Encouraged and supported by his mother, a baby takes his first steps and experiences the physical potential of his growing body. During the first year, infants grow rapidly, move on their own, increasingly investigate their surroundings, and make sense of complex sights and sounds.
On a brilliant June morning, 16-month-old Caitlin emerged from her front door, ready for the short drive to the child-care home where she spent her weekdays while her mother, Carolyn, and her father, David, worked. Clutching a teddy bear in one hand and her mother’s arm with the other, Caitlin descended the steps. “One! Two! Threeee!” Carolyn counted as she helped Caitlin down. “How much she’s changed!” Carolyn thought to herself, looking at the child who, not long ago, had been a newborn. With her first steps, Caitlin had passed from infancy to toddlerhood—a period spanning the second year of life. At first, Caitlin did, indeed, “toddle” with an awkward gait, tipping over frequently. But her face reflected the thrill of conquering a new skill.

As they walked toward the car, Carolyn and Caitlin spotted 3-year-old Eli and his father, Kevin, in the neighboring yard. Eli dashed toward them, waving a bright yellow envelope. Carolyn bent down to open the envelope and took out a card. It read, “Announcing the arrival of Grace Ann. Born: Cambodia. Age: 16 months.” Carolyn turned toward Kevin and Eli. “That’s wonderful news! When can we see her?”

“Let’s wait a few days,” Kevin suggested. “Monica’s taken Grace to the doctor this morning. She’s underweight and malnourished.” Kevin described Monica’s first night with Grace in a hotel room in Phnom Penh. Grace lay on the bed, withdrawn and fearful. Eventually she fell asleep, gripping crackers in both hands.

Carolyn felt Caitlin’s impatient tug at her sleeve. Off they drove to child care, where Vanessa had just dropped off her 18-month-old son, Timmy. Within moments, Caitlin and Timmy were in the sandbox, shoveling sand into plastic cups and buckets with the help of their caregiver, Ginette.

A few weeks later, Grace joined Caitlin and Timmy at Ginette’s child-care home. Although still unable to crawl or walk, she had grown taller and heavier, and her sad, vacant gaze had given way to an alert expression, a ready smile, and an enthusiastic desire to imitate and explore. When Caitlin headed for the sandbox, Grace stretched out her arms, asking Ginette to carry her there, too. Soon Grace was pulling herself up at every opportunity. Finally, at age 18 months, she walked!

This chapter traces physical growth during the first two years—one of the most remarkable and busiest times of development. We will see how rapid changes in the infant’s body and brain support learning, motor skills, and perceptual capacities. Caitlin, Grace, and Timmy will join us along the way to illustrate individual differences and environmental influences on physical development.

Body Growth

TAKE A MOMENT... The next time you’re walking in your neighborhood park or at the mall, note the contrast between infants’ and toddlers’ physical capabilities. One reason for the vast changes in what children can do over the first two years is that their bodies change enormously—faster than at any other time after birth.

Changes in Body Size and Muscle–Fat Makeup

By the end of the first year a typical infant’s height is about 32 inches—more than 50 percent greater than at birth. By 2 years, it is 75 percent greater (36 inches).
Similarly, by 5 months of age, birth weight has doubled, to about 15 pounds. At 1 year it has tripled, to 22 pounds, and at 2 years it has quadrupled, to about 30 pounds.

Figure 5.1 illustrates this dramatic increase in body size. But rather than making steady gains, infants and toddlers grow in little spurts. In one study, children who were followed over the first 21 months of life went for periods of 7 to 63 days with no growth, then added as much as half an inch in a 24-hour period! Almost always, parents described their babies as irritable, very hungry, and sleeping more on the days before a spurt (Lampl, 1993; Lampl & Johnson, 2011).

One of the most obvious changes in infants’ appearance is their transformation into round, plump babies by the middle of the first year. This early rise in “baby fat,” which peaks at about 9 months, helps the infant maintain a constant body temperature. In the second year, most toddlers slim down, a trend that continues into middle childhood (Fomon & Nelson, 2002). In contrast, muscle tissue increases very slowly during infancy and will not reach a peak until adolescence. Babies are not very muscular; their strength and physical coordination are limited.

**FIGURE 5.1 Body growth during the first two years.** These photos depict the dramatic changes in body size and proportions during infancy and toddlerhood in two children—a boy, Shanwel, and a girl, Mai. In the first year, the head is quite large in proportion to the rest of the body, and height and weight gain are especially rapid. During the second year, the lower portion of the body catches up. Notice, also, how both children added “baby fat” in the early months of life and then slimmed down, a trend that continues into middle childhood.
Changes in Body Proportions

As the child's overall size increases, parts of the body grow at different rates. Two growth patterns describe these changes. The first is the cephalocaudal trend—from the Latin for “head to tail.” During the prenatal period, the head develops more rapidly than the lower part of the body. At birth, the head takes up one-fourth of total body length, the legs only one-third. Notice how, in Figure 5.1, the lower portion of the body catches up. By age 2, the head accounts for only one-fifth and the legs for nearly one-half of total body length.

In the second pattern, the proximodistal trend, growth proceeds, literally, from “near to far”—from the center of the body outward. In the prenatal period, the head, chest, and trunk grow first; then the arms and legs; and finally the hands and feet. During infancy and childhood, the arms and legs continue to grow somewhat ahead of the hands and feet.

Individual and Group Differences

In infancy, girls are slightly shorter and lighter than boys, with a higher ratio of fat to muscle. These small sex differences persist throughout early and middle childhood and are greatly magnified at adolescence. Ethnic differences in body size are apparent as well. Grace was below the growth norms (height and weight averages for children her age). Early malnutrition played a part, but even after substantial catch-up, Grace—as is typical for Asian children—remained below North American norms. In contrast, Timmy is slightly above average in size, as African-American children tend to be (Bogin, 2001).

Children of the same age differ in rate of physical growth; some make faster progress toward mature body size than others. But current body size is not enough to tell us how quickly a child’s physical growth is moving along. Although Timmy is larger and heavier than Caitlin and Grace, he is not physically more mature. In a moment, you will see why.

The best estimate of a child’s physical maturity is skeletal age, a measure of bone development. It is determined by X-raying the long bones of the body to see the extent to which soft, pliable cartilage has hardened into bone, a gradual process that is completed in adolescence. When skeletal ages are examined, African-American children tend to be slightly ahead of Caucasian-American children in skeletal age. And girls are considerably ahead of boys—the reason Timmy’s skeletal age lags behind that of Caitlin and Grace. At birth, the sexes differ by about 4 to 6 weeks, a gap that widens over infancy and childhood (Tanner, Healy, & Cameron, 2001). Girls are advanced in development of other organs as well. This greater physical maturity may contribute to girls’ greater resistance to harmful environmental influences. As noted in Chapter 2, girls experience fewer developmental problems than boys and have lower infant and childhood mortality rates.

Brain Development

At birth, the brain is nearer to its adult size than any other physical structure, and it continues to develop at an astounding pace throughout infancy and toddlerhood. We can best understand brain growth by looking at it from two vantage points: (1) the microscopic level of individual brain cells and (2) the larger level of the cerebral cortex, the most complex brain structure and the one responsible for the highly developed intelligence of our species.

Development of Neurons

The human brain has 100 to 200 billion neurons, or nerve cells, that store and transmit information, many of which have thousands of direct connections with other neurons. Unlike other body cells, neurons are not tightly packed together. Between them are tiny gaps, or synapses, where fibers from different neurons come close together but do not touch (see Figure 5.2 on page 162). Neurons send messages to one another by releasing chemicals called neurotransmitters, which cross the synapse.
The basic story of brain growth concerns how neurons develop and form this elaborate communication system. Figure 5.3 summarizes major milestones of brain development. In the prenatal period, neurons are produced in the embryo’s primitive neural tube. From there, they migrate to form the major parts of the brain (see Chapter 3). Once neurons are in place, they differentiate, establishing their unique functions by extending their fibers to form synaptic connections with neighboring cells. During infancy and toddlerhood, neural fibers and synapses increase at an astounding pace (Gilmore et al., 2012; Moore, Persaud, & Torchia, 2013). Because developing neurons require space for these connective structures, a surprising aspect of brain growth is that as synapses form, many surrounding neurons die—20 to 80 percent, depending on the brain region (Stiles, 2008). Fortunately, during the prenatal period, the neural tube produces far more neurons than the brain will ever need.

As neurons form connections, stimulation becomes vital to their survival. Neurons that are stimulated by input from the surrounding environment continue to establish new synapses, forming increasingly elaborate systems of communication that support more complex abilities. At first, stimulation results in a massive overabundance of synapses, many of which serve identical functions, thereby ensuring that the child will acquire the motor, cognitive, and social skills that our species needs to survive. Neurons that are seldom stimulated soon lose their synapses, in a process called synaptic pruning that returns neurons not needed at the moment to an uncommitted state so they can support future development. In all, about 40 percent of synapses are pruned during childhood and adolescence (Webb, Monk, & Nelson, 2001). For this process to advance, appropriate stimulation of the child’s brain is vital during periods in which the formation of synapses is at its peak (Bryk & Fisher, 2012).

If few neurons are produced after the prenatal period, what causes the extraordinary increase in brain size during the first two years? About half the brain’s volume is made up of glial cells, which are responsible for myelination, the coating of neural fibers with an insulating fatty sheath (called myelin) that improves the efficiency of message transfer. Certain types of glial cells also participate directly in neural communication, by picking up and passing on neuronal signals and releasing neurotransmitters. Glial cells multiply rapidly from the end of
pregnancy through the second year of life—a process that continues at a slower pace through middle childhood and accelerates again in adolescence. Gains in neural fibers and myelination account for the overall increase in size of the brain, from nearly 30 percent of its adult weight at birth to 70 percent by age 2 (Johnson, 2011; Knickmeyer et al., 2008). Growth is especially rapid during the first year, when the brain more than doubles in size.

Brain development can be compared to molding a “living sculpture.” First, neurons and synapses are overproduced. Then, cell death and synaptic pruning sculpt away excess building material to form the mature brain—a process jointly influenced by genetically programmed events and the child’s experiences. The resulting “sculpture” is a set of interconnected regions, each with specific functions—much like countries on a globe that communicate with one another (Johnston et al., 2001). This “geography” of the brain permits researchers to study its organization and the activity of its regions using neurobiological techniques.

Measures of Brain Functioning

Table 5.1 describes major measures of brain functioning. Among these methods, the two most frequently used detect changes in electrical activity in the cerebral cortex. In an electroencephalogram (EEG), researchers examine brain-wave patterns for stability and organization—signs of mature functioning of the cortex (see Figure 5.4). And as a child processes a particular stimulus, event-related potentials (ERPs) detect the general location of brain-wave activity—a technique often used to study preverbal infants’ responsiveness to various stimuli, the impact of experience on specialization of specific regions of the cortex, and atypical brain functioning in children at risk for learning and emotional problems (DeBoer, Scott, & Nelson, 2007; Gunnar & de Haan, 2009).

Neuroimaging techniques, which yield detailed, three-dimensional computerized pictures of the entire brain and its active areas, provide the most precise information about which brain regions are specialized for certain capacities. The most promising of these methods is functional magnetic resonance imaging (fMRI). Unlike positron emission tomography (PET), fMRI does not depend on X-ray photography, which requires injection of a radioactive substance. Rather, when a child is exposed to a stimulus, fMRI detects changes in blood flow and oxygen metabolism throughout the brain.

Table 5.1 Measuring Brain Functioning

<table>
<thead>
<tr>
<th>METHOD</th>
<th>DESCRIPTION</th>
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<tr>
<td>Electroencephalogram (EEG)</td>
<td>Electrodes embedded in a head cap record electrical brain-wave activity in the brain’s outer layers—the cerebral cortex. Researchers use an advanced tool called a geodesic sensor net (GSN) to hold interconnected electrodes (up to 128 for infants and 256 for children and adults) in place through a cap that adjusts to each person’s head shape, yielding improved brain-wave detection.</td>
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<tr>
<td>Event-related potentials (ERPs)</td>
<td>Using the EEG, the frequency and amplitude of brain waves in response to particular stimuli (such as a picture, music, or speech) are recorded in the cerebral cortex. Enables identification of general regions of stimulus-induced activity.</td>
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<tr>
<td>Functional magnetic resonance imaging (fMRI)</td>
<td>While the person lies inside a tunnel-shaped apparatus that creates a magnetic field, a scanner magnetically detects increased blood flow and oxygen metabolism in areas of the brain as the individual processes particular stimuli. The scanner typically records images every 1 to 4 seconds; these are combined into a computerized moving picture of activity anywhere in the brain (not just its outer layers). Not appropriate for children younger than age 5 to 6, who cannot remain still during testing.</td>
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<tr>
<td>Positron emission tomography (PET)</td>
<td>After injection or inhalation of a radioactive substance, the person lies on an apparatus with a scanner that emits fine streams of X-rays, which detect increased blood flow and oxygen metabolism in areas of the brain as the person processes particular stimuli. As with fMRI, the result is a computerized image of activity anywhere in the brain. Not appropriate for children younger than age 5 to 6.</td>
</tr>
<tr>
<td>Near-infrared spectroscopy (NIRS)</td>
<td>Using thin, flexible optical fibers attached to the scalp through a head cap, infrared (invisible) light is beamed at the brain; its absorption by areas of the cerebral cortex varies with changes in blood flow and oxygen metabolism as the individual processes particular stimuli. The result is a computerized moving picture of active areas in the cerebral cortex. Unlike fMRI and PET, NIRS is appropriate for infants and young children, who can move within limited range during testing.</td>
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brain magnetically, yielding a colorful, moving picture of parts of the brain used to perform a given activity (see Figure 5.5a and b).

Because PET and fMRI require that the participant lie as motionless as possible for an extended time, they are not suitable for infants and young children. A neuroimaging technique that works well in infancy and early childhood is near infrared spectroscopy (NIRS), in which infrared (invisible) light is beamed at regions of the cerebral cortex to measure blood flow and oxygen metabolism while the child attends to a stimulus (refer again to Table 5.1). Because the apparatus consists only of thin, flexible optical fibers attached to the scalp using a head cap, a baby can sit on the parent’s lap and move during testing—as Figure 5.5c illustrates (Hespos et al., 2010). But unlike PET and fMRI, which map activity changes throughout the brain, NIRS examines only the functioning of the cerebral cortex.

The measures just reviewed are powerful tools for uncovering relationships between the brain and psychological development. But like all research methods, they have limitations. Even though a stimulus produces a consistent pattern of brain activity, investigators cannot be certain that an individual has processed it in a certain way (Kagan, 2013). And a researcher who takes a change in brain activity as an indicator of information processing must make sure that the change was not due instead to hunger, boredom, fatigue, or body movements. Consequently, other methods must be combined with brain-wave and -imaging findings to clarify their meaning (de Haan & Gunnar, 2009). Now let’s turn to the developing organization of the cerebral cortex.

Development of the Cerebral Cortex

The cerebral cortex surrounds the rest of the brain, resembling half of a shelled walnut. It is the largest brain structure—accounting for 85 percent of the brain’s weight and containing the greatest number of neurons and synapses. Because the cerebral cortex is the last part of the brain to stop growing, it is sensitive to environmental influences for a much longer period than any other part of the brain.

Regions of the Cortex

Figure 5.6 shows specific functions of regions of the cerebral cortex, such as receiving information from the senses, instructing the body to move, and thinking. The order in which cortical regions develop corresponds to the order in which various capacities emerge in the infant and growing child. For example, a burst of synaptic growth occurs in the auditory and visual cortices and in areas responsible for body movement over the first year—a period of dramatic gains in auditory and visual perception and mastery of
motor skills (Gilmore et al., 2012). Language areas are especially active from late infancy through the preschool years, when language development flourishes (Pujol et al., 2006).

