 2001). Although researchers still do not know what causes SIDS, specific steps that parents can take are now known to reduce its risk of occurring:

KEY THEME
Sociocultural Influence

1. "*Back to Sleep.*" Up until the 1990s, parents were often advised to place their babies in a prone position (on their stomachs) when ready for sleep. However, research conducted around the world (Australia, Britain, New Zealand, the Netherlands, Norway, Sweden, and many other countries, including the United States) reveals that when parents stop this practice, the incidence of SIDS declines (Hauck & Hunt, 2000). Thus in 1994 pediatricians initiated a "Back to Sleep" campaign to encourage parents to place healthy infants on their backs to sleep. This single change has been estimated to reduce the incidence of SIDS as much as 50 percent in some nations, and greater than 40 percent in the United States (American Academy of Pediatrics, 2000).

2. *Eliminate exposure to cigarette smoke and other drugs.* Numerous studies have confirmed that a mother's smoking or use of other drugs during pregnancy is associated with a greater likelihood of SIDS (Mitchell & Milerad, 1999). However, exposure even to passive smoke after birth (from mother, father, or other live-in adults) increases the risk as well.

3. *Provide firm bedding.* The incidence of SIDS in Australia and New Zealand had been among the highest in the world. In these countries, less firm bedding (use of wool or of bark from the ti tree) appears to have contributed to the risk of SIDS, especially for infants sleeping prone, perhaps because of a tendency for this softer bedding to trap carbon dioxide.

4. *Avoid overheating.* High room temperature and high body temperature because of excessive bedding and/or clothing are also known to increase the incidence of SIDS (Guntheroth & Spiers, 2001). Adequate ventilation also helps to prevent overheating of the infant, as well as to disperse carbon dioxide.

sudden infant death syndrome (SIDS) Sudden, unexplained death of an infant or a toddler as a result of cessation of breathing during sleep.

SIDS is associated with a number of other factors, including the colder months of the year, economically depressed neighborhoods, having a cold, being male, being either a later-born or one of a multiple birth, and low birth weight. In addition to susceptibility to the buildup of carbon dioxide and increased temperature, other infant characteristics that are hypothesized to play a causative role include a deficit in arousal and anomalies associated with heart rate (Hauck & Hunt, 2000). Parents

Placing infants on their backs in preparation for sleep appears to have reduced the frequency of sudden infant death syndrome (SIDS). The decline in SIDS associated with this practice is reported in many countries, including the United States, where pediatricians in the 1990s launched a "back to sleep" campaign.

may have little control over some of these factors. Unfortunately, efforts to educate everyone about a better sleeping position or use of firmer bedding have not reached all caregivers (Brenner et al., 1998; Kemp et al., 1998). The rate of placing infants on their stomachs is higher than average among African American families, younger mothers, and low-income families, and in some regions of the United States, in daycare centers where infants are put to sleep during nap periods (Moon & Biliter, 2000; Willinger et al., 2000). As more and more parents turn to daycare centers, family daycare providers, or other family members (e.g., grandparents or siblings) to care for their young infants, it is vital that these alternative caregivers also be informed about the importance of infants being placed on their backs for naps and during other sleep periods (Flick et al., 2001; Moon, Patel, & McDermott Shaefer, 2000). Research indicates that babies accustomed to sleeping on their backs, if placed prone or on their sides (because of the possibility of rolling into a prone position), are particularly susceptible to increased risk of SIDS (Hauck & Hunt, 2000; Mitchell et al., 1999).

Although the benefits far outweigh the drawbacks, one unintended outcome of having infants sleep on their backs has been more frequent reports of misshapen heads, particularly, flattening of the back of the head (Najarian, 1999). The problem, not normally serious, can be substantially reduced by varying head position each time the baby is placed for sleep and giving the infant plenty of experience on his or her stomach during periods when awake and under the watchful eye of a parent. Adequate "tummy time" also helps to strengthen the shoulders and arms and minimizes possible delays in achieving various milestones of motor development associated with the upper body (American Academy of Pediatrics, 2000).

KEY THEME
Sociocultural Influence

Controversy continues over the question of where an infant should sleep. Historically, and in most cultures today (such as Japan), an infant and mother sleeping together (co-sleeping) is the norm (Latz, Wolf, & Lozoff, 1999). In fact, Mayan mothers view putting very young children in a separate room at night as almost equivalent to child neglect (Morrelli et al., 1992). However, American mothers typically justify such a practice, especially after the baby is a few months old, as a way to encourage self-reliance and independence.

Decisions about sleeping arrangements are deeply ingrained in cultural beliefs concerning the values of closeness and interdependence and of privacy and self-reliance. James McKenna and his colleagues contend that in co-sleeping arrangements, mothers and infants engage in greater synchronized sleep, breathing, and arousal patterns that serve to protect infants from *apnea,* irregular patterns of temporary cessations in breathing (Mosko, Richard, & McKenna, 1997). However, little evidence has been found to demonstrate that this practice has a protective effect

against SIDS. Co-sleeping is especially hazardous on a couch or if the parent smokes, consumes alcohol, or uses other drugs (Hauck & Hunt, 2000). A far safer alternative to bed sharing for those who wish to be in close contact appears to be having the baby sleep within arm's length but in an infant crib.

Motor Milestones

Reflexes are often viewed as fixed responses to a stimulus. However, many early motor behaviors that young infants soon produce consist of coordinated actions. For example, babies exhibit **rhythmical stereotypies,** repeated sequences of motions performed with no apparent goal (Thelen, 1996). Rubbing one foot against the other, rocking back and forth, bouncing up and down, swaying side to side, striking or banging objects, mouthing and tonguing activities, and shaking and nodding the head are just a few of the movements that exercise bones, joints, and muscles. Stereotypies, along with early reflexes, appear to be the bits and pieces of the primitive melody of behavior that eventually are recruited and integrated into organized voluntary motor skills and activities (Thelen, 1996).

KEY THEME
Child's Active Role

Many more organized goal-directed voluntary actions emerge during the first year as infants gradually gain neuromotor control of their heads, arms, and legs. Some of these actions—grasping, crawling, and walking, for example—are motor milestones: once mastered, new worlds open up to the infant. Moreover, they lead caregivers to respond in different ways: childproofing the home to prevent accidents, allowing greater independence, expecting more mature behavior. Most gains in infant movement illustrate progress in coordinating (1) *postural control,* the ability to maintain an upright orientation to the environment; (2) *locomotion,* the ability to maneuver through space; and (3) *manual control,* the ability to manipulate objects (Keogh & Sugden, 1985).

● **Postural Control** Keeping the head upright and stable at about two to three months of age represents one of the first milestones in infant motor development. As the Motor Skill Development chronology indicates, this achievement is followed by mastery of other significant postural skills, such as maintaining an upright sitting position, moving to a standing position, and standing without assistance. The milestones, built on various postural reflexes among other things, often reflect a cephalocaudal progression. **Cephalocaudal development** (*cephalocaudal* combines the Greek words for *head* and *tail*) describes the tendency for systems and parts of the body near the head to become organized sooner than those more distant from the head. Head control, for example, precedes control of the trunk, and command of the legs is the last to develop. The integration of postural skills is also important. For example, the ability to keep the head upright while sitting or while standing on a stable surface is one thing; the ability to do this when being carried about or during self-movement requires integration of far more information to retain motor control.

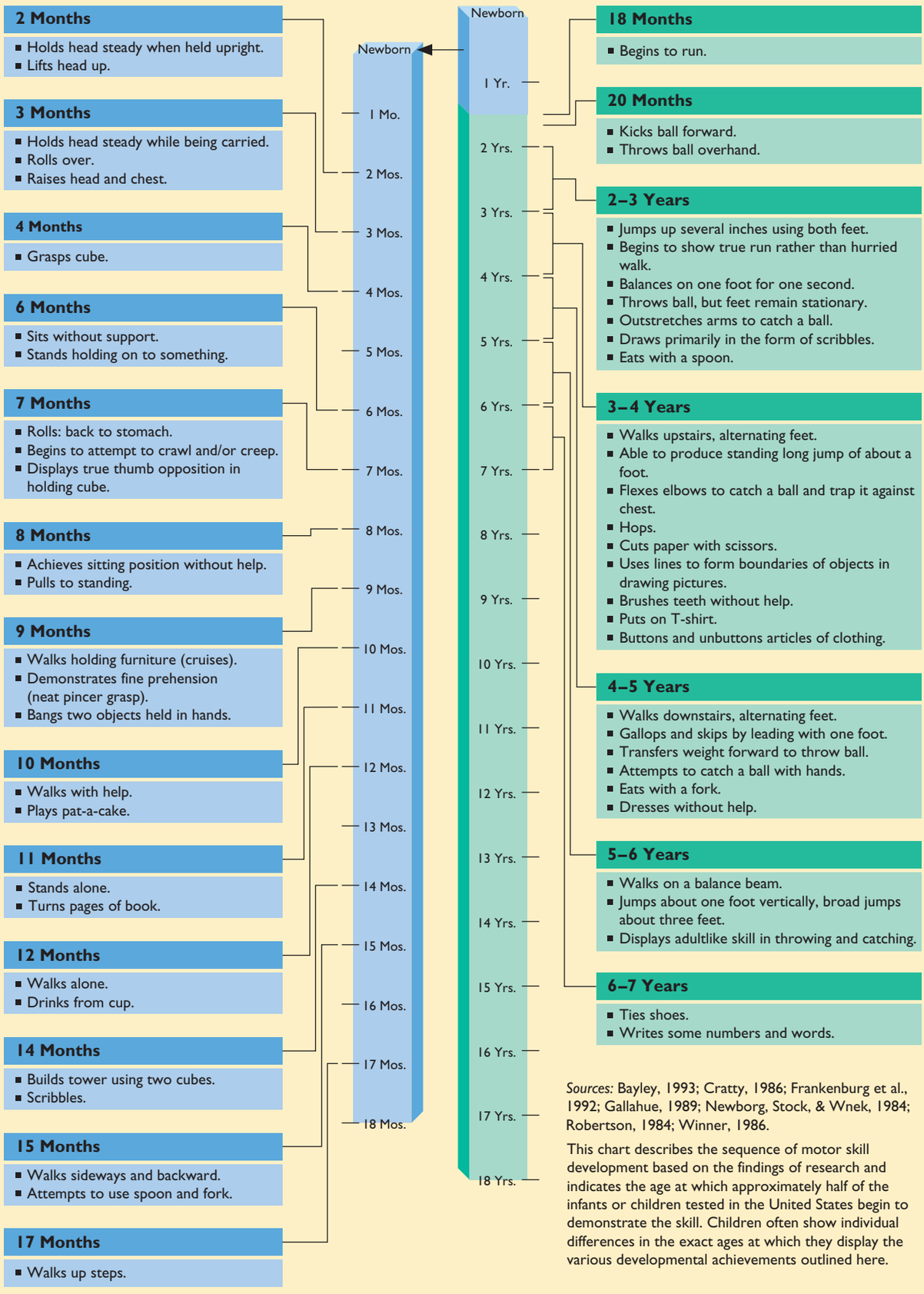
● **Locomotion** Achievements in the ability to move about the environment are also summarized in the chronology. One early milestone in locomotion is the capacity to roll over. Then comes success at initiating forward motion, a skill marked by considerable variation (Adolph, Vereijken, & Denny, 1998; Freedland & Bertenthal, 1994). Some infants use arms to pull and legs to push, others use only arms or legs, and still others scoot forward while sitting. *Crawling,* locomotion with stomach touching the floor, may soon give way to *creeping,* locomotion on hands and knees—and then again it may not. The varieties of forward motion invented by babies often generate lively discussions among caregivers.

Once babies are able to pull themselves upright, they often *cruise,* that is, move by holding onto furniture or other objects to help maintain their balance while stepping sideways (Barela, Jeka, & Clark, 1999). Forward walking while holding onto someone's hand typically follows. By about twelve months of age, about half of American

rhythmical stereotypies
Repeated sequences of movements, such as leg kicking, hand waving, or head banging, that have no apparent goal.

cephalocaudal development
Pattern in which organs, systems, and motor movements near the head tend to develop earlier than those near the feet.

CHRONOLOGY: *Motor Skill Development*



2 Months
- Holds head steady when held upright.
- Lifts head up.

3 Months
- Holds head steady while being carried.
- Rolls over.
- Raises head and chest.

4 Months
- Grasps cube.

6 Months
- Sits without support.
- Stands holding on to something.

7 Months
- Rolls: back to stomach.
- Begins to attempt to crawl and/or creep.
- Displays true thumb opposition in holding cube.

8 Months
- Achieves sitting position without help.
- Pulls to standing.

9 Months
- Walks holding furniture (cruises).
- Demonstrates fine prehension (neat pincer grasp).
- Bangs two objects held in hands.

10 Months
- Walks with help.
- Plays pat-a-cake.

11 Months
- Stands alone.
- Turns pages of book.

12 Months
- Walks alone.
- Drinks from cup.

14 Months
- Builds tower using two cubes.
- Scribbles.

15 Months
- Walks sideways and backward.
- Attempts to use spoon and fork.

17 Months
- Walks up steps.

18 Months
- Begins to run.

20 Months
- Kicks ball forward.
- Throws ball overhand.

2–3 Years
- Jumps up several inches using both feet.
- Begins to show true run rather than hurried walk.
- Balances on one foot for one second.
- Throws ball, but feet remain stationary.
- Outstretches arms to catch a ball.
- Draws primarily in the form of scribbles.
- Eats with a spoon.

