LEARNING QUESTIONS

6.1 How are the brains of children and adolescents similar to and different from the brains of adults? What disorders are linked with the structure and function of the brain?

6.2 How do the senses develop during infancy?

6.3 How do children’s bodies change from infancy through adolescence?

6.4 What factors influence and shape motor development?

6.5 What role does nutrition play in development?

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Chapter 6: Physical Development: The Brain and the Body

In this chapter, we present some of the central issues in regard to the physical development of infants, children, and adolescents. However, as we look at physical development it is important to remember that it affects and is affected by all other areas of development. For example, infants who experience a high level of stress (emotional) because of abuse or neglect are found to have higher levels of stress hormones later in life (physical), which may result in hypervigilance, which is the tendency to watch for and anticipate danger in the environment (cognitive) (Gunnar, 2007). Keeping in mind the fact that human beings are not just the sum of their parts, we present separate chapters on the basic building blocks of development—physical, cognitive, and social-emotional development—but we do so with the awareness that we cannot really separate the effects of one “building block” from those of the others. We will remind you of these reciprocal influences as we discuss each one.

We begin by looking at how the brain develops, including some information on disorders associated with brain development. We then discuss how our senses develop. Next we show how the body grows from infancy through the sexual maturation of adolescence, and examine how we move from the physical helplessness of newborns to the highly developed motor skills we see in children and adolescents. In the final section, we describe the critical role that nutrition plays in supporting healthy growth.

Test your knowledge of child development by deciding whether each of the following statements is true or false, and then check your answers as you read the chapter.

1. T □ F □: Humans use only 10% of their brains.
2. T □ F □: Newborn babies form synapses (the connections between nerve cells) in their brains at the rate of a hundred new connections each second.
3. T □ F □: Children who practice the violin every day for many years become better at playing the violin in part because their activity makes physical changes in the structure of their brains.
4. T □ F □: There is good cause for alarm about the increase in the incidence of autism spectrum disorder in recent years.
5. T □ F □: Infants are born with a preference for the foods common in their culture.
6. T □ F □: Adolescent girls who go through puberty earlier than their peers are happier than girls who go through puberty later.
7. T □ F □: In the United States, 90% of adolescents between the ages of 15 and 19 have had sex at least once.
8. T □ F □: Keyboarding is less effective than writing in cursive for promoting reading, writing, and cognitive skills.
9. T □ F □: The rate of childhood obesity appears to have finally leveled off in the United States.
10. T □ F □: The most effective way to prevent eating disorders is to give adolescents information about how harmful these behaviors can be to the adolescent’s body.

How are the brains of children and adolescents similar to and different from the brains of adults? What disorders are linked with the structure and function of the brain?

We begin our study of brain development by addressing two common misconceptions. The first is the well-known myth that humans use only 10% of their brains. As we describe the parts and the functions of the brain in the following sections, it should become clear to you that we use all parts of our brains (Boyd, 2008). The second misconception is that what we think has little to do with how our bodies function and that our body's functioning has little to do with our thoughts. Not only will you be learning about the impact of the brain on the body's activities, but you will also learn about the impact the body has on the brain and the effect that experience has on the development of both body and brain. To see one of the surprising ways in which the brain and the body interact, try Active Learning: Brain and Body.

Active LEARNING

Brain and Body

Sit comfortably in a chair. Cross your right leg over your left (at the knee or ankle). Circle your right foot to the right (in a clockwise direction). Now, using your right hand, draw a number “6” in the air. Were you able to keep your foot circling to the right? A few people can, but most people cannot. This is easy to do using your right foot and your left hand, so the problem lies in the fact that the left side of your brain controls the right side of your body and seems to be able to go in only one direction at a time. You know that your body is physically capable of doing both actions, but your brain may not let you do both at the same time.

STRUCTURES OF THE BRAIN

The brain is an organ of the body made up of a number of different parts. We can examine the brain from two perspectives: from side to side and from back to front. As you can see in the photo of the brain on the facing page, the brain is divided down the middle into two halves, or hemispheres. Some parts of the brain are found on both sides, and some are found only on one side. For example, the motor cortex that controls the body's movements is similar on both sides, but the language centers of the brain appear on the left side for up to 95% of right-handed people and 75% of lefties (Somers et al., 2015). The two sides of the brain communicate with each other through the structure that joins them, called the corpus callosum. Although the two sides have some distinct functions, there is no such thing as being totally right-brained or left-brained. Both halves of our brains are involved in complex ways in almost everything we do. For example, although much of language is processed on the left side, specific aspects of language, such as humor and the emotional tone of what you say, are found in the right hemisphere (Kinsbourne, 2009).

We get a different view of the brain when we look at it from the side as shown in Figure 6.1. The parts, or lobes, of the brain have some distinct functions; however, most aspects of human functioning involve many parts of the brain in coordination with one another. For example, the occipital lobe is known to control vision but the parietal, temporal, and frontal lobes also play a role in vision (Merck Manual, 2008).
Look at Figure 6.1 to identify the parts of the brain in this image and the functions they perform.

- The **brain stem** is the most primitive part of the brain and controls basic survival functions such as breathing, heart rate, and sleep.
- The **cerebellum** is located at the top of the brain stem and receives information from the sensory systems, spinal cord, and other parts of the brain to coordinate balance and voluntary movement.
- The **cerebrum or cortex** accounts for about two-thirds of the brain’s mass and handles the higher functions of thought and action. The cerebrum includes many different parts, including:
  - the **occipital lobe**, which processes vision;
  - the **temporal lobe**, which processes auditory information and enables us to understand language;
  - the **parietal lobe**, which processes sensory input and is where taste, temperature, and touch are integrated or processed; and
  - the **frontal lobe**, which processes complex thoughts, planning, movement, language, and impulse control.

The **amygdala** and the **hippocampus** shown in Figure 6.2 are located deep inside the brain. The amygdala contributes to our emotions and moods, and the hippocampus processes and stores memory (Bear, Connors, & Paradiso, 2007; Sprenger, 2013).

Although this is a good description of some of the functions that we currently know are associated with different areas of the brain, brain research is one of the most active areas in the field of child development, so our understanding of brain functions and development will undoubtedly continue to change as research continues.
As we continue our discussion of the brain, this overview should help you think about how different aspects of physical development link back to the different parts of the brain and the functions they control. In future chapters you will learn more about the cognitive, language, and emotion centers of the brain and their functions.

**DEVELOPMENTAL PROCESSES**

The brain is changing and developing from infancy through adolescence. In this section, we describe the development of the connections between nerve cells, called synapses, as well as the development of the myelin sheath that coats the nerve cells. You may be surprised to learn that your personal experiences as you grow up affect the way your brain forms connections between synapses and develops the myelin sheath.

**Neurons and Synaptic Connections**

The human brain is made of approximately 86 billion nerve cells, called **neurons** (Azevedo et al., 2009). Each nerve cell sends messages via special chemicals called **neurotransmitters** to other nerve cells through extensions of the cell called **axons** and receives messages through receptors called **dendrites**. The place where the axon from one neuron meets the dendrite of another neuron is called the **synapse**, as illustrated in Figure 6.3. Just about everything we do depends on communication between nerve cells. Neurotransmitters are released from one cell and bring their “message” to the second cell. Adults have approximately 1 quadrillion of these synaptic connections (Kasthuri & Lichtman, 2010). Neurons and their synaptic connections make up what is called the **grey matter** of the brain.

Infants are born with almost all the neurons they will ever have; however, they have relatively few synapses or connections between them. As a result, babies have fewer inborn

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**FIGURE 6.2**

**Amygdala and hippocampus.** These brain structures lie deep inside the brain. The amygdala is responsible for our emotions and moods, and the hippocampus processes and stores long-term memory.

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**Neurons** The cells that make up the nervous system of the body.

**Neurotransmitters** Chemicals that transmit nerve impulses across a synapse from one nerve cell to another.

**Axons** The parts of a nerve cell that conduct impulses away from the cell body.

**Dendrites** The portions of a neuron that receive impulses from other neurons.

**Synapse** The place where the axon from one neuron meets the dendrite of another neuron.

**Grey matter** The neurons and synapses that make up the brain.

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behavior patterns than other animals, and this makes them more open to learning from their environment. The experiences they have actually shape the development of synaptic connections and the formation of their brains (Rosenzweig, Breedlove, & Watson, 2005). The development of new synapses is referred to as **synaptogenesis**. After a baby is born, new synapses may be formed at the rate of more than **1 million connections per second** (Greenough, Black, & Wallace, 1987). One reason why infants’ brains are more active than adults’ brains is because they are so busy forming these connections (Gopnik, Meltzoff, & Kuhl, 1999).

By the time children enter early childhood, synaptogenesis in the areas of the brain responsible for vision, hearing, and language has already greatly diminished, but production in the prefrontal cortex, in the very front of the frontal lobe, is just reaching its peak and this process will not be complete until late adolescence or early adulthood.

### Plasticity of the Brain

The ability of the infant brain to change in form and function is referred to as **plasticity**. If you, as an adult, had half of your brain (one hemisphere) removed, the result would be catastrophic. You would lose movement in the opposite side of your body, and you would lose the functions handled in that hemisphere. However, until about age 4 or 5, children who have had one hemisphere removed to treat an otherwise untreatable condition, such as severe epilepsy, can recover almost full function (Eliot, 1999). In one study of children who had an entire temporal lobe removed, there was no significant decline in the group’s overall IQ following the surgery (Westerveld et al., 2000). Even when the surgery involved the left temporal lobe (the part of the brain associated with language), there was no loss of verbal intelligence and nonverbal intellectual functioning actually improved significantly. This occurs because the brain at this young age has enough plasticity for brain cells that were originally intended to serve one function (for example, controlling movement) to turn into cells that control another function instead (for example, language). In the study by Westerveld et al. (2000), the small group of children who did experience significant losses following the surgery tended to be the oldest children in the group because plasticity decreases with age.
At various times within the first years of life, babies’ brains produce so many new synaptic connections that the density of connections is greater than that found in the adult brain (Blakemore & Choudhury, 2006). However, many of these connections do not survive. In a process called pruning, synaptic connections that are not used deteriorate and disappear. Just as you prune away dead branches on a tree to strengthen it, this process of pruning away unused synapses strengthens the brain. Rather than being a terrible loss, this process makes the brain much more efficient. For example, unlike adults, newborn infants can distinguish between all speech sounds in any language. However, during their first year of life, they are exposed only to the specific sounds in the particular language they hear each day. This strengthens the synapses for those sounds, but those synapses that were not used because the infant never hears those sounds are pruned away. This increases the infant’s ability to discriminate the sounds in the language the baby is hearing (Blakemore & Choudhury, 2006), and by the end of that time, babies can no longer distinguish between language sounds that are found only in languages they don’t regularly hear.

The process of pruning follows a “use it or lose it” principle. Greenough et al. (1987) described two ways that this happens: experience-expectant mechanisms and experience-dependent mechanisms. Experience-expectant brain development occurs because our brain expects certain events to happen. For example, in the normal course of events, our eyes will be exposed to light. When these expected events occur, the pathways that are used are retained. In their classic experiments with kittens, Hubel and Wiesel (1965) showed that if this does not happen, the eye still develops normally, but the part of the brain that processes visual information does not function. Kittens with one eye closed for a period of time after birth were never able to develop vision in that eye, even when the eye was later open. This is why children who have an eye that has considerably less vision or doesn’t coordinate with the other eye (a condition called amblyopia or “lazy eye”) must have intervention early in their lives or they may lose effective vision in that eye as the brain “turns it off.”

Experience-dependent brain development is much more individual and depends on each person’s particular experiences. In addition to unused synapses being pruned away, new synapses can develop in response to stimulation. For example, Elbert, Pantev, Wienbruch, Rockstroh, and Taub (1995) studied the brains of violinists. If you pretend to play the violin, the fingers of your left hand move all around, pressing on the strings to produce different notes, while the fingers of your right hand usually stay in one position, holding the bow. Elbert et al. found that the area of the right side of the brain that controls the left hand has many more synaptic connections than the same area of the left side of the brain in violinists. It is unlikely that these people are born this way, making them more likely to become violinists. Instead, the constant use of the fingers of the left hand to move and hold the appropriate strings on the violin further develops that part of the right side of the brain.

Myelination of Neurons

So far we have discussed the development of synapses through the process of synaptogenesis, but for messages to be sent successfully, another necessary process in the development of the nervous system is myelination. For neurons to work efficiently, they need to be coated with a fatty substance known as myelin, as shown in Figure 6.4. This coating of the axons that connect the neurons constitutes the white matter of the brain.

Picture an electrical cord between the wall socket and your lamp. How does the message travel from your light switch to turn on the lamp on your desk? Within the electrical cord is a metal wire that carries the electrical current. If bare wire were used with no insulation, not only would you get a shock when you touched it, but your light would not work very well. Only some of the current, not all of it, would be likely to arrive at its destination. For that reason, an electrical cord is always insulated with some material that cannot carry an electric current so that all of the current goes to its destination. In a similar fashion, the neurons in the nervous system are insulated with myelin so that the message the neurotransmitters send will be received most effectively.
When babies are born, just as the synaptic connections are not complete, so too the myelin sheath does not yet cover all of the nerves in the nervous system. The process of producing synaptic connections, pruning away those that are not being used, and myelinating the connections that are left will continue throughout childhood and adolescence. Myelination begins in the lower centers at the base of the brain and continues through the higher centers of the cortex (Deoni et al., 2011). As researchers learn more about the normal progression of myelination, they are also likely to find evidence of abnormal processes that may contribute to such disorders as autism and schizophrenia (Deoni et al., 2011).