The cortical regions with the most extended period of development are the frontal lobes. The prefrontal cortex, lying in front of areas controlling body movement, is responsible for thought—in particular, consciousness, inhibition of impulses, integration of information, and use of memory, reasoning, planning, and problem-solving strategies. From age 2 months on, the prefrontal cortex functions more effectively. But it undergoes especially rapid myelination and formation and pruning of synapses during the preschool and school years, followed by another period of accelerated growth in adolescence, when it reaches an adult level of synaptic connections (Nelson, 2002; Nelson, Thomas, & de Haan, 2006; Sowell et al., 2002).

LATERALIZATION AND PLASTICITY OF THE CEREBRAL CORTEX  The cerebral cortex has two hemispheres, or sides, that differ in their functions. Some tasks are done mostly by the left hemisphere, others by the right. For example, each hemisphere receives sensory information from the side of the body opposite to it and controls only that side.1 For most of us, the left hemisphere is largely responsible for verbal abilities (such as spoken and written language) and positive emotion (for example, joy). The right hemisphere handles spatial abilities (judging distances, reading maps, and recognizing geometric shapes) and negative emotion (such as distress) (Nelson & Bosquet, 2000). In left-handed people, this pattern may be reversed or, more commonly, the cerebral cortex may be less clearly specialized than in right-handers.

Why does this specialization of the two hemispheres, called lateralization, occur? Studies using fMRI reveal that the left hemisphere is better at processing information in a sequential, analytic (piece-by-piece) way, a good approach for dealing with communicative information—both verbal (language) and emotional (a joyful smile). In contrast, the right hemisphere is specialized for processing information in a holistic, integrative manner, ideal for making sense of spatial information and regulating negative emotion. A lateralized brain may have evolved because it enabled humans to cope more successfully with changing environmental demands (Falk, 2005). It permits a wider array of functions to be carried out effectively than if both sides processed information in exactly the same way. However, the popular notion of a “right-brained” or “left-brained” person is an oversimplification. The two hemispheres communicate and work together, doing so more rapidly and effectively with age.

Researchers study the timing of brain lateralization to learn more about brain plasticity. A highly plastic cerebral cortex, in which many areas are not yet committed to specific functions, has a high capacity for learning. And if a part of the cortex is damaged, other parts can take over the tasks it would have handled. But once the hemispheres lateralize, damage to a specific region means that the abilities it controls cannot be recovered to the same extent or as easily as earlier.

At birth, the hemispheres have already begun to specialize. Most newborns favor the right side of the body in their head position and reflexive reactions (Grattan et al., 1992; Rönnqvist & Hopkins, 1998). Most also show greater activation (detected with either ERP or NIRS) in the left hemisphere while listening to speech sounds or displaying a positive state of arousal. In contrast, the right hemisphere reacts more strongly to nonspeech sounds and to stimuli (such as a sour-tasting fluid) that evoke a negative reaction (Fox & Davidson, 1986; Hespos et al., 2010).

Nevertheless, research on brain-damaged children and adults offers evidence for substantial plasticity in the young brain, summarized in the Biology and Environment box on page 166.

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1The eyes are an exception. Messages from the right half of each retina go to the right hemisphere; messages from the left half of each retina go to the left hemisphere. Thus, visual information from both eyes is received by both hemispheres.
Brain Plasticity: Insights from Research on Brain-Damaged Children and Adults

In the first few years of life, the brain is highly plastic. It can reorganize areas committed to specific functions in a way that the mature brain cannot. Adults who suffered injury to a part of the brain in infancy and early childhood usually show fewer cognitive impairments than adults with later-occurring injury (Holland, 2004; Huttenlocher, 2002). Nevertheless, the young brain is not totally plastic. When it is injured, its functioning is compromised. And the more brain tissue destroyed in infancy or early childhood, the poorer the outcomes (Anderson et al., 2006).

The extent of plasticity depends on several factors, including age at time of injury, site and severity of damage, skill area, and environmental supports for recovery.

Brain Plasticity in Infancy and Early Childhood

In a large study of children with injuries to the cerebral cortex that occurred around the time of birth or in the first six months of life, language and spatial skills were assessed repeatedly into adolescence (Stiles, Reilly, & Levine, 2012; Stiles et al., 2005, 2008, 2009). All the children had experienced early brain seizures or hemorrhages. Brain-imaging techniques (fMRI and PET) revealed the precise site of damage.

Regardless of whether injury occurred in the left or right cerebral hemisphere, the children showed delays in language development that persisted until about 3½ years of age. That damage to either hemisphere affected early language competence indicates that at first, language functioning is broadly distributed in the brain. But by age 5, the children caught up in vocabulary and grammatical skills. Undamaged areas—in either the left or the right hemisphere—had taken over these language functions.

Compared with language, spatial skills were more impaired after early brain injury. When preschool through adolescent-age youngsters were asked to copy designs, those with early right-hemispheric damage had trouble with holistic processing—accurately representing the overall shape. In contrast, children with left-hemispheric damage captured the basic shape but omitted fine-grained details. Nevertheless, the children showed improvements in their drawings with age—gains that did not occur in brain-injured adults (Stiles, Reilly, & Levine, 2012; Stiles et al., 2003, 2008, 2009).

Clearly, recovery after early brain injury is greater for language than for spatial skills. Why is this so? Researchers speculate that spatial processing is the older of the two capacities in our evolutionary history and, therefore, more laterized at birth (Stiles et al., 2008). But early brain injury has less impact than later injury on both language and spatial skills, revealing the young brain’s plasticity.

The Price of High Plasticity in the Young Brain

Despite impressive recovery of language and (to a lesser extent) spatial skills, children with early brain injuries show deficits in a wide variety of complex mental abilities during the school years. For example, their reading and math progress is slow. In telling stories, they produce simpler narratives than agemates without early brain injuries. And as the demands of daily life increase, they have difficulty managing homework and other responsibilities (Anderson, Spencer-Smith, & Wood, 2011; Stiles, Reilly, & Levine, 2012).

High brain plasticity, researchers explain, comes at a price. When healthy brain regions take over the functions of damaged areas, a “crowding effect” occurs: Multiple tasks must be done by a smaller-than-usual volume of brain tissue (Stiles, 2012). Consequently, the brain processes information less quickly and accurately than it would if it were intact. Complex mental abilities of all kinds suffer into middle childhood, and often longer, because performing them well requires the collaboration of many regions in the cerebral cortex. In sum, the full impact of an early brain injury may not be apparent for many years, until higher-order skills are expected to develop.

Age of Injury and Plasticity

In infancy and childhood, the goal of brain growth is to form neural connections that ensure mastery of essential skills. Animal research reveals that plasticity is greatest while the brain is forming many new synapses; it declines during synaptic pruning (Murphy & Corbett, 2009). At the same time, for as yet unexplained reasons, some young children suffer permanent damage following a localized brain injury (Anderson, Spencer-Smith, & Wood, 2011). Age likely combines with other influences—insult site and severity and environmental factors, such as warm, stimulating parenting and access to intervention services—to affect outcomes.

Furthermore, brain plasticity is not restricted to early childhood. Though far more limited, reorganization in the brain can occur later, even in adulthood. For example, adult stroke victims often display considerable recovery, especially in response to stimulation of language and motor skills. Brain-imaging findings reveal that structures adjacent to the permanently damaged area or in the opposite cerebral hemisphere reorganize to support the impaired ability (Kalra & Ratan, 2007; Murphy & Corbett, 2009). When an individual practices relevant tasks, the brain strengthens existing synapses and generates new ones.

Plasticity seems to be a basic property of the nervous system. Researchers hope to discover how brain plasticity and experience work together throughout life, so they can help people of all ages—with and without brain injuries—develop at their best.
Furthermore, early experience greatly influences the organization of the cerebral cortex. For example, deaf adults who, as infants and children, learned sign language (a spatial skill) depend more than hearing individuals on the right hemisphere for language processing (Neville & Bavelier, 2002). And toddlers who are advanced in language development show greater left-hemispheric specialization for language than their more slowly developing age-mates (Luna et al., 2001; Mills et al., 2005). Apparently, the very process of acquiring language and other skills promotes lateralization.

In sum, the brain is more plastic during the first few years than it will ever be again. An overabundance of synaptic connections supports brain plasticity and, therefore, young children's ability to learn, which is fundamental to their survival. And although the cortex is programmed from the start for hemispheric specialization, experience greatly influences the rate and success of its advancing organization.

Sensitive Periods in Brain Development

Animal studies confirm that early, extreme sensory deprivation results in permanent brain damage and loss of functions—findings that verify the existence of sensitive periods in brain development. For example, early, varied visual experiences must occur for the brain's visual centers to develop normally. If a 1-month-old kitten is deprived of light for just three or four days, these areas of the brain degenerate. If the kitten is kept in the dark during the fourth week of life and beyond, the damage is severe and permanent (Crair, Gillespie, & Stryker, 1998). And the general quality of the early environment affects overall brain growth. When animals reared from birth in physically and socially stimulating surroundings are compared with those reared in isolation, the brains of the stimulated animals are larger and show much denser synaptic connections (Sale, Berardi, & Maffei, 2009).

Human Evidence: Victims of Deprived Early Environments

For ethical reasons, we cannot deliberately deprive some infants of normal rearing experiences and observe the impact on their brains and competencies. Instead, we must turn to natural experiments, in which children were victims of deprived early environments that were later rectified. Such studies have revealed some parallels with the animal evidence just described.

For example, when babies are born with cataracts in both eyes (clouded lenses, preventing clear visual images), those who have corrective surgery within four to six months show rapid improvement in vision, except for subtle aspects of face perception, which require early visual input to the right hemisphere to develop (Maurer & Lewis, 2013; Maurer, Mondloch, & Lewis, 2007). The longer cataract surgery is postponed beyond infancy, the less complete the recovery in visual skills. And if surgery is delayed until adulthood, vision is severely and permanently impaired (Lewis & Maurer, 2005).

Studies of infants placed in orphanages who were later exposed to family rearing confirm the importance of a generally stimulating environment for psychological development. In one investigation, researchers followed the progress of a large sample of children transferred between birth and 3½ years from extremely deprived Romanian orphanages to adoptive families in Great Britain (Beckett et al., 2006; O'Connor et al., 2000; Rutter et al., 1998, 2004, 2010). On arrival, most were impaired in all domains of development. Cognitive catch-up was impressive for children adopted before 6 months, who consistently attained average mental test scores in childhood and adolescence, performing as well as a comparison group of early-adopted British-born children.

But Romanian children who had been institutionalized for more than the first six months showed serious intellectual deficits (see Figure 5.7 on page 168). Although they improved in mental test scores during middle childhood and adolescence, they remained substantially below average. And most displayed at least three serious mental health problems, such as inattention, overactivity, unruly behavior, and autistic-like symptoms (social disinterest, stereotyped behavior) (Kreppner et al., 2007, 2010). A major correlate of both time spent in the institution and poor
deficits. (Adapted from Beckett et al., 2006.)

improved between ages 6 and 11, they continued to show serious intellectual age performed well below average. And although those adopted after age 2 extreme early deprivation. Romanian children adopted after 6 months of

Children transferred from Romanian orphanages to British adoptive homes in the first six months of life attained average scores and fared as well as British early-adopted children, suggesting that they had fully recovered from extreme early deprivation. Romanian children adopted after 6 months of age performed well below average. And although those adopted after age 2 improved between ages 6 and 11, they continued to show serious intellectual deficits. (Adapted from Beckett et al., 2006.)

FIGurE 5.7 Relationship of age at adoption to mental test scores at ages 6 and 11 among British and Romanian adoptees.

Children transferred from Romanian orphanages to British adoptive homes in the first six months of life attained average scores and fared as well as British early-adopted children, suggesting that they had fully recovered from extreme early deprivation. Romanian children adopted after 6 months of age performed well below average. And although those adopted after age 2 improved between ages 6 and 11, they continued to show serious intellectual deficits. (Adapted from Beckett et al., 2006.)

Neurobiological findings indicate that early, prolonged institutionalization leads to a generalized decrease in activity of the cerebral cortex—especially the prefrontal cortex, which governs complex cognition and impulse control. Neural fibers connecting the prefrontal cortex with other brain structures involved in control of emotion are also reduced (Eluvathingal et al., 2006; Nelson, 2007b). And activation of the left cerebral hemisphere, governing positive emotion, is diminished relative to right cerebral activation, governing negative emotion (McLaughlin et al., 2011).

Additional evidence confirms that the chronic stress of early, deprived orphanage rearing disrupts the brain's capacity to manage stress. In another investigation, researchers followed the development of children who had spent their first eight months or more in Romanian institutions and were then adopted into Canadian homes (Gunnar & Cheatham, 2003; Gunnar et al., 2001). Compared with agemates adopted shortly after birth, these children showed extreme stress reactivity, as indicated by high concentrations of the stress hormone cortisol in their saliva—a physiological response linked to persistent illness, delayed physical growth, and learning and behavior problems, including deficits in attention and control of anger and other impulses. The longer the children spent in orphanage care, the higher their cortisol levels—even 6½ years after adoption.

In other research, orphanage children displayed abnormally low cortisol—a blunted physiological stress response that may be the central nervous system's adaptation to earlier, frequent cortisol elevations (Loman & Gunnar, 2010).

Finally, early deprived rearing may also disrupt the brain's typical response to pleasurable social experiences. After sitting on their mother's lap and playing an enjoyable game, preschoolers adopted, on average, at age 1½ years from Romanian orphanages had abnormally low urine levels of oxytocin—a hormone released by the brain that evokes calmness and contentment in the presence of familiar, trusted people (Fries et al., 2005). As we will see in Chapter 7, children who spend their infancy in neglectful institutions often display attachment difficulties.

APPROPRIATE STIMULATION Unlike the orphanage children just described, Grace, whom Monica and Kevin had adopted in Cambodia at 16 months of age, showed favorable progress. Two years earlier, they had adopted Grace's older brother, Eli. When Eli was 2 years old, Monica and Kevin sent a letter and a photo of Eli to his biological mother, describing a bright, happy child. The next day, the Cambodian mother tearfully asked an adoption agency to send her baby daughter to join Eli and his American family.

Although Grace's early environment was very depleted, her biological mother's loving care—holding gently, speaking softly, playfully stimulating, and breastfeeding—may have prevented irreversible damage to her brain. Besides offering gentle, appropriate stimulation, sensitive adult care helps normalize cortisol production in both typically developing and emotionally traumatized infants and young children (Gunnar & Quevedo, 2007; Tarullo & Gunnar, 2006). Good parenting seems to protect the young brain from the potentially damaging effects of both excessive and inadequate stress-hormone exposure.

In the Bucharest Early Intervention Project, 136 institutionalized Romanian babies were randomized into conditions of either care as usual or transfer to high-quality foster families between 6 and 31 months of age. Specially trained social workers provided foster parents with counseling and support. Follow-ups between 2½ and 8 years revealed that the foster-care group exceeded the institutional-care group in intelligence test scores, language skills, emotional responsiveness, social skills, and EEG and ERP assessments of brain development (Fox, Nelson & Zeanah, 2013; Nelson, Fox, & Zeanah, 2014). On all measures, the earlier the foster placement, the better the outcome. But consistent with an early sensitive period,
foster-care group remained behind never-institutionalized agemates living with Bucharest families.

In addition to impoverished environments, ones that overwhelm children with expectations beyond their current capacities interfere with the brain's potential. In recent years, expensive early learning centers have sprung up, in which infants are trained with letter and number flash cards and slightly older toddlers are given a full curriculum of reading, math, science, art, gym, and more. There is no evidence that these programs yield smarter, better “super-babies” (Hirsh-Pasek & Golinkoff, 2003). To the contrary, trying to prime infants with stimulation for which they are not ready can cause them to withdraw, thereby threatening their interest in learning and creating conditions much like stimulus deprivation!