3–4 Years
- Walks upstairs, alternating feet.
- Able to produce standing long jump of about a foot.
- Flexes elbows to catch a ball and trap it against chest.
- Hops.
- Cuts paper with scissors.
- Uses lines to form boundaries of objects in drawing pictures.
- Brushes teeth without help.
- Puts on T-shirt.
- Buttons and unbuttons articles of clothing.

4–5 Years
- Walks downstairs, alternating feet.
- Gallops and skips by leading with one foot.
- Transfers weight forward to throw ball.
- Attempts to catch a ball with hands.
- Eats with a fork.
- Dresses without help.

5–6 Years
- Walks on a balance beam.
- Jumps about one foot vertically, broad jumps about three feet.
- Displays adultlike skill in throwing and catching.

6–7 Years
- Ties shoes.
- Writes some numbers and words.

Sources: Bayley, 1993; Cratty, 1986; Frankenburg et al., 1992; Gallahue, 1989; Newborg, Stock, & Wnek, 1984; Robertson, 1984; Winner, 1986.

This chart describes the sequence of motor skill development based on the findings of research and indicates the age at which approximately half of the infants or children tested in the United States begin to demonstrate the skill. Children often show individual differences in the exact ages at which they display the various developmental achievements outlined here.

A major motor milestone that babies around a year of age typically reach is that of walking. Although this baby is not quite old enough to walk independently, infants show surprisingly coordinated leg movements well before this milestone is reached. Do you think this kind of practice might also help her to begin walking earlier? Although we typically think of the onset of walking as primarily the result of maturation, cross-cultural research suggests that in communities in which a great deal of opportunity is provided to acquire this ability, children begin to walk at somewhat earlier ages.

babies and infants in many other countries walk alone, a skill that continues to be refined throughout infancy and early childhood.

Prewalking and walking skills likely depend on the growth of higher brain centers, but even before independent walking, many of the components of this ability are evident. For example, when babies six months of age are placed on a treadmill and held so they do not have to support their full weight, they display alternating stepping similar to that involved in walking (Thelen & Ulrich, 1991). Even six-week-olds produce surprisingly coordinated leg movements when lying on their backs (Thelen, Skala, & Kelso, 1987). Thus even though the coordinated action pattern underlying these abilities may be available much earlier, the task constraints of maintaining upright posture, lifting the leg against gravity, moving forward, and other factors may delay the onset of walking.

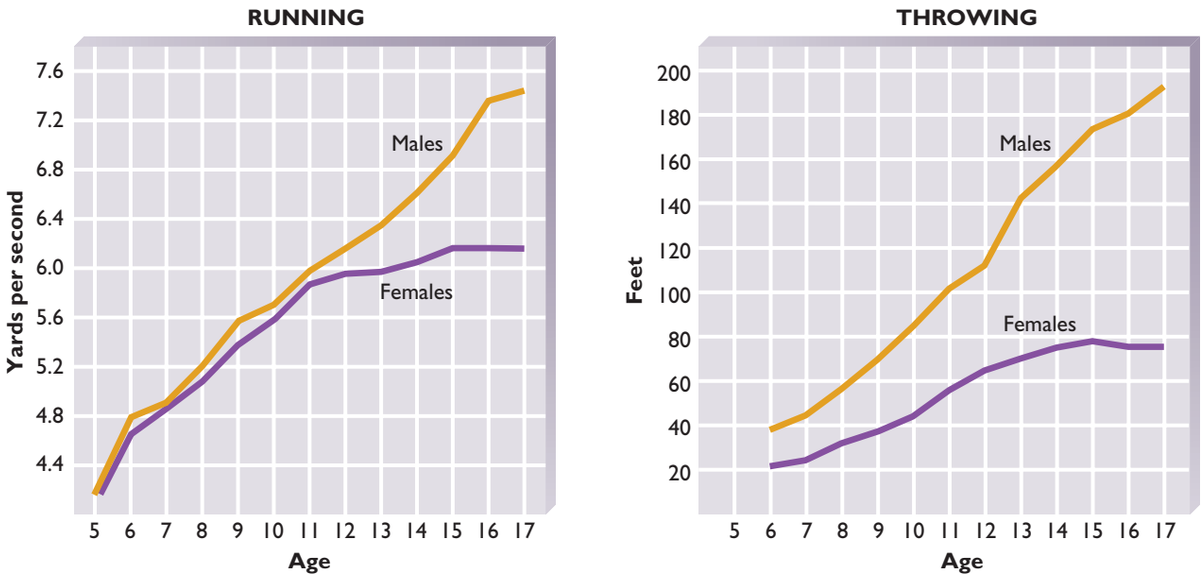
● **Manual Control** In the weeks that follow birth, infants make enormous progress in reaching. Moving the hand to the mouth appears to be among the earliest goal-directed actions (Lew & Butterworth, 1997; Rochat, 1993). However, newborns also display *prereaching* in their attempts to contact objects that catch their attention. These early efforts are neither accurate nor coordinated with grasping. Still, movements show speeding up, slowing down, and changes in direction, just as in later, more accurate reaches (Rönnqvist & von Hofsten, 1994; von Hofsten & Rönnqvist, 1993). Systematic reaching for objects begins at about three months of age. By about five to six months, infants display mature, *ballistic* reaches to rapidly and accurately retrieve an object in the visual field. In gaining mastery over this response, babies engage in a series of submovements, not always perfectly executed but often quickly corrected to meet the goal of obtaining the target (Berthier, 1996; Berthier & Robin, 1998) and will even intercept a target moving past their line of sight (Robin, Berthier, & Clifton, 1996). The ability to see their own hands is not necessary in early reaching; however, infants eventually make greater use of visual cues to help them retrieve an object (Clifton et al., 1993; McCarty et al., 2001; Robin, Berthier, & Clifton, 1996).

When first attempting to reach, very young infants typically keep their hands closed in fistlike fashion. By about four months of age, infants awkwardly pick up an object by grasping it with the palm of the hand. Over the next few months, they shift from using the inner palm to using opposing thumb and fingertips, a progression that culminates in a *neat pincer grasp* at about nine months of age.

Another important component of motor skill is increased coordination between the two hands. Very young infants often attempt to grasp objects with both hands, but once babies gain an ensemble of skills, including head control and postural balance while sitting by themselves and when leaning forward, one-handed reaches and more consistent, stable reaching become a part of their repertoire (Rochat & Goubet, 1995; Spencer et al., 2000). Increased coordination is further reflected in the appearance of complementary hand orientations, such as holding a toy dump truck in one hand while using the other hand to fill it with sand. This *functional asymmetry* emerges at about five to six months of age but becomes especially refined as the child enters the second year and begins to display self-help and advanced motor tasks requiring sophisticated use of both arms and hands.

Motor Skills in the Preschool and Later-Childhood Years

Many fundamental motor skills that the child acquires in the first two years of life continue to be modified and refined in the preschool and elementary school years. For example, between two and six months after learning to walk, children typically begin to run. In the months and years that follow, they show increasingly effective body and eye-hand or eye-foot *coordination,* evident in their greater ability to hop and skip or, perhaps, kick, dribble, and catch a ball. With increasing age, children also demonstrate better *balance,* reflected in the ability to walk greater distances on a beam or stand on one foot for a longer period of time; increased *speed,* shown by running short distances more rapidly; improved *agility,* revealed, for example, in the



Source: Gallahue, 1989, adapted from Haubenstricker & Seefeldt, 1986.

FIGURE 5.5
Running Speed and Throwing Distance for Boys and Girls at Different Ages

Boys tend to outperform girls on many motor skill tasks during the elementary school years, as indicated by these data on speed of running and distance throwing a ball, summarized from a number of studies carried out since 1960. The differences between girls and boys often increase substantially as children enter adolescence.

ability to shift directions quickly while running; and greater *power,* shown by jumping higher or longer distances or throwing a ball farther and faster than at younger ages. The Motor Skill Development chronology summarizes major accomplishments for some of these abilities during early childhood.

In general, activities that exercise large muscles attract the interest of toddlers and preschoolers—pulling and pushing things, stacking and nesting large objects, and, eventually, riding toys such as kiddie cars and tricycles. As preschoolers begin to organize and display more interest in energetic games and athletic activities—jumping, hopping, running, balancing, and catching or throwing a ball—feats that emphasize speed, strength, and efficiency of performance become frequent ingredients of their everyday schedule. When first attempting to execute these skills, young children often fail to prepare or follow through on their actions, and the speed or force needed to complete them in a mature way is absent. Before finally demonstrating mastery of a skill, children may have difficulty synchronizing all of the complex movements.

Older preschoolers supplement their large-muscle and athletic exercises with coloring and drawing, cutting and sculpting, and other activities that demand greater neural control and small-muscle coordination, a longer attention span, and more sophisticated planning and organization. Motor skills during middle childhood become more efficient and better controlled, involve complex and coordinated movements, and are exhibited quickly and in a wider variety of contexts and circumstances (Keogh & Sugden, 1985). With the exception of balance, boys tend to slightly outperform girls on many gross motor tasks by the time they enter elementary school (Gallahue, 1989). However, differences between boys and girls may become especially large for some activities as children enter the adolescent years, as Figure 5.5 indicates for running speed and the distance a youngster can throw a ball.

Fine motor coordination improves dramatically during the school years. For example, writing as a motor production activity independent of drawing emerges around six years of age (Adi-Japha & Freeman, 2001). In addition, model construction or needlework, mastering the complex finger sequencing needed to play musical instruments, and more detailed drawings confirm that motor skills are undergoing significant developmental advances.

KEY THEME
Individual Differences

As children grow older, differences in individual abilities often increase. The effect may, of course, stem from practice, because some children focus on acquiring particular competence relevant to their social and cultural milieus. The acquisition of expertise or specialized motor skills in sports, dance, crafts, hobbies, playing musical

instruments, and, in some cultures, trade- or work-related endeavors permits older children to become more effective members of their society, and gain greater social status among peers and adults.

Determinants of Motor Development

KEY THEME
Nature/Nurture

Are the emergence, refinement, and integration of motor skills primarily dependent on genetic or maturational factors? Or are they the consequence of practice, cultural, or other experiential factors? Many pioneers in developmental psychology advocated a strong maturational theory to explain the orderly acquisition of motor skills. But changes, just as in other domains of development, are better understood in terms of the confluence of both biological and experiential factors.

● **Biological Contributions** One of the strongest arguments in support of a genetic or maturational basis for the development of motor skills is their tendency to be displayed at predictable times and in similar ways in normal children. Moreover, the onset of such skills as sitting and walking show greater concordance for identical than for fraternal twins. Greater similarity in gross motor activities such as running, jumping, and throwing is found in children who are more closely related biologically (Malina, 1980). Even intellectually and physically disabled babies attain major milestones in an orderly manner, although at a later age than other children. For example, blind children who show substantial delays in acquiring postural, locomotion, and manual coordination skills eventually acquire them nonetheless (Tröster & Brambring, 1993).

● **Experiential Contributions** Could experiential variables also play a role in motor development? With respect to the acquisition of expert motor skill, the answer is most certainly yes. However, it may be true for attaining basic developmental milestones as well. Lack of opportunity to engage in physical activity seriously interferes with reaching developmental milestones. For example, babies who spent most of their first year in an orphanage lying in cribs and receiving few other forms of stimulation typically did not walk before age three or four (Dennis, 1960). When special programs encourage blind infants to acquire self-initiated movement, they do so at ages more comparable to their sighted peers' (Fraiberg, 1977).

In the Navajo culture babies are often swaddled for most of the day. Wayne Dennis's research with Hopi infants who were also cared for in this way suggests that this baby, despite the lack of opportunity to practice sitting up, crawling, and standing alone, will begin to walk about the same time as an infant who has not been swaddled.

Several investigators in the 1930s conducted studies with sets of twins to test the role of experience in motor skill development. Typically, one twin received extensive training in, say, handling blocks, climbing stairs, or roller skating; the other twin did not (Gesell & Thompson, 1934; Hilgard, 1932; McGraw, 1935). When given a chance to acquire the skills, the untrained twin often rapidly achieved the same level of accomplishment displayed by the trained twin. In another early study, Wayne and Marsena Dennis investigated child-rearing practices among the Hopi Indians (Dennis & Dennis, 1940). Some Hopi Indian mothers followed the tribal tradition of tightly swaddling their babies in a cradleboard; the mother would strap the board to her back for all but about an hour a day during her waking hours for the first six to twelve months of her child's life. These Hopi babies had little opportunity to practice sitting up, crawling, and walking. Other Hopi mothers reared infants without swaddling. The researchers found that swaddling had little bearing on when infants initiated walking, an observation reconfirmed in a later study of the effects of Hopi rearing customs (Harriman & Lukosius, 1982).

What can we conclude from these investigations? Perhaps that the typical range of daily activities and experiences in which infants and children are engaged is sufficient to promote normal locomotor development. But consider other findings. Infants from one to seven weeks of age, given a few minutes of daily practice with the placing and stepping reflexes, retain them and begin walking earlier than infants who receive no special training or whose legs are passively moved back and forth (Zelazo, 1983). Moreover, practice in sitting helps infants acquire these skills (Zelazo et al., 1993).

