As you progress through the Babies and Toddlers simulation module, how you decide the following will impact the biosocial, cognitive, and psychosocial development of your child.

<table>
<thead>
<tr>
<th>Biosocial</th>
<th>Cognitive</th>
<th>Psychosocial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will you vaccinate your baby?</td>
<td>What activities will you expose your baby to?</td>
<td>How will you soothe your baby when he or she is crying?</td>
</tr>
<tr>
<td>Will you breast-feed your baby?</td>
<td>(music class, reading, educational videos)?</td>
<td>Can you identify your baby’s temperament style?</td>
</tr>
<tr>
<td>If so, for how long?</td>
<td>What activities will you do to promote language development?</td>
<td></td>
</tr>
<tr>
<td>What kind of foods will you feed your baby during the first year?</td>
<td>Which of Piaget’s stages of cognitive development is your child in?</td>
<td></td>
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<tr>
<td>How will you encourage motor skill development?</td>
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<tr>
<td>How do your baby’s height and weight compare to national norms?</td>
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<td></td>
<td></td>
<td>Can you identify your baby’s attachment style?</td>
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<td></td>
<td></td>
<td>What kind of discipline will you use with your child?</td>
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</tbody>
</table>
The First Two Years

Adults don’t change much in a year or two. They might have longer, grayer, or thinner hair; they might gain or lose weight; they might learn something new. But if you saw friends you hadn’t seen for two years, you’d recognize them immediately.

Imagine caring for a newborn every day for a month. You would learn everything about that baby—how to diaper and bathe, when to play and rock, when, where, and how to put the baby to sleep. Then imagine you moved to a distant city for two years. When you returned and were asked to pick up the child at a day-care center, you would have to ask the teacher which child to take! And that toddler would hesitate to come with you.

In those two years, the child’s weight would have quadrupled, height increased by a foot, and hair grew. The child would now understand words and photographs (ideally your photo had been shown often) and express new emotions—with new fears, including of you, now a stranger.

Two years are less than 3 percent of the average human life. However, in those 24 months, people reach half of their adult height; learn to run, climb, and talk in sentences; and express every emotion—not just joy and fear but also love, jealousy, and shame. Invisible growth of the brain is even more awesome. The next three chapters describe this transformation.
Our first child, Bethany, was born while I was in graduate school. At 14 months, she was growing well and talking but had not yet taken her first step. My husband was worried. I told him that genes determine age of motor skills. I had read that babies in Paris are late walkers, and my grandmother was French.

To my relief, Bethany soon took a few steps, and she was running by 18 months. By kindergarten, she was the fastest runner in her class; years later she ran a marathon. My genetic explanation was bolstered when our next two children, Rachel and Elissa, were also slow to walk. My students with Guatemalan and Ghanaian ancestors bragged about their infants who walked at 10 months; those from China had later walkers. Proof of genes?

Fourteen years after Bethany, Sarah was born. I could finally afford a full-time caregiver, Mrs. Todd. She thought Sarah was the most advanced baby she had ever known, except for her own daughter, Gillian.

“She’ll be walking by a year,” Mrs. Todd told me. “Gillian walked at 10 months.”

“Well see,” I graciously replied.

I underestimated Mrs. Todd. She bounced my delighted baby on her lap, day after day, and spent hours giving her “walking practice.” Sarah took her first step at 12 months—late for a Todd, early for a Berger, and a humbling lesson for me.

As a scientist, I know that a single case proves nothing. The two-month age gap between Bethany and Sarah might indeed be partly genetic, especially since Sarah shares only half her genes with Bethany and since my daughters are only one-eighth French (a fraction I had ignored when I needed reassurance about my late-walking first-born).

Nonetheless, every developmental scientist is now well aware that caregivers influence every aspect of growth. You will soon read about caregiving that enables babies to grow, move, see, and learn. Genes provide the scaffold, but every day shapes and guides each infant to become a distinct—and special—human being.
Body Changes

In infancy, growth is so rapid and the consequences of neglect so severe that gains are closely monitored. Medical checkups, including measurement of height, weight, and head circumference, indicate whether an infant is progressing as expected—or not.

Body Size

Newborns lose several ounces in the first three days and then gain an ounce a day for months. Their weight at birth has doubled by 4 months and tripled by a year, so a 7-pound newborn might be 21 pounds at 12 months (9,525 grams, up from 3,175 grams at birth).

That is an average, but variation is substantial, depending not only on genes and nutrition but also on birthweight. Small babies may double their weight in two months and quadruple by age 1.

Height also increases rapidly: A typical newborn grows 10 inches (25 centimeters) by age 1, measuring about 30 inches (76 centimeters). Physical growth then slows, but not by much. Most 24-month-olds weigh about 28 pounds (13 kilograms) and have added another 4 inches (10 centimeters) in the previous year. Typically, 2-year-olds are half their adult height.

Growth is often expressed in a percentile, a number that ranks each person compared to others the same age. Thus, a 12-month-old's weight at the 30th percentile means that 29 percent of 12-month-old babies weigh less and 70 percent weigh more.

Any percentile between 10 and 90 may be fine: The crucial factor is whether the percentile is close to the previous one for that individual (see Figure 5.1). Healthy big babies continue to be big for their age; healthy small babies continue to be small.

When an infant’s weight percentile moves markedly up or down, or when the weight and height percentiles are far apart, that signifies trouble. A notable drop, say, from the 50th to the 20th percentile, suggests poor nutrition. A sudden increase—perhaps with weight increasing from the 30th to the 60th, especially if height stays at the 30th percentile—signifies overfeeding.

Parents were once blamed. Especially when the percentile dropped, it was thought that parents made feeding stressful, leading to failure to thrive. Now pediatricians consider it “outmoded” to blame parents, because failure to thrive may be caused by allergies, the microbiome, or diseases (Jaffe, 2011, p. 100). Similarly,
babies are overweight because of the social context: Blaming parents alone is not fair, nor is blaming genes alone.

**Sleep**

Throughout life, health and growth correlate with regular and ample sleep (El-Sheikh & Kelly, 2017). As with many health habits, sleep patterns begin in the first year.

Newborns sleep about 15 to 17 hours a day. Every week brings a few more waking minutes. For the first two months, the norm for total time asleep is 14¼ hours; for the next three months, 13¼ hours; for the next 12 months, 12¾ hours. Preterm and breast-fed infants wake up often, sometimes needing another meal soon after the previous one (called *cluster feeding*).

Remember that norms are averages; about 5 percent of babies sleep 19 hours a day and another 5 percent sleep 9 hours or less, according to parent reports (Sadeh et al., 2009). National averages vary as well. Two-year-olds in New Zealand sleep two hours more each day than those in Japan (13 ½ hours compared to 11 2/3) (Sadeh et al., 2010).

“Sleeping through the night” is sought by every exhausted parent, but when this occurs depends not only on the baby but on the parent’s definition of “night.” If night is from midnight to 5 a.m., many babies occasionally sleep “all night” at 3 months. But if night is from 8 p.m. to 6 a.m., almost no infant sleeps through the night (C. Russell et al., 2013).

Over the first few months, the time spent in each stage of sleep changes. Preterm newborns seem to be frequently dozing, never in deep sleep, but that may be caused partially by the constant bright lights and frequent feedings in the traditional NICU (neonatal intensive care unit). When they come home, they usually adjust to a day–night schedule (Bueno & Menna-Barreto, 2016).

About half of the sleep of full-term newborns is REM (rapid eye movement) **sleep**, with flickering eyelids and rapid brain waves. That indicates dreaming, now thought to consolidate memories. REM sleep declines over the early weeks, as does “transitional sleep,” the half-awake stage. At 3 or 4 months, quiet sleep (also called slow-wave sleep) increases markedly.

Sleep varies not only because of biology (maturation and genes) but also because of culture and caregivers. Infants who are fed formula and cereal sleep longer and more soundly — easier for parents but not better for the baby.

Where the baby sleeps varies markedly by culture. **Bed-sharing** (in the parents’ bed) or **co-sleeping** (in the parents’ room) is the norm in some places but rare in others (Esposito et al., 2015).

Feeding patterns are also influential. Bed-sharing is more common in breast-fed babies. A study in Sweden found that most breast-fed preterm infants (who need feeding every two or three hours) sleep with their mothers — especially if the mother had trouble getting back to sleep if she got up to feed her infant (Blomqvist et al., 2017).

The brain patterns of newborns do not allow long stretches of deep sleep. Some infants develop longer sleep patterns within a few months, but some do not — and that affects the entire family (Piteo et al., 2013). This could be a cause or a consequence. Mothers’ sleep patterns correlate with those of partners and children, so everyone’s sleep is disturbed if the baby keeps waking up the mother (El-Sheikh & Kelly, 2017).