How, then, can we characterize appropriate stimulation during the early years? To answer this question, researchers distinguish between two types of brain development. The first, experience-expectant brain growth, refers to the young brain's rapidly developing organization, which depends on ordinary experiences—opportunities to explore the environment, interact with people, and hear language and other sounds. As a result of millions of years of evolution, the brains of all infants, toddlers, and young children expect to encounter these experiences and, if they do, grow normally. The second type of brain development, experience-dependent brain growth, occurs throughout our lives. It consists of additional growth and the refinement of established brain structures as a result of specific learning experiences that vary widely across individuals and cultures (Greenough & Black, 1992). Reading and writing, playing computer games, weaving an intricate rug, and practicing the violin are examples. The brain of a violinist differs in certain ways from the brain of a poet because each has exercised different brain regions for a long time.

Experience-expectant brain development occurs early and naturally, as caregivers offer babies and preschoolers age-appropriate play materials and engage them in enjoyable daily routines—a shared meal, a game of peekaboo, a bath before bed, a picture book to talk about, or a song to sing. The resulting growth provides the foundation for later-occurring, experience-dependent development (Belsky & de Haan, 2011; Huttenlocher, 2002). No evidence exists for a sensitive period in the first few years of life for mastering skills that depend on extensive training, such as reading, musical performance, or gymnastics (Bruer, 1999). To the contrary, rushing early learning also harms the brain by overwhelming its neural circuits, thereby reducing the brain's sensitivity to the everyday experiences it needs for a healthy start in life.

**Changing States of Arousal**

Rapid brain growth means that the organization of sleep and wakefulness changes substantially between birth and 2 years, and fussiness and crying also decline. The newborn baby takes round-the-clock naps that total about 16 to 18 hours. Total sleep time declines slowly; the average 2-year-old still needs 12 to 13 hours. But periods of sleep and wakefulness become fewer and longer, and the sleep-wake pattern increasingly conforms to a night-day schedule. Most 6- to 9-month-olds take two daytime naps; by about 18 months, children generally need only one nap (Galland et al., 2012). Finally, between ages 3 and 5, napping subsides.

These changing arousal patterns are due to brain development, but they are also affected by cultural beliefs and practices and parents' needs (Super & Harkness, 2002). Dutch parents, for example, view sleep regularity as far more important than U.S. parents do. And whereas U.S. parents regard a predictable sleep schedule as emerging naturally from within the child, Dutch parents believe that a schedule must be imposed, or the baby's development might suffer (Super & Harkness, 2010; Super et al., 1996). At age 6 months, Dutch babies are put to bed earlier and sleep, on average, 2 hours more per day than their U.S. agemates.

Motivated by demanding work schedules and other needs, many Western parents try to get their babies to sleep through the night as early as 3 to 4 months by offering an evening feeding—a practice that may be at odds with young infants' neurological capacities. Not until
Cultural Variation in Infant Sleeping Arrangements

Western child-rearing advice from experts strongly encourages the nighttime separation of baby from parent. For example, the most recent edition of Benjamin Spock’s *Baby and Child Care* recommends that babies sleep in their own room by 3 months of age, explaining, “By 6 months, a child who regularly sleeps in her parents’ room may feel uneasy sleeping anywhere else” (Spock & Needelman, 2012, p. 62). And the American Academy of Pediatrics (2012b) has issued a controversial warning that parent–infant bedsharing may increase the risk of sudden infant death syndrome (SIDS).

Yet parent–infant “cosleeping” is the norm for approximately 90 percent of the world’s population, in cultures as diverse as the Japanese, the rural Guatemalan Maya, the Inuit of northwestern Canada, and the !Kung of Botswana. Japanese and Korean children usually lie next to their mothers throughout infancy and early childhood, and many continue to sleep with a parent or other family member until adolescence (Takahashi, 1990; Yang & Hahn, 2002). Among the Maya, mother–infant bedsharing is interrupted only by the birth of a new baby, when the older child is moved next to the father or to another bed in the same room (Morelli et al., 1992). Bedsharing is also common in U.S. ethnic minority families (McKenna & Volpe, 2007). African-American children, for example, frequently fall asleep with their parents and remain with them for part or all of the night (Buswell & Spatz, 2007).

Cultural values strongly influence infant sleeping arrangements. In one study, researchers interviewed Guatemalan Mayan and American middle-SES mothers about their sleeping practices. Mayan mothers stressed the importance of promoting an *interdependent self*, explaining that cosleeping builds a close parent–child bond, which is necessary for children to learn the ways of people around them. In contrast, American mothers emphasized an *independent self*, mentioning their desire to instill early autonomy, prevent bad habits, and protect their own privacy (Morelli et al., 1992).

Over the past two decades, cosleeping has increased in Western nations. An estimated 11 percent of U.S. infants routinely bedshare, and an additional 30 to 35 percent sometimes do (Buswell & Spatz, 2007; Colson et al., 2013). Proponents of the practice say that it helps infants sleep, makes breastfeeding more convenient, and provides valuable bonding time (McKenna & Volpe, 2007).

During the night, cosleeping babies breastfeed three times longer than infants who sleep alone. Because infants arouse to nurse more often when sleeping next to their mothers, some researchers believe that cosleeping does not reduce mothers’ total sleep time, although they experience more brief awakenings, which permit them to check on their baby (Mao et al., 2004).

Infant sleeping practices affect other aspects of family life. For example, Mayan babies doze off in the midst of ongoing family activities and are carried to bed by their mothers. In contrast, for many North American parents, bedtime often requires a lengthy, elaborate ritual. Perhaps bedtime struggles, so common in Western homes but rare elsewhere in the world, are related to the stress young children feel when they must fall asleep without assistance (Latz, Wolf, & Lozoff, 1999).

Critics warn that bedsharing will promote emotional problems, especially excessive dependency. Yet a longitudinal study following children from the end of pregnancy through age 18 years showed that young people who had bedshared in the early years were no different from others in any aspect of adjustment (Okami, Weisner, & Olmstead, 2002). Another concern is that infants might become trapped under the parent’s body or in soft bedding and suffocate. Parents who are obese or who use alcohol, tobacco, or illegal drugs do pose a serious risk to their sleeping babies, as does the use of quilts and comforters or an overly soft mattress (American Academy of Pediatrics, 2012b).

But with appropriate precautions, parents and infants can cosleep safely (Ball & Volpe, 2013). In cultures where cosleeping is widespread, parents and infants usually sleep with light covering on hard surfaces, such as firm mattresses, floor mats, and wooden planks, or infants sleep in a cradle or hammock next to the parents’ bed (McKenna, 2001, 2002). And when sharing the same bed, infants typically lie on their back or side facing the mother—positions that promote frequent, easy communication between parent and baby and arousal if breathing is threatened.

Finally, breastfeeding mothers usually assume a distinctive sleeping posture. They face the infant, with knees drawn up under the baby’s feet and arm above the baby’s head. Besides facilitating feeding, the position prevents the infant from sliding down under covers or up under pillows (Ball, 2006). Because this posture is also seen in female great apes while sharing sleeping nests with their infants, researchers believe it may have evolved to enhance infant safety.
year, as REM sleep (the state that usually prompts waking) declines, do infants move in the direction of an adultlike sleep–wake schedule (Ficca et al., 1999).

Even after infants sleep through the night, they continue to wake occasionally. When babies begin to crawl and walk, they often show temporary periods of disrupted sleep (Scher, Epstein, & Tirosh, 2004). In studies carried out in Australia, Israel, and the United States, night wakings increased around 6 months and again between 1½ and 2 years and then declined (Armstrong, Quinn, & Dadds, 1994; Scher, Epstein, & Tirosh, 2004; Scher et al., 1995). As Chapter 7 will reveal, around the middle of the first year, infants are forming a clear-cut attachment to their familiar caregiver and begin protesting when he or she leaves. And the challenges of toddlerhood—the ability to range farther from the caregiver and increased awareness of the self as separate from others—often prompt anxiety, evident in disturbed sleep and clinginess. When parents offer comfort, these behaviors subside.

**Ask Yourself**

- **REVIEW** How do overproduction of synapses and synaptic pruning support infants’ and children’s ability to learn?
- **CONNECT** Explain how inappropriate stimulation—either too little or too much—can impair cognitive and emotional development in the early years.
- **APPLY** Which infant enrichment program would you choose: one that emphasizes gentle talking and touching and social games, or one that includes reading and number drills and classical music lessons? Explain.
- **REFLECT** What is your attitude toward parent–infant cosleeping? Is it influenced by your cultural background? Explain.

### Influences on Early Physical Growth

Physical growth, like other aspects of development, results from the continuous and complex interplay between genetic and environmental factors. Heredity, nutrition, relative freedom from disease, and emotional well-being all affect early physical growth.

#### Heredity

Because identical twins are much more alike in body size than fraternal twins, we know that heredity is important in physical growth (Estourgie-van Burk et al., 2006). When diet and health are adequate, height and rate of physical growth are largely determined by heredity. In fact, as long as negative environmental influences such as poor nutrition or illness are not severe, children and adolescents typically show *catch-up growth*—a return to a genetically determined growth path—once conditions improve. After her adoption, Grace grew rapidly until, at age 2, she was nearly average in size by Cambodian standards. Still, the health of the brain, the heart, the digestive system, and many other internal organs may be permanently compromised. (Recall the consequences of inadequate prenatal nutrition for long-term health, discussed in Chapter 3.)

Genetic makeup also affects body weight: The weights of adopted children correlate more strongly with those of their biological than of their adoptive parents (Kinnunen, Pietilainen, & Rissanen, 2006). At the same time, environment—in particular, nutrition—plays an especially important role.

#### Nutrition

Nutrition is especially crucial for development in the first two years because the baby’s brain and body are growing so rapidly. Pound for pound, an infant’s energy needs are at least twice those of an adult. Twenty-five percent of infants’ total caloric intake is devoted to growth, and babies need extra calories to keep rapidly developing organs functioning properly (Meyer, 2009).
BREASTFEEDING VERSUS BOTTLE-FEEDING  Babies not only need enough food but also the right kind of food. In early infancy, breast milk is ideally suited to their needs, and bottled formulas try to imitate it. Applying What We Know above summarizes major nutritional and health advantages of breastfeeding.

Because of these benefits, breastfed babies in poverty-stricken regions of the world are much less likely to be malnourished and 6 to 14 times more likely to survive the first year of life. The World Health Organization recommends breastfeeding until age 2 years, with solid foods added at 6 months. These practices, if widely followed, would save the lives of more than 800,000 infants annually (World Health Organization, 2012). Even breastfeeding for just a few weeks offers some protection against respiratory and intestinal infections, which are devastating to young children in developing countries. Also, because a nursing mother is less likely to get pregnant, breastfeeding helps increase spacing among siblings, a major factor in reducing infant and childhood deaths in nations with widespread poverty. (Note, however, that breastfeeding is not a reliable method of birth control.)

Yet many mothers in the developing world do not know about these benefits. In Africa, the Middle East, and Latin America, most babies get some breastfeeding, but fewer than 40 percent are exclusively breastfed for the first six months, and one-third are fully weaned from the breast before 1 year (UNICEF, 2013). In place of breast milk, mothers give their babies commercial formula or low-grade nutrients, such as rice water or highly diluted cow or goat milk. Contamination of these foods as a result of poor sanitation is common and often leads to illness and infant death. The United Nations has encouraged all hospitals and maternity units in

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**Applying What We Know**

**Reasons to Breastfeed**

<table>
<thead>
<tr>
<th>NUTRITIONAL AND HEALTH ADVANTAGES</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides the correct balance of fat and protein</td>
<td>Compared with the milk of other mammals, human milk is higher in fat and lower in protein. This balance, as well as the unique proteins and fats contained in human milk, is ideal for a rapidly myelinating nervous system.</td>
</tr>
<tr>
<td>Ensures nutritional completeness</td>
<td>A mother who breastfeeds need not add other foods to her infant’s diet until the baby is 6 months old. The milks of all mammals are low in iron, but the iron contained in breast milk is much more easily absorbed by the baby’s system. Consequently, bottle-fed infants need iron-fortified formula.</td>
</tr>
<tr>
<td>Helps ensure healthy physical growth</td>
<td>One-year-old breastfed babies are leaner (have a higher percentage of muscle to fat), a growth pattern that persists through the preschool years and that is associated with a reduction in later overweight and obesity.</td>
</tr>
<tr>
<td>Protects against many diseases</td>
<td>Breastfeeding transfers antibodies and other infection-fighting agents from mother to baby and enhances functioning of the immune system. Compared with bottle-fed infants, breastfed babies have far fewer allergic reactions and respiratory and intestinal illnesses. Breast milk also has anti-inflammatory effects, which reduce the severity of illness symptoms. Breastfeeding in the first four months (especially when exclusive) is linked to lower blood cholesterol levels in adulthood and, thereby, may help prevent cardiovascular disease.</td>
</tr>
<tr>
<td>Protects against faulty jaw development and tooth decay</td>
<td>Sucking the mother’s nipple instead of an artificial nipple helps avoid malocclusion, a condition in which the upper and lower jaws do not meet properly. It also protects against tooth decay due to sweet liquid remaining in the mouths of infants who fall asleep while sucking on a bottle.</td>
</tr>
<tr>
<td>Ensures digestibility</td>
<td>Because breastfed babies have a different kind of bacteria growing in their intestines than do bottle-fed infants, they rarely suffer from constipation or other gastrointestinal problems.</td>
</tr>
<tr>
<td>Smooths the transition to solid foods</td>
<td>Breastfed infants accept new solid foods more easily than do bottle-fed infants, perhaps because of their greater experience with a variety of flavors, which pass from the maternal diet into the mother’s milk.</td>
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Sources: American Academy of Pediatrics, 2012a; Druet et al., 2012; Ip et al., 2009; Owen et al., 2008.
developing countries to promote breastfeeding as long as mothers do not have viral or bacterial infections (such as HIV or tuberculosis) that can be transmitted to the baby. Today, most developing countries have banned the practice of giving free or subsidized formula to new mothers.

Partly as a result of the natural childbirth movement, breastfeeding has become more common in industrialized nations, especially among well-educated women. Today, 77 percent of American mothers begin breastfeeding after birth, but more than one-third stop by 6 months (Centers for Disease Control and Prevention, 2013). And despite the health benefits of breast milk, only 50 percent of preterm infants are breastfed at hospital discharge. Breastfeeding a preterm baby presents special challenges, including maintaining a sufficient milk supply with artificial pumping until the baby is mature enough to suck at the breast and providing the infant with enough sucking experience to learn to feed successfully. Kangaroo care (see Chapter 4) and the support of health professionals are helpful.

Breast milk is so easily digestible that a breastfed infant becomes hungry quite often—every 1½ to 2 hours, compared to every 3 or 4 hours for a bottle-fed baby. This makes breastfeeding inconvenient for many employed women. Not surprisingly, mothers who return to work sooner wean their babies from the breast earlier (McCarter-Spaulding, Lucas, & Gore, 2011; Smith & Forrester, 2013). But mothers who cannot be with their babies all the time can still combine breast- and bottle-feeding. The U.S. Department of Health and Human Services (2010) advises exclusive breastfeeding for the first 6 months and inclusion of breast milk in the baby’s diet until at least 1 year.

Women who do not breastfeed sometimes worry that they are depriving their baby of an experience essential for healthy psychological development. Yet breastfed and bottle-fed infants in industrialized nations do not differ in quality of the mother–infant relationship or in later emotional adjustment (Jansen, de Weerth, & Riksen-Walraven, 2008; Lind et al., 2014). Some studies report a slight advantage in intelligence test performance for children and adolescents who were breastfed, after controlling for many factors. Most, however, find no cognitive benefits (Der, Batty, & Deary, 2006).

**ARE CHUBBY BABIES AT RISK FOR LATER OVERWEIGHT AND OBESITY?** From early infancy, Timmy was an enthusiastic eater who nursed vigorously and gained weight quickly. By 5 months, he began reaching for food on his parents’ plates. Vanessa wondered: Was she overfeeding Timmy and increasing his chances of long-term overweight?

