As these parents share an intimate moment with their children, they convey a sense of delight in their growing family and help their older daughter welcome the new baby.
When I met Yolanda and Jay one fall in my child development class, Yolanda was just two months pregnant. After months of wondering if the time in their lives was right, they had decided to have a baby. Both were full of questions: “How does the baby grow before birth?” “When is each organ formed?” “Has its heart begun to beat?” “Can it hear, feel, or sense our presence?”

Yolanda and Jay wanted to do everything possible to make sure their baby would be born healthy. At first, they believed that the uterus completely shielded the developing organism from any dangers in the environment, but after browsing through several pregnancy books, Yolanda and Jay realized they were wrong. Yolanda started to wonder about her diet and whether she should keep up her daily aerobics routine. And she asked me whether an aspirin for a headache, a glass of wine at dinner, or a few cups of coffee during study hours might be harmful.

In this chapter, we answer Yolanda and Jay’s questions, along with many more that scientists have asked about the events before birth. First, we trace prenatal development, paying special attention to environmental supports for healthy growth, as well as damaging influences that threaten the child’s health and survival. Next, we turn to the events of childbirth, including the choices available to women in industrialized nations about where and how to give birth.

Yolanda and Jay’s son Joshua was strong, alert, and healthy at birth. But the birth process does not always go smoothly. We will consider the pros and cons of medical interventions, such as pain-relieving drugs and surgical deliveries, designed to ease a difficult birth and protect the health of mother and baby. Our discussion also addresses the development of infants born underweight or too early, before the prenatal period is complete. We conclude with the remarkable capacities of newborns.

**Prenatal Development**

The sperm and ovum that unite to form the new individual are uniquely suited for the task of reproduction. The ovum is a tiny sphere, measuring \( \frac{1}{175} \) inch in diameter—the size of the period at the end of this sentence. But in its microscopic world, it is a giant—the largest cell in the human body, making it a perfect target for the much smaller sperm, which measure only \( \frac{1}{500} \) inch.

**Conception**

About once every 28 days, in the middle of a woman’s menstrual cycle, an ovum bursts from one of her ovaries, two walnut-sized organs located deep inside her abdomen, and is drawn into one of two fallopian tubes—long, thin structures that lead to the hollow, soft-lined uterus (see Figure 3.1). While the ovum is traveling, the spot on the ovary from which it was released, now called the corpus luteum, secretes hormones that prepare the lining of the uterus to receive a fertilized ovum. If pregnancy does not occur, the corpus luteum shrinks, and the lining of the uterus is discarded two weeks later with menstruation.

The male produces sperm in vast numbers—an average of 300 million a day—in the testes, two glands located in the scrotum, sacs that lie just behind the penis. Each sperm develops a tail that permits it to swim long distances upstream in the female reproductive tract, through the cervix (opening of the uterus) and into the fallopian tube, where fertilization usually takes place. The journey is difficult: Only 300 to 500 reach their destination. Sperm live for up to six days and can lie in wait for the ovum, which survives for only one day after being released into the fallopian tube. However, most conceptions result from intercourse occurring during a three-day period—on the day of ovulation or during the two days preceding it (Wilcox, Weinberg, & Baird, 1995).

With conception, the story of prenatal development begins to unfold. The vast changes that take place during the 38 weeks of pregnancy are usually divided into three phases: (1) the
period of the zygote, (2) the period of the embryo, and (3) the period of the fetus. As we consider each, refer to Table 3.1, which summarizes milestones of prenatal development.

**Period of the Zygote**

The period of the zygote lasts about two weeks, from fertilization until the tiny mass of cells drifts down and out of the fallopian tube and attaches itself to the wall of the uterus. The zygote’s first cell duplication is long and drawn out; it is not complete until about 30 hours after conception. Gradually, new cells are added at a faster rate. By the fourth day, 60 to 70 cells exist that form a hollow, fluid-filled ball called a blastocyst (refer again to Figure 3.1). The cells on the inside, called the embryonic disk, will become the new organism; the outer ring of cells, termed the trophoblast, will become the structures that provide protective covering and nourishment.

**Implantation.** Between the seventh and ninth days, implantation occurs: The blastocyst burrows deep into the uterine lining. Surrounded by the woman’s nourishing blood, it starts to grow in earnest. At first, the trophoblast (protective outer layer) multiplies fastest. It forms a membrane, called the amnion, that encloses the developing organism in amniotic fluid, which helps keep the temperature of the prenatal world constant and provides a cushion against any jolts caused by the woman’s movements. A yolk sac emerges that produces blood cells until the liver, spleen, and bone marrow are mature enough to take over this function (Moore & Persaud, 2008).

As many as 30 percent of zygotes do not survive these first two weeks. In some, the sperm and ovum do not join properly. In others, cell duplication never begins. By preventing implantation in these cases, nature eliminates most prenatal abnormalities (Sadler, 2006).
TABLE 3.1 Milestones of Prenatal Development

<table>
<thead>
<tr>
<th>TRIMESTER</th>
<th>PERIOD</th>
<th>WEEKS</th>
<th>LENGTH AND WEIGHT</th>
<th>MAJOR EVENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Zygote</td>
<td>1</td>
<td></td>
<td>The one-celled zygote multiplies and forms a blastocyst.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>The blastocyst burrows into the uterine lining. Structures that feed and protect the developing organism begin to form—amnion, chorion, yolk sac, placenta, and umbilical cord.</td>
</tr>
<tr>
<td>Embryo</td>
<td>3–4</td>
<td></td>
<td>⅛ inch (6 mm)</td>
<td>A primitive brain and spinal cord appear. Heart, muscles, ribs, backbone, and digestive tract begin to develop.</td>
</tr>
<tr>
<td></td>
<td>5–8</td>
<td></td>
<td>1 inch (2.5 cm); ¼ ounce (4 g)</td>
<td>Many external body structures (face, arms, legs, toes, fingers) and internal organs form. The sense of touch begins to develop, and the embryo can move.</td>
</tr>
<tr>
<td>Fetus</td>
<td>9–12</td>
<td></td>
<td>3 inches (7.6 cm); less than 1 ounce (20 g)</td>
<td>Rapid increase in size begins. Nervous system, organs, and muscles become organized and connected, and new behavioral capacities (kicking, thumb sucking, mouth opening, and rehearsal of breathing) appear. External genitals are well-formed, and the fetus’s sex is evident.</td>
</tr>
<tr>
<td>Second</td>
<td>13–24</td>
<td></td>
<td>12 inches (30 cm); 1.1 pounds (820 g)</td>
<td>The fetus continues to enlarge rapidly. In the middle of this period, fetal movements can be felt by the mother. Vernix and lanugo keep the fetus’s skin from chapping in the amniotic fluid. Most of the brain’s neurons are present by 24 weeks. Eyes are sensitive to light, and the fetus reacts to sound.</td>
</tr>
<tr>
<td>Third</td>
<td>25–38</td>
<td></td>
<td>20 inches (50 cm); 7.5 pounds (3,400 g)</td>
<td>The fetus has a chance of survival if born during this time. Size increases. Lungs mature. Rapid brain development causes sensory and behavioral capacities to expand. In the middle of this period, a layer of fat is added under the skin. Antibodies are transmitted from mother to fetus to protect against disease. Most fetuses rotate into an upside-down position in preparation for birth.</td>
</tr>
</tbody>
</table>

Photos (from top to bottom): © Claude Cortier/Photo Researchers, Inc.; © G. Moscoso/Photo Researchers, Inc.; © John Watney/Photo Researchers, Inc.; © James Stevenson/Photo Researchers, Inc.; © Lennart Nilsson, A Child Is Born/Bonniers.

THE PLACENTA AND UMBILICAL CORD. By the end of the second week, cells of the trophoblast form another protective membrane—the chorion, which surrounds the amnion. From the chorion, tiny hairlike villi, or blood vessels, emerge. As these villi burrow into the uterine wall, the placenta starts to develop. By bringing the embryo’s and mother’s blood close together but preventing them from mixing directly, the placenta permits food and oxygen to reach the organism and waste products to be carried away.

The placenta is connected to the developing organism by the umbilical cord. It contains one large vein that delivers blood loaded with nutrients and two arteries that remove waste products. The force of blood flowing through the cord keeps it firm, so it seldom tangles while the embryo, like a space-walking astronaut, floats freely in its fluid-filled chamber (Moore & Persaud, 2008).
Period of the Embryo

The period of the embryo lasts from implantation through the eighth week of pregnancy. During these brief six weeks, the groundwork is laid for all body structures and organs.

Last half of the first month. In the first week of this period, the embryonic disk forms three layers of cells: (1) the ectoderm, which will become the nervous system and skin; (2) the mesoderm, from which will develop the muscles, skeleton, circulatory system, and other internal organs; and (3) the endoderm, which will become the digestive system, lungs, urinary tract, and glands. These three layers give rise to all parts of the body.

At first, the nervous system develops fastest. The ectoderm folds over to form the neural tube, which will become the spinal cord and brain. At 3½ weeks, production of neurons (nerve cells that store and transmit information) begins deep inside the neural tube at an astounding pace—more than 250,000 per minute. Once formed, neurons travel along tiny threads to their permanent locations, where they will form the major parts of the brain (Nelson, Thomas, & de Haan, 2006).

Meanwhile, the heart begins to pump blood, and the muscles, backbone, ribs, and digestive tract appear. At the end of the first month, the embryo—only ⁵/₁₆ inch long—consists of millions of organized groups of cells with specific functions.

The second month. In the second month, growth continues rapidly. The eyes, ears, nose, jaw, and neck form. Tiny buds become arms, legs, fingers, and toes. Internal organs are more distinct: The intestines grow, the heart develops separate chambers, and the liver and spleen take over production of blood cells so that the yolk sac is no longer needed. Now 1 inch long and ¹/₄ ounce in weight, the embryo can sense its world. It responds to touch, particularly in the mouth area and on the soles of the feet. And it can move, although its tiny flutters are still too light to be felt by the mother (Moore & Persaud, 2008).

Period of the Fetus

The period of the fetus, from the ninth week to the end of pregnancy, is the longest prenatal period. During this “growth and finishing” phase, the organism increases rapidly in size.

The third month. In the third month, the organs, muscles, and nervous system start to become organized and connected. When the brain signals, the fetus kicks, bends its arms, opens its mouth, and even sucks its thumb. The tiny lungs expand and contract in an early rehearsal of breathing movements. By the twelfth week, the external genitals are well-formed, and the sex of the fetus can be detected with ultrasound (Sadler, 2006). Other finishing touches appear, such as fingernails, tooth buds, and eyelids that open and close. The heartbeat can now be heard through a stethoscope.
Prenatal development is sometimes divided into trimesters, or three equal time periods. At the end of the third month, the first trimester is complete.

**THE SECOND TRIMESTER.** By the middle of the second trimester, between 17 and 20 weeks, the new being has grown large enough that the mother can feel its movements. A white, cheeselike substance called vernix protects its skin from chapping during the long months spent bathing in the amniotic fluid. White, downy hair called lanugo also appears over the entire body, helping the vernix stick to the skin.

At the end of the second trimester, many organs are well-developed, and most of the brain's billions of neurons are in place. However, glial cells, which support and feed the neurons, continue to increase at a rapid rate throughout pregnancy, as well as after birth. Consequently, brain weight increases tenfold from the twentieth week until birth (Roelfsema et al., 2004).

Brain growth means new behavioral capacities. The 20-week-old fetus can be stimulated or irritated by sounds. And if a doctor looks inside the uterus using fetoscopy (see Table 2.2 on page 44), fetuses try to shield their eyes from the light with their hands, indicating that sight has begun to emerge (Moore & Persaud, 2008). Still, a fetus born at this time cannot survive. Its lungs are immature, and the brain cannot yet control breathing and body temperature.

**THE THIRD TRIMESTER.** During the final trimester, a fetus born early has a chance for survival. The point at which the fetus can first survive, called the age of viability, occurs sometime between 22 and 26 weeks (Moore & Persaud, 2008). A baby born between the seventh and eighth month, however, usually needs oxygen assistance to breathe because tiny air sacs in the lungs are not yet ready to inflate and exchange carbon dioxide for oxygen.

The brain continues to make great strides. The cerebral cortex, the seat of human intelligence, enlarges. As neurological organization improves, the fetus spends more time awake—about 11 percent at 28 weeks, a figure that rises to 16 percent just before birth (DiPietro et al., 1996). Between 30 and 34 weeks, fetuses show rhythmic alternations between sleep and wakefulness that gradually increase in organization (Rivkees, 2003). Around this time, synchrony between fetal heart rate and motor activity peaks: A rise in heart rate is usually followed within five seconds by a burst of motor activity (DiPietro et al., 2006). These are clear signs that coordinated neural networks are beginning to form in the brain. The fetus also shows signs of developing temperament. In one study, more active fetuses...
during the third trimester became 1-year-olds who could better handle frustration and 2-year-olds who were less fearful, in that they more readily interacted with toys and with an unfamiliar adult in a laboratory (DiPietro et al., 2002). Perhaps fetal activity is an indicator of healthy neurological development.

The third trimester brings greater responsiveness to stimulation. As we will see later when we discuss newborn capacities, fetuses acquire taste and odor preferences from bathing in and swallowing amniotic fluid. Between 23 and 30 weeks, connections form between the cerebral cortex and brain regions involved in pain sensitivity. By this time, painkillers should be used in any surgical procedures performed on a fetus (Lee et al., 2005).

Within the next six weeks, fetuses distinguish the tone and rhythm of different voices and sounds. They show systematic heart rate changes to a male versus a female speaker, to the mother’s voice versus a stranger’s, and to a simple familiar melody versus an unfamiliar melody (Granier-Deferre et al., 2003; Huotilainen et al., 2005; Kislevsky et al., 2003; Lecanuet et al., 1993).

In the final three months, the fetus gains more than 5 pounds and grows 7 inches. In the eighth month, a layer of fat is added to assist with temperature regulation. The fetus also receives antibodies from the mother’s blood that protect against illnesses, since the newborn’s own immune system will not work well until several months after birth. In the last weeks, most fetuses assume an upside-down position.

**Period of the fetus: thirty-sixth week.** This fetus fills the uterus. To support its need for nourishment, the umbilical cord and placenta have grown large. Notice the vernix (cheeselike substance) on the skin, which protects it from chapping. The fetus has accumulated a layer of fat to assist with temperature regulation after birth. In two more weeks, it will be full-term.
that it dies. The embryonic period is the time when serious de­
fects are most likely to occur because the foundations for all body parts are being laid down. During the fetal period, terato­
genic damage is usually minor. However, organs such as the brain, ears, eyes, teeth, and genitals can still be strongly affected.