KEY THEME
Individual Differences

Esther Thelen and her colleagues (Thelen & Smith, 1994, 1998) have applied a far broader perspective to the role of experience in motor development. Thelen has argued that all complex motor skills require the assembling and reassembling of multiple processes involving, among other things, motivation, elements of the nervous system that regulate posture and balance, increased bone and muscle strength, and changes in body proportions. The assemblages are further constrained by the biodynamics of the human body, as well as the situational context. However, when the right improvisation of components exists, infants display mastery of motor skills or advance to new levels of competence. Neither biological nor experiential factors alone are responsible. Instead, motor development is a dynamic system; its multiple components become "tuned" into sequences of more effective, self-organized actions over time (Lockman & Thelen, 1993).

Cross-Cultural Differences

KEY THEME
Sociocultural Influence

Given the multiple processes involved, it should not be surprising to learn that ethnic and cultural differences in motor development exist as well. At birth and throughout their first year, African American babies, as well as infants among the Wolof of Senegal, Gusii of Kenya, Yoruba of Nigeria, Bantu of South Africa, and Ganda of Uganda, typically outperform Caucasian infants on a variety of motor skills (Lester & Brazelton, 1982; Werner, 1972). Parents in a fairly prosperous rural community in Kenya made extensive efforts to teach their infants to sit or walk (Super, 1976). In fact, their language, as in some other regions of East Africa, contained distinctive words to denote the specialized training. The more caregivers promoted specific motor skills, the earlier their children tended to display them. For example, 93 percent of one group of caregivers said they taught their babies to crawl, and babies in this group began crawling at about five-and-a-half months of age. In contrast, only 13 percent of the caregivers in a nearby group expressed support for teaching their infants to crawl, and these babies did not crawl until about eight months of age.

Many factors could contribute to the cultural differences, but one finding strongly implicates child-rearing efforts. Advanced motor development in this part of Kenya was limited to sitting, standing, and walking, skills considered culturally important. Other milestones not taught or valued, such as head control or the ability to roll over, were acquired later than they are by American infants. A similar observation comes from Jamaica. Some mothers in that country perform special stretching and massaging

exercises to encourage their infants to sit and walk alone (Hopkins & Westra, 1990). Children of these mothers sit by themselves and walk earlier than other children.

We cannot be certain whether training focused on particular skills or more general experiences are responsible for cultural differences. Children in East Africa, for example, spend more time in an upright position, seated on a caregiver's lap or riding on her back, than children in the United States (Super, 1976). The activities may strengthen trunk and leg muscles to aid the earlier appearance of sitting, standing, and walking. However, gains achieved from training in one of two particular skills, such as stepping or sitting, do not appear to generalize to the other (Zelazo, 1998; Zelazo et al., 1993). Infants who become increasingly proficient in crawling up and down a slope have to relearn how to go up and down the same slope when they start to walk (Adolph, 1997).

Children of the Ache of Eastern Paraguay are significantly delayed in acquiring a host of motor skills. For example, walking is not exhibited until twenty-one to twenty-three months of age (Kaplan & Dove, 1987). This small band, which engages in hunting and gathering, does not encourage the acquisition of motor skills in infants. When families migrate to the forests, the women closely supervise their children younger than three years, preventing them from venturing more than a yard or so into the uncleared vegetation (Kaplan & Dove, 1987). For the Ache, keeping infants close by may be crucial for their continued survival, but it gives little opportunity for infants to practice motor skills. Because the Ache have been relatively isolated and the total population at times quite small, genetic factors cannot be ruled out as contributing to the delay, but cultural concerns and efforts to either promote or discourage the acquisition of motor skills appear to have a significant effect on their development.

FOR YOUR REVIEW

- How do primitive and postural reflexes differ? What purpose do they serve for the infant?
- What are the factors associated with SIDS? What steps can caregivers take to reduce the likelihood of its occurring?
- Why does controversy exist concerning the sleeping arrangements for young infants?
- When are rhythmical stereotypies exhibited?
- What are the major milestones associated with the development of postural control, locomotion, and manual control? How does the principle of cephalocaudal development apply to the emergence of the major motor milestones?
- What kinds of improvements in motor skills are observed in the preschool and later childhood years?
- What are factors that contribute to motor development? How do cultural practices influence their acquisition?

Body Growth and Development

Just as the emergence of increasingly sophisticated motor skills provides a highly visible indicator of development, so too does the change in physical size. For parent and child alike, the ever-higher marks penciled on the bathroom wall give eloquent testimony to increasing maturity. A long-absent aunt who cries, "My, how you've grown!" may summon a grin from the wary seven-year-old or a blush from the self-conscious thirteen-year-old. She is, however, confirming for both children the social importance of this sign of change.

We tend to use the words *grow* and *develop* interchangeably in describing the physical transformations of childhood, but they do not refer to the same processes.

Strictly speaking, *growth* is the increase in size of the body or its organs, whereas *development* refers not only to changes in size but also to the orderly patterns, such as growth spurts, and the more complicated levels of functioning that often accompany increases in height and weight.

Norms of Growth

By recording information about the height and weight of large numbers of children from diverse populations, we can determine whether a particular child's individual growth falls within the range expected for his or her chronological age and ethnic background. These **norms,** quantitative measures that provide typical values and variations in height and weight for children, have become an essential reference for attempting to answer questions about how biological and experiential factors influence growth.

● **Length and Height** The most rapid increase in body length occurs during the fourth month of prenatal development, when the fetus grows about 1.5 millimeters a day. The fetus continues to grow rapidly, albeit at a somewhat slower rate, during the remaining prenatal weeks. The newborn maintains a high rate of growth for several months following birth. In fact, if growth rate during the first six months after birth were sustained, the average ten-year-old would be about one hundred feet tall (McCall, 1979). Girls can be expected to reach approximately half their adult height a little before two years of age and boys a little after two years of age (Fredriks et al., 2000).

Throughout infancy and childhood boys and girls grow at similar rates, although individual children, of course, may differ enormously. For example, sudden growth spurts of one-quarter to one-half inch can occasionally occur literally overnight in infants and toddlers (Lampl, Veldhuis, & Johnson, 1992). Over a longer span of time, growth rate generally follows a slow and steady pace throughout much of childhood. At about ten or eleven years of age, however, many girls begin an adolescent growth spurt, a period in which height increments occur at nearly double the rate in childhood. Because the growth spurt usually does not start in boys until about two years later, girls may tower over their male peers for a brief period in early adolescence. During the approximately three years over which the growth spurt occurs, girls add about twenty-eight centimeters (eleven inches) and boys about thirty centimeters

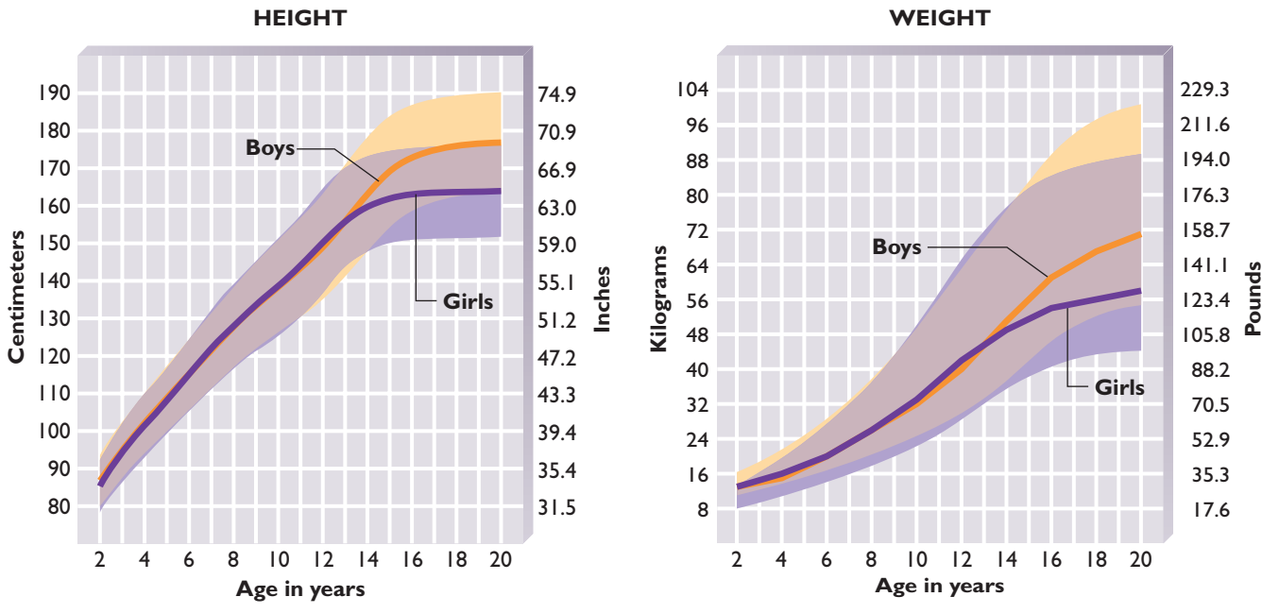
KEY THEME
Individual Differences

Variation in height and weight are just two of the many ways that children of similar ages differ in their physical development. These children in junior high school joining together to socialize after school illustrate a wide variation in height. Some may not have begun their adolescent growth spurt, others may be in the middle of this developmental phase, and still others may have already completed it.

norms Measures of average values and variations in some aspect of development, such as physical size and motor skill development, in relation to age.

FIGURE 5.6 Growth in Height and Weight over the First Twenty Years

Height and, to a lesser extent, weight rapidly increase in the first two years following birth. Changes in height and weight continue at a fairly modest rate throughout childhood, followed by a brief, more rapid upturn sometime during the preadolescent or adolescent years. However, there is a wide range in height and weight among children, especially during the adolescent years. For example, this figure (based on children in the United States) shows height and weight growth charts for boys and girls between the 3rd and 97th percentiles.



Source: Centers for Disease Control and Prevention, National Center for Health Statistics, 2000.

(twelve inches), or about 17 percent of their total height (Abbassi, 1998). Figure 5.6 illustrates the growth typically observed in many populations of children during their first eighteen years.

● **Weight** In contrast to that of height, the maximum rate of increase in weight takes place shortly after birth. In their first few days, newborns typically lose excess body fluids and shed 5 to 10 percent of their birth weight. They then usually make rapid weight gains, normally doubling their birth weight in about five months and nearly tripling it by the end of the first year (Pinyerd, 1992). If the gains for the first six months were sustained, the average ten-year-old would weigh in at about 240,000 tons (McCall, 1979). Weight gains are smallest during childhood between ages two and three and gradually increase until just before adolescence (see Figure 5.6).

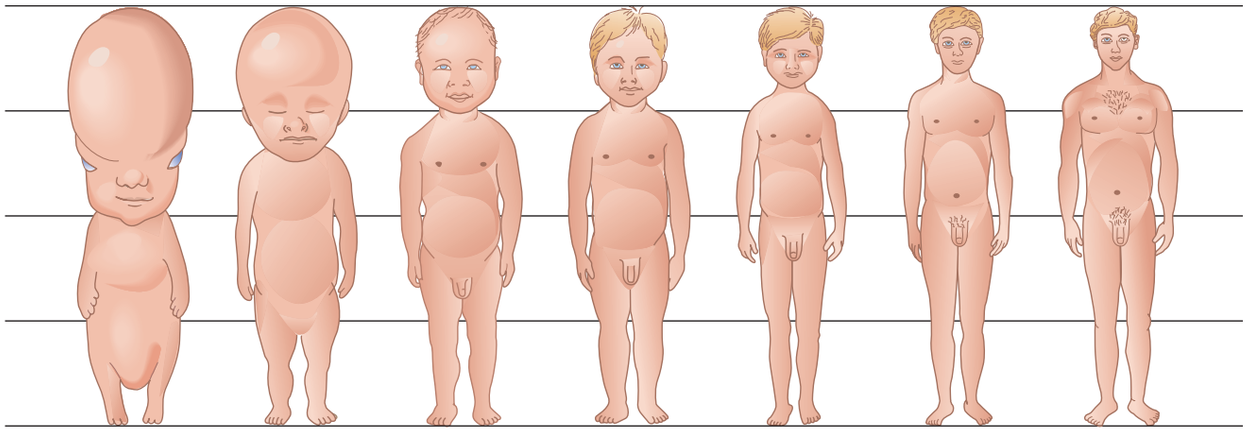
Patterns in Body Growth

Specific organs and systems of the body often develop at rates different from that for the body as a whole. The most dramatic example probably is head size. Two months after conception, the head constitutes nearly 50 percent of total body length. By birth, however, head size represents only about 25 percent, and by adulthood only about 12 to 13 percent of total body length, as Figure 5.7 shows. The central nervous system, along with the head, undergoes an early and extremely rapid increase in weight. By five or six years of age, the child has reached 90 percent of the adult level for brain and head size.

Other organs, for example, the muscles and the respiratory and digestive systems, follow the pattern of overall weight change: substantial gains during the first two years; a slower, more stable increase throughout childhood; and a rapid increase during

FIGURE 5.7 Changes in Body Proportions During Prenatal and Postnatal Growth

The size of the human head in proportion to the rest of the body shows striking changes over the course of prenatal to adult development. Two months after conception, the head takes up about half of the entire length of the body. By adulthood, the head makes up only about 12 to 13 percent of total body length. The head's tendency to grow more rapidly than regions of the body near the "tail" demonstrates the pattern of cephalocaudal development.