Parents “are rarely well-prepared for the degree of sleep disruption a newborn infant engenders.” As a result, many become “desperate” and institute patterns that they may later regret (C. Russell et al., 2013, p. 68). But what patterns are best? Experts, strangers, and relatives give conflicting advice (see Opposing Perspectives).
Where Should Babies Sleep?

In Asia, Africa, and Latin America, infants usually sleep beside their mothers. By contrast, most U.S. infants sleep in cribs in their own rooms.

Each culture criticizes other patterns. In developing nations, separating mother and child at night may be considered abusive; in Western nations, some psychiatrists feared that children would be traumatized if they woke when their parents had sex. Many North American pediatricians note that sudden infant death (SIDS) is more common among bed-sharing babies.

A 19-nation study found that Asian and African mothers worry about separation, whereas mothers with European roots worry more about privacy. In the extremes of that study, 82 percent of Vietnamese babies slept with their mothers, as did only 6 percent in New Zealand (Mindell et al., 2010) (see Figure 5.2). Sleeping alone may encourage independence for both child and adult—a quality valued in some cultures, discouraged in others.

Sleeping patterns are changing in the United States. Since 2000, co-sleeping has been recommended by North Americans who advocate attachment parenting (Sears & Sears, 2001).

Many companies sell “co-sleepers” that allow babies to sleep beside their mothers without the SIDS risk posed by a soft mattress or blankets. Bed-sharing itself (not just co-sleeping) is becoming more popular in the United States. The rate doubled from 1993 to 2010 (6.5 percent to 13.5 percent) (Colson et al., 2013).

Many experts seek to safeguard infants who sleep with their parents (Ball & Volpe, 2013). Their advice includes never sleeping beside a baby if the parent has been drinking alcohol or taking psychoactive drugs, and never using a soft comforter, pillow, or mattress near a sleeping infant. Beyond that, much depends on the family. One issue is how co-sleeping affects the mother’s sleep.

If co-sleeping continues for months and years, that might disrupt the relationship between the parents, which affects the entire family. One study found that when infants and mothers sleep in the same room, the mothers do not sleep as well. They wake up more often during the night, not only to feed the baby but also when the baby is simply stirring for a few moments (Volkovich et al., 2015).

The typical pattern in the United States in the twenty-first century is for infants to sleep in the parents’ bedroom at first but have their own room by 6 months. One study found that when babies continued to sleep with their mothers, the mothers were more often depressed and unhappy with the father’s lack of involvement in child care (Teti et al., 2015).

According to these authors, in cultures where co-sleeping is the norm, the practice does not affect the parental relationship. However, even in Japan bed-sharing and marital strain often occur together. One Japanese mother wrote:

“I take care of my baby at night, since my husband would never wake up until morning whatever happens. Babies, who cannot turn over yet, are at risk of suffocation and SIDS because they would not be able to remove a blanket by themselves if it covers over their face. In my case, I sleep with my older child and baby. By the way, my husband sleeps in a separate room because of his bad snoring.”

[Shimizu et al., 2014]

Contrary to this woman’s rationalization, sudden infant death syndrome (or SIDS, discussed later) is twice as likely when babies sleep beside their parents. Researchers pinpoint the reason: Many parents occasionally sleep beside their baby after drinking or taking drugs. Then bed-sharing can be fatal (P. Fleming et al., 2015).

As one review explained, “There are clear reasons . . . [for bed-sharing] . . . warmth, comfort, bonding, and cultural tradition, but there are also clear reasons against doing so, such as increased risk of sudden infant death syndrome” (Esposito et al., 2015).

As with many aspects of child care, deciding sleep location is complicated, cultural, and complex. Over time, sleep patterns of each family member affect the sleep of the others.

A good night’s rest benefits everyone, so parents need to establish sleep hygiene (calming routines and regular schedules) (Bathory & Tomopoulos, 2017; El-Sheikh & Kelly, 2017). Exactly what that means is . . . opposing perspectives.
Brain Development
From two weeks after conception to two years after birth, the brain grows more rapidly than any other organ. If teething or a stuffed-up nose temporarily slows eating, body weight is affected but not brain weight, a phenomenon called head-sparing. That term expresses well what nature does — protecting the cells of the brain.

Those brain cells are called neurons, which are specialized cells that transmit messages, activating movement, senses, memories, and more. Neurons are found in every part of the body, but they are particularly numerous and significant in the brain. The adult human brain has about 86 billion neurons.

**Dendrites, Axons, and Synapses** Messages from one neuron to another are transmitted via fibers that reach toward other neurons. Those fibers are either dendrites, which bring messages to the cell body, or axons, extending out to reach dendrites of other cells. Most neurons have one axon and several dendrites. Axons and dendrites do not touch; the tiny gap between them is a synapse.

At birth, the brain contains far more neurons than a person needs. By contrast, the newborn's brain has far fewer dendrites, axons, and synapses than the person will eventually have, and much less myelin — the whitish substance that coats the axons to speed transmission. Because of the new dendrites, axons, and myelin, the brain is twice as large at age 1 as its size at birth, and three times as large by age 2.

To be specific, an estimated fivefold increase in dendrites in the cortex occurs in the 24 months after birth, with about 100 trillion synapses present at age 2. According to one expert, “40,000 new synapses are formed every second in the infant's brain” (Schore & McIntosh, 2011, p. 502).

The rapid brain growth in infancy is one reason that head circumference is a measure of infant growth. Although thousands of dendrites and axons develop, the particular ones that grow depend on experience, an example of the plasticity described in Chapter 1. Plasticity is crucial, allowing evolution of our species and of every developing person: Human brains need to be flexible to adjust to whatever the context of their life might be.

**Hormones** The brain produces many hormones, which are chemicals that pulse through the body affecting appetite, emotions, sleep, and many other aspects of development. During infancy, two hormones in a mother’s bloodstream are known to be crucial: cortisol and oxytocin (Ludmer et al., 2018). These affect the quality of her caregiving, and that, in turn, affects hormones in the infant.

Research on cortisol is most definitive. Too much cortisol can disrupt thinking and brain development lifelong. If a mother is highly stressed, with high levels of cortisol during pregnancy and the first few months of an infant’s life, her baby is likely to have high levels of cortisol during the first year (Jonas et al., 2018). Children who are mistreated in infancy are impaired in learning later on, partly because of a flood of cortisol affecting their developing brains.

The connection between cortisol in the mother and in the baby is most evident with breast-feeding mothers. The mother’s cortisol is in her breast milk. Usually breast-feeding reduces stress in both mother and child, because touch and gaze reduce cortisol. But highly stressed breast-feeding mothers can increase cortisol. Generally, formula-fed infants experience higher cortisol from their own stress (Lester et al., 2018).

The crucial hormone for social bonding is oxytocin. Parents who are particularly nurturant with their babies have higher levels of oxytocin (Gordon et al., 2010; Vittner et al., 2018), and their babies respond in kind. It is proven that oxytocin increases the flow of breast milk and that breast-feeding increases oxytocin, so it is also likely that infants’ oxytocin increases when they are breast-fed — although research in this area is just beginning.

**Head-sparing** A biological mechanism that protects the brain when malnutrition disrupts body growth. The brain is the last part of the body to be damaged by malnutrition.

**Dendrite** A fiber that extends from a neuron and receives electrochemical impulses transmitted from other neurons via their axons.

**Axon** A fiber that extends from a neuron and transmits electrochemical impulses from that neuron to the dendrites of other neurons.

**Synapse** The intersection between the axon of one neuron and the dendrites of other neurons.

**Myelin** The coating on axons that speeds transmission of signals from one neuron to another.

**Cortisol** The primary stress hormone; fluctuations in the body’s cortisol level affect human emotions.

**Oxytocin** The primary bonding hormone, evident lifelong but particularly high at birth and in lactation.
Brains from Back to Front

To further understand brain development over the life span, it helps to understand more about the parts of the brain. Every small area of the brain has a name and location (see Figure 5.3), and each connects to other areas. Scientists are often amazed at the specifics. For example, one particular area controls the thumb (Bauer et al., 2014).

Scientists are also amazed at the interconnections: A single thought or impulse activates several parts, with details that vary by age and culture. Like the rest of human development (Chapter 1), brains are multidirectional and multicultural.

The parts we now describe are not isolated parts. Mammal brains have several regions that develop in sequence: hindbrain (behind, at the lower back of the head), cerebellum, midbrain, and forebrain (also called the cerebrum, the site of the cortex). Each specializes, but each also connects to all the other parts.

The hindbrain begins with the first structure to arise from that bulb at the top of the neural tube, at about five weeks after conception. The basics of life preservation—automatic breathing, sleeping, beating of the heart—are in the hindbrain.

Envisioning the brain from back to front, the next part is the cerebellum, a structure that refines basic movement. The cerebellum allows smoother coordination: People dance and draw, not just walk and scribble.