- PRESCRIPTION AND NONPRESCRIPTION DRUGS. In the early 1960s, the world learned a tragic lesson about drugs and prenatal development. At that time, a sedative called thalidomide was widely available in Canada, Europe, and South America. When taken by mothers four to six weeks after conception, thalidomide produced gross deformities of the embryo’s arms and legs and, less frequently, damage to the ears, heart, kidneys, and genitals. About 7,000 infants worldwide were affected (Moore & Persaud, 2008). As these children grew older, many scored below average in intelligence. Perhaps the drug damaged the central nervous system directly, or the rearing conditions of these severely deformed youngsters impaired their intellectual development.

Another medication, a synthetic hormone called diethyl­
stilbestrol (DES), was widely prescribed between 1945 and 1970 to prevent miscarriages. As daughters of these mothers reached adolescence and young adulthood, they showed unusually high rates of cancer of the vagina, malformations of the uterus, and infertility. Similarly, young men were at increased risk of genital abnormalities and cancer of the testes (Hammes & Laitman, 2003; Palmer et al., 2001).

Currently, the most widely used, potent teratogen is a vita­
m A derivative called Accutane, used to treat severe acne (also known by the generic name isotretinoin). Hundreds of thou­sands of women of childbearing age in industrialized nations take it. Exposure during the first trimester results in eye, ear, skull, brain, heart, and immune system abnormalities (Honein, Paulozzi, & Erickson, 2001). Accutane’s packaging warns users to avoid pregnancy by using two methods of birth control, but many women do not heed this advice (Garcia-Bournissen et al., 2008).

Indeed, any drug with a molecule small enough to pene­
trate the placental barrier can enter the embryonic or fetal bloodstream. Yet many pregnant women continue to take over­
the-counter medications without consulting their doctors. Several studies suggest that regular aspirin use is linked to low

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**FIGURE 3.2** Sensitive periods in prenatal development. Blue horizontal bars indicate highly sensitive periods. Green horizontal bars indicate periods that are somewhat less sensitive. (Adapted from Before We Are Born, 7th ed., by K. L. Moore and T. V. N. Persaud, p. 313. Copyright © 2008, reprinted with permission from Elsevier, Inc.)
birth weight, infant death around the time of birth, poorer motor development, and lower intelligence scores in early childhood, although other research fails to confirm these findings (Barr et al., 1990; Kozer et al., 2003; Streissguth et al., 1987). Coffee, tea, cola, and cocoa contain another frequently consumed drug, caffeine. As amounts exceed 100 milligrams per day (equivalent to one cup of coffee), low birth weight and miscarriage increase (CARE Study Group, 2008; Weng, Odouli, & Li, 2008). And antidepressant medication taken during the third trimester is linked to increased risk of birth complications, including respiratory distress (Oberlander et al., 2006).

Because children’s lives are involved, we must take findings like these seriously. At the same time, we cannot be sure that these frequently used drugs actually cause the problems just mentioned. Often mothers take more than one drug. If the embryo or fetus is injured, it is hard to tell which drug might be responsible or whether other factors correlated with drug taking are at fault. Until we have more information, the safest course of action is the one Yolanda took: Avoid these drugs entirely. Unfortunately, these infants are born drug-addicted. They are often feverish and irritable, and their cries are abnormally shrill—a common symptom among stressed newborns (Bauer et al., 2005). When mothers with many problems of their own must care for these babies, who are difficult to calm, cuddle, and feed, behavior problems are likely to persist. After infancy, some children get better, while others remain jittery and inattentive. The kind of parenting they receive may explain why problems persist for some but not for others (Cosden, Peerson, & Elliott, 1997).

Evidence suggests that some cocaine-exposed babies develop lasting difficulties. Cocaine constricts the blood vessels, causing oxygen delivered to the developing organism to fall for 15 minutes following a high dose. It also can alter the production and functioning of neurons and the chemical balance in the fetus’s brain. These effects may contribute to eye, bone, genital, urinary tract, kidney, and heart deformities; brain hemorrhages and seizures; and severe growth retardation (Covington et al., 2002; Feng, 2005; Mayes, 1999). Some studies report perceptual, motor, attention, memory, language, and impulse-control problems that persist into the preschool years (Dennis et al., 2006; Lester et al., 2003; Linares et al., 2006; Noland et al., 2005; Singer et al., 2004). But other investigations reveal no major negative effects of prenatal cocaine exposure (Behnke et al., 2006; Frank et al., 2005; Hurt et al., 2005). These contradictory findings indicate how difficult it is to isolate the precise damage caused by illegal drugs.

Marijuana, the most widely used illegal drug, has been linked to low birth weight and smaller head size (a measure of brain growth); to attention, memory, and academic difficulties and to depression in childhood; and to poorer problem-solving performance in adolescence (Goldschmidt et al., 2004; Gray et al., 2005). As with cocaine, however, these effects are not well-established.

**ILLEGAL DRUGS.** Nearly 4 percent of U.S. pregnant women use highly addictive mood-altering drugs, such as cocaine and heroin (U.S. Department of Health and Human Services, 2007d). Babies born to users of these drugs are at risk for a wide variety of problems, including prematurity, low birth weight, physical defects, breathing difficulties, and death around the time of birth (Behnke et al., 2001; Schuetze & Eiden, 2006; Walker, Rosenberg, & Balaban-Gil, 1999). In addition, these infants are born drug-addicted. They are often feverish and irritable, and their cries are abnormally shrill—a common symptom among stressed newborns (Bauer et al., 2005). When

![Image of a baby](https://example.com/image.jpg)

This 3-day-old infant, who was born many weeks before his due date and is underweight, breathes with the aid of a respirator. Prematurity and low birth weight can result from a variety of environmental influences during pregnancy, including maternal drug use and cigarette smoking.

**TOBACCO.** Although smoking has declined in Western nations, an estimated 17 percent of U.S. women smoke during their pregnancies (U.S. Department of Health and Human Services, 2007d). The best-known prenatal effect of smoking is low birth weight. But the likelihood of other serious consequences, such as miscarriage, prematurity, impaired heart rate and breathing during sleep, infant death, and asthma and cancer later in childhood, also increases (Franco et al., 2000; Jaakkola & Gissler, 2004). The more cigarettes a mother smokes, the greater the chances that her baby will be affected. If a pregnant woman stops smoking at any time, even during the last trimester, she reduces the likelihood that her infant will be born underweight and suffer from future problems (Klesges et al., 2001).

Newborns of smoking mothers also display slight behavioral abnormalities. They are less attentive to sounds, display more muscle tension, are more excitable when touched and visually stimulated, and more often have colic (persistent crying) (Law et al., 2003; Sondergaard et al., 2002). Some studies report that prenatally exposed children and adolescents have shorter attention spans, poorer memories, lower mental test scores, and more behavior problems (Fried, Watkinson, & Gray, 2003; Huizink & Mulder, 2006; Nigg & Breslau, 2007; Thapar et al., 2003). However, other factors closely associated with smoking, such as lower maternal education and income levels, may contribute to these outcomes (Huijbregts et al., 2006).
How does smoking harm the fetus? Nicotine, the addictive substance in tobacco, constricts blood vessels, lessens blood flow to the uterus, and causes the placenta to grow abnormally. This reduces the transfer of nutrients, so the fetus gains weight poorly. Also, nicotine raises the concentration of carbon monoxide in the bloodstream of both mother and fetus. Because carbon monoxide displaces oxygen from red blood cells, it can damage the central nervous system and slow body growth.

From one-third to one-half of nonsmoking pregnant women are “passive smokers” because their husbands, relatives, or co-workers use cigarettes. Passive smoking is also related to low birth weight, infant death, childhood respiratory illnesses, and possible long-term impairments in attention and learning (Hanke, Sobala, & Kalinika, 2004; Makin, Fried, & Watkinson, 1991; Pattenden et al., 2006). Clearly, expectant mothers should avoid smoke-filled environments.

**ALCOHOL** In his moving book *The Broken Cord*, Michael Dorris (1989), a Dartmouth College anthropology professor, described what it was like to rear his adopted son Abel (called Adam in the book), whose biological mother drank heavily throughout pregnancy and died of alcohol poisoning shortly after his birth. A Sioux Indian, Abel was born with **fetal alcohol spectrum disorder (FASD)**, a term encompassing a range of physical, mental, and behavioral outcomes caused by prenatal alcohol exposure. Children with FASD are given one of three diagnoses, which vary in severity:

1. **Fetal alcohol syndrome (FAS)**, distinguished by (a) slow physical growth, (b) a pattern of three facial abnormalities (short eyelid openings, a thin upper lip, and a smooth or flattened philtrum, or indentation running from the bottom of the nose to the center of the upper lip), and (c) brain injury, evident in a small head and impairment in at least three areas of functioning—for example, memory, language and communication, attention span and activity level (overactivity), planning and reasoning, motor coordination, or social skills. Other defects—of the eyes, ears, nose, throat, heart, genitals, urinary tract, or immune system—may also be present. Abel was diagnosed as having FAS. As is typical for this disorder, his mother drank heavily throughout pregnancy.

2. **Partial fetal alcohol syndrome (p-FAS)**, characterized by (a) two of the three facial abnormalities just mentioned and (b) brain injury, again evident in at least three areas of impaired functioning. Mothers of children with p-FAS generally drank alcohol in smaller quantities, and children’s defects vary with the timing and length of alcohol exposure. Furthermore, recent evidence suggests that paternal alcohol use around the time of conception may induce genetic alterations, thereby contributing to symptoms (Abel, 2004).

3. **Alcohol-related neurodevelopmental disorder (ARND)**, in which at least three areas of mental functioning are impaired, despite typical physical growth and absence of facial abnormalities. Again, prenatal alcohol exposure, though confirmed, is less pervasive than in FAS (Chudley et al., 2005; Loock et al., 2005).

Even when provided with enriched diets, FAS babies fail to catch up in physical size during childhood. Mental impairment associated with all three FASD diagnoses is also permanent: In his teens and twenties, Abel had trouble concentrating and keeping a routine job, and he suffered from poor judgment. For example, he would buy something and not wait for change or wander off in the middle of a task. He died at age 23, after being hit by a car. The more alcohol a pregnant woman consumes, the poorer the child’s motor coordination and intelligence and achievement test scores and the greater the likelihood of antisocial behavior and other mental health problems in adolescence (Burden, Jacobson, & Jacobson, 2005; Mattson, Calarco, & Lang, 2006; Streissguth et al., 2004).

Alcohol produces its devastating effects by interfering with the production and migration of neurons in the primitive neural tube. Brain-imaging research reveals reduced brain size, damage to many brain structures, and abnormalities in brain functioning, including transferring messages from one part of the brain to another (Riley, McGee, & Sowell, 2004; Spadoni et al., 2007). Also, the body uses large quantities of oxygen to metabolize alcohol. A pregnant woman’s heavy drinking draws away oxygen that the developing organism needs for cell growth.
About 25 percent of U.S. mothers report drinking at some time during their pregnancies. As with heroin and cocaine, alcohol abuse is higher in poverty-stricken women. On some Native-American reservations, the incidence of FAS is as high as 10 to 20 percent (Szelanko, Wood, & Thurman, 2006; U.S. Department of Health and Human Services, 2007d). Even mild drinking, less than one drink per day, is associated with reduced alcohol abuse is higher in poverty-stricken women. Therefore, expectant mothers should avoid alcohol entirely.

**Radiation.** Defects due to ionizing radiation were tragically apparent in children born to pregnant women who survived the bombing of Hiroshima and Nagasaki during World War II. Similar abnormalities surfaced in the nine months following the 1986 Chernobyl, Ukraine, nuclear power plant accident. After each disaster, the incidence of miscarriage and babies born with underdeveloped brains, physical deformities, and slow physical growth rose dramatically (Hoffman, 2001; Schull, 2003).

Even when a radiation-exposed baby seems normal, problems may appear later. For example, low-level radiation, resulting from industrial leakage or medical X-rays, can increase the risk of childhood cancer (Fattibene et al., 1999). In middle childhood, prenatally exposed Chernobyl children had abnormal brain-wave activity, lower intelligence test scores, and rates of language and emotional disorders two to three times greater than those of nonexposed Russian children (Loganovskaja & Loganovsky, 1999; Loganovsky et al., 2008).

**Environmental Pollution.** In industrialized nations, an astounding number of potentially dangerous chemicals are released into the environment. In the United States, more than 75,000 are in common use. When 10 newborns were randomly selected from U.S. hospitals for analysis of umbilical cord blood, researchers uncovered a startling array of contaminants—287 in all! They concluded that many babies are “born polluted” by chemicals that not only impair prenatal development but increase the chances of life-threatening diseases and health problems later on (Houlihan et al., 2005).

Pregnant women are wise to avoid eating long-lived predatory fish, such as swordfish, albacore tuna, and shark, which are heavily contaminated with mercury. High levels of prenatal mercury exposure disrupt production and migration of neurons, causing widespread brain damage (Clarkson, Magos, & Myers, 2003; Hubbs-Tait et al., 2005).

For many years, polychlorinated biphenyls (PCBs) were used to insulate electrical equipment until researchers showed that they entered waterways and the food supply. Prenatal exposure to high levels of PCBs results in low birth weight, skin deformities, brain-wave abnormalities, and delayed cognitive development (Chen & Hsu, 1994; Chen et al., 1994). Even at low levels, PCBs are linked to reduced birth weight, smaller head size, persisting attention and memory difficulties, and lower intelligence test scores in childhood (Jacobson & Jacobson, 2003; Stewart et al., 2000; Walkowiak et al., 2001).

Another teratogen, lead, is present in paint flaking off the walls of old buildings and in certain materials used in industrial occupations. High levels of prenatal lead exposure are related to prematurity, low birth weight, brain damage, and a wide variety of physical defects. Babies with low-level exposure show slightly poorer mental and motor development (Bellinger, 2005).

Finally, prenatal exposure to dioxins—toxic compounds resulting from incineration—is linked to brain, immune system, and thyroid damage in babies. It is also associated with an increased incidence of breast and uterine cancers in women, perhaps through altering hormone levels (ten Tusscher & Koppe, 2004). Furthermore, even tiny amounts of dioxin in the maternal bloodstream cause a dramatic change in sex ratio of offspring: Affected men father nearly twice as many girls as boys (Ishihara et al., 2007). Dioxin seems to impair the fertility of Y-bearing sperm prior to conception.

**Infectious Disease.** Most infectious diseases seem to have no prenatal impact. Nevertheless, a few cause extensive damage.

In the mid-1960s, a worldwide epidemic of rubella (three-day, or German, measles) led to the birth of more than 20,000 North American babies with serious defects. Consistent with the sensitive-period concept, over 50 percent of infants whose mothers become ill during the embryonic period show eye cataracts; deafness; heart, genital, urinary, and intestinal abnormalities; and mental retardation (Eberhart-Phillips, Frederick, & Baron, 1993). Infection during the fetal period is less harmful, but low birth weight, hearing loss, and bone defects may still
occur. And the brain abnormalities resulting from prenatal rubella increase the risk of severe mental illness in adulthood (Brown, 2006). Routine vaccination in infancy and childhood has made new rubella outbreaks unlikely in industrialized nations (Hyde et al., 2006). But an estimated 100,000 cases of prenatal infection occur annually in developing countries with weak or absent immunization programs (Robinson et al., 2006).