Source: Adapted from Robbins et al., 1928.

adolescence. However, the reproductive system follows a strikingly different pattern: only during adolescence do organs associated with reproduction begin to mature and rapidly approach their adult size. These different patterns mirror the functional importance of various systems of the body at specific points in development.

● **Directionality of Growth** In addition to growth that generally follows the *cephalocaudal principle* (the region nearer the head matures more quickly than other areas), body growth also tends to reflect a pattern of **proximodistal development.** This principle points up the fact that regions nearer the trunk of the body tend to grow and become more differentiated earlier than those more peripheral to the body. A good example is the ability of infants to gain control of their arms and legs much sooner than of areas more distant, such as their fingers and toes. However, not all physical growth conforms to either the cephalocaudal or proximodistal principles of development. During the adolescent growth spurt, for example, some parts of the body undergo rapid growth in a pattern almost the reverse of the proximodistal principle. We are all familiar with the teenager who seems to be all hands and feet. Hands and feet are in fact among the first body parts to show a dramatic change during this period; they are followed by arms and legs and, last of all, the trunk (Tanner, 1978). An adolescent, in other words, is likely to outgrow his shoes first, then his trousers, and finally his jacket.

● **Individual and Group Differences** Children show substantial deviations from the norm in their rates of physical growth and development. Individual variations in size are already noticeable at birth; for example, boys tend to be slightly longer and heavier than girls at this time (Copper et al., 1993). Individual differences in growth become especially evident during the adolescent years, when children are likely to show enormous variation in the timing, speed, and duration of the adolescent growth spurt. In the United States, the onset of rapid adolescent growth typically occurs between ages ten and fourteen for girls and between ages twelve and sixteen for boys (Sinclair, 1985). A girl who once towered over her childhood girlfriends may suddenly find at age thirteen that she is looking up to them, temporarily at least. A

KEY THEME
Individual Differences

proximodistal development Pattern in which organs and systems of the body near the middle tend to develop earlier than those near the periphery.

boy whose athletic skills were unremarkable may find himself the starting center for the junior high basketball team if he undergoes an early adolescent growth spurt.

Variability in growth occurs among ethnic and cultural groups as well. For example, although individual differences account for much of the variability in size, American infants of African heritage tend to weigh slightly less than American infants of European heritage at birth, even when social class, gestational age, and other factors known to affect birth weight are equated (Goldenberg et al., 1991). Variability in height among ethnically and culturally diverse populations is also exhibited throughout childhood.

Determinants of Body Growth and Development

KEY THEME
Nature/Nurture

What are the roles of nature and nurture in human physical growth? On the one hand, the contributions of nature, or heredity, are suggested by research indicating significant biological influences on physical development, as well as correlations among related family and cultural members in mature size and in the onset and pattern of physical changes. On the other hand, nurture, or environment—including diet, disease, and social and emotional circumstances—has a bearing on physical growth as well.

● **Genetic Factors** A person's height is likely to be closely related to that of his or her mother and father. A late-maturing adolescent often shares late maturity with other family members (Rallison, 1986). What is true for the family in miniature is also true for larger human populations that are genetically related. The Lese of Zaire, for example, are much taller as a group than their nearby neighbors the Efe, the pygmies of the Ituri rain forest. Even body proportions differ among groups. For example, although many individual differences and much overlap occur among people of different ethnic backgrounds, leg and arm lengths tend to be relatively greater in individuals of African descent, and even more so in Australian aborigines, than in other ethnic groups when length of the torso is equated (Eveleth & Tanner, 1990). Such similarities and differences implicate genetic factors in physical development. But genes do not control growth *directly*. Genes regulate physical development by means of neural and hormonal activity in different organs and body systems.

● **Neural Control** Many researchers believe the brain includes a growth center, a genetically established program or template that monitors and compares expected and actual rates and levels of growth for the individual. The claim has been supported by observations of **catch-up growth,** an increase in growth rate that often occurs if some environmental factor interferes with normal increases in height during infancy or childhood. Illness or malnutrition, for example, may disrupt physical growth. However, if the duration and severity are limited and do not occur at some critical time, the child's rate of growth often accelerates once she or he recovers. The acceleration continues until height "catches up" to the level expected had no disruption occurred.

The presence of a growth center is also suggested by the converse finding: **lagging-down growth** (Prader, 1978). Some rare congenital and hormonal disorders produce unusually rapid growth. If the disorder is corrected, growth halts or slows until actual and projected height match the trajectory established before the disruption. Where might this neural control center be located? Researchers theorize that the *hypothalamus,* a small region near the base of the brain (see Figure 5.2), orchestrates the genetic instructions for growth.

catch-up growth Increase in growth rate after some factor, such as illness or poor nutrition, has disrupted the expected, normal growth rate.

lagging-down growth Decrease in growth rate after some factor, such as a congenital or hormonal disorder, has accelerated the expected, normal growth rate.

hormones Chemicals produced by various glands that are secreted directly into the bloodstream and can therefore circulate to influence cells in other locations of the body.

● **Hormonal Influences** **Hormones,** chemicals produced by various glands that are secreted directly into the bloodstream and can therefore circulate to influence cells in other locations of the body, furnish another key mechanism for converting genetic instructions into physical development. For example, hormones produced by cells in the hypothalamus, the suspected site of the growth center, trigger or inhibit production of still other hormones in the nearby *pituitary gland* (see Figure 5.2),

including one known as *human growth hormone (HGH).* Infants with insufficient HGH may be nearly normal in size at birth, but their growth slows dramatically over the ensuing months and years; they typically reach an adult height of only about four to four-and-a-half feet. HGH, however, only indirectly promotes growth. It spurs the production of *somatomedins,* specialized hormones manufactured by many other cells in the body that directly regulate cell division for growth (Underwood, 1991).

The hypothalamus and pituitary gland produce still other hormones important for physical changes, including those that occur during puberty. However, variations in amounts of many hormones, as long as they fall within a reasonable range, do not account for individual differences in height. Individual differences seem to depend on the sensitivity of cells to the hormones (Tanner, 1978). For example, the pygmy Efe produce normal quantities of HGH but seem unable to use it to produce one kind of somatomedin important for growth to heights typical of other groups (Merimee, Zapf, & Froesch, 1981).

● **Nutrition and Health** For a large proportion of the world's children, adequate nutrition and exposure to diseases may be the primary determinants of whether physical growth proceeds normally or even at all. We pointed out some consequences of malnutrition for fetal development in the chapter titled "The Prenatal Period and Birth." Illness and nutritional deprivation can affect postnatal growth as well. During much of the first half of the twentieth century in Western Europe, for example, the average height gain of children at various ages increased gradually over the years except during World Wars I and II and periods of agricultural and economic crises, when food was far more limited. In 1984, a severe, three-month-long drought struck Kenya while researchers were engaged in a study of malnutrition in that region (McDonald et al., 1994). Food intake was cut sharply. The normal rate of weight gain among elementary school children was halved.

Severe protein-energy malnutrition can have a particularly devastating effect on growth. Infants with *marasmus* fail to grow because they lack sufficient calories. Consequences include eventual loss in weight; wrinkly, aged-looking skin; an abdomen that is often shrunken; and a hollow appearance to the body, suggesting emaciation. Another prevalent form of protein-energy malnutrition is *kwashiorkor,* or failure to develop because the diet either contains an inadequate balance of protein or includes potentially harmful toxins. Kwashiorkor typically appears in one- to-three-year old children who have been weaned, usually because of the arrival of a newborn sibling, and whose subsequent sources of protein are inadequate or contaminated.

SEE FOR YOURSELF
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Hunger and Nutrition in Children

In many countries, large numbers of young children suffer from *kwashiorkor.* This young child, living in a refugee camp at Bakauu, Rwanda, displays the distended, bloated stomach so typical of this nutritional disorder because his diet either does not include sufficient protein or contains toxins.

The symptoms of kwashiorkor include lethargic behavior and an apathetic look, wrinkled skin, and a thin, wispy, reddish-orange cast to the hair, but most defining is edema or swelling, especially of the stomach, to give the child a bloated appearance (Balint, 1998). Kwashiorkor leads not only to disruption in growth of the body but also to deterioration of the brain. Although some of the damage can be quickly reversed when adequate nutrition is reinstated early (Gunston et al., 1992), long-term cognitive deficits and poorer school-related performance may persist due to impaired attention and memory (Galler et al., 1990). Studies of the effects of supplementary feeding during the first few years of life provided for nutritionally deprived families in Colombia, Guatemala, Jamaica, Taiwan, and Indonesia indicate that both motor and mental development are enhanced (Pollitt, 1994). Benefits to intellectual development extend into adolescence even when the supplementary diet is discontinued in the preschool years (Pollitt et al., 1993).

KEY THEME
Interaction Among Domains

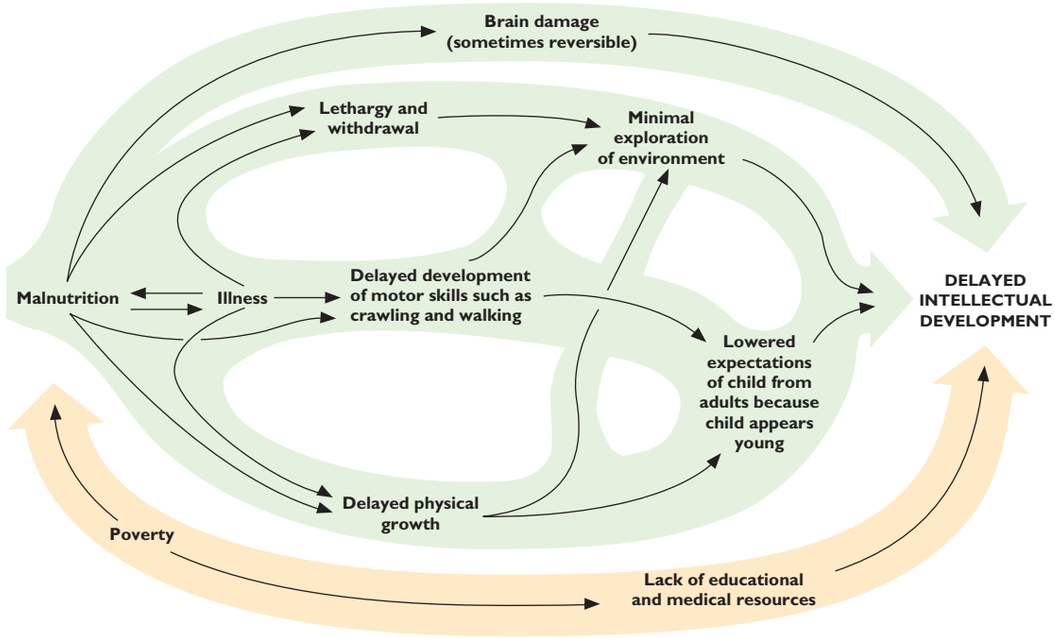
As Figure 5.8 suggests, malnutrition operates at many levels to produce negative consequences for development. For example, cognitive deficits may stem from lessened motivation or curiosity and an inability to respond to or engage the environment (Brown & Pollitt, 1996). To illustrate, during the relatively brief drought in Kenya, schoolchildren became less attentive in class and less active on the playground (McDonald et al., 1994). To counter the disruption in motivation, attention, and activity level that can accompany malnutrition, some projects have been designed to encourage mothers to become more competent and effective teachers and caregivers for their young children. When nutritionally deprived children in Jamaica have been given extra play opportunities and mothers have been taught how to positively influences their children's development, children have shown substantially higher performance on developmental and intelligence tests over a fourteen-year time period compared to children not receiving the intervention (Grantham-McGregor et al., 1994). However, the scores of malnourished children, even those given this kind of intervention, continue to fall below those of children who have been adequately nourished, a finding consistently reported in studies on the long-term consequences of malnutrition (Drewett et al., 2001). Even in the United States, lower academic performance and less positive interpersonal relationships are reported among large numbers of children living in families in which inadequate amounts of nutritional food are available (Alaimo, Olson, & Frongillo, 2001).

Deficiencies in specific nutritional elements—for example, vitamins A, B complexes, D, and K, as well as iron and calcium—are also linked to growth disorders affecting hundreds of thousands of children throughout the world (Balint, 1998; Hansen, 1990). Some of these disorders, especially iron-deficiency anemia, spawn lower performance on intelligence and other kinds of psychological tests. Although the problem is often assumed to be limited to low-income countries, iron-deficiency anemia is a major nutritional concern in the United States, affecting perhaps as many as 20 percent of some ethnic groups (Pollitt, 1994). More alarming is the claim that, for more than three-quarters of the children in the United States, the quality of their diet is poor or in need of improvement (Federal Interagency Forum, 1999).

● **Social-Emotional Factors** How important are social-emotional factors in physical growth? Early studies of institutionalized children painted vivid images of massive disruption in physical growth, or even death, if a warm, consistent caregiver was unavailable to the infant (Spitz, 1946b). A label of **failure to thrive** was attached to these children. Today this label is often applied to any boy or girl who falls below the third percentile in weight or height compared with other children of the same age. Some children fall into this classification simply because they have inherited short stature or are normally slow in growth; others qualify due to disease or some other medical cause.

failure to thrive Label applied to any child whose growth in height or weight is below the third percentile for children of the same age.