We have already learned that synaptogenesis is affected by our experiences through the process of experience-dependent brain development. There is also evidence that myelination is affected by our experiences. Bengtsson et al. (2005) compared brain development in children who spent long hours practicing piano to that in children who did not play piano. Their evidence indicates that the extra stimulation that certain neurons experience when children are practicing results in more myelination of those neurons, including those in the corpus callosum, which connect the two hemispheres of the brain. The corpus callosum is involved in the ability to coordinate movements of your two hands at the same time. In this study, children who played piano had increased brain efficiency, and this increased ability continued into adolescence.

**Brain Development Through Childhood and Adolescence**

As we’ve said, the brain continues to develop through childhood and adolescence. Specific brain structures that experience growth during middle childhood include the frontal lobe, the parietal lobe, and the corpus callosum. The growth of the corpus callosum is important because the increasing connectivity and coordination between different areas of the brain contribute to the improvement of motor skills, visual-spatial skills, and coordination (American Psychological Association Division of Educational Psychology, 2014). Ongoing
synaptic pruning in middle childhood allows children to use fewer and more select regions of the brain to complete the tasks they are performing and this allows them to perform tasks more efficiently (Mah & Ford-Jones, 2012). For example, compare the way a 6-year-old pitcher throws a ball to a batter to the way a 12-year-old does the same thing. Compared to the younger child, the older child’s throw is more precise and purposeful, and this is based in part on increased efficiency of brain function in the areas of the brain that control motor function.

In early adolescence, there is another overproduction of synapses, this time in the frontal lobes of the brain. Until this overproduction of synaptic connections is pruned away, it results in inefficiency of thought. For instance, when children and adolescents were shown a picture of a face (for example, a sad face) and heard a word that might or might not match that expression (“happy” or “sad”), it took longer for the 11- and 12-year-old participants to correctly decide whether the image and word matched than it did either younger or older participants in the study (McGivern, Andersen, Byrd, Mutter, & Reilly, 2002). The decrease in early adolescent performance was attributed to the proliferation of synapses at this age, and the increased efficiency in later adolescence was attributed to the synaptic pruning that had occurred.

The normal pruning process is complete in some areas of the brain by age 12, but in others, especially the prefrontal cortex, the process is not complete until well into adolescence or early adulthood (Blakemore & Choudhury, 2006; Giedd, 2004; Gogtay et al., 2004). Because the prefrontal cortex is the part of the brain that controls judgment and planning and regulates impulse control, the tendency of some adolescents to act on their emotions without thinking through a situation may be related to the immaturity of this system in their brain. Because the connections between the centers for reasoning and the centers for emotions, such as the amygdala, are still developing during adolescence, their emotional responses are less tempered by reasoning than will be the case in adulthood (Society for Neuroscience, 2007).

Our understanding of the immaturity of the adolescent brain has had consequences for adolescents who are in the judicial system. In a landmark case in 2005, the Supreme Court overturned the death sentence of Christopher Simmons, who had murdered an elderly woman when he was 17. This decision effectively made it illegal to execute people who committed crimes before the age of 18. It was affected by the argument entered into evidence by the American Society for Adolescent Psychiatry that although adolescents may know right from wrong, they are less able to control their impulses, are more influenced by their peers, and are less able to think through the consequences of their actions because of the immaturity of their brain development, in particular, the prefrontal cortex, which controls these functions (Dittmann, 2005; Lehmann, 2004).

The number and type of changes that occur in adolescence may make the brain especially vulnerable to the effect of neurotoxins (such as alcohol and other drugs) during this period of development (Squeglia, Jacobus, & Tapert, 2009). For instance, use of alcohol and marijuana during adolescence has been shown to affect both the structure and the functioning of the brain. Heavy drinking is associated with impaired performance on tests of memory, attention, spatial skills, and executive functioning, and marijuana use is associated with decreases in several aspects of cognitive functioning, including learning. Furthermore, these deficits are seen in adolescents who are not currently using substances, suggesting that they are the result of long-term changes in the brain. Any cognitive deficits that result at this time in development have potential consequences for future academic, occupational, and social functioning as the adolescent moves into early adulthood.

**DISORDERS RELATED TO BRAIN DEVELOPMENT**

With the use of functional magnetic resonance imaging (fMRI), researchers today are able to examine the connectivity between different areas of the brain as early as the second trimester of a pregnancy. Research conducted by Moriah Thomason and her colleagues is giving us new insight into the order and timing of connections that allow different parts of the brain
to communicate with each other (Thomason et al., 2015). This line of research could lead to very early diagnosis of brain disorders and better interventions and therapies for children with such conditions.

When brain development does not occur as expected, or when there is damage to the brain at any point, a number of disorders may result. We discuss here three very different types of outcome: cerebral palsy, autism spectrum disorder, and schizophrenia. We discuss cerebral palsy because specific brain abnormalities are known to cause this disorder. We include autism and schizophrenia in this section on the brain because, although their precise cause (or causes) remains elusive, there is almost universal agreement that there is an underlying biological explanation connected with brain development.

**Cerebral Palsy**

Cerebral palsy is an umbrella term that describes a group of brain-based disorders affecting a person’s ability to move and maintain balance and posture. People with cerebral palsy may experience difficulties with muscle tone, coordination, movement, and speech. The condition is caused by abnormal development of the brain or damage to it, either prenatally, during birth, or after birth up to age 3 (Abdel-Hamid, Ratanawongsa, Zeldin, & Bazzano, 2015; National Institute of Neurological Disorders and Stroke [NINDS], 2015). Approximately 800,000 children and adults in the United States live with one or more symptoms of cerebral palsy (NINDS, 2015), and the prevalence rate has remained largely unchanged over the past 40 years (Abdel-Hamid et al., 2015).

Risk factors for cerebral palsy include premature birth, low birth weight, conception of two or more fetuses, maternal exposure to toxins or infections, and lack of oxygen during the birth process (Abdel-Hamid, 2011). While some children are profoundly affected and will need total care throughout their lives, others show only mild impairment and require little or no special assistance. Although this condition does not get progressively worse, early intervention and therapy can be beneficial because it can help prevent or delay the onset of secondary problems. Medications can help control seizures and muscle spasms, surgery can lengthen muscles and tendons that are too short to function, and physical therapy can help the child build necessary skills. An exciting new avenue of research is investigating the use of a drug that allows the regrowth of the myelin coating on nerve cells in the brain (Fancy et al., 2011). When a lack of oxygen disrupts the nerve cells’ ability to create myelin, those cells die and this can lead to cerebral palsy. Research with mice discovered a drug that allows the myelin to regrow and repair the damage and, although this research is far from being ready to use in humans, it offers hope for a new pharmaceutical treatment of this type of brain injury. There are also new technologies that let children with cerebral palsy use limited head movements to operate a computer that has a voice synthesizer, which can transform their motions into spoken language.

**Autism Spectrum Disorder**

In 2013, the American Psychiatric Association (APA) issued the fifth revision of its *Diagnostic and Statistics Manual* (DSM-5). The DSM-5 contains the descriptions, symptoms, and other criteria used by clinicians, researchers, and mental health professionals across the country to diagnose mental disorders. One of the most important changes in this edition involved the diagnosis of autism spectrum disorder. Previously, individuals could be diagnosed in one of four separate categories of autism which included Asperger’s syndrome, a less severe condition.
Autism spectrum disorder
A disorder characterized by pervasive impairment in social communication and interaction and by restricted or repetitive behaviors, interests, or activities. Severity is classified by how much support the individual needs to function effectively.

in which individuals often had good language and cognitive skills. Currently, autism spectrum disorder is classified by severity, but it is not divided into different types.

**Autism spectrum disorder (ASD)** involves a pervasive impairment in social communication and interaction, and restricted or repetitive behaviors, interests, or activities (APA, 2013). The degree of impairment can run from mild to severe, with severity determined by how much support the individual needs to function effectively. Some children with autism have few words and respond only to focused, direct approaches from other people, while those with less severe symptoms may speak normally, but cannot successfully maintain the normal back and forth of conversation (APA, 2013). The individual shows symptoms in early childhood, even if the condition is not recognized and diagnosed until later in development.

Over the years, a number of possible causes of ASD have been proposed, including ones with a biological basis and others with an environmental cause. **Journey of Research: Searching for the Cause of Autism Spectrum Disorder** describes the history of our understanding of this disorder. Today research into the neurological basis of autism spectrum disorder and other similar developmental disorders is one of the most exciting and active areas in the field of child development.

**Journey of Research**

**Searching for the Cause of Autism Spectrum Disorder**

In an early description of autism spectrum disorder, the psychiatrist Leo Kanner (1949) identified the cause as parental coldness, marked by a mechanical attention to the child’s needs that lacked any genuine warmth. From this perspective, the infant’s aloofness and withdrawal were seen as an adaptive response to an almost intolerable situation. As a result of Kanner’s description, the psychological literature from the 1940s through the early 1970s was filled with references to “refrigerator mothers” (Frith, 2003). Today inadequate parenting has been eliminated as a possible cause of ASD as more contemporary research has focused on possible biological causes, including genetics and neurological differences.

Strong evidence for a possible genetic cause comes from the observation that ASD runs in families. According to the Centers for Disease Control and Prevention (2016b), if one identical twin has ASD, the other twin will have the same diagnosis about 36% to 95% of the time, depending on the particular study, while if one nonidentical twin has ASD, the other twin will be affected 0% to 31% of the time. Another genetic difference is that boys are 4.5 times more likely than girls to be diagnosed with ASD (CDC, 2016b).

A different line of research has searched for possible environmental causes (or triggers) of autism spectrum disorder. You may have heard of research that looked at the role of mercury as a preservative in the measles-mumps-rubella (MMR) vaccine given to infants. In 1998, the British medical journal *Lancet* published a study that appeared to find a link between ASD and this vaccine (Wakefield et al., 1998). Since that time numerous research studies have been conducted to investigate this possible link, but the scientific consensus today is that the clinical evidence does not support the idea that immunizations are a cause for ASD (CDC, 2012b; National Research Council, 2011). For example, in Montreal, Canada, when the mercury compound that was the suspected cause of ASD was removed from the vaccine, there was no corresponding decrease in the incidence of ASD (Fombonne, Zakarian, Bennett, Meng, & McLean-Heywood, 2005).

In 2016, a group of researchers from Johns Hopkins University presented a paper at a professional meeting that reported an increased risk of autism in children born to women who had high levels of folate in their blood at the time of their delivery (Hamblin, 2016). The media latched on to the information and headlines and newscasts widely reported on this potential risk. However, as you know from Chapter 5, an adequate amount of folate
plays an important role in preventing neural tube and spinal defects during pregnancy. Since receiving all this attention, the researchers have expressed concern that people are misinterpreting their research. At this point, the source of the high level of folate in the affected women is not known. It might come from supplements a woman has taken during her pregnancy, but it also could come from naturally occurring folate in her diet or a problem she has with metabolizing the folate she takes in from any source. For this reason, the researchers do not want pregnant woman and those planning for a pregnancy to discontinue using folate as recommended by their physicians.

Other environmental factors such as air pollution, nutritional factors, and environmental toxins all continue to be investigated. However, the major area of research being carried out today is the link between ASD and brain function and structure. We describe this research next.

The three active avenues of neurological research that hold great promise for a better understanding of the causes of autism include studies of brain structure, brain functioning, and the connectivity between different parts of the brain. We will look briefly at each of these lines of research.

Among the studies of brain structure, imaging studies have found enlargement of the amygdala, the area of the brain that is active in emotional experience and expression, in the brains of young children with ASD. This research found that the larger the amygdala, the more difficulty the person had with social relationships (Sparks et al., 2002). Another structural difference involves total brain volume. The brains of young children who have been diagnosed with ASD have greater brain volume than typically developing children, at least until early adolescence when a crossover occurs. Beyond that point, the brain volume of typically developing adolescents exceeds that of adolescents diagnosed with autism, as shown in Figure 6.5 (Lange et al., 2015). This line of research continues to

**FIGURE 6.5**

*Brain volume comparison of children with autism and typically developing children.* One of the structural differences in the brain of children diagnosed with autism (blue line) is that their total brain volume is greater than that of typically developing children (green line) early in development, but in early adolescence the groups reverse and typically developing children have the greater total brain volume from that point. These lines represent the growth curve that best represents all the individual results shown around them. New technologies continue to give us greater insight into structural and functional differences in the neurology of children with autism spectrum disorders.

![Brain Volume Comparison](image_url)
look for specific parts of the brain associated with different symptoms of autism, such as problems with social interaction or repetitive behaviors (Ha, Sohn, Kim, Sim, & Cheon, 2015).

A second line of neurological research looks for functional differences in children diagnosed with ASD. Findings include the fact that it takes more effort for children with autism to interpret a speaker’s intention during social communication and this is linked to hyperactivation of certain parts of the brain. However, for some other cognitive tasks children with ASD have lower activation of the brain than other children (Ha et al., 2015). Children with ASD have been shown to have deficits in working memory that may affect language skills (Schuh & Eigsti, 2012), and they have an impaired ability to analyze the emotions in facial expressions (Ha et al., 2015). There is evidence that the brains of typically developing infants respond differently when they see faces than when they see objects, but the brains of infants with ASD do not seem to respond differently, which may indicate that they do not differentiate people from objects (McCleery, Akshoomoff, Dobkins, & Carver, 2009).