The human immunodeficiency virus (HIV), which can lead to acquired immune deficiency syndrome (AIDS), a disease that destroys the immune system, has infected increasing numbers of women over the past two decades. In developing countries, where 95 percent of new infections occur, more than half affect women. In South Africa, for example, one-fourth of all pregnant women are HIV-positive (Kasmauski & Jaret, 2003; Quinn & Overbaugh, 2005). HIV-infected expectant mothers pass the deadly virus to the developing organism 20 to 30 percent of the time.

AIDS progresses rapidly in infants, with most becoming ill by age 6 months and surviving only five to eight months after the appearance of symptoms (O’Rahilly & Müller, 2001). The antiviral drug zidovudine (ZDV) reduces prenatal AIDS transmission by as much as 95 percent, but it is not widely available in impoverished regions of the world (United Nations, 2006a).

The developing organism is especially sensitive to the family of herpes viruses, for which no vaccine or treatment exists. Among these, cytomegalovirus (the most frequent prenatal infection, transmitted through respiratory or sexual contact) and herpes simplex 2 (which is sexually transmitted) are especially dangerous. In both, the virus invades the mother’s genital tract, infecting babies either during pregnancy or at birth.

Toxoplasmosis, caused by a parasite found in many animals, can affect pregnant women who eat raw or undercooked meat or who come in contact with the feces of infected cats. If it strikes during the first trimester, it is likely to cause eye and brain damage. Later infection is linked to mild visual and cognitive impairments (Jones, Lopez, & Wilson, 2003). Expectant mothers can avoid toxoplasmosis by making sure that the meat they eat is well-cooked, having pet cats checked for the disease, and turning over the care of litter boxes to other family members.

Other Maternal Factors

Besides avoiding teratogens, expectant parents can support the development of the embryo and fetus in other ways. In the following sections, we examine nutrition, emotional stress, blood type, age, and previous births.

■ NUTRITION. During the prenatal period, when children are growing more rapidly than at any other time, they depend totally on the mother for nutrients. A healthy diet that results in a weight gain of 25 to 30 pounds (10 to 13.5 kilograms) helps ensure the health of mother and baby.

Prenatal malnutrition can cause serious damage to the central nervous system. The poorer the mother’s diet, the greater the loss in brain weight, especially if malnutrition occurred during the last trimester. During that time, the brain is increasing rapidly in size, and a maternal diet high in all the basic nutrients is necessary for it to reach its full potential (Morgane et al., 1993). An inadequate diet during pregnancy can also distort the structure of other organs, including the liver, kidneys, pancreas, and cardiovascular system, resulting in lifelong health problems (Barker, 2002; Fowden, Giussani, & Forhead, 2005; Roseboom, de Rooij, & Painter, 2006).

Many studies show that providing pregnant women with adequate food has a substantial impact on the health of their newborn babies. Vitamin-mineral enrichment is particularly crucial. For example, taking a folic acid supplement around the time of conception reduces by more than 70 percent abnormalities of the neural tube, such as anencephaly and spina bifida (see Table 2.2 on page 44) (MCR Vitamin Study Research Group, 1991; Scholl, Heidiger, & Belsky, 1996). U.S. government guidelines recommend that all women of childbearing age consume 0.4 milligrams of folic acid per day. For women who have previously had a pregnancy affected by a neural tube defect, the recommended amount is 4 to 5 milligrams (dosage must be carefully monitored, as excessive intake can be harmful) (American Academy of Pediatrics, 2006). Currently, bread, flour, rice, pasta, and other grain products are being fortified with folic acid.

When poor nutrition persists throughout pregnancy, infants usually require more than dietary improvement. Successful interventions must also break the cycle of apathetic mother–baby interactions. Some do so by teaching parents how to interact effectively with their infants, while others focus on stimulating infants to promote active engagement with their physical
and social surroundings (Grantham-McGregor et al., 1994; Grantham-McGregor, Schofield, & Powell, 1987).

Although prenatal malnutrition is highest in developing countries, women and children in the industrialized world are also affected. The U.S. Special Supplemental Food Program for Women, Infants, and Children (WIC), which provides food packages to low-income pregnant women, reaches about 90 percent of those who qualify. But many who need nutrition intervention are not eligible for WIC.

**EMOTIONAL STRESS.** When women experience severe emotional stress during pregnancy, their babies are at risk for a wide variety of difficulties, including miscarriage, prematurity, low birth weight, respiratory and digestive illnesses, sleep disturbances, and irritability during the first three years (Field et al., 2007; Mulder et al., 2002; Wadhwa, Sandman, & Garite, 2001). Intense maternal anxiety is also related to several commonly occurring physical defects, such as cleft lip and palate, heart deformities, and pyloric stenosis (tightening of the infant’s stomach outlet, which often must be treated surgically) (Carmichael & Shaw, 2000).

How can maternal stress affect the fetus? **TAKE A MOMENT…** To understand this process, list the changes you sensed in your own body the last time you were under stress. When we experience fear and anxiety, stimulant hormones released into our bloodstream cause us to be “poised for action.” Large amounts of blood are sent to parts of the body involved in the defensive response—the brain, the heart, and the muscles in the arms, legs, and trunk. Blood flow to other organs, including the uterus, is reduced, depriving the fetus of a full supply of oxygen and nutrients.

Stress hormones also cross the placenta, causing a dramatic rise in fetal heart rate (Monk et al., 2000, 2004). They also may permanently alter fetal neurological functioning, thereby heightening stress reactivity in later life (Monk et al., 2003). In one study, researchers identified mothers who had been directly exposed to the September 11, 2001 World Trade Center collapse during their pregnancies. At age 9 months, their babies were tested for saliva concentrations of cortisol, a hormone involved in regulating the stress response. Infants whose mothers had reacted to the disaster with severe anxiety had abnormally low cortisol levels, a symptom of reduced physiological capacity to manage stress (Yehuda et al., 2005). Consistent with this finding, maternal emotional stress during pregnancy predicts anxiety, short attention span, anger, aggression, and overactivity among preschool and school-age children, above and beyond the impact of other risk factors (de Weerth & Buitelans, 2005; Gutteling et al., 2006; Van den Bergh, 2004).

But stress-related prenatal complications are greatly reduced when mothers have partners, other family members, and friends who offer social support (Federenko & Wadhwa, 2004). The link between social support and positive pregnancy outcomes is particularly strong for low-income women, who often lead highly stressful daily lives (Hoffman & Hatch, 1996).

**RH FACTOR INCOMPATIBILITY.** When the inherited blood types of mother and fetus differ, serious problems sometimes result. The most common cause of these difficulties is **Rh factor incompatibility.** When the mother is Rh-negative (lacks the Rh blood protein) and the father is Rh-positive (has the protein), the baby may inherit the father’s Rh-positive blood type. If even a little of a fetus’s Rh-positive blood crosses the placenta into the Rh-negative mother’s bloodstream, she begins to form antibodies to the foreign Rh protein. If these enter the fetus’s system, they destroy red blood cells, reducing the oxygen supply to organs and tissues. Miscarriage, mental retardation, heart damage, and infant death can occur.

It takes time for the mother to produce Rh antibodies, so firstborn children are rarely affected. The danger increases with each additional pregnancy. Fortunately, Rh incompatibility can be prevented in most cases. After the birth of each Rh-positive baby, Rh-negative mothers are routinely given a vaccine to prevent the buildup of antibodies.

**MATERNAL AGE.** In Chapter 2, we noted that women who delay childbearing until their thirties or forties face increased risk of infertility, miscarriage, and babies born with chromosomal defects. Are other pregnancy complications more common among older mothers? Research consistently indicates that healthy women in their thirties have about the same rates of prenatal and birth complications as those in their twenties (Blanco et al., 1996; Dildy et al., 1996; Prysak, Lorenz, & Kidy, 1995). Thereafter, as Figure 3.3 reveals, complication rates increase, with a sharp rise among women age 50 to 55—an age at which because of menopause (end of menstruation) and
agging reproductive organs, few women can conceive naturally (Salihu et al., 2003).

In the case of teenage mothers, does physical immaturity cause prenatal complications? Infants born to teenagers have a higher rate of problems, but not directly because of maternal age. Most pregnant teenagers come from low-income backgrounds, where stress, poor nutrition, and health problems are common. Also, many are afraid to seek medical care or, in the United States, do not have access to care because they lack health insurance (U.S. Department of Health and Human Services, 2008f).

The Importance of Prenatal Health Care

Yolanda had her first prenatal appointment three weeks after missing her menstrual period. After that, she visited the doctor’s office once a month until she was seven months pregnant, then twice during the eighth month, increasing her visits to once a week when birth grew near. The doctor kept track of her general health, her weight gain, and the capacity of her uterus and cervix to support the fetus. The fetus’s growth was also carefully monitored.

Yolanda’s pregnancy, like most others, was free of complications. But unexpected difficulties can arise, especially if mothers have health problems. For example, women with diabetes need careful monitoring. Extra sugar in the diabetic mother’s blood-

stream causes the fetus to grow larger than average, making pregnancy and birth problems more common. Another complication, experienced by 5 to 10 percent of pregnant women, is pre eclampsia (sometimes called toxemia), in which blood pressure increases sharply and the face, hands, and feet swell in the last half of pregnancy. If untreated, pre eclampsia can cause convulsions in the mother and fetal death. Usually, hospitalization, bed rest, and drugs can lower blood pressure to a safe level (Vidaeff, Carroll, & Ramin, 2005). If not, the baby must be delivered at once.

Unfortunately, 16 percent of pregnant women in the United States wait until after the first trimester to seek prenatal care, and 4 percent receive none at all. Why do these mothers delay going to the doctor? One reason is a lack of health insurance. Although the poorest of these mothers are eligible for government-sponsored health services, many low-income women do not qualify.

Besides financial hardship, situational barriers (difficulty finding a doctor, getting an appointment, and arranging transportation) and personal barriers (psychological stress and the demands of taking care of other young children) prevent many mothers from seeking prenatal care. Clearly, public education about the importance of early and sustained prenatal care is badly needed. Refer to Applying What We Know above, which lists “do’s and don’ts” for a healthy pregnancy, based on our discussion of the prenatal environment.
PART II  Foundations of Development

During a routine prenatal visit, a doctor uses ultrasound to evaluate the development of this expectant mother’s 5-month-old fetus. All pregnant women should receive regular prenatal care to protect their own health as well as the health of their babies.

ASK YOURSELF

REVIEW
Why is it difficult to determine the prenatal effects of many environmental agents, such as drugs and pollution?

APPLY
Nora, pregnant for the first time, believes that a few cigarettes and a glass of wine a day won’t be harmful. Provide Nora with research-based reasons for not smoking or drinking.

REFLECT
If you had to choose five environmental influences to publicize in a campaign aimed at promoting healthy prenatal development, which ones would you choose, and why?

Childbirth

Yolanda and Jay agreed to return the following spring to share their experiences with my next class. Two-week-old Joshua came along as well. Their story revealed that the birth of a baby is one of the most dramatic and emotional events in human experience. Yolanda explained:

By morning, we knew I was in labor. It was Thursday, so we went in for my usual weekly appointment. The doctor said, yes, the baby was on the way, but it would be a while. He told us to go home and relax and come to the hospital in three or four hours. We checked in at three in the afternoon; Joshua arrived at two o’clock the next morning. When, finally, I was ready to deliver, it went quickly; a half hour or so and some good hard pushes, and there he was! His face was red and puffy, and his head was misshapen, but I thought, “Our son! I can’t believe he’s really here.”

Jay was also elated by Joshua’s birth. “I wanted to support Yolanda and to experience as much as I could. It was awesome, indescribable,” he said, holding Joshua and kissing him gently. In the following sections, we explore the experience of childbirth, from both the parents’ and the baby’s point of view.

The Stages of Childbirth

It is not surprising that childbirth is often referred to as labor. It is the hardest physical work a woman may ever do. A complex series of hormonal changes between mother and fetus initiates the process, which naturally divides into three stages:

1. Dilation and effacement of the cervix. This is the longest stage of labor, lasting an average of 12 to 14 hours with a first birth and 4 to 6 hours with later births. Contractions of the uterus gradually become more frequent and powerful, causing the cervix, or uterine opening, to widen and thin to nothing, forming a clear channel from the uterus into the birth canal, or vagina (see Figure 3.4a and b).

2. Delivery of the baby. This stage is much shorter, lasting about 50 minutes for a first birth and 20 minutes with later births. Strong contractions of the uterus continue, but the mother also feels a natural urge to squeeze and push with her abdominal muscles. As she does so with each contraction, she forces the baby down and out (see Figure 3.4c and d).

3. Delivery of the placenta. Labor comes to an end with a few final contractions and pushes. These cause the placenta to separate from the wall of the uterus and be delivered in about 5 to 10 minutes.

To accommodate the well-developed brain, a newborn’s head is large in relation to the trunk and legs. This newborn’s body readily turns pink as he takes his first few breaths.
The Baby’s Adaptation to Labor and Delivery

At first glance, labor and delivery seem like a dangerous ordeal for the baby. The strong contractions exposed Joshua’s head to a great deal of pressure, and they squeezed the placenta and the umbilical cord, temporarily reducing Joshua’s supply of oxygen.

Fortunately, healthy babies are well-equipped to withstand these traumas. The force of the contractions causes the infant to produce high levels of stress hormones. But in contrast to high maternal stress levels during pregnancy, which can endanger the baby, the infant’s production of stress hormones during childbirth is adaptive. It helps the baby withstand oxygen deprivation by sending a rich supply of blood to the brain and heart (Gluckman, Sizonenko, & Bassett, 1999). In addition, stress hormones prepare the baby to breathe by causing the lungs to absorb any remaining fluid. Finally, stress hormones arouse the infant into alertness (Lagercrantz &Slotkin, 1986). Joshua was born wide awake, ready to interact with the surrounding world.

Assessing the Newborn’s Physical Condition: The Apgar Scale

Infants who have difficulty making the transition to life outside the uterus require special help at once. To assess the newborn’s physical condition quickly, doctors and nurses use the Apgar Scale. As Table 3.2 on page 76 shows, a rating of 0, 1, or 2 on each of five characteristics is made at 1 minute and again at 5 minutes after birth. A combined Apgar score of 7 or better indicates that the infant is in good physical condition. If the score is between 4 and 6, the baby needs assistance in establishing breathing and other vital signs. If the score is 3 or below, the infant is in serious danger and requires emergency medical attention. Two Apgar ratings are given because some babies have trouble adjusting at first but do quite well after a few minutes (Apgar, 1953).

Approaches to Childbirth

Childbirth practices, like other aspects of family life, are molded by the society of which mother and baby are a part. In many village and tribal cultures, expectant mothers are well-acquainted with the childbirth process, having witnessed it many times. They also know that they will be assisted. Among the Mayans of the Yucatán, for example, the mother leans against a woman called the “head helper,” who supports her weight and breathes with her during each contraction (Jordan, 1993).