The role of the cerebellum is obvious when it is impaired: Alcohol is toxic to this part of the brain. This can be temporary, as when a drunk person cannot talk clearly or walk a straight line, or permanent, as in fetal alcohol syndrome, when a pregnant woman’s drinking damages the cerebellum of her fetus.

Next to the cerebellum is the midbrain, which processes inputs from the hindbrain. The term midbrain suggests a large middle structure. That is accurate in some creatures, and in the human embryo. For the human fetus, baby, child, and adult, however, the midbrain is soon overwhelmed by the forebrain.

The forebrain becomes by far the biggest part, with 90 percent of the volume of the human brain. The forebrain includes the cerebral cortex, which covers the cerebrum with six layers of cells. This cortex is large, “comprising 80 percent of the human brain overall” (Kolb & Whishaw, 2013, p. 55).

FIGURE 5.3
Connections A few of the hundreds of named parts of the brain are shown here. Although each area has particular functions, the entire brain is interconnected. The processing of emotions, for example, occurs primarily in the limbic system, where many brain areas are involved, including the amygdala, hippocampus, and hypothalamus.
Different parts of the cerebral cortex have different names. The visual cortex contains about 20 distinct parts that allow recognition of colors, shapes, motion, and so on; the auditory cortex interprets words, music, and other sounds; the motor cortex has areas for each body part, from the right pinky finger to the left foot and so on.

An area at the very front of the brain (right behind the forehead) is the prefrontal cortex, which specializes in anticipation, planning, reflection, and reasoning. This area is crucial for human development, but it is the last to reach maturity. It is virtually absent in infants (babies cannot decide whether, when, and how to cry, as adults do) and is not fully developed until about age 25 (which is why teenagers sometimes seem irrational). Within each of these parts (hindbrain, cerebellum, midbrain, cerebrum) are dozens of specific areas.

This book does not mention most of them, and some are explained in later chapters. However, three areas in one region merit mention now. That region is the limbic system, a cluster of brain areas deep in the brain where the cerebellum meets the midbrain, which is heavily involved in emotions.

The limbic system contains many parts. Three (amygdala, hippocampus, hypothalamus) are crucial for understanding human development, because their activity in infancy affects fear, depression, and anxiety lifelong (Ng et al., 2017; Qiu et al., 2015; Braun, 2011).

The amygdala is a tiny structure, about the same shape and size as an almond. It registers strong emotions. Frightening a baby is likely to increase amygdala size and activity, causing terrifying nightmares or sudden terrors later on.

Another structure in the emotional network is the hippocampus, located next to the amygdala. The size and structure of the hippocampus are markedly affected by cortisol in infancy (Dahmen et al., 2018). The hippocampus is a central processor of memory, especially memory for locations, and it affects the amygdala by summoning memory. Some places feel comforting (perhaps a mother’s chest), and others evoke fear (perhaps a doctor’s office).

Emotions that first emerged in infancy continue even when the experiences that originated those emotions are long gone. For instance, the touch of another person makes some adults cringe but is welcomed by those who enjoy being caressed and massaged. The cause may be an amygdala activated by the unconscious memories from the hippocampus.

Sometimes considered part of the limbic system is the hypothalamus, which responds to signals from the amygdala and to memories from the hippocampus by producing hormones, especially cortisol. Stress affects the hypothalamus, and vice versa.

The first months of life are crucial for every aspect of brain development, including how all these structures and parts connect to the other parts. Adult personality—how quickly a person becomes angry, for instance, or how readily amused they are—may be the result of brain connections and regions molded by early experiences.

The transmission of oxytocin occurs lifelong. People respond to the hormonal levels of oxytocin in their caregivers, a finding that extends from grandparent to parent to infant (Fujiwara et al., 2019). This is partly genetic, as well as a product of experience.

### Exuberance and Pruning

Early dendrite growth is called transient exuberance: exuberant because it is so rapid and transient because some of it is temporary.

Thinking and learning require connections among many parts of the brain, and eliminating some unused neural connections makes the brain more efficient (Gao et al., 2017). Just as a gardener might prune a rose bush by cutting away some growth to enable more, or more beautiful, roses to bloom, inactive brain connections atrophy and die while new dendrites form.

As one expert explains it, there is an “exuberant overproduction of cells and connections followed by a several-year sculpting of pathways by massive elimination” (Insel, 2014, p. 1727). Notice the word sculpting, as if a gifted artist created an intricate sculpture from raw marble or wood. Human infants are gifted artists, developing their brains to adjust to whatever family, culture, or society they are born into.

For example, to understand any sentence in this text, you need to know the letters, the words, the surrounding sentences, the ideas they convey, and how they relate to your other thoughts and knowledge. Those connections are essential for your understanding, which is unlike that of other people whose brains developed in homes unlike yours.

**transient exuberance** The great but temporary increase in the number of dendrites that develop in an infant’s brain during the first two years of life.
Thus, your brain automatically interprets these Roman letters, and, for most of you, is befuddled when viewing Arabic, Cyrillic, or Chinese. You may not notice the differences between one Chinese word and another, but you immediately see that a “b” is not a “d,” despite obvious similarities.

Further evidence of the benefit of cell death comes from a sad symptom of fragile X syndrome (described in Chapter 3), “a persistent failure of normal synapse pruning” (Irwin et al., 2002, p. 194). Without pruning, the dendrites of children with fragile X syndrome are too dense and long, making thinking difficult.

Similar problems occur for children with autism spectrum disorder: Their brains are unusually large and full, making communication between neurons less efficient and some sounds and sights overwhelming (Lewis et al., 2013).

Thus, pruning is essential. Normally, as brains mature, the process of extending and eliminating dendrites is exquisitely attuned to experience, as the appropriate links in the brain are established, protected, and strengthened (Gao et al., 2017). As with the rose bush, pruning needs to be done carefully, allowing further growth.

**Necessary and Possible Experiences**

A scientist named William Greenough identified two experience-related aspects of brain development (Greenough et al., 1987). Adults who understand these two avoid the difference-equals-deficit error explained in Chapter 1, while still providing the experiences every baby needs.

- **Experience-expectant growth.** Certain functions require basic experiences in order to develop, just as a tree requires water. Those experiences are part of almost every infant’s life, and thus, almost all human brains grow as their genes direct. Brains expect such experiences; development suffers without them.

- **Experience-dependent growth.** Human brains are quite plastic. Some brain connections are affected by specific experiences. These experiences are not essential: They happen in some families and cultures but not in others.

Thus, basic expected experiences must happen for normal brain maturation to occur, and they almost always do. For example, in deserts and in the Arctic, on isolated farms and in crowded cities, babies have things to see, objects to manipulate, and people to love them.

Infants everywhere welcome such experiences: They look around, grab for objects, smile at people. As a result, their brains develop. Without expected experiences, brains wither.

In contrast, dependent experiences might happen; because of them, one brain differs from another. Babies’ experiences vary in the languages they hear, the faces they see, the emotions their caregivers express, and, as you just read, where they sleep.

Depending on those particulars, infant brains are structured and connected one way or another; some neurons and dendrites grow and thrive while others die (Stiles & Jernigan, 2010). If you know someone who cannot sleep peacefully alone, you can wonder about their early life (when the hindbrain connected with the limbic system). Overall, all people are both similar (experience-expectant) and unique (experience-dependent).
One example comes from face recognition: All infants need to see faces (experience-expectant), and they all are attracted to face-like structures—a round form with eyes above a mouth. (Toy manufacturers know this very well.) But which particular facial feature they notice depends on whom they see (experience-dependent).

**Harming the Body and Brain**

Most infants develop well. Feeding and health care vary, but every family tries to ensure that their children survive in good health and thrive within their culture.

For brain development, it does not matter whether a person learns French or Farsi, or expresses emotions dramatically or subtly (e.g., throwing themselves to the floor or merely pursing their lips, a cultural difference). However, infant brains do not grow normally if they lack basic expected experiences.

**Necessary Stimulation** Some adults imagine that babies need quiet, perhaps in a room painted one neutral color. That is a mistake.

Babies need stimulation—sights and sounds, emotional expression, and social interaction that encourages movement (arm waving, then crawling, grabbing, and walking). Severe lack of stimulation stunts the brain: “Enrichment and deprivation studies provide powerful evidence of . . . widespread effects of experience on the complexity and function of the developing system” of the brain (Stiles & Jernigan, 2010, p. 345).

Proof came first from rodents! Some “deprived” rats (raised alone in small, barren cages) were compared with “enriched” rats (raised in large cages with toys and other rats). At autopsy, the brains of the enriched rats were larger, with more dendrites (Diamond, 1988; Greenough & Volkmar, 1973).

Subsequent research with other mammals confirms that isolation and sensory deprivation stunt development. That is now sadly evident in longitudinal studies of orphans from Romania, described in Chapter 7.