The third line of neurological research has examined connectivity between brain regions. This research has found that instead of having efficient, strong connections among specific neurons, children with ASD have less efficient connections among many more neurons (Müller et al., 2011). You can see this illustrated in Figure 6.6. This overabundance is a result of a slowed process of pruning away synapses that are not used (Tang et al., 2014). As we have mentioned, failing to do this results in less efficient transmission of information. Recent research that used electroencephalograms (EEGs) with children younger than those in studies employing fMRIs has found the same overconnectivity previously seen in older children (Uddin, 2015). This research is important because it may help us find a sensitive and reliable biomarker for autism that could become part of an early identification process.

Accurately estimating the prevalence of autism spectrum disorder (ASD) is not easy, but there has been a steady increase in this estimate in the United States in recent years.
(see Table 6.1). By the most recent estimate from the Centers for Disease Control and Prevention, 1 in 68 children has been identified with ASD, an estimated prevalence that is 30% higher than in 2008 and a staggering 120% higher than the estimate in 2002.

When we try to understand the increase in number of cases of ASD, it is important to think about how we recognize and diagnose the disorder. At least part of the increase may be attributable to improved case finding in recent years (Gernsbacher, Dawson, & Goldsmith, 2005). That would mean that even if the real incidence of ASD hasn’t increased, we may be doing a better job of identifying (and, therefore, being able to count) children with the disorder. Also, the criteria we use to diagnose ASD has broadened over the years (Gernsbacher et al., 2005). As the definition became more inclusive, we would expect that more children would be identified. We also continue to develop reliable ways to diagnose autism at younger and younger ages. Today 18% of all diagnoses are made for children under the age of 3, and diagnoses made as early as 18 months are considered valid and stable (Chawarska, Lin, Paul, & Volkmar, 2007; Lord et al., 2006). However, as we continue our efforts to identify all cases of autism and as we make identification at younger and younger ages, it also is possible that our statistics include some children who are mistakenly identified as autistic. In fact, a recent study found that 13% of children diagnosed with autism were no longer considered autistic upon further testing (Blumberg et al., 2016). All of these factors taken together probably contribute to the increase in the number of cases diagnosed in recent years.

Of course, any increase in the true incidence of ASD would be a cause for concern, but the fact that we are now identifying more children who might otherwise have been overlooked and not receive early and comprehensive intervention services is not necessarily a bad thing.

**TABLE 6.1**

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<th>Surveillance Year</th>
<th>Birth Year</th>
<th>Number of ADDM Sites Reporting</th>
<th>Prevalence per 1,000 children (Range)</th>
<th>This is about 1 in X children</th>
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<td>2000</td>
<td>1992</td>
<td>6</td>
<td>6.7 (4.5–9.9)</td>
<td>1 in 150</td>
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<tr>
<td>2002</td>
<td>1994</td>
<td>14</td>
<td>6.6 (3.3–10.6)</td>
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<tr>
<td>2004</td>
<td>1996</td>
<td>8</td>
<td>8.0 (4.6–9.8)</td>
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<tr>
<td>2006</td>
<td>1998</td>
<td>11</td>
<td>9.0 (4.2–12.1)</td>
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<tr>
<td>2012</td>
<td>2004</td>
<td>11</td>
<td>14.6 (8.2–24.6)</td>
<td>1 in 68</td>
</tr>
</tbody>
</table>

SOURCE: Centers for Disease Control and Prevention (2016b).
Under the Individuals with Disabilities Education Act (IDEA), all states have specialists trained to work with young children diagnosed with ASD (National Institute of Mental Health [NIMH], 2009). After being assessed by a team of specialists, a child's strengths and weaknesses can be identified and an effective treatment plan designed to target the symptoms. Together with the family, the team develops an Individualized Family Service Plan (IFSP) describing the services to be provided to the family, not just the child, and this plan is reviewed at least once every 6 months.

The optimal intervention consists of at least 2 years of intensive intervention during the preschool years (NINDS, 2008). We know that early intensive behavioral intervention can bring about substantial improvement in IQ and adaptive behavior (skills needed for everyday life) for many autistic children, although some will need ongoing close supervision and care throughout their lives. In a few rare cases, children with ASD can even show extraordinary abilities in a limited area of expertise. For example, Stephen Wiltshire was diagnosed with autism at age 3 and didn't learn to speak until 9 years of age, yet his amazing renderings of cityscapes are now shown around the world, and he has been honored for his contribution to the art world by Queen Elizabeth II (Stephen Wiltshire Gallery, 2012).

Schizophrenia
Some disorders of the brain do not appear until adolescence. Schizophrenia is a very rare but serious mental disorder that affects between 0.3% and 0.7% of the population (APA, 2013). It is related to both structural and functional differences in many regions of the brain (Ren et al., 2013). Diagnosis requires two or more of the following symptoms: delusions (unrealistic, fixed beliefs such as believing that you are being pursued by the CIA), hallucinations (most commonly, hearing voices that are not there), disorganized speech, very disorganized or catatonic behavior (lack of reaction to the environment), or negative symptoms (for example, reduced expression of emotion and reduction in self-motivated behavior), which must be present for at least 1 month. Symptoms often first appear in late adolescence, but the onset can be much later into the mid-30s (APA, 2013).

In the very rare cases when children and younger teens develop this disorder, it is referred to as early-onset schizophrenia (McDonell & McClellan, 2007). However, although schizophrenia may not be diagnosed until adolescence, in many cases the disorder is preceded either by a gradual deterioration in social and cognitive functioning or by ongoing difficulties in these areas (Quee et al., 2014). After the symptoms of schizophrenia develop, functioning in these areas continues to decline, resulting in difficulty with social, academic, and occupational functioning (Tandon et al., 2013; McClellan & Stock, 2013).

Although we do not understand all the causes of schizophrenia, it is clear that genes play a large role, as shown by research with twins. If one identical twin is schizophrenic, there is a 40% to 60% chance the other will be as well, while a fraternal twin has only a 5% to 15% chance of sharing this condition with a twin (McClellan & Stock, 2013). Prenatal disruption of brain development by factors such as the mother's experience of starvation or influenza increases the possibility the child will develop schizophrenia (Brown & Susser, 2008; Limosin, Rouillon, Payan, Cohen, & Strub, 2003), as does early head injuries for those with a
There is also a growing body of evidence that adolescent marijuana use can increase the risk of schizophrenia for some teens who are more vulnerable to the disorder because of genetic predisposition, a dysfunctional environment, and other factors that are not yet entirely clear. For this reason, parents, teachers, and health care providers should be aware of the possibility and look for a decline in school performance and odd behavior in teens who are using marijuana (Evins, Green, Kane, & Murray, 2012).

Schizophrenia is a chronic disorder with little likelihood of a cure. Treatment includes medication, together with work with the adolescent’s family to promote understanding of the disorder, and training for the individual in social skills, life skills, and problem solving skills, together with specialized education programs (McClellan & Stock, 2013; Volkmar & Tsatsanis, 2002).

**CHECK YOUR UNDERSTANDING**

1. What are the roles of neurons and synapses?
2. What is the difference between experience-expectant and experience-dependent brain development?
3. What role does myelination play in brain development?
4. How are cerebral palsy, autism spectrum disorder, and schizophrenia related to brain development?

**DEVELOPMENT OF THE SENSES**

### 6.2 How do the senses develop during infancy?

A central function of the brain is to take in and make sense of our experiences. The first step in that process is the use of our senses to connect us to the world. In this section, we focus on the very beginning of sensory development to show how the development of the senses in infancy brings infants into the social world.

In the early days of the field of psychology, William James (1890/1990) described the world of the infant as “one great blooming, buzzing confusion” (p. 462), and the idea that newborns were unable to make sense of their world persisted for years. Today we know this statement seriously underestimates the capabilities of newborns to receive information about the world through all their senses in an organized way and to respond to that information. Although all the senses begin developing during the prenatal period and become functional before birth, some are more advanced in their development than others. There is no doubt the newborn can hear, see, taste, smell, and respond to touch. We look here at how each of the senses develop during infancy and how they connect the infant to other people.

### VISION

Although newborns are capable of focusing their eyes, their vision is much worse than normal adult vision. It is difficult to measure the visual acuity of young infants (or the ability to see things in sharp detail), but one estimate is that at birth, acuity is around 20/400 to 20/800 (meaning that the infant can see at 20 feet what an adult with normal vision could see at 400 to 800 feet). By 1 month, acuity has improved to 20/200 to 20/400, and by 6 months it is 20/25 to 20/30. Until they are about 3 months old, infants can focus on objects...
that are 8 to 10 inches in front of them (American Optometric Association, 2013; University of Calgary, n.d.). That is one reason why we often put our faces close to infants when we are talking to them—they don't see us clearly until we get that close. They will not develop adult levels of visual acuity until sometime between 6 months and 3 years (Slater, Field, & Hernandez-Reif, 2007).

However, from birth, infants are attracted to looking at the faces of people around them, especially their mother. In addition, they tend to concentrate on areas of high contrast—that is, where darkest dark meets lightest light. At first this may mean they scan the parent's hairline, but at 2 months of age, infants concentrate attention on the eyes, where the white of the eye surrounds a darker center (Farroni, Menon, & Johnson, 2006; Ramsey-Rennels & Langlois, 2007). Think about how you would feel when holding a baby who looks you directly in the eye. Many parents respond with the feeling that “this baby knows me.” This is surely an adaptive way babies attract others to interact with them. In fact, research has shown that mothers are more likely to continue to interact warmly with their infants when they are looking their mothers in the eye (Nomikou, Rohlfing, & Szufnarowska, 2013).

HEARING

Hearing becomes functional while the fetus is still in the womb, and one sound fetuses hear loudly is their mother's voice. Kisilevsky and colleagues (2003) have shown that even prenatally, fetuses will respond differently to the sound of their mother's voice than to the voice of another woman. A tape recording of the infant's mother reading a poem out loud or a tape recording of another woman reading the same poem were played close to the woman's stomach near the end of her pregnancy. When the fetuses heard their mothers' voices, their heart rate accelerated, but when they heard a stranger speaking, their heart rate decelerated, as though they were paying attention and trying to figure out who was speaking. The fact that the same poem elicited two different responses depending upon who was speaking tells us that the fetuses can discriminate between them. In other research that compared the preference of newborns for their mother's voice versus their father's voice, there was a clear preference for listening to the mother's voice (Lee & Kisilevsky, 2014).

These two studies look at different aspects of hearing: what we pay attention to and what we prefer to listen to. When a stimulus is presented repeatedly, we tend to lose interest in it, but if the stimulus changes, it recaptures our attention. This is a process known as habituation, which you will learn about in Chapters 7 and 8. The first study showed that fetuses are familiar with the sounds of their own mother's voice, but the novelty of another person's voice grabs their attention. The second study shows that given two options, newborns have a preference for their mother's voice over their father's. Whether this is because of differences in their familiarity with the voices or the characteristics of them (for example, male voices are deeper) is not known at this time.

In addition to voices, fetuses hear the mother's heartbeat and sounds of digestion, as well as other outside sounds. In fact, in the first few months after birth many babies seem to need a certain level of noise to go to sleep, perhaps because they were used to that level of noise before they were born. Many parents resort to leaving a vacuum cleaner running or putting the baby near a running clothes dryer to provide a level of background sound. Teddy bears that have built-in “heart sounds” also can help soothe babies.

SMELL

Babies are born with a functioning sense of smell and show preference for some smells over others. By 4 days of age, even bottle-fed infants show a preference for the smell of breast milk (Marlier & Schaal, 2005). They also know their mother's smell from very early in their
lives (Lipsitt & Rovee-Collier, 2012) and research has shown that babies who are being breast-fed recognize their mother’s scent within the first 2 weeks of life (Vaglio, 2009). Babies are even soothed by the scent of clothes that their mother has been wearing (Sullivan & Toubas, 1998).

**TASTE**

Infants prefer sweet taste and react negatively to salty, sour, and bitter tastes (Bezerra, Russo, & Alves, 2013; Rosenstein & Oster, 2005). Mother’s milk is sweet, so this draws the baby to the food and to the mother. Sweet taste is widely used to calm infants and reduce their pain response when they must undergo a painful procedure (Harrison, Beggs, & Stevens, 2012). In addition, mother’s milk, as well as amniotic fluid, can carry chemosensory molecules from the foods the mother eats, imparting the flavor from that food (Fifer, Monk, & Grose-Fifer, 2004). This means that babies are introduced to the tastes of their local foods even before birth, and there is evidence that early experience with particular tastes becomes acceptance or preference for such tastes later in life (Mennella, Griffin, & Beauchamp, 2004).

**TOUCH**

Touch can be very soothing. In one study, babies who were held in skin-to-skin contact with their mothers cried less when given a slightly painful medical procedure (in this case, it was a heel stick to extract a small amount of blood) (Gray, Watt, & Blass, 2000). Many adults who have had a massage know how relaxing it can be. Infant massage is part of the everyday experience of babies in many parts of the world. In India, Uganda, and Bali, for example, babies are given a massage with oil after their bath and before they are put to bed (Field, 2014). Tiffany Field (2014) and her colleagues have found that infant massage improves growth and effectively soothes babies of all ages, even premature ones. Massage with children can be helpful in improving conditions that range from anxiety (Field, 2010) to HIV (Diego, Hernandez-Reif, Field, Friedman, & Shaw, 2001). The research by Field and her colleagues appears to show that not only can massage make you feel better, but it also can improve your body’s ability to fight off the effects of disease.

**CROSS-MODAL TRANSFER OF PERCEPTION**

So far we have described how infants perceive the world through their individual senses. However, the senses also have to work together. For example, if you closed your eyes and touched an apple, when you opened your eyes and someone showed you an apple and an orange, you would know you had just touched the apple and not the orange by simply looking at the two. In other words, your perception of “apple” crosses from the tactile mode to the visual mode.