In Western nations, childbirth has changed dramatically over the centuries. Before the late 1800s, birth usually took
TABLE 3.2  The Apgar Scale

<table>
<thead>
<tr>
<th>Sign</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>No heartbeat</td>
<td>Under 100 beats per minute</td>
<td>100 to 140 beats per minute</td>
</tr>
<tr>
<td>Respiratory effort</td>
<td>No breathing for 60 seconds</td>
<td>Irregular, shallow breathing</td>
<td>Strong breathing and crying</td>
</tr>
<tr>
<td>Reflex irritability (sneezing, coughing, and grimacing)</td>
<td>No response</td>
<td>Weak reflexive response</td>
<td>Strong reflexive response</td>
</tr>
<tr>
<td>Muscle tone</td>
<td>Completely limp</td>
<td>Weak movements of arms and legs</td>
<td>Strong movements of arms and legs</td>
</tr>
<tr>
<td>Color&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Blue body, arms, and legs</td>
<td>Body pink with blue arms and legs</td>
<td>Body, arms, and legs completely pink</td>
</tr>
</tbody>
</table>

*The skin tone of nonwhite babies makes it difficult to apply the "pink" color criterion. However, newborns of all races can be rated for pinkish glow resulting from the flow of oxygen through body tissues.*

Source: Apgar, 1953.

place at home and was a family-centered event. The industrial revolution brought greater crowding to cities, along with new health problems. As a result, childbirth moved from home to the hospital, where the health of mothers and babies could be protected. Once doctors assumed responsibility for childbirth, women’s knowledge of it declined, and relatives and friends no longer participated (Borst, 1995).

By the 1950s and 1960s, women had begun to question the medical procedures that had come to be used routinely during labor and delivery. Many felt that use of strong drugs and delivery instruments had robbed them of a precious experience and were often neither necessary nor safe for the baby. Gradually, a natural childbirth movement arose in Europe and spread to North America. Its purpose was to make hospital birth as comfortable and rewarding for mothers as possible. Today, most hospitals offer birth centers that are family-centered and home-like and that encourage early contact between parents and baby.

**Natural, or Prepared, Childbirth**

Yolanda and Jay chose natural, or prepared, childbirth—a group of techniques aimed at reducing pain and medical intervention and making childbirth as rewarding an experience as possible. Although many natural childbirth programs exist, most draw on methods developed by Grantly Dick-Read (1959) in England and Fernand Lamaze (1958) in France. These physicians recognized that cultural attitudes had taught women to fear the birth experience. An anxious, frightened woman in labor tenses muscles, turning the mild pain that sometimes accompanies strong contractions into intense pain.

In a typical natural childbirth program, the expectant mother and a companion (a partner, relative, or friend) participate in three activities:

- **Classes.** Yolanda and Jay attended a series of classes in which they learned about the anatomy and physiology of labor and delivery. Knowledge about the birth process reduces a mother’s fear.

- **Relaxation and breathing techniques.** During each class, Yolanda practiced breathing exercises aimed at counteracting the pain of uterine contractions.
Interaction with infants in the days after birth (Kennell et al., 1991) at home increased during the 1970s and 1980s but remains small, at about 1 percent (Studelska, 2006). Additional training in childbirth management is an important part of the success of natural childbirth techniques. It is associated with shorter labors, fewer birth complications, higher newborn Apgar scores, and more positive maternal interaction with infants in the days after birth (Kennell et al., 1991; Sauls, 2002; Sosa et al., 1980).

Home Delivery

Home birth has always been popular in certain industrialized nations, such as England, the Netherlands, and Sweden. The number of North American women choosing to have their babies at home increased during the 1970s and 1980s but remains small, at about 1 percent (Studelska, 2006). Although some home births are attended by doctors, many more are handled by certified nurse-midwives, who have degrees in nursing and additional training in childbirth management.

Is it just as safe to give birth at home as in a hospital? For healthy women who are assisted by a well-trained doctor or midwife, it seems so because complications rarely occur (Fullerton, Navarro, & Young, 2007; Johnson & Daviss, 2005). However, if attendants are not carefully trained and prepared to handle emergencies, the rate of infant death is high (Mehlmadrona & Madrona, 1997). When mothers are at risk for any kind of complication, the appropriate place for labor and delivery is the hospital, where life-saving treatment is available.

Medical Interventions

Four-year-old Melinda walks with a halting, lumbering gait and has difficulty keeping her balance. She has cerebral palsy, a general term for a variety of impairments in muscle coordination caused by brain damage before, during, or just after birth. For about 10 percent of these children, including Melinda, brain damage was caused by anoxia, or inadequate oxygen supply, during labor and delivery (Anslow, 1998; Bracci, Perrone, & Buonocore, 2006). Her mother got pregnant accidentally, was frightened and alone, and arrived at the hospital at the last minute. Melinda was in breech position, turned so that the buttocks or feet would be delivered first, and the umbilical cord was wrapped around her neck. Had her mother come to the hospital earlier, doctors could have monitored Melinda’s condition and delivered her surgically as soon as squeezing of the umbilical cord led to distress, thereby reducing the damage or preventing it entirely.

In cases like Melinda’s, medical interventions are clearly justified. But in others, they can interfere with delivery and even pose new risks. In the following sections, we examine some commonly used medical procedures during childbirth.

Fetal Monitoring

Fetal monitors are electronic instruments that track the baby’s heart rate during labor. An abnormal heartbeat may indicate that the baby is in distress due to anoxia and needs to be delivered immediately. Continuous fetal monitoring, which is required in most U.S. hospitals, is used in over 80 percent of American births (Natale & Dodman, 2003). The most popular type of monitor is strapped across the mother’s abdominal throughout labor. A second, more accurate method involves threading a recording device through the cervix and placing it directly under the baby’s scalp.

Fetal monitoring is a safe medical procedure that has saved the lives of many babies in high-risk situations. But in healthy pregnancies, it does not reduce the already low rates of infant brain damage and death (Priddy, 2004). Furthermore, most infants have some heartbeat irregularities during labor, so critics worry that fetal monitors identify many babies as in danger who, in fact, are not. Monitoring is linked to an increase in the number of cesarean (surgical) deliveries, which we will discuss shortly (Thacker & Stroup, 2003).

Still, fetal monitors will probably continue to be used routinely in the United States, even though they are not necessary in most cases. Doctors fear that they will be sued for malpractice if an infant dies or is born with problems and they cannot show that they did everything possible to protect the baby.

Labor and Delivery Medication

Some form of medication is used in more than 80 percent of U.S. births (Althaus & Wax, 2005). Analgesics, drugs used to re-
lieve pain, may be given in mild doses during labor to help a mother relax. **Anesthetics** are a stronger type of painkiller that blocks sensation. Currently, the most common approach to controlling pain during labor is **epidural analgesia**, in which a regional pain-relieving drug is delivered continuously through a catheter into a small space in the lower spine, numbing the pelvic region. Because the mother retains the capacity to feel the pressure of the contractions and to move her trunk and legs, she is able to push during the second stage of labor.

Although pain-relieving drugs help women cope with childbirth and enable doctors to perform essential medical interventions, they also can cause problems. Epidural analgesia, for example, weakens uterine contractions. As a result, labor is prolonged, and the chances of cesarean (surgical) delivery increase (Klein, 2006). And because drugs rapidly cross the placenta, exposed newborns tend to be sleepy and withdrawn, to suck poorly during feedings, and to be irritable when awake (Caton et al., 2002; Eltzschig, Lieberman, & Camann, 2003).

### Cesarean Delivery

A **cesarean delivery** is a surgical birth; the doctor makes an incision in the mother's abdomen and lifts the baby out of the uterus. Forty years ago, cesarean delivery was rare. Since then, cesarean rates have climbed internationally, reaching 16 percent in Finland, 20 percent in New Zealand, 22 percent in Australia, 26 percent in Canada, and 30 percent in the United States (Betrán et al., 2007; Society of Obstetricians and Gynaecologists, 2008; U.S. Department of Health and Human Services, 2008f).

Cesareans have always been warranted by medical emergencies and in breech births, in which the baby risks head injury or anoxia (as in Melinda's case). But these factors do not explain the worldwide rise in cesarean deliveries. Instead, medical control over childbirth is largely responsible. Because many needless cesareans are performed, pregnant women should ask questions about the procedure before choosing a doctor. Although the operation itself is safe, mother and baby require more time for recovery. Anesthetic may have crossed the placenta, making cesarean newborns sleepy and unresponsive and at increased risk for breathing difficulties (McDonagh, Osterweil, & Guise, 2005).

### Ask Yourself

**Review**

Describe the features and benefits of natural childbirth. What aspect contributes greatly to favorable outcomes, and why?

**Apply**

How might use of epidural analgesia negatively affect the parent-newborn relationship? Does your answer illustrate bidirectional influences between parent and child, emphasized in ecological systems theory? Explain.

**Reflect**

If you were an expectant parent, would you choose home birth? Why or why not?

### Preterm and Low-Birth-Weight Infants

The average newborn weighs **7⅛ pounds (3,400 grams)**. Birth weight is the best available predictor of infant survival and healthy development. Many newborns who weigh less than **3⅓ pounds (1,500 grams)** experience difficulties that are not overcome, an effect that becomes stronger as length of pregnancy and birth weight decrease (Bolisetty et al., 2006; Dombrowski, Noonan, & Martin, 2007). Frequent illness, inattention, overactivity, sensory impairments, poor motor coordination, language delays, low intelligence test scores, deficits in school learning, and emotional and behavior problems are some of the difficulties that persist through childhood and adolescence and into adulthood (Bayless, 2007; Grunau, Whitfield, & Fay, 2004; Hultman et al., 2007; Lefebvre, Mazurier, & Tessier, 2005).

About 1 in 13 American infants is born underweight. Although the problem is common among twins (see Chapter 2) and can strike unexpectedly, it is highest among poverty-stricken women (U.S. Department of Health and Human Services, 2007a). These mothers, as noted earlier, are more likely to be undernourished and to be exposed to other harmful environmental influences. In addition, they often do not receive adequate prenatal care.

### Preterm versus Small-for-Date Infants

Despite many obstacles to healthy development, most low-birthweight infants go on to lead normal lives. About half of those born at 23 to 24 weeks' gestation and weighing only a couple of pounds at birth have no disability. To better understand why some babies do better than others, researchers divide them into two groups. **Preterm** infants are those born several weeks or more before their due date. Although they are small, their weight may still be appropriate, based on time spent in the uterus. **Small-for-date** babies are below their expected weight considering length of the pregnancy. Some small-for-date infants are actually full-term. Others are preterm infants who are especially underweight.

Of the two types of babies, small-for-date infants usually have more serious problems. During the first year, they are more likely to die, catch infections, and show evidence of brain damage. By middle childhood, they have lower intelligence test scores, are less attentive, achieve less well in school, and are socially immature (Hediger et al., 2002; O’Keefe et al., 2003). Small-for-date infants probably experienced inadequate nutrition before birth. Perhaps their mothers did not eat properly, the placenta did not function normally, or the babies themselves had defects that prevented them from growing as they should.

Even among preterm newborns whose weight is appropriate for length of pregnancy, just seven more days—from 34 to 35 weeks—greatly reduces rates of illness, costly medical procedures, and lengthy hospital stays (Gladstone & Katz, 2004). And despite being low-risk for disabilities, a substantial number of 34-week preterms are below average in physical growth and
mildly to moderately delayed in cognitive development in early and middle childhood (de Haan et al., 2000; Pietz et al., 2004). Yet doctors often induce births several weeks preterm, under the misconception that these babies are developmentally “mature.”

Consequences for Caregiving

The appearance and behavior of preterm babies—scrawny and thin-skinned, sleepy and unresponsive, irritable when briefly awake—can lead parents to be less sensitive in caring for them. Compared with full-term infants, preterm babies—especially those who are very ill at birth—are less often held close, touched, and talked to gently (Feldman, 2007). When they are born to isolated, poverty-stricken mothers who cannot provide good nutrition, health care, and parenting, the likelihood of unfavorable outcomes increases. In contrast, parents with stable life circumstances and social supports usually can overcome the stresses of caring for a preterm infant. In these cases, even sick preterm babies have a good chance of catching up in development by middle childhood (Ment et al., 2003).

These findings suggest that how well preterm infants develop has a great deal to do with the parent–child relationship. Consequently, interventions directed at supporting both sides of this tie are more likely to help these infants recover.

Interventions for Preterm Infants

A preterm baby is cared for in a special Plexiglas-enclosed bed called an isolete. Temperature is carefully controlled because these babies cannot yet regulate their own body temperature effectively. To help protect the baby from infection, air is filtered before it enters the isolete. Infants born more than six weeks early commonly have a disorder called respiratory distress syndrome. Their tiny lungs are so poorly developed that the air sacs collapse, causing serious breathing difficulties. When a preterm infant breathes with the aid of a respirator, it is fed through a stomach tube, and receives medication through an intravenous needle, the isolete can be very isolating indeed!

- SPECIAL INFANT STIMULATION. In proper doses, certain kinds of stimulation can help fragile preterm infants develop. In some intensive care nurseries, preterm babies rock in suspended hammocks or are exposed to an attractive mobile or a tape recording of a heartbeat, soft music, or the mother’s voice. These experiences promote faster weight gain, more predictable sleep patterns, and greater alertness (Aronn et al., 2006; Marshall-Baker, Lickliter, & Cooper, 1998; Standley, 1998).

Touch is especially important. In baby animals, touching the skin releases brain chemicals that support physical growth—effects believed to occur in humans as well. When preterm infants were massaged several times each day in the hospital, they gained weight faster and, at the end of the first year, were advanced in mental and motor development over preterm babies not given this stimulation (Field, 2001; Field, Hernandez-Reif, & Freedman, 2004).

In developing countries where hospitalization is not always possible, skin-to-skin “kangaroo care,” which is widely used in developing countries to promote the survival and recovery of preterm babies. Because of its many physical and psychological benefits, kangaroo care has spread to western nations, where it supplements hospital intensive care.

- TRAINING PARENTS IN INFANT CAREGIVING SKILLS. Interventions that support parents of preterm infants generally teach them about the infant’s characteristics and promote caregiving skills. For parents with adequate economic and personal resources to care for a preterm infant, just a few sessions of coaching in recognizing and responding to the baby’s needs are linked to steady gains in mental test performance that, after several years, resemble those of full-term children (Achenbach et al., 1990).
When preterm infants live in stressed, low-income households, long-term, intensive intervention is necessary. In the Infant Health and Development Program, preterm babies born into poverty received a comprehensive intervention that combined medical follow-up, weekly parent training sessions, and cognitively stimulating child care from 1 through 3 years of age. More than four times as many intervention children as controls (39 versus 9 percent) were within normal range in intelligence, psychological adjustment, and physical growth (Bradley et al., 1994). In addition, mothers in the intervention group were more affectionate and more often encouraged play and cognitive mastery in their children—one reason their 3-year-olds may have been developing so favorably (McCarton, 1998). At ages 5 and 8, children who had attended the child-care program regularly—for more than 350 days over the three-year period—continued to show better intellectual functioning. In contrast, children who attended only sporadically gained little or even lost ground (Hill, Brooks-Gunn, & Waldfogel, 2003).