**Stress and the Brain** Some infants experience the opposite problem, too much of the wrong kind of stimulation. Overstimulated infants—as when televisions are blaring and lights are blinking throughout the first year—may have trouble concentrating years later. That is the main symptom of ADHD (attention deficit/hyperactivity disorder) (Christakis et al., 2018).

Likewise, if the brain produces an overabundance of cortisol early in life (as when an infant is frequently terrified), that derails the connections from parts of the brain, causing atypical responses to stress lifelong. Years later, that child or adult may be hypervigilant (always on the alert) or emotionally flat (never happy or sad).

Note that infants respond to emotions, not directly to physical pain. Occasional pain—from routine inoculations, brief hunger, an unwanted bath or diaper change—are part of normal infant life. However, intense and frequent fear can lead to a harmful flood of cortisol (Propper & Holochwost, 2013).

Understanding this distinction is crucial for caregivers. All babies cry. As already noted, infants cannot decide to stop crying on command. In this case, adults with overactive limbic systems might yell at their babies (frightening the baby), or worse, shake them.

Because infants have immature brains, the whiplash from shaking ruptures blood vessels and breaks neural connections, causing **shaken baby syndrome**, an example of **abusive head trauma** (Christian & Block, 2009). Death is possible; intellectual impairment is likely.

**Especially for Parents of Grown Children** Suppose you realize that you seldom talked to your children until they talked to you and that you often put them in cribs and playpens. Did you limit their brain growth and their sensory capacity? (see response, page 140)

**shaken baby syndrome** A life-threatening injury that occurs when an infant is forcefully shaken back and forth, a motion that ruptures blood vessels in the brain and breaks neural connections.
Not every infant who has neurological symptoms of head trauma is the victim of abuse: Legal experts worry about false accusations (Byard, 2014). Nonetheless, infants are vulnerable, so the response to a screaming, frustrating baby should be to comfort or walk away, never to shake, yell, or hit.

### WHAT HAVE YOU LEARNED?

1. What facts indicate that infants grow rapidly in the first year?
2. Why are pediatricians not troubled when an infant is at the 20th percentile in height and weight, month after month?
3. How do sleep patterns change from birth to 18 months?
4. What are the arguments for and against bed-sharing?
5. How can pruning increase brain potential?
6. What is the difference between experience-expectant and experience-dependent growth?
7. What should caregivers remember about brain development when an infant cries?

---

**sensation** The response of a sensory organ (eyes, ears, skin, tongue, nose) when it detects a stimulus.

**perception** When the brain is conscious of a sensation or idea. Perception sometimes combines several senses and ideas: You might suddenly perceive that your mother is angry because of her face and voice and your past experience of her anger.

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### Perceiving and Moving

Young human infants combine motor ineptness and sensory acuteness (Konner, 2010). Most mammals have the opposite combination. Kittens, for instance, are born deaf, with eyes sealed shut, but they can walk immediately. By contrast, human senses are crucial from birth on, but skilled movement takes months and years.

Thus, newborns listen and look from day 1, and then they gradually master deliberate movement by practicing whatever they can do. The interaction between the senses and movement is continuous in the early months, with every sensation propelling the infant to attempt new motor skills. Here are the specifics.

### The Senses

**Sensation** occurs when a sensory system detects a stimulus, as when the inner ear reverberates with sound, or the eye’s retina and pupil intercept light. Thus, sensations begin when an outer organ (eye, ear, nose, tongue, or skin) meets anything that can be seen, heard, smelled, tasted, or touched.

**Perception** occurs when a sensation reaches the brain and the person is aware of it. For example, right this moment, if you stop to listen, you can hear sounds—perhaps voices in the hall, the hum of an air conditioner, a car on the street, your own stomach gurgling—that you did not notice before. You could sense them, but you did not perceive them.

All of the senses function at birth. Newborns have open eyes, sensitive ears, and responsive noses, tongues, and skin. Very young babies use all those senses to attend to everything, developing perceptions. For instance, in the first months of life, they smile at everyone, listen attentively to every voice, and suck almost anything. By two months, they are more selective.

Genes developed over a million years affect all of the senses. Humans cannot hear what mice hear, or see what bats see, or smell what puppies smell; humans do not need those sensory abilities. However, survival requires that human babies respond to people, and newborns innately do so with every sense they have (Konner, 2010; Zeifman, 2013).
**Hearing**  Even before birth, fetal hearing responds to the social world: Loud sounds trigger reflexes, and voices make the fetus stop to listen—or at least slows down its movement and speeds up the heart rate—in the last trimester. Newborns recognize their mother’s voice (Voegtline et al., 2013; Lee & Kisilevsky, 2014). They also respond to the father’s voice if he often spoke to the fetus.

Newborn hearing is tested in every U.S. hospital, and, if necessary, remediation begins in the early weeks. Deaf babies are given hearing aids; parents of infants are taught to use signs. Some infants undergo surgery to get **cochlear implants**, which bypass damage to the structures of the ear via a microphone attached to the skull that converts sound waves into electrical impulses and transmits them to the auditory cortex. If this surgery occurs by age 1, the child’s ability to understand and produce spoken language is not delayed (Tobey et al., 2013).

Since early hearing is so crucial, developmentalists worry about two problems with universal newborn hearing tests. Very few babies are profoundly deaf; most are able to hear some noises. But a positive result means a deficit: More testing is needed. However, parents and pediatricians must follow up. They understand deafness, but they may not realize the damage from impaired hearing (Nikolopoulos, 2015).

Second, sometimes infants are born with normal hearing, but ear infections harm later ability. That slows down language learning (Friedmann & Rusou, 2015). Ear infections are common, and painful, during infancy—one reason that good medical care is crucial.

**Seeing**  Vision is probably the least mature sense at birth, but it develops rapidly. Many newborns seem “apparently blind” (Brodsky, 2016). The reason is limited experience; the fetus had nothing much to see. Newborns focus only on things quite close to their eyes, such as the face of their breast-feeding mother, and even that may be blurry.

Almost immediately, experience combines with maturation of the visual cortex to improve vision. By 2 months, infants not only stare at faces but also, with perception and the beginning of cognition, smile. (Smiling can occur earlier but not because of perception.)

**Binocular vision** (coordinating both eyes to see one image) cannot develop in the womb (nothing is far enough away), so many newborns use their two eyes independently, momentarily appearing wall-eyed or cross-eyed. Usually, experience allows both eyes to focus on a single thing between 2 and 4 months (Seemiller et al., 2018). However, if cataracts or other problems affect vision, remediation is needed in the first weeks so that the brain can correctly process what the eyes sense (Lambert & Lyons, 2016).

As perception builds, visual scanning improves. Thus, 3-month-olds look closely at the eyes and mouth, smiling more at happy faces than at angry or expressionless ones. They pay attention to patterns, colors, and motion—the mobile above the crib, for instance.

Because of this rapid development, babies should be allowed to see many sights. A crying baby might be distracted by being taken outside to watch passing cars. Infant vision is attracted to movement and to the eyes (more than the hair, for instance). By age 1, infants have learned to interpret facial expressions, to follow the eyes of someone else to see what they are looking at, and to use their own eyes to communicate (Grossman, 2017).

**Tasting and Smelling**  As with vision and hearing, smell and taste also function at birth. Infants prefer the taste of their pregnant mothers’ diet, spices and all, which they swallowed as amniotic fluid (part of preparing the lungs to function).
Each culture’s smells and tastes not only prepare infants to adjust to their families but also aid survival. For example, bitter foods provide some defense against malaria, hot spices help preserve food and may prevent food poisoning, some spices slow cancer, and so on (Kuete, 2017; Aggarwal & Yost, 2011; Prasad et al., 2012).

Notice plasticity again: Early experiences affect sensations, which become perceptions and then preferences. Taste sensations endure when a person leaves home. Immigrants buy expensive ingredients in specialty stores because a particular food was cheap and plentiful when they were children. Thousands of miles away, those foods are imported luxuries.

Early adaptation also occurs for the sense of smell. When breast-feeding mothers used a chamomile balm to ease cracked nipples, their babies preferred that smell two years later, in contrast to babies whose mothers used an odorless ointment (Delaunay-El Allam et al., 2010).

Because babies recognize each person’s scent, they prefer to sleep next to their favorite caregivers, and they nuzzle into their caregivers’ cheeks and chests—especially when the adults are shirtless. Parents help infants who are frightened of the bath (some love bathing; some hate it) by joining the baby in the tub: The smell of the adult’s body mixes with the smell of soap and with the familiar touch, sight, and voice of the caregiver. The entire experience provides sensory comfort.

**Learning About a Lime** As with every other normal infant, Jacqueline’s curiosity leads to taste and then to a slow reaction, from puzzlement to tongue-out disgust. Jacqueline’s responses demonstrate that the sense of taste is acute in infancy and that quick brain perceptions are still to come.