When no specific genetic, biological, or medical basis can be identified for growth retardation, the condition is labeled *nonorganic failure-to-thrive syndrome.* For some reason, these children are not taking in or processing sufficient nutrients to maintain normal growth despite the availability of adequate nutritional resources. Why might



Source: From *Malnutrition, Poverty and Intellectual Development* by J. Larry Brown and Ernesto Pollitt. Copyright © 1996 by Scientific American, Inc. All rights reserved.

FIGURE 5.8
The Many Routes by Which Malnutrition Affects Development

Nutritional deprivation can influence development at many different levels. More frequent and severe illness, delayed growth, and slower motor skill development are among the more visible consequences. Lower intellectual development is often an outcome as well. Malnutrition can damage the brain directly. However, limited capacity to engage the environment and other repercussions from the kinds of experiences a malnourished child receives may take a further toll on intellectual development. The context in which it often persists, such as poverty and the lack of essential resources, must also be factored into a consideration of how nutritional deprivation affects development.

this be the case? Research has not yet uncovered the answer. However, characteristics associated with both parent and child may be involved. These infants and young children with the syndrome tend to be more passive and apathetic and display less facial expressivity than other infants and children (Maggioni & Lifshitz, 1995). They may also be fussier about what they eat, despite the best efforts of parents to encourage food intake. These responses, in turn, can contribute to feelings of incompetence in the parents (Bithoney et al., 1995).

Parental behavior can further complicate the situation. For example, mothers of failure-to-thrive infants are often reported to display less pleasure, positive affect, and support in their communications and tend to be more abusive or neglectful (Drotar, 1991; Liggon et al., 1992). Concerned about their children becoming overweight or about allergic reactions, still other parents restrict the amounts of food (often healthy) or overemphasize some foods (often unhealthy) at the expense of others (Roesler, Barry, & Brock, 1994; Dennison, Rockwell, & Baker, 1997). One consistent long-term consequence of failure to thrive is decreased height, although evidence for continuing cognitive or social deficits remains mixed (Boddy, Skuse, & Andrews, 2000; Drewett, Corbett, & Wright, 1999).

● **Secular Trends** Increased knowledge of nutrition and the ability to treat disease have yielded dramatic changes in patterns of growth in many societies in recent generations. These generational changes are termed **secular trends.** Children today grow faster and become taller as adults than did previous generations in most regions of the world. Between 1880 and 1950, the average height of Western European and American children increased by nearly four inches. A slower increase or even stability in size has been found since the 1960s. Similar findings have been reported for other cultures, although at different times. For example, in Japan the most substantial changes in height took place between 1950 and 1970 (Tanner, 1978). Improved nutrition, better medical care, and the abolition of child labor account not only for secular trends in greater height across generations but also for the larger size of children from professional, highly educated, and urban families compared with children of poorer families and those in rural populations (Tanner, 1978).

secular trend Consistent pattern of change over generations.

The Social-Emotional Consequences of Body Growth

KEY THEME
Interaction Among Domains

Is physical size important to development and the way others interact with a child? If so, perhaps it is because the adult world appears to have strong preferences concerning height and weight.

KEY THEME
Individual Differences

● **Height** Many societies share a mystique about tallness, the notion that height directly correlates with such traits as competence and leadership. Research has shown that height does affect impressions of a child's abilities. Mothers of young children of the same age, for example, perceive taller boys as more competent (able to get along better with others, less likely to cry when frustrated, and so forth). They treat smaller boys as younger and in a more overprotective manner (Sandberg, Brook, & Campos, 1994). The same is true of children judged on the basis of maturity of facial features (Zebrowitz, Kendall-Tackett, & Fafel, 1991). Moreover, boys believe it is important to be tall and muscular; those substantially shorter than the average height for their age report extensive teasing from their peers; greater dissatisfaction with their skills, especially in athletic endeavors; and increasing unhappiness as they approach adolescence (Finch, 1978).

KEY THEME
Sociocultural Influence

Despite these observations, lower self-esteem or other behavorial problems among children of short stature have not been consistently reported. And short adults typically function well within the norm socially and intellectually (Kranzler et al., 2000; Sandberg et al., 1994; Zimet et al., 1997). Until 1985, little could be done to alter the course of growth or eventual height for most children. Today, however, human growth hormone can be produced synthetically. For children whose lack of growth stems from insufficient HGH or because of other genetic or physiological conditions, the breakthrough represented an enormously positive step toward more typical growth. However, increasing numbers of children who are genetically short or whose delay in growth is a normal part of their pattern of maturation are also being given HGH to speed up growth or increase their height, even though this practice is not officially recommended in many countries, including the United States (Cuttler et al., 1996).

Should such treatments, which tend to be motivated by perceptions and expectations about the benefits of being tall rather than by a medical condition, be encouraged? It is an expensive course of treatment and many children who are not HGH deficient gain few long-term benefits from its administration (Brook, 2000). Nor is the potential for negative side effects fully understood (Betts, 2000; Drug and Therapeutics Committee, 1995), although some pediatric endocrinologists believe it is very safe. In some countries HGH is officially approved for use with individuals born with Turner syndrome (e.g., France, Japan, and Sweden) and with children of short stature or who are simply failing to grow at normal rates (Bercu, 1996). However, attempting to alter normal physical development to conform to a cultural stereotype is a drastic action that raises many ethical issues.

WHAT DO YOU THINK?

When Should HGH Be Prescribed for Children?

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● **Obesity** Most estimates of obesity today make use of a measure called the *body mass index (BMI).* The BMI is determined by dividing the weight of a child or adult (in kilograms) by the square of his or her height (in meters). Children and adults above the 95th percentile for their age on this measure compared with a reference population (which for the United States usually has been a large sample of children and adults who were tested in this country in the 1970s) or whose BMI is above 30 are considered obese. Children between the 85th and 95th percentile or who show rapid changes in weight relative to other children their age also are considered at risk for becoming obese (Strauss, 1999; Styne, 2001).

KEY THEME
Sociocultural Influence

Being overweight has strong social-emotional consequences in most cultures. At earlier times it carried positive connotations of substance and prosperity in industrialized societies and still does in many developing countries today (Sobal & Stunkard, 1989). For example, adolescent females in some regions of the world are encouraged

to increase their body fat in preparation for marriage (Brown & Konner, 1987). However, in contemporary Western cultures obesity is often viewed negatively. For example, children as young as six, when describing drawings or photographs of people who are chubby or thin, are likely to label obese figures as "lazy," "cheater," or "liar," although they seldom apply such terms to their overweight friends (Kirkpatrick & Sanders, 1978; Lawson, 1980). In addition, overweight ten- and eleven-year-olds experience more negative interactions involving peers than do other children (Baum & Foreham, 1984). Although research has revealed a mixed pattern of findings, self-esteem may suffer as well (Klesges et al., 1992; Pierce & Wardle, 1997), especially for children who feel (or are made to feel) that they are responsible for being overweight (e.g., because of over-eating or insufficient exercise) even as early as five years of age in girls (Davidson & Birch, 1999).

KEY THEME
Nature/Nurture

Genetic factors predispose some children to obesity. At least five single gene disorders are known to be related to its early onset (Farooqi & O'Rahilly, 2000). Behavioral genetics studies further suggest a relationship as a function of multiple genes, perhaps because of inherited differences in metabolic processes (Strauss, 1999). Not surprisingly, either because of a genetic component or because parents serve as models for their children's eating and exercise habits, overweight parents are more likely to have obese children (Birch & Davison, 2001). Early obesity as well as the longer a child continues to be overweight increase the likelihood he or she will be obese as an adult (Strauss, 1999; Whitaker et al., 1997).

Controlling weight is complicated by the tendency of heavy children to be more sensitive to external food-related cues and less responsive to internal hunger cues compared with their normal-weight peers (Ballard et al., 1980; Costanzo & Woody, 1979). Infants and children are responsive to the amount of energy provided by the foods they consume (Birch & Davison, 2001; Fomon, 1993). However, eleven-year-old obese children tend to eat faster than other children. They also fail to slow down their rate of food intake as they near the end of their meal, a pattern of responding that is at odds with what is typically observed in children of normal weight (Barkeling, Ekman, & Rössner, 1992). Obese children also are somewhat less accurate in reporting how much they eat (Maffeis et al., 1994).

KEY THEME
Individual Differences

Leann Birch and her colleagues (cf. Birch & Davison, 2001) believe that children can learn to become unresponsive to internal satiation cues through child-feeding practices imposed by parents. For example, some parents, perhaps many, express concerns about their infants gaining sufficient weight. As a consequence, they may initiate meal-related practices designed to encourage food consumption (e.g., to "clean their plates") and use certain foods such as sweets to reward good behavior and to calm and quiet the child. These efforts, however, could have the unintended effect of shifting the child's reliance on internal signals for hunger to external signals based on how much has been eaten and of increasing preferences for some foods that may not be so healthy for the child. In addition, if concerns begin to emerge about becoming overweight, parents may attempt to restrict ingestion of high caloric foods, an action that seems to have the unintended consequence of making the forbidden foods even more attractive to children.

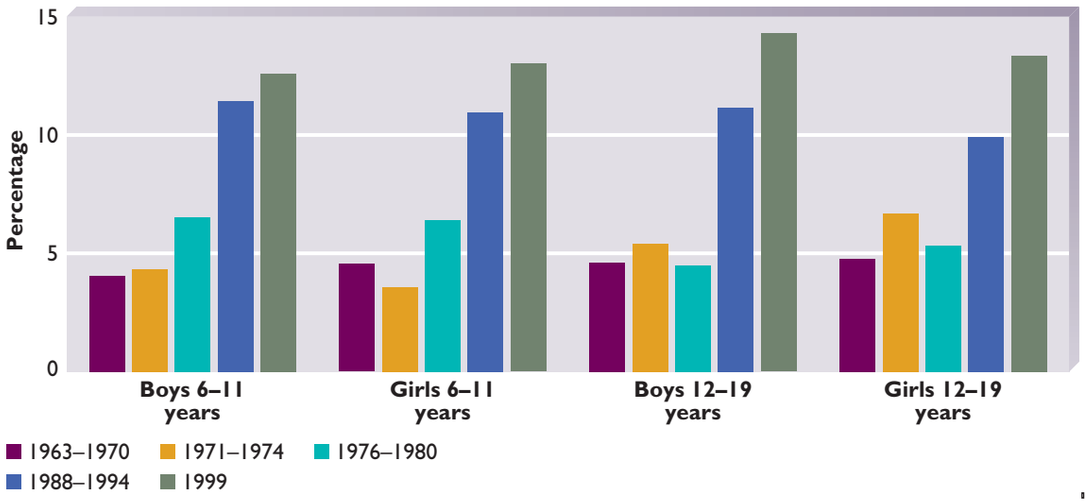
Recent health surveys reveal a worrisome increase in obesity among children and adolescents in the United States (see Figure 5.9). Increases have been greatest among African American, Hispanic American, and Native American children (Crawford et al., 2001). Although less information is available from other countries, increases in obesity in children also have been reported in England (Reilly & Dorosty, 1999) and are taking place in many other regions of the world if the reports of the rise of obesity for adults are any indication (Taubes, 1998).

KEY THEME
Sociocultural Influence

What are the reasons for this secular trend? Researchers have advanced various hypotheses. For example, compared with a generation ago, children spend more time in sedentary activities such as watching television. In general, children who watch more television per day have a higher BMI (Andersen et al., 1998; Robinson, 2001); the likelihood of becoming overweight is correlated with the number of hours

FIGURE 5.9 Trends in Overweight (BMI ≥ 95th Percentile): United States

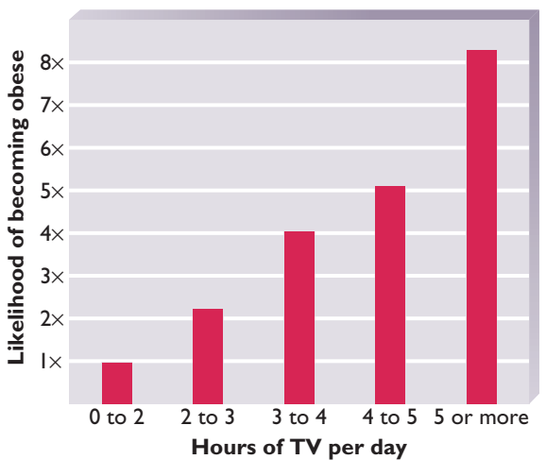
These data, collected from a series of studies carried out in the United States between 1963 and 1999, reveal the marked increase that has taken place in the number of children and adolescents who are considered obese. Some believe obesity has become a health epidemic in this and in other countries because of the dramatic change and accompanying health risks that are associated with being overweight.



Source: Centers for Disease Control and Prevention, 2002.

FIGURE 5.10
The Relationship Between Becoming Overweight and Hours of Television Viewing per Day

The more time children spend watching television each day, the more likely they are to be overweight. Ten- to fifteen-year-olds who were reported to watch more than five hours of television each day in 1990 were greater than eight times (8× in the figure) more likely to have become overweight (BMI greater than 85th percentile) between 1986 and 1990 than children who watched less than two hours each day. These findings provide powerful arguments for the view that obesity is increasing among children because they do not spend enough time engaging in physical activity or because the advertising messages on television encourage excessive food consumption.



Source: Adapted from Strauss, 1999. Data from Gortmaker et al., 1996.

children watch television, as can be seen in Figure 5.10. Perhaps an even greater influence stems from television advertising, which rarely promotes consumption of fresh fruits and vegetables over calorie-laden snack and convenience foods; consumption of these latter foods has gone up substantially over the last twenty-five years (Jahns, Siega-Riz, & Popkin, 2001). Although culture may attach a negative label to being overweight on the one hand, television may actively serve to promote it on the other.