Most chubby babies thin out during toddlerhood and the preschool years, as weight gain slows and they become more active. Infants and toddlers can eat nutritious foods freely without risk of becoming overweight. But recent evidence does indicate a strengthening relationship between rapid weight gain in infancy and later obesity (Druet et al., 2012). The trend may be due to the rise in overweight and obesity among adults, who promote unhealthy eating habits in their young children. Interviews with 1,500 U.S. parents of 4- to 24-month-olds revealed that many routinely served older infants and toddlers french fries, pizza, candy, sugary fruit drinks, and soda. On average, infants consumed 20 percent and toddlers 30 percent more calories than they needed (Siega-Riz et al., 2010). At the same time, as many as one-fourth ate no fruits and one-third no vegetables.

How can parents prevent their infants from becoming overweight children and adults? One way is to breastfeed for the first six months, which is associated with slower weight gain over the first year, leaner body build through early childhood, and 10 to 20 percent reduced obesity risk in later life (Gunnarsdottir et al., 2010; Koletzko et al., 2013). Another strategy is for parents to

**LOOK and LISTEN**

Ask several parents of 1- to 2-year-olds to keep a diary of all the foods and drinks they offer their toddler over a weekend. How healthy are the toddlers’ diets? Did any of the parents report heightened awareness of family nutrition as a result of the diary exercise?
Social Issues: Health

U.S. Public Policy Changes Improve Infant Feeding Practices in Low-Income Families

In a study in which researchers made periodic home visits to several hundred low-income first-time mothers and their babies, inappropriate feeding practices were pervasive. Rather than a mostly breast-milk diet for the first half-year, the majority of infants were fed formula. And more than 75 percent received solid foods and juices too soon—by age 3 months (Thompson & Bentley, 2013). Inappropriate feeding of solids and liquids in infancy is consistently associated with greater daily caloric intake and excessive weight gain during the first two years (Smith & Forrester, 2013).

The U.S. Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is a federally funded initiative that provides nutrition education and food to low-income mothers and to their children from birth to age 5. Though not reaching all families in need, WIC serves about half of U.S. infants—2 million annually, two-thirds of whom live in poverty (U.S. Department of Agriculture, 2014).

A WIC counselor meets with breastfeeding mothers to provide nutrition education and enhanced food packages— incentives that increase the number of breastfed babies and the duration of breastfeeding.

To induce improvements in infant feeding practices, in 2009 WIC strengthened its breastfeeding counseling and educational materials for new mothers. It also offered mothers who breastfeed enhanced food packages for the first 12 months. A “fully breastfeeding package” includes no formula while providing the largest quantity and variety of healthy foods for the mother. A “partially breastfeeding package” includes some formula plus extra healthy foods for the mother, but less than in the fully breastfeeding package. A “formula only package” contains more formula for the baby but only a basic food package for the mother, limited to the first 6 months.

Are WIC’s policy changes effective? To find out, researchers first confirmed that maternal food package choice is an accurate indicator of feeding practices at home (Whaley, Koliet, & Jiang, 2012). Then they examined the distribution of the three types of food packages to 5,000 California families before and after the policy changes. As Figure 5.8 shows, following the new policies, enrollment in the fully breastfeeding option increased sharply—to double its former rate. In contrast, the partially breastfeeding and formula-only package options declined (Whaley et al., 2012). Furthermore, more mothers continued to select the fully breastfeeding packages when their babies reached ages 2 and 6 months, indicating that WIC incentives lengthened the duration of breastfeeding.

Full breastfeeding for the first half-year followed by a healthy infant diet is a WIC priority—part of a national early obesity prevention strategy. The findings just described are particularly impressive, given that the WIC policy changes coincided with the late-2000s recession and a rise in poverty, which is typically linked to reduced breastfeeding and increased unhealthy eating practices.

Avoid giving babies foods loaded with sugar, salt, and saturated fats. As the Social Issues: Health box above illustrates, policy changes directed at low-income families, where breastfeeding rates are lowest and unhealthy feeding practices are highest, are a vital child health measure. And once toddlers learn to walk, climb, and run, parents can also provide plenty of opportunities for energetic play. Finally, as Chapter 11 will reveal, because excessive television viewing is linked to overweight in older children, parents should limit the time very young children spend in front of the TV.
Malnutrition

Osita is an Ethiopian 2-year-old whose mother has never had to worry about his gaining too much weight. When she weaned him at 1 year, he had little to eat besides starchy rice flour cakes. Soon his belly enlarged, his feet swelled, his hair fell out, and a rash appeared on his skin. His bright-eyed curiosity vanished, and he became irritable and listless.

In developing countries and war-torn areas where food resources are limited, malnutrition is widespread. Recent evidence indicates that about one-third of the world’s children suffer from malnutrition before age 5 (World Health Organization, 2013). The 8 percent who are severely affected suffer from two dietary diseases.

Marasmus is a wasted condition of the body caused by a diet low in all essential nutrients. It usually appears in the first year of life when a baby’s mother is too malnourished to produce enough breast milk and bottle-feeding is also inadequate. Her starving baby becomes painfully thin and is in danger of dying.

Osita has kwashiorkor, caused by an unbalanced diet very low in protein. The disease usually strikes after weaning, between 1 and 3 years of age. It is common in regions where children get just enough calories from starchy foods but little protein. The child’s body responds by breaking down its own protein reserves, which causes the swelling and other symptoms that Osita experienced.

Children who survive these extreme forms of malnutrition often grow to be smaller in all body dimensions and suffer from lasting damage to the brain, heart, liver, pancreas, and other organs (Müller & Krawinkel, 2005; Spoelstra et al., 2012). When their diets do improve, they tend to gain excessive weight (Black et al., 2013). A malnourished body protects itself by establishing a low basal metabolism rate, which may endure after nutrition improves. Also, malnutrition may disrupt appetite control centers in the brain, causing the child to overeat when food becomes plentiful.

Learning and behavior are also seriously affected. Animal evidence reveals that a deficient diet permanently reduces brain weight and alters the production of neurotransmitters in the brain—an effect that can disrupt all aspects of development (Bedi, 2003; Haller, 2005). Children who experienced marasmus or kwashiorkor show poor fine-motor coordination, have difficulty paying attention, often display conduct problems, and score low on intelligence tests into adulthood (Galler et al., 1990, 2012; Waber et al., 2014). They also display a more intense stress response to fear-arousing situations, perhaps caused by the constant, gnawing pain of hunger (Fernald & Grantham-McGregor, 1998).

Recall from our discussion of prenatal malnutrition in Chapter 3 that the passivity and irritability of malnourished children worsen the impact of poor diet. These behaviors may appear even when protein-calorie deprivation is only mild to moderate. They also accompany iron-deficiency anemia, a condition common among poverty-stricken infants and children that interferes with many central nervous system processes. Withdrawal and listlessness reduce the nutritionally deprived child’s ability to pay attention, explore, and evoke sensitive caregiving from parents, whose lives are already disrupted by poverty and stressful living conditions (Corapci, Radan, & Lozoff, 2006; Grantham-McGregor & Ani, 2001). For this reason, interventions for malnourished children must improve the family situation as well as the child’s nutrition.

Inadequate nutrition is not confined to developing countries. Because government-supported supplementary food programs do not reach all families in need, an estimated 22 percent of U.S. children suffer from food insecurity—uncertain access to enough food for a healthy, active life. Food insecurity is especially high among single-parent families (35 percent) and low-income ethnic minority families—for example, Hispanics and African Americans (23 and 25 percent, respectively) (U.S. Department of Agriculture, 2013). Although few of these children have marasmus or kwashiorkor, their physical growth and ability to learn are still affected.
Learning Capacities

Learning refers to changes in behavior as the result of experience. Babies come into the world with built-in learning capacities that permit them to profit from experience immediately. Infants are capable of two basic forms of learning, which we introduced in Chapter 1: classical and operant conditioning. They also learn through their natural preference for novel stimulation. Finally, shortly after birth, babies learn by observing others; they can imitate the facial expressions and gestures of adults.

Classical Conditioning

Newborn reflexes, discussed in Chapter 4, make classical conditioning possible in the young infant. In this form of learning, a neutral stimulus is paired with a stimulus that leads to a reflexive response. Once the baby's nervous system makes the connection between the two stimuli, the neutral stimulus produces the behavior by itself. Classical conditioning helps infants recognize which events usually occur together in the everyday world, so they can anticipate what is about to happen next. As a result, the environment becomes more orderly and predictable. Let's take a closer look at the steps of classical conditioning.

Emotional Well-Being

We may not think of affection as necessary for healthy physical growth, but it is as vital as food. Growth faltering is a term applied to infants whose weight, height, and head circumference are substantially below age-related growth norms and who are withdrawn and apathetic (Black, 2005). In as many as half such cases, a disturbed parent–infant relationship contributes to this failure to grow normally.

Lana, an observant nurse at a public health clinic, became concerned about 8-month-old Melanie, who was 3 pounds lighter than she had been at her last checkup. Lana noted that Melanie kept her eyes on nearby adults, anxiously watching their every move, and rarely smiled at her mother. During feeding and diaper changing, Melanie's mother sometimes appeared depressed and distant, at other times impatient and hostile. Melanie tried to protect herself by tracking her mother's whereabouts and, when she approached, avoiding her gaze.

Often an unhappy marriage and parental psychological disturbance contribute to these serious caregiving problems. And most of the time, the baby is irritable and displays abnormal feeding behaviors, such as poor sucking or vomiting, that both disrupt growth and lead parents to feel anxious and helpless, which stress the parent–infant relationship further (Batchelor, 2008; Linscheid, Budd, & Rasnake, 2005).

In Melanie's case, her alcoholic father was out of work, and her parents argued constantly. Melanie's mother had little energy to meet Melanie's psychological needs. When treated early, by intervening in infant feeding problems, helping parents with their own life challenges, and encouraging sensitive caregiving, babies show quick catch-up growth. But if the disorder is not corrected in infancy, most of these children remain small and show lasting cognitive and emotional difficulties (Black et al., 2007; Crookston et al., 2013).

Ask Yourself

- **REVIEW** Explain why breastfeeding can have lifelong consequences for the development of babies born in poverty-stricken regions of the world.
- **CONNECT** How are bidirectional influences between parent and child involved in the impact of malnutrition on psychological development? After her adoption, how did those influences change for Grace?
- **APPLY** Eight-month-old Shaun is well below average in height and painfully thin. He cries during feedings and is listless and irritable. Shaun’s single mother feels overwhelmed and discouraged. Why do Shaun and his mother need intervention quickly? What should health professionals do?
- **REFLECT** Imagine that you are the parent of a newborn baby. Describe feeding practices you would use, and ones you would avoid, to prevent overweight and obesity.

5.5 Describe infant learning capacities, the conditions under which they occur, and the unique value of each.
As Carolyn settled down in the rocking chair to nurse Caitlin, she often stroked Caitlin's forehead. Soon Carolyn noticed that each time she did this, Caitlin made active sucking movements. Caitlin had been classically conditioned. Figure 5.9 shows how it happened:

1. Before learning takes place, an unconditioned stimulus (UCS) must consistently produce a reflexive, or unconditioned, response (UCR). In Caitlin's case, sweet breast milk (UCS) resulted in sucking (UCR).

2. To produce learning, a neutral stimulus that does not lead to the reflex is presented just before, or at about the same time as, the UCS. Carolyn stroked Caitlin's forehead as each nursing period began. The stroking (neutral stimulus) was paired with the taste of milk (UCS).

3. If learning has occurred, the neutral stimulus alone produces a response similar to the reflexive response. The neutral stimulus is then called a conditioned stimulus (CS), and the response it elicits is called a conditioned response (CR). We know that Caitlin has been classically conditioned because stroking her forehead outside the feeding situation (CS) results in sucking (CR).

If the CS is presented alone enough times, without being paired with the UCS, the CR will no longer occur, an outcome called extinction. In other words, if Carolyn repeatedly strokes Caitlin's forehead without feeding her, Caitlin will gradually stop sucking in response to stroking.

Young infants can be classically conditioned most easily when the association between two stimuli has survival value. In the example just described, learning which stimuli regularly accompany feeding improves the infant's ability to get food and survive (Blass, Ganchrow, & Steiner, 1984).

In contrast, some responses, such as fear, are very difficult to classically condition in young babies. Until infants have the motor skills to escape unpleasant events, they have no biological need to form these associations. After age 6 months, however, fear is easy to condition. **TAKE A MOMENT...** Return to Chapter 1 to review John Watson's well-known experiment in which he conditioned Little Albert to withdraw and cry at the sight of a furry white rat. Then test your knowledge of classical conditioning by identifying the UCS, UCR, CS, and CR in Watson's study.
Operant Conditioning

In classical conditioning, babies build expectations about stimulus events in the environment, but they do not influence the stimuli that occur. In operant conditioning, infants act, or operate, on the environment, and stimuli that follow their behavior change the probability that the behavior will occur again. A stimulus that increases the occurrence of a response is called a reinforcer. For example, sweet liquid reinforces the sucking response in newborns. Removing a desirable stimulus or presenting an unpleasant one to decrease the occurrence of a response is called punishment. A sour-tasting fluid punishes newborn babies’ sucking response, causing them to purse their lips and stop sucking entirely.

Many stimuli besides food can serve as reinforcers of infant behavior. For example, newborns will suck faster on a nipple that produces interesting sights and sounds, including visual designs, music, or human voices (Floccia, Christophe, & Bertoncini, 1997). Even preterm babies will seek reinforcing stimulation. In one study, they increased their contact with a soft teddy bear that “breathed” at a rate reflecting the infant’s respiration, whereas they decreased their contact with a nonbreathing bear (Thoman & Ingersoll, 1993). As these findings suggest, operant conditioning is a powerful tool for finding out what stimuli babies can perceive and which ones they prefer.

As infants get older, operant conditioning expands to include a wider range of responses and stimuli. For example, researchers have hung special mobiles over the cribs of 2- to 6-month-olds. When the baby’s foot is attached to the mobile with a long cord, the infant can, by kicking, make the mobile turn. Under these conditions, it takes only a few minutes for infants to start kicking vigorously (Rovee-Collier, 1999; Rovee-Collier & Barr, 2001). As you will see in Chapter 6, operant conditioning with mobiles is frequently used to study infants’ memory and their ability to group similar stimuli into categories. Once babies learn the kicking response, researchers see how long and under what conditions they retain it when exposed again to the original mobile or to mobiles with varying features.

Operant conditioning also plays a vital role in the formation of social relationships. As the baby gazes into the adult’s eyes, the adult looks and smiles back, and then the infant looks and smiles again. As the behavior of each partner reinforces the other, both continue their pleasurable interaction. In Chapter 7, we will see that this contingent responsiveness contributes to the development of infant–caregiver attachment.

Habituation

At birth, the human brain is set up to be attracted to novelty. Infants tend to respond more strongly to a new element that has entered their environment, an inclination that ensures that they will continually add to their knowledge base. Habituation refers to a gradual reduction in the strength of a response due to repetitive stimulation. Time spent looking at the stimulus, heart rate, respiration rate, and brain activity may all decline, indicating a loss of interest. Once this has occurred, a new stimulus—a change in the environment—causes responsiveness to return to a high level, an increase called recovery. For example, when you walk through a familiar space, you notice things that are new and different—a recently hung picture on the wall or a piece of furniture that has been moved. Habituation and recovery promote learning by focusing our attention on those aspects of the environment we know least about.