**The First Blood Test** This baby will cry, but most experts believe the heel prick shown here is well worth it. The drops of blood will reveal the presence of any of several genetic diseases, including sickle-cell anemia, cystic fibrosis, and phenylketonuria. Early diagnosis allows early treatment, and the cries subside quickly with a drop of sugar water or a suck of breast milk.

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**Touch and Pain** The senses of touch and pain are closely connected in infants. Touch may cause pain, and yet often it relieves pain. Wrapping, rubbing, massaging, and cradling are soothing. Even when their eyes are closed, some infants stop crying and visibly relax when held securely. In the first year of life, the heart rate slows and muscles relax when babies are stroked gently and rhythmically on their arms (Fairhurst et al., 2014).

Everywhere, parents cuddle their infants, rocking, carrying, and so on. Some touch (gentle of course) seems experience-expectant, essential for normal growth. Beyond that, how much a baby is touched is experience-dependent, varying by culture. In some regions of the world, daily massage begins soon after birth (Trivedi, 2015).

As with other senses, cultural traditions regarding touch are not always ideal. In rural India, mothers immediately bathe and massage their newborns. This may chill a fragile infant. Instead, public health workers now teach mothers to wipe their newborns gently and breast-feed immediately—preserving body heat and reducing death (Acharya et al., 2015).
By contrast, some mothers in Western nations do not caress their infants enough: They need to know that, in the first months of life, maternal touch pleases babies and increases joy in motherhood.

In theory, birth itself might be painful for the fetus, who is squeezed through the birth canal. One famous twentieth-century psychiatrist wrote about the trauma of being born (Rank, 1929). However, that idea is no longer popular.

Pain receptors are undeveloped early in life: Some experiences that adults find very painful (circumcision, setting a broken bone) seem much less so to newborns. Indeed, some twentieth-century doctors thought that newborns felt no pain (Rodkey & Riddell, 2013).

Experts now believe that infants feel some pain — as indicated by changes in cortisol, heartbeat, and brain waves — but that immature brain waves protect them against the intensity of pain that adults and older children feel (Moultrie et al., 2016). Especially in infancy, the other senses reduce pain: A drop of sugar water before a heel stick decreases crying and listening to their mother’s voice, or even to calming music, reduces distress (Filippa et al., 2017).

It was once assumed that babies in a NICU were impervious to the intravenous lines, blood draws, alarms, lights, pokes, and so on. Now many NICUs have eliminated bright lights and noisy monitors, reduced distress through careful swaddling and positioning, and taught parents how to touch their fragile newborns (Wallace & Jones, 2017). That improves later social and cognitive development (Montiroso et al., 2017).

Because all of the senses mature rapidly over the first year, infants increasingly seem to feel pain over the first months of life. Some cry inconsolably for more than three hours, more than three days a week. Digestive pain (colic) caused by the gut microbiome is the usual explanation (Pärtty & Kalliomäki, 2017).

Pediatricians know that colic usually disappears by 3 months, so they are not troubled by it, but many parents are overwhelmed. Therefore, developmentalists take crying seriously; it may impair the relationship between infant and caregiver. That relationship — in which all of the senses are attuned to human caregiving — is the crucial aspect of early sensation and perception.

Addiction in Newborns

In 2018, almost 200 people per day died of opioids in the United States, and thousands more are addicted. Some of them are pregnant women; four times as many newborns are born addicted now than a few years ago (Haigh et al., 2018). If an addicted pregnant woman is weaned to methadone, that helps her quit heroin, fentanyl, and so on, which is better for her fetus. However, the newborn may still experience withdrawal, with convulsions and inconsolable crying.

Usually addicted newborns are treated in the NICU, where they are given morphine for withdrawal symptoms. Gradually, less morphine is needed, and the babies are sent home, morphine-free, 22 days (on average) after birth.

Doctors in one hospital decided to put addicted newborns, not in the NICU but in quiet, dimly lit, private rooms (Grossman et al., 2017). A caregiver (mother, father, partner, grandparent, or volunteer) was always with the infant, providing sensory care — cradling, singing, rocking. Ideally the mother breast-fed on demand.

The message to the family, conveyed in the last weeks of pregnancy, is that the most important medical treatment is human comfort. Nurses in this hospital were taught to appreciate the mother instead of condemning her addiction. Morphine was administered to the infant only if nothing else worked to mitigate the pain.

By focusing on sensory calming, much less morphine was needed. In this study, infants were able to leave the hospital, on average, after 6 days — compared to 22 days under the previous NICU and morphine treatment (Grossman et al., 2017).
Motor Skills

The most dramatic motor skill (any movement ability) is independent walking, which explains why I worried when my 14-month-old daughter had not yet taken a step (as described in the introduction to this chapter). All basic motor skills, from the newborn’s head-lifting to the toddler’s stair-climbing, develop in infancy.

Responsive movement begins with reflexes, as explained in Chapter 4. Reflexes become skills if they are practiced and encouraged. As you saw in the chapter’s beginning, Mrs. Todd set the foundation for my fourth child’s walking when Sarah was only a few months old. Similarly, some very young babies can swim — if adults build on the swimming reflex by floating with them in calm, warm water.

Gross Motor Skills

Deliberate actions that coordinate many parts of the body, producing large movements, are called gross motor skills. These skills emerge directly from reflexes and proceed in a cephalocaudal (head-down) and proximodistal (center-out) direction. Infants first control their heads, lifting them up to look around. Then they control their upper bodies, their arms, and finally their legs and feet. (See At About This Time, which shows age norms for gross motor skills.)

Each motor skill requires maturation and practice. For example, sitting requires muscles to steady the torso, no simple feat. By 3 months, most infants can sit propped up in a lap.

By 6 months, babies can usually sit unsupported, but “novice sitting and standing infants lose balance just from turning their heads or lifting their arms” (Adolph & Franchak, 2017). Babies never propped up (as in some institutions for orphaned children) sit much later, as do blind babies who cannot use vision to adjust their balance.

All humans move forward (inchng, bear-walking, scooting, creeping, or crawling) before they walk, but many resist being placed on their stomachs. Another variation is that heavier babies master gross motor skills later than leaner ones because practice and balance are harder when the body is heavy.

As soon as they are able, babies stand and then take some independent steps, falling frequently at first, about 32 times per hour. They persevere because walking

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Table: Age Norms (in Months) for Gross Motor Skills

<table>
<thead>
<tr>
<th>Skill</th>
<th>When 50% of All Babies Master the Skill</th>
<th>When 90% of All Babies Master the Skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sit unsupported</td>
<td>6</td>
<td>7.5</td>
</tr>
<tr>
<td>Stands holding on</td>
<td>7.4</td>
<td>9.4</td>
</tr>
<tr>
<td>Crawls (creeps)</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Stands not holding</td>
<td>10.8</td>
<td>13.4</td>
</tr>
<tr>
<td>Walking well</td>
<td>12.0</td>
<td>14.4</td>
</tr>
<tr>
<td>Walk backward</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>Run</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Jump up</td>
<td>26</td>
<td>29</td>
</tr>
</tbody>
</table>

Note: As the text explains, age norms are affected by culture and cohort. The first five norms are based on babies from countries on five continents [Brazil, Ghana, Norway, United States, Oman, and India] (World Health Organization, 2006). The next three are from a U.S.-only source [Coovadia & Wittenberg, 2004; based on Denver II (Frankenburg et al., 1992)]. Mastering skills a few weeks earlier or later does not indicate health or intelligence. Being very late, however, is a cause for concern.
Perceiving and Moving

is much quicker than crawling, and it has other advantages—better sight lines and free hands (Adolph & Tamis-LeMonda, 2014).

Once toddlers can walk by themselves, they practice obsessively, barefoot or not, at home or in stores, on sidewalks or streets, on lawns or in mud. Some caregivers encourage practice, holding infants upright in the bath or after diapering. Indeed, “practice, not merely maturation, underlies improvements . . . in 1 hour of free play, the average toddler takes about 2400 steps, travels the length of about 8 U.S. football fields, and falls 17 times” (Adolph & Franchak, 2017).

That illustrates the drive that underlies every motor skill: Children are powerfully motivated to do whatever they can as soon as they can.

**Fine Motor Skills** Small body movements are called **fine motor skills**. The most valued fine motor skills are finger movements, enabling humans to write, draw, type, tie, and so on. Movements of the tongue, jaw, lips, and toes are fine movements, too.

- Newborns have a strong reflexive grasp but lack control.
- During their first two months, babies excitedly stare and wave their arms at objects dangling within reach.
- By 3 months, they can usually touch such objects, but because of limited eye–hand coordination, they cannot yet grab and hold on unless an object is placed in their hands.
- By 4 months, infants sometimes grab, but their timing is off: They close their hands too early or too late.
- By 6 months, with a concentrated, deliberate stare, most babies can reach, grab, and hold on to almost any graspable object. Some can even transfer an object from one hand to the other.