Infants, even from birth, show some aspects of cross-modal transfer of perception, but their abilities are limited in a number of ways. They can visually recognize something they have only touched and not seen (as in the apple example above), but they cannot recognize by touch something they have just seen but not previously touched (Sann & Streri, 2007). These abilities are strengthened as infants grow older and have more experience with seeing, touching, hearing, smelling, and tasting many things in their world.

Many toys designed for young children incorporate features that let them use their senses to explore the world. **Active Learning: How Toys Stimulate Babies’ Senses** lets you identify some of these features for yourself in a popular type of infant’s toy.
Active LEARNING

How Toys Stimulate Babies’ Senses

This toy can be held by any of the handles, all of which have different textures. When a baby shakes it, it makes a soft chiming sound. Find at least five different ways in which this toy provides appropriate sensory stimulation for a baby.

Possible answers:
1. The high contrast between black and white attracts babies’ eyes to the bull’s eye on top.
2. Different textures develop the sense of touch.
3. The sound it makes stimulates hearing.
4. Babies are attracted to faces, so they will be drawn to the butterfly’s face.
5. It is entirely soft and therefore safe for a baby to use.
6. Babies can hold the cube with both hands.

To review, we have seen that infants prefer to look at faces, naturally “look you in the eye,” recognize their mother’s voice, and prefer her scent and the taste of her milk. Clearly from the minute we are born, we are well equipped to enter a social world and we are prepared to form relationships with those who take care of us. Although true attachment will not develop until later in the first year of life, as we discuss in Chapter 10, infants prefer the special people who care for them, and they have inborn mechanisms that draw these people into relationships with them.

CHECK YOUR UNDERSTANDING

1. How does each of the senses develop during infancy?
2. How do infant sensory preferences connect infants to their caregivers?
3. What is cross-modal transfer of perception?

BODY GROWTH AND CHANGES

How do children’s bodies change from infancy through adolescence?

In this section, we discuss how bodily proportions change from the large head and small body of the infant to adult proportions. During middle childhood, bones lengthen, muscles strengthen, and baby teeth are replaced with adult ones. Finally, we discuss the major changes that happen to the body during puberty as children move into sexual maturity.
CHANGING BODILY PROPORTIONS

Of course all babies are beautiful, but beyond that they share some physical characteristics that draw us to them. When they are born, the comparative proportions of their heads and bodies are very different from those of older children and adults. A baby’s head is very large in comparison to his small, helpless-looking body. If you do the activity described in Active Learning: Head-to-Body Proportions with a young child, you will see for yourself how short the child’s arms are in comparison to the size of her head.

Active Learning

Head-to-Body Proportions

Take your right hand and reach over your head to touch your left ear. No problem, right? Now ask a toddler or preschooler to do the same thing, helping her if necessary. How far does the child’s hand get over her head? Most likely the child’s arm will not reach the opposite ear because her head is much larger in relation to the rest of her body than the head of an adult is to his body.

As children mature, their arms and legs lengthen, and the rest of the body catches up in size to the head. This fact has been used in some countries as a rough test of the child’s readiness to attend school. In one area of Tanzania, where there were inadequate birth records to document children’s ages, this test was used to determine the level of children’s physical maturation and therefore their readiness to start school (Beasley et al., 2000).

To prepare for this activity, or, if you do not have access to a child, you can watch the video of this Active Learning.

In addition to a large head, infants also have large eyes, a small nose and mouth, and relatively fat cheeks. There may be an evolutionary reason for this appearance. It makes babies appear cute, and we are attracted to taking care of them (Vance, 2007). This attraction is even stronger for women who have larger amounts of reproductive hormones in their system (Sprengelmeyer et al., 2009). A secret that few parents will reveal is that some aspects of baby care can be very unpleasant because they must deal with all kinds of bodily fluids, smells, and being up half the night, but as a new mother once wrote: “It’s a good thing God made babies so cute; otherwise you would send them right back to the hospital!” We protect and nurture our babies in spite of the difficulties of caring for them in part because of the effect that their bodily proportions have on us.

Growth during infancy and until age 2 is very rapid. The average infant doubles her birth weight by about 5 months of age, and triples it by her first birthday. During this same time,
Part II: Biological Beginnings and Physical Development

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the infant will add about 10 inches or 50% to her length at birth. If the same rate of growth applied to the average 11- or 12-year-old, it would be terrifying, but after the second birthday, growth slows. Two-year-olds are approximately half the height they will be in adulthood, so to predict a child’s adult height, you could double the height of that 2-year-old. However, a better indicator would be to look at the height of family members. Assuming adequate nutrition, height is highly genetic, so it is very likely that a child’s eventual height will fall somewhere within the range of the height of her close relatives.

As children’s rate of growth slows in early childhood, their trunk and limbs catch up in size with the earlier growth of their head so their bodily proportions change and become more similar to those of an adult. Figure 6.7 shows how the size of the head relative to the body changes between birth and 15-1/2 years of age. The growth centers found at ends of bones will remain soft until sometime in adolescence, when the ends will harden and growth will stop.

During early childhood, the proportion of body fat and muscle in the body also is changing. The layer of subcutaneous fat in a 5-year-old is only about one-half the thickness of the layer of fat in a 9-month-old infant, so young children lose the chubbiness we associate with infants (Huelke, 1998). Both boys and girls lose fat and gain muscle during early childhood, but in slightly different proportions. By the time they are 5 years old, girls have slightly more fat than boys, and boys have slightly more muscle (Sakai, Demura, & Fujii, 2012).

Children settle down into a steady growth rate in middle childhood, adding on average a little over 2 inches in height each year, and gaining about 6.5 pounds (American Academy of Pediatrics, 2004). Although growth charts usually show growth curves as a smooth and continuous function, growth typically occurs in growth spurts of about 24 hours, followed by days or weeks of no growth (Adolph & Berger, 2006).

As children approach adolescence, growth hormones work together with sex hormones (particularly estrogen for adolescent females and testosterone for adolescent males) to produce another period of rapid increase in height in both girls and boys known as the adolescent growth spurt. Girls, on average, begin their growth spurt at about 9 to 10 years of age, and boys typically start about 2 years later (Malina, Bouchard, & Oded, 2004). At the peak of the adolescent growth spurt, a young person can add 4 inches in height in a single year. This pubertal growth spurt ends by about age 15 for girls and age 16 or 17 for boys. Active Learning: Your Growth in Childhood guides you in looking back at your own physical development during childhood.

Infant facial features. Do you recognize in this photo the facial features we find so endearing in infants? An infant’s large head, round face, and big eyes are characteristics that attract us and motivate us to care for the infant.

Adolescent growth spurt
The period of rapid increase in height and weight that occurs in early adolescence.

Active Learning
Your Growth in Childhood
Families often keep track of their children’s growth. See whether your family kept a baby book detailing your growth in the early years. If your parents later marked your growth on a wall, look at the rate of change over time. Were there some periods of more rapid growth compared to other times in your life? If possible, compare these changes to those of your siblings or of your friends or classmates. At what points were girls taller than boys? When did this change?
As the body grows and proportions change, the face changes as well. One factor in this change is the development of teeth. Babies are usually born toothless (a fact that most nursing mothers appreciate), but within the first year, baby teeth emerge. However, these baby teeth will not last very long. Permanent teeth begin to push up through the gums, loosening their baby teeth. It is a very exciting development for children when, at about age 6, they lose their first baby tooth. Their molars (the teeth in the back of their mouth) don’t normally loosen until around ages 10 to 12. Why do we lose our first teeth? Unlike bones, teeth do not grow. Instead, our bodies develop much larger teeth under the gums that eventually push out and replace the smaller ones.

**SEXUAL DEVELOPMENT**

*Prepubescence* refers to the years immediately before puberty when hormonal changes begin. The earliest events in the pubertal sequence occur in middle childhood, sooner than many people realize. The pubertal changes and range of ages at which they typically occur are shown in Figure 6.8. At some point between ages 5 and 9, the adrenal glands increase production of androgens in both boys and girls. These hormones will later be linked to the growth of facial hair and increased muscle mass in boys and to the growth of pubic and armpit hair in both boys and girls. A few years later, estrogen produced by the girl’s ovaries will trigger changes in the growth of her uterus, vagina, and breasts and will cause fat to accumulate in the distribution pattern typical of females. Estrogen is also necessary to support the girl’s menstrual cycles, which can begin as early as age 10.

*Losing baby teeth.* Do you remember feeling as excited about losing your baby teeth as this girl appears to be? Notice that her two bottom teeth are new ones coming in and are larger than the others.

*Prepubescence* The period before puberty when hormonal changes begin.
Puberty, the physical changes that occur in adolescence and make an individual capable of sexual reproduction, begins (and therefore also ends) earlier for girls than for boys. During puberty, primary and secondary sex characteristics develop. Primary sex characteristics involve changes that occur in the organs necessary for reproduction—the vagina, ovaries, and uterus of the female, and the testes and penis of the male. For females, this process culminates in menarche (the first menstrual flow or period) and the beginning of ovulation. For males, it culminates in spermarche, or the ability to produce viable sperm. Characteristics that are associated with gender but do not directly involve the sex organs are secondary sex characteristics. Breast development in females, deepening of the voice in males, and growth of pubic and underarm hair in both genders are examples of secondary sex characteristics. They are important outward signs to others that a child is becoming physically mature. These changes often affect the way that both peers and adults interact with a young person. As young people look less like children and more like adults, they tend to be treated more like adults.

The Timing of Puberty

Many factors, including diet, health, body type, weight, and racial background, affect the timing of puberty. Heredity also plays a role because daughters often go through puberty at about the same age their mothers did (Ersoy, Balkan, Gunay, & Egemen, 2005). There are also some consistent racial and ethnic differences for both boys and girls. On average, African American girls and boys mature earlier than Hispanic children who develop earlier than non-Hispanic White children (Herman-Giddens et al., 2012; Herman-Giddens, 2013).

Girls from families with more social and economic resources reach menarche 3 months to 3 years before girls from disadvantaged families, perhaps because of better diet and better overall health in more well-to-do families (Parent et al., 2003). Chemicals found in the environment called endocrine disruptors also may play a role in the timing of puberty because of their effect on the hormonal (or endocrine) system of the body. You read about the effects these chemicals have on prenatal development in Chapter 5. Endocrine disruptors include a wide range of chemicals that are found in our food and drinking water, as well as in air, soil, house dust, and various household and commercial chemicals (Meeker, 2012). They have been implicated in lowering the age of puberty, as have hormones in the milk and meat that we eat (Daniel & Balog, 2009). Interestingly, some studies have found that the same chemicals associated with early puberty in girls are associated with delayed puberty in boys (Meeker, 2012).

Another individual characteristic that affects pubertal timing is body fat. A critical level of body fat is necessary for girls to maintain regular menstrual periods. That is why women who are anorexic, or who exercise so strenuously that their reserves of body fat drop to extremely low levels, may have irregular periods or stop menstruating altogether. Although the relationship is not as well established for boys, there is some evidence that body mass index also is related to the timing of puberty for boys, but again evidence points to the opposite result. For boys, being overweight may delay the onset of puberty, although the reason for this delay is still unclear (Solorzano & McCartney, 2010; Kaplowitz, 2008).

In a small percentage of girls, the earliest physical changes in the pubertal sequence, such as the beginning of breast buds and appearance of pubic hair, have been reported as early as 6 or 7 years of age (Nield, Cakan, & Kamat, 2007). This occurrence is known as precocious puberty (Parent et al., 2003). Rare medical conditions, such as brain tumors or exposure to endocrine disruptors, can be responsible for these early changes, but in most cases the girls are simply the earliest-maturing girls in their peer group (Kaplowitz, 2008).

Because the physical changes of puberty have such a profound effect on how others see the young person, undergoing these changes relatively earlier—or considerably later—than age-mates can have a significant impact on development. Early maturing boys tend to have a positive self-image and feel good about themselves in a number of ways, including being more self-confident and seeing themselves as independent. Because boys who mature

**Puberty** The physical changes that occur in adolescence and make an individual capable of sexual reproduction.

**Primary sex characteristics** Physical characteristics directly involved in reproduction.

**Menarche** A girl’s first menstrual period.

**Spermarche** The beginning of production of viable sperm.

**Secondary sex characteristics** Physical characteristics associated with gender that do not directly affect the sex organs.

**Precocious puberty** A condition in which pubertal changes begin at an extraordinarily early age (as young as 6 or 7 years of age).
earlier are taller and heavier than their peers in early adolescence, they are more likely to be athletes and this gives them a lot of status in the peer group (Hyde & Gengenbach, 2007). However, early maturing boys tend to spend their time with older peers because their physical development is a better match with that of older adolescents, and this can expose them to behaviors they are not ready to handle (Goldstein, 2011; Mendle, Turkheimer, & Emery, 2007). For instance, they are also more likely than their on-time peers to begin using drugs or alcohol (Faden, Ruffin, Newes-Adeyi, & Chen, 2010; Westling, Andrews, Hampson, & Peterson, 2008). These risks are even greater for early-maturing adolescents growing up in disadvantaged neighborhoods or with parents who are harsh or inconsistent in their discipline (Ge, Brody, Conger, Simons, & Murry, 2002). It has been easy to think that the relative psychological immaturity of early maturers or their association with older peers is responsible for the problematic behaviors we see. However, it is possible that it is child characteristics that existed before the onset of puberty that are responsible for the chance of a young person engaging in risky behaviors. In support of this idea, there is evidence from longitudinal research that boys who experience early puberty also had greater behavioral difficulties and poorer psychosocial adjustment earlier in their childhood (Mensah et al., 2013).

