section **three**

Babies are such a nice way to start people.

—Don Herold
American Writer, 20th Century

Infancy

As newborns, we were not empty-headed organisms. We had some basic reflexes, among them crying, kicking, and coughing. We slept a lot, and occasionally we smiled, although the meaning of our first smiles was not entirely clear. We ate and we grew. We crawled and then we walked, a journey of a thousand miles beginning with a single step. Sometimes we conformed; sometimes others conformed to us. Our development was a continuous creation of more complex forms. We needed the meeting eyes of love. We juggled the necessity of curbing our will with becoming what we could will freely. Section 3 contains three chapters: "Physical Development in Infancy" (Chapter 4), "Cognitive Development in Infancy" (Chapter 5), and "Socioemotional Development in Infancy" (Chapter 6).

chapter 4

PHYSICAL DEVELOPMENT IN INFANCY

chapter **outline**

1 Physical Growth and Development in Infancy

Learning Goal 1 Discuss physical growth and development in infancy.

Patterns of Growth
Height and Weight
The Brain
Sleep
Nutrition

2 Motor Development

Learning Goal 2 Describe infants' motor development.

The Dynamic Systems View
Reflexes
Gross Motor Skills
Fine Motor Skills

3 Sensory and Perceptual Development

Learning Goal 3 Summarize the course of sensory and perceptual development in infancy.

What Are Sensation and Perception?
The Ecological View
Visual Perception
Other Senses
Intermodal Perception
Nature, Nurture, and Perceptual Development
Perceptual-Motor Coupling

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

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

For many years, maternity units in hospitals favored bottle feeding and did not give mothers adequate information about the benefits of breast feeding. In recent years, the World Health Organization and UNICEF have tried to reverse the trend toward bottle feeding of infants in many impoverished countries. They instituted "baby-friendly" programs in many countries (Grant, 1993). They also persuaded the International Association of Infant Formula Manufacturers to stop marketing their baby formulas to hospitals in countries where the governments support the baby-friendly initiatives (Grant, 1993). For the hospitals themselves, costs actually were reduced as infant formula, feeding bottles, and separate nurseries became unnecessary. For example, baby-friendly Jose Fabella Memorial Hospital in the Philippines reported saving 8 percent of its annual budget. Still, there are many places in the world where the baby-friendly initiatives have not been implemented.

The advantages of breast feeding in impoverished countries are substantial (Coovadia & others, 2012; UNICEF, 2013). However, these advantages must be balanced against

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

topical **connections**

In the previous chapter, we followed the physical development that takes place from fertilization through the germinal, embryonic, and fetal periods of prenatal development. We learned that by the time the fetus has reached full gestational age (approximately 40 weeks), it has grown from a fertilized egg, barely visible to the human eye, to a fully formed human weighing approximately 7½ pounds measuring 20 inches in length. Also remarkable is the fact that by the end of the prenatal period the brain has developed approximately 100 billion neurons.

looking ***back***

the risk of passing the human immunodeficiency virus (HIV) to babies through breast milk if the mothers have the virus (Goga & others, 2012; Muluye & others, 2012). In some areas of Africa, more than 30 percent of mothers have HIV, but the majority of these mothers don't know that they are infected (Mepham, Bland, and Newell, 2011). Later in the chapter, in the section on nutrition, we will look more closely at recent research on breast feeding in the United States, outlining the benefits for infants and mothers and discussing several life-threatening diseases that infants can contract as a result of malnutrition.

preview

It is very important for infants to get a healthy start. When they do, their first two years of life are likely to be a time of amazing development. In this chapter, we focus on the biological domain and the infant's physical development, exploring physical growth, motor development, and sensory and perceptual development.

1 Physical Growth and Development in Infancy

LG1 Discuss physical growth and development in infancy.

- Patterns of Growth
- Height and Weight
- The Brain
- Sleep
- Nutrition

A baby is the most complicated object made by unskilled labor.

—Anonymous

Infants' physical development in the first two years of life is extensive. Newborns' heads are quite large in comparison with the rest of their bodies. They have little strength in their necks and cannot hold their heads up, but they have some basic reflexes. In the span of 12 months, infants become capable of sitting anywhere, standing, stooping, climbing, and usually walking. During the second year, growth decelerates, but rapid increases in such activities as running and climbing take place. Let's now examine in greater detail the sequence of physical development in infancy.

PATTERNS OF GROWTH

An extraordinary proportion of the total body is occupied by the head during prenatal development and early infancy (see Figure 4.1). The **cephalocaudal pattern** is the sequence in which the earliest growth always occurs at the top—the head—with physical growth and differentiation of features gradually working their way down from top to bottom (for example, shoulders, middle trunk, and so on) (Pedroso, 2008). This same pattern occurs in the head area, because the top parts of the head—the eyes and brain—grow faster than the lower parts, such as the jaw.

Motor development generally proceeds according to the cephalocaudal principle. For example, infants see objects before they can control their torso, and they can use their hands long before they can crawl or walk. However, development does not follow a rigid blueprint. One study found that infants reached for toys with their feet prior to reaching with their hands (Galloway & Thelen, 2004). On average, infants first touched the toy with their feet when they were 12 weeks old and with their hands when they were 16 weeks old.

Growth also follows the **proximodistal pattern,** the sequence in which growth starts at the center of the body and moves toward the extremities. For example, infants control the muscles of their trunk and arms before they control their hands and fingers, and they use their whole hands before they can control several fingers.

cephalocaudal pattern Developmental sequence in which the earliest growth always occurs at the top—the head—with physical growth in size, weight, and feature differentiation gradually working from top to bottom.

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

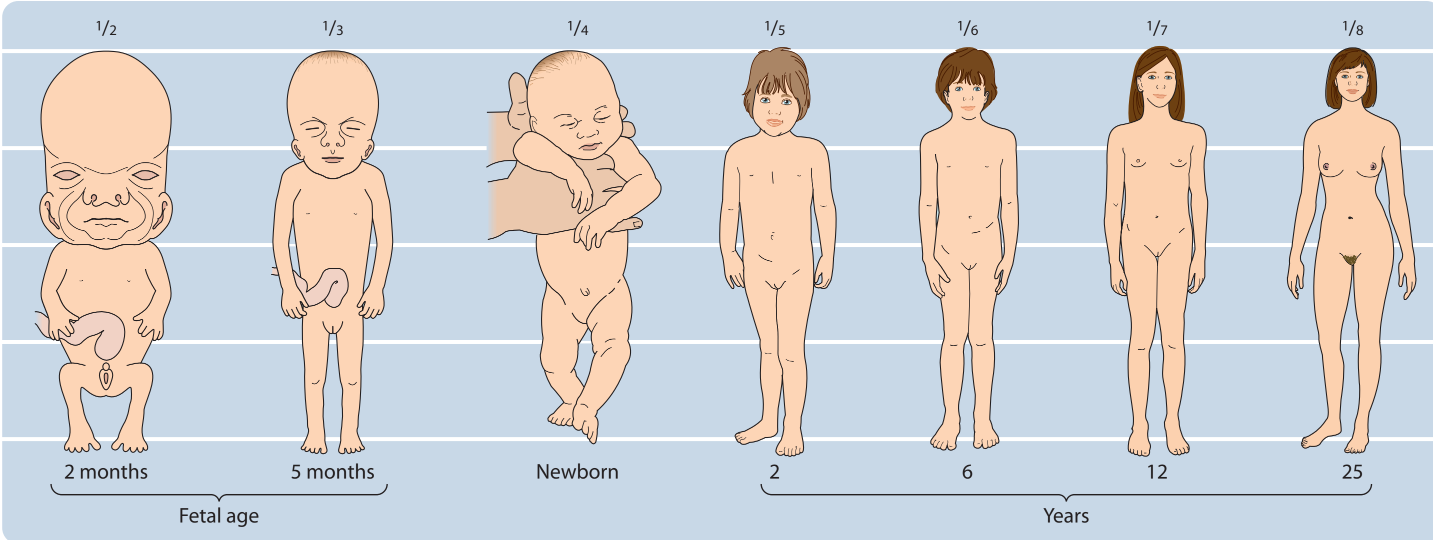


FIGURE **4.1**

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

HEIGHT AND WEIGHT

The average North American newborn is 20 inches long and weighs 7 pounds. Ninety-five percent of full-term newborns are 18 to 22 inches long and weigh between 5 and 10 pounds.

In the first several days of life, most newborns lose 5 to 7 percent of their body weight before they adjust to feeding by sucking, swallowing, and digesting. Then they grow rapidly, gaining an average of 5 to 6 ounces per week during the first month. They have doubled their birth weight by the age of 4 months and have nearly tripled it by their first birthday. Infants grow about 1 inch per month during the first year, approximately doubling their birth length by their first birthday.

Growth slows considerably in the second year of life (Burns & others, 2013). By 2 years of age, infants weigh approximately 26 to 32 pounds, having gained a quarter to half a pound per month during the second year to reach about one-fifth of their adult weight. At 2 years of age, infants average 32 to 35 inches in height, which is nearly half of their adult height.

THE BRAIN

We described the amazing growth of the brain from conception to birth in Chapter 3. By the time it is born, the infant that began as a single cell is estimated to have a brain that contains approximately 100 billion nerve cells, or neurons. Extensive brain development continues after birth, through infancy and later (Diamond, 2013; Nelson, 2012). Because the brain is still developing so rapidly in infancy, the infant's head should be protected from falls or other injuries and the baby should never be shaken. *Shaken baby syndrome,* which includes brain swelling and hemorrhaging, affects hundreds of babies in the United States each year (Swaiman & others, 2012). A recent analysis found that fathers were the most frequent perpetrators of shaken baby syndrome, followed by child care providers and boyfriends of the victim's mother (National Center on Shaken Baby Syndrome, 2012).

Studying the brain's development in infancy is not as easy as it might seem. Even some of the latest brain-imaging technologies (described in

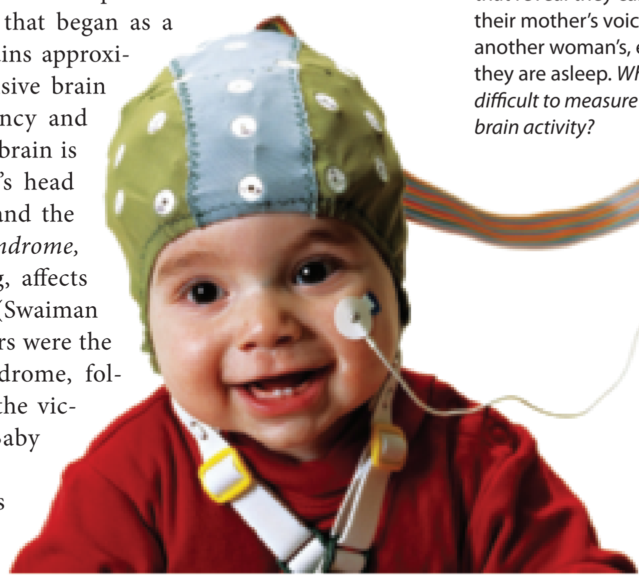


FIGURE **4.2**

MEASURING THE ACTIVITY OF AN INFANT'S BRAIN. By attaching up to 128 electrodes to a baby's scalp to measure the brain's activity, Charles Nelson and his colleagues (2006) have found that even newborns produce distinctive brain waves that reveal they can distinguish their mother's voice from another woman's, even while they are asleep. *Why is it so difficult to measure infants' brain activity?*

developmental **connection**

Brain Development

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

Chapter 1) cannot make out fine details in adult brains and cannot be used with babies (Nelson, 2012). Positron-emission tomography (PET) scans pose a radiation risk to babies, and infants often wriggle too much for technicians to be able to capture accurate images using magnetic resonance imaging (MRI). However, researchers have been successful in using the electroencephalogram (EEG), a measure of the brain's electrical activity, to learn about the brain's development in infancy (Bell & Diaz, 2012; Cuevas & others, 2012). Among the researchers who are making strides in finding out more about the brain's development in infancy are Charles Nelson (Nelson, 2007, 2012) and John Richards and his colleagues (Mallin & Richards, 2012; Richards, 2009, 2010; Richards, Reynolds, & Courage, 2010) (see Figure 4.2).

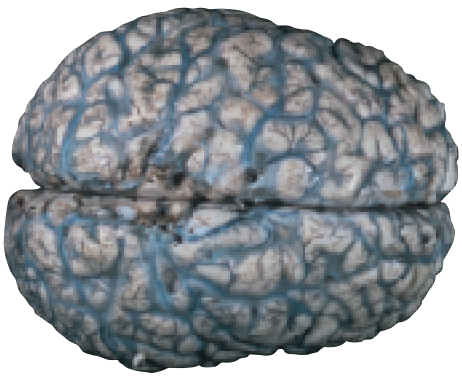


FIGURE **4.3**

THE HUMAN BRAIN'S HEMISPHERES. The two hemispheres of the human brain are clearly seen in this photograph. It is a myth that the left hemisphere is the exclusive location of language and logical thinking and that the right hemisphere is the exclusive location of emotion and creative thinking.

The Brain's Development At birth, the newborn's brain is about 25 percent of its adult weight. By the second birthday, the brain is about 75 percent of its adult weight. However, the brain's areas do not mature uniformly.

Mapping the Brain Scientists analyze and categorize areas of the brain in numerous ways (Geng & others, 2012; South & Isaacs, 2013). The portion farthest from the spinal cord is known as the forebrain. This region includes the cerebral cortex and several structures beneath it. The cerebral cortex covers the forebrain like a wrinkled cap. The brain has two halves, or hemispheres (see Figure 4.3). Based on ridges and valleys in the cortex, scientists distinguish four main areas, called lobes, in each hemisphere. Although the lobes usually work together, each has a somewhat different primary function (see Figure 4.4):

- *Frontal lobes* are involved in voluntary movement, thinking, personality, and intentionality or purpose.
- *Occipital lobes* function in vision.
- *Temporal lobes* have an active role in hearing, language processing, and memory.
- *Parietal lobes* play important roles in registering spatial location, attention, and motor control.

To some extent, the type of information handled by neurons depends on whether they are in the left or right hemisphere of the cortex (Van der Haegen & others, 2011). Speech and grammar, for example, depend on activity in the left hemisphere in most people; humor and the use of metaphors depends on activity in the right hemisphere (Griffiths & others, 2012; Marinkovic & others, 2012; McGettigan & others, 2012). This specialization of function in one hemisphere of the cerebral cortex or the other is called **lateralization.** However, most neuroscientists agree that complex functions such as reading or performing music involve both hemispheres (Stroobant, Buijus, & Vingerhoets, 2009). Labeling people as "left-brained" because they are logical thinkers and "right-brained" because they are creative thinkers does not correspond to the way the brain's hemispheres work. Complex thinking in normal people is the outcome of communication between both hemispheres of the brain (Ibrahim & Eviatar, 2012).

At birth, the hemispheres of the cerebral cortex already have started to specialize: Newborns show greater electrical brain activity in the left hemisphere than the right hemisphere when they are listening to speech sounds (Telkemeyer & others, 2011). How are the areas of the brain different in the newborn and the infant from those in an adult, and why do the differences matter? Important differences have been documented at both the cellular and the structural levels.