**VERY LOW BIRTH WEIGHT, ENVIRONMENTAL ADVANTAGES, AND LONG-TERM OUTCOMES.** Although very-low-birth-weight babies often have lasting problems, in a Canadian study, participants who had weighed between 500 to 1,000 grams at birth were doing well as young adults (Saigal et al., 2006). At 22 to 25 years of age, they resembled normal-birth-weight individuals in educational attainment, rates of marriage and parenthood, and (for those who had no neurological or sensory impairments) employment status. Researchers believe that home, school, and societal advantages combine to explain these excellent outcomes (Hack & Klein, 2006). Most participants were reared in two-parent middle-SES homes, attended good schools where they received special services, and benefited from Canada's government-sponsored, universal health-care system.

But even the best environments cannot “fix” the serious biological risks associated with being born severely underweight. An even better course of action would be to prevent this serious threat to infant survival and development. The high rate of underweight babies in the United States—one of the worst in the industrialized world—could be greatly reduced by improving the health and social conditions described in the Social Issues box on the following pages.

**Birth Complications, Parenting, and Resilience**

In the preceding sections, we considered a variety of birth complications. Can any general principles help us understand how infants who survive a traumatic birth are likely to develop? A landmark study carried out in Hawaii provides answers to this question.

In 1955, Emmy Werner and Ruth Smith began to follow nearly 700 infants on the island of Kauai who had experienced mild, moderate, or severe birth complications. Each was matched on SES and ethnicity with a healthy newborn (Werner & Smith, 1982). Findings revealed that the likelihood of long-term difficulties increased if birth trauma was severe. But among mildly to moderately stressed children, those growing up in stable families did almost as well on measures of intelligence and psychological adjustment as those with no birth problems. Children exposed to poverty, family disorganization, and mentally ill parents often developed serious learning difficulties, behavior problems, and emotional disturbance.

The Kauai study tells us that as long as birth injuries are not overwhelming, a supportive home environment can restore children's growth. But the most intriguing cases in this study were the handful of exceptions. A few children with both fairly serious birth complications and troubled family environments grew into competent, well-adjusted adults. Werner and Smith found that these children relied on factors outside the family and within themselves to overcome stress. Some had attractive personalities that drew positive responses from relatives, neighbors, and peers. In other instances, a grandparent, aunt, uncle, or babysitter provided the needed emotional support (Werner, 1989, 2001; Werner & Smith, 1992).

Do these outcomes remind you of the characteristics of resilient children, discussed in Chapter 1? The Kauai study and other similar investigations reveal that the impact of early biological risks often wanes as children's personal characteristics and social experiences contribute increasingly to their functioning (Resnick et al., 1999). In sum, when the overall balance of life events tips toward the favorable side, children with serious birth problems can develop successfully.

**The Newborn Baby’s Capacities**

Newborn infants have a remarkable set of capacities that are crucial for survival and for evoking adult attention and care. In relating to their physical and social worlds, babies are active from the very start.
A Cross-National Perspective on Health Care and Other Policies for Parents and Newborn Babies

Infant mortality—the number of deaths in the first year of life per 1,000 live births—is an index used around the world to assess the overall health of a nation's children. The United States has the most up-to-date health-care technology in the world, but it has made less progress in reducing infant deaths than many other countries. Over the past three decades, it has slipped in the international rankings, from seventh in the 1950s to twenty-sixth in 2008. Members of America's poor ethnic minorities are at greatest risk. African-American and Native-American babies are twice as likely as white infants to die in the first year of life (U.S. Census Bureau, 2009a, 2009b).

**Neonatal mortality**, the rate of death within the first month of life, accounts for 67 percent of the U.S. infant death rate. Two factors are largely responsible. The first is serious physical defects, most of which cannot be prevented. The percentage of babies born with physical defects is about the same in all ethnic and income groups. The second leading cause of neonatal mortality is low birth weight, which is largely preventable. African-American and Native-American babies are more than twice as likely as white infants to be born early and underweight (U.S. Census Bureau, 2009b).

Widespread poverty and weak health-care programs for mothers and young children are largely responsible for these trends. Each country in Figure 3.5 that outranks the United States in infant survival provides all its citizens with government-sponsored health-care benefits. And each takes extra steps to make sure that pregnant mothers and babies have access to good nutrition, high-quality medical care, and social and economic supports that promote effective parenting.

For example, all Western European nations guarantee women a certain number of prenatal visits at very low or no cost. After a baby is born, a health professional routinely visits the home to provide counseling about infant care and to arrange continuing medical services. Paid, job-protected employment leave is another vital societal intervention for new parents. Canadian mothers are eligible for 15 weeks' maternity leave at 55 percent of prior earnings (up to a maximum of $413 per week), and Canadian mothers or fathers can take an additional year of parental leave at the same rate in certain cases—for example, when a child is ill following birth or adoption. Paid leave is widely available in other industrialized nations as well. Sweden has the most generous parental leave program in the world. Mothers can begin maternity leave 60 days prior to expected delivery, extending it to six weeks after birth; fathers are granted two weeks of birth leave. In addition, either parent

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**FIGURE 3.5** Infant mortality in 30 nations. Despite its advanced health-care technology, the United States ranks poorly. It is twenty-eighth in the world, with a death rate of 6.6 infants per 1,000 births. (Adapted from U.S. Census Bureau, 2009a.)

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This Inuit mother, from Baffin Island in northernmost Canada, experienced pregnancy complications and had to be flown 190 miles to deliver her son. Limited access to health care and social services in remote areas compromises the future of many Inuit newborns.
Newborn Reflexes

A reflex is an inborn, automatic response to a particular form of stimulation. Reflexes are the newborn baby’s most obvious organized patterns of behavior. When Jay let Joshua’s head drop slightly, Joshua reacted with the Moro (or “embracing”) reflex, flinging his arms wide and bringing them back toward his body. As Yolanda stroked Joshua’s cheek, he turned his head in her direction—a response called the rooting reflex. When she put her finger in Joshua’s palm, he grabbed on tightly, in the palmar grasp reflex.

Some reflexes have survival value. In our evolutionary past when infants were carried about all day, the Moro reflex helped a baby who lost support to embrace and, along with the grasp reflex, regain its hold on the mother’s body. The rooting reflex helps a breastfed baby find the mother’s nipple. Babies display it only when hungry and touched by another person, not when they touch themselves (Rochat & Hespos, 1997). And if newborns could not suck, our species would be unlikely to survive for a single generation! At birth, babies adjust their sucking pressure to how easily milk flows from the nipple (Craig & Lee, 1999).

A few reflexes form the basis for complex motor skills that will develop later. The stepping reflex looks like a primitive walking response. Unlike other reflexes, it appears in a wide range of situations—with the newborn’s body in a sideways or upside-down orientation, with feet touching walls or ceilings, and even with legs dangling in the air (Adolph & Berger, 2006). When stepping is exercised regularly, babies are likely to walk several weeks earlier than if stepping is not practiced (Zelazo et al., 1993).

In the Moro reflex, loss of support or a sudden loud sound causes this baby to arch her back, extend her arms outward, and then bring them in toward her body.

The palmar grasp reflex is so strong during the first week after birth that many infants can use it to support their entire weight.

mothers who are eligible for unpaid work leave take far less than 12 weeks, while new fathers tend to take little or none at all (OECD, 2006). In 2002, California became the first state to guarantee a mother or father paid leave—up to six weeks at half salary, regardless of the size of the company. Nevertheless, six weeks of childbirth leave (the norm in the United States) is not enough. When a family is stressed by a baby’s arrival, leaves of six weeks or less are linked to increased maternal anxiety, depression, marital dissatisfaction, sense of role overload (conflict between work and family responsibilities), and negative interactions with the baby. A longer leave (12 weeks or more) predicts favorable maternal mental health, supportive marital interaction, and sensitive caregiving (Feldman, Sussman, & Zigler, 2004; Hyde et al., 2007).

In countries with low infant mortality rates, expectant parents need not wonder how they will get health care and other resources to support their baby’s development. The powerful impact of universal, high-quality health care, generous parental leave, and other social services on maternal and infant well-being provides strong justification for these policies.

In the United States, the federal government mandates only 12 weeks of unpaid leave for employees in businesses with at least 50 workers. Most women, however, work in smaller businesses, and even those who work in large enough companies may be unable to afford to take unpaid leave (Hewlett, 2003). And because of financial pressures, many new mothers who are eligible for unpaid work leave take far less than 12 weeks, while new fathers tend to take little or none at all (OECD, 2006). In 2002, California became the first state to guarantee a mother or father paid leave—up to six weeks at half salary, regardless of the size of the company.

Yet in the United States, the federal government mandates only 12 weeks of unpaid leave for employees in businesses with at least 50 workers. Most women, however, work in smaller businesses, and even those who work in large enough companies may be unable to afford to take unpaid leave (Hewlett, 2003).
However, there is no special need for infants to practice the stepping reflex because all normal babies walk in due time.

Reflexes help parents and infants establish gratifying interaction. A baby who searches for and successfully finds the nipple, sucks easily during feedings, and grasps when the hand is touched encourages parents to respond lovingly. Caregivers can also make use of reflexes in comforting the baby. For example, on short trips with Joshua to the grocery store, Yolanda brought along a pacifier. If he became fussy, sucking helped quiet him until she could feed, change, or hold him.

Most newborn reflexes disappear during the first six months, due to a gradual increase in voluntary control over behavior as the cerebral cortex develops. Pediatricians test reflexes carefully because responses that are weak or absent, overly rigid or exaggerated, or evident beyond the time when they should normally disappear can signal brain damage (Schott & Rossor, 2003).

Newborn States

Throughout the day and night, newborn infants move in and out of five states of arousal, or degrees of sleep and wakefulness, described in Table 3.3. Much to the relief of their fatigued parents, newborns spend the greatest amount of time asleep—about 16 to 18 hours a day. However, striking individual differences in daily rhythms exist that affect parents’ attitudes toward and interaction with the baby. A few newborns sleep for long periods, increasing the energy their well-rested parents have for sensitive, responsive care. Other babies cry a great deal, and their parents must exert great effort to soothe them. If these parents do not succeed, they may feel anxious, less competent, and less positively toward their infant. Babies who spend more time alert probably receive more social stimulation and opportunities to explore and, therefore, may have a slight advantage in mental development (Gertner et al., 2002; Smart & Hiscock, 2007).

### TABLE 3.3 Infant States of Arousal

<table>
<thead>
<tr>
<th>STATE</th>
<th>DESCRIPTION</th>
<th>DAILY DURATION IN NEWBORN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular sleep</td>
<td>The infant is at full rest and shows little or no body activity. The eyelids are closed, no eye movements occur, the face is relaxed, and breathing is slow and regular.</td>
<td>8-9 hours</td>
</tr>
<tr>
<td>Irregular sleep</td>
<td>Gentle limb movements, occasional stirring, and facial grimacing occur. Although the eyelids are closed, occasional rapid eye movements can be seen beneath them. Breathing is irregular.</td>
<td>8-9 hours</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>The infant is either falling asleep or waking up. Body is less active than in irregular sleep but more active than in regular sleep. The eyes open and close; when open, they have a glazed look. Breathing is even but somewhat faster than in regular sleep.</td>
<td>Varies</td>
</tr>
<tr>
<td>Quiet alertness</td>
<td>The infant’s body is relatively inactive, with eyes open and attentive. Breathing is even.</td>
<td>2-3 hours</td>
</tr>
<tr>
<td>Waking activity and crying</td>
<td>The infant shows frequent bursts of uncoordinated body activity. Breathing is very irregular. Face may be relaxed or tense and wrinkled. Crying may occur.</td>
<td>1-4 hours</td>
</tr>
</tbody>
</table>


Of the states listed in Table 3.3, the two extremes—sleep and crying—have been of greatest interest to researchers. Each tells us something about normal and abnormal early development.

**SLEEP.** Observing Joshua as he slept, Yolanda and Jay wondered why his eyelids and body twitched and his rate of breathing varied. Sleep is made up of at least two states. During irregular, or rapid-eye-movement (REM), sleep, brain-wave activity is remarkably similar to that of the waking state. The eyes dart beneath the lids; heart rate, blood pressure, and breathing are uneven; and slight body movements occur. In contrast, during regular, or non-rapid-eye-movement (NREM) sleep, the body is almost motionless, and heart rate, breathing, and brain-wave activity are slow and even.

Like children and adults, newborns alternate between REM and NREM sleep, but they spend far more time in the REM state than they ever will again. REM sleep accounts for 50 percent of a newborn baby’s sleep time. By 3 to 5 years, it has declined to an adultlike level of 20 percent (Louis et al., 1997). The stimulation of REM sleep is vital for growth of the central nervous system. Young infants seem to have a special need for this stimulation because they spend little time in an alert state, when they can get input from the environment. The percentage of REM sleep is especially great in the fetus and in preterm babies, who are even less able than full-term newborns to take advantage of external stimulation (de Weerd & van den Bosche, 2003; DiPietro et al., 1996).

Because normal newborn sleep behavior is organized and patterned, observations of sleep states can help identify central nervous system abnormalities. In infants who are brain-damaged or who have experienced birth trauma, disturbed REM–NREM sleep cycles are often present. Babies with poor sleep organization are likely to be behaviorally disorganized and, therefore, to have difficulty learning and evoking caregiver interactions that enhance their development. In the preschool
years, they show delayed motor, cognitive, and language development (Feldman, 2006; Holditch-Davis, Belyea, & Edwards, 2005). And the brain-functioning problems that underlie newborn sleep irregularities may culminate in sudden infant death syndrome, a major cause of infant mortality (see the Biology and Environment box on the following page).

**CRYING.** Crying is the first way that babies communicate, letting parents know they need food, comfort, or stimulation. The baby’s cry is a complex stimulus that varies in intensity, from a whimper to a message of all-out distress (Gustafson, Wood, & Green, 2000). But most of the time, the nature of the cry, combined with the experiences leading up to it, helps guide parents toward its cause.

Young infants usually cry because of physical needs, most commonly hunger, but babies may also cry in response to temperature change when undressed, a sudden noise, or a painful stimulus. Newborns (as well as older babies) often cry at the sound of another crying baby (Dondi, Simion, & Caltran, 1999). Some researchers believe that this response reflects an inborn capacity to react to the suffering of others. Furthermore, crying typically increases during the early weeks, peaks at about six weeks, and then declines. Because this trend appears in many cultures with vastly different infant care practices, researchers believe that normal readjustments of the central nervous system underlie it (Barr, 2001).