Researchers studying infants’ understanding of the world rely on habituation and recovery more than any other learning capacity. For example, a baby who first habituates to a visual pattern (a photo of a baby) and then recovers to a new one (a photo of a bald man) appears to remember the first stimulus and perceive the second one as new and different from it. This method of studying infant perception and cognition, illustrated in Figure 5.10, can be used with newborns, including preterm infants (Kavšek & Bornstein, 2010). It has even been used to study the fetus’s sensitivity to external stimuli in the third trimester of pregnancy—for example, by measuring changes in fetal heart rate or brain waves when various repeated sounds are presented, followed by a different sound (see Chapter 3).
Recovery to a new stimulus, or novelty preference, assesses infants’ recent memory. **TAKE A MOMENT…** Think about what happens when you return to a place you have not seen for a long time. Instead of attending to novelty, you are likely to focus on aspects that are familiar: “I recognize that—I’ve been here before!” Like adults, infants shift from a novelty preference to a familiarity preference as more time intervenes between habituation and test phases in research. That is, babies recover to the familiar stimulus rather than to a novel stimulus (see Figure 5.10) (Colombo, Brez, & Curtindale, 2013; Courage & Howe, 1998; Flom & Bahrick, 2010; Richmond, Colombo, & Hayne, 2007). By focusing on that shift, researchers can also use habituation to assess remote memory, or memory for stimuli to which infants were exposed weeks or months earlier.

With age, babies habituate and recover to stimuli more quickly, indicating that they process information more efficiently. Habituation and recovery have been used to assess a wide range of infant perceptual and cognitive capacities—speech perception, musical and visual pattern perception, object perception, categorization, and knowledge of the social world. But despite the strengths of habituation research, its findings are not clear-cut. When looking, sucking, heart rate, or brain activity declines and recovers, what babies actually know about the stimuli to which they responded is uncertain. We will return to this difficulty in Chapter 6.

**Imitation**

Babies come into the world with a primitive ability to learn through imitation—by copying the behavior of another person. For example, Figure 5.11 on page 180 shows a human newborn imitating two adult facial expressions (Meltzoff & Moore, 1977). The newborn’s capacity to imitate extends to certain gestures, such as head and index-finger movements, and has been demonstrated in many ethnic groups and cultures (Meltzoff & Kuhl, 1994; Nagy et al., 2005). As the figure reveals, even newborn primates, including chimpanzees (our closest evolutionary relatives), imitate some behaviors (Ferrari et al., 2006; Myowa-Yamakoshi et al., 2004).

Nevertheless, some studies have failed to reproduce the human findings (see, for example, Anisfeld, 2005). And because newborn mouth and tongue movements occur with increased frequency to almost any arousing change in stimulation (such as lively music or flashing lights), some researchers argue that certain newborn “imitative” responses are actually mouthing—a common early exploratory response to interesting stimuli (Jones, 2009). Furthermore, imitation is harder to induce in babies 2 to 3 months old than just after birth. Therefore, skeptics believe that the newborn imitative response is little more than an automatic response that declines with age, much like a reflex (Heyes, 2005).

Others claim that newborns imitate a variety of facial expressions and head movements with effort and determination, even after short delays—when the adult is no longer demonstrating the behavior (Hayne, 2002; Meltzoff & Moore, 1999; Paukner, Ferrari, & Suomi, 2011). Furthermore, these investigators argue that imitation—unlike reflexes—does not decline. Rather, they claim, human babies several months old often do not imitate an adult’s behavior right away because they first try to play familiar social games—mutual gazing, cooing, smiling, and waving their arms. But when an adult models a gesture repeatedly, older human infants soon get down to business and imitate (Meltzoff & Moore, 1994). Similarly, imitation declines in baby chimps around 9 weeks of age, when mother–baby mutual gazing and other face-to-face exchanges increase.

According to Andrew Meltzoff, newborns imitate much as older children and adults do—by actively trying to match body movements they see with ones they feel they themselves make.
Later we will encounter evidence that young babies are remarkably adept at coordinating information across sensory systems.

Scientists have identified specialized cells in motor areas of the cerebral cortex in primates—called **mirror neurons**—that may underlie early imitative capacities (Ferrari & Coudé, 2011). Mirror neurons fire identically when a primate hears or sees an action and when it carries out that action on its own (Rizzolatti & Craighero, 2004). Humans have especially elaborate neural mirroring systems, which enable us to observe another person’s behavior (such as smiling or throwing a ball) while simulating the behavior in our own brain. These systems are believed to be the biological basis of a variety of interrelated, complex social abilities, including imitation, empathic sharing of emotions, and understanding others’ intentions (Iacoboni, 2009; Schulte-Ruther et al., 2007).

Brain-imaging findings support functioning neural mirroring systems in human infants as early as 6 months of age. Using NIRS, researchers found that the same motor areas of the cerebral cortex were activated in 6-month-olds and in adults when they observed a model engage in a behavior that could be imitated (tapping a box to make a toy pop out) as when they themselves engaged in the motor action (Shimada & Hiraki, 2006). In contrast, when infants and adults observed an object that appeared to move on its own, without human intervention (a ball hanging from the ceiling on a string, swinging like a pendulum), motor areas were not activated.

Still, Meltzoff’s view of newborn imitation as a flexible, voluntary capacity remains controversial. Some critics contend that babies learn to imitate gradually through rich social experiences (Ray & Hayes, 2011). And even researchers who believe that newborns can imitate agree that many opportunities to see oneself act, to watch others’ responses, and to engage in imitative games with caregivers are required for infants to become proficient imitators (Marshall & Meltzoff, 2011). Consistent with this view, human neural mirroring systems, though possibly functional at birth, undergo an extended period of development (Ferrari et al., 2013; Heyes, 2010). And as we will see in Chapter 6, the capacity to imitate expands greatly over the first two years.

However limited it is at birth, imitation is a powerful means of learning. Using imitation, infants explore their social world, learning from other people. As they notice similarities between their own actions and those of others, they experience other people as “like me” and learn about themselves (Meltzoff, 2007). By tapping into infants’ ability to imitate, adults can get infants to exhibit desirable behaviors. Finally, caregivers take great pleasure in a baby who participates in imitative exchanges—a capacity that strengthens the parent–infant bond.
Motor Development

Carolyn, Monica, and Vanessa each kept a baby book, filled with proud notations about when their children held up their heads, reached for objects, sat by themselves, and walked alone. Parents are understandably excited about these new motor skills, which allow babies to master their bodies and the environment in new ways. For example, sitting upright gives infants a new perspective on the world. Reaching permits babies to find out about objects by acting on them. And when infants can move on their own, their opportunities for exploration multiply.

Babies' motor achievements have a powerful effect on their social relationships. When Caitlin crawled at 7½ months, Carolyn and David began to restrict her movements by saying no and expressing mild impatience. When she walked three days after her first birthday, the first “testing of wills” occurred (Biringen et al., 1995). Despite her mother’s warnings, she sometimes pulled items from shelves that were off limits. “I said, ‘Don't do that!’” Carolyn would repeat firmly, taking Caitlin's hand and redirecting her attention.

At the same time, newly walking babies more actively attend to and initiate social interaction (Clearfield, 2011; Karasik et al., 2011). Caitlin frequently toddled over to her parents to express a greeting, give a hug, or show them an object of interest. Carolyn and David, in turn, increased their verbal responsiveness, expressions of affection, and playful activities. Caitlin’s delight as she worked on new motor skills triggered pleasurable reactions in others, which encouraged her efforts further (Mayes & Zigler, 1992). Motor, social, cognitive, and language competencies developed together and supported one another.

The Sequence of Motor Development

Gross-motor development refers to control over actions that help infants get around in the environment, such as crawling, standing, and walking. Fine-motor development has to do with smaller movements, such as reaching and grasping. Table 5.2 on page 182 shows the average ages at which U.S. infants and toddlers achieve a variety of gross- and fine-motor skills. It also presents the age range during which most babies accomplish each skill, indicating large individual differences in rate of motor progress. Also, a baby who is a late reacher will not necessarily be a late crawler or walker. We would be concerned about a child’s development only if many motor skills were seriously delayed.

Historically, researchers assumed that the motor milestones listed in Table 5.2 are separate, innate abilities that emerge in a fixed sequence governed by a built-in maturational timetable. This view has long been discredited. Rather, motor skills are interrelated: Each is a product of earlier motor attainments and a contributor to new ones. And children acquire motor skills in highly individual ways. For example, before her adoption, Grace spent most of her days lying in a hammock. Because she was rarely placed on her tummy and on firm surfaces that enabled her to move on her own, she did not try to crawl. As a result, she pulled to a stand and walked before she crawled! Babies display such skills as rolling, sitting, crawling, and walking in diverse orders rather than in the sequence implied by motor norms (Adolph, Karasik, & Tamis-LeMonda, 2010).

Many influences—both internal and external to the child—join together to support the vast transformations in motor competencies of the first two years. The dynamic systems perspective, introduced in Chapter 1, helps us understand how motor development takes place.

Motor Skills as Dynamic Systems

According to the dynamic systems theory of motor development, mastery of motor skills involves acquiring increasingly complex systems of action. When motor skills work as a system, separate abilities blend together, each cooperating with others to produce more effective ways of exploring and controlling the environment. For example, control of the head and upper chest combine into sitting with support. Kicking, rocking on all fours, and reaching combine...
Each new skill is a joint product of the following factors: (1) central nervous system development, (2) the body’s movement capacities, (3) the goals the child has in mind, and (4) environmental supports for the skill. Change in any element makes the system less stable, and the child starts to explore and select new, more effective motor patterns. The factors that induce change vary with age. In the early weeks of life, brain and body growth are especially important as infants achieve control over the head, shoulders, and upper torso. Later, the baby’s goals (getting a toy or crossing the room) and environmental supports (parental encouragement, objects in the infants’ everyday setting) play a greater role.

The broader physical environment also profoundly influences motor skills. Infants with stairs in their home learn to crawl up stairs at an earlier age and also more readily master a back-descent strategy—the safest but also the most challenging position because the baby must turn around at the top, give up visual guidance of her goal, and crawl backward (Berger, Theuring, & Adolph, 2007). And if children were reared on the moon with its reduced gravity, they would prefer jumping to walking or running!

When a skill is first acquired, infants must refine it. For example, in trying to crawl, Caitlin often collapsed on her tummy and moved backward. Soon she figured out how to propel herself forward by alternately pulling with her arms and pushing with her feet, “belly-crawling” in various ways for several weeks. As they attempt a new skill, most babies move back and forth between its presence and absence: An infant might roll over, sit, crawl, or take a few steps but not do so again until the following week. And related, previously mastered skills often become less secure. As the novice walker experiments with balancing the body vertically over two small moving feet, balance during sitting may become temporarily less stable (Chen et al.,

**TABLE 5.2** Gross- and Fine-Motor Development in the First Two Years

<table>
<thead>
<tr>
<th>MOTOR SKILL</th>
<th>AVERAGE AGE ACHIEVED</th>
<th>AGE RANGE IN WHICH 90 PERCENT OF INFANTS ACHIEVE THE SKILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>When held upright, holds head erect and steady</td>
<td>6 weeks</td>
<td>3 weeks–4 months</td>
</tr>
<tr>
<td>When prone, lifts self by arms</td>
<td>2 months</td>
<td>3 weeks–4 months</td>
</tr>
<tr>
<td>Rolls from side to back</td>
<td>2 months</td>
<td>3 weeks–5 months</td>
</tr>
<tr>
<td>Grasps cube</td>
<td>3 months, 3 weeks</td>
<td>2–7 months</td>
</tr>
<tr>
<td>Rolls from back to side</td>
<td>4½ months</td>
<td>2–7 months</td>
</tr>
<tr>
<td>Sits alone</td>
<td>7 months</td>
<td>5–9 months</td>
</tr>
<tr>
<td>Crawls</td>
<td>7 months</td>
<td>5–11 months</td>
</tr>
<tr>
<td>Pulls to stand</td>
<td>8 months</td>
<td>5–12 months</td>
</tr>
<tr>
<td>Plays pat-a-cake</td>
<td>9 months, 3 weeks</td>
<td>7–15 months</td>
</tr>
<tr>
<td>Stands alone</td>
<td>11 months</td>
<td>9–16 months</td>
</tr>
<tr>
<td>Walks alone</td>
<td>11 months, 3 weeks</td>
<td>9–17 months</td>
</tr>
<tr>
<td>Builds tower of two cubes</td>
<td>11 months, 3 weeks</td>
<td>10–19 months</td>
</tr>
<tr>
<td>Scribbles vigorously</td>
<td>14 months</td>
<td>10–21 months</td>
</tr>
<tr>
<td>Walks up stairs with help</td>
<td>16 months</td>
<td>12–23 months</td>
</tr>
<tr>
<td>Jumps in place</td>
<td>23 months, 2 weeks</td>
<td>17–30 months</td>
</tr>
<tr>
<td>Walks on tiptoe</td>
<td>25 months</td>
<td>16–30 months</td>
</tr>
</tbody>
</table>

*Note: These milestones represent overall age trends. Individual differences exist in the precise age at which each milestone is attained.*

2007). This variability is evidence of loss of stability in the system—in dynamic systems theory, a necessary transition between a less mature and a more mature stable state.

Motor mastery involves intense practice. In learning to walk, for example, toddlers practice six or more hours a day, traveling the length of 29 football fields! They fall, on average, 32 times per hour but rarely cry, returning to motion within a few seconds (Adolph et al., 2012). Gradually their small, unsteady steps change to a longer stride, their feet move closer together, their toes point to the front, and their legs become symmetrically coordinated (Adolph, Vereijken, & Shrout, 2003). As movements are repeated thousands of times, they promote new synaptic connections in the brain that govern motor patterns.

In tackling challenging motor tasks, babies are steadfast problem solvers, taking into account multiple sources of information. They explore ways of adapting to varied surfaces and openings, such as sliding down a steep slope and turning sideways to fit through a narrow doorway (Franchak & Adolph, 2012; Gill, Adolph, & Vereijken, 2009). And when conditions are uncertain—for instance, a ledge that may not be passable—toddlers are more likely to back off when the penalty for error is high (a fall). In these situations, they also place greater weight on caregivers’ advice (Adolph et al., 2010). If their mother says “go,” they usually proceed; if she says “no,” they avoid.

Dynamic systems theory shows us why motor development cannot be genetically determined. Because it is motivated by exploration and the desire to master new tasks and varies with context, heredity can map it out only at a general level. Rather than being hardwired into the nervous system, motor behaviors are softly assembled from multiple components, allowing for different paths to the same motor skill (Spencer, Perone, & Buss, 2011; Thelen & Smith, 2006).

Dynamic Motor Systems in Action

To find out how infants acquire motor capacities, researchers conduct microgenetic studies (see Chapter 1), following babies from their first attempts at a skill until it becomes smooth and effortless. Using this strategy, James Galloway and Esther Thelen (2004) held sounding toys alternately in front of infants’ hands and feet, from the time they first showed interest until they engaged in well-coordinated reaching and grasping. As Figure 5.12 illustrates, the infants violated the normative sequence of arm and hand control preceding leg and foot control, shown in Table 5.2. They first explored the toys with their feet—as early as 8 weeks of age, at least a month before reaching with their hands!

Why did babies reach “feet first”? Because the hip joint constrains the legs to move less freely than the shoulder joint constrains the arms, infants could more easily control their leg movements. Consequently, foot reaching required far less practice than hand reaching. As these findings confirm, rather than following a strict, predetermined pattern, the order in which motor skills develop depends on the anatomy of the body part being used, the surrounding environment, and the baby’s efforts.

Furthermore, in building a more effective dynamic system, babies often use advances in one motor skill to support advances in others. For example, beginning to walk frees the hands for carrying, and new walkers like to fetch distant objects and transport them—often just for the fun of carrying but also to share with their caregivers (Karasik, Tamis-LeMonda, & Adolph, 2011). Observations of new walkers reveal that, surprisingly, they fall less often when carrying objects than when their hands are empty (Karasik et al., 2012). Even though combining walking with carrying is a more attention-demanding task, toddlers integrate object carrying into their emerging “walking system,” using it to improve their balance (see Figure 5.13 on page 184).
Cultural Variations in Motor Development

Cross-cultural research further illustrates how early movement opportunities and a stimulating environment contribute to motor development. Half a century ago, Wayne Dennis (1960) observed infants in Iranian orphanages who were deprived of the tantalizing surroundings that induce infants to acquire motor skills. These babies spent their days lying on their backs in cribs, without toys to play with—conditions far worse than Grace experienced lying in a hammock in her Cambodian home. As a result, most did not move on their own until after 2 years of age. When they finally did move, the constant experience of lying on their backs led them to scoot in a sitting position rather than crawl on their hands and knees. Because babies who scoot come up against furniture with their feet (not their hands), they are far less likely to pull themselves to a standing position in preparation for walking. Indeed, by 3 to 4 years of age, only 15 percent of the Iranian orphans were walking alone.