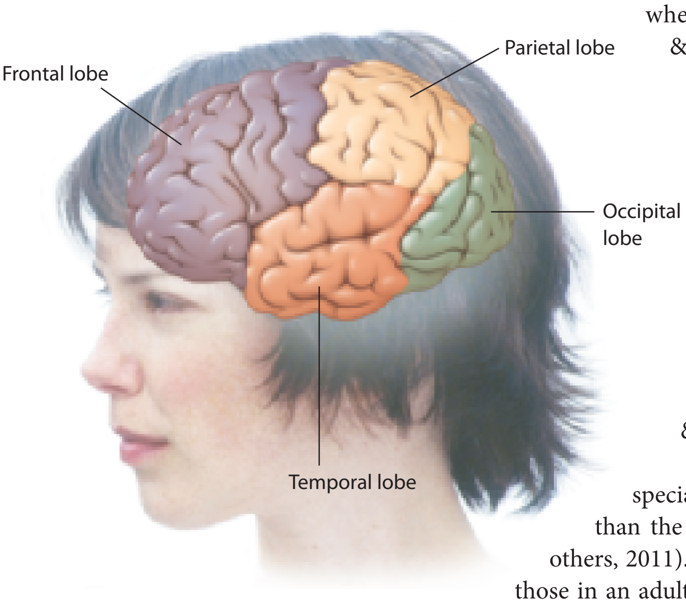


FIGURE **4.4**

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

Changes in Neurons Within the brain, the type of nerve cells called neurons send electrical and chemical signals, communicating with each other. As we indicated in Chapter 3, a *neuron* is a nerve cell that handles information processing (see Figure 4.5). Extending from the neuron's cell body are two types of fibers known as axons and dendrites. Generally, the axon carries signals away from the cell body and dendrites carry signals toward it. A *myelin sheath,* which is a layer of fat cells, encases many axons (see Figure 4.5). The myelin sheath insulates axons and helps electrical signals travel faster down the axon. Myelination also is

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

involved in providing energy to neurons and in communication (Fancy & others, 2012; Harris & Attwell, 2012). At the end of the axon are terminal buttons, which release chemicals called *neurotransmitters* into *synapses,* which are tiny gaps between neurons' fibers. Chemical interactions in synapses connect axons and dendrites, allowing information to pass from neuron to neuron (Emes & Grant, 2013; Marzo, Gousset, & Zurzolo, 2012). Think of the synapse as a river that blocks a road. A grocery truck arrives at one bank of the river, crosses by ferry, and continues its journey to market. Similarly, a message in the brain is "ferried" across the synapse by a neurotransmitter, which pours out information contained in chemicals when it reaches the other side of the river.

Neurons change in two very significant ways during the first years of life. First, *myelination,* the process of encasing axons with fat cells, begins prenatally and continues after birth, even into adolescence (Lebel & others, 2012). Second, connectivity among neurons increases, creating new neural pathways, as Figure 4.6 illustrates. New dendrites grow, connections among dendrites increase, and synaptic connections between axons and dendrites proliferate. Whereas myelination speeds up neural transmissions, the expansion of dendritic connections facilitates the spreading of neural pathways in infant development.

Researchers have discovered an intriguing aspect of synaptic connections. Nearly twice as many of these connections are made as will ever be used (Huttenlocher & Dabholkar, 1997). The connections that are used become strengthened and survive, while the unused ones are replaced by other pathways or disappear. In the language of neuroscience, these connections will be "pruned" (Campbell & others, 2012; Ren, Zhang, & Zhao, 2012). For example, the more babies engage in physical activity or use language, the more those pathways will be strengthened.

Changes in Regions of the Brain Figure 4.7 vividly illustrates the dramatic growth and later pruning of synapses in the visual, auditory, and prefrontal cortex (Huttenlocher & Dabholkar, 1997). Notice that "blooming and pruning" vary considerably by brain region. For example, the peak of synaptic overproduction in the visual cortex occurs at about the fourth postnatal month, followed by a gradual retraction until the middle to end of the preschool years. In areas of the brain involved in hearing and language, a similar, though somewhat later, course is detected. However, in the prefrontal cortex, the area of the brain where higher-level thinking and self-regulation occur, the peak of overproduction takes place at about 1 year of age; it is not until middle to late adolescence that the adult density of synapses is achieved. Both heredity and environment are thought to influence the timing and course of synaptic overproduction and subsequent retraction.

Meanwhile, the pace of myelination also varies in different areas of the brain (Gogtay & Thompson, 2010). Myelination for visual pathways occurs rapidly after birth and is completed in the first six months. Auditory myelination is not completed until 4 or 5 years of age.

In general, some areas of the brain, such as the primary motor areas, develop earlier than others, such as the primary sensory areas. The frontal lobes are immature in the newborn.

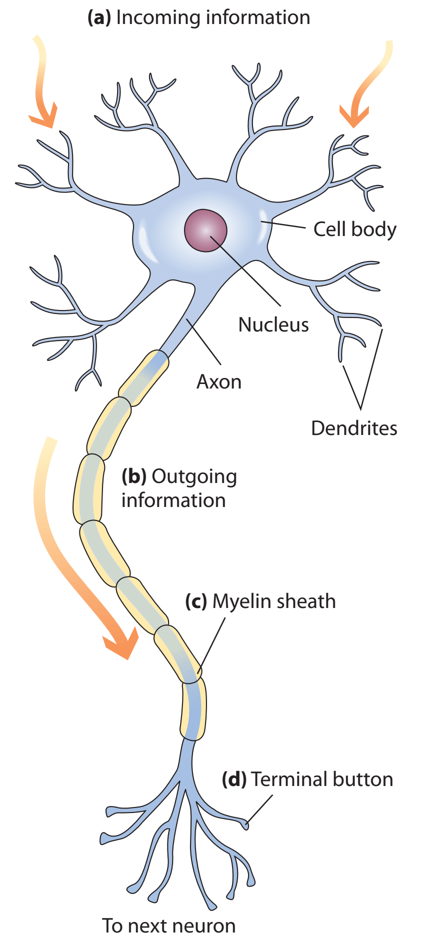


FIGURE **4.5**

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

developmental **connection**

Brain Development

Changes in the prefrontal cortex in adolescents and older adults have important implications for their cognitive development. Chapter 11, p. •••; Chapter 17, p. •••

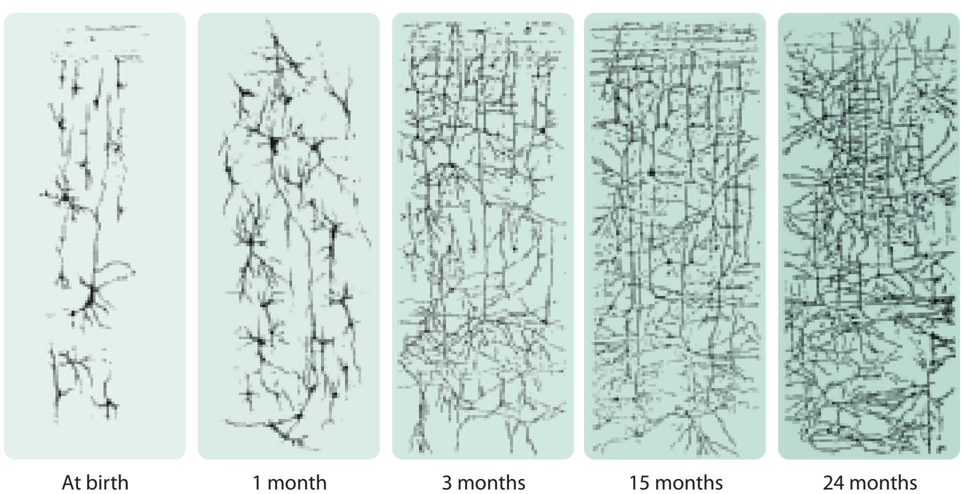


FIGURE **4.6**

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

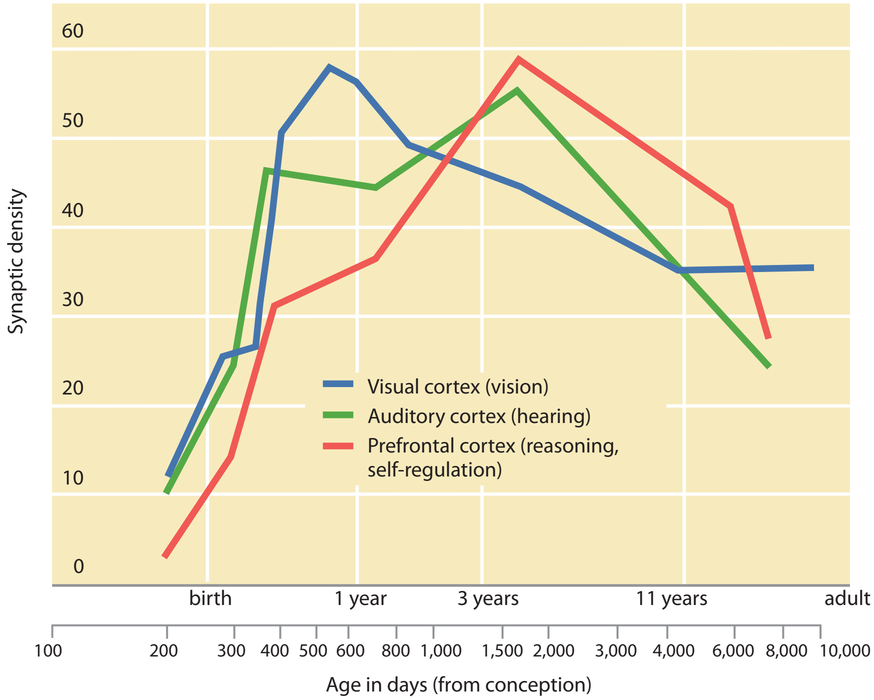


FIGURE 4.7

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

However, as neurons in the frontal lobes become myelinated and interconnected during the first year of life, infants develop an ability to regulate their physiological states, such as sleep, and gain more control over their reflexes. Cognitive skills that require deliberate thinking do not emerge until later in the first year (Bell, 2012; Morasch & others, 2013). Indeed, the prefrontal region of the frontal lobe has the most prolonged development of any brain region, with changes detectable at least into emerging adulthood (Blakemore, 2012; Steinberg, 2012, 2013).

Early Experience and the Brain Children who grow up in a deprived environment may have depressed brain activity (McLaughlin & others, 2011; Roeber & others, 2012). As shown in Figure 4.8, a child who grew up in the unresponsive and unstimulating environment of a Romanian orphanage showed considerably depressed brain activity compared with a normal child.

Are the effects of deprived environments irreversible? There is reason to think the answer is no. The brain demonstrates both flexibility and resilience. Consider 14-year-old Michael Rehbein. At age 7, he began to experience uncontrollable seizures—as many as 400 a day. Doctors said the only solution was to remove the left hemisphere of his brain where the seizures were occurring. Recovery was slow, but his right hemisphere began to reorganize and take over functions that normally occur in the brain's left hemisphere, including speech (see Figure 4.9).

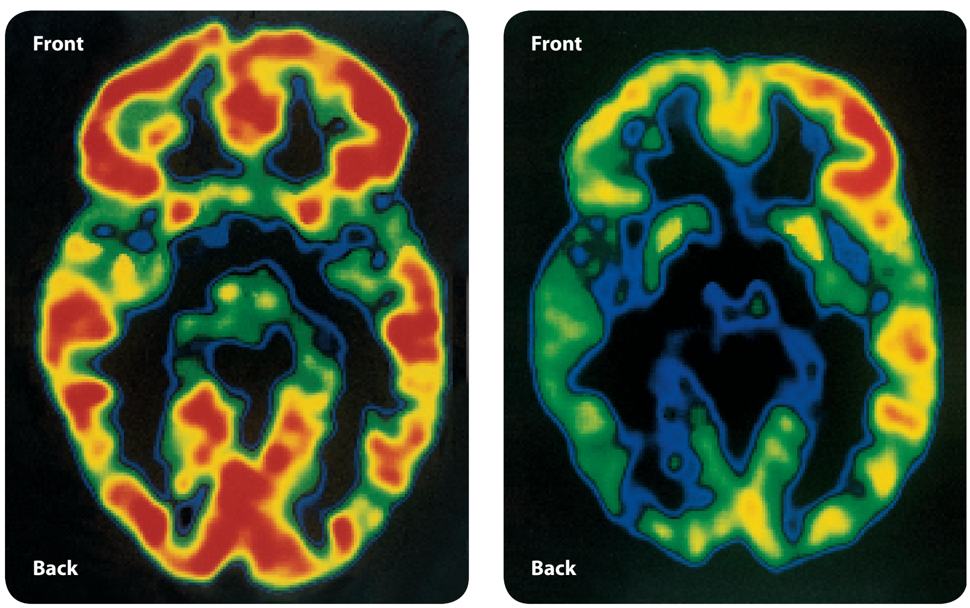
Neuroscientists believe that what wires the brain—or rewires it, in the case of Michael Rehbein—is repeated experience. Each time a baby tries to touch an attractive object or gazes intently at a face, tiny bursts of electricity shoot through the brain, knitting together neurons into circuits. The results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

developmental **connection**

Nature and Nurture

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

The Neuroconstructivist View Not long ago, scientists thought that our genes determined how our brains were "wired" and that the cells in the brain responsible for processing



(a) **(b)**

FIGURE 4.8

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

information just maturationally unfolded with little or no input from environmental experiences. Whatever brain your heredity had dealt you, you were essentially stuck with. This view, however, turned out to be wrong. Instead, the brain has plasticity and its development depends on context (Diamond, 2013; Nelson, 2012).

The infant's brain depends on experiences to determine how connections are made (Diamond, 2013). Before birth, it appears that genes mainly direct basic wiring patterns. Neurons grow and travel to distant places awaiting further instructions (C. A. Nelson, 2012). After birth, the inflowing stream of sights, sounds, smells, touches, language, and eye contact help shape the brain's neural connections.

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

SLEEP

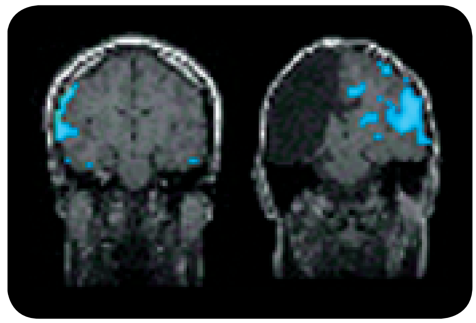
When we were infants, sleep consumed more of our time than it does now. The typical newborn sleeps approximately 18 hours a day, but newborns vary a lot in how much they sleep (Sadeh, 2008). The range is from about 10 hours to about 21 hours a day.

Infants also vary in their preferred times for sleeping and their patterns of sleep. Although the total amount of time spent sleeping remains somewhat consistent, an infant may change from sleeping 7 or 8 hours several times a day to sleeping for only a few hours three or four times a day. By about 1 month of age, many American infants have begun to sleep longer at night. By 6 months of age, they usually have moved closer to adult-like sleep patterns, spending the most time sleeping at night and the most time awake during the day (Sadeh, 2008). A recent research review concluded that infants 0 to 2 years of age slept an average of 12.8 hours out of the 24, within a range of 9.7 to 15.9 hours (Galland & others, 2012). A recent study revealed that by 6 months of age the majority of infants slept through the night, awakening their mothers only once or twice a week (Weinraub & others, 2012).