**Soothing Crying Infants.** Although parents do not always interpret their baby’s cry correctly, their accuracy improves with experience (Thompson & Leger, 1999). Fortunately, there are many ways to soothe a crying baby when feeding and diaper changing do not work. The technique Western parents usually try first, lifting the baby to the shoulder and rocking or walking, is the most effective. Another common soothing method is swaddling—wrapping the baby snugly in a blanket. The Quechua, who live in the cold, high-altitude desert regions of Peru, dress their young babies in layers of clothing and blankets that cover the head and body. In addition to reducing crying and promoting sleep, swaddling helps babies conserve energy for early growth in the harsh Peruvian highlands (Tronick, Thomas, & Daltabuit, 1994).

In many tribal and village societies and non-Western developed nations, infants spend most of the day and night in close physical contact with their caregivers. Among the !Kung of the desert regions of Botswana, Africa, mothers sling their young babies on their hips, so infants can see their surroundings and nurse at will. Japanese mothers and babies also spend much time in close body contact (Small, 1998). Infants in these cultures show shorter bouts of crying than their North American counterparts (Barr, 2001).

**Abnormal Crying.** Like reflexes and sleep patterns, the infant's cry offers a clue to central nervous system distress. The cries of brain-damaged babies and those who have experienced prenatal and birth complications are often shrill, piercing, and shorter in duration than those of healthy infants (Green, Irwin, & Gustafson, 2000). Even newborns with a fairly common problem—colic, or persistent crying—tend to have high-pitched, harsh-sounding cries (Zeskind & Barr, 1997). Although the cause of colic is unknown, certain newborns, who react especially strongly to unpleasant stimuli, are susceptible.
The Mysterious Tragedy of 
Sudden Infant Death Syndrome

Millie awoke with a start one morning and looked at the clock. It was 7:30, and Sasha had missed both her night waking and her early morning feeding. Wondering if she was all right, Millie and her husband Stuart tiptoed into the room. Sasha lay still, curled up under her blanket. She had died silently during her sleep.

Sasha was a victim of sudden infant death syndrome (SIDS), the unexpected death, usually during the night, of an infant under 1 year of age that remains unexplained after thorough investigation. In industrialized nations, SIDS is the leading cause of infant mortality between 1 and 12 months, accounting for about 20 percent of these deaths in the United States (Mathews & MacDorman, 2008). Although the precise cause of SIDS is not known, its victims usually show physical problems from the beginning. Early medical records of SIDS babies reveal higher rates of prematurity and low birth weight, poor Apgar scores, and limp muscle tone. Abnormal heart rate and respiration and disturbances in sleep-wake activity and in REM-NREM cycles while asleep are also involved (Cornwell & Feigenbaum, 2006; Kato et al., 2003). At the time of death, many SIDS babies have a mild respiratory infection (Samuels, 2003). This seems to increase the chances of respiratory failure in an already vulnerable baby.

One hypothesis about the cause of SIDS is that impaired brain functioning prevents these infants from learning how to respond when their survival is threatened—for example, when respiration is suddenly interrupted. Between 2 and 4 months, when SIDS is most likely to occur, reflexes decline and are replaced by voluntary, learned responses. Respiratory and muscular weaknesses may stop SIDS babies from acquiring behaviors that replace defensive reflexes (Lipsitt, 2003). As a result, when breathing difficulties occur during sleep, infants do not wake up, shift their position, or cry out for help. Instead, they simply give in to oxygen deprivation and death. In support of this interpretation, autopsies reveal that SIDS babies, more often than other infants, show abnormalities in brain centers controlling breathing (Paterson et al., 2006).

In an effort to reduce the occurrence of SIDS, researchers are studying environmental factors related to it. Babies exposed to cigarette smoke both during and after pregnancy are twice as likely as nonexposed infants to die of SIDS (Anderson, Johnson, & Batal, 2005; Shah, Sullivan, & Carter, 2006). Prenatal abuse of drugs that depress central nervous system functioning (opiates and barbiturates) increases the risk of SIDS as much as fifteenfold (Hunt & Hauck, 2006). SIDS babies are also more likely to sleep on their stomachs than on their backs and often are wrapped very warmly in clothing and blankets (Hauck et al., 2003).

Researchers suspect that nicotine, depressant drugs, excessive body warmth, and respiratory infection all lead to physiological stress, which disrupts the normal sleep pattern. When sleep-deprived infants experience a sleep "rebound," they sleep more deeply, which results in loss of muscle tone in the airway passages. In at-risk babies, the airway may collapse, and the infant may fail to arouse sufficiently to reestablish breathing (Simpson, 2001). In other cases, healthy babies sleeping face down on soft bedding may die from continued breathing their own exhaled breath.

Quitting smoking, changing an infant’s sleeping position, and removing a few bedclothes can reduce the incidence of SIDS. Public education campaigns that encourage parents to put their infants down on their backs have helped reduce the incidence of SIDS by half in many Western nations (Bjard & Krous, 2003).

Colic generally subsides between 3 and 6 months (Barr et al., 2005; St. James-Roberts et al., 2003).

Most parents try to respond to a crying baby with extra care and attention, but sometimes the cry is so unpleasant and persistent that parents become frustrated and angry. Preterm and ill babies are more likely to be abused by highly stressed parents, who frequently mention a high-pitched, grating cry as one factor that caused them to lose control (St. James-Roberts, 2007; Zeskind & Lester, 2001). We will discuss a host of additional influences on child abuse in Chapter 8.
Sensory Capacities

On his visit to my class, Joshua looked wide-eyed at my bright pink blouse and turned to the sound of his mother's voice. During feedings, he lets Yolanda know through his sucking rhythm that he prefers the taste of breast milk to a bottle of plain water. In the following sections, we explore the newborn's responsiveness to touch, taste, smell, sound, and visual stimulation.

• TOUCH. In our discussion of preterm infants, we saw that touch helps stimulate early physical growth. As we will see in Chapter 6, it is vital for emotional development as well. Therefore, it is not surprising that sensitivity to touch is well-developed at birth. The newborn responds to touch, especially around the mouth, on the palms, and on the soles of the feet. During the prenatal period, these areas, along with the genitals, are the first to become sensitive to touch (Humphrey, 1978; Streri, 2005).

At birth, infants are highly sensitive to pain. If male newborns are circumcised, anesthetic is sometimes not used because of the risk of giving drugs to a very young infant. Babies often respond with a high-pitched, stressful cry and a dramatic rise in heart rate, blood pressure, palm sweating, pupil dilation, and muscle tension (Lehr et al., 2007; Warnock & Sandrin, 2004). Brain-imaging research suggests that because of central nervous system immaturity, preterm and male babies feel the pain of a medical injection especially intensely (Bartocci et al., 2006).

Recent research establishing the safety of certain local anesthetics for newborns promises to ease the pain of these procedures. Offering a nipple that delivers a sugar solution is also helpful in reducing crying and discomfort, and combining the sweet liquid with gentle holding by the parent lessens pain even more. Research on infant mammals indicates that physical touch releases endorphins—painkilling chemicals in the brain (Axelin, Salantera, & Lehtonen, 2006; Gormally et al., 2001).

• TASTE AND SMELL. Newborns can distinguish several basic tastes. Like adults, they relax their facial muscles in response to sweetness, purse their lips when the taste is sour, and show a distinct archlike mouth opening when it is bitter (Steiner, 1979; Steiner et al., 2001). These reactions are important for survival: The food that best supports the infant's early growth is the sweet-tasting milk of the mother's breast. Not until 4 months do babies prefer a salty taste to plain water, a change that may prepare them to accept solid foods (Mennella & Beauchamp, 1998).

As with taste, certain odor preferences are present at birth. The smell of bananas or chocolate causes a relaxed, pleasant facial expression, whereas the odor of rotten eggs makes the infant frown (Steiner, 1979). During pregnancy, the amniotic fluid is rich in tastes and smells that vary with the mother's diet—early experiences that influence newborns' preferences. In a study carried out in the Alsatian region of France, where anise is frequently used to flavor foods, researchers tested newborns for their reaction to the anise odor (Schaal, Marlier, & Soussignan, 2000). The mothers of some babies had regularly consumed anise during the last two weeks of pregnancy; the other mothers had never consumed it. When presented with the anise odor on the day of birth, the babies of non-anise-consuming mothers were far more likely to turn away with a negative facial expression (see Figure 3.6). These different reactions were still apparent four days later, even though all mothers had refrained from consuming anise during this time.

In many mammals, the sense of smell plays an important role in feeding and in protecting the young from predators by helping mothers and babies identify each other. Although smell is less well-developed in humans, traces of its survival value remain. If one breast is washed to remove its natural scent, most newborns grasp the unwashed breast, indicating that they are guided by smell (Varendi & Porter, 2001). At 4 days of age, breastfed babies prefer the smell of their own mother’s breast to that of an unfamiliar lactating mother (Cernoch & Porter, 1985). And both breast- and bottle-fed 3- to 4-day-olds orient more and display more mouthing to the smell of unfamiliar
And babies only a few days old can tell the difference between sounds with negative or neutral emotional qualities (Mastropieri & Turkewitz, 1999; Sansavini, Bertoncini, & Trehub, 2004). Naturally similar nonspeech sounds (Vouloumanos, 2001) help newborns by initially distinguishing their caregiver from other people. Responses by newborns of anise-consuming mothers spent more time turning toward the odor and sucking, licking, and chewing. Responses by newborns of non-anise-consuming mothers more often turned away with a negative facial expression (From B. Schaal, L. Marlier, & R. Soussignan, 2000, "Human Foetuses Learn Odours from Their Pregnant Mother's Diet," Chemical Senses, 25, p. 731. Reprinted by permission of Benoist Schaal.)

Newborn infants can hear a wide variety of speech sounds. Indeed, researchers have found only a few speech sounds in human languages that newborns cannot discriminate (Saffran, Werker, & Werner, 2006). These capacities reveal that the baby is marvelously prepared for the awesome task of acquiring language.

Immediately after birth, infants will suck more on a nipple to hear a recording of their mother's voice than that of an unfamiliar woman and to hear their native language as opposed to a foreign language—preferences that may have developed from hearing the muffled sounds of the mother's voice before birth (Moon, Cooper, & Fifer, 1993; Spence & DeCasper, 1987).

**FIGURE 3.6** Examples of facial expressions of newborns exposed to the odor of anise whose mothers' diets differed in anise-flavored foods during late pregnancy. (a) Babies of anise-consuming mothers spent more time turning toward the odor and sucking, licking, and chewing. (b) Babies of non-anise-consuming mothers more often turned away with a negative facial expression. (From B. Schaal, L. Marlier, & R. Soussignan, 2000, "Human Foetuses Learn Odours from Their Pregnant Mother's Diet," Chemical Senses, 25, p. 731. Reprinted by permission of Benoist Schaal.)

As a result, newborns cannot focus their eyes well, and visual acuity, or fineness of discrimination, is limited. At birth, infants perceive objects at a distance of 20 feet about as clearly as adults do at 600 feet (Slater, 2001). In addition, unlike adults (who see nearby objects most clearly), newborn babies see unclearly across a wide range of distances (Banks, 1980; Hainline, 1998). Images such as the parent's face, even from close up, look blurred. Nevertheless, newborns prefer to look at simple, facelike stimuli over patterns with scrambled facial features (Monfils et al., 1999). And they gaze more at colored rather than gray stimuli, although they are not yet good at discriminating colors (Adams & Courage, 1998; Kellman & Arterberry, 2006). Despite limited vision and slow, imprecise eye movements, newborns actively explore their visual world by scanning it for interesting sights and tracking moving objects.

**HEARING.** Newborn infants can hear a wide variety of sounds, and their sensitivity improves greatly over the first few months (Saffran, Werker, & Werner, 2006). At birth, infants prefer complex sounds, such as noises and voices, to pure tones. And babies only a few days old can tell the difference between a few sound patterns—a series of tones arranged in ascending versus descending order, utterances with two versus three syllables, the stress patterns of words, such as ma-ma versus ma-ma, and happy-sounding speech as opposed to speech with negative or neutral emotional qualities (Mastropieri & Turkewitz, 1999; Sansavini, Bertoncini, & Giovannelli, 1997; Trehub, 2001).

Young infants listen longer to human speech than structurally similar nonspeech sounds (Vouloumanos & Werker, 2004). And they make fine-grained distinctions among many

**ASK YOURSELF**

**REVIEW**
What functions does REM sleep serve in young infants? Can sleep tell us anything about the health of the newborn's central nervous system? Explain.

**APPLY**
How do the diverse capacities of newborn babies contribute to their first social relationships? Provide as many examples as you can.

**REFLECT**
Are newborns more competent than you thought they were before you read this chapter? Which of their capacities most surprised you?
Adjusting to the New Family Unit

Nature helps prepare expectant mothers and fathers for their new role. Toward the end of pregnancy, mothers begin producing the hormone oxytocin, which stimulates uterine contractions; causes the breasts to "let down" milk; induces a calm, relaxed mood; and promotes responsiveness to the baby (Russell, Douglas, & Ingram, 2001). And in several studies, first-time fathers enrolled in prenatal classes showed hormonal changes around the time of birth—specifically, slight increases in prolactin (a hormone that stimulates milk production in females) and estrogens (sex hormones produced in larger quantities in females) and a drop in androgens (sex hormones produced in larger quantities in males). In animal and human research, these changes are associated with positive emotional reactions to infants (Storey et al., 2000; Wynne-Edwards, 2001).

Although birth-related hormones can facilitate caregiving, their release and effects may depend on experiences, such as a positive couple relationship and paternal close contact with the pregnant mother. Furthermore, humans can parent effectively without experiencing birth-related hormonal changes, as successful adoption reveals. And as we have seen, a great many factors—family functioning to social policies—are involved in good infant care.

Indeed, the early weeks after the baby's arrival are full of profound challenges. The mother needs to recuperate from childbirth. If she is breastfeeding, energies must be devoted to working out this intimate relationship. The father needs to support the mother in her recovery and become a part of this new threesome. At times, he may feel ambivalent about the baby, who constantly demands and gets the mother's attention. And as we will see in Chapter 6, siblings—especially those who are young and firstborn—understandably feel displaced. They sometimes react with jealousy and anger.

While all this is going on, the tiny infant demands to be fed, changed, and comforted at odd times of the day and night. The family schedule becomes irregular and uncertain. Yolanda spoke candidly about the changes she and Jay experienced:

When we brought Joshua home, he seemed so small and helpless, and we worried about whether we would be able to take proper care of him. It took us 20 minutes to change the first diaper! I rarely feel rested because I'm up two to four times every night, and I spend a good part of my waking hours trying to anticipate Joshua's rhythms and needs. If Jay weren't so willing to help by holding and walking Joshua, I think I'd find it much harder.

How long does this time of adjustment to parenthood last? In Chapter 14, we will see that when marital relationships are positive, social support is available, and families have sufficient income, the stress caused by the birth of a baby remains manageable. Nevertheless, as one pair of counselors who have worked with many new parents pointed out, "As long as children are dependent on their parents, those parents find themselves preoccupied with thoughts of their children, This does not keep them from enjoying other aspects of their lives, but it does mean that they never return to being quite the same people they were before they became parents" (Colman & Colman, 1991, p. 198).