Finger skills improve toward the end of the first year and throughout the second, as babies master the **pincer movement** (using thumb and forefinger to pick up tiny objects) and self-feeding (first with hands, then fingers, then utensils) (Ho, 2010). (See At About This Time.)

As with gross motor skills, fine motor skills are shaped by practice, which is relentless from the third month of prenatal development throughout childhood. Practice is especially obvious in the first year, when “infants flap their arms, rotate their hands, and wiggle their fingers, and exhibit bouts of rhythmical waving, rubbing, and banging while holding objects” (Adolph & Franchak, 2017).

### Cultural Variations

Mastery of every motor skill depends, not only on maturation and practice, but also on culture and opportunity. For example, when given “sticky mittens” (with Velcro) that allow grabbing, infants master hand skills sooner than usual. Their perception advances as well (Reid et al., 2019).

Indeed, all senses and motor skills expand cognitive awareness, with practice advancing both skill and cognition (Libertus & Hauf, 2017). The importance of context is illustrated by follow-up studies on the “sticky mittens” experiments.

Some researchers have given 2-month-olds practice in reaching for toys without sticky mittens. The infants advanced as much as those

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**Video:** Fine Motor Skills in Infancy and Toddlerhood shows the sequence in which babies and toddlers acquire fine motor skills.

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### AT ABOUT THIS TIME

<table>
<thead>
<tr>
<th>Age Norms (in Months) for Fine Motor Skills</th>
<th>When 50% of All Babies Master the Skill</th>
<th>When 90% of All Babies Master the Skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasps rattle when placed in hand</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Reaches to hold an object</td>
<td>4.5</td>
<td>6</td>
</tr>
<tr>
<td>Thumb and finger grasp</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Stacks two blocks</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>Imitates vertical line (drawing)</td>
<td>30</td>
<td>39</td>
</tr>
</tbody>
</table>

Data from World Health Organization, 2006.
with special mittens (Williams et al., 2015). It seems that practice of every motor skill advances development, not only of the skill but overall (Leonard & Hill, 2014). In another example, when U.S. infants are grouped by ethnicity, African American babies generally are ahead of Hispanic American babies when it comes to walking. In turn, Hispanic American babies are ahead of those of European descent. The reason may be cultural traditions that began with ancestors and continue when their descendants live in the United States. It is known that, internationally, the earliest walkers are in sub-Saharan Africa, where many well-nourished and healthy babies walk at 10 months. How might culture affect this? In many African communities, babies are massaged and stretched from birth onward and are encouraged to walk as soon as possible (Adolph & Franchak, 2017). Some cultures encourage running over long distances: The fastest, strongest people are admired, likely to have many children. Selective adaptation, plus childhood practice, may explain why African runners are often the fastest in the world. The latest walkers may be in Mongolia (15 months), where infants cannot practice because they are bundled up against the cold (Adolph & Robinson, 2013). The other reason some cultures discourage walking is that danger (poisonous snakes, open fires) is nearby, so toddlers are safer if they cannot wander.

Remember that difference is not deficit. Cultures differ, and hence babies differ. However, slow development relative to local norms may indicate a problem that needs attention; lags are much easier to remedy during infancy than later on. Also remember dynamic systems: If one sense or motor skill is impaired, the other parts are affected as well. This is true throughout childhood: Fine motor skills are aided by the ability to sit; language development depends on hearing; reading depends on vision — so careful monitoring of basic sensory and motor skills in infancy is part of good infant care.

**WHAT HAVE YOU LEARNED?**

1. What particular sounds capture infant attention?
2. How does an infant’s vision change over the first year?
3. Why is hearing more acute than vision in the early weeks?
4. Why do some babies prefer certain tastes and smells that others dislike?
5. What is known and unknown about infant pain?
6. What is universal and what is cultural in the development of motor skills?
7. What is the relationship between motor skills and the senses?
8. Why do caregivers vary in which motor skills they encourage?

**Surviving and Thriving**

None of this discussion of infant body size, senses, and motor skills would matter if babies did not thrive and grow. In North America, most people now take that for granted. However, more than a billion infants worldwide died in the past half-century.

Regarding infant survival, life on this planet is improving. In 1950, one young child in seven died, but only about one child in thirty died in 2017 (United Nations, 2017). Some nations have improved dramatically. Chile’s rate of infant
immunization, which primes the body’s immune system to resist a particular disease. Immunization (often via vaccination) is said to have had “a greater impact on human mortality reduction and population growth than any other public health intervention besides clean water” (Baker, 2000, p. 199).

In the first half of the twentieth century, almost every child had measles and chicken pox; many had other childhood diseases. Usually they recovered, and then they were immune. That prevented the disease in adulthood when it was much more serious. Indeed, some parents took their toddlers to play with children who were sick with an infectious disease, hoping their child would catch it and become immune.

Scientist at Work

Susan Beal studied medicine, married, and beginning at age 30, bore five children. At age 40, she began to study SIDS.

She was often phoned at dawn and told that another baby had died. Her husband became the sole caregiver while Beal drove to interview the families (eventually 500 of them) who just lost their baby. Parents were grateful. Some blamed themselves and each other; Beal reassured them that no one knew why SIDS occurred.

Thousands of scientists were testing hypotheses (the cat? the quilt? natural honey? homicide? spoiled milk?) to no avail. They found correlations (winter, formula feeding, baby aged 2–6 months) but no explanations. Beal learned additional factors that mattered (parental cigarette-smoking) and others that did not (birth order).

During those years, many Australians were anti-immigrant, but Beal put prejudice aside. That allowed her to notice that among the Australian infants with Chinese immigrant parents or grandparents, almost none died of SIDS. She observed that, contrary to usual Australian practice or the recommendation of pediatricians in every developed nation, Chinese parents put their babies to sleep on their backs, not their stomachs.

Beal convinced a large group of non-Chinese parents to put their babies to sleep on their backs. Almost no back-sleeping babies died.

Beal published her findings in the Medical Journal of Australia (Beal, 1988). Two scientists in the Netherlands read the article and then recommended back-sleeping (Engelberts & de Jonge, 1990). Many new mothers followed that advice. SIDS was reduced in the Netherlands by 40 percent in a year—a stunning replication.

Worldwide, putting babies “Back to Sleep” has now cut the SIDS rate dramatically (Mitchell & Krous, 2015). According to the Centers for Disease Control and Prevention (the official body that tracks health throughout the United States), the SIDS
True Dedication This young Buddhist monk lives in a remote region of Nepal, where until recently measles was a common, fatal disease. Fortunately, a UNICEF porter carried the vaccine over mountain trails for two days so that this boy—and his whole community—could be immunized.

Death rate is less than a third of what it was (38 per 100,000 live births in 2016 compared to 130 in 1990) (see Figure 5.4). In the United States alone, at least 100,000 children and young adults are alive who would be dead if they had been born before 1990.

Although SIDS is much less common than it was, some U.S. parents still put newborns to sleep on their stomachs, partly because of past tradition. Education matters as well. SIDS rates are much higher among low-SES families than high-SES ones, and rates are five times higher among African American babies than among Asian American ones. (Babies of European descent are midway between those two.)

Sleeping position is not the only risk. Other risks are low birthweight, exposure to cigarette smoke, soft pillows, bed-sharing, and abnormalities in the brain stem, heart, or microbiome (Neary & Breckenridge, 2013; Hauck & Tanabe, 2017).

Most SIDS victims experience several risks, a cascade of biological and social circumstances. But thanks to cross-cultural research and one perceptive woman, the major risk—stomach-sleeping—need not occur.

Success and Survival Beginning with smallpox in the nineteenth century, doctors discovered that giving a small dose of a virus to healthy people stimulates antibodies and provides protection. By 1980, smallpox, the most lethal disease for children in the past, disappeared; vaccination against smallpox is no longer needed.

Other diseases that every child once contracted are now rare. Only 784 cases of polio were reported anywhere in the world in 2003, and, since 2000, 21 million children who would have died of complications of measles are alive—all because of increases in global vaccination rates (Dabbagh et al., 2018).

Unfortunately, two problems are apparent: war and ignorance. Civil war in Nigeria, combined with false rumors, halted immunization of young children. Polio reappeared, sickening almost 2,000 West Africans in 2005. Over the next several years, public health workers and community leaders rallied. Nigeria’s polio rate fell again, to six cases in 2014.

However, in 2014, more than 300 children in Pakistan and Afghanistan were diagnosed with polio. A rush to immunize led to fewer cases in 2015, but until no cases are reported worldwide for several years (as with smallpox), no nation can afford to relax for polio or any other disease (Martinez et al., 2017).