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

Cultural variations influence infant sleeping patterns. For example, in the Kipsigis culture in Kenya, infants sleep with their mothers at night and are permitted to nurse on demand (Super & Harkness, 1997). During the day, they are strapped to their mothers' backs, accompanying them on daily rounds of chores and social activities. As a result, the Kipsigis infants do not sleep through the night until much later than American infants do. During the first eight months of postnatal life, Kipsigis infants rarely sleep longer than three hours at a stretch, even at night. This sleep pattern contrasts with that of American infants, many of whom begin to sleep up to eight hours a night by 8 months of age.

(a)



(b)

FIGURE **4.9**

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

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

—William Shakespeare

English Playwright, 17th Century

neuroconstructivist view Perspective holding that biological processes and environmental conditions influence the brain's development; the brain has plasticity and is context dependent; and development of the brain and cognitive development are closely linked.

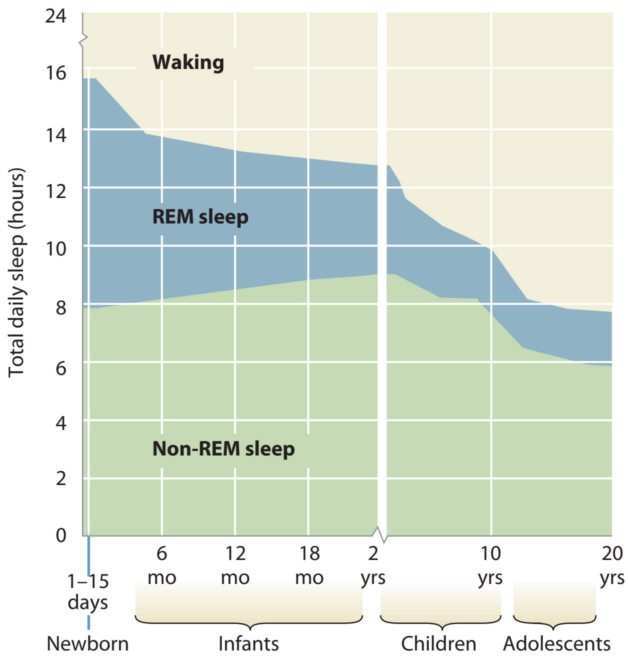


FIGURE **4.10**

DEVELOPMENTAL CHANGES IN REM AND NON-REM SLEEP

developmental **connection**

Sleep

Sleep patterns change in adolescence and are linked to changes in the brain. Chapter 11, p. •••

developmental **connection**

Sleep

What are some sleep problems that children encounter in early childhood? Chapter 7, p. •••

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

REM Sleep In REM sleep, the eyes flutter beneath closed lids; in non-REM sleep, this type of eye movement does not occur and sleep is more quiet (Sankupellay & others, 2011). Figure 4.10 shows developmental changes in the average number of total hours spent in REM and non-REM sleep. By the time they reach adulthood, individuals spend about one-fifth of their night in REM sleep, and REM sleep usually appears about one hour after non-REM sleep. However, about half of an infant's sleep is REM sleep, and infants often begin their sleep cycle with REM sleep rather than non-REM sleep. A much greater amount of time is taken up by REM sleep in infancy than at any other point in the life span. By the time infants reach 3 months of age, the percentage of time they spend in REM sleep falls to about 40 percent, and REM sleep no longer begins their sleep cycle.

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

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

Shared Sleeping Sleeping arrangements for newborns vary from culture to culture (Mindell & others, 2010a, b). For example, sharing a bed with a mother is a common practice in many cultures, such as Guatemala and China, whereas in others, such as the United States and Great Britain, newborns sleep in a crib, either in the same room as the parents or in a separate room. In some cultures, infants sleep with the mother until they are weaned, after which they sleep with siblings until middle and late childhood (Walker, 2006). Whatever the sleeping arrangements, it is recommended that the infant's bedding provide firm support and that cribs should have side rails.

Shared sleeping remains a controversial issue, with some experts recommending it and others arguing against it, although recently the recommendation trend has been to avoid infant-parent bed sharing, especially until the infant is at least 6 months of age (McIntosh, Tonkin, & Gunn, 2010; Norton & Grellner, 2011). The American Academy of Pediatrics Task Force on Infant Positioning and SIDS (AAPTFIPS) (2000) recommends against shared sleeping. Its members argue that in some instances bed sharing might lead to sudden infant death syndrome (SIDS), as could be the case if a sleeping mother rolls over on her baby. Recent studies have found that bed sharing is linked with a higher incidence of SIDS, especially when parents smoke (Senter & others, 2010).

SIDS **Sudden infant death syndrome (SIDS)** is a condition that occurs when infants stop breathing, usually during the night, and die suddenly without any apparent reason. SIDS continues to be a leading cause of infant death in the United States, with nearly 3,000 infant deaths annually attributed to SIDS (Montagna & Chokroverty, 2011). Risk of SIDS is highest at 2 to 4 months of age (NICHD, 2011).

Since 1992, the American Academy of Pediatrics (AAP) has recommended that infants be placed to sleep on their backs (supine position) to reduce the risk of SIDS, and the frequency of prone sleeping (on the stomach) among U.S. infants has dropped dramatically (AAPTFIPS, 2000). Researchers have found that SIDS does indeed decrease when infants sleep on their backs rather than their stomachs or sides (Yiallourou & others, 2011). Among the reasons given for prone sleeping being a risk factor for SIDS are that it impairs the infant's arousal from sleep and restricts the infant's ability to swallow effectively (Franco & others, 2010). One study revealed that 26 percent of U.S. mothers of 3-month-old infants did not use the recommended supine position for their infants' nighttime sleep (Hauck & others, 2008).

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

- SIDS is less likely to occur in infants who use a pacifier when they go to sleep (Moon & others, 2012).

- Low birth weight infants are 5 to 10 times more likely to die of SIDS than are their normal-weight counterparts (Horne & others, 2002).
- Two recent reviews concluded that breast feeding is linked to a lower incidence of SIDS (Hauck & others, 2011; Zotter & Pichler, 2012)
- Infants whose siblings have died of SIDS are two to four times as likely to die of it (Lenoir, Mallet, & Calenda, 2000).
- Six percent of infants with *sleep apnea,* a temporary cessation of breathing in which the airway is completely blocked, (usually for 10 seconds or longer), die of SIDS (Katz, Mitchell, & D'Ambrosio, 2012; McNamara & Sullivan, 2000).
- African American and Eskimo infants are four to six times more likely than all others to die of SIDS (Ige & Shelton, 2004; Kitsantas & Gaffney, 2010).
- SIDS is more common in lower socioeconomic groups (Mitchell & others, 2000).
- SIDS is more common in infants who are passively exposed to cigarette smoke (Dietz & others, 2010).
- SIDS is more common when infants and parents share the same bed (Senter & others, 2010).
- SIDS is more common if infants sleep in soft bedding (Task Force on Sudden Infant Death Syndrome & Moon, 2011).
- SIDS is less common when infants sleep in a bedroom with a fan. One study revealed that sleeping in a bedroom with a fan lowers the risk of SIDS by 70 percent (Coleman-Phox, Odouli, & Li, 2008).
- SIDS occurs more often in infants with abnormal brain stem functioning involving the neurotransmitter serotonin (Broadbent & others, 2012; Duncan & others, 2010).
- Heart arrhythmias are estimated to occur in as many as 10 to 15 percent of SIDS cases, and two recent studies revealed that gene mutations are linked to the occurrence of these arrhythmias in SIDS cases (Brion & others, 2012; Van Norstrand & others, 2012).

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

NUTRITION

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

Nutritional Needs and Eating Behavior Individual differences among infants in terms of their nutrient reserves, body composition, growth rates, and activity patterns make defining actual nutrient needs difficult (Byrd-Bredbenner & others, 2013; Schiff, 2013). However, because parents need guidelines, nutritionists recommend that infants consume approximately 50 calories per day for each pound they weigh—more than twice an adult's requirement per pound.

A number of developmental changes involving eating characterize the infant's first year (Black & Hurley, 2007; Golley & others, 2012; Symon & Bammann, 2012). As infants' motor skills improve, they change from using suck-and-swallow movements with breast milk or formula to chew-and-swallow movements with semisolid and then more complex foods (van Dijk, Hunnius, & van Geert, 2012). As their fine motor control improves in the first year, they transition from being fed by others toward self-feeding. "By the end of the first year of life, children can sit independently, can chew and swallow a range of textures, are learning to feed themselves, and are making the transition to the family diet and meal patterns" (Black & Hurley, 2007, p. 1). At this point, infants need to have a diet that includes a variety of foods—especially fruits and vegetables.

Caregivers play very important roles in infants' early development of eating patterns (Lumeng & others, 2012). Caregivers who are not sensitive to developmental changes in infants' nutritional needs, neglectful caregivers, and conditions of poverty can contribute to the development of eating problems in infants (Black & Lozoff, 2008). A recent study found that low maternal sensitivity when infants were 15 and 24 months of age was linked to a higher risk of obesity in adolescence (Anderson & others, 2012).

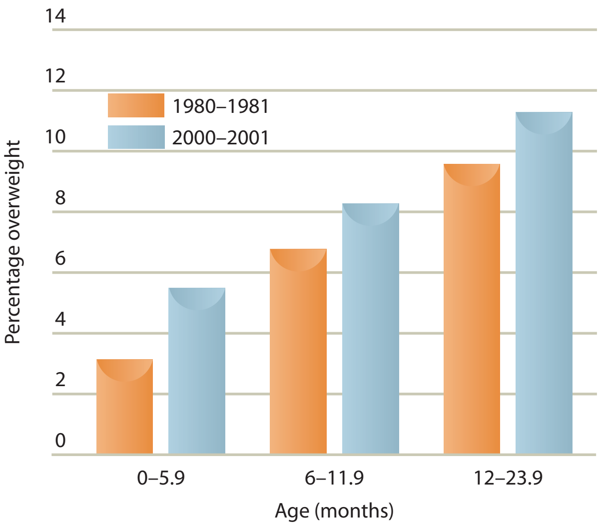


FIGURE **4.11**

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

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

Such poor dietary patterns early in development can result in more infants being overweight (Dattilo & others, 2012; Gross & others, 2012). One analysis revealed that in 1980, 3.4 percent of U.S. babies less than 6 months old were overweight, a percentage that increased to almost 10 percent in 2004 (the latest U.S. government data reported) and is likely even higher today (Centers for Disease Control and Prevention, 2010; Kim & others, 2006). As shown in Figure 4.11, as younger infants become older infants, an even greater percentage are overweight.

In addition to consuming too many French fries, sweetened drinks, and desserts, are there other factors that might explain this increase in overweight U.S. infants? A mother's weight gain during pregnancy and a mother's own high weight before pregnancy may be factors (McKinney & Murray, 2013). One important factor likely is whether an infant is breast fed or bottle fed (Lawrence, 2012; Lewallen, 2012). Breast-fed infants have lower rates of weight gain than bottle-fed infants in childhood and adolescence, and it is estimated that breast feeding reduces the risk of obesity by approximately 20 percent (Li & others, 2007; Scott, Ng, & Cobiac, 2012). Also, a recent study found that the introduction of solid foods before 4 months of age was associated with an increased risk of obesity at 3 years of age (Huh & others, 2011).

Breast versus Bottle Feeding For the first four to six months of life, human milk or an alternative formula is the baby's source of nutrients and energy. For years, debate has focused on whether breast feeding is better for the infant than bottle feeding. The growing consensus is that breast feeding is better for the baby's health (McKinney & Murray, 2013; Vasquez & Berg, 2012). Since the 1970s, breast feeding by U.S. mothers has soared (see Figure 4.12). In 2008 more than 75 percent of U.S. mothers breast fed their newborns, and 44 percent breast fed their 6-month-olds (Centers for Disease Control and Prevention, 2011). The American Academy of Pediatrics Section on Breastfeeding (2012) recently reconfirmed its recommendation of exclusive breast feeding in the first six months followed by continued breast feeding as complementary foods are introduced, and further breast feeding for one year or longer as mutually desired by the mother and infant.

What are some of the benefits of breast feeding? The following conclusions have been supported by research:

Outcomes for the Child

- *Gastrointestinal infections.* Breast-fed infants have fewer gastrointestinal infections (Garofalo, 2010).
- *Lower respiratory tract infections.* Breast-fed infants have fewer lower respiratory tract infections (Prameela, 2011).
- *Allergies.* A research review by the American Academy of Pediatrics indicated that there is no evidence that breast feeding reduces the risk of allergies in children (Greer & others, 2008).
- *Asthma.* The research review by the American Academy of Pediatrics concluded that exclusive breast feeding for three months protects against wheezing in babies, but whether it prevents asthma in older children is unclear (Greer & others, 2008).
- *Otitis media.* Breast-fed infants are less likely to develop this middle ear infection (Pelton & Leibovitz, 2009).
- *Overweight and obesity.* Consistent evidence indicates that breast-fed infants are less likely to become overweight or obese in childhood, adolescence, and adulthood (Scott, Ng, & Cobiac, 2012).

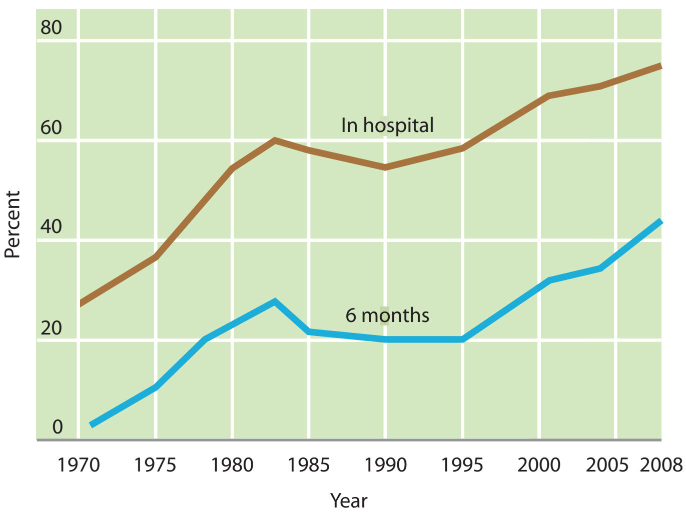


FIGURE **4.12**

TRENDS IN BREAST FEEDING IN THE UNITED STATES, 1970–2008

- *Diabetes.* Breast-fed infants are less likely to develop type 1 diabetes in childhood (Ping & Hagopian, 2006) and type 2 diabetes in adulthood (Villegas & others, 2008).
- *SIDS.* Breast-fed infants are less likely to experience SIDS (Zotter & Pichler, 2012).