In many cultures, the concern with being overweight seems to have contributed to another problem: efforts to initiate dieting, even by children who are within a normal weight range.

ATYPICAL DEVELOPMENT

Dieting and Eating Disorders

KEY THEME
Child's Active Role

In the United States, many young people, especially women, are dissatisfied with their weight. Concerns about becoming obese are expressed as early as age five (Feldman, Feldman, & Goodman, 1988). These concerns continue to be expressed among eight-year-olds from nearly all ethnic groups (Robinson et al., 2001), and various studies report that up to half of third-grade girls have attempted to diet (Strauss, 1999). In fact, more than 40 percent of high school women report that they are dieting (Centers for Disease Control, 1991), and as many as 75 percent indicate that they have attempted to lose five or more pounds at some time (Emmons, 1996). Similar percentages of girls have been found to be dieting in Australia, and the levels may be the same in many other countries (Paxton et al., 1991).

Repeated messages from fashion magazines, and perhaps from family and peers (that occasionally escalate to the level of teasing), stress the importance of slenderness for beauty and success and undoubtedly place enormous pressure even on preteenagers to control weight. During the adolescent years, girls believe it is increasingly important to have a boyfriend and to be physically attractive. Having dates, at least among Caucasian girls and African American girls whose mothers are more highly educated, is correlated with lower body fat, an indication that concern about weight has some basis in real experience (Halpern et al., 1999).

The large number of girls who attempt to diet has become an almost normative, although troubling, aspect of growing up in many cultures. Sometimes, however, young people initiate more drastic steps to encourage weight loss. For example, in one recent study nearly 10 percent of girls and 4 percent of boys in the sixth through eighth grades indicated they have resorted to vomiting or use of laxatives in their efforts to remain thin (Krowchuck et al., 1998). A substantial number of teenagers, especially girls, including many who are not obese, go to great and even life-threatening lengths to reduce their weight. Anorexia nervosa and bulimia nervosa are two self-initiated forms of extreme weight control efforts, disorders that affect perhaps as many as 3 percent of women in industrialized countries at some time during their lifetime (Walsh & Devlin, 1998). *Anorexia nervosa* is a kind of self-imposed starvation. Individuals with anorexia appear to be obsessed with the fear of appearing too heavy and as a consequence become dangerously thin. As weight loss becomes severe, muscle tissue degenerates, bone marrow changes, menstrual periods are disrupted in girls, and cardiac stress and arrhythmias can occur. *Bulimia nervosa* is an eating disorder in which the individual often engages in recurrent bouts of binge eating, sometimes consuming enormous quantities of high-calorie, easily digested food. For many, binge eating alternates with self-induced vomiting, actions sometimes accompanied by use of laxatives or diuretics. Although they share with anorexics an intense concern about their bodies, individuals suffering from bulimia often fall within a normal weight range for their age and height.

KEY THEME
Sociocultural Influence

A substantial increase in these disorders, particularly the more frequent of the two, bulimia, has been reported since the 1970s (Bryant-Waugh & Lask, 1995). Its incidence is greatest among Caucasian, middle- to upper-income young women (Harris, 1991), but both disorders appear to be increasing in males and in some cultural groups that have begun to adopt Western values. Their frequency may also be greater in certain groups, such as athletes and dancers, who are especially concerned about weight gain. Eating disorders may begin as part of the larger spectrum of anxieties children, adolescents, and young adults experience about physical changes, especially as they approach and continue through puberty (Keel, Fulkerson, & Leon,

1997). For some individuals, an inherited, biological susceptibility, particularly in cases of anorexia nervosa, may exist (Katzman et al., 2000). Because sociocultural, psychological, and biological factors appear to interact, it should not be surprising that the treatments most effective for dealing with such disorders have been difficult to identify. However, about two-thirds of individuals who display anorexia nervosa show good recovery if treatment is begun early (Herpetz-Dahlmann et al., 2001). Because eating disorders can have serious long-term consequences, individuals experiencing one of them should be strongly encouraged to seek professional help.

FOR YOUR REVIEW

- What are norms for growth? How do they provide information about whether physical growth is proceeding appropriately?
- What are the patterns of growth observed from infancy through adolescence? How do they differ for various parts of the body? How do they differ between individuals and ethnic groups? What evidence is there for secular trends in growth?
- Does growth always conform to the cephalocaudal and proximodistal principles of development?
- How do genetic factors, neural control, and hormonal variations affect growth? What are catch-up and lagging-down growth?
- What are the consequences of poor nutrition and social-emotional factors for growth? What are marasmus, kwashiorkor, and failure to thrive?
- What are the concerns about short stature and obesity in many cultures? What factors may be contributing to the increase in obesity observed in many Western nations?
- Why are dieting and eating disorders of concern, and what factors lead to such efforts to control weight?

Concerns about attractiveness, physical size, and especially weight become especially common among girls during adolescence. Repeated messages in fashion magazines and on television often portray unrealistic body shape and weight-control efforts.

Physical Maturity

Having learned about major advances in the brain, motor skills, and physical size, we can now turn to the many changes that signal the transition from childhood to adulthood. The growth spurt of early adolescence is only one of numerous indicators of approaching physical maturity. Accompanying the growth spurt are important progressions indicating sexual maturity. We briefly consider these and the psychological issues a young person may confront during the passage from late childhood to early adulthood.

Defining Maturity

Because rate and final level of growth vary so greatly among individuals and for different parts of the body, researchers have turned to other criteria to define physical maturity. One reliable indicator is **skeletal maturity,** the extent to which *ossification,* the chemical transformation of cartilage into bony tissue, has been completed. The change begins prenatally about the eighth week after conception, when cartilage in the ribs and in the center of the long bones of the arms and legs is transformed. The process continues into late adolescence or early adulthood, when bones in the wrist and ankle are finally completely formed. Although skeletal maturity has become the standard for defining the end of physical growth, other, visible markers of approaching maturity appear just before and during the adolescent years. These important markers comprise a series of events associated with **puberty,** the developmental milestone reached when a young person gains the ability to reproduce.

KEY THEME
Continuity/Discontinuity

During puberty, the *primary sexual organs*—testes and penis in males; vagina, uterus, and ovaries in females—enlarge and become capable of functioning. *Secondary sexual characteristics* that distinguish men from women, such as facial hair or breasts, also mature. Boys take on a more muscular and angular look as shoulders widen and the fat tissue of childhood is replaced with muscle. Girls' hips broaden, a change especially adaptive to bearing children. Girls also tend to retain a higher proportion of fat to muscle tissue and assume a more rounded appearance overall than boys.

KEY THEME
Individual Differences

Like the growth spurt, the timing of each of the many events associated with puberty differs enormously from one young person to another. As a rule, however, this cluster of characteristics tends to appear somewhat earlier in girls than in boys. The Adolescent Sexual Development chronology summarizes the approximate ages at which many of the developmental changes typically associated with the adolescent years take place for girls and boys growing up in North America and Europe.

Although there are numerous indicators of increasing sexual maturity, perhaps none are more significant than **menarche,** the first menstrual period in females, and **spermarche,** the occurrence of the first ejaculation of sperm in males. Menarche typically takes place between about twelve and thirteen years of age for females and spermarche between thirteen and fourteen years of age in males. However, as with other indicators of puberty, their initial appearance varies considerably from one individual to the next. For example, in the United States, the events accompanying sexual maturity begin somewhat earlier in African American girls than in Caucasian American girls (Biro et al., 2001).

What triggers these remarkable changes? The brain, including the hypothalamus and pituitary gland, and various hormones are centrally involved. *Adrenarche* initiates many of the changes taking place during early adolescence (McClintock & Herdt, 1996). Adrenarche refers to the maturation of the adrenal glands, small glands located above the kidneys. These glands release hormones important for the growth spurt and the emergence of underarm and pubic hair in girls. In addition, adrenarche may play an important role in the emergence of sexual attraction, which Martha McClintock and Gilbert Herdt (1996) argue typically occurs as early as ten years of age. In girls the hypothalamus may monitor metabolic cues associated with body size or the ratio of fat to muscle, because body mass index appears to be a good, although not the only, predictor of onset of menarche (Kaplowitz et al., 2001).

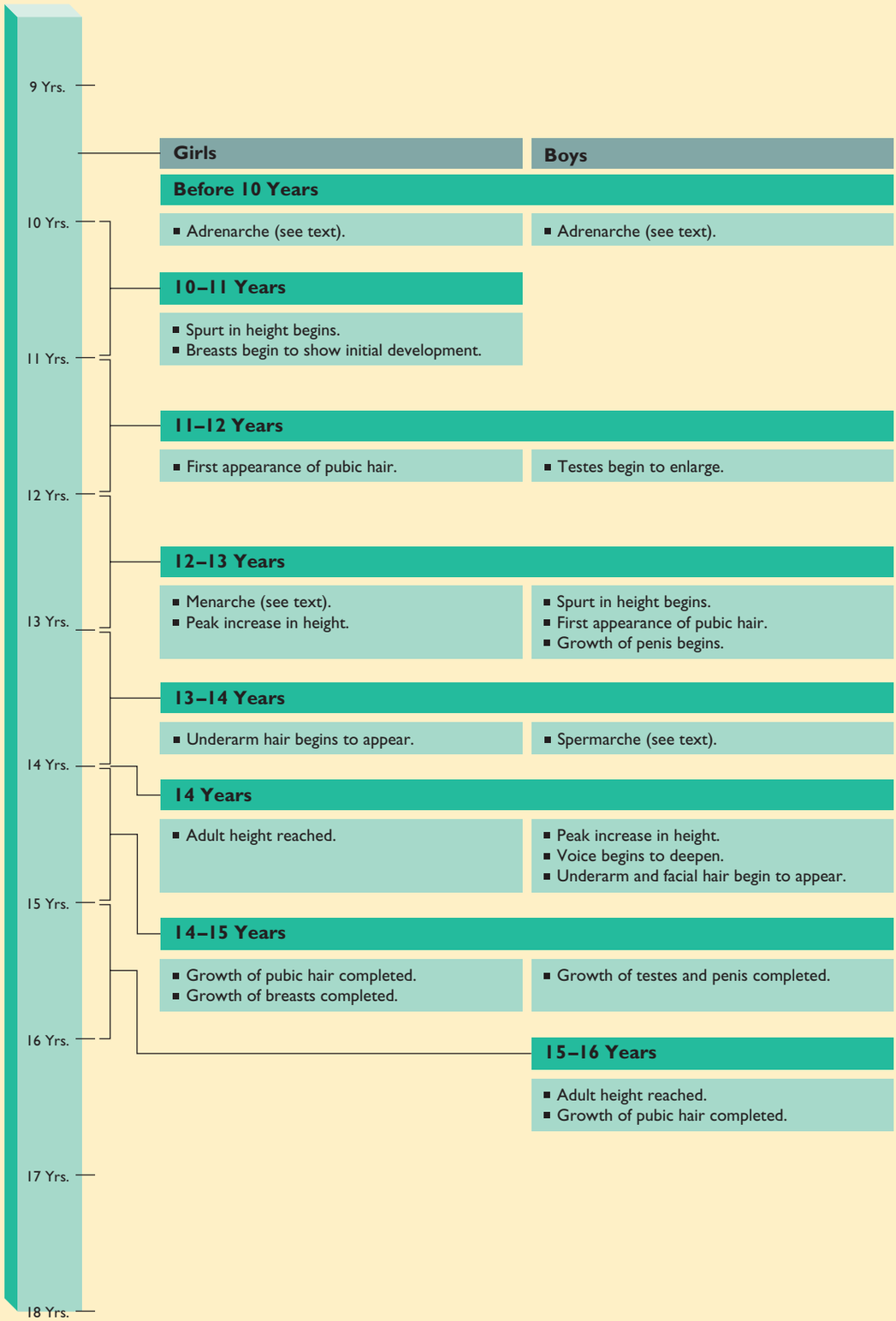
skeletal maturity Extent to which cartilage has ossified to form bone; provides the most accurate estimate of how much additional growth will take place in the individual.

puberty Developmental period during which a sequence of physical changes takes place that transforms the person from an immature individual to one capable of reproduction.

menarche First occurrence of menstruation.

spermarche The first ejaculation of sperm by males entering puberty.

CHRONOLOGY: *Adolescent Sexual Development*



Sources: Malina & Bouchard, 1991; McClintock & Herdt, 1996; Tanner, 1990.

These ages are typical for individuals reared in the United States and many other Western nations. However, considerable individual differences exist in the ages at which these various developmental changes occur.

Still other *gonadotropic* (gonad-seeking) hormones released by the pituitary gland stimulate, in the case of females, the production of estrogen and progesterone by the ovaries and regulate the menstrual cycle. Estrogen promotes the development of the breasts, uterus, and vagina, as well as the broadening of the pelvis. Even family relationships, such as greater stress in the family, which can affect hormonal balances, may accelerate female development (Ellis & Garber, 2000). In the case of males, gonadotropic hormones contribute to the production of sperm and elevate the production of testosterone by the testes. Testosterone, in turn, promotes further growth in height, an increase in size of the penis and testes, and the appearance of secondary sexual characteristics such as pubic and facial hair.