FIGURE 5.4

Alive Today As more parents learn that a baby should be on his or her “back to sleep,” the SIDS rate continues to decrease. Other factors are also responsible for the decline—for example, fewer parents smoke cigarettes in the baby’s room.
Another troubling example is measles. Once almost every child contracted that virus, but rates fell dramatically with infant immunization (the MMR—measles, mumps, and rubella). But recently, measles has increased in many nations of Europe and the Middle East because vaccination rates have fallen (Dabbagh et al., 2018) (see Figure 5.5).

This problem is evident in the United States as well. In the spring of 2017, an outbreak of measles in Minnesota put 20 people (mostly infants) in the hospital and led to emergency immunization of thousands (Hall et al., 2017). In 2018, a measles outbreak appeared in New York City, with 92 cases—mostly among Orthodox Jewish children who, for religious and cultural reasons, have low rates of immunization. A thousand more were affected in 2019.

Worldwide, the data show that 8 percent more infants were immunized in the past decade, but variations are evident by region, and about 14 percent of all infants still do not get the basic protection (VanderEnde et al., 2018).

Immunization protects not only from temporary sickness but also from complications, including deafness, blindness, sterility, and meningitis. Sometimes such damage is not apparent until decades later. Having a virus (e.g., mumps, measles, or chicken pox) in childhood doubles the risk of schizophrenia in adulthood (Khandaker et al., 2012). If a young boy contracts mumps, the result can be infertility in adulthood.

Immunization also protects those who cannot be safely vaccinated, such as infants under 3 months and people with impaired immune systems (HIV-positive, aged, or undergoing chemotherapy). Fortunately, each vaccinated child stops transmission of the disease, a phenomenon called herd immunity. Usually, if 90 percent of the people in a community (a herd) are immunized, no one dies of that disease.

 Everywhere, some children are not vaccinated for valid medical reasons, but Minnesota is one of the 20 states that allow a child to be unvaccinated because a parent has a “personal belief.” When rates of immunized children fall below herd immunity, outbreaks harm infants.

Many parents are concerned about the potential side effects of vaccines, in part because of the media attention when an individual is sickened by vaccination. Humans tend to overestimate the frequency of a memorable case, and thus they avoid immunization.
However, no one notices when a child does not get polio, measles, or chicken pox, or when no one dies from those diseases. Polio was an epidemic in the early 1950s, killing 2,000 people (mostly children) a year. Chicken pox was more common but less fatal, yet before the varicella (chicken pox) vaccine, more than a hundred people in the United States died each year from that disease, and a million were itchy and feverish for a week.

The fear that infant immunization leads to autism is unfounded, as detailed in Chapter 11. It is easy to understand why parents of a child with serious developmental disorders seek to blame something other than genes or teratogens, but blaming immunization makes some parents fearful and other children sick.

Given that pediatricians and public health professionals advocate vaccination, why do some parents hesitate to immunize their children? Apparently, some reasons pertain to the parents’ moral values: They seek purity and personal freedom. That leads them to reject vaccines as artificial, or to resist the government telling them what to do.

Instead of fighting against parental values, public health workers might frame the message to respect such values. For instance, “Boost your child’s natural defenses. Keep your child free of infection.” “Take personal control over your child’s health” (Amin et al., 2017).

**Nutrition**

As already explained, infant mortality worldwide has plummeted for several reasons: fewer sudden infant deaths, advances in prenatal and newborn care, clean water, and, as you just read, immunization. One more measure is making a huge difference: better nutrition.

**Breast Milk** The best defense against malnutrition is the one humans have relied on for a million years or more: breast milk. The World Health Organization now recommends exclusive (no formula, juice, cereal, or water) breast-feeding for the first six months of life.

That recommendation is based on extensive research from all nations of the world. The specific fats and sugars in breast milk make it more digestible and better for the brain than any substitute (Drover et al., 2009; Wambach & Riordan, 2014).

Ideally, nutrition starts with colostrum, a thick, high-calorie fluid secreted by the mother’s breasts at birth. This benefit is not understood in some cultures, where mothers are forbidden to breast-feed until their milk “comes in” two or three days after birth. (Sometimes other women nurse the newborn; sometimes herbal tea is given.) This is one time when culture is harmful: Colostrum saves infant lives, especially if the infant is preterm (Moles et al., 2015; Andreas et al., 2015).

Breast-feeding mothers should be well nourished and hydrated; then their bodies will make the perfect food for their babies. Formula is preferable only in unusual cases, such as when the mother is HIV-positive or uses toxic or addictive drugs.

Even with HIV, however, exclusive breast-feeding may be best. In some
nations, infants’ risk of catching HIV from their infected mothers is lower than the risk of dying from infections, diarrhea, or malnutrition as a result of bottle-feeding (A. Williams et al., 2016).

In China, a study of more than a thousand babies in eight cities compared three groups of babies: those exclusively breast-fed (by their own mothers or wet nurses), those fed no breast milk, and those fed a combination of foods, formula, and breast milk. Based on all of the data, the researchers suggest that the WHO recommendation for exclusive breast-feeding for the first six months “should be reinforced in China” (Ma et al., 2014, p. 290).

The more research is done, the better breast milk seems (see Table 5.1). For instance, the composition of breast milk adjusts to the age of the baby, with milk for premature babies distinct from that for older infants. Quantity increases to meet the demand: Twins and even triplets can be exclusively breast-fed for months.

Each generation of scientists, and consequently each generation of mothers, knows more about breast milk. Indeed, the benefits of breast milk are recognized by doctors in every nation.

Fifty years ago in the United States, breast-feeding mothers were considered old-fashioned or ignorant. Now formula-feeding mothers are unfairly criticized. Some authors write about a prejudice called lactivism, the idea that every mother who loves her baby must breast-feed (Jung, 2015). Not so.

### TABLE 5.1

<table>
<thead>
<tr>
<th>The Benefits of Breast-Feeding</th>
<th>For the Baby</th>
<th>For the Mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance of nutrition (fat, protein, etc.) adjusts to age of baby</td>
<td>Easier bonding with baby</td>
<td></td>
</tr>
<tr>
<td>Breast milk has micronutrients not found in formula</td>
<td>Reduced risk of breast cancer and osteoporosis</td>
<td></td>
</tr>
<tr>
<td>Less infant illness, including allergies, ear infections, stomach upsets</td>
<td>Natural contraception (with exclusive breast-feeding, for several months)</td>
<td></td>
</tr>
<tr>
<td>Better childhood vision</td>
<td>Pleasure of breast stimulation</td>
<td></td>
</tr>
<tr>
<td>Less adult illness, including diabetes, cancer, heart disease</td>
<td>Satisfaction of meeting infant’s basic need</td>
<td></td>
</tr>
<tr>
<td>Protection against many childhood diseases, since breast milk contains antibodies from the mother</td>
<td>No formula to prepare; no sterilization</td>
<td></td>
</tr>
<tr>
<td>Stronger jaws, fewer cavities, advanced breathing reflexes (less SIDS)</td>
<td>Easier travel with the baby</td>
<td></td>
</tr>
<tr>
<td>Higher IQ, less likely to drop out of school, more likely to attend college</td>
<td>For the Family</td>
<td></td>
</tr>
<tr>
<td>Later puberty, fewer teenage pregnancies</td>
<td>Increased survival of other children (because of spacing of births)</td>
<td></td>
</tr>
<tr>
<td>Less likely to become obese or hypertensive by age 12</td>
<td>Increased family income (because formula and medical care are expensive)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less stress on father, especially at night</td>
<td></td>
</tr>
</tbody>
</table>

Information from Victora et al., 2016; Horta et al., 2018; Wambach & Riordan, 2014.
138 CHAPTER 5 The First Two Years: Biosocial Development

Some diseases result directly from malnutrition. One is marasmus, which occurs during the first year, when body tissues waste away. Another is kwashiorkor, which occurs after age 1. In kwashiorkor, growth slows down, hair becomes thin, skin becomes splotchy, and the face, legs, and abdomen swell with fluid (edema).

Worldwide, about half of all childhood deaths occur because malnutrition makes a childhood disease lethal. This is true not just for the leading causes of childhood deaths (diarrhea and pneumonia), but also for milder diseases such as measles (Walker et al., 2013; Roberts, 2017).

If a malnourished child survives, growth may be affected. Some experience stunting (being short for their age), because chronic malnutrition kept them from growing. Severe stunting is 3 standard deviations from typical height. Among well-fed children, less than 1 percent are naturally that short, but in many nations, 35 percent are stunted.

Even worse is wasting, when children are severely underweight for their age and height (3 or more standard deviations below average). Many nations, especially in East Asia, Latin America, and central Europe, have seen improvement in child nutrition in the past decades, with an accompanying decrease in wasting and stunting (see Figure 5.6). India is one such nation (Dasgupta et al., 2016). However, much more is necessary: Improvement means that in 2014, instead of most children in India being severely malnourished, only 17 percent of children were severely stunted, and 5 percent were severely wasted (UNICEF, 2015). Of course, that is still too many.