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

Outcomes for the Mother

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

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

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

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

Which women are least likely to breast feed? They include mothers who work full-time outside of the home, mothers under age 25, mothers without a high school education, African American mothers, and mothers in low-income circumstances (Merewood & others, 2007). In one study of low-income mothers in Georgia, interventions (such as counseling focused on the benefits of breast feeding and the free loan of a breast pump) increased the incidence of breast feeding (Ahluwalia & others, 2000). Increasingly, mothers who return to work in the infant's first year of life use a breast pump to extract breast milk that can be stored for later feeding of the infant when the mother is not present.

The American Academy of Pediatrics Section on Breastfeeding (2012) strongly endorses exclusive breast feeding through 6 months and further recommends breast feeding for another year. Are there circumstances when mothers should not breast feed? Yes, a mother should not breast feed (1) when she is infected with HIV or some other infectious disease that can be transmitted through her milk, (2) if she has active tuberculosis, or (3) if she is taking any drug that may not be safe for the infant (Goga & others, 2012).

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

A further issue in interpreting the benefits of breast feeding was underscored in large-scale research reviews (Agency for Healthcare Research and Quality, 2007; Ip & others,

developmental connection

Research Methods

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

2009). While highlighting a number of breast feeding benefits for children and mothers, the report issued a caution about breast feeding research: None of the findings imply causality. Breast versus bottle feeding studies are correlational not experimental, and women who breast feed are wealthier, older, more educated, and likely more health-conscious than their bottle feeding counterparts, which could explain why breast fed children are healthier.

Malnutrition in Infancy Many infants around the world are malnourished (UNICEF, 2013). Early weaning of infants from breast milk to inadequate sources of nutrients, such as unsuitable and unsanitary cow's milk formula, can cause protein deficiency and malnutrition in infants. However, as we saw in the chapter opening story, a concern in developing countries is the increasing number of women who are HIV-positive and the fear that they will transmit this virus to their offspring (Muluye & others, 2012). Breast feeding is more optimal for mothers and infants in developing countries, except for mothers who have or are suspected of having HIV/AIDS.

A recent large-scale study that examined feeding practices in 28 developing countries found that the practices were far from optimal (Arabi & others, 2012). In this study, only 25 percent of infants 5 months of age and younger were breast fed. Also, feeding guidelines call for introducing complementary foods (solid and semisolid foods) beginning at 6 months. However, in this study, only 50 percent of the caregivers reported feeding their 6- to 8-month-olds complementary foods.

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

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

Even if not fatal, severe and lengthy malnutrition is detrimental to physical, cognitive, and social development (Bentley, Wasser, & Creed-Kanashiro, 2011; Laus & others, 2011). One study found that Asian Indian children who had a history of chronic malnutrition performed more poorly on tests of attention and memory than their counterparts who were not malnourished (Kar, Rao, & Chandramouli, 2008). And a longitudinal study revealed that Barbadian infants who had experienced moderate to severe protein/energy malnutrition had persisting attention deficits when they were 40 years old (Galler & others, 2012). Researchers also have found that interventions can benefit individuals who have experienced malnutrition in infancy. Consider the following studies:

- Standard nutritional care combined with a psychosocial intervention (group meetings with mothers and play sessions with infants, as well as six months of home visits) reduced the negative effects of malnutrition on severely malnourished Bangladesh 6- to 24-month-olds' cognitive development (Najar & others, 2008).
- Guatemalan infants whose mothers had been given nutritious supplements during pregnancy, and who themselves had been given more nutritious, high-calorie foods in their first two years of life, were more active, more involved, more helpful with their peers, less anxious, and happier than their counterparts who had not been given nutritional supplements at the time they entered elementary school (Barrett, Radke-Yarrow, & Klein, 1982).

To read further about providing nutritional supplements to improve infants' and young children's nutrition, see *Connecting Development to Life*.

Adequate early nutrition is an important aspect of healthy development (Schiff, 2013). In addition to sound nutrition, children need a nurturing, supportive environment (Anderson & others, 2012). One individual who has stood out as an advocate of caring for children is T. Berry Brazelton, who is featured in *Connecting with Careers*.

marasmus A wasting away of body tissues in the infant's first year, caused by severe protein-calorie deficiency.

kwashiorkor A condition caused by severe protein deficiency in which the child's abdomen and feet become swollen with water; usually appears between 1 and 3 years of age.

connecting development to life

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

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

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

Participants in the WIC program. *What are some changes the WIC program is trying to implement?*

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

connecting with careers

T. Berry Brazelton, Pediatrician

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

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

For more information about what pediatricians do, see page 45 in the Careers in Life-Span Development appendix.

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

Review *Connect* Reflect

LG1 Discuss physical growth and development in infancy.

Review

- What are cephalocaudal and proximodistal patterns?
- What changes in height and weight take place in infancy?
- What are some key features of the brain and its development in infancy?
- What changes occur in sleep during infancy?
- What are infants' nutritional needs?

Connect

- What types of brain research technology can be used to study infants that cannot be used to study them before they are born? Which can be used on adults but not infants? How might this affect our understanding of the human brain across the life span?

Reflect *Your Own Personal Journey of Life*

- What sleep and nutrition guidelines would you follow for enhancing the health and safety of your own infant?

2 Motor Development

LG2 Describe infants' motor development.

The Dynamic Systems View | Reflexes | Gross Motor Skills | Fine Motor Skills

Esther Thelen is shown conducting an experiment to discover how infants learn to control their arm movements to reach and grasp for objects. A computer device is used to monitor the infant's arm movements and to track muscle patterns. Thelen's research is conducted from a dynamic systems perspective. *What is the nature of this perspective?*

As a newborn, Ramona, whom you read about in the chapter opening, could suck, fling her arms, and tightly grip a finger placed in her tiny hand. Within just two years, she would be toddling around on her own, opening doors and jars as she explored her little world. Are her accomplishments inevitable? How do infants develop their motor skills, and which skills do they develop when?

THE DYNAMIC SYSTEMS VIEW

Developmentalist Arnold Gesell (1934) thought his painstaking observations had revealed how people develop their motor skills. He had discovered that infants and children develop rolling, sitting, standing, and other motor skills in a fixed order and within specific time frames. These observations, said Gesell, show that motor development comes about through the unfolding of a genetic plan, or *maturation*.

Later studies, however, demonstrated that the sequence of developmental milestones is not as fixed as Gesell indicated and not due as much to heredity as Gesell argued (Adolph & Berger, 2013; Adolph & Robinson, 2013). In the last two decades, the study of motor development experienced a renaissance as psychologists developed new insights about *how* motor skills develop (Thelen & Smith, 1998, 2006). One increasingly influential theory is dynamic systems theory, proposed by Esther Thelen.

According to **dynamic systems theory,** infants assemble motor skills for perceiving and acting. Notice that perception and action are coupled, according to this theory (Thelen & Smith, 2006). To develop motor skills, infants must perceive something in the environment that motivates them to act and use their perceptions to fine-tune their movements. Motor skills represent solutions to the infant's goals (Keen, 2011).

How is a motor skill developed, according to this theory? When infants are motivated to do something, they might create a new motor behavior. The new behavior is the result of many converging factors: the development of the nervous system, the body's physical properties and its possibilities for movement, the goal the child is motivated to reach, and the environmental support for the skill. For example, babies learn to walk only when maturation of the nervous system allows them to control certain leg muscles, when their legs have grown enough to support their weight, and when they want to move.

dynamic systems theory The perspective on motor development that seeks to explain how motor behaviors are assembled for perceiving and acting.

Mastering a motor skill requires the infant's active efforts to coordinate several components of the skill. Infants explore and select possible solutions to the demands of a new task; they assemble adaptive patterns by modifying their current movement patterns. The first step occurs when the infant is motivated by a new challenge—such as the desire to cross a room—and gets into the "ballpark" of the task demands by taking a couple of stumbling steps. Then, the infant "tunes" these movements to make them smoother and more effective. The tuning is achieved through repeated cycles of action and perception of the consequences of that action. According to the dynamic systems view, even universal milestones, such as crawling, reaching, and walking, are learned through this process of adaptation: Infants modulate their movement patterns to fit a new task by exploring and selecting possible configurations (Adolph & Robinson, 2013).

To see how dynamic systems theory explains motor behavior, imagine that you offer a new toy to a baby named Gabriel (Thelen & others, 1993). There is no exact program that can tell Gabriel ahead of time how to move his arm and hand and fingers to grasp the toy. Gabriel must adapt to his goal—grasping the toy—and the context. From his sitting position, he must make split-second adjustments to extend his arm, holding his body steady so that his arm and torso don't plow into the toy. Muscles in his arm and shoulder contract and stretch in a host of combinations, exerting a variety of forces. He improvises a way to reach out with one arm and wrap his fingers around the toy.

Thus, according to dynamic systems theory, motor development is not a passive process in which genes dictate the unfolding of a sequence of skills over time. Rather, the infant actively puts together a skill to achieve a goal within the constraints set by the infant's body and environment. Nature and nurture, the infant and the environment, are all working together as part of an ever-changing system.

As we examine the course of motor development, we will describe how dynamic systems theory applies to some specific skills. First, though, let's examine how the story of motor development begins with reflexes.

How might dynamic systems theory explain the development of learning to walk?

REFLEXES

The newborn is not completely helpless. Among other things, it has some basic reflexes. For example, when submerged in water, the newborn automatically holds its breath and contracts its throat to keep water out. **Reflexes** are built-in reactions to stimuli; they govern the newborn's movements, which are automatic and beyond the newborn's control. Reflexes are genetically carried survival mechanisms. They allow infants to respond adaptively to their environment before they have had the opportunity to learn.

The rooting and sucking reflexes are important examples. Both have survival value for newborn mammals, who must find a mother's breast to obtain nourishment. The **rooting reflex** occurs when the infant's cheek is stroked or the side of the mouth is touched. In response, the infant turns its head toward the side that was touched in an apparent effort to find something to suck. The **sucking reflex** occurs when newborns automatically suck an object placed in their mouth. This reflex enables newborns to get nourishment before they have associated a nipple with food and also serves as a self-soothing or self-regulating mechanism.

Another example is the **Moro reflex,** which occurs in response to a sudden, intense noise or movement (see Figure 4.13). When startled, the newborn arches its back, throws back its head, and flings out its arms and legs. Then the newborn rapidly closes its arms and legs. The Moro reflex is believed to be a way of grabbing for support while falling; it would have had survival value for our primate ancestors.

Some reflexes—coughing, sneezing, blinking, shivering, and yawning, for example—persist throughout life. They are as important for the adult as they are for the infant. Other reflexes, though, disappear several months following birth, as the infant's brain matures and voluntary control over many behaviors develops. The rooting and Moro reflexes, for example, tend to disappear when the infant is 3 to 4 months old.

The movements of some reflexes eventually become incorporated into more complex, voluntary actions. One important example is the **grasping reflex,** which occurs when something touches the infant's palms (see Figure 4.13). The infant responds by grasping tightly. By the end of the third month, the grasping reflex diminishes and the infant shows a more

reflexes Built-in reactions to stimuli that govern the newborn's movements, which are automatic and beyond the newborn's control.

rooting reflex A newborn's built-in reaction that occurs when the infant's cheek is stroked or the side of the mouth is touched. In response, the infant turns his or her head toward the side that was touched, in an apparent effort to find something to suck.

sucking reflex A newborn's built-in reaction to automatically suck an object placed in its mouth. The sucking reflex enables the infant to get nourishment before he or she has associated a nipple with food and also serves as a self-soothing or self-regulating mechanism.

Moro reflex A neonatal startle response that occurs in reaction to a sudden, intense noise or movement. When startled, the newborn arches its back, throws its head back, and flings out its arms and legs. Then the newborn rapidly pulls its arms and legs close to the center of the body.

grasping reflex A neonatal reflex that occurs when something touches the infant's palms. The infant responds by grasping tightly.

FIGURE 4.13

NEWBORN REFLEXES. Young infants have several reflexes, including the Moro reflex (*Top*) and grasping reflex (*Bottom*).

voluntary grasp. As its motor coordination becomes smoother, the infant will grasp objects, carefully manipulate them, and explore their qualities.

The old view of reflexes is that they were exclusively genetic, built-in mechanisms that govern the infant's movements. The new perspective on infant reflexes is that they are not automatic or completely beyond the infant's control. For example, infants can control such movements as alternating their legs to make a mobile jiggle or change their sucking rate to listen to a recording (Adolph & Berger, 2013).

GROSS MOTOR SKILLS

Ask any parents about their baby, and sooner or later you are likely to hear about one or more motor milestones, such as "Cassandra just learned to crawl," "Jesse is finally sitting alone," or "Angela took her first step last week." Parents proudly announce such milestones as their children transform themselves from babies unable to lift their heads to toddlers who grab things off the grocery store shelf, chase a cat, and participate actively in the family's social life (Thelen, 2000). These milestones are examples of **gross motor skills,** which are skills that involve large-muscle activities, such as moving one's arms and walking.

The Development of Posture How do gross motor skills develop? As a foundation, these skills require postural control (Thelen & Smith, 2006). For example, to track moving objects, you must be able to control your head in order to stabilize your gaze; before you can walk, you must be able to balance on one leg.

Posture is more than just holding still and straight. Posture is a dynamic process that is linked with sensory information in the skin, joints, and muscles, which tell us where we are in space; in vestibular organs in the inner ear that regulate balance and equilibrium; and in vision and hearing (Thelen & Smith, 2006).

Newborn infants cannot voluntarily control their posture. Within a few weeks, though, they can hold their heads erect, and soon they can lift their heads while prone. By 2 months of age, babies can sit while supported on a lap or an infant seat, but they cannot sit independently until they are 6 or 7 months of age. Standing also develops gradually during the first year of life. By about 8 to 9 months of age, infants usually learn to pull themselves up and hold on to a chair, and they often can stand alone by about 10 to 12 months of age.

Learning to Walk Locomotion and postural control are closely linked, especially in walking upright (Adolph & Berger, 2013; Adolph & Robinson, 2013). To walk upright, the baby must be able both to balance on one leg as the other is swung forward and to shift the weight from one leg to the other.

Even young infants can make the alternating leg movements that are needed for walking. The neural pathways that control leg alternation are in place from a very early age, even at birth or before. Indeed, researchers have found that alternating leg movements occur during the fetal period and at birth (Adolph & Robinson, 2013).

If infants can produce forward stepping movements so early, why does it take them so long to learn to walk? The key skills in learning to walk appear to be stabilizing balance on one leg long enough to swing the other forward and shifting the weight without falling. These are difficult biomechanical problems to solve, and it takes infants about a year to do it.

In learning to locomote, infants learn what kinds of places and surfaces are safe for locomotion (Adolph & others, 2012). Karen Adolph (1997) investigated how experienced and inexperienced crawling infants and walking infants go down steep slopes (see Figure 4.14). Newly crawling infants, who averaged about 8½ months in age, rather indiscriminately went down the steep slopes, often falling in the process (with their mothers next to the slope to

gross motor skills Motor skills that involve large-muscle activities, such as walking.