Summary

Prenatal Development

List the three phases of prenatal development, and describe the major milestones of each.

» The period of the zygote lasts about two weeks, from fertilization until implantation of the blastocyst in the uterine lining. During this time, structures that will support prenatal growth begin to form, including the placenta and the umbilical cord.

» The period of the embryo lasts from two to eight weeks, during which the foundations for all body structures are laid down. In the first week of this period, the neural tube forms, and the nervous system starts to develop.

Other organs follow and grow rapidly. At the end of this phase, the embryo responds to touch and can move.

» The period of the fetus, lasting until the end of pregnancy, involves dramatic increase in body size and completion of physical structures. At the end of the second trimester, most of the brain's neurons are in place. At the beginning of the third trimester, between 22 and 26 weeks, the fetus reaches the age of viability. The brain continues to develop rapidly, and new sensory and behavioral capacities emerge. The lungs, gradually mature, the fetus fills the uterus, and birth is near.

Prenatal Environmental Influences

What are teratogens, and what factors influence their impact?

» Teratogens are environmental agents that cause damage during the prenatal period. Their impact varies with the amount and length of exposure, the genetic makeup of mother and fetus, the presence or absence of other harmful agents, and the age of the organism at time of exposure. The developing organism is especially vulnerable during the embryonic period.
List agents that are known or suspected teratogens, and discuss evidence supporting the harmful impact of each.

» Currently, the most widely used potent teratogen is Accutane, a drug used to treat acne. The prenatal impact of many other commonly used medications, such as aspirin and caffeine, is hard to separate from other factors correlated with drug taking. Babies whose mothers use heroin, methadone, or cocaine during pregnancy are at risk for a wide variety of problems, including prematurity, low birth weight, physical defects, and breathing difficulties around the time of birth.

» Infants of parents who use tobacco are often born underweight and may have attention, learning, and behavior problems in childhood. Maternal alcohol consumption can lead to fetal alcohol spectrum disorder (FASD). Fetal alcohol syndrome (FAS) involves slow physical growth, facial abnormalities, and impairment in mental functioning. Milder forms—partial fetal alcohol syndrome (p-FAS) and alcohol-related neurodevelopmental disorder (ARND)—affect children whose mothers consumed smaller quantities of alcohol.

» Prenatal exposure to high levels of radiation, mercury, PCBs, lead, and dioxins leads to physical malformations and severe brain damage. Low-level exposure has also been linked to diverse impairments, including lower intelligence test scores and, in the case of radiation, language and emotional disorders.

» Among infectious diseases, rubella (German measles) causes a wide variety of abnormalities. Babies with prenatally transmitted HIV rapidly develop AIDS, leading to rapid physical decline and early death. Cytomegalovirus, herpes simplex 2, and toxoplasmosis can also be devastating to the fetus.

Describe the impact of other maternal factors on prenatal development.

» When the mother’s diet is inadequate, low birth weight and damage to the brain and other organs are major concerns. A folic acid supplement greatly reduces neural tube abnormalities.

» Severe emotional stress is linked to many pregnancy complications, although its impact can be reduced by providing the mother with emotional support. Rh factor incompatibility—an Rh-negative mother carrying an Rh-positive fetus—can lead to oxygen deprivation, brain and heart damage, and infant death.

» Aside from the risk of chromosomal abnormalities in older women, maternal age through the thirties is not a major cause of prenatal problems. Poor health and environmental risks associated with poverty are the strongest predictors of pregnancy complications.

Why is early and regular health care vital during the prenatal period?

» Unexpected difficulties, such as preeclampsia, can arise, especially when mothers have health problems to begin with. Yet many U.S. low-income women lack health insurance or experience situational barriers that prevent them from seeking prenatal care.

Approaches to Childbirth

Describe natural childbirth and home delivery, noting any benefits and concerns associated with each.

» Natural, or prepared, childbirth involves classes in which prospective parents learn about labor and delivery, relaxation and breathing techniques to counteract pain, and coaching during childbirth. Social support, a vital part of natural childbirth, is linked to fewer birth complications and shorter labors. Home birth is safe for healthy mothers who are assisted by a well-trained doctor or midwife, but mothers at risk for any kind of complication are safer giving birth in a hospital.

Medical Interventions

List common medical interventions during childbirth, circumstances that justify their use, and any dangers associated with each.

» When pregnancy and birth complications make anoxia likely, fetal monitors help save the lives of many babies. However, when used routinely, they may identify infants as in danger who, in fact, are not.

» Medication to relieve pain is necessary in complicated deliveries. When given in large doses, it may prolong labor and produce a depressed state in the newborn that affects the early mother-infant relationship.

» Cesarean deliveries are justified in cases of medical emergency and serious maternal illness and sometimes when babies are in breech position. Many unnecessary cesareans are performed, especially in the United States.

Preterm and Low-Birth-Weight Infants

Describe risks associated with preterm birth and low birth weight, along with effective interventions.

» Low birth weight, a major cause of neonatal infant mortality and wide-ranging developmental problems, is most common in infants born to poverty-stricken women. Compared with preterm infants, whose weight is appropriate for time spent in the uterus, small-for-date infants usually have longer-lasting difficulties.

» Some interventions provide special stimulation in the intensive care nursery. Others teach parents how to care for and interact with their babies. Preterm infants in stressed, low-income households need long-term, intensive intervention.
Birth Complications, Parenting, and Resilience

What factors predict positive outcomes in infants who survive a traumatic birth?

> When infants experience birth trauma, a supportive home environment can help restore their growth. Even infants with fairly serious birth complications can recover with the help of favorable experiences with parents, relatives, neighbors, and peers.

The Newborn Baby’s Capacities

Describe the newborn baby’s reflexes and states of arousal, including sleep characteristics and ways to soothe a crying baby.

> Reflexes are the newborn baby’s most obvious organized patterns of behavior. Some have survival value, others provide the foundation for voluntary motor skills, and still others contribute to early social relationships.

> A crying baby stimulates strong feelings of discomfort in nearby adults. The intensity of the cry and the experiences that led up to it help parents identify what is wrong. Once feeding and diaper changing have been tried, the most effective soothing technique is lifting the baby to the shoulder and rocking and walking.

Adjusting to the New Family Unit

Describe typical changes in the family after the birth of a new baby.

> The new baby’s arrival is exciting but stressful, as the mother recuperates from childbirth and the family schedule becomes irregular and uncertain. When parents are sensitive to each other’s needs, adjustment problems are usually temporary, and the transition to parenthood goes well.

Important Terms and Concepts

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Babies acquire new motor skills by building on previously acquired capacities. Eager to explore his world, this baby has just about mastered the art of crawling. Once he can fully move on his own, he will make dramatic strides in understanding his surroundings.
n a brilliant June morning, 16-month-old Caitlin emerged from her front door, ready for the short drive to the child-care home where she spent her weekdays while her mother, Carolyn, and her father, David, worked. Clutching a teddy bear in one hand and her mother’s arm with the other, Caitlin descended the steps. “One! Two! Thre­eeeee!” Carolyn counted as she helped Caitlin down. “How much she’s changed,” Carolyn thought to herself, looking at the child who, not long ago, had been a newborn. With her first steps, Caitlin had passed from infancy to toddlerhood—a period spanning the second year of life. At first, Caitlin did, indeed, “toddle” awkwardly, rocking from side to side and frequently tipping over. But her face reflected the thrill of conquering a new skill.

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

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

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

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

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

**Body Growth**

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

**Changes in Body Size and Muscle–Fat Makeup**

By the end of the first year, a typical infant’s height is about 32 inches—more than 50 percent greater than at birth. By 2 years, it is nearly 75 percent greater (36 inches). Similarly, by 5 months of age, birth weight has doubled, to about 15 pounds. At 1 year it has tripled, to 22 pounds, and at 2 years it has quadrupled, to about 30 pounds. Figure 4.1 illustrates this dramatic increase in body size.

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

**Individual and Group Differences**

In infancy, girls are slightly shorter and lighter than boys, with a higher ratio of fat to muscle. These small sex differences persist throughout early and middle childhood and are greatly magnified at adolescence. Ethnic differences in body size are apparent as well. Grace was below the growth norms (height and weight averages for children her age). Early malnutrition contributed, but even after substantial catch-up Grace—as is typical for Asian children—remained below North American norms. In contrast, Timmy is slightly above average, as African-American children tend to be (Bogin, 2001).
Children of the same age also differ in rate of physical growth; some progress more rapidly than others. The best way of estimating a child's physical maturity is to use skeletal age, a measure of bone development. It is determined by X-raying the long bones of the body to see the extent to which soft, pliable cartilage has hardened into bone, a gradual process that is completed in adolescence. When skeletal ages are examined, African-American children tend to be slightly ahead of Caucasian children at all ages, and girls are considerably ahead of boys (Tanner, Healy, & Cameron, 2001). Girls' greater physical maturity may contribute to their greater resistance to harmful environmental influences. As noted in Chapter 2, girls experience fewer developmental problems and have lower infant and childhood mortality rates.

Changes in Body Proportions

As the child's overall size increases, different parts of the body grow at different rates. Two growth patterns describe these changes. The first is the cephalocaudal trend—from the Latin for "head to tail." During the prenatal period, the head develops more rapidly than the lower part of the body. At birth, the head takes up one-fourth of total body length, the legs only one-third. Notice how, in Figure 4.1, the lower portion of the body catches up. By age 2, the head accounts for only one-fifth and the legs for nearly one-half of body length.

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

**Brain Development**

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

**Development of Neurons**

The human brain has 100 to 200 billion neurons, or nerve cells that store and transmit information, many of which have thousands of direct connections with other neurons. Unlike other body cells, neurons are not tightly packed together. Between them are synapses—tiny gaps where fibers from different neurons come close together but do not touch (see Figure 4.2). Neurons send messages to one another by releasing chemicals called neurotransmitters, which cross the synapse.

The basic story of brain growth concerns how neurons develop and form this elaborate communication system. In the prenatal period, neurons are produced in the embryo's primitive neural tube. From there, they migrate to form the major parts of the brain (see page 64 in Chapter 3). Once neurons are in place, they differentiate, establishing their unique functions by extending their fibers to form synaptic connections with neighboring cells. During the first two years, neural fibers and synapses increase at an astounding pace (Huttenlocher, 2002; Moore & Persaud, 2008). Because developing neurons require space for these connective structures, a surprising aspect of brain growth is that as synapses form, many surrounding neurons die—20 to 80 percent, depending on the brain region (de Haan & Johnson, 2003; Stiles, 2001). Fortunately, during the prenatal period, the neural tube produces far more neurons than the brain will ever need.

As neurons form connections, stimulation becomes vital to their survival. Neurons that are stimulated by input from the surrounding environment continue to establish synapses, forming increasingly elaborate systems of communication that support more complex abilities. At first, stimulation results in massive overabundance of synapses, many of which serve identical functions, thereby ensuring that the child will acquire the motor, cognitive, and social skills that our species needs to survive. Neurons that are seldom stimulated soon lose their synapses, in a process called synaptic pruning that returns neurons not needed at the moment to an uncommitted state so they can support future development (Nelson, Thomas, & de Haan, 2006).

If few neurons are produced after the prenatal period, what causes the dramatic increase in brain size during the first two years? About half the brain's volume consists of glial cells, which are responsible for myelination, the coating of neural fibers with an insulating fatty sheath (called myelin) that increases the efficiency of message transfer. Gial cells multiply dramatically from the end of pregnancy through the second year of life, a process that slows through middle childhood and accelerates again in adolescence. Gains in neural fibers and myelination are responsible for the extraordinary gain in overall size of the brain—from nearly 30 percent of its adult weight at birth to 70 percent by age 2 (Johnson, 2005; Thatcher et al., 1996).

Brain development can be compared to molding a "living sculpture." After neurons and synapses are overproduced, cell death and synaptic pruning sculpt away excess building material to form the mature brain—a process jointly influenced by genetically programmed events and the child's experiences. The resulting sculpture is a set of interconnected regions, each with specific functions—much like countries on a globe that communicate with one another (Johnston et al., 2001).

**Neurophysiological Methods**

This "geography" of the brain permits researchers to study its developing organization and the activity of its regions. To do so, scientists use neurophysiological methods (see Table 4.1).

For example, EEG brain-wave patterns can be examined for stability and organization—signs of mature cortical functioning. As the individual processes a stimulus, ERPs detect the general location of brain-wave activity in the cerebral cortex—a method often used to study preverbal infants' responsiveness to various stimuli and the impact of experience on specialization of cortical regions (DeBoer, Scott, & Nelson, 2007).
### TABLE 4.1  Methods for Measuring Brain Functioning

<table>
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<tr>
<th>METHOD</th>
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<tr>
<td>Electroencephalogram (EEG)</td>
<td>Electrodes, usually embedded in a head cap, are attached to the scalp with conductive gel to record electrical brain-wave activity in the brain's outer layers—the cerebral cortex.</td>
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<tr>
<td>Event-related potentials (ERPs)</td>
<td>Using the EEG, the frequency and amplitude of brain waves in response to particular stimuli (such as a picture, music, or speech) are recorded in the cerebral cortex. Enables identification of general regions of stimulus-induced activity.</td>
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<tr>
<td>Functional magnetic resonance imaging (fMRI)</td>
<td>While the person lies inside a tunnel-shaped apparatus that creates a magnetic field, a scanner magnetically detects increased blood flow and oxygen metabolism in areas of the brain as the individual processes particular stimuli. The result is a computerized moving picture of activity anywhere in the brain (not just its outer layers).</td>
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<tr>
<td>Positron emission tomography (PET)</td>
<td>After injection or inhalation of a radioactive substance, the person lies inside an apparatus with a scanner that emits fine streams of X-rays, which detect increased blood flow and oxygen metabolism in areas of the brain as the person processes particular stimuli. As with fMRI, the result is a computerized image of activity anywhere in the brain.</td>
</tr>
<tr>
<td>Near-Infrared Optical Topography (NIROT)</td>
<td>Using thin, flexible optical fibers attached to the scalp through a head cap, infrared (invisible) light is beamed at the brain; its absorption by areas of the cerebral cortex varies with changes in blood flow and oxygen metabolism as the individual processes particular stimuli. The result is a computerized moving picture of active areas in the cerebral cortex. Unlike fMRI and PET, NIROT is appropriate for infants and young children, who can move within limited range during testing.</td>
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Neuroimaging techniques, which yield detailed, three-dimensional computerized pictures of the entire brain and its active areas, provide the most precise information about which brain regions are specialized for certain capacities. The most promising of these methods is fMRI. Unlike PET, fMRI does not depend on X-ray photography. Rather, when an individual is exposed to a stimulus, fMRI detects changes in blood flow and oxygen metabolism magnetically, yielding a colorful, moving picture of parts of the brain used to process information or perform an activity (see Figure 4.3a and b).