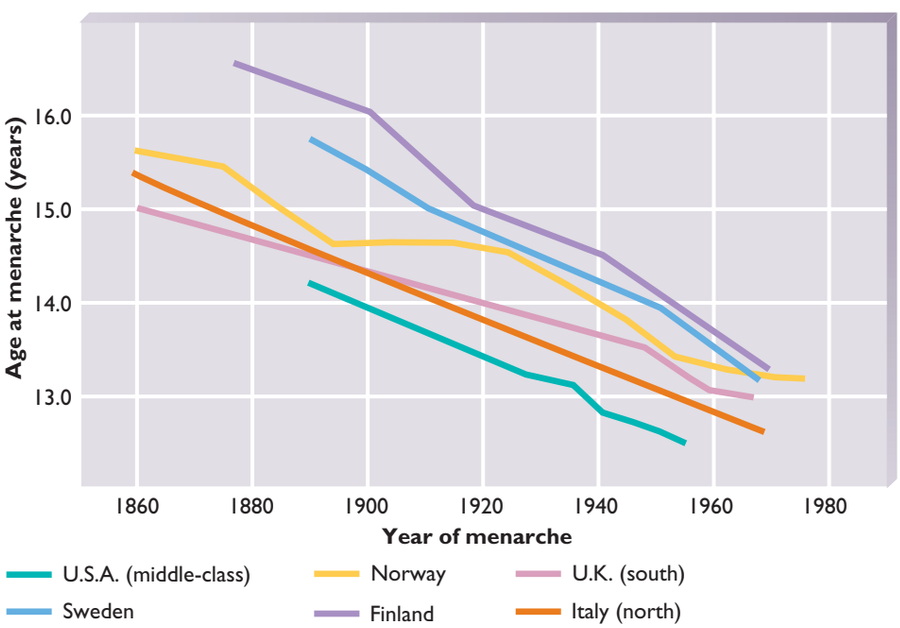
Early Versus Late Maturity

KEY THEME
Individual Differences

Today adult height in most industrialized societies is typically reached by about age seventeen; a century ago, it often was not achieved until about age twenty-three (Rallison, 1986). Changes in the age of menarche reveal a similar trend toward increasingly early occurrences over recent generations (see Figure 5.11). The secular changes stem from improved socioeconomic conditions, including more adequate nutrition. Do the individual differences that are a part of this transition affect socioemotional development? The answer appears to be yes. For example, girls who are unprepared for menarche, either due to lack of information or because of its early onset, perceive the event more negatively than other girls, whose reactions are often a mixture of positive and negative feelings (Koff & Rierdan, 1995; Ruble & Brooks-Gunn, 1982). Thanks to greater communication within the family, including emotional support and assurance that menstruation is normal and healthy, girls' reactions to menarche today seem more positive (Brooks-Gunn & Ruble, 1980; Koff & Rierdan, 1995).

KEY THEME
Interaction Among Domains

The limited research conducted with boys suggests that they are often uninformed, surprised, and confused about spermarche (Stein & Reiser, 1994). For many boys, sex education classes may either fail to explain what they need to know or are provided too late to prepare them. Their feelings about the event are mixed, and they seldom talk about it with others (Gaddis & Brooks-Gunn, 1985; Stein & Reiser, 1994). Nevertheless, early maturity seems to have positive aspects for boys (Alsaker, 1992; Petersen, 1988). Compared with early maturers, late-maturing boys report



Source: Adapted from Tanner, 1990.

FIGURE 5.11
Secular Trends in the Age of Menarche

Evidence exists for a secular trend in the decrease in age of the onset of menarche from 1845 through 1960. Although most of the data were obtained by questioning adolescents and young adults, some, especially those from earlier generations, depended on the memories of older individuals.

more negative feelings about themselves, feel more rejected, express stronger dependency and affiliative needs, and are more rebellious toward their parents (Mussen & Jones, 1957). Although late maturers want to be well liked and accepted, their efforts to obtain social approval often translate into attention-getting, compensatory, and childish behaviors disruptive to success with peers and adults (Mussen & Jones, 1958). The differences continue to be observed even into adulthood (Jones, 1965).

What are girls' reactions to early and late maturity? Here the picture differs (Alsaker, 1992; Greif & Ulman, 1982; Simmons, Blyth, & McKinney, 1983). Early maturity may enhance status and prestige for girls just as for boys, but it can also be embarrassing; decrease their popularity, at least among agemates; and lead to greater social pressure and expectations from older friends, parents, and other adults to conform to more mature behavior patterns (Brooks-Gunn, 1989). In research carried out in Sweden, girls who reached menarche early were more likely than late-maturing girls to engage in a variety of norm-breaking activities, such as staying out late, cheating on exams, pilfering, or using alcohol (Magnusson, Stattin, & Allen, 1986). Early maturing girls preferred older and more mature friends who may have inspired their greater independence from socially approved conventions of behavior. Indeed, among those maturing early but reporting no older friends, the frequency of norm-breaking activities was about the same as for girls who matured later.

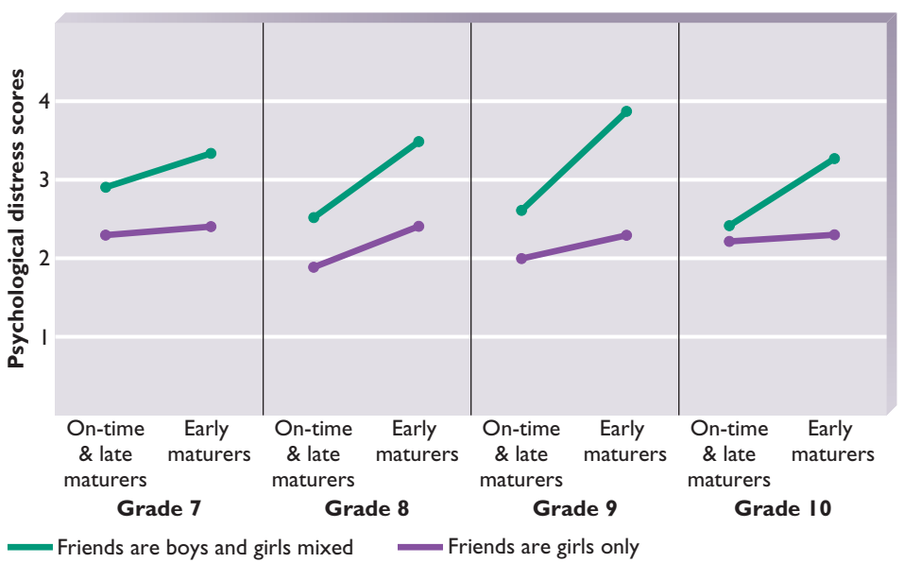
As they grew older, early maturers with and without older friends began to look more alike in their frequency of many norm-breaking activities, and late maturers began to engage in such activities as use of alcohol as often as early maturers. Still, a few unacceptable behaviors, such as the use of drugs, remained higher throughout adolescence among early-maturing than among late-maturing girls. As illustrated in Figure 5.12, another important component of girls' responses to early maturity appears to be whether their group of friends includes only other girls or also boys (Ge, Conger, & Elder, 1996). Early-maturing girls growing up in a rural area of the United States reported that they felt somewhat more stress than their on-time or late-maturing counterparts. They continued to report this greater stress over several years but particularly if their friends included boys. Although peer influences may be a factor in norm-breaking, other changes taking place within the family, including less careful monitoring by parents, may contribute as well (Dick et al., 2000).

KEY THEME
Sociocultural Influence

Some of the negative consequences of early maturity for females may also spring from the cultural ideals of beauty and maturity that exist in most Western societies. Slenderness and long legs are considered desirable traits in women. Although initially

FIGURE 5.12
Psychological Distress Reported by Early-, On-Time, and Late-Maturing Girls as a Function of Sex Composition of Their Friends

In general, early-maturing girls report somewhat greater stress than girls who mature late or on time. However, this increased stress in early maturers is especially evident when their group of friends includes boys, as well as girls. Early-maturing girls undergoing greater stress may initiate friendships that include boys, which continue to heighten their concerns throughout the adolescent years.



Source: Ge, Conger, & Elder, 1996.

taller than their peers during the growth spurt, early-maturing girls have less opportunity to grow tall and often end up somewhat shorter, heavier, and more robust than their later-maturing peers (Biro et al., 2001). Not surprisingly, early-maturing girls are therefore initially less satisfied with their weight and appearance than late-maturing girls (Williams & Currie, 2000). Personality disturbances such as depression are also slightly more frequent among girls who mature early (Stice, Presnell, & Bearman, 2001). In contrast, early-maturing boys more quickly assume the rugged, muscular physique stereotypically portrayed in American society as ideal for men and are more pleased by their weight and appearance than late-maturing boys (Petersen, 1988).

Girls who mature early and boys who mature late are also out of step with most of their classmates. Young people usually prefer friends who share interests, and interests change with increasing maturity. Late-maturing boys may find that their peers move on to other pursuits, making it more difficult to maintain positive relationships with their friends. Early-maturing girls may redirect friendships to older peers and boys. But this desire can be a problem, because it can contribute to increased behavior and school problems and greater personal unhappiness caused by pressures to conform to the interests of these older peers or boys. In other words, biological, immediate social, and broader cultural factors combine to help define the consequences of early and late maturity.

Sexual Behavior

KEY THEME
Child's Active Role

Few changes accompanying puberty are as contentious in many families as the increased sexuality that attends physical maturity. Anthropological research indicates that the majority of cultures are likely to permit or at least tolerate some sexual activity during the teen years. But Western societies have generally been more restrictive in its expression (Schlegel & Barry, 1991). Many mothers in the United States tend to underestimate the extent of sexual activity among their offspring; their children, in turn, tend to underestimate the degree to which their mothers disapprove of this activity (Jaccard, Dittus, & Gordon, 1998). Nevertheless, large numbers of teenagers are sexually active, and at young ages. To further illustrate this point, 30 percent of students entering sixth grade (averaging 11.7 years of age) in impoverished areas of one major city in the United States report that they have engaged in sexual intercourse (Kinsman et al., 1998). Levels of sexual activity similar to those found in the United States are often reported in other Western nations (Newcomer & Baldwin, 1992).

KEY THEME
Individual Differences

What factors play a role in whether a teenager will engage in sexual activity? Several different family variables seem to be instrumental, according to a recent review by Brent Miller, Brad Benson, and Kevin Galbraith (2001). One especially important parameter is how the members of the family "connect" with each other. More specifically, when parents are warm and supportive of their children, that is, seem to be close and responsive to them, teenagers are more likely to remain sexually abstinent until somewhat older. Additionally, a similar outcome occurs when parents maintain relatively closer supervision and monitoring of their children's behavior, although evidence exists that there is a limit to this factor; when parents become intrusive and overcontrolling, sexual activity may be started somewhat earlier by their offspring. Not surprisingly, another important factor is the values the parents hold concerning the appropriateness of sexual activity among teenagers. On the other hand, research on the extent to which parents communicate with their sons and daughters about sexual issues does not appear to be related to the timing in which sexual activity is initiated. However, few studies have examined when such communications begin; information about this subject may often be initiated by parents only after they become aware that their children are sexually active.

Other contextual variables associated with the family also are related to sexual activity. In general, children in families living in neighborhoods in which there is greater poverty, higher crime rates, and less stability—factors that are generally correlated with lower education and income—tend to engage in earlier onset of sexual activity. Children of single parents are more likely to initiate sexual behavior earlier,

and so are children who are growing up in abusive family environments or who have older teenage siblings who are already parents (East & Jacobson, 2001).

Aside from the moral and ethical issues that adolescent sexual behavior raises, there are important health and social consequences. Among the most frequent concerns are sexually transmitted diseases (STDs), teenage pregnancy, and the tendency of teenage parents to drop out of school. Adolescents appear to be more susceptible than adults to STDs, and an estimated 3 million are infected each year by one of these diseases—a number that has spread considerable alarm among members of the medical profession (Eng & Butler, 1997; McIlhaney, 2000). In the 1980s approximately 20 percent of unmarried American women of European heritage eighteen years or younger and 40 percent of African heritage became pregnant during their adolescent years (Furstenberg, Brooks-Gunn, & Chase-Lansdale, 1989). The rate of teen pregnancy has shown some decline throughout the 1990s but still remains far higher in the United States than in other technologically advanced countries. Moreover, approximately 300,000 of the nearly half million teenage women delivering their first child and 75 percent of all adolescents giving birth to a child each year will remain unmarried, a substantial increase from 40 years ago when only 15 percent who gave birth were unmarried (Allen et al., 1997; Coley & Chase-Lansdale, 1998). Only about half of these women will finish high school (Hotz, McElroy, & Sanders, 1997). Moreover, their children will often have difficulty when they begin school (Brooks-Gunn & Chase-Lansdale, 1995).

Controversy: Thinking It Over

What Should Sex Education Programs Emphasize?

Because of the risks associated with sexual activity, such as pregnancy and contracting AIDS or other STDs, many individuals working with elementary, junior high, and high school students in the United States and other countries around the world have argued that young people need to be better educated about their sexuality.

What Is the Controversy?