Newly crawling infant

Experienced walker

FIGURE **4.14**

THE ROLE OF EXPERIENCE IN CRAWLING AND WALKING INFANTS' JUDGMENTS OF WHETHER TO GO DOWN A SLOPE. Karen Adolph (1997) found that locomotor experience rather than age was the primary predictor of adaptive responding on slopes of varying steepness. Newly crawling and walking infants could not judge the safety of the various slopes. With experience, they learned to avoid slopes where they would fall. When expert crawlers began to walk, they again made mistakes and fell, even though they had judged the same slope accurately when crawling. Adolph referred to this as the specificity of learning because it does not transfer across crawling and walking.

catch them). After weeks of practice, the crawling babies became more adept at judging which slopes were too steep to crawl down and which ones they could navigate safely. New walkers also could not judge the safety of the slopes, but experienced walkers accurately matched their skills with the steepness of the slopes. They rarely fell downhill, either refusing to go down the steep slopes or going down backward in a cautious manner. Experienced walkers perceptually assessed the situation—looking, swaying, touching, and thinking before they moved down the slope. With experience, both the crawlers and the walkers learned to avoid the risky slopes where they would fall, integrating perceptual information with the development of a new motor behavior. In this research, we again see the importance of perceptual-motor coupling in the development of motor skills. Thus, practice is very important in the development of new motor skills (Adolph & others, 2012).

Practice is especially important in learning to walk (Adolph & Robinson, 2013). "Thousands of daily walking steps, each step slightly different from the last because of variations in the terrain and the continually varying biomechanical constraints on the body, may help infants to identify the relevant" combination of strength and balance required to improve their walking skills (Adolph, Vereijken, & Shrout, 2003, p. 495). In a recent study, Adolph and her colleagues (2012) observed 12- to 19-month-olds during free play. Locomotor experience was extensive, with the infants averaging 2,368 steps and 17 falls per hour.

The First Year: Motor Development Milestones and Variations Figure 4.15 summarizes the range in which infants accomplish various gross motor skills during the first year, culminating in the ability to walk easily. The timing of these milestones, especially the later ones, may vary by as much as two to four months, and experiences can modify the onset of these accomplishments (Adolph & Berger, 2013). For example, since 1992, when pediatricians began recommending that parents place their babies on their backs when they sleep, fewer babies crawled, and those who did crawled later (Davis & others, 1998). Also, some infants do not follow the standard sequence of motor accomplishments. For example, many American infants never crawl on their belly or on their hands and knees. They may discover an idiosyncratic form of locomotion before walking, such as rolling, or they might never locomote until they get upright (Adolph & Robinson, 2013). In the African Mali tribe, most infants do not crawl (Bril, 1999). And in Jamaica, approximately one-fourth of babies skip crawling (Hopkins, 1991).

According to Karen Adolph and Sarah Berger (2005), "the old-fashioned view that growth and motor development reflect merely the age-related output of maturation is, at best, incomplete. Rather, infants acquire new skills with the help of their caregivers in a real-world environment of objects, surfaces, and planes."

Development in the Second Year The motor accomplishments of the first year bring increasing independence, allowing infants to explore their environment more extensively and to initiate interaction with others more readily. In the second year of life, toddlers become more

A baby is an angel whose wings decrease as his legs increase.

—French Proverb

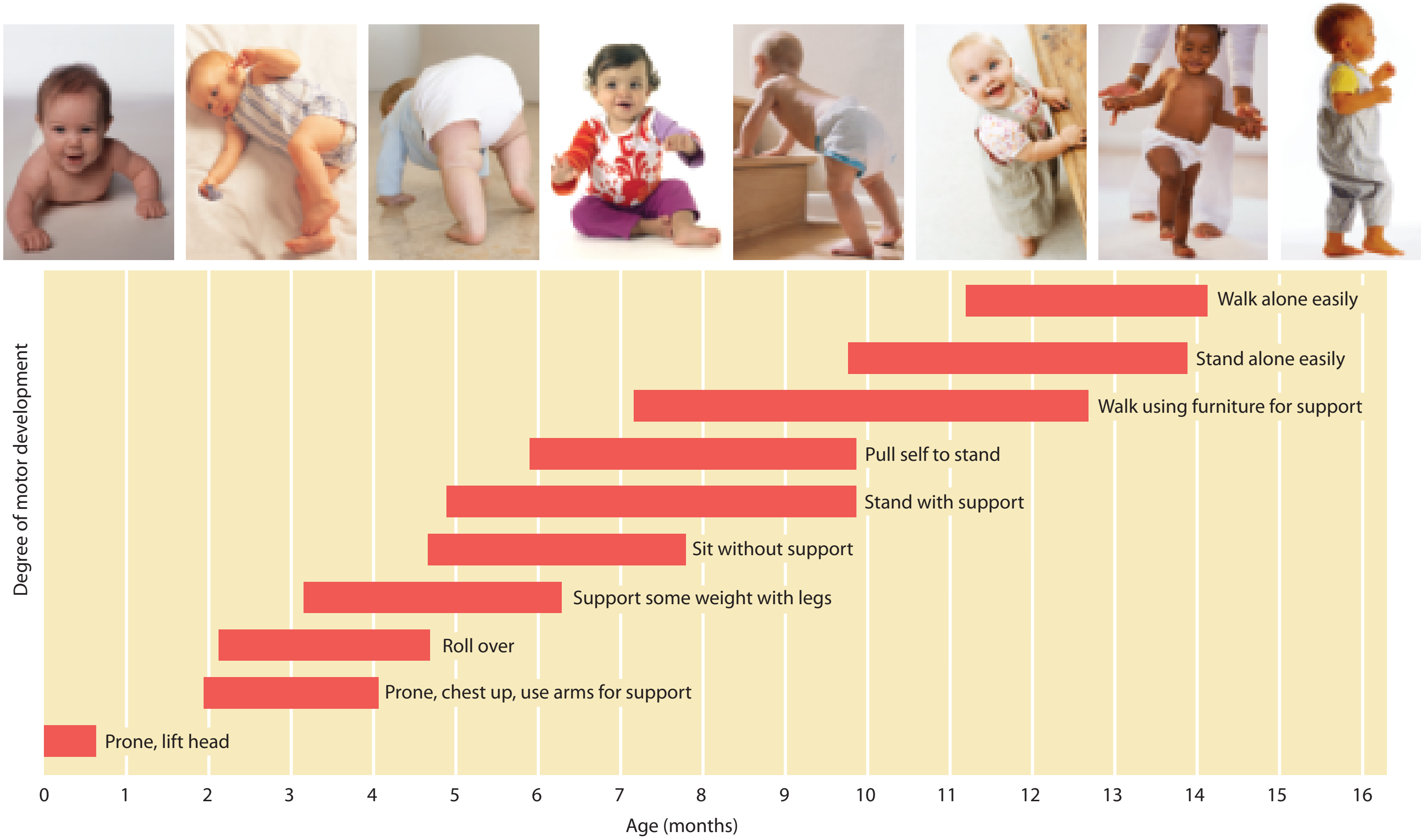


FIGURE 4.15

MILESTONES IN GROSS MOTOR DEVELOPMENT. The horizontal red bars indicate the range in which most infants reach various milestones in gross motor development.

motorically skilled and mobile. Motor activity during the second year is vital to the child's competent development, and few restrictions, except for safety, should be placed on their adventures.

By 13 to 18 months, toddlers can pull a toy attached to a string and use their hands and legs to climb up a number of steps. By 18 to 24 months, toddlers can walk quickly or run stiffly for a short distance, balance on their feet in a squatting position while playing with objects on the floor, walk backward without losing their balance, stand and kick a ball without falling, stand and throw a ball, and jump in place.

Can parents give their babies a head start on becoming physically fit and physically talented through structured exercise classes? Most infancy experts recommend against structured exercise classes for babies. But there are other ways to guide infants' motor development.

Mothers in developing countries tend to stimulate their infants' motor skills more than mothers in more developed countries (Hopkins, 1991). In many African, Indian, and Caribbean cultures, mothers massage and stretch their infants during daily baths (Adolph, Karasik, & Tamis-LeMonda, 2010). Mothers in the Gusii culture of Kenya also encourage vigorous movement in their babies.

(*Left*) In the Algonquin culture in Quebec, Canada, babies are strapped to a cradle board for much of their infancy. (*Right*) In Jamaica, mothers massage and stretch their infants' arms and legs. *To what extent do cultural variations in the activity infants engage in influence the time at which they reach motor milestones?*

Do these cultural variations make a difference in the infant's motor development? When caregivers provide babies with physical guidance by physically handling them in special ways (such as stroking, massaging, or stretching) or by giving them opportunities for exercise, the infants often reach motor milestones earlier than infants whose caregivers have not provided these activities (Adolph, Karasik, & Tamis-LeMonda, 2010). For example, Jamaican mothers expect their infants to sit and walk alone two to three months earlier than English mothers do (Hopkins & Westra, 1990). And in sub-Saharan Africa, traditional practices in many villages involve mothers and siblings engaging babies in exercises, such as frequent exercise for trunk and pelvic muscles (Super & Harkness, 1997).

Many forms of restricted movement—such as Chinese sandbags, orphanage restrictions, and failure of caregivers to encourage movement in Budapest—have been found to produce substantial delays in motor development (Adolph, Karasik, & Tamis-LeMonda, 2010). In some rural Chinese provinces, for example, babies are placed in a bag of fine sand, which acts as a diaper and is changed once a day. The baby is left alone, face up, and is visited only when being fed by the mother (Xie & Young, 1999). Some studies of swaddling show slight delays in motor development, but other studies show no delays. Cultures that do swaddle infants usually do so early in the infant's development when the infant is not mobile; when the infant becomes more mobile, swaddling decreases.

A young girl using a pincer grip to pick up puzzle pieces.

FINE MOTOR SKILLS

Whereas gross motor skills involve large muscle activity, **fine motor skills** involve finely tuned movements. Grasping a toy, using a spoon, buttoning a shirt, or anything that requires finger dexterity demonstrates fine motor skills. Infants have hardly any control over fine motor skills at birth, but newborns do have many components of what will become finely coordinated arm, hand, and finger movements (McCormack, Hoerl, & Butterfill, 2012).

The onset of reaching and grasping marks a significant achievement in infants' ability to interact with their surroundings (Greif & Needham, 2012; Sgandurra & others, 2012; Ziemer, Plumert, & Pick, 2012). During the first two years of life, infants refine how they reach and grasp (Needham, 2009). Initially, infants reach by moving their shoulders and elbows crudely, swinging toward an object. Later, when infants reach for an object they move their wrists, rotate their hands, and coordinate their thumb and forefinger. Infants do not have to see their own hands in order to reach for an object (Clifton & others, 1993). Cues from muscles, tendons, and joints, not sight of the limb, guide reaching by 4-month-old infants.

Infants refine their ability to grasp objects by developing two types of grasps. Initially, infants grip with the whole hand, which is called the *palmer grasp.* Later, toward the end of the first year, infants also grasp small objects with their thumb and forefinger, which is called the *pincer grip.* Their grasping system is very flexible. They vary their grip on an object depending on its size, shape, and texture, as well as the size of their own hands relative to the object's size. Infants grip small objects with their thumb and forefinger (and sometimes their middle finger too), whereas they grip large objects with all of the fingers of one hand or both hands.

Perceptual-motor coupling is necessary for the infant to coordinate grasping (Barrett, Traupman, & Needham, 2008). Which perceptual system the infant is most likely to use to coordinate grasping varies with age. Four-month-old infants rely greatly on touch to determine how they will grip an object; 8-month-olds are more likely to use vision as a guide (Newell & others, 1989). This developmental change is efficient because vision lets infants preshape their hands as they reach for an object.

FIGURE **4.16**

INFANTS' USE OF "STICKY MITTENS" TO EXPLORE OBJECTS. Amy Needham and her colleagues (2002) found that "sticky mittens" enhanced young infants' object exploration skills.

Experience plays a role in reaching and grasping. In one study, 3-month-old infants participated in play sessions wearing "sticky mittens"—"mittens with palms that stuck to the edges of toys and allowed the infants to pick up the toys" (Needham, Barrett, & Peterman, 2002, p. 279) (see Figure 4.16). Infants who participated in sessions with the mittens grasped and manipulated objects earlier in their development than a control group of infants who did not receive the "mitten" experience. The experienced infants looked at the objects longer, swatted at them more during visual contact, and were more likely to mouth the objects. In a recent study, 5-month-old infants whose parents trained them to use the sticky mittens for 10 minutes a day over a two-week period showed advances in their reaching behavior at the end of the two weeks (Libertus & Needham, 2010).

fine motor skills Motor skills that involve more finely tuned movements, such as finger dexterity.

Just as infants need to exercise their gross motor skills, they also need to exercise their fine motor skills (Needham, 2009). Especially when they can manage a pincer grip, infants delight in picking up small objects. Many develop the pincer grip and begin to crawl at about the same time, and infants at this time pick up virtually everything in sight, especially on the floor, and put the objects in their mouth. Thus, parents need to be vigilant in regularly monitoring what objects are within the infant's reach (Keen, 2005).

Rachel Keen (2011) emphasizes that tool use is an excellent context for studying problem solving in infants because tool use provides information about how infants plan to reach a goal. Researchers in this area have studied infants' intentional actions, which range from picking up a spoon in different orientations to retrieving rakes from inside tubes.

Review *Connect* Reflect

LG2 Describe infants' motor development.

Review

- What is the dynamic systems view?
- What are some reflexes that infants have?
- How do gross motor skills develop in infancy?
- How do fine motor skills develop in infancy?

Connect

- What are the differences between the grasping reflex present at birth and the fine motor grasping skills an infant develops between 4 and 12 months of age?

Reflect *Your Own Personal Journey of Life*

- Think of a motor skill that you perform. How would dynamic systems theory explain your motor skill performance?

3 Sensory and Perceptual Development

LG3 Summarize the course of sensory and perceptual development in infancy.

- What Are Sensation and Perception?
- The Ecological View
- Visual Perception
- Other Senses
- Intermodal Perception
- Nature, Nurture, and Perceptual Development
- Perceptual-Motor Coupling

The experiences of the first three years of life are almost entirely lost to us, and when we attempt to enter into a small child's world, we come as foreigners who have forgotten the landscape and no longer speak the native tongue.

—Selma Fraiberg

Developmentalist and Child Advocate, 20th Century

How do sensations and perceptions develop? Can a newborn see? If so, what can it perceive? What about the other senses—hearing, smell, taste, and touch? What are they like in the newborn, and how do they develop? Can an infant put together information from two modalities, such as sight and sound? These are among the intriguing questions that we will explore in this section.

WHAT ARE SENSATION AND PERCEPTION?

How does a newborn know that her mother's skin is soft rather than rough? How does a 5-year-old know what color his hair is? Infants and children "know" these things as a result of information that comes through the senses. Without vision, hearing, touch, taste, and smell, we would be isolated from the world; we would live in dark silence, a tasteless, colorless, feelingless void.

Sensation occurs when information interacts with sensory *receptors*—the eyes, ears, tongue, nostrils, and skin. The sensation of hearing occurs when waves of pulsating air are collected by the outer ear and transmitted through the bones of the inner ear to the auditory nerve. The sensation of vision occurs as rays of light contact the eyes, become focused on the retina, and are transmitted by the optic nerve to the visual centers of the brain.