Late-maturing boys, on the other hand, have a more negative self-concept and are more likely to feel inadequate and rejected. Consequently, they may suffer from depression (Kaltiala-Heino, Kosunen, & Rimpela, 2003) or engage in alcohol or substance use as a way of compensating for their low social status (Weichold, Silbereisen, & Schmitt-Rodermund, 2003).

When a girl physically matures earlier than the other girls her age, it often sets her apart and isolates her from them. It might even inspire a bit of jealousy or envy (Reynolds & Juvonen, 2011). Attention from boys (especially older boys) can make these girls targets of peer rumors and gossip (Reynolds & Juvonen, 2011). Early maturing girls also tend to
experience more anxiety in social situations because of their increased self-consciousness (Blumenthal et al., 2011). Furthermore, because girls physically mature on average about 2 years before boys do, boys the same age may be intimidated by a girl who is becoming a woman in front of their eyes (Reynolds & Juvonen, 2011).

Similar to what we saw with early maturing boys, this social isolation from age-mates might drive the early-maturing girl to spend time with older adolescents (Weichold et al., 2003). A physically mature but chronologically young adolescent girl may be particularly susceptible to peer pressure to drink, smoke, or be sexually active because she does not yet have the cognitive maturity to know whether, when, and how to say no—and to stick to it (Weichold et al., 2003).

It is girls who mature at the same time as their age-mates who appear to have the advantage. They fit in comfortably with girls their own age and also with most of the boys, and they find support from a peer group that is dealing with the same issues and concerns they have. Girls who mature slightly later than average do not gain weight when their early-developing peers do so they remain relatively thin, which fits well with the cultural stereotype of what an attractive young woman should look like. Consequently, these girls tend to have positive body images (Mendle et al., 2007).

The good news regarding pubertal timing is that by the end of high school, almost all adolescents have undergone the physical changes of puberty, and a distinction between early and late maturers no longer has much meaning (Natsuaki, Biehl, & Ge, 2009). Unless the differences in timing of physical maturation have been responsible for other risky behaviors that become problematic in and of themselves (Copeland et al., 2010; van Jaarsveld, Fidler, Simon, & Wardle, 2007), adolescents are again on a pretty level playing field in this regard. Active Learning: Timing of Puberty helps you reflect on your own experiences as you went through puberty.

**Active Learning**

**Timing of Puberty**

Think back to when you went through puberty. (Some of you, especially boys, may still be experiencing some of these changes such as growth in height and increase in facial hair.) Do you remember your changes occurring before, after, or at the same time as those of your peers? When you compared yourself with others, were those comparisons favorable or not, and why? You might want to discuss your experiences with others to find out more about the range of ways in which adolescents experience puberty and variations in its timing, as well as the possible impact of these differences on adolescent development.

**Risks of Sexual Maturation: Pregnancy and STDs**

After adolescents go through puberty, males can produce viable sperm, and females can become pregnant. For most adolescents, their growing interest in the opposite sex eventually leads to romantic relationships, and for some of those adolescents, it also leads to the decision to become sexually active. In 2015, in the United States, 41% of all high school students reported that they had had sexual intercourse at least once (CDC, 2015). However, U.S. teens are waiting longer to become sexually active than they have in the past. Sexually inexperienced teens report not having sex because it is against their religion or morals, they did not want to become pregnant, or they hadn’t yet found the right person (Guttmacher...
Institute, 2014). When adolescents do become sexually active, their decision carries with it the risks of becoming pregnant and of contracting a sexually transmitted infection.

**Teen pregnancy.** In 2014, the teen birthrate in the United States reached a historic low of 24.2 births per thousand teens age 15–19, a rate 61% lower than in 1991 (see Figure 6.9; Hamilton, Martin, Osterman, & Curtin, 2015). Although the rates for Black and Hispanic teens are more than double the rate for non-Hispanic White teens, all groups have decreased during this time. Almost the entire decline in pregnancies among older teens (18 and 19 years of age) can be attributed to an increased use of contraceptives. Among younger teens, about one-quarter of the decline was due to reduced levels of sexual activity, and the remainder to increased reliance on contraception (Guttmacher Institute, 2014). As you can see from Figure 6.10, despite the decline, the adolescent pregnancy rate in the United States is still considerably higher than in other Western and industrialized nations (World Data Bank, 2015; Hamilton & Ventura, 2012).

What accounts for this difference between countries? U.S. teens and European teens have similar levels of sexual activity, but European teens are more likely to use contraception than their U.S. counterparts and to use more effective methods (Guttmacher Institute, 2014). Schalet (2011) attributed the lower rates of adolescent births and abortions among adolescents in the Netherlands to several cultural differences. Dutch adolescents are less likely than American adolescents to grow up in poverty, and poverty is one risk factor for early childbearing. They also are more likely to have been educated on the use of contraception and to encounter fewer barriers if they want contraception or abortion services than American adolescents. Another important cultural difference is that Dutch parents are more accepting of adolescent sexuality in the context of a committed relationship which makes it easier for their adolescents to ask for advice or assistance when they need it. Schalet (2011) has argued that giving adolescents a sense of sexual autonomy gives them a greater sense of control over their sexuality and enables them to make better decisions.

Why is it so important to continue to work toward reducing the rate of teen pregnancy even further? This is because having a child during the teen years has implications for the mother, her child, and society. Only half of young women who give birth during high school go on to graduate, compared with 90% of those who do not give birth, and failure to graduate leads to lower incomes and higher rates of poverty. The children of teen mothers suffer more
health problems. They also are more likely to be put in jail during their teen years, to be unemployed, and daughters of teen mothers are more likely to give birth themselves during their teen years. The cost to society of these problems plus increased foster care placement for the children of teenage mothers is estimated to be at least $9.4 billion a year (CDC, 2016a).

Approaches to reducing teen pregnancy in the United States have included school-based clinic services, mentoring and role-modeling programs, self-esteem initiatives, and opportunity development programs. Child Trends, a nonprofit and nonpartisan research center, assessed a wide range of interventions and found that the most successful ones included sex education and HIV education, engaged teens in school-based and outside activities, or were early childhood programs that lifted children’s abilities and aspirations (Manlove et al., 2002). Allen, Seitz, and Apfel (2007) have suggested that the only effective approach will target the whole person instead of trying to deal with adolescents as a “bundle of sexual urges to be controlled” (p. 197). They suggest that we need to find ways to build competencies that protect the adolescent not only from risky sexual activity but also from a range of other risky behaviors.

**STIs and STDs.** Teens who are sexually active also risk contracting a sexually transmitted infection (STI) or a sexually transmitted disease (STD). Although these terms are sometimes used interchangeably, a sexually transmitted infection is caused by a microorganism passed from one individual to another through intimate contact, while a sexually transmitted disease is the pathology that can result from such an infection (Shuford, 2008). The CDC (2013c) estimates that there are about 19 million new sexually transmitted diseases each year, and almost half occur in young people between the ages of 15 and 24 (see Figure 6.11). Of course, many cases go undiagnosed and are never reported. It might surprise you to learn that
prevalence is high even among adolescents who have only recently become sexually active (26%) and those who had only a single sexual partner (20%) (Forhan et al., 2009).

Many STIs do not produce symptoms that make the individual aware he or she should seek medical treatment, and some may not require treatment. For instance, 90% of new cases of an HPV (human papillomavirus) infection clear without treatment within 2 years (National Cancer Institute, 2010). However, these infections can go on to produce cancerous cells. An estimated 12,000 women are diagnosed with cervical cancer annually and 4,000 die from it (National Cancer Institute, 2010).

In June 2006, the Food and Drug Administration approved a vaccine that can prevent the types of HPV most likely to lead to cervical cancer. Since the vaccine was introduced, the prevalence of those types of HPV declined 56% among teen girls between ages 14 and 19 (Reagan-Steiner et al., 2015). Unfortunately, despite the evidence of its effectiveness, voluntary vaccination rates remain relatively low. In 2014, 40% of females between ages 13 and 17 had received the three doses required for full protection (CDC, 2015l). Increasing the rate to 80% (a target other countries have met) would prevent 50,000 girls from developing cervical cancer during their lifetime (CDC, 2015a). The most frequent reasons given by parents for not having their daughters vaccinated were parents’ belief that their daughters did not need the vaccine or were not sexually active, or the parents felt they did not have enough information to make an informed decision (Wong et al., 2011). However, 13% of teens become sexually active before age 15 (Guttmacher Institute, 2012). Because early vaccination is important for full protection, parents need to be realistic in deciding if and when they will have their adolescent daughters vaccinated. The Centers for Disease Control and Prevention (2015f) also recommend the vaccine for boys, preferably when they are 11 or 12 years old. Each year over 9,000 men develop cancers related to the HPV virus.

Other commonly occurring STIs include bacterial infections like chlamydia, gonorrhea, and syphilis. Each can be treated and cured, but if left untreated they can lead to serious

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**FIGURE 6.11**

Rates of STIs in different populations. Adolescents and young adults are at greater risk of contracting a number of sexually transmitted infections than the general population, as shown by these figures from the Centers for Disease Control and Prevention.

SOURCE: CDC (2013c).
complications, including infertility and death in the case of syphilis (CDC, 2014h; Guttmacher Institute, 2012). Although adolescents 14 and older can obtain treatment for STIs without parental consent in all 50 states, they may not know where to get the care they need, may not be able to afford it, or may be afraid that if they get treatment, their treatment will not remain confidential (Forhan et al., 2009).

It is a different story with viral infections, such as HIV/AIDS, hepatitis B, and herpes, which can be treated but not cured (Guttmacher Institute, 2012). In 2014, young people between the ages of 13 and 24 years of age accounted for an estimated 22% of the new HIV infections (CDC, 2016f). Eighty percent of this group were gay and bisexual males. However, when we talk about the number of cases of AIDS among adolescents, we need to remember this infection takes about 10 years to develop. Even if an individual is infected while an adolescent, symptoms may not become evident until the person is in his or her 20s, so the eventual rate of HIV infections may be considerably higher. Estimates are that 44% of young people infected with HIV do not know they are infected (CDC, 2016f). Figure 6.12 shows how the rate of new infections differs by the race/ethnicity and sex of the young person. Despite the progress we have made in developing drugs that help extend the life of infected individuals, AIDS is still an epidemic.

**CHECK YOUR UNDERSTANDING**

1. How do bodily proportions change from infancy through middle childhood?
2. What physical changes happen during prepubescence?
3. What are the consequences of early and late puberty for boys and girls?
4. Why are teen pregnancy and birth rates higher in the United States than in other developed countries?
MOTOR DEVELOPMENT

6.4 What factors influence and shape motor development?

As children’s bodies grow and change, their physical abilities are also developing. In this section, we examine the development of motor skills. We begin with a description of babies’ first movements: the reflexes. We then describe how the myelination of the nervous system plays a large role in determining the sequence in which motor milestones are achieved. Finally, we discuss other factors, such as physical activity, that influence the development of motor skills in older children and adolescents.

INFANT REFLEXES

Newborns can’t move around on their own and they don’t have much control over their limbs, but from the time they are born they have a set of involuntary, patterned motor responses called reflexes that are controlled by the lower brain centers. These help them respond to some of the stimuli in their environment.

The reflexes are hardwired into the newborn’s nervous system, so they don’t need to be learned. As the higher centers of the brain develop and take over from the lower centers in the first few months of life, most of these reflexes disappear on a predictable timetable (see Table 6.2) and are replaced by voluntary and intentional actions. For instance, if you gently touch a newborn’s cheek, she will reflexively turn in the direction of the touch which puts her in position to nurse. It doesn’t take very long, however, for even a young infant to learn the signals indicating that she is about to be fed. At that point, she will begin to turn in the direction of her caregiver as soon as she senses that it is mealtime, but this now is a voluntary action.

<table>
<thead>
<tr>
<th>Reflex</th>
<th>Description</th>
<th>When This Reflex Disappears</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucking Reflex</td>
<td>When something touches the roof of the baby’s mouth, her lips close, and she will suck reflexively.</td>
<td>About 2 months</td>
</tr>
<tr>
<td>Crawling Reflex</td>
<td>When the baby is placed on his tummy, his legs will make crawling motions even though he is not able to move forward.</td>
<td>About 2 months</td>
</tr>
<tr>
<td>Moro Reflex (or Startle Reflex)</td>
<td>When a baby loses support and feels like she is falling or hears a loud sound, she will flail her arms and legs outward. Most babies will cry when startled and then will pull their limbs back in.</td>
<td>About 3 months</td>
</tr>
<tr>
<td>Stepping Reflex</td>
<td>If the baby’s weight is supported but his feet touch the ground, he will lift and set his feet in a “walking” motion.</td>
<td>About 3 months</td>
</tr>
<tr>
<td>Tonic Neck Reflex</td>
<td>When a baby is placed on her back and her head is turned to the side, she will stretch out the arm and leg in the direction she is facing and pull inward the opposite arm and leg, often called a “fencer’s pose.”</td>
<td>About 4 months</td>
</tr>
<tr>
<td>Babinski Reflex</td>
<td>When the side of a baby’s foot is stroked, his big toe points up and the other toes will fan out.</td>
<td>About 4 months</td>
</tr>
<tr>
<td>Rooting Reflex</td>
<td>If the baby’s cheek is gently stroked, she will turn in the direction of the touch and begin to suck with her mouth.</td>
<td>About 4 months</td>
</tr>
<tr>
<td>Palmar Grasp</td>
<td>When the baby’s palm is touched with another’s index finger, he will clench the finger.</td>
<td>About 6 months</td>
</tr>
<tr>
<td>Gag Reflex</td>
<td>The baby’s reflexive gag helps prevent choking.</td>
<td>This reflex does not disappear.</td>
</tr>
<tr>
<td>Blinking Reflex</td>
<td>The baby will blink when the eye is touched or exposed suddenly to bright light.</td>
<td>This reflex does not disappear.</td>
</tr>
</tbody>
</table>

TABLE 6.2

Newborn Reflexes

Cephalocaudal development of motor skills. The cephalocaudal direction of myelination results in infants gaining control of their bodies in sequence from the head down to the toes. The effects of the cephalocaudal direction of myelination are illustrated in the following photo series.