Cultural variations in infant-rearing practices also affect motor development. **TAKE A MOMENT...** Take a quick survey of several parents you know: Should sitting, crawling, and walking be deliberately encouraged? Answers vary widely from culture to culture. Japanese mothers, for example, believe such efforts are unnecessary (Seymour, 1999). Among the Zinacanteco Indians of southern Mexico and the Gusii of Kenya, rapid motor progress is actively discouraged. Babies who walk before they know enough to keep away from cooking fires and weaving looms are viewed as dangerous to themselves and disruptive to others (Greenfield, 1992).

In contrast, among the Kipsigis of Kenya and the West Indians of Jamaica, babies hold their heads up, sit alone, and walk considerably earlier than North American infants. In both societies, parents emphasize early motor maturity, practicing formal exercises to stimulate particular skills (Adolph, Karasik, & Tamis-LeMonda, 2010). In the first few months, babies are seated in holes dug in the ground, with rolled blankets to keep them upright. Walking is promoted by frequently standing babies in adults’ laps, bouncing them on their feet, and exercising the stepping reflex (see Chapter 4) (Hopkins & Westra, 1988; Super, 1981). As parents in these cultures support babies in upright postures and rarely put them down on the floor, their infants usually skip crawling—a motor skill regarded as crucial in Western nations!

Finally, because it decreases exposure to “tummy time,” the current Western practice of having babies sleep on their backs to protect them from SIDS delays gross-motor milestones of rolling, sitting, and...
crawling (Scrutton, 2005). Regularly exposing infants to the tummy-lying position during waking hours prevents these delays.

**Fine-Motor Development: Reaching and Grasping**

Of all motor skills, reaching may play the greatest role in infant cognitive development. By grasping things, turning them over, and seeing what happens when they are released, infants learn a great deal about the sights, sounds, and feel of objects.

Reaching and grasping, like many other motor skills, start out as gross, diffuse activity and move toward mastery of fine movements. Figure 5.14 illustrates some milestones of reaching over the first nine months. Newborns will actively work to bring their hands into their field of vision: In a dimly lit room, they keep their hand within a narrow beam of light, moving the hand when the light beam moves (van der Meer, 1997). Newborns also make poorly coordinated swipes, called **prereaching**, toward an object in front of them, but because of poor arm and hand control they rarely contact the object. Like newborn reflexes, prereaching drops out around 7 weeks of age, when babies improve in eye movements involved in tracking and fixating on objects, which are essential for accurate reaching (von Hofsten, 2004). Yet these early behaviors suggest that babies are biologically prepared to coordinate hand with eye in the act of exploring.

**DEVELOPMENT OF REACHING AND GRASPING** At about 3 to 4 months, as infants develop the necessary eye, head, and shoulder control, reaching reappears as purposeful, forward arm movements in the presence of a nearby toy and gradually improves in accuracy (Bhat, Heathcock, & Galloway, 2005). By 5 to 6 months, infants reach for an object in a room that has been darkened during the reach by switching off the lights—a skill that improves over the next few months (Clifton et al., 1994; McCarty & Ashmead, 1999). This indicates that the baby does not need to use vision to guide the arms and hands in reaching. Rather, reaching is largely controlled by **proprioception**—our sense of movement and location in space, arising from stimuli within the body. When vision is freed from the basic act of reaching, it can focus on more complex adjustments, such as fine-tuning actions to fit the distance and shape of objects.

Reaching improves as depth perception advances and as infants gain greater control of body posture and arm and hand movements. Four-month-olds aim their reaches ahead of a moving object so they can catch it (von Hofsten, 1993). Around 5 months, babies reduce their efforts when an object is moved beyond their reach (Robin, Berthier, & Clifton, 1996). By 7 months, the arms become more independent: Infants reach for an object by extending one arm rather than both (Fagard & Pezé, 1997). During the next few months, infants become more efficient at reaching for moving objects—ones that spin, change direction, and move

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### Figure 5.14
**Some milestones of reaching and grasping.** The average age at which each skill is attained is given. (Ages from Bayley, 1969; Rochat, 1989.)
Once infants can reach, they increase the quantity and variety of their exploratory behaviors with objects— mouthing, fingering, looking, and combining these actions (Lobo & Galloway, 2013). They also modify their grasp. The newborn’s grasp reflex is replaced by the ulnar grasp, a clumsy motion in which the young infant’s fingers close against the palm. Still, even 4- to 5-month-olds modify their grasp to suit an object’s size, shape, and texture (rigid versus soft)— a capacity that improves over the second half-year as infants adjust the hand more precisely and do so in advance of contacting the object (Cicuto et al., 2012; Witherington, 2005).

Around 4 to 5 months, when infants begin to sit up, both hands become coordinated in exploring objects. Babies of this age can hold an object in one hand while the other scans it with the tips of the fingers, and they frequently transfer objects from hand to hand (Rochat & Goubet, 1995). By the end of the first year, infants use the thumb and index finger in a well-coordinated pincer grasp. Then the ability to manipulate objects greatly expands. The 1-year-old can pick up raisins and blades of grass, turn knobs, and open and close small boxes.

Between 8 and 11 months, reaching and grasping are well-practiced. As a result, attention is released from the motor skill to events that occur before and after obtaining the object. For example, 10-month-olds easily modify their reach to anticipate their next action. They reach for a ball faster when they intend to throw it than when they intend to drop it carefully through a narrow tube (Claxton, Keen, & McCarty, 2003). Around this time, too, infants begin to solve simple problems that involve reaching, such as searching for and finding a hidden toy.

Finally, the capacity to reach for and manipulate an object increases infants’ attention to the way an adult reaches for and plays with that same object (Hauf, Aschersleben, & Prinz, 2007). As babies watch what others do, they broaden their understanding of others’ behaviors and of the range of actions that can be performed on various objects, gradually incorporating those possibilities into their own object-related behaviors.

**EARLY EXPERIENCE AND REACHING** Like other motor milestones, reaching is affected by early experience. In cultures where mothers carry their infants on their hips or in slings for most of the day, babies have rich opportunities to explore with their hands. Among the !Kung of Botswana, infants grasp their mothers’ colorful, beaded necklaces to steady themselves while breastfeeding as the mother moves. While riding along, they also frequently swipe at and manipulate their mother’s jewelry and other dangling objects (Konner, 1977). As a result, !Kung infants are advanced in development of reaching and grasping. And because babies of Mali and Uganda spend half or more of their day held in sitting or standing positions, which facilitate reaching, they, too, develop manual skills earlier than Western infants, who spend much of their day lying down (Adolph, Karasik, & Tamis-LeMonda, 2010).

Babies’ visual surroundings are also influential. In a well-known study, institutionalized infants given a moderate amount of visual stimulation—at first, simple designs and, later, a mobile hung over their crib—reached for objects six weeks earlier than infants given nothing to look at. A third group given massive stimulation—patterned crib bumpers and mobiles at an early age— also reached sooner than unstimulated babies. But this heavy enrichment took its toll. These infants looked away and cried a great deal, and they were less advanced in reaching than the moderately stimulated group (White & Held, 1966). Recall from our discussion of brain development that more stimulation is not necessarily better. Trying to push infants beyond their readiness to handle stimulation can undermine the development of important motor skills.
Perceptual Development

In Chapter 4, you learned that the senses of touch, taste, smell, and hearing—but not vision—are remarkably well-developed at birth. Now let’s turn to a related question: How does perception change over the first year? Our discussion will address hearing and vision, the focus of almost all research. Unfortunately, little evidence exists on how touch, taste, and smell develop after birth. Also, in Chapter 4 we used the word sensation to talk about these capacities. It suggests a fairly passive process—what the baby’s receptors detect when exposed to stimulation. Now we use the word perception, which is active: When we perceive, we organize and interpret what we see.

As we review the perceptual achievements of infancy, you may find it hard to tell where perception leaves off and thinking begins. The research we are about to discuss provides an excellent bridge to the topic of Chapter 6—cognitive development during the first two years.

Hearing

On Timmy’s first birthday, Vanessa bought several CDs of nursery songs, and she turned one on each afternoon at naptime. Soon Timmy let her know his favorite tune. If she put on “Twinkle, Twinkle,” he stood up in his crib and whimpered until she replaced it with “Jack and Jill.” Timmy’s behavior illustrates the greatest change in hearing over the first year of life: Babies start to organize sounds into complex patterns.

Between 4 and 7 months, infants display a sense of musical phrasing. They prefer Mozart minuets with pauses between phrases to those with awkward breaks (Krumhansl & Jusczyk, 1990). Around 6 to 7 months, they can distinguish musical tunes on the basis of variations in rhythmic patterns, including beat structure (duple or triple) and accent structure (emphasis on the first note of every beat unit or at other positions) (Hannon & Johnson, 2004). They are also sensitive to features conveying the purpose of familiar types of songs, preferring to listen to high-pitched playsongs (aimed at entertaining) and low-pitched lullabies (used to soothe) (Tsang & Conrad, 2010). By the end of the first year, infants recognize the same melody when it is played in different keys (Trehub, 2001). As we will see next, 6- to 12-month-olds make comparable discriminations in human speech: They readily detect sound regularities, which will facilitate later language learning.

SPEECH PERCEPTION  Recall from Chapter 4 that newborns can distinguish nearly all sounds in human languages and that they prefer listening to speech over nonspeech sounds and to their native tongue rather than a rhythmically distinct foreign language. Brain-imaging evidence reveals that in young infants, discrimination of speech sounds activates both auditory and motor areas in the cerebral cortex (Kuhl et al., 2014). Researchers speculate that while perceiving speech sounds, babies also generate internal motor plans that prepare them for producing those sounds.

As infants listen to people talk, they learn to focus on meaningful sound variations. ERP brain-wave recordings reveal that around 5 months, infants become sensitive to syllable stress patterns in their own language (Weber et al., 2004). Between 6 and 8 months, they start to “screen out” sounds not used in their native tongue and, in the case of bilingual infants, in both native languages (Albareda-Castellot, Pons, & Sebastián-Gallés, 2010; Curtin & Werker, 2007). As the Biology and Environment box on page 188 explains, this increased responsiveness to native-language sounds is part of a general “tuning” process in the second half of the first year—a possible sensitive period in which babies acquire a range of perceptual skills for picking up socially important information.

Soon after, infants focus on larger speech units that are critical to figuring out meaning. They recognize familiar words in spoken passages and listen longer to speech with clear clause and phrase boundaries (Johnson & Seidl, 2008; Soderstrom et al., 2003). Around 7 to 9 months, infants extend this sensitivity to speech structure to individual words: They begin to divide the speech stream into wordlike units (Jusczyk, 2002; Saffran, Werker, & Werner, 2006).
Specific Learning and Music: A Sensitive Period for Culture-
“Tuning in” to Familiar Speech, Faces, and Music

To share experiences with members of their family and community, babies must become skilled at making perceptual discriminations that are meaningful in their culture. As we have seen, at first babies are sensitive to virtually all speech sounds but, around 6 months, they narrow their focus, limiting the distinctions they make to the language they hear and will soon learn.

The ability to perceive faces shows a similar perceptual narrowing effect—perceptual sensitivity that becomes increasingly attuned with age to information most often encountered. After habituating to one member of each pair of faces in Figure 5.15, 6-month-olds were shown the familiar face and the novel face side by side. For both pairs, they recovered to (looked longer at) the novel face, indicating that they could discriminate the individual faces of both humans and monkeys equally well (Pascalis, de Haan, & Nelson, 2002). But at 9 months, infants no longer showed a novelty preference when viewing the monkey pair. Like adults, they could distinguish only the human faces. Similar findings emerge with sheep faces: Four- to 6-month-olds easily distinguish them, but 9- to 11-month-olds no longer do (Simpson et al., 2011).

This perceptual narrowing effect appears again in musical rhythm perception. Western adults are accustomed to the even-beat pattern of Western music—repetition of the same rhythmic structure in every measure of a tune—and easily notice rhythmic changes that disrupt this familiar beat. But present them with music that does not follow this typical Western rhythmic form—Baltic folk tunes, for example—and they fail to pick up on rhythmic-pattern deviations. In contrast, 6-month-olds can detect such disruptions in both Western and non-Western melodies. By 12 months, however, after added exposure to Western music, babies are no longer aware of deviations in foreign musical rhythms, although their sensitivity to Western rhythmic structure remains unchanged (Hannon & Trehub, 2005b).

Several weeks of regular interaction with a foreign-language speaker and of daily opportunities to listen to non-Western music fully restore 12-month-olds’ sensitivity to wide-ranging speech sounds and music rhythms (Hannon & Trehub, 2005a; Kuhl, Tsao, & Liu, 2003). Similarly, 6-month-olds given three months of training in discriminating individual monkey faces, in which each image is verbally labeled with a distinct name (“Carlos,” “Iona”) instead of the generic label “monkey,” retain their ability to discriminate monkey faces at 9 months (Scott & Monesson, 2009). Adults given similar extensive experiences, by contrast, show little improvement in perceptual sensitivity.

Taken together, these findings suggest a heightened capacity—or sensitive period—in the second half of the first year, when babies are biologically prepared to “zero in” on socially meaningful perceptual distinctions. Notice how, between 6 and 12 months, learning is especially rapid across several domains (speech, faces, and music) and is easily modified by experience. This suggests a broad neurological change—perhaps a special time of experience-expectant brain growth (see page 169) in which babies analyze everyday stimulation of all kinds similarly, in ways that prepare them to participate in their cultural community.

**ANALYZING THE SPEECH STREAM** How do infants make such rapid progress in perceiving the structure of speech? Research reveals that they have an impressive statistical learning capacity. By analyzing the speech stream for patterns—repeatedly occurring sequences of sounds—they acquire a stock of speech structures for which they will later learn meanings, long before they start to talk around age 12 months.

For example, when presented with controlled sequences of nonsense syllables, babies as young as 5 months listened for statistical regularities: They locate words by discriminating syllables that often occur together (indicating that they belong to the same word) from syllables that seldom occur together (indicating a word boundary) (Johnson & Tyler, 2010). Consider the English word sequence *pretty#baby*. After listening to the speech stream for just one
minute (about 60 words), babies can distinguish a word-internal syllable pair (pretty) from a word-external syllable pair (ty#ba). They prefer to listen to new speech that preserves the word-internal pattern (Saffran, Aslin, & Newport, 1996; Saffran & Thiessen, 2003).

Once infants begin locating words, they focus on the words and discover additional statistical cues that signal word boundaries (Thiessen, Kronstein, & Hufnagle, 2012). For example, 7- to 8-month-olds detect regular syllable-stress patterns—for example, in English and Dutch, that the onset of a strong syllable (hap-py, rab-bit) often signals a new word (Swingley, 2005; Thiessen & Saffran, 2007). By 10 months, babies can detect words that start with weak syllables, such as “surprise,” by listening for sound regularities before and after the words (Kooijman, Hagoort, & Cutler, 2009).

Clearly, babies have a powerful ability to extract patterns from complex, continuous speech. Their remarkable statistical learning capacity also extends to visual stimuli and is present in the first weeks of life (Aslin & Newport, 2012). Statistical learning seems to be a general capacity that infants use to analyze complex stimulation.