Perception is the interpretation of what is sensed. The air waves that contact the ears might be interpreted as noise or as musical sounds, for example. The physical energy transmitted to

sensation The product of the interaction between information and the sensory receptors—the eyes, ears, tongue, nostrils, and skin.

perception The interpretation of what is sensed.

the retina of the eye might be interpreted as a particular color, pattern, or shape, depending on how it is perceived.

THE ECOLOGICAL VIEW

For the past several decades, much of the research on perceptual development in infancy has been guided by the ecological view of Eleanor and James J. Gibson (E. J. Gibson, 1969, 1989, 2001; J. J. Gibson, 1966, 1979). They argue that we do not have to take bits and pieces of data from sensations and build up representations of the world in our minds. Instead, our perceptual system can select from the rich information that the environment itself provides.

According to the Gibsons' **ecological view,** we directly perceive information that exists in the world around us. This view is called *ecological* "because it connects perceptual capabilities to information available in the world of the perceiver" (Kellman & Arterberry, 2006, p. 112). Thus, perception brings us into contact with the environment so we can interact with and adapt to it. Perception is designed for action. Perception gives people such information as when to duck, when to turn their bodies through a narrow passageway, and when to put their hands up to catch something.

In the Gibsons' view, objects have **affordances,** which are opportunities for interaction offered by objects that fit within our capabilities to perform activities. A pot may afford you something to cook with, and it may afford a toddler something to bang. Adults typically know when a chair is appropriate for sitting, when a surface is safe for walking, or when an object is within reach. We directly and accurately perceive these affordances by sensing information from the environment—the light or sound reflecting from the surfaces of the world—and from our own bodies through muscle receptors, joint receptors, and skin receptors, for example (Ziemer, Plumert, & Pick, 2012).

An important developmental question is: What affordances can infants or children detect and use? In one study, for example, when babies who could walk were faced with a squishy waterbed, they stopped and explored it, then chose to crawl rather than walk across it (Gibson & others, 1987). They combined perception and action to adapt to the demands of the task.

Similarly, as we described earlier in the section on motor development, infants who were just learning to crawl or just learning to walk were less cautious when confronted with a steep slope than experienced crawlers or walkers were (Adolph, 1997). The more experienced crawlers and walkers perceived that a slope *affords* the possibility for not only faster locomotion but also for falling. Again, infants coupled perception and action to make a decision about what do in their environment. Through perceptual development, children become more efficient at discovering and using affordances.

Studying infants' perceptions has not been an easy task. For instance, if newborns have limited communication abilities and are unable to verbalize what they are seeing, hearing, smelling, and so on, how can we study their perception? *Connecting Through Research* describes some of the ingenious ways researchers study infants' perceptions.

How would you use the Gibsons' ecological theory of perception and the concept of affordance to explain the role that perception is playing in this toddler's activity?

VISUAL PERCEPTION

What do newborns see? How does visual perception develop in infancy?

Visual Acuity and Human Faces Psychologist William James (1890/1950) called the newborn's perceptual world a "blooming, buzzing confusion." More than a century later, we can safely say that he was wrong (Johnson, 2012, 2013). Even the newborn perceives a world with some order. That world, however, is far different from the one perceived by the toddler or the adult.

Just how well can infants see? At birth, the nerves and muscles and lens of the eye are still developing. As a result, newborns cannot see small things that are far away. The newborn's vision is estimated to be 20/240 on the well-known Snellen chart used for eye examinations, which means that a newborn can see at 20 feet what a normal adult can see at 240 feet (Aslin & Lathrop, 2008). In other words, an object 20 feet away is only as clear to the newborn as it would be if it were 240 feet away from an adult with normal vision (20/20). By 6 months of age, though, on *average* vision is 20/40 (Aslin & Lathrop, 2008).

ecological view The view that perception functions to bring organisms in contact with the environment and to increase adaptation.

affordances Opportunities for interaction offered by objects that fit within our capabilities to perform functional activities.

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How Can Newborns' Perception Be Studied?

The creature has poor motor coordination and can move itself only with great difficulty. Although it cries when uncomfortable, it uses few other vocalizations. In fact, it sleeps most of the time, about 16 to 17 hours a day. You are curious about this creature and want to know more about what it can do. You think to yourself, "I wonder if it can see. How could I find out?"

You obviously have a communication problem with the creature. You must devise a way that will allow the creature to "tell" you that it can see. While examining the creature one day, you make an interesting discovery. When you move an object horizontally in front of the creature, its eyes follow the object's movement.

The creature's head movement suggests that it has at least some vision. In case you haven't already guessed, the creature you have been reading about is the human infant, and the role you played is that of a researcher interested in devising techniques to learn about the infant's visual perception. After years of work, scientists have developed research methods and tools sophisticated enough to examine the subtle abilities of infants and to interpret their complex actions (Bendersky & Sullivan, 2007).

Visual Preference Method

Robert Fantz (1963) was a pioneer in this effort. Fantz made an important discovery that advanced the ability of researchers to investigate infants' visual perception: Infants look at different things for different lengths of time. Fantz placed an infant in a "looking chamber," which had two visual displays on the ceiling above the infant's head. An experimenter viewed the infant's eyes by looking through a peephole. If the infant was fixating on one of the displays, the experimenter could see the display's reflection in the infant's eyes. This allowed the experimenter to determine how long the infant looked at each display. Fantz (1963) found that infants only two days old look longer at patterned stimuli, such as faces and concentric circles, than at red, white, or yellow discs. Infants 2 to 3 weeks old also preferred to look at patterns—a face, a piece of printed matter, or a bull's-eye—longer than at red, yellow, or white discs (see Figure 4.17). Fantz' research method—studying whether infants can distinguish one stimulus from another by measuring the length of time they attend to different stimuli—is referred to as the **visual preference method.**

Habituation and Dishabituation

Another way that researchers have studied infant perception is to present a stimulus (such as a sight or a sound) a number of times. If the infant decreases its response to the stimulus after several presentations, it indicates that the infant is no longer interested in looking at the stimulus. If the researcher now presents a new stimulus, the infant's response will recover—indicating the infant can discriminate between the old and new stimulus (Snyder & Torrence, 2008).

Habituation is the name given to decreased responsiveness to a stimulus after repeated presentations of the stimulus. **Dishabituation** is the recovery of a habituated response after a change in stimulation. Newborn infants can habituate to repeated sights, sounds, smells, or touches (Rovee-Collier, 2004). Among the measures researchers use in

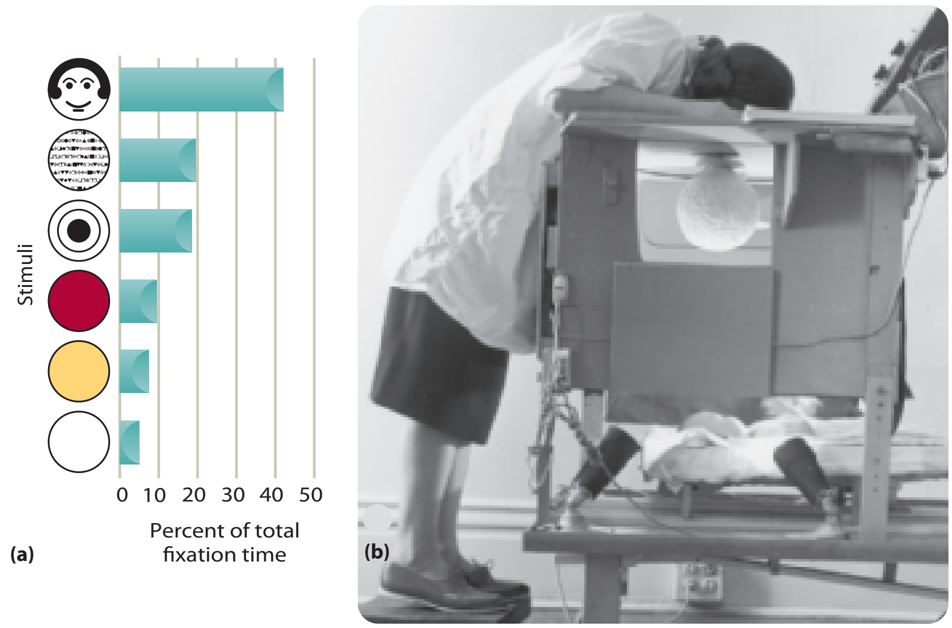

FIGURE **4.17**

FANTZ' EXPERIMENT ON INFANTS' VISUAL PERCEPTION. (*a*) Infants 2 to 3 weeks old preferred to look at some stimuli more than others. In Fantz' experiment, infants preferred to look at patterns rather than at color or brightness. For example, they looked longer at a face, a piece of printed matter, or a bull's-eye than at red, yellow, or white discs. (*b*) Fantz used a "looking chamber" to study infants' perception of stimuli.

visual preference method A method used to determine whether infants can distinguish one stimulus from another by measuring the length of time they attend to different stimuli.

habituation Decreased responsiveness to a stimulus after repeated presentations of the stimulus.

dishabituation Recovery of a habituated response after a change in stimulation.

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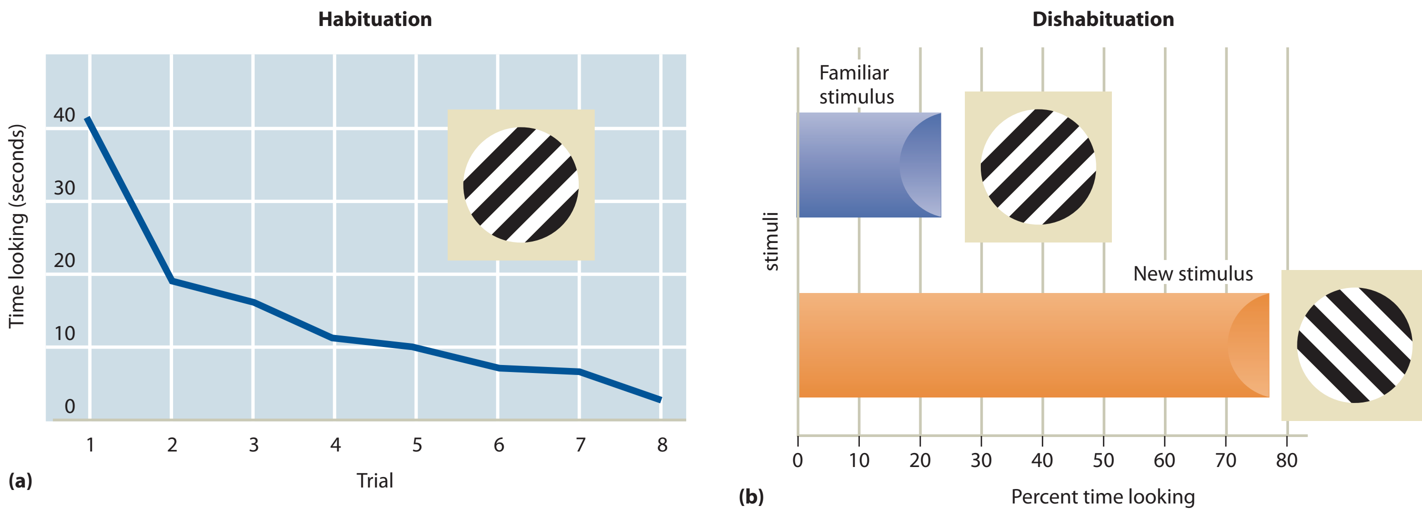

FIGURE **4.18**

HABITUATION AND DISHABITUATION. In the first part of one study, (*a*) 7-hour-old newborns were shown a stimulus. As indicated, the newborns looked at it an average of 41 seconds when it was first presented to them (Slater, Morison, & Somers, 1988). Over seven more presentations of the stimulus, they looked at it less and less. In the second part of the study, (*b*) infants were presented with both the familiar stimulus to which they had just become habituated and a new stimulus (which was rotated 90 degrees). The newborns looked at the new stimulus three times as long as the familiar stimulus.

habituation studies are sucking behavior (sucking stops when the young infant attends to a novel object), heart and respiration rates, and the length of time the infant looks at an object. Figure 4.18 shows the results of one study of habituation and dishabituation with newborns (Slater, Morison, & Somers, 1988).

High-Amplitude Sucking

To assess an infant's attention to sound, researchers often use a method called *high-amplitude sucking*. In this method, infants are given a nonnutritive nipple to suck, and the nipple is connected to a sound generating system. The researcher computes a baseline high-amplitude sucking rate in a one-minute silent period. Following the baseline, presentation of a sound is made contingent on the rate of high-amplitude sucking. Initially babies suck frequently so the sound occurs often. Gradually they lose interest in hearing the same sound, so they begin to suck less often. Then the researcher changes the sound that is being presented. If the babies renew their vigorous sucking, the inference is that they have discriminated the sound change and are sucking more because they want to hear the interesting new sound (Menn & Stoel-Gammon, 2009).

FIGURE **4.19**

AN INFANT WEARING EYE-TRACKING HEADGEAR. Photo from Karen Adolph's laboratory at New York University.

The Orienting Response and Tracking

A technique that can be used to determine whether an infant can see or hear is the *orienting response,* which involves turning one's head toward a sight or sound. Another technique, *tracking,* consists of eye movements that follow (*track*) a moving object and can be used to evaluate an infant's early visual ability, or a startle response can determine an infant's reaction to a noise (Bendersky & Sullivan, 2007). The most important recent advance in measuring infant perception is the development of sophisticated eye-tracking equipment (Franchak & others, 2011; Morgante, Zolfaghari, & Johnson, 2012; Navab & others, 2012). Figure 4.19 shows an

connecting through research

(continued)

infant wearing an eye-tracking headgear in a recent study on visually guided motor behavior and social interaction.

One of the main reasons that infant perception researchers are so enthusiastic about the recent availability of sophisticated eye-tracking equipment is that looking time is among the most important measures of infant perceptual and cognitive development (Aslin, 2012). The new eye-tracking equipment allows for far greater precision in assessing various aspects of infant looking and gaze than is possible with human observation (Oakes, 2012). Among the areas of infant perception in which eye-tracking equipment is being used are memory, joint attention, and face processing (Falck-Yttere & others, 2012; Richmond & Nelson, 2009; Wheeler & others, 2011). Further, eye-tracking equipment is improving our understanding of atypically developing infants, such as those with autism (Sasson & Elison, 2012), and infants at risk for atypical developmental outcomes, including infants at risk for developing autism and preterm infants (Bedford & others, 2012).

A recent eye-tracking study shed light on the effectiveness of TV programs and DVDs that claim to educate infants (Kirkorian, Anderson, & Keen, 2012). In this study, 1-year-olds, 4-year-olds, and adults watched *Sesame Street* and the eye-tracking equipment recorded precisely what they looked at on the screen. The 1-year-olds were far less likely to consistently look at the same part of the screen as their older counterparts, suggesting that the 1-year-olds showed little understanding of the *Sesame Street* video but instead were more likely to be attracted by what was salient than by what was relevant.

Equipment

Technology can facilitate the use of most methods for investigating the infant's perceptual abilities. Video-recording equipment allows researchers to investigate elusive behaviors. High-speed computers make it possible to perform complex data analysis in minutes. Other equipment records respiration, heart rate, body movement, visual fixation, and sucking behavior, which provide clues to what the infant is perceiving. For example, some researchers use equipment that detects whether a change in infants' respiration follows a change in the pitch of a sound. If so, it suggests that the infants heard the pitch change.