1. **Head and neck:** Parents of newborn infants must be careful to support the baby's head, but as myelination proceeds downward, babies become able to hold up their head independently.

2. **Neck and shoulders:** A newborn placed on his stomach will remain in that position, but as myelination moves down the neck, the baby will be able to raise his head to see the world.

3. **Shoulders:** As the shoulders come under control, the baby will reach the next milestone: rolling over (from stomach to back and from back to stomach).

4. **Arms and chest:** With control of this region, the baby will be able to use his arms to push up from his stomach to survey a larger area around him. However, his legs are still flat to the floor.

5. **Hips:** When the hips and back come under the baby's control, she can now begin to sit up, at first with support and then independently.

6. **Thighs:** With control of the legs, babies can pull their legs underneath them and begin to crawl. Often babies will initially crawl backward, in part because their control of their arms is greater than their control of their legs (Greene, 2004).

7. **Lower legs:** With control traveling from the thighs to the lower part of the legs, babies begin to pull up on furniture to a standing position.

8. **Feet:** Control of the feet is needed to walk independently. At first babies walk with feet wide apart and hands raised to help with balance. As they gain more control of their feet and toes and better balance, their gait becomes more like that of an adult.
Gross motor skills involve the large muscle groups of the body—for example, the legs and arms.

Fine motor skills involve small movements, mostly of the hands and fingers, but also of the lips and tongue.

Reflexes and voluntary behavior are not entirely distinct types of response. There is a continuum that represents different mixes of reflexive and voluntary behavior that we see as motor development proceeds (Anderson, Roth, & Campos, 2005). However, if a reflex is missing or fails to disappear when it should, this can be an indication of a neurological problem, and the infant should be assessed by a doctor.

DEVELOPMENT OF MOTOR SKILLS

Children are developing both gross motor skills, which involve the large muscle groups of the body (for example, the legs and arms), and fine motor skills, which involve small movements, mostly of the hands and fingers, but also of the lips and tongue. Conscious motor activity is largely controlled by the motor cortex, located in the rear portion of the frontal lobe. The motor cortex runs across the top of the brain, from ear to ear.

Myelination of Motor Neurons

The brain connects through the spinal cord to all of the neurons in the body. As we discussed previously, the nervous system works more efficiently when neurons have been coated with the fatty substance known as myelin. This is true not only for the neurons in the brain but also for the motor neurons in the body. Myelination of motor neurons is far from complete at birth. This fatty coating, the myelin sheath, is set down in the nervous system in the body in two directions: from the head downward (in a cephalocaudal direction, from head to tail) and from the torso out to the extremities of the fingers and toes (in a proximodistal direction, from the center of the body out toward the extremities). Infants gain control of their bodies in a sequence that reflects these patterns of myelination. We see this sequence of motor milestones in the information that many parents joyfully record in their baby books.

The proximodistal direction of myelination, from the central axis of the body out to the extremities, results in the following steps in motor development:

1. Torso: Babies will roll over, using control of their chest and shoulders.
2. Arms: Control of the arms begins with the ability to swipe at objects infants see. They become able to use their arms to push up from the ground, which eventually develops into crawling.

Proximodistal development of motor skills. Look at how you hold your pen or pencil. Which fingers do you use, and how do you use them? Compare how your hand works to how these children are able to use their hands. Why do you think that preschoolers are often given “fat crayons” to use instead of pens?

Gross motor skills Skills that involve the large muscle groups of the body—for example, the legs and arms.

Fine motor skills Skills that involve small movements, mostly of the hands and fingers, but also of the lips and tongue.

Proximodistal Development that proceeds from the central axis of the body toward the extremities.
3. Hands: When infants begin to purposefully grasp objects, they scoop objects with all their fingers up against their palms, in what is called the \textit{palmar grasp}.

4. Fingers: As they gain control of their fingers, babies can use thumb and forefinger to pick up things as small as Cheerios. This is called the \textit{pincer grasp}. Only later can they control the rest of their fingers to be able to use a \textit{tripod grasp}, using thumb, forefinger, and middle finger to hold a pencil.

Motor skills interact with other areas of infant development. In a classic study, Eleanor Gibson related the development of crawling with the development of depth perception. She created what she called the \textit{visual cliff}, a Plexiglas covered table shown in Figure 6.13 that gives the illusion that one side drops off from table level to floor level while actually keeping a baby safe from falling (Gibson & Walk, 1960). She found that about 4 to 6 weeks after babies learn to crawl they begin to refuse to crawl over the visual cliff. She argued that babies developed an awareness and fear of heights as a result of learning to crawl and experiencing the ups and downs that come with mobility. However, in more recent years, Adolph, Kretch, and Lobue (2014) have argued that infants’ avoidance of the cliff is due to their growing ability to perceive the relationship between their own body and the environment. Once they begin to crawl, that experience increases infants’ awareness of their own body and how it relates to the world around it so they know when they can master climbing down a cliff and when it is too high for them. When babies first begin to walk they must learn this all over again. Initially they walk right over the cliff (Kretch & Adolph, 2013).

The new ability to move around has other effects as well. Infants can now try to stay near their parents as attachment develops; they can explore more freely which increases learning; and they can get into more trouble which means that parents and others will do more to control their behavior.

\textbf{Motor Development in Older Children}

Both fine and gross motor skills show considerable development during early childhood and throughout the school years. Table 6.3 summarizes some of the changes typically shown between the ages of 3 and 10 years.

Fine motor skills enable the 3-year-old to hold a crayon using her fingers rather than her fist, to build a tower of blocks, and to use scissors to cut paper. Four-year-olds begin to feed and dress themselves, and color inside the lines (American Academy of Pediatrics, 2009a). During the school years, the development of fine motor skills is reflected in improvements in handwriting, both printing and cursive, and in the detail and complexity children incorporate into their drawings. Many children also now enjoy activities that rely on fine motor skills and good eye-hand coordination, such as beading, sewing, building models, and playing complex video games.

New gross motor skills for 3- and 4-year-olds typically include running, jumping, hopping, and riding a tricycle. When children begin school, their gross motor skills are still relatively undeveloped, but by fifth or sixth grade, most have made great strides and their motor skills are almost as coordinated as those of an adult. They are increasingly able to control and coordinate parts of their body, and their flexibility, balance, reflexes, and strength all improve. Because the ligaments in their limbs are not yet firmly attached to the bones, children in middle childhood are quite flexible compared to children of other ages (Cain, 2005). For all these reasons, many enjoy participating in physical activities such as group and individual sports that depend on gross motor skills.

As children have become increasingly skilled at keyboarding, there has been a debate within the educational community about whether they still need to learn cursive writing. Some advocates make the philosophical argument that cursive is a skill all educated people
should possess, but there also is brain research to support the idea that cursive writing affects brain functioning in a way that keyboarding does not. Think about the difference between shaping a complex series of curves, loops, and slants as you form a written sentence versus what is involved when you copy the same sentence by striking keys on a keyboard. Writing in cursive activates different circuits in the brain than keyboarding (Klemm, 2013) and the use of the fine motor skills and eye-hand coordination required by cursive writing promotes reading, writing, and cognitive skills (James & Engelhardt, 2012). William Klemm (2013), an advocate for cursive writing, has said it benefits brain development similar to the way learning to play a musical instrument does, but while not everyone can afford to take music lessons, everyone can use paper and pencil to write.

Physical activity is important for motor development of children at all ages. As schools cut back on recess time, it becomes even more important for families to ensure that their children are running, biking, and playing actively for their long-term health and the development of their muscles. The CDC (2015e) recommends that children take part in 60 minutes of exercise per day, including aerobic, muscle-strengthening, and bone-strengthening activities. These activities do not need to include intensive involvement in sports, unless a child loves sports. Walking to school, riding a bike, or raking leaves can all be sources of healthful exercise. Physical activity is related not only to optimal functioning of children’s muscles but also to optimal functioning of their brains (Bear et al., 2007; Chaddock-Heyman, Hillman, Cohen, & Kramer, 2014; Hillman, Buck, Themanson, Pontifex, & Castelli, 2009). The message, then, is for children to walk away from the TV, computer, and video games and go outside to play.

**BODY AWARENESS**

As young children gain more control over their bodies by walking, running, and hopping, and as they increase their ability to pick up and manipulate objects, they also develop their sense of
TABLE 6.3

Motor skill development. Children between the ages of 3 and 10 develop a wide range of fine motor and gross motor skills. As you review the developmental milestones in this table, think about the ways in which they enable children to interact more effectively with the environment while at the same time making them more independent.

<table>
<thead>
<tr>
<th>Age</th>
<th>Fine Motor/Visual Perception</th>
<th>Gross Motor Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Years</td>
<td>• Picks up blocks&lt;br&gt;• Places shapes in holes&lt;br&gt;• Turns pages of a book&lt;br&gt;• Paints at an easel</td>
<td>• Stands on one foot&lt;br&gt;• Jumps down from a step&lt;br&gt;• Kicks a large ball with force</td>
</tr>
<tr>
<td>4 Years</td>
<td>• Holds a pencil in adult way&lt;br&gt;• Copies a square accurately&lt;br&gt;• Brings thumbs into opposition with each finger in turn&lt;br&gt;• Colors inside lines</td>
<td>• Pedals a bicycle&lt;br&gt;• Bounces a large ball&lt;br&gt;• Runs smoothly</td>
</tr>
<tr>
<td>5–6 Years</td>
<td>• Picks up and replaces minute objects&lt;br&gt;• Has good control when writing and drawing with pencils and paint brushes&lt;br&gt;• Prefers to use dominant hand&lt;br&gt;• Copies a square and triangle&lt;br&gt;• Copies letters V, T, H, O, X, L, A, C, U, Y&lt;br&gt;• Writes a few letters spontaneously&lt;br&gt;• Draws a person with six or more body parts and facial features&lt;br&gt;• Cuts out a simple picture&lt;br&gt;• Draws a house with door, windows, roof, and chimney&lt;br&gt;• Starts to color neatly within outlines&lt;br&gt;• Counts fingers on one hand with index finger of the other hand&lt;br&gt;• Prints first name</td>
<td>• Walks easily on a narrow line&lt;br&gt;• Skips on alternate feet&lt;br&gt;• Stands on one foot (right or left) for 8-10 seconds&lt;br&gt;• Jumps 7 to 10 feet forward on each foot&lt;br&gt;• Throws a beanbag without trapping it against the body&lt;br&gt;• Throws a beanbag onto a target 5 out of 10 times&lt;br&gt;• Catches a ball two-handed, away from the body&lt;br&gt;• Catches a tennis ball two-handed, away from the body&lt;br&gt;• Aims and throws accurately&lt;br&gt;• Stands on either leg for 15–20 seconds&lt;br&gt;• Walks along a narrow line on tiptoes&lt;br&gt;• Jumps repeatedly with feet together&lt;br&gt;• Skips with alternating feet&lt;br&gt;• Times of running with controlled landing</td>
</tr>
<tr>
<td>6–7 Years</td>
<td>• Prints all numbers 1–9 without a model to copy (some may be reversed)&lt;br&gt;• Prints first and last name&lt;br&gt;• Discriminates left from right&lt;br&gt;• Has good control over pencil, with change in direction&lt;br&gt;• Threads small beads onto a cord confidently&lt;br&gt;• Uses scissors to cut more complex shapes&lt;br&gt;• Ties own shoelaces</td>
<td>• Catches a tennis ball two-handed, away from the body&lt;br&gt;• Aims and throws accurately&lt;br&gt;• Stands on either leg for 15–20 seconds&lt;br&gt;• Walks along a narrow line on tiptoes&lt;br&gt;• Jumps repeatedly with feet together&lt;br&gt;• Skips with alternating feet&lt;br&gt;• Times of running with controlled landing</td>
</tr>
<tr>
<td>7–10 Years</td>
<td>• Prints all numbers and letters (without reversing any)&lt;br&gt;• Becomes competent in cursive handwriting&lt;br&gt;• Manipulates and places pegs competently in a peg board with either hand&lt;br&gt;• Manipulates scissors competently</td>
<td>• Stands and balances on either leg for 30 seconds and beyond&lt;br&gt;• Walks along a narrow line heel to toe&lt;br&gt;• Hops repeatedly on either leg with controlled landing</td>
</tr>
</tbody>
</table>

SOURCES: Adapted from Bailey (2005) and Lammas & Poland (2014). Reprinted with permission from the authors.

**Proprioception** The sense of knowing where the parts of one’s body are located in space without the need to look at them.
Young children must learn how to use this feedback to move effectively through their environment and control their motor activity. Until they do, their movement may appear clumsy or awkward, or they may have difficulty judging how much force or strength they need to accomplish a task. Children develop body awareness naturally as a part of their normal activity, but parents and caregivers can enhance this development with some of the simple games young children love to play. Simon Says (“Simon says do this... Do this... Do this”) or the Hokey Pokey allow children to consciously move specific parts of their body and gain a sense of where they are in relationship to the rest of their body. Many people have enjoyed asking a toddler, “Where is your nose? Where are your ears?” and children delight in showing they know the answer. Body awareness also can be facilitated by structured activities, such as introducing children to simple forms of yoga (Wenig, 2007). Yoga can help children develop strength, flexibility, coordination, and body awareness while engaging in a relaxing and noncompetitive physical activity.