By the middle of the first year, infants also attend to regularities in word sequences. In a study using nonsense words, 7-month-olds distinguished the ABA structure of “ga ti ga” and “li na li” from the ABB structure of “wo fe fe” and “ta la la” (Marcus et al., 1999). They seemed to detect simple word-order rules, a capacity that may eventually help them figure out basic grammar. And as with statistical learning, the capacity to extract ABA and ABB rules also applies to sequences of visual stimuli—and to musical stimuli as well (Dawson & Gerken, 2009; Johnson et al., 2009).

Finally, the more rapidly 10-month-olds detect words within the speech stream (as indicated by ERP recordings), the larger their vocabulary at age 2 years (Junge et al., 2012). Certain features of adults’ utterances facilitate such rapid detection. Natural speech, for example, is full of both uninterrupted strings of words and pauses enabling listeners to hear isolated words. Infants exposed to a brief quantity of speech containing both isolated words and the same words embedded in the speech stream ("Doggie!" “See the doggie there?”) are better able to discriminate those words when later exposed to fluent speech (Lew-Williams, Pelucchi, & Saffran, 2011). As we will see in Chapter 6, adults’ style of communicating with infants greatly facilitates analysis of the structure of speech.

Vision

For exploring the environment, humans depend on vision more than any other sense. Although at first a baby’s visual world is fragmented, it undergoes extraordinary changes during the first 7 to 8 months of life.

Visual development is supported by rapid maturation of the eye and visual centers in the cerebral cortex. Recall from Chapter 4 that the newborn baby focuses and perceives color poorly. Around 2 months, infants can focus on objects about as well as adults, and their color vision is adultlike by 4 months (Kellman & Arterberry, 2006). Visual acuity (fineness of discrimination) increases steadily throughout the first year, reaching 20/80 by 6 months and an adult level of about 20/20 by 4 years (Slater et al., 2010). Scanning the environment and tracking moving objects also improve over the first half-year as infants see more clearly and better control their eye movements. In addition, as young infants build an organized perceptual world, they scan more thoroughly and systematically, strategically picking up important information (Johnson, Slemmer, & Amso, 2004; von Hofsten & Rosander, 1998). Consequently, scanning enhances perception, and—in bidirectional fashion—perception also enhances scanning.

As babies explore their visual field, they figure out the characteristics of objects and how they are arranged in space. To understand how they do so, let’s examine the development of three aspects of vision: depth, pattern, and object perception.

**DEPTH PERCEPTION** Depth perception is the ability to judge the distance of objects from one another and from ourselves. It is important for understanding the layout of the environment and for guiding motor activity.
Figure 5.16 shows the visual cliff, designed by Eleanor Gibson and Richard Walk (1960) and used in the earliest studies of depth perception. It consists of a Plexiglas-covered table with a platform at the center, a “shallow” side with a checkerboard pattern just under the glass, and a “deep” side with a checkerboard several feet below the glass. The researchers found that crawling babies readily crossed the shallow side, but most avoided the deep side. They concluded that around the time infants crawl, most distinguish deep from shallow surfaces and steer clear of drop-offs.

The visual cliff shows that crawling and avoidance of drop-offs are linked, but not how they are related or when depth perception first appears. Recent research has looked at babies’ ability to detect specific depth cues, using methods that do not require that they crawl.

**Emergence of Depth Perception** How do we know when an object is near rather than far away? **TAKE A MOMENT...** Try these exercises to find out. Pick up a small object (such as your cup) and move it toward and away from your face. Did its image grow larger as it approached and smaller as it receded? Next time you take a bike or car ride, notice that nearby objects move past your field of vision more quickly than those far away.

**Motion** is the first depth cue to which infants are sensitive. Babies 3 to 4 weeks old blink their eyes defensively when an object moves toward their face as though it is going to hit (Nánez & Yonas, 1994). **Binocular depth cues** arise because our two eyes have slightly different views of the visual field. The brain blends these two images, resulting in perception of depth. Research in which two overlapping images are projected before the baby, who wears special goggles to ensure that each eye receives only one image, reveals that sensitivity to binocular cues emerges between 2 and 3 months and improves rapidly over the first year (Birch, 1993; Brown & Miracle, 2003). Finally, beginning at 3 to 4 months and strengthening between 5 and 7 months, babies display sensitivity to pictorial depth cues—the ones artists often use to make a painting look three-dimensional. Examples include receding lines that create the illusion of perspective, changes in texture (nearby textures are more detailed than faraway ones), overlapping objects (an object partially hidden by another object is perceived to be more distant), and shadows cast on surfaces (indicating a separation in space between the object and the surface) (Kavšek, Yonas, & Granrud, 2012; Shuwairi, Albert, & Johnson, 2007).

Why does perception of depth cues emerge in the order just described? Researchers speculate that motor development is involved. For example, control of the head during the early weeks of life may help babies notice motion and binocular cues. Around 5 to 6 months, the ability to turn, poke, and feel the surface of objects may promote perception of pictorial cues (Bushnell & Boudreau, 1993; Soska, Adolph, & Johnson, 2010). And as we will see next, one aspect of motor progress—**independent movement**—plays a vital role in refinement of depth perception.

**Independent Movement and Depth Perception** At 6 months, Timmy started crawling. “He’s fearless!” exclaimed Vanessa. “If I put him down in the middle of the bed, he crawls right over the edge. The same thing happens by the stairs.” Will Timmy become wary of the side of the bed and the staircase as he becomes a more experienced crawler? Research suggests that he will. Infants with more crawling experience (regardless of when they started to crawl) are far more likely to refuse to cross the deep side of the visual cliff (Campos et al., 2000).

From extensive everyday experience, babies gradually figure out how to use depth cues to detect the danger of falling. But because the loss of body control that leads to falling differs
greatly for each body position, babies must undergo this learning separately for each posture (Adolph & Kretch, 2012). In one study, 9-month-olds, who were experienced sitters but novice crawlers, were placed on the edge of a shallow drop-off that could be widened (Adolph, 2002, 2008). While in the familiar sitting position, infants avoided leaning out for an attractive toy at distances likely to result in falling. But in the unfamiliar crawling position, they headed over the edge, even when the distance was extremely wide! And newly walking babies will step repeatedly over a risky drop-off (Kretch & Adolph, 2013a). They will also careen down slopes and over uneven surfaces without making necessary postural adjustments (Adolph et al., 2008; Joh & Adolph, 2006). Thus, they fall frequently.

Even experienced crawlers and walkers encounter new depth-at-an-edge situations that require additional learning. In one study, researchers encouraged crawling and walking babies to cross bridges varying in width over drop-offs (with an adult following alongside to catch infants if they began to fall). Most avoided crossing impossibly narrow bridges. And the greater their experience, the narrower the bridge both crawlers and walkers attempted to cross. Nevertheless, walkers perceived the likelihood of falling from a narrow bridge more accurately than crawlers. While crossing, crawlers could not easily see and adjust the placement of their hind limbs to prevent falls. In contrast, experienced walkers had figured out how to turn their body to accommodate the narrow passageway (see Figure 5.17) (Kretch & Adolph, 2013b). As infants and toddlers discover how to avoid falling in different postures and situations, their understanding of depth expands.

Independent movement promotes other aspects of three-dimensional understanding. For example, seasoned crawlers are better than their inexperienced agemates at remembering object locations and finding hidden objects (Campos et al., 2000). Why does crawling make such a difference?

TAKE A MOMENT... Compare your own experience of the environment when you are driven from one place to another with what you experience when you walk or drive yourself. When you move on your own, you are much more aware of landmarks and routes of travel, and you take more careful note of what things look like from different points of view. The same is true for infants. In fact, crawling promotes a new level of brain organization, as indicated by more organized EEG brain-wave activity in the cerebral cortex (Bell & Fox, 1996). Perhaps crawling strengthens certain neural connections, especially those involved in vision and understanding of space.

PATTERN PERCEPTION Even newborns prefer to look at patterned rather than plain stimuli (Fantz, 1961). As they get older, infants prefer more complex patterns. For example, 3-week-olds look longest at black-and-white checkerboards with a few large squares, whereas 8- and 14-week-olds prefer those with many squares (Brennan, Ames, & Moore, 1966).

A general principle, called contrast sensitivity, explains early pattern preferences (Banks & Ginsburg, 1985). Contrast refers to the difference in the amount of light between adjacent regions in a pattern. If babies are sensitive to (can detect) the contrast in two or more
patterns, they prefer the one with more contrast. To understand this idea, look at the checkerboards in the top row of Figure 5.18. To us, the one with many small squares has more contrasting elements. Now look at the bottom row, which shows how these checkerboards appear to infants in the first few weeks of life. Because of their poor vision, very young babies cannot resolve the small features in more complex patterns, so they prefer to look at the large, bold checkerboard. Around 2 months, when detection of fine-grained detail has improved, infants become sensitive to the contrast in complex patterns and spend more time looking at them (Gwiazda & Birch, 2001).

**Combining Pattern Elements** In the early weeks of life, infants respond to the separate parts of a pattern. They stare at single high-contrast features, generally on the edges, and have difficulty shifting their gaze away toward other interesting stimuli (Hunnius & Geuze, 2004a, 2004b). At 2 to 3 months, when scanning ability and contrast sensitivity improve, infants thoroughly explore a pattern's internal features, pausing briefly to look at each part (Bronson, 1994).

Once babies can take in all aspects of a pattern, they integrate the parts into a unified whole. Around 4 months, babies are so good at detecting pattern organization that they perceive subjective boundaries that are not really present. For example, they perceive a square in the center of Figure 5.19a, just as you do (Ghim, 1990). And like adults, 3- to 4-month-olds engage in boundary extension: When re-exposed to a photo of a natural scene, they remember it as extending beyond its original boundaries. The visual system seems to interpret the photographed scene like a view through a window, which is understood to extend beyond the edges of the window (Quinn & Intraub, 2007).

Older infants carry this sensitivity to subjective form further. For example, 9-month-olds look much longer at an organized series of moving lights that resembles a human being walking than at an upside-down or scrambled version (Proffitt & Bertenthal, 1990). At 12 months, infants can detect familiar objects represented by incomplete drawings, even when as much as two-thirds of the drawing is missing (see Figure 5.19b) (Rose, Jankowski, & Senior, 1997). As these findings reveal, infants' increasing knowledge of objects and actions supports pattern perception.

**Face Perception** Infants' tendency to search for structure in a patterned stimulus applies to face perception. Newborns prefer to look at photos and simplified drawings of faces with features arranged naturally (upright) rather than unnaturally (upside down or sideways) (see Figure 5.20a and b) (Cassia, Turati, & Simion, 2004; Mondloch et al., 1999). They also track a facelike pattern moving across their visual field farther than they track other stimuli (Johnson, 1999). And although they rely more on outer features (hairline and chin) than inner features to distinguish real faces, newborns prefer photos of faces with eyes open and a direct gaze (Farroni et al., 2002; Turati et al., 2006). Yet another amazing capacity is their tendency to look longer at both human and animal faces judged by adults as attractive—a preference that may be the origin of the widespread social bias favoring physically attractive people (Quinn et al., 2008; Slater et al., 2010).

Some researchers claim that these behaviors reflect a built-in capacity to orient toward members of one's own species, just as many newborn animals do (Johnson, 2001a; Slater et al., 2011). Others assert that newborns simply prefer any stimulus in which
the most salient elements are arranged horizontally in the upper part of a pattern—like the “eyes” in Figure 5.20b. Indeed, newborns do prefer patterns with these characteristics over other arrangements (Cassia, Turati, & Simion, 2004; Simion et al., 2001). Possibly, however, a bias favoring the facial pattern promotes such preferences. Still other researchers argue that newborns are exposed to faces more often than to other stimuli—early experiences that could quickly “wire” the brain to detect faces and prefer attractive ones (Bukacha, Gauthier, & Tarr, 2006).

Although newborns respond to facelike structures, they cannot discriminate a complex facial pattern from other, equally complex patterns (see Figure 5.20c). But from repeated exposures to their mother’s face, they quickly learn to prefer her face to that of an unfamiliar woman, although they mostly attend to its broad outlines. Around 2 months, when they can combine pattern elements into an organized whole, babies prefer a complex drawing of the human face to other equally complex stimulus arrangements (Dannemiller & Stephens, 1988). And they clearly prefer their mother’s detailed facial features to those of another woman (Bartrip, Morton, & de Schonen, 2001).

Around 3 months, infants readily make fine distinctions among the features of different faces—for example, between photographs of two strangers, even when the faces are moderately similar (Farroni et al., 2007). At 5 months, infants perceive emotional expressions as meaningful wholes. They treat positive faces (happy and surprised) as different from negative ones (sad and fearful) (Bornstein & Arterberry, 2003). And by 7 months, they discriminate among a wider range of facial expressions, including happiness, surprise, sadness, fearfulness, and anger (Witherington et al., 2010).

Experience influences face processing, leading babies to form group biases at a tender age. As early as 3 months, infants prefer and more easily discriminate among female faces than among male faces (Quinn et al., 2002; Ramsey-Rennels & Langlois, 2006). The greater time infants spend with female adults explains this effect, since babies with a male primary caregiver prefer male faces. Furthermore, 3- to 6-month-olds exposed mostly to members of their own race prefer to look at the faces of members of that race, and between 6 and 9 months their ability to discriminate other-race faces weakens (Kelly et al., 2007, 2009). This own-race bias is absent in babies who have frequent contact with members of other races or who view picture books of other-race faces, and it can be reversed through exposure to racial diversity (Anzures et al., 2013; Heron-Delaney et al., 2011). **TAKE A MOMENT...** Notice how early experience promotes perceptual narrowing with respect to gender and racial information in faces, as occurs for species information, discussed in the Biology and Environment box on page 188.

Clearly, extensive face-to-face interaction with caregivers contributes to infants’ refinement of face perception. And as babies recognize and respond to the expressive behavior of others, face perception supports their earliest social relationships.

**Object Perception**

Research on pattern perception involves only two-dimensional stimuli, but our environment is made up of stable, three-dimensional objects. Do young infants perceive a world of independently existing objects—knowledge essential for distinguishing among the self, other people, and things?
SIZE AND SHAPE CONSTANCY  As we move around the environment, the images that objects cast on our retina constantly change in size and shape. To perceive objects as stable and unchanging, we must translate these varying retinal images into a single representation.

Size constancy—perception of an object’s size as the same, despite changes in the size of its retinal image—is evident in the first week of life. To test for it, researchers habituated infants to a small cube at varying distances from the eye, in an effort to desensitize them to changes in the cube’s retinal image size and direct their attention to the object’s actual size. When the small cube was presented together with a new, large cube—but at different distances so that they cast retinal images of the same size—all babies recovered to (looked longer at) the novel large cube, indicating that they distinguished objects on the basis of actual size, not retinal image size (Slater et al., 2010).

Perception of an object’s shape as stable, despite changes in the shape projected on the retina, is called shape constancy. Habituation research reveals that it, too, is present within the first week of life, long before babies can actively rotate objects with their hands and view them from different angles (Slater & Johnson, 1999).

In sum, both size and shape constancy seem to be built-in capacities that assist babies in detecting a coherent world of objects. Yet they provide only a partial picture of young infants’ object perception.

PERCEPTION OF OBJECT IDENTITY  At first, babies rely heavily on motion and spatial arrangement to identify objects (Jusczyk et al., 1999; Spelke & Hermer, 1996). When two objects are touching and either move in unison or stand still, babies younger than 4 months cannot distinguish them. Infants, of course, are fascinated by moving objects. As they observe objects’ motions, they pick up additional information about objects’ boundaries, such as shape, color, and texture.

For example, as Figure 5.21 reveals, around 2 months, babies realize that a moving rod whose center is hidden behind a box is a complete rod rather than two rod pieces. Motion, a textured background, and a small box (so most of the rod is visible) are necessary for young infants to infer object unity. They need all these cues to heighten the distinction between objects in the display because their ability to scan for salient information is still immature (Amso & Johnson, 2006; Johnson, 2009).