Scientists have had to be very creative when assessing the development of infants, discovering ways to "interview" them even though they cannot yet talk. Other segments of the population, such as adults who have suffered from a stroke, have difficulty communicating verbally. What kinds of methods or equipment do you think researchers might use to evaluate their perceptual abilities?

Infants show an interest in human faces soon after birth (Lee & others, 2012). Figure 4.20 shows a computer estimation of what a picture of a face looks like to an infant at different ages from a distance of about 6 inches. Infants spend more time looking at their mother's face than a stranger's face as early as 12 hours after being born (Bushnell, 2003). By 3 months of age, infants match voices to faces, distinguish between male and female faces, and discriminate between faces of their own ethnic group and those of other ethnic groups (Gaither & others, 2012; Kelly & others, 2005, 2007; Liu & others, 2011).

As infants develop, they change the way they gather information from the visual world, including human faces (Otsuka & others, 2012). One study recorded eye movements of 3-, 6-,

FIGURE **4.20**

VISUAL ACUITY DURING THE FIRST MONTHS OF LIFE. The four photographs represent a computer estimation of what a picture of a face looks like to a 1-month-old, 2-month-old, 3-month-old, and 1-year-old (which approximates the visual acuity of an adult).

and 9-month-old infants as they viewed clips from an animated film—*A Charlie Brown Christmas* (Frank, Vul, & Johnson, 2009). From 3 to 9 months of age, infants gradually began focusing their attention more on the faces in the animated film and less on salient background stimuli.

Also, as we discussed in the *Connecting Through Research* interlude, young infants can perceive certain patterns. With the help of his "looking chamber," Robert Fantz (1963) revealed that even 2- to 3-week-old infants prefer to look at patterned displays rather than nonpatterned displays. For example, they prefer to look at a normal human face rather than one with scrambled features, and prefer to look at a bull's-eye target or black-and-white stripes rather than a plain circle.

Color Vision The infant's color vision also improves (Aslin & Lathrop, 2008). By 8 weeks, and possibly as early as 4 weeks, infants can discriminate some colors (Kelly, Borchert, & Teller, 1997). By 4 months of age, they have color preferences that mirror adults' in some cases, preferring saturated colors such as royal blue over pale blue, for example (Bornstein, 1975).

A recent study of the reactions to blue, yellow, red, and green hues by 4- to 5-month-old infants revealed that they looked longest at reddish hues and shortest at greenish hues (Franklin & others, 2010). In part, the changes in vision described here reflect maturation. Experience, however, is also necessary for color vision to develop normally (Sugita, 2004).

Perceptual Constancy Some perceptual accomplishments are especially intriguing because they indicate that the infant's perception goes beyond the information provided by the senses (Johnson, 2012, 2013; Slater & others, 2011). This is the case in perceptual constancy, in which sensory stimulation is changing but perception of the physical world remains constant. If infants did not develop perceptual constancy, each time they saw an object at a different distance or in a different orientation, they would perceive it as a different object. Thus, the development of perceptual constancy allows infants to perceive their world as stable. Two types of perceptual constancy are size constancy and shape constancy.

Size constancy is the recognition that an object remains the same even though the retinal image of the object changes as you move toward or away from the object. The farther away from us an object is, the smaller its image is on our eyes. Thus, the size of an object on the retina is not sufficient to tell us its actual size. For example, you perceive a bicycle standing right in front of you as smaller than the car parked across the street, even though the bicycle casts a larger image on your eyes than the car does. When you move away from the bicycle, you do not perceive it to be shrinking even though its image on your retinas shrinks; you perceive its size as constant.

But what about babies? Do they have size constancy? Researchers have found that babies as young as 3 months of age show size constancy (Bower, 1966; Day & McKenzie, 1973). However, at 3 months of age, this ability is not full-blown. It continues to develop until 10 or 11 years of age (Kellman & Banks, 1998).

Shape constancy is the recognition that an object remains the same shape even though its orientation to us changes. Look around the room you are in right now. You likely see objects of varying shapes, such as tables and chairs. If you get up and walk around the room, you will see these objects from different sides and angles. Even though your retinal image of the objects changes as you walk and look, you will still perceive the objects as having the same shape.

Do babies have shape constancy? As with size constancy, researchers have found that babies as young as 3 months of age have shape constancy (Bower, 1966; Day & McKenzie, 1973). Three-month-old infants, however, do not have shape constancy for irregularly shaped objects such as tilted planes (Cook & Birch, 1984).

Perception of Occluded Objects Look around where you are now. You likely see that some objects are partly occluded by other objects that are in front of them—possibly a desk behind a chair, some books behind a computer, or a car parked behind a tree. Do infants perceive an object as complete when it is occluded by an object in front of it?

In the first two months of postnatal development, infants don't perceive occluded objects as complete; instead, they perceive only what is visible (Johnson, 2009). Beginning at about 2 months of age, infants develop the ability to perceive that occluded objects are whole (Slater, Field, & Hernandez-Reif, 2007). How does perceptual completion develop? In Scott Johnson's

size constancy The recognition that an object remains the same even though the retinal image of the object changes as you move toward or away from the object.

shape constancy The recognition that an object's shape remains the same even though its orientation to us changes.

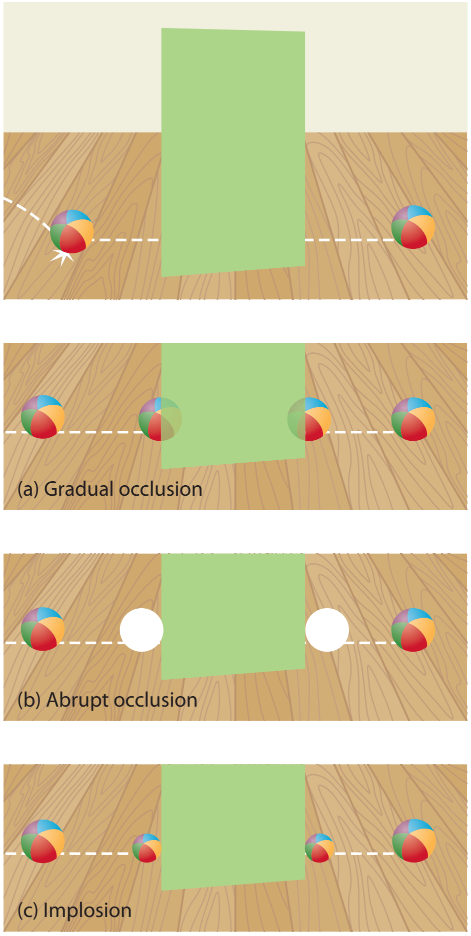

FIGURE **4.21**

INFANTS' PREDICTIVE TRACKING OF A BRIEFLY OCCLUDED MOVING BALL. The top photograph shows the visual scene that infants experienced. At the beginning of each event, a multicolored ball bounced up and down with an accompanying bouncing sound, and then rolled across the floor until it disappeared behind the partition. The bottom drawing shows the three stimulus events that the 5- to 9-month-old infants experienced: (*a*) Gradual occlusion—the ball gradually disappears behind the right side of the occluding partition located in the center of the display. (*b*) Abrupt occlusion—the ball abruptly disappears when it reaches the location of the white circle and then abruptly reappears two seconds later at the location of the second white circle on the other side of the occluding partition. (*c*) Implosion—the rolling ball quickly decreases in size as it approaches the occluding partition and rapidly increases in size as it reappears on the other side of the occluding partition.

research (2004, 2009, 2010, 2011, 2012, 2013; Johnson & others, 2000), learning, experience, and self-directed exploration via eye movements play key roles in the development of perceptual completion in young infants.

Many objects that are occluded appear and disappear behind closer objects, as when you are walking down the street and see cars appear and disappear behind buildings as they move or you move. Infants develop the ability to track briefly occluded moving objects at about 3 to 5 months of age (Bertenthal, 2008). One study explored the ability of 5- to 9-month-old infants to track moving objects that disappeared gradually behind an occluded partition, disappeared abruptly, or imploded (shrank quickly in size) (Bertenthal, Longo, & Kenny, 2007) (see Figure 4.21). In this study, the infants were more likely to accurately predict the moving object when it disappeared gradually rather than when it vanished abruptly or imploded.

Depth Perception Might infants even perceive depth? To investigate this question, Eleanor Gibson and Richard Walk (1960) constructed a miniature cliff with a dropoff covered by glass in their laboratory. They placed infants on the edge of this visual cliff and had their mothers coax them to crawl onto the glass (see Figure 4.22). Most infants would not crawl out on the glass, choosing instead to remain on the shallow side, an indication that they could perceive depth.

The 6- to 12-month-old infants in the visual cliff experiment had extensive visual experience. Do younger infants without this experience still perceive depth? Since younger infants do not crawl, this question is difficult to answer. Two- to 4-month-old infants show differences in heart rate when they are placed directly on the deep side of the visual cliff instead of on the shallow side (Campos, Langer, & Krowitz, 1970). However, these differences might mean that young infants respond to differences in some visual characteristics of the deep and shallow cliffs, with no actual knowledge of depth (Adolph & Kretch, 2012). Although researchers do not know exactly how early in life infants can perceive depth, we do know that infants develop the ability to use binocular cues to depth by about 3 to 4 months of age.

OTHER SENSES

Other sensory systems besides vision also develop during infancy. We will explore development in hearing, touch and pain, smell, and taste.

Hearing During the last two months of pregnancy, as the fetus nestles in its mother's womb, it can hear sounds such as the mother's voice, music, and so on (Kisilevsky & others, 2009). Two psychologists wanted to find out if a fetus who heard Dr. Seuss' classic story *The Cat in the Hat* while still in the mother's womb would prefer hearing the story after birth (DeCasper & Spence, 1986). During the last months of pregnancy, 16 women read *The Cat in the Hat* to their fetuses. Then shortly after the babies were born, their mothers read either *The Cat in the Hat* or a story with a different rhyme and pace, *The King, the Mice and the Cheese* (which was not read to them during prenatal development). The infants sucked on a nipple in a different way when the mothers read the two stories, suggesting that the infants recognized the pattern and tone of *The Cat in the Hat* (see Figure 4.23). This study illustrates not only that a fetus can hear but also that it has a remarkable ability to learn and remember even before birth. A recent fMRI study confirmed capacity of the fetus to hear at 33 to 34 weeks into the prenatal period by assessing fetal brain response to auditory stimuli (Jardri & others, 2012).

The fetus can also recognize the mother's voice, as one study demonstrated (Kisilevsky & others, 2003). Sixty term fetuses (mean gestational age, 38.4 weeks) were exposed to a tape recording either of their mother or of a female stranger reading a passage. The sounds of the tape were delivered through a loudspeaker held just above the mother's abdomen. Fetal heart rate increased in response to the mother's voice but decreased in response to the stranger's voice.

What kind of changes in hearing take place during infancy? They involve perception of a sound's loudness, pitch, and localization:

- *Loudness.* Immediately after birth, infants cannot hear soft sounds quite as well as adults can; a stimulus must be louder to be heard by a newborn than by an adult

(Trehub & others, 1991). For example, an adult can hear a whisper from about 4 to 5 feet away, but a newborn requires that sounds be closer to a normal conversational level to be heard at that distance.

- *Pitch.* Infants are also less sensitive to the pitch of a sound than adults are. *Pitch* is the perception of the frequency of a sound. A soprano voice sounds high-pitched, a bass voice low-pitched. Infants are less sensitive to low-pitched sounds and are more likely to hear high-pitched sounds (Aslin, Jusczyk, & Pisoni, 1998). A recent study revealed that by 7 months of age, infants can process simultaneous pitches when they hear voices but they are more likely to encode the higher-pitched voice (Marie & Trainor, 2012). By 2 years of age, infants have considerably improved their ability to distinguish sounds with different pitches.
- *Localization.* Even newborns can determine the general location from which a sound is coming, but by 6 months of age, they are more proficient at *localizing* sounds or detecting their origins. Their ability to localize sounds continues to improve during the second year (Burnham & Mattock, 2010).

FIGURE **4.22**

EXAMINING INFANTS' DEPTH PERCEPTION ON THE VISUAL CLIFF. Eleanor Gibson and Richard Walk (1960) found that most infants would not crawl out on the glass, which, according to Gibson and Walk, indicated that they had depth perception. However, some critics point out that the visual cliff is a better indication of the infant's social referencing and fear of heights than of the infant's perception of depth.

Touch and Pain Do newborns respond to touch? Can they feel pain?

Newborns do respond to touch. A touch to the cheek produces a turning of the head; a touch to the lips produces sucking movements.

Newborns can also feel pain (Field & Hernandez-Reif, 2008; Gunnar & Quevado, 2007). If and when you have a son and consider whether he should be circumcised, the issue of an infant's pain perception probably will become important to you. Circumcision is usually performed on young boys about the third day after birth. Will your young son experience pain if he is circumcised when he is 3 days old? An investigation by Megan Gunnar and her colleagues (1987) found that newborn infant males cried intensely during circumcision. The circumcised infant also displays amazing resiliency. Within several minutes after the surgery, they can nurse and interact in a normal manner with their mothers. And, if allowed to, the newly circumcised newborn drifts into a deep sleep, which seems to serve as a coping mechanism.

For many years, doctors performed operations on newborns without anesthesia. This practice was accepted because of the dangers of anesthesia and because of the supposition that newborns do not feel pain. As researchers demonstrated that newborns can feel pain, the practice of operating on newborns without anesthesia is being challenged. Anesthesia now is used in some circumcisions (Morris & others, 2012).

(a) (b)

FIGURE **4.23**

HEARING IN THE WOMB. (*a*) Pregnant mothers read *The Cat in the Hat* to their fetuses during the last few months of pregnancy. (*b*) When they were born, the babies preferred listening to a recording of their mothers reading *The Cat in the Hat,* as evidenced by their sucking on a nipple that produced this recording, rather than another story, *The King, the Mice and the Cheese.*

FIGURE **4.24**

NEWBORNS' PREFERENCE FOR THE SMELL OF THEIR MOTHER'S BREAST PAD. In the experiment by MacFarlane (1975), 6-day-old infants preferred to smell their mother's breast pad rather than a clean one that had never been used, but 2-day-old infants did not show this preference, indicating that odor preference requires several days of experience to develop.

The important ability to connect information about vision with information about touch is evident during infancy. Coordination of vision and touch has been well documented in 6-month-olds (Rose, 1990) and in one study was demonstrated in 2- to 3-month-olds (Streri, 1987).

Smell Newborns can differentiate odors (Doty & Shah, 2008). The expressions on their faces seem to indicate that they like the way vanilla and strawberry smell but do not like the way rotten eggs and fish smell (Steiner, 1979). In one investigation, 6-day-old infants who were breast fed showed a clear preference for smelling their mother's breast pad rather than a clean breast pad (MacFarlane, 1975) (see Figure 4.24). However, when they were 2 days old, they did not show this preference, indicating that they require several days of experience to recognize this odor.