You can observe the development of body awareness in young children for yourself with the activity described in Active Learning: Developing Body Awareness.

Active LEARNING

Two-year-old Sabrina demonstrates her developing sense of body awareness.

Developing Body Awareness

Offer to play a variation of the game Simon Says with a child between ages 3 and 8. Tell the child that he or she should do the actions exactly as “Simon says.” Begin by having the child do the movements with you as you say “Simon says touch your nose” or “Simon says touch your knees.” Do this with about 10 body parts. Then just give the directions and allow the child to do the actions on his or her own without a model. Finally, ask the child to keep following the directions but with eyes closed. Body awareness is a sense of where your body is in space even when you can’t see it, and this last task is much harder for a young child. Note how many errors the child makes in the three conditions. Does he or she have more difficulty touching different parts of the body with eyes closed? If you have a chance to try this activity with children of different ages, do you see differences in their ability to do the tasks as they get older? As always, if the game becomes difficult or frustrating for the child, thank him or her for playing with you and end the game.

To prepare for this activity, or, if you do not have access to a child, you can watch the video of this Active Learning.

Motor Disability: Developmental Coordination Disorder

Although we expect to see some variability in the ages at which children reach motor milestones, the DSM-5 recognizes a condition called developmental coordination disorder (DCD).
in which delays in reaching these milestones interfere with daily living or academic performance (APA, 2013). It is usually first noticed when a young child has a significant delay in reaching milestones like sitting up, walking, jumping, or standing on one foot, or has problems with fine motor skills such as writing, using scissors, or tying shoelaces. Over time, these difficulties can interfere with a child’s social development because the child may not be able to play with other children. They can also affect academic performance once children begin school. Although these problems first appear in the early years of life, the diagnosis is generally not made until age 5 because of the wide range of ages at which children normally develop different motor skills.

About 6% of school-aged children have this condition, and it is more common in boys (APA, 2013). Possible causes include biological factors such as prenatal malnutrition (Davidson, 2003) or abnormalities in the neurotransmitter or receptor systems in the central nervous system (Barnhart, Davenport, Epps, & Nordquist, 2003). The condition can be improved with physical education and daily exercise that help the brain and body work together, but in some cases occupational therapy or physical therapy is necessary to help children master daily self-help activities (Barnhart et al., 2003; Tokolahi, 2014).

CHECK YOUR UNDERSTANDING

1. What is the difference between gross motor and fine motor skills?
2. How does the process of myelination affect the order in which motor skills develop?
3. How can you promote body awareness in young children?
4. What is developmental coordination disorder?

NUTRITION

6.5 What role does nutrition play in development?

Growth and development rely to a large extent on healthy nutrition for infants, children, and adolescents. In this section, we discuss how to get babies off to a healthy start and how to provide a healthy diet for children and teens. We also describe problems with nutrition, from malnourishment to obesity to eating disorders.

BREAST-FEEDING

A number of national agencies and organizations, including the Centers for Disease Control and Prevention and the American Academy of Pediatrics, as well as international agencies including the United Nations Children’s Fund (UNICEF) and the World Health Organization (WHO), have strongly advocated for breast-feeding infants because of the benefits associated with it. Table 6.4 summarizes some of those benefits, for both the mother and her infant.

When a woman begins breast-feeding, her breasts initially produce a thick, yellowish substance called colostrum which is rich in nutrients to fuel the newborn’s early growth and antibodies that help protect the newborn from infection (USDHHS, 2014). Colostrum is very easy for the newborn to digest. In the next 3 to 5 days, the mother’s body will begin producing breast milk which will appear thin and watery compared to the colostrum, but which contains the right balance of fat, sugar, water, and protein for the newborn. The antibodies provided through colostrum and the mother’s milk not only help the infant fight off infections, but may also promote earlier development of the infant’s own immune system (Jackson & Nazar, 2006).
The American Academy of Pediatrics (2012) recommends that babies be exclusively breast-fed until 6 months of age, with other foods gradually supplementing it between 6 months and 1 year. Mothers are urged to wait to introduce solid foods into an infant’s diet because doing this too early has been associated with development of allergies later in the child’s life (Nwaru et al., 2010). While the number of American women who breast-feed their infants has risen in recent years, many do not continue to breast-feed for the recommended length of time. For example, in 2011, 79% of new mothers began breast-feeding, but the number dropped sharply to 49% at 6 months, and 27% by 12 months (CDC, 2014c).

For infants in poor and developing countries, the consequences for being breast-fed are even more significant. A systematic review of breast-feeding and infant mortality concluded that in developing countries infants between birth and 5 months of age who were not breast-fed were 14 times more likely to die than infants that were exclusively breast-fed (Sankar et al., 2015). In these countries where the water is often contaminated and sanitation is poor, UNICEF (2015) claims that optimal levels of breast-feeding could save more lives than any other preventive intervention.

Although the benefits of breast-feeding for many aspects of physical health are well-established, there remains a debate about the impact on children’s later cognitive development (Ip et al., 2007; Tawia, 2013). Because breast milk provides ideal nutrition for the newborn and promotes overall healthier development, it is logical to think that these factors would positively impact cognitive development. However, early research that came to this conclusion has been criticized because mothers who choose to breast-feed differ from those who don’t. They tend to be older, more educated, have higher incomes, and are more likely to be married or have a partner (Dennis, 2002; Li, Darling, Maurice, Barker, & Grummer-Strawn, 2005;
Persad & Mensinger, 2008). Each of these demographic characteristics also is associated with better cognitive outcomes for children. That means that women who breast-feed their infants would be more likely to have brighter children, regardless of whether they breast-fed their infants or not.

A more recent study found a statistically significant effect for breast-feeding on measured intelligence in children ages 7 to 16 even after controlling for the mother’s demographic characteristics (Kanazawa, 2015). In this case, each month of breast-feeding was associated with an increase of .16 IQ points, or a total of 3.86 IQ points if the mother breast-fed for the full 2 years recommended by the World Health Organization. To put this finding in perspective, we remind you of the distinction made in Chapter 3 between statistical significance and practical significance. While these results are statistically significant, a question remains about what impact a less than 4-point increase in IQ test scores has on a child’s cognitive development.

In light of the questions raised about the magnitude of some of the benefits attributed to breast-feeding (Jung, 2015), there has been some backlash against the heavy promotion of breast-feeding as the only good choice a new mother can make. Critics feel that this promotional campaign has resulted in blaming or shaming women who can’t or don’t breast-feed. We know there are some circumstances under which breast-feeding is not recommended. You learned in Chapter 5 that HIV can be transmitted from an infected mother to her infant through breast milk, and when a woman is undergoing chemotherapy or using antibiotics, antianxiety medications, or antidepressants, these substances also can be passed to an infant through her breast milk (American Academy of Pediatrics Committee on Drugs, 2001). Therefore, in these instances, a woman should not breast-feed. For many more women, however, the decision is influenced by more practical considerations, such as the woman’s need to return to work. In these cases, formula does provide all the nutrients necessary for typically developing infants, although it does not provide the immunity that breast milk provides.

The debate is not so much about a choice between breast-feeding or bottle-feeding as it is between breast-feeding and breast milk. Breast-feeding gives women a wonderful opportunity to form a strong attachment to their infant in the process, but one clear advantage of bottle-feeding is that fathers also can participate in feeding the infant. However, it does not need to be formula in those bottles. Mothers can pump breast milk to be used later for bottle-feeding, and that breast milk will provide all the nutritional benefits and healthful immunity it offers. Work places can also do more to support a woman’s decision to breast-feed (Gartner et al., 2005; Skafida, 2012) by providing private settings where mothers can pump milk for their babies. Providing training and support for breast-feeding while a woman is in the hospital would also support a woman’s intention to breast-feed (Ogbuanu et al., 2009).

In conclusion, whether breast milk comes from the breast or is given to the baby from a bottle, it provides all the nutrition, as well as some immunity to a range of infections and diseases, that are needed for healthy development. Babies who are not breast-fed can still receive good nutrition from formula. Each new mother makes this decision based on her personal circumstances and her understanding of the options available to her.

HEALTHY EATING

You may remember learning about the food pyramid in elementary or high school. In 2012, the U.S. Department of Agriculture (USDA) replaced that image with a new logo, called “My Plate,” which graphically shows us the proportion of fruits, vegetables, grains, protein, and dairy that should make up a healthy meal. As Figure 6.14 shows, fruits and vegetables should make up half of the plate. The USDA also recommends that we cut back on solid fats, added sugars and salt, and be sure that at least half of the grains we consume are whole grain.

Children who get off to a good start with a diet that contains a variety of healthy foods benefit throughout childhood and adolescence and into adulthood, but a healthful diet is particularly necessary to support the periods of rapid growth that occur in infancy and again at the start of adolescence.
A national survey in which American parents reported on what their infants and toddlers ate found that most are eating a healthy diet with more fruits and vegetables and fewer desserts, sweetened drinks, and salty foods than those who were interviewed 6 years earlier. However, many were still not receiving enough fiber from fruit, vegetables, legumes, and whole grains, and were receiving too much salt and saturated fat (Butte et al., 2010). All of these are risk factors for heart disease and high cholesterol later in life. In addition to healthy food choices, there are some other foods that pose a special risk for young children and should not be part of their diet. Unpasteurized milk or juices made from unwashed fruits can contain harmful bacteria. Honey can contain the botulinum organism, and raw eggs can contain salmonella. Adults also need to be particularly careful about giving young children firm, round foods such as popcorn, whole grapes, or hot dogs because these foods are approximately the size of a child’s airway and can lodge in the child’s throat and cause choking (American Academy of Pediatrics, 2006b).

Between 4% and 8% of children suffer from one or more food allergies (Branum & Lukacs, 2009; Gupta et al., 2011), with the incidence peaking among 3- to 5-year-olds (Gupta et al., 2011). Although any food can cause an allergic reaction, 90% of childhood allergies are caused by just 6 common foods: milk, eggs, peanuts, tree nuts (such as walnuts or cashews), soy, and wheat (American Academy of Pediatrics, 2013). Most allergic reactions to food are not serious or life-threatening, but they can be (Sicherer et al., 2010). In one study, slightly more than a third of the children with allergies had a history of severe reactions (Gupta et al., 2011). Although anaphylaxis, a severe reaction to an allergen that affects many systems in the body, is rare, preschool children are more likely to experience a severe reaction than older children. To help prevent allergy-related problems, many preschools have “no-share” food policies regarding food that can be brought into the classroom.

Healthy eating continues to be important as children enter middle childhood, but as they get older, they have more autonomy over what they eat because more of their food is consumed away from home. The good news is that the diets of most American children do a good job of meeting their nutritional needs (Clark & Fox, 2009), but the shortcomings described previously for infants’ and toddlers’ diets continue to be a problem for older children and for adolescents (Child Trends, 2013b; Volkarsky, 2010).

The root of some of these nutritional problems lies with the kind of foods favored by school-aged children. Hamburgers, cheeseburgers, and pizza contribute substantial amounts of fat and sodium to the diet, and whole milk and ice cream contribute saturated fat. On a typical day, one-third of American children and over 40% of American adolescents consume food or beverages from a fast-food restaurant (Poti, Duffey, & Popkin, 2014). Meals from these restaurants tend to be high in calories, total fat, saturated fat, sugar, and sodium; they are also low on nutritious foods such as milk, fruits, and vegetables (other than potatoes) (Bowman, Gortmaker, Ebbeling, Pereira, & Ludwig, 2004; Powell & Nguyen, 2013). Although eating fast food contributes to high rates of obesity in the United States, recent research has found that it is the quality of the remainder of the child’s diet that is more strongly associated with weight status and dietary outcomes (Poti et al., 2014). Educating children during middle childhood about wise food choices can help ensure that the quality of their diet improves, rather than deteriorates, as they move through the elementary school years.

A number of American schoolchildren eat one or more meals a day at school. In 2012 and 2013, about 13.2 million children participated in the School Breakfast Program on a typical day.
day, and 85% received a free or reduced-price breakfast (Food Research and Action Center, 2010). Eating breakfast improves attention and memory (Rampersaud et al., 2005), with the benefit being greater for children who otherwise have poorer diets (Hoyland, Dye, & Lawton, 2009; Kristjansson et al., 2007). However, a primary reason why school breakfast programs are associated with better academic performance is not what you might expect. Children who eat their breakfast at school have better attendance than those who don’t, so when we try to interpret the impact of a school breakfast program on students’ cognitive performance, at least part of that effect may be attributable to their better school attendance rather than to the nutritional value of the meal itself (Hoyland et al., 2009; Kristjansson et al., 2007).

On a typical day, even more U.S. children (30.7 million) participate in the school lunch program, with about 70% receiving free or reduced-price lunches. Children who participate are more likely than those who don’t to consume low-fat milk, fruits, and vegetables and less likely to consume less healthy items like dessert and snacks (Condon, Crepinsek, & Fox, 2009). Some real challenges remain, however. For one thing, many elementary schools give children only 20 minutes for lunch, hardly enough time to wait in line to get their food and enjoy a nutritious meal, and many school kitchens do not have the space or equipment to prepare many of its foods from scratch. Try Active Learning: School Lunches to find out about the choices that children make from the foods currently offered by their schools.

School lunches. School lunches can offer children healthy alternatives that help to improve the overall quality of their diets.