Nearly everyone agrees that sex education should begin in the home at a young age, taught by parents. Moreover, parents generally wish to see instruction about sexuality provided in the schools (Henry J. Kaiser Family Foundation, 2000). For example, it is not unusual to find that about 80 percent of adults in the United States believe that sex education is appropriate, and, when given the opportunity, only a small proportion of parents ask to have their children excused from sex education classes (Fine, 1988). In fact, sex education is either required or recommended in all states today and in most other countries in which formal education is offered. But beyond that, much less accord exists about sex education and, in particular, on what the focus of the instructional content should be, especially in the United States. Should the emphasis be on encouraging young people to abstain from sexual relationships until they are married? Or should sex education in the schools attempt to promote the acquisition of skills to handle maturely the complexities and consequences of interpersonal relationships and provide clear information and access to resources that will help young people to think clearly about and be comfortable with their emerging sexuality?

What Are the Opposing Arguments?

From the perspective of some, the only effective way for teenagers to avoid the potentially negative outcomes associated with sexual relationships is to abstain from them. Harmful consequences, both psychological and physical, are the inevitable result of such premature activity. Moreover, to promote anything other than abstinence in sex education classes sends a mixed message that communicates a double standard: "Avoid sexual relationships, but in case you can't, here is what you should know."

To others, however, a message that focuses only on abstinence ignores the fact that many teenagers are already engaging in sexual relationships. In fact, somewhere between 800,000 and 900,000 adolescent girls less than nineteen years of age will become pregnant each year in the United States alone, and about half of them can be expected to deliver babies (Centers for Disease Control, 2000). The number who are sexually active is substantially higher. Youths need information on the best ways to avoid pressure to initiate sexual activity and to prevent becoming infected with sexually transmitted diseases and becoming pregnant. Thus a more balanced perspective is to encourage postponing sexual involvement but, for those already involved or likely to initiate it, to emphasize engaging in it responsibly and safely.

What Answers Exist? What Questions Remain?

Tests of the effectiveness of various sex education curricula have yielded mixed results, although some success has been reported. Knowledge of sexuality typically increases, but young people do not consistently report that they are involved in fewer sexual relationships or practice sex more responsibly or safely after exposure to many of these programs. Moreover, little evidence exists to indicate that abstinence-only programs are any more effective than other programs in reducing initiation into sexual activity or risky behaviors associated with it. Rarely have sex education programs been found to lead to an increase in sexual activity, another fear that is occasionally expressed (Grunseit et al., 1997). Nevertheless, some types of programs seem to hold considerable promise for delaying the onset of sexual activity or in reducing the number of partners, unplanned pregnancies, or rate of sexually transmitted diseases (Franklin et al., 1997; Grunseit et al., 1997; Kirby, 1997). One example is Teen Outreach. This program is designed to involve high schoolers in voluntary community service and encourages them to reflect on the normative tasks of adolescence, such as career goals and appropriate social relationships; only a small component of the curriculum is geared to sex education. Students participating in it, however, displayed a significant decline in pregnancy and other school-related problems compared with other students who did not participate (Allen et al., 1997). What makes this or other sex education programs more effective? At the present time, the essential ingredients are unknown. In that many young people are already sexually active before they participate in sex education classes, do programs need to be offered at earlier ages? Should the curricula include emphasis on more than the biology of reproduction? For example, could young people benefit from learning the social skills needed to respond to the many pressures they face to engage in sexual relationships? Have programs stressing abstinence, which for the most part have only recently gained widespread adoption, not been in schools long enough to prove themselves? Or are these programs too biased and narrow in their focus, often emphasizing fear instead of knowledge, extolling a simplistic solution to a complex problem that can have life-and-death consequences? What do you think is required for a successful program?

FOR YOUR REVIEW

- How is maturity defined?
- What are the developmental changes that accompany puberty?
- What are the social and behavior consequences of early and late maturity for males and females?
- What factors are related to sexual behavior in adolescents? What are the health implications of such behavior?
- What are the controversies associated with sex education programs in the public schools?

CHAPTER RECAP

Summary of Developmental Themes

Nature/Nurture *What roles do nature and nurture play in brain, motor skill, and physical development?*

Brain development, the acquisition of motor skills, and physical growth are the product of complex systems influenced by both biology and experience. Biological processes, both genetic and hormonal, augment the proliferation and migration of neurons, events associated with the development of motor skills and growth. At the same time, the transformation from relatively immature infant to increasingly competent child and adolescent is affected by experience and the many different forms of influence caregivers provide. Important stimulation ranges from providing adequate emotional, social, and nutritional support for physical growth to practice and training in encouraging the acquisition of motor skills and talents.

Sociocultural Influence *How does the sociocultural context influence brain, motor skill, and physical development?*

Motor skill and physical growth are embedded within settings, resources, and beliefs promoted by the society in which the child lives. For example, the extent to which a culture encourages specific skills, from the acquisition of motor milestones to skilled athletic ability, or values a particular physical attribute, such as being slender, affects the efforts of children to display these qualities. Knowledge of nutrition, views about physical appearance, and the availability of leisure time, as well as educational practices, have produced changing secular trends for many aspects of development, including growth in height, prevalence of obesity, and onset of menarche.

Child's Active Role *How does the child play an active role in the process of brain, motor skill, and physical development?*

Babies seem to be intrinsically motivated to exercise rudimentary motor skills. Once a child attains locomotion or other skills, she or he provokes new reactions from caregivers that may include being denied access to cupboards and light sockets or being prevented from pouncing on the usually patient family dog. New physical competencies may also be exercised to improve their speed, accuracy, and efficiency. From these efforts can emerge expertise that fuels further progress in athletic, artistic, and other endeavors. Rapid growth or early maturity may affect not only the child's interests but also the expectations and reactions of others. Excessive concerns about weight, for example, and the emergence of sexual maturity may influence the kinds of interactions in which the child or adolescent engages both within and outside the home, interactions that can have dramatic consequences for future development.

Continuity/Discontinuity *Are brain, motor skill, and physical development continuous or discontinuous?*

Brain development, the acquisition of motor skills, and physical development show spurts at certain times in development. The patterns often give rise to conceptions of stagelike development. But even dramatic changes such as those exhibited in attaining motor milestones in infancy or during the pubertal changes of adolescence are grounded in processes undergoing continuous transformations. Small, incremental changes in the relative strength of muscles or production of hormones, for example, may initiate substantive dynamic reorganizations in complex systems of behavior. Physical and skill changes observed in children may bring about dramatic reactions from others that are interpreted as stagelike.

Individual Differences *How prominent are individual differences in brain, motor skill, and physical development?*

Individual differences are a hallmark of motor skill development and physical growth. Variations may arise from biological or experiential factors that can limit or augment development and physical growth. The differences can significantly influence the child and the reactions of others, as early or late maturity or precocious or delayed skill acquisition demonstrates. Individual differences are pervasive and readily apparent, and an important aspect of behavior to be appreciated as well as explained.

Interaction Among Domains *How do brain, motor skill, and physical development interact with other domains of development?*

A child's physical size and weight, as well as improvements in the execution and coordination of motor skills, have dramatic influences on the responses and expectations of caregivers, peers, and others and, in turn, on how the child feels about his or her body and abilities. For example, once capable of walking, the child has a greater ability to initiate independence, which may lead parents to grant more freedoms and at the same time demand more responsibilities. Similarly, the young adolescent's status with peers is often influenced by signs of his or her physically maturing body and other aspects of physical stature, coordination, and skill. These qualities are evaluated by others and influence the child's evaluation of self.

Summary of Topics

The Brain and Nervous System

- New methodologies to investigate the brain, including positron emission tomography (PET), functional magnetic resonance imaging (fMRI), and recording of event-related potentials, have recently promoted widespread attention to the brain and its development.

The Developing Brain

- Brain growth proceeds rapidly during the fetal and early postnatal period. Much of *neuron* proliferation and migration to various regions of the brain occurs before birth; however, extensive neuron differentiation continues throughout the first few years after birth. New neuron formation, as well as their continued differentiation, may take place into adulthood.
- *Glial cell* formation, *myelination,* and the operation and organization of nervous system networks also begin prenatally and continue after birth.

Plasticity in Brain Development

- The unspecialized nature of early neurons permits the brain to exhibit considerable *plasticity*; various regions of the brain take on different functions should injury occur to regions that normally process that information.
- Neuron differentiation may proceed at critical or sensitive times for experience-expectant information but occurs throughout development for experience-dependent information.

Brain Lateralization

- Infants display behaviors suggestive of hemispheric specialization, or *lateralization,* at birth. However, both hemispheres may have equal potential for higher order processing of information.

Motor Skill Development

- Two complementary patterns, differentiation—the substitution of global, diffuse actions with more refined skills—and integration—the emergence of increasingly coordinated actions—characterize the major dimensions of change in the development of motor skills.

The First Actions: Reflexes

- *Reflexes*, involuntary responses to stimulation controlled by subcortical processes, are among the earliest motor actions displayed in newborns. Primitive reflexes help to increase the likelihood of survival, whereas postural reflexes help the infant to maintain a specific orientation in his or her environment.
- Failure to integrate higher order voluntary and lower order brain reflex mechanisms that control breathing may be one factor contributing to *sudden infant death syndrome (SIDS)*. Parents can take a number of steps to reduce SIDS, including placing the infant on his or her back for sleeping, avoiding smoking in the infant's presence, providing firm bedding, ensuring adequate ventilation, and preventing the infant from becoming overheated.

Motor Milestones

- *Rhythmical stereotypies*, repeated motor actions with no apparent goal, are among the earliest organized motor behaviors displayed by infants.
- Postural, locomotor, and manual control undergo regular patterns of development. The *cephalocaudal principle* highlights the fact that regions nearer the head tend to undergo more rapid development than regions farther away from the head.

Motor Skills in the Preschool and Later-Childhood Years

- Throughout infancy and childhood, motor skills become more efficient, more coordinated, and more powerful and reveal an increase in balance, speed, and agility when being performed.

Determinants of Motor Development

- Genetic preadaptation may contribute to the emergence of motor skills, but research indicates that experience can be important as well.

Cross-Cultural Differences

- Some societies promote the acquisition of basic motor skills, and, as a consequence, such skills often appear somewhat earlier among infants and very young children in those societies.

Body Growth and Development

- The term *grow* essentially applies to the increase in size of the body or its organs. *Grow* and *develop* are often used interchangeably; however, the latter refers not only to changes in size but also to any orderly pattern of change.

Norms of Growth

- *Norms* derived from measurements carried out on a large sample of individuals within a population provide an estimate of the range of what is considered typical in development. Growth norms reveal rapid height and weight just before and after birth, much slower but regular increases in size beginning at about two years of age, and a final growth spurt before or during early adolescence in most humans.

Patterns in Body Growth

- Some regions of the body, for example, the head, do not show the typical pattern of continued growth during childhood and into adolescence. Regions nearer the center of the body also tend to develop somewhat sooner than regions more peripheral, a reflection of the principle of *proximodistal development.*

Determinants of Body Growth and Development

- Biological factors help to regulate physical development. Cells in the hypothalamus may determine whether growth is proceeding according to genetic instructions. *Catch-up growth*, the tendency for the rate of growth to increase for a period of time after disease or illness, and *lagging-down growth*, the tendency for it to decrease for a period of time after rapid gains, suggest a template in the brain for growth.
- Human growth hormone interacts in complex ways with other hormones to influence growth. Nutrition and disease are key factors affecting growth as well.
- Some children display *failure to thrive* because of inability to process or take in sufficient nutrients to grow normally as a result of social and emotional factors.
- Improved nutrition and prevention of disease have yielded a *secular trend* of increased height in humans in many regions of the world over the past several centuries.

The Social-Emotional Consequences of Body Growth

- Although children, especially boys, prefer being tall, little evidence exists to indicate that those who develop normally but who are constitutionally small are seriously disadvantaged. Nevertheless, parents of children with short stature often request synthetic growth hormone for their children despite lack of evidence that it provides long-term benefits in terms of height.
- Being overweight in today's society typically has negative connotations for children. The numbers of children and adolescents who are obese has shown a dramatic increase over the past several decades. The reasons may include a more sedentary lifestyle, as well as the increasing availability of calorie-laden convenience foods and drinks.
- Control of weight by efforts to diet are frequently reported among children. Of additional concern is the increased number of individuals, especially girls, who display eating disorders such as anorexia nervosa and bulimia.

Physical Maturity

- The growth spurt associated with early adolescence is only one of many indicators of the transition from childhood to adulthood.

Defining Maturity

- Maturity is defined not by size but by ossification of bone material, or *skeletal maturity*. *Puberty* is defined as the period during which the individual gains the ability to reproduce. *Menarche,* or the first occurrence of menstruation, and *spermarche,* the initial occurrence of ejaculation of sperm, signal the ability to reproduce in females and males, respectively.
- Many signs of approaching sexual maturity, including the adolescent growth spurt, begin earlier in girls than in boys.

Early Versus Late Maturity

- Boys seem to benefit from early maturity, but the consequences for girls are less positive. The different consequences may stem from the reactions and pressures of peers and perceived cultural values regarding body size and shape.

Sexual Behavior

- Among the factors that seem to be related to whether youth engage in sexual behavior appear to be the "connectedness" they feel with their families, the extent to which they are supervised, and the attitudes their parents hold with respect to such activity. Fewer resources in the family, as well as the presence of an older teenage sibling who is already a parent, also are associated with increased sexual activity in young people.
- Health concerns associated with sexual activity among young people include substantial increases in the incidence of sexually transmitted diseases and pregnancy. Although the number of teenagers giving birth to children in the United States has shown some decline over the past decade, it still remains higher than in virtually all other Western societies.
- The effectiveness of various kinds of education programs designed to reduce the risk associated with sexual activity among young people remains uncertain.