Taste Sensitivity to taste is present even before birth (Doty & Shah, 2008). Human newborns learn tastes prenatally through the amniotic fluid and in breast milk after birth (Beauchamp & Mennella, 2009; Mennella, 2009). In one study, even at only 2 hours of age, babies made different facial expressions when they tasted sweet, sour, and bitter solutions (Rosenstein & Oster, 1988) (see Figure 4.25). At about 4 months of age, infants begin to prefer salty tastes, which as newborns they had found to be aversive (Doty & Shah, 2008).

INTERMODAL PERCEPTION

Imagine yourself playing basketball or tennis. You are experiencing many visual inputs: the ball coming and going, other players moving around, and so on. However, you are experiencing many auditory inputs as well: the sound of the ball bouncing or being hit, the grunts and groans of other players, and so on. There is good correspondence between much of the visual and auditory information: When you see the ball bounce, you hear a bouncing sound; when a player stretches to hit a ball, you hear a groan. When you look at and listen to what is going on, you do not experience just the sounds or just the sights—you put all these things together. You experience a unitary episode. This is **intermodal perception,** which involves integrating information from two or more sensory modalities, such as vision and hearing (Bremner & others, 2012). Most perception is intermodal (Bahrick, 2010).

Early, exploratory forms of intermodal perception exist even in newborns (Bahrick & Hollich, 2008). For example, newborns turn their eyes and their head toward the sound of a voice or rattle when the sound is maintained for several seconds (Clifton & others, 1981), but the newborn can localize a sound and look at an object only in a crude way (Bechtold, Bushnell, & Salapatek, 1979). These early forms of intermodal perception become sharpened with experience in the first year of life (Kirkham & others, 2012). In one study, infants as young as 3 months old looked more at their mother when they also heard her voice and longer at their father when they also heard his voice (Spelke & Owsley, 1979). Thus, even young infants can coordinate visual-auditory information involving people.

FIGURE **4.25**

NEWBORNS' FACIAL RESPONSES TO BASIC TASTES. Facial expressions elicited by (*a*) a sweet solution, (*b*) a sour solution, and (*c*) a bitter solution.

Can young infants put vision and sound together as precisely as adults do? In the first six months, infants have difficulty connecting sensory input from different modes, but in the second half of the first year they show an increased ability to make this connection mentally.

What is intermodal perception? Which senses is this infant using to integrate information about the toy?

NATURE, NURTURE, AND PERCEPTUAL DEVELOPMENT

Now that we have discussed many aspects of perceptual development, let's explore one of developmental psychology's key issues as it relates to perceptual development: the nature-nurture issue. There has been a longstanding interest in how strongly infants' perception is influenced by nature or nurture (Johnson, 2011, 2012, 2013; Slater & others, 2011). In the field of perceptual development, nature proponents are referred to as *nativists* and those who emphasize learning and experience are called *empiricists*.

In the nativist view, the ability to perceive the world in a competent, organized way is inborn or innate. At the beginning of our discussion of perceptual development, we examined the ecological view of the Gibsons because it has played such a pivotal role in guiding research in perceptual development. The Gibsons' ecological view leans toward a nativist explanation of perceptual development because it holds that perception is direct and evolved over time to allow the detection of size and shape constancy, a three-dimensional world, intermodal perception, and so on, early in infancy. However, the Gibsons' view is not entirely nativist because they emphasized that perceptual development involves distinctive features that are detected at different ages (Slater & others, 2011).

The Gibsons' ecological view is quite different from Piaget's constructivist view that reflects an empiricist approach to explaining perceptual development. According to Piaget, much of perceptual development in infancy must await the development of a sequence of cognitive stages for infants to construct more complex perceptual tasks. Thus, in Piaget's view the ability to perceive size and shape constancy, a three-dimensional world, intermodal perception, and so on, develops later in infancy than the Gibsons envision.

Much of early perception develops from innate (nature) foundations and the basic foundation of many perceptual abilities can be detected in newborns, whereas other abilities unfold maturationally (Bornstein, Arterberry, & Mash, 2011). However, as infants develop, environmental experiences (nurture) refine or calibrate many perceptual functions, and they may be the driving force behind some functions (Amso & Johnson, 2010). The accumulation of experience with and knowledge about their perceptual world contributes to infants' ability to process coherent perceptions of people and things (Johnson, 2012, 2013). Thus, a full portrait of perceptual development includes the influence of nature, nurture, and a developing sensitivity to information (Arterberry, 2008).

What roles do nature and nurture play in the infant's perceptual development?

PERCEPTUAL-MOTOR COUPLING

As we come to the end of this chapter, we return to the important theme of perceptual-motor coupling. The distinction between perceiving and doing has been a time-honored tradition in psychology. However, a number of experts on perceptual and motor development question whether this distinction makes sense (Adolph & Robinson, 2013; Thelen & Smith, 2006). The main thrust of research in Esther Thelen's dynamic systems approach is to explore how people assemble motor behaviors for perceiving and acting. The main theme of the ecological approach of Eleanor and James J. Gibson is to discover how perception guides action. Action can guide perception, and perception can guide action. Only by moving one's eyes, head, hands, and arms and by moving from one location to another can an individual fully experience his or her environment and learn how to adapt to it. Perception and action are coupled (Kim & Johnson, 2010).

Babies, for example, continually coordinate their movements with perceptual information to learn how to maintain balance, reach for objects in space, and move across various surfaces and terrains (Adolph & Berger, 2013; Thelen & Smith, 2006). They are motivated to move by

The infant is by no means as helpless as it looks and is quite capable of some very complex and important actions.

—HERB PICK

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intermodal perception The ability to relate and integrate information from two or more sensory modalities, such as vision and hearing.

How are perception and action coupled in children's development?

what they perceive. Consider the sight of an attractive toy across the room. In this situation, infants must perceive the current state of their bodies and learn how to use their limbs to reach the toy. Although their movements at first are awkward and uncoordinated, babies soon learn to select patterns that are appropriate for reaching their goals.

Equally important is the other part of the perception-action coupling. That is, action educates perception (Adolph & Robinson, 2013). For example, watching an object while exploring it manually helps infants to discriminate its texture, size, and hardness. Locomoting in the environment teaches babies about how objects and people look from different perspectives, or whether various surfaces will support their weight.

How do infants develop new perceptual-motor couplings? Recall from our discussion earlier in this chapter that in the traditional view of Gesell, infants' perceptual-motor development is prescribed by a genetic plan to follow a fixed and sequential progression of stages in development. The genetic determination view has been replaced by the dynamic systems view that infants learn new perceptual-motor couplings by assembling skills for perceiving and acting. New perceptual-motor coupling is not passively accomplished; rather, the infant actively develops a skill to achieve a goal within the constraints set by the infant's body and the environment (Adolph & Robinson, 2013).

Children perceive in order to move and move in order to perceive. Perceptual and motor development do not occur in isolation from each other but instead are coupled.

Review *Connect* Reflect

LG3 Summarize the course of sensory and perceptual development in infancy.

Review

- What are sensation and perception?
- What is the ecological view of perception?
- How does visual perception develop in infancy?
- How do hearing, touch and pain, smell, and taste develop in infancy?
- What is intermodal perception?
- What roles do nature and nurture play in perceptual development?
- How is perceptual-motor development coupled?

Connect

- Perceptual-motor coupling was discussed in the previous section as well as in this section. Describe how this concept could be linked to the concept of nature versus nurture (p. 33).

Reflect *Your Own Personal Journey of Life*

- How much sensory stimulation would you provide your own baby? A little? A lot? Could you overstimulate your baby? Explain.

topical **connections**

In the next chapter, you will read about the remarkable cognitive changes that characterize infant development and how early infants competently process information about their world. Advances in infants' cognitive development—together with the development of the brain and perceptual-motor advances discussed in this chapter—allow infants to adapt more effectively to their environment. In Chapter 7, we will further explore physical development when we examine how children progress through the early childhood years (ages 3 to 5). Young children's physical development continues to change and to become more coordinated in early childhood, although gains in height and weight are not as dramatic in early childhood as in infancy.

looking ***forward***

reach your **learning goals**

Physical Development in Infancy

1 Physical Growth and Development in Infancy

LG1 Discuss physical growth and development in infancy.

Patterns of Growth

- The cephalocaudal pattern is the sequence in which growth proceeds from top to bottom. The proximodistal pattern is the sequence in which growth starts at the center of the body and moves toward the extremities.

Height and Weight

- The average North American newborn is 20 inches long and weighs 7 pounds. Infants grow about 1 inch per month in the first year and nearly triple their weight by their first birthday. The rate of growth slows in the second year.

The Brain

- One of the most dramatic changes in the brain in the first two years of life is dendritic spreading, which increases the connections between neurons. Myelination, which speeds the conduction of nerve impulses, continues through infancy and even into adolescence. The cerebral cortex has two hemispheres (left and right). Lateralization refers to specialization of function in one hemisphere or the other. Early experiences play an important role in brain development. Neural connections are formed early in an infant's life. Before birth, genes mainly direct neurons to different locations. After birth, the inflowing stream of sights, sounds, smells, touches, language, and eye contact help shape the brain's neural connections, as does stimulation from caregivers and others. The neuroconstructivist view is an increasingly popular view of the brain's development.

Sleep

- Newborns usually sleep about 18 hours a day. By 6 months of age, many American infants approach adult-like sleeping patterns. REM sleep—during which dreaming occurs—is present more in early infancy than in childhood and adulthood. Sleeping arrangements for infants vary across cultures. In America, infants are more likely to sleep alone than in many other cultures. Some experts believe shared sleeping can lead to sudden infant death syndrome (SIDS), a condition that occurs when a sleeping infant suddenly stops breathing and dies without an apparent cause.

Nutrition

- Infants need to consume about 50 calories per day for each pound they weigh. The growing consensus is that in most instances breast feeding is superior to bottle feeding for both the infant and the mother, although the correlational nature of studies must be considered. Severe infant malnutrition is still prevalent in many parts of the world. A special concern in impoverished countries is early weaning from breast milk and the misuse and hygiene problems associated with bottle feeding in these countries. The Women, Infants, and Children (WIC) program has produced positive benefits in low-income families.

2 Motor Development

LG2 Describe infants' motor development.

The Dynamic Systems View

- Thelen's dynamic systems theory seeks to explain how motor behaviors are assembled for perceiving and acting. Perception and action are coupled. According to this theory, motor skills are the result of many converging factors, such as the development of the nervous system, the body's physical properties and its movement possibilities, the goal the child is motivated to reach, and environmental support for the skill. In the dynamic systems view, motor development is far more complex than the result of a genetic blueprint.

Reflexes

- Reflexes—automatic movements—govern the newborn's behavior. They include the sucking, rooting, and Moro reflexes. The rooting and Moro reflexes disappear after three to four months. Permanent reflexes include coughing and blinking. For infants, sucking is an especially important reflex because it provides a means of obtaining nutrition.

Gross Motor Skills

- Gross motor skills involve large-muscle activities. Key skills developed during infancy include control of posture and walking. Although infants usually learn to walk by their first birthday, the neural pathways that allow walking begin to form earlier. The age at which infants reach milestones in the development of gross motor skills may vary by as much as two to four months, especially for milestones in late infancy.

Fine Motor Skills

- Fine motor skills involve finely tuned movements. The onset of reaching and grasping marks a significant accomplishment, and this becomes more refined during the first two years of life.

3 Sensory and Perceptual Development

LG3 Summarize the course of sensory and perceptual development in infancy.

What Are Sensation and Perception?

- Sensation occurs when information interacts with sensory receptors. Perception is the interpretation of sensation.

The Ecological View

- Created by the Gibsons, the ecological view states that we directly perceive information that exists in the world around us. Perception brings people in contact with the environment to interact with and adapt to it. Affordances provide opportunities for interaction offered by objects that fit within our capabilities to perform activities.

Visual Perception

- Researchers have developed a number of methods to assess the infant's perception, including the visual preference method (which Fantz used to determine young infants' preference for looking at patterned over nonpatterned displays), habituation and dishabituation, and tracking. The infant's visual acuity increases dramatically in the first year of life. Infants' color vision improves as they develop. Young infants systematically scan human faces. As early as 3 months of age, infants show size and shape constancy. At approximately 2 months of age, infants develop the ability to perceive that occluded objects are complete. In Gibson and Walk's classic study, infants as young as 6 months of age indicated they could perceive depth.

Other Senses

- The fetus can hear during the last two months of pregnancy. Immediately after birth, newborns can hear, but their sensory threshold is higher than that of adults. Developmental changes in the perception of loudness, pitch, and localization of sound occur during infancy. Newborns can respond to touch and feel pain. Newborns can differentiate odors, and sensitivity to taste may be present before birth.

Intermodal Perception

- Early, exploratory forms of intermodal perception—the ability to relate and integrate information from two or more sensory modalities—are present in newborns and become sharpened over the first year of life.

Nature, Nurture, and Perceptual Development

- In perception, nature advocates are referred to as nativists and nurture proponents are called empiricists. The Gibsons' ecological view that has guided much of perceptual development research leans toward a nativist approach but still allows for developmental changes in distinctive features. Piaget's constructivist view leans toward an empiricist approach, emphasizing that many perceptual accomplishments must await the development of cognitive stages in infancy. A strong empiricist approach is unwarranted. A full account of perceptual development includes the roles of nature, nurture, and the developing sensitivity to information.

Perceptual-Motor Coupling

- Perception and action are often not isolated but rather are coupled. Individuals perceive in order to move and move in order to perceive.

key terms

cephalocaudal pattern 110
proximodistal pattern 110
lateralization 112
neuroconstructivist view 115
sudden infant death syndrome (SIDS) 116
marasmus 120
kwashiorkor 120
dynamic systems theory 122
reflexes 123
rooting reflex 123
sucking reflex 123
Moro reflex 123
grasping reflex 123
gross motor skills 124
fine motor skills 127
sensation 128
perception 128
ecological view 129
affordances 129
visual preference method 130
habituation 130
dishabituation 130
size constancy 133
shape constancy 133
intermodal perception 137

key people

Charles Nelson 112
John Richards 112
Esther Thelen 122
Karen Adolph 124
Rachel Keen 128
Eleanor and James J. Gibson 129
Robert Fantz 130
William James 129
Scott Johnson 133
Richard Walk 134

Chapter 4 | PHYSICAL DEVELOPMENT IN INFANCY

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Learning Objectives	Application Activities	Activity Type	Page Reference
Discuss the patterns of physical growth and development in infancy.	—Cooing at Four Months	—Video	pp. 108–109
Discuss the brain during infancy.	—Crossing the Midline: A Critical Step in Brain Development 1–15 Weeks —Influences on Infant Brain Development —Structure of Neurons —The Neuron	—Video —Video —Interactive exercise —Click & drag activity	pp. 109–113
Discuss sleep and sleep habits during infancy.	—REM Sleep at 2 Weeks —Active Sleep Without REM at 2 Weeks —Sudden Infant Death Syndrome: Expert Interview	—Video —Video —Video	pp. 113–115
Discuss nutrition in infancy.	—Breast vs. Bottle Feeding —Nutritional Benefits of Feeding	—Video —Video	pp. 115–119