Active Learning

School Lunches

Talk to a couple of elementary school-aged children who regularly get their lunch from their school cafeteria. It doesn’t matter whether they purchase their lunch or get it through the school lunch program. Ask them what they like and don’t like about the lunches, whether they usually get low-fat milk or 100% fruit juice with their meals, and whether they usually eat any fruit or vegetables. Ask the children you talk to what they would do to improve the foods they are served. You can then decide whether their suggestions would make the meals more nutritious or not. For instance, they might say they would prefer white bread to the whole wheat bread their cafeteria uses, but this would not be a more nutritious change. Compare what you find to what your classmates find when they interview children of different ages. Do different factors influence children’s food decisions as they get older?

To prepare for this activity, or, if you do not have access to a child, you can watch the video of this Active Learning.
As adolescents spend more time away from their parents, they make more of their own choices about what to eat. Parents may not provide all the teenager’s food, but it still is important that they continue to encourage healthy eating. Parental encouragement is associated with greater consumption of fruits and vegetables and lower consumption of fast foods (Bauer, Laska, Fulkerson, & Neumark-Sztainer, 2011).

MALNOURISHMENT

An estimated 19 million children in developing countries suffer from severe malnutrition, and the younger children are, the greater the effect of malnutrition on their growth (Management of Acute Malnutrition in Infants Project, 2009). The lack of nutrients affects brain development as well as other aspects of physical health and growth. If the infant survives malnutrition, and many do not, the effects are irreversible and can last a lifetime even if they get plenty of food later in life. In a study in Barbados, adults who had been malnourished as infants were more likely to have ongoing attention deficits and conduct problems that began in childhood but continued through adulthood (Galler et al., 2012a; Galler et al., 2012b).

We often associate malnourishment with children who live in third world countries or countries being torn apart by war, but it exists to some extent in every country, including the United States. However, a much greater threat in the United States than malnutrition is undernutrition, a deficiency of calories or of one or more essential nutrients. A paradoxical situation called food insecurity exists for people who do not always have access to the nutritious food needed to meet their basic needs (Franklin et al., 2012). When food is not consistently available, adults and children may adopt the strategy of overeating when it is. This pattern of feast and famine can result in weight gain over time. It is estimated that 1 in 7 American households experience food insecurity. Low-income, ethnic minority, and female-headed households are at the greatest risk, and adolescents may be even more vulnerable than younger children (Franklin et al., 2012). Food insecurity is associated with higher rates of illness, lower academic achievement, and more aggression, withdrawal, and emotional distress (Ashiabi & O’Neal, 2008).

OBESITY AND BEING OVERWEIGHT

Being overweight or obese has serious negative consequences for children. For one thing, overweight children are likely to become overweight adolescents who in turn become overweight adults (Malina, Bouchard, & Oded, 2004; Singh, Mulder, Twisk, van Mechelen, & Chinapaw, 2008), and we know children who are overweight or obese have an increased risk of developing a number of life-threatening health conditions, including type 2 diabetes and asthma (Black, Smith, Porter, Jacobsen, & Koebnick, 2012; Brüske, Flexeder, & Heinrich, 2014; Long, Marano, Shabo, & Wilson, 2012). The American Diabetes Association (2008) estimates that 1 in 3 children born in 2000 will develop diabetes in their lifetime, and this ratio climbs to 1 in 2 for minority children. The long-term effects of obesity (being 20% or more over an individual’s ideal weight) include elevated blood pressure, increased levels of cholesterol, and even some cancers (Malina et al., 2004). In addition to the tremendous personal cost of diabetes to the affected individuals, total economic cost in the United States in 2012 was $245 billion (American Diabetes Association, 2013).

The good news is that after years of national attention to the problem of childhood obesity, we finally appear to be making some progress. After years of increasing rates of obesity, the percentage of children ages 2 to 19 considered obese has not increased in the last 10 years (CDC, 2015b), and recent statistics have found a decrease in the rate of obesity among 2- to 5-year-old children (CDC, 2015b). The exact reasons for the decline are hard to identify, but lower consumption of sugary beverages, more nutritious meals and snacks at child care centers, more emphasis on physical activity, and increased rates of breast-feeding may all be
making a contribution. Although there was no comparable decrease in other age groups in this study, we can hope that as these young children move from early childhood into middle childhood, they will sustain this progress.

Minority and low-income children continue to be at a disproportionately high risk of being obese, but their parents are often in denial about their children’s weight. In a study of low-income mothers by Rich and colleagues (2005), all the participating children were at or above the 95th percentile in weight for their height (which is considered obese), but 81% of their parents said their child was healthy and 50% were not concerned about their child’s weight. Parents often explained their lack of concern by saying the child would simply grow out of it, was tall or big-boned, or looked just fine. Unfortunately, overweight children do not typically grow out of the problem, so results such as these remind us how important it is to understand parents’ perspectives on a situation if we want to design interventions to change their behavior. Parents not only need to have information about childhood obesity, but they also need to be motivated to use it to improve their children’s health (Weatherspoon, Venkatesh, Horodynski, Stommel, & Brophy-Herb, 2013).

EATING DISORDERS

At the other end of the spectrum are eating disorders that are associated with children and adolescents being severely underweight. Although there are a number of eating disorders, the dramatic nature of anorexia nervosa and bulimia nervosa keeps them in the forefront of our attention. Anorexia nervosa is a condition in which individuals intentionally restrict their food intake to a point that it may become life-threatening. Despite their thinness, anorexics still see themselves as grossly overweight and remain fearful of gaining weight. This condition takes a terrible toll on the young person’s overall health. A number of changes can easily be seen, including thinning hair, brittle nails, a yellowing of the skin, and the growth of fine downy hair on the face, arms, and back, but many anorexics experience more serious hidden changes, including gastrointestinal and cardiovascular problems, and osteoporosis. As we said earlier in this chapter, a woman’s body needs a certain level of body fat to sustain her periods so as a young woman’s level of body fat falls, she either will fail to begin menstruating, or her menstrual periods will become erratic or cease altogether. Because anorexia can be life-threatening, hospitalization may be required, but hospitalization often occurs late in the process after a great deal of physical damage has already been done. Although some programs have had success with helping the anorexic regain weight, relapses following treatment are common, and mortality from anorexia is higher than for other psychiatric disorders (Arcelus, Mitchell, Wales, & Nielsen, 2011).

Bulimia nervosa is an eating disorder that is characterized by eating binges in which enormous amounts of food are consumed, followed by self-induced vomiting or the excessive use of laxatives to get rid of the food. Individuals with bulimia base their self-esteem largely on their weight and feel out of control during binge eating (APA, 2013). Many cases of bulimia go undetected because the goal of bulimics is to maintain their weight rather than lose a great deal of weight and much of the behavior associated with bulimia is secret behavior.
The prevalence of bulimia among young women is estimated at 1% to 1.5% and the prevalence of anorexia is estimated at 0.4%. Both of these disorders are much less common in men (APA, 2013). Participating in activities where weight is a continuing issue (such as gymnastics or dance for females and wrestling for males) can put both girls and boys at risk.

There are no simple explanations for what causes eating disorders. Both anorexia and bulimia can begin with normal dieting and concerns about weight that reflect the emphasis our culture places on thinness. Research based on twin studies has found some evidence for a genetic link, and children with an anxiety disorder or who demonstrate obsessional behavior are at increased risk of developing anorexia (APA, 2013). Girls who mature earlier than other girls are at risk because their early physical maturation is associated with being heavier than their peers (Berger et al., 2009; Tyrka, Graber, & Brooks-Gunn, 2000). Psychological factors such as depression and low body esteem also are predictive of developing eating disorders in both boys and girls (Gardner et al., 2000; Keel & Forney, 2013). Another possible cause is a dysfunctional family dynamic. However, it is difficult to know whether any family dysfunction we see in families of anorexics is a cause of the disorder or a result of the stress of having a child with this problem (Sim et al., 2009). You will learn more about the role that media plays in promoting disordered eating in Chapter 14.

In a review of programs designed to prevent eating disorders (rather than to treat them once they occur), Stice and Shaw (2004) found that the most effective programs were ones that target high-risk groups of adolescents rather than the general population of adolescents. They also found that older adolescents benefited more than younger ones, perhaps because the risk of developing an eating disorder increases after age 15. It may surprise you to learn that programs that focus on providing information to adolescents about the harmful effects of disordered eating were ineffective at producing a change in the adolescent’s behavior. Rather, it was programs that focused on changing maladaptive attitudes (such as seeing a thin body as the ideal body type or feeling very dissatisfied with your own body) and maladaptive behaviors (such as fasting or overeating) that were the most effective.

CHECK YOUR UNDERSTANDING

1. What are some benefits of breast-feeding for mothers and babies?
2. How does eating breakfast affect children’s performance in school?
3. What are the effects of food insecurity on healthy eating habits?
4. Identify recent trends in obesity and being overweight in American children.
5. How are the symptoms of anorexia nervosa and bulimia nervosa different?

CONCLUSION

The healthy development and functioning of the human body is central to all aspects of human experience. We have seen in this chapter that physical development relates to many aspects of emotional, social, and cognitive development. In the next chapters, we look at these areas, with the clear understanding that all of these aspects of development are linked to what we have studied in this chapter: brain function, sensory development, physical changes such as those in puberty, and the health of the body.
Part II: Biological Beginnings and Physical Development

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CHAPTER SUMMARY

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6.1 How are the brains of children and adolescents similar to and different from the brains of adults? What disorders are linked with the structure and function of the brain?

Human brains are divided into two hemispheres, which are connected by the corpus callosum. Each area of the brain handles some specialized functions. The brain is made up of neurons. Although infants have billions of neurons, they have relatively few synapses that connect them. In early brain development, synaptogenesis forms connections between neurons, and myelination improves the efficiency of the neural impulses. Cells in a young brain have a plasticity that allows them to take over new functions if some part of the brain is damaged. Unused synapses are pruned, but when an individual encounters typical experiences, experience-expectant brain development occurs and those synaptic connections are retained. When an individual encounters unique experiences, experience-dependent brain development occurs and new synapses are formed. Brain development continues through adolescence, especially the development of the prefrontal cortex. There is another round of overproduction and pruning of synapses in adolescence.

Cerebral palsy is a condition that involves problems with body movement and muscle coordination resulting from damage to the brain prenatally, at birth, or shortly thereafter. Autism spectrum disorder (ASD), which is characterized by pervasive impairment in social communication and interaction and by restricted or repetitive behaviors, interests, or activities, may be caused by differences in patterns of brain development (for example, failure to prune unnecessary synapses or different patterns of connectivity). It is not caused by poor parenting. The increased incidence of ASD may be the result of some combination of better case finding, earlier diagnosis, misdiagnosis, and a true increase in the disorder. Schizophrenia is a very rare but serious mental disorder related to both structural and functional differences in many regions of the brain. Symptoms include delusions, hallucinations, disorganized speech, very disorganized or catatonic behavior, and reduced expression of emotion and self-motivated behavior. When children and younger teens develop this disorder, it is referred to as early-onset schizophrenia.

6.2 How do the senses develop during infancy?

Although an infant’s visual acuity is initially poor, it develops to adult levels by 6 months to 3 years after birth. Infants focus on their parents’ eyes, seemingly inviting interaction. Hearing is well developed at birth, and infants have shown a preference for their mothers’ voices, which they heard while still in the womb. The infant’s sense of smell also is highly developed at birth, and infants prefer sweet tastes to other tastes. Both smell and taste preferences are shaped by exposure to chemosensory molecules prenatally, so after birth infants prefer smells and tastes associated with the foods their mothers ate. Infants are sensitive to touch, which promotes development and well-being. Infants show cross-modal transfer of perception.

6.3 How do children’s bodies change from infancy through adolescence?

Infants grow very rapidly in the first few years of life, and the rate of growth slows substantially until the child experiences the adolescent growth spurt. The child’s body proportions change to become more similar to adult body proportions. When adolescents go through puberty, they become capable of reproducing. Girls experience menarche, and boys experience spermarche. Both primary sex characteristics and secondary sex characteristics develop. The timing of puberty has an impact on an individual’s social, emotional, and cognitive development. Maturing early has some advantages for boys and disadvantages for girls, but both early maturing boys and early maturing girls can be at risk of being drawn into risky behavior if they associate with older peers. Adolescents who are sexually active are at risk of a pregnancy or getting a sexually transmitted disease. The adolescent pregnancy rate has decreased in recent years, but still is higher than in other developed countries.

6.4 What factors influence and shape motor development?

Infants are born with a set of reflexes, but reflexes are fairly quickly replaced with voluntary movement as the nervous system matures. Children gain control over both fine motor skills and gross motor skills, and these skills develop following the cephalocaudal and proximodistal principles (moving from the head to the tail, and from...
the center of the body to the extremities) in the pattern of myelination of motor neurons. **Proprioception** helps children develop body awareness. Some children have a **developmental coordination disorder**. Motor development is shaped by a complex interaction of genes, maturation, and environmental experiences. Throughout development, children and adolescents benefit from physical activity.

**6.5 What role does nutrition play in development?**

Breast-feeding helps an infant get off to a good start and has benefits for the nursing mother as well, but levels of breast-feeding in the United States are not as high as is recommended. Although children in the United States tend to have healthy diets, they eat too much sugar, fat, and sodium and too few fruits, vegetables, and have too little fiber in their diets, which has consequences for their health. Children in the United States are more likely to suffer from **undernutrition** than malnutrition. When an adequate diet is not always available, people may experience **food insecurity** and overeat when food is available. **Obesity** is a major health risk because it is associated with diabetes and other health problems, but the rate of childhood obesity may be leveling off. At the other extreme, some children and adolescents experience eating disorders, such as **anorexia nervosa** or **bulimia nervosa**.

**KEY TERMS**

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