In other nations, primarily in Africa, wasting is increasing. In northern Nigeria, many people have fled from Boko Haram, a jihadist military organization. The children suffer from malnutrition, measles, and malaria, and this combination makes child deaths several times higher than emergency levels (Roberts, 2017).

Most adults who were severely malnourished as infants have lower IQs throughout life, even if they eat enough later on (Waber et al., 2014). Some of this is directly related to brain growth.

Some long-term effects of malnutrition in infancy are indirect. For instance, severely malnourished infants have less energy and reduced curiosity. As you have seen, young children naturally want to do whatever they can: A child with no energy is a child who is not learning. When they become adults, children who were malnourished tend to be cognitively impaired (Waber et al., 2018).

Prevention, more than treatment, is needed. Ideally, prenatal nutrition, then breast-feeding, and then supplemental iron and vitamin A, stop malnutrition before it starts.

Once malnutrition is apparent, highly nutritious formula (usually fortified peanut butter) often restores weight, and antibiotics can help. Unfortunately, some children hospitalized for marasmus or kwashiorkor die even with good medical care because their digestive systems are already failing (M. Smith et al., 2013; Gough et al., 2014).
That sad outcome is less common than it was. Indeed, this entire chapter can be seen as good news: Infants are more likely to live and learn in the twenty-first century than at any previous time.

Back to the opening anecdote: Babies have always been genetically primed to develop (see, hear, walk, talk, and so on), but we now have a better understanding of the impact of good caregiving. That is a reason to be thankful. My daughter Sarah makes me proud. Should I be grateful to Mrs. Todd for that?

WHAT HAVE YOU LEARNED?

1. What is the best protection against SIDS?
2. What are four reasons that immunization benefits a community?
3. What are the advantages of breast-feeding?
4. When should a woman not breast-feed?
5. Which is worse and why: stunting or wasting?

SUMMARY

Body Changes

1. In the first year, infants triple their birth weight, grow almost a foot, and increase in head circumference. These all indicate development and are measured by percentiles, which compare each baby to others the same age.
2. Sleep is crucial for good health lifelong. Infants gradually sleep less every day, but frequent waking is common. Whether a child sleeps beside their parents, or in the same room, or in their own room is a decision profoundly affected by culture.
3. Brains develop rapidly, increasing in size from about 25 percent to 75 percent of the adult brain’s weight in the first two years. Brain growth of synapses, axons, and dendrites is dramatic in the early months. Two hormones, cortisol and oxytocin, can affect later development.
4. Some stimulation is experience-expectant, needed for normal brain development, and other events are experience-dependent, shaping the brain. Exuberant growth and extensive pruning aid cognition.
5. Experience is vital for brain development. An infant who is socially isolated, over-stressed, or deprived of stimulation may be impaired lifelong. Too much stimulation also damages the brain.

Perceiving and Moving

6. At birth, the senses already respond to stimuli. Prenatal experience makes hearing the most mature sense. Vision is the least mature, but it improves quickly, with binocular vision.
7. The senses of smell, taste, and touch are present at birth and help infants respond to their social world. Pain may be felt, with researchers seeking to understand how infant pain differs from pain later on.
8. Infants gradually improve their motor skills as they begin to grow, and brain maturation continues. Gross motor skills are soon evident, from rolling over to sitting up (at about 6 months), from standing to walking (at about 1 year), and from climbing to running (before age 2).
9. Fine motor skills also improve, as infants learn to grab, aim, and manipulate almost anything within reach. With all motor skills, infants are motivated to use their bodies as much as possible.

Surviving and Thriving

10. The first days and months of life were often fatal a century ago. Now cultural awareness has reduced SIDS by ensuring that babies sleep on their back, and immunization has eliminated smallpox and reduced the rate of many childhood diseases.
11. Public health workers are concerned that immunization rates are below herd immunity in some regions of the world and in some U.S. states. Epidemics of polio, measles, and other preventable diseases still occur.
12. Most babies are breast-fed at birth, with life-giving colostrum before the mother’s milk “comes in.” Many infants are breast-fed at 6 months, sometimes exclusively (as doctors recommend), providing protection against diseases and malnutrition.
13. Severe malnutrition can cause death, both directly and indirectly if a child catches measles, an intestinal virus, or some other illness. Both stunting and wasting are less common than they were a decade ago, but both still harm children in developing nations.
CHAPTER 5  The First Two Years: Biosocial Development

KEY TERMS

- percentile (p. 118)
- REM (rapid eye movement)
- sleep (p. 119)
- bed-sharing (p. 119)
- co-sleeping (p. 119)
- head-sparing (p. 121)
- dendrite (p. 121)
- axon (p. 121)
- synapse (p. 121)
- myelin (p. 121)
- cortisol (p. 121)
- oxytocin (p. 121)
- transient exuberance (p. 123)
- experience-expectant growth (p. 124)
- experience-dependent growth (p. 124)
- shaken baby syndrome (p. 125)
- sensation (p. 126)
- perception (p. 126)
- binocular vision (p. 127)
- motor skill (p. 130)
- gross motor skills (p. 130)
- fine motor skills (p. 131)
- sudden infant death syndrome (SIDS) (p. 133)
- immunization (p. 133)
- protein-calorie malnutrition (p. 137)
- stunting (p. 138)
- wasting (p. 138)

APPLICATIONS

1. Immunization regulations and practices vary, partly for social and political reasons. Ask at least two faculty or administrative staff members what immunizations the students at your college must have and why. If you hear “It’s a law,” ask why.

2. Observe three infants (whom you do not know) in public places such as a store, playground, or bus. Look closely at body size and motor skills, especially how much control each baby has over his or her legs and hands. From that, estimate the baby’s age in months, and then ask the caregiver how old the infant is.

3. This project can be done alone, but it is more informative if several students pool responses. Ask 3 to 10 adults whether they were bottle-fed or breast-fed and, if breast-fed, for how long. If someone does not know, or expresses embarrassment, that itself is worth noting. Do you see any correlation between adult body size and infant feeding?

Especially For ANSWERS

Response for New Parents (from p. 119): From the psychological and cultural perspectives, babies can sleep anywhere as long as the parents can hear them if they cry. The main consideration is safety: Infants should not sleep on a mattress that is too soft, nor beside an adult who is drunk or on drugs. Otherwise, families should decide for themselves.

Response for Parents of Grown Children (from p. 125): Probably not. Brain development is programmed to occur for all infants, requiring only the stimulation that virtually all families provide—warmth, reassuring touch, overheard conversation, facial expressions, movement. Extras such as baby talk, music, exercise, mobiles, and massage may be beneficial but are not essential.

Response for Nurses and Pediatricians (from p. 127): Urge the parents to begin learning sign language and investigating the possibility of cochlear implants. Babbling has a biological basis and begins at a specified time in deaf as well as hearing babies. If their infant can hear, sign language does no harm. If the child is deaf, however, lack of communication may be destructive.

Response for Nurses and Pediatricians (from p. 135): It is difficult to convince people that their method of child rearing is wrong, although you should try. In this case, listen respectfully and then describe specific instances of serious illness or death from a childhood disease. Suggest that the mother ask her grandparents whether they knew anyone who had polio, tuberculosis, or tetanus (they probably did). If you cannot convince this mother, do not despair: Vaccination of 95 percent of toddlers helps protect the other 5 percent. If the mother has genuine religious reasons, talk to her clergy adviser.

 Observation Quiz ANSWERS

Answer to Observation Quiz (from p. 130): Jumping up, with a three-month age range for acquisition. The reason is that the older an infant is, the more impact both nature and nurture have.

Answer to Observation Quiz (p. 138): Most is East Asia, primarily because China has prioritized public health. Least is Western and Central Africa, primarily because of civil wars. In some nations, high birth rates have dramatically increased the numbers of stunted children, even though rates in the region are lower.
Before the measles vaccine was introduced in 1963, 30 million people globally contracted measles each year. About 2 million of them died, usually because they were both malnourished and sick. (World Health Organization, April 28, 2017). Thankfully, worldwide vaccination efforts now mean that no child need die of measles.

Measles is highly infectious, so 95 percent of the population needs to be immunized in order for “herd immunity” to protect the entire community. The United States achieved that: A decade ago, the measles incidence was close to zero. Experts thought measles would soon be eliminated in all developed countries, so public health workers focused on the very poorest nations.

By June 2019, more than 1,000 measles cases had been reported in 28 states, the most since 1992 (measles was declared eliminated in 2000) (Centers for Disease Control and Prevention, June 17, 2019). To understand what went wrong, note that many states allow personal or religious exemptions to immunization requirements. Thus, as the U.S. map shows, several states are not at that safe 94 percent—leaving many vulnerable, not only to discomfort but also to complications, including pneumonia, encephalitis, and even death.