As infants become familiar with many objects and improvements in scanning assist them in integrating each object’s features into a unified whole, they rely more on shape, color, and pattern and less on motion (Johnson, 2011; Slater et al., 2010). Babies as young as 4½ months can discriminate two touching objects on the basis of their features in very simple, easy-to-process situations. And prior exposure to one of the test objects enhances 4½-month-olds’ ability to discern the boundary between two touching objects—a finding that highlights the role of experience (Dueker, Modi, & Needham, 2003; Needham, 2001).

In everyday life, objects frequently move in and out of sight, so infants must keep track of their disappearance and reappearance to perceive their identity. Habituation research, in which a ball moves back and forth behind a screen, reveals that at age 4 months, infants first perceive the ball’s path as continuous (Johnson et al., 2003). Between 4 and 5 months, infants can monitor more intricate paths of objects. As indicated by their future-oriented eye movements (looking ahead to where they expect an object to reappear from behind a barrier), 5-month-olds even keep track of an object that travels on a curvilinear course at varying speeds (Rosander & von Hofsten, 2004). Again, experience—the opportunity to track a moving object along a fully visible path of movement just before testing—enhances young infants’ predictive eye tracking (Johnson & Shuwairi, 2009).
From 4 to 11 months, infants increasingly use featural information to detect the identity of an object traveling behind a screen. At first, they need strong featural cues—a change in two features (size and shape, or shape and color)—to signify that a disappearing object is distinct from an emerging object. Later in the first year, change in a single feature is sufficient (Bremner et al., 2013; Wilcox & Woods, 2009). And as before, experience—in particular, physically manipulating the object—boosts older infants’ attention to its surface features.

In sum, perception of object identity is mastered gradually over the first year. We will consider a related attainment, infants’ understanding of object permanence—awareness that an object still exists when hidden—in Chapter 6.

Intermodal Perception

Our world provides rich, continuous intermodal stimulation—simultaneous input from more than one modality, or sensory system. In intermodal perception, we make sense of these running streams of light, sound, tactile, odor, and taste information, perceiving them as integrated wholes. We know, for example, that an object’s shape is the same whether we see it or touch it, that lip movements are closely coordinated with the sound of a voice, and that dropping a rigid object on a hard surface will cause a sharp, banging sound.

Recall that newborns turn in the general direction of a sound and reach for objects in a primitive way. These behaviors suggest that infants expect sight, sound, and touch to go together. Research reveals that babies perceive input from different sensory systems in a unified way by detecting amodal sensory properties, information that is not specific to a single modality but that overlaps two or more sensory systems, such as rate, rhythm, duration, intensity, temporal synchrony (for vision and hearing), and texture and shape (for vision and touch). Consider the sight and sound of a bouncing ball or the face and voice of a speaking person. In each event, visual and auditory information are conveyed simultaneously and with the same rate, rhythm, duration, and intensity.

Even newborns are impressive perceivers of amodal properties. After touching an object (such as a cylinder) placed in their palms, they recognize it visually, distinguishing it from a different-shaped object (Sann & Streri, 2007). And they require just one exposure to learn the association between the sight and sound of a toy, such as a rhythmically jangling rattle (Morrongiello, Fenwick, & Chance, 1998).

Within the first half-year, infants master a remarkable range of intermodal relationships. Three- to 5-month-olds can match faces with voices on the basis of lip–voice synchrony, emotional expression, and even age and gender of the speaker. Around 6 months, infants can perceive and remember the unique face–voice pairings of unfamiliar adults (Flom, 2013).

How does intermodal perception develop so quickly? Young infants seem biologically primed to focus on amodal information. Their detection of amodal relations—for example, the common tempo and rhythm in sights and sounds—precedes and provides the basis for detecting more specific intermodal matches, such as the relation between a particular person’s face and the sound of her voice or between an object and its verbal label (Bahrick, 2010).

Intermodal sensitivity is crucial for perceptual development. In the first few months, when much stimulation is unfamiliar and confusing, it enables babies to notice meaningful correlations between sensory inputs and rapidly make sense of their surroundings. As a result, inexperienced perceivers notice a unitary event, such as a hammer’s tapping, without being distracted by momentarily irrelevant aspects of the situation, such as the hammer’s color or orientation (Bahrick, Lickliter, & Flom, 2004).
In addition to easing perception of the physical world, intermodal perception facilitates processing of the social world. For example, as 3- to 4-month-olds gaze at an adult's face, they initially require both vocal and visual input to distinguish positive from negative emotional expressions (Flom & Bahrick, 2007; Kahana-Kalman & Walker-Andreuws, 2001). Only later do infants discriminate positive from negative emotion in each sensory modality—first in voices (around 5 months), later (from 7 months on) in faces (Bahrick, Hernandez-Reif, & Flom, 2005).

Research suggests that intermodal perception supports diverse aspects of learning. In one study, 3-month-olds were given an operant conditioning task in which kicking their foot made a mobile hung with cylinder-shaped blocks turn. Some babies held in their palms a cylinder, others held a cube, and still others were given no object. Infants given matching amodal information—who viewed the cylinders while holding a cylinder—learned the kicking response fastest (Kraebel, 2012). Those given mismatching information (who held a cube) showed inhibited learning.

Furthermore, because communication is often intermodal (simultaneously verbal, visual, and tactile), infants receive much support from other senses in acquiring language. When parents speak to infants, they often provide temporal synchrony between words, object motions, and touch—for example, saying “doll” while moving a doll and occasionally having the doll touch the infant (Gogate & Bahrick, 1998, 2001). In doing so, caregivers greatly increase the chances that babies will remember the association between the word and the object.

In sum, intermodal stimulation fosters all aspects of psychological development. When caregivers provide many concurrent sights, sounds, and touches, babies process more information and learn faster (Bahrick, 2010). Intermodal perception is yet another fundamental capacity that assists infants in their active efforts to build an orderly, understandable world.

**Understanding Perceptual Development**

Now that we have reviewed the development of infant perceptual capacities, how can we put together this diverse array of amazing achievements? Widely accepted answers come from the work of Eleanor and James Gibson. According to the Gibsons’ differentiation theory, infants actively search for invariant features of the environment—those that remain stable—in a constantly changing perceptual world. In pattern perception, for example, young babies search for features that stand out and orient toward faces. Soon they explore internal features, noticing stable relationships among them. As a result, they detect patterns, such as complex designs and individual faces. Similarly, infants analyze the speech stream for regularities, detecting words, word-order sequences, and—within words—syllable-stress patterns. The development of intermodal perception also reflects this principle (Bahrick & Lickliter, 2012). Babies seek out invariant relationships—first, amodal properties, such as common rate and rhythm, in a voice and face, later more detailed associations, such as unique voice–face matches.

The Gibsons described their theory as differentiation (where differentiate means “analyze” or “break down”) because over time the baby detects finer and finer invariant features among stimuli. In addition to pattern perception and intermodal perception, differentiation applies to depth and object perception: Recall how in each, sensitivity to motion precedes detection of fine-grained features. So one way of understanding perceptual development is to think of it as a built-in tendency to seek order and consistency—a capacity that becomes increasingly fine-tuned with age (Gibson, 1970; Gibson, 1979).

Acting on the environment is vital in perceptual differentiation. According to the Gibsons, perception is guided by the discovery of affordances—the action possibilities that a situation offers an organism with certain motor capabilities (Gibson, 2000, 2003). By moving about and exploring the environment, babies figure out which objects can be grasped, squeezed, bounced, or stroked and which surfaces are safe to cross or present the possibility of falling. Sensitivity to affordances means that we spend far less time correcting ineffective actions than we would otherwise: It makes our actions future-oriented and largely successful rather than reactive and blundering.
To illustrate, recall how infants’ changing capabilities for independent movement affect their perception. When babies crawl, and again when they walk, they gradually realize that a sloping surface affords the possibility of falling (see Figure 5.22). With added weeks of practicing each skill, they hesitate to crawl or walk down a risky incline. Experience in trying to keep their balance on various surfaces makes crawlers and walkers more aware of the consequences of their movements. Crawlers come to detect when surface slant places so much body weight on their arms that they will fall forward, and walkers come to sense when an incline shifts body weight so their legs and feet can no longer hold them upright.

Infants do not transfer their learning about slopes or drop-offs from crawling to walking because the affordances for each posture are different (Adolph, Kretch, & LoBue, 2014). Learning is gradual and effortful because newly crawling and walking babies cross many types of surfaces in their homes each day. As they experiment with balance and postural adjustments to accommodate each, they perceive surfaces in new ways that guide their movements. As a result, they act more competently.

As we conclude this chapter, it is only fair to note that some researchers believe that babies do more than make sense of experience by searching for invariant features and discovering affordances: They also impose meaning on what they perceive, constructing categories of objects and events in the surrounding environment. We have seen the glimmerings of this cognitive point of view in this chapter. For example, older babies interpret a familiar face as a source of pleasure and affection and a pattern of blinking lights as a moving human being. This cognitive perspective also has merit in understanding the achievements of infancy. In fact, many researchers combine these two positions, regarding infant development as proceeding from a perceptual to a cognitive emphasis over the first year of life.

**Ask Yourself**

- **REVIEW** Using examples, explain why intermodal stimulation is vital for infants’ developing understanding of their physical and social worlds.
- **CONNECT** According to differentiation theory, perceptual development reflects infants’ active search for invariant features. Provide examples from research on hearing, pattern perception, and intermodal perception.
- **APPLY** After several weeks of crawling, Ben learned to avoid going headfirst over a drop-off. Now he has started to walk. Can his mother trust him not to step over a risky drop-off? Explain, using the concept of affordances.
- **REFLECT** Are young infants more competent than you thought they were before you read this chapter? List the capacities that most surprised you.
Brain Development (p. 159)

5.1 Discuss major changes in body size, muscle–fat makeup, body proportions, and variations in rate of physical growth over the first two years.

- Height and weight gains are greater during the first two years than at any other time after birth. Body fat develops quickly during the first nine months, whereas muscle development is slow and gradual.
- Parts of the body grow at different rates, following cephalo-caudal and proximodistal trends, resulting in changing body proportions.
- Girls are ahead of boys in physical maturity, and African-American children tend to be ahead of Caucasian-American children, based on skeletal age.

5.2 Describe brain development during infancy and toddlerhood, current methods of measuring brain functioning, and appropriate stimulation to support the brain’s potential.

- Early in development, the brain grows faster than any other organ of the body. Once neurons are in place, they rapidly form synapses and release neurotransmitters, which cross synapses to send messages to other neurons. During the peak period of synaptic growth in any brain area, many surrounding neurons die. Neurons that are seldom stimulated lose their synapses in a process called synaptic pruning. Gial cells, responsible for myelination, multiply rapidly through the second year, contributing to large gains in brain weight.
- Measures of brain functioning include those that detect changes in electrical activity in the cerebral cortex (EEG, ERPs), neuroimaging techniques (PET, fMRI), and NIRS, which uses infrared light and is suitable for infants and young children.
- The cerebral cortex is the largest, most complex brain structure and the last to stop growing. Its regions develop in the general order in which various capacities emerge in the growing child, with the fronto-lateral cortex having the most extended period of development. The hemispheres of the cerebral cortex specialize, a process called lateralization. In the first few years of life, there is high brain plasticity, with many areas not yet committed to specific functions.

5.3 How does organization of sleep and wakefulness change over the first two years?

- Infants’ changing arousal patterns are primarily affected by brain growth, but the social environment also plays a role. Periods of sleep and wakefulness become fewer but longer over the first two years, conforming to a night–day schedule. Most parents in Western nations try to get their babies to sleep through the night much earlier than parents throughout most of the world, who are more likely to sleep with their babies.

5.4 Cite evidence indicating that heredity, nutrition, and parental affection contribute to early physical growth.

- Twin and adoption studies reveal that heredity contributes to body size and rate of physical growth.
- Breast milk is ideally suited to infants’ growth needs. Breastfeeding protects against disease and prevents malnutrition and infant death in poverty-stricken areas of the world.
- Most infants and toddlers can eat nutritious foods freely without risk of becoming overweight. However, the relationship between rapid weight gain in infancy and obesity at older ages is strengthening, perhaps because of a rise in unhealthy early feeding practices, in which babies are given high-fat foods and sugary drinks.

5.5 Describe infant learning capacities, the conditions under which they occur, and the unique value of each.

- Classical conditioning is based on the infant’s ability to associate events that usually occur together in the everyday world. Infants can be classically conditioned most easily when the pairing of an unconditioned stimulus (UCS) and a conditioned stimulus (CS) has survival value—for example, learning which stimuli regularly accompany feeding.
- In operant conditioning, infants act on their environment and their behavior is followed by either reinforcers, which increase the occurrence of a preceding behavior, or punishment, which either removes a desirable stimulus or presents an unpleasant one to decrease the occurrence of a response. In young infants, interesting sights and sounds and pleasurable caregiver interaction serve as effective reinforcers.
- Habituation and recovery reveal that at birth, babies are attracted to novelty. Novelty preference (recovery to a novel stimulus) assesses recent memory, whereas familiarity preference (recovery to the familiar stimulus) assesses remote memory.
Motor Development (p. 181)

5.6 Discuss the general course of motor development during the first two years, along with factors that influence it.

- According to the dynamic systems theory of motor development, children acquire new motor skills by combining existing skills into increasingly complex systems of action. Each new skill is a joint product of central nervous system development, the body’s movement possibilities, the child’s goals, and environmental supports for the skill.
- Movement opportunities and a stimulating environment profoundly affect motor development, as shown by research on infants reared in deprived institutions. Cultural values and child-rearing customs contribute to the emergence and refinement of early motor skills.

Perceptual Development (p. 187)

5.7 What changes in hearing and in depth, pattern, object, and intermodal perception take place during infancy?

- Infants organize sounds into increasingly complex patterns and, in the middle of the first year, become more sensitive to the sounds of their own language. They have an impressive statistical learning capacity, which enables them to detect speech regularities for which they will later learn meanings.
- Rapid maturation of the eye and visual centers in the cerebral cortex supports the development of focusing, color discrimination, and visual acuity during the first few months. The ability to scan the environment and track moving objects also improves.
- Research on depth perception reveals that responsiveness to motion develops first, followed by sensitivity to binocular and then to pictorial depth cues. Experience in crawling enhances depth perception, but babies must learn to use depth cues for each body position in order to avoid drop-offs.
- Contrast sensitivity accounts for infants’ early pattern preferences. At first, babies stare at single, high-contrast features. Over time, they discriminate increasingly complex and meaningful patterns.

Important Terms and Concepts

- affordances (p. 196)
- amodal sensory properties (p. 195)
- brain plasticity (p. 165)
- cephalocaudal trend (p. 161)
- cerebral cortex (p. 164)
- classical conditioning (p. 176)
- conditioned response (CR) (p. 177)
- conditioned stimulus (CS) (p. 177)
- contrast sensitivity (p. 191)
- differentiation theory (p. 196)
- dynamic systems theory of motor development (p. 181)
- experience-dependent brain growth (p. 169)
- experience-expectant brain growth (p. 169)
- glial cells (p. 162)
- growth faltering (p. 176)
- habituation (p. 178)
- imitation (p. 179)
- intermodal perception (p. 195)
- kwashiorkor (p. 175)
- lateralization (p. 165)
- marasmus (p. 175)
- mirror neurons (p. 180)
- myelination (p. 162)
- neurons (p. 161)
- neurotransmitters (p. 161)
- operant conditioning (p. 178)
- perceptual narrowing effect (p. 188)
- pincer grasp (p. 186)
- prefrontal cortex (p. 165)
- prerreaching (p. 183)
- proximodistal trend (p. 161)
- punishment (p. 178)
- recovery (p. 178)
- reinforcer (p. 178)
- shape constancy (p. 194)
- size constancy (p. 194)
- statistical learning capacity (p. 188)
- synapses (p. 161)
- synaptic pruning (p. 162)
- ulnar grasp (p. 186)
- unconditioned response (UCR) (p. 177)
- unconditioned stimulus (UCS) (p. 177)