Because PET and fMRI require the participant to lie as motionless as possible in an enclosed space, they are not suitable for infants and young children (Nelson, Thomas, & de Haan, 2006). A neuroimaging technique that works well in infancy and early childhood is NIROT. Because the apparatus consists only of optical fibers attached to the scalp using a head cap, a baby can sit on the parent’s lap and move during testing—as Figure 4.3c illustrates (Meek, 2002; Taga et al., 2003). Unlike PET and fMRI, which map activity changes throughout the brain, NIROT is limited to examining the functioning of the cerebral cortex.

#### Development of the Cerebral Cortex

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

**REGIONS OF THE CORTEX.** Figure 4.4 shows specific functions of regions of the cerebral cortex. The order in which cortical regions develop corresponds to the order in which various capacities emerge in the infant and growing child. For example, a burst of synaptic growth occurs in the auditory and visual cortices and in areas responsible for body movement over the first year—a period of dramatic gains in auditory and visual perception and mastery of motor skills (Johnson, 2005). Language areas are especially active from late infancy through the preschool years, when language development flourishes (Pujol et al., 2006; Thompson, 2000).

The cortical regions with the most extended period of development are the frontal lobes, which are responsible for thought—in particular, consciousness, inhibition of impulses, integration of information, and use of memory, reasoning, planning, and problem-solving strategies. From age 2 months on, the frontal lobes function more effectively. But they undergo especially rapid myelination and formation and pruning of synapses during the preschool and school years, followed by another period of accelerated growth in adolescence, when the frontal lobes reach an adult level of synapses (Nelson, 2002; Nelson, Thomas, & de Haan, 2006; Sowell et al., 2002).

**LATERALIZATION AND PLASTICITY OF THE CORTEX.** The cerebral cortex has two hemispheres, or sides, that differ in their functions. Some tasks are done mostly by the left hemisphere, others by the right. For example, each hemisphere receives sensory information from the side of the body opposite to it and controls only that side.1 For most of us, the left hemisphere is largely responsible for verbal abilities (such as spoken and written language) and positive emotion (such as joy). The right hemisphere handles spatial abilities (judging distances, reading maps, and recognizing geometric shapes) and negative emotion (such as distress) (Banish & Heller, 1998; Nelson & Bosquet, 2000). In left-handed people, this pattern may be reversed—or, more commonly, the cerebral cortex may be less clearly specialized than in right-handers.

Why does this specialization of the two hemispheres, called **lateralization**, occur? Studies using fMRI reveal that the left hemisphere is better at processing information in a sequential, analytic (piece-by-piece) way, a good approach for dealing with communicative information—both verbal (language) and emotional (a joyful smile). In contrast, the right hemisphere is specialized for processing information in a holistic, integrative manner, ideal for making sense of spatial information and regulating negative emotion. A lateralized brain is certainly adaptive (Rogers, 2000). It permits a wider array of functions to be carried out effectively than if both sides processed information in the same way.

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

At birth, the hemispheres have already begun to specialize. Most newborns show greater ERP brain-wave activity in the left hemisphere while listening to speech sounds or displaying a positive state of arousal. In contrast, the right hemisphere reacts more strongly to nonspeech sounds and to stimuli (such as a sour-tasting fluid) that evoke a negative reaction (Davidson, 1994; Fox & Davidson, 1986).

Nevertheless, research on brain-damaged children and adults offers dramatic evidence for substantial plasticity in the young brain. Among preschoolers with brain injuries sustained in the first year of life, deficits in language and spatial abilities were milder than those observed in brain-injured adults (Akshoomoff et al., 2002; Stiles et al., 2005). As the children gained perceptual, motor, and cognitive experiences, other stimulated cortical structures compensated for the damaged areas, regardless of the site of injury. Still, mild deficits in complex skills, such as reading, math, and telling stories, were evident in the school years—the price these children pay for massive brain reorganization. When healthy brain regions take over the functions of damaged areas, multiple tasks must be done by a smaller-than-usual volume of brain tissue, so the

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1The eyes are an exception. Messages from the right half of each retina go to the right hemisphere; messages from the left half of each retina go to the left hemisphere. Thus, visual information from both eyes is received by both hemispheres.
brain processes information less quickly and accurately than it would if it were intact (Huttenlocher, 2002).

Another illustration of how early experience greatly influences brain organization comes from studies of deaf adults who, as infants and children, learned sign language (a spatial skill). Compared with hearing adults, these individuals depend more on the right hemisphere for language processing (Neville & Bavelier, 2002). Also, toddlers who are advanced in language development show greater left-hemispheric specialization for language than their more slowly developing agemates (Luna et al., 2001; Mills et al., 2005). Apparently, the very process of acquiring language and other skills promotes lateralization.

In sum, the brain is more plastic during the first few years than it will ever be again. An overabundance of synaptic connections supports brain plasticity and, therefore, young children's ability to learn, which is fundamental to their survival.

**Sensitive Periods in Brain Development**

Animal studies confirm that early, extreme sensory deprivation results in permanent brain damage and loss of functions—findings that verify the existence of sensitive periods in brain development. For example, early, varied visual experiences must occur for the brain's visual centers to develop normally. If a 1-month-old kitten is deprived of light for just three or four days, these areas of the brain degenerate. If the kitten is kept in the dark during the fourth week of life and beyond, damage is severe and permanent (Crair, Gillespie, & Stryker, 1998). And the general quality of the early environment affects overall brain growth. When animals reared from birth in physically and socially stimulating surroundings are compared with those reared in isolation, the brains of the stimulated animals show much denser synaptic connections (Greenough & Black, 1992).

**HUMAN EVIDENCE: VICTIMS OF DEPRIVED EARLY ENVIRONMENTS.** For ethical reasons, we cannot deliberately deprive some infants of normal rearing experiences and observe the impact on their brains and competencies. Instead, we must turn to natural experiments, in which children were victims of deprived early environments that were later rectified. Such studies are consistent with the animal evidence just described.

In one investigation, researchers followed the progress of a large sample of children transferred between birth and 3½ years from extremely deprived Romanian orphans to adoptive families in Great Britain (Beckett et al., 2006; O'Connor et al., 2000; Rutter et al., 1998, 2004). On arrival, most were impaired in all domains of development. By the preschool years, catch-up in physical size was dramatic. Cognitive catch-up, assessed at ages 6 and 11, was impressive for children adopted before 6 months, who attained average mental test scores and performed as well as a comparison group of early-adopted British-born children. But Romanian children who had been institutionalized for more than the first six months showed persisting intellectual deficits. And most had serious mental health problems, such as inattention, overactivity, and unruly behavior, that are seldom seen in children adopted before 6 months of age (Kreppner et al., 2007).

Additional evidence shows that the chronic stress of early, deprived orphanage rearing disrupts the brain's capacity to manage stress, with long-term physical and psychological consequences. In another investigation, researchers followed children who had spent their first eight months or more in Romanian institutions and were then adopted into Canadian homes (Gunnar et al., 2001; Gunnar & Cheatham, 2003). Compared with agemates adopted shortly after birth, these children showed extreme stress reactivity, as indicated by high concentrations of the stress hormone cortisol in their saliva—a physiological response linked to persistent illness and learning and behavior problems.

In other investigations, orphanage children displayed abnormally low cortisol—a blunted stress response that may be the central nervous system's adaptation to earlier, frequent cortisol elevations (Carlson & Earls, 1997; Gunnar & Vasquez, 2001). Extremely low cortisol interferes with release of growth hormone (GH) and, thus, can stunt physical growth.
■ APPROPRIATE STIMULATION. Unlike the orphanage children just described, Grace, whom Monica and Kevin had adopted in Cambodia at 16 months of age, showed favorable progress. Two years earlier, they had adopted Grace's older brother, Eli. When Eli was 2 years old, Monica and Kevin sent a letter and a photo of Eli to his biological mother, describing a bright, happy child. The next day, the Cambodian mother tearfully asked an adoption agency to send her baby daughter to join Eli and his American family.

Although Grace's early environment was very depleted, her biological mother's loving care—holding tenderly, speaking softly, and breastfeeding—may have prevented irreversible damage to her brain. Besides offering gentle, appropriate stimulation, sensitive adult care helps normalize cortisol production in both typically developing and emotionally traumatized infants and young children (Gunnar & Quevedo, 2007; Tarullo & Gunnar, 2006).

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

How, then, can we characterize appropriate stimulation during the early years? To answer this question, researchers distinguish between two types of brain development. The first, experience-expectant brain growth, refers to the young brain's rapidly developing organization, which depends on ordinary experiences—opportunities to see and touch objects, to hear language and other sounds, and to move about and explore the environment. As a result of millions of years of evolution, the brains of all infants, toddlers, and young children expect to encounter these experiences and, if they do, grow normally. The second type of brain development, experience-dependent brain growth, consists of additional growth and refinement of established brain structures as a result of specific learning experiences that occur throughout our lives, varying widely across individuals and cultures (Greenough & Black, 1992). Reading and writing, playing computer games, and practicing the violin are examples. The brain of a violinist differs in certain ways from the brain of a poet because each has exercised different brain regions for a long time (Thompson & Nelson, 2001).

Experience-expectant brain growth occurs early and naturally, as caregivers offer babies and preschoolers age-appropriate play materials and engage them in enjoyable daily routines—a shared meal, a game of peekaboo, a bath before bed, or a picture book to talk about. The resulting growth provides the foundation for later-occurring experience-dependent development (Huttenlocher, 2002; Shonkoff & Phillips, 2001). No evidence exists for a sensitive period in the first few years of life for mastering skills that depend on extensive training, such as reading, musical performance, or gymnastics (Bruer, 1999). To the contrary, rushing early learning harms the brain by overwhelming its neural circuits, thereby reducing the brain's sensitivity to the everyday experiences it needs for a healthy start in life.

Changing States of Arousal

Rapid brain growth means that the organization of sleep and wakefulness changes substantially between birth and age 2, and fussiness and crying also decline. The newborn baby takes round-the-clock naps totaling about 16 to 18 hours (Davis, Parker & Montgomery, 2004). Total sleep time declines slowly; the average 2-year-old still needs 12 to 13 hours. But the sleep-wake pattern increasingly conforms to a night-day schedule. Most 6- to 9-month-olds take two daytime naps; by 18 months, children generally need only one nap. Between ages 3 and 5, napping subsides (Igloowstein et al., 2003).

These changing arousal patterns are due to brain development, but they are also affected by the social environment. In
Cultural Variation in Infant Sleeping Arrangements

For decades, North American child-rearing advice from experts has strongly encouraged the nighttime separation of baby from parent. For example, in the most recent edition of Benjamin Spock's *Baby and Child Care* recommends that infants be moved into their own room by 3 months of age. Explaining, "By 6 months, a child who regularly sleeps in her parents' room may become dependent on this arrangement" (Spock & Needelman, 2004, p. 60).

Yet parent-infant "cosleeping" is the norm for approximately 90 percent of the world's population, in cultures as diverse as the Japanese, the rural Guatemalan Maya, the Inuit of Canada, and the !Kung of Botswana. Japanese and Korean children usually lie next to their mothers in infancy and early childhood (Takahashi, 1990; Yang & Hahn, 2002). Among the Maya, mother-infant cosleeping is interrupted only by the birth of a new baby, when the older child is moved next to the father or to another bed in the same room (Morelli et al., 1992). Cosleeping is also common in some American subcultures, including African-American families and Appalachian families of eastern Kentucky (Abbott, 1992; Brenner et al., 2003).

Cultural values—specifically, collectivism versus individualism (see Chapter 2)—strongly influence infant sleeping arrangements. In one study, researchers interviewed Guatemalan Mayan mothers and American middle-class mothers about their sleeping practices. Mayan mothers stressed a collectivist perspective, explaining that cosleeping helps build a close parent-child bond, which children need to learn the ways of people around them. In contrast, American mothers took an individualistic perspective, mentioning the importance of instilling early independence, preventing bad habits, and protecting their own privacy (Morelli et al., 1992).

Over the past 15 years, cosleeping has increased dramatically in Western nations, perhaps because more mothers are breastfeeding. Today, the rate of bedsharing among U.S. mothers of young babies may be as high as 50 percent (Buswell & Spatz, 2007; Willinger et al., 2003). Research suggests that cosleeping evolved to protect infants' survival and health. During the night, cosleeping babies breastfeed three times as long as infants who sleep alone. Because infants arouse to nurse more often when sleeping near to their mothers, some researchers believe that cosleeping may actually help safeguard babies at risk for sudden infant death syndrome (SIDS) (see page 85 in Chapter 3). SIDS is rare in Asian cultures where cosleeping is widespread, including Cambodia, China, Japan, Korea, Thailand, and Vietnam (McKenna, 2002; McKenna & McBade, 2005).

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

Critics warn that cosleeping children will develop emotional problems, especially excessive dependency. Yet a longitudinal study following children from birth through age 18 showed that young people who had bedshared in the early years were no different from others in any aspect of adjustment (Okami, Weisner, & Olmsted, 2002). Another concern is that infants might become trapped under the parent's body or in soft covers and suffocate. Parents who are obese or who use alcohol, tobacco, or illegal drugs do pose a serious risk to their sleeping babies, as does the use of quilts and comforters or an overly soft mattress (Willinger et al., 2003).

But with appropriate precautions, parents and infants can cosleep safely (McKenna & Velpe, 2007). In cultures where cosleeping is widespread, parents and infants usually sleep with light covering on hard surfaces, such as firm mattresses, floor mats, and wooden planks, or infants sleep in a cradle or hammock next to the parents' bed (McKenna, 2001, 2002). And when sharing the same bed, infants typically lie on their back or side facing the mother—positions that promote frequent, easy communication between parent and baby and arousal if breathing is threatened.

As the Cultural Influences box above reveals, isolating infants to promote sleep is rare elsewhere in the world. When babies sleep with their parents, their average sleep period remains constant at three hours from 1 to 8 months of age. Only at the end of the first year, as REM sleep (the state that usually prompts waking) declines, do infants move in the direction of an adultlike sleep-waking schedule (Ficca et al., 1999).
Influences on Early Physical Growth

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

Heredity

Because identical twins are much more alike in body size than fraternal twins, we know that heredity is important in physical growth (Estourgie-van Burket al., 2006). When diet and health are adequate, height and rate of physical growth are largely determined by heredity. In fact, as long as negative environmental influences such as poor nutrition and illness are not severe, children and adolescents typically show catch-up growth—a return to a genetically influenced growth path once conditions improve. Still, the brain, the heart, the digestive system, and many other internal organs may be permanently compromised (Hales & Ozanne, 2003).

Genetic makeup also affects body weight: The weights of adopted children correlate more strongly with those of their biological than of their adoptive parents (Sørensen, Holst, & Stunkard, 1998). At the same time, environment—in particular, nutrition—plays a vital role.

Nutrition

Nutrition is especially crucial for development in the first two years because the baby's brain and body are growing so rapidly. Pound for pound, an infant's energy needs are twice those of an adult. Twenty-five percent of infants' total caloric intake is devoted to growth, and babies need extra calories to keep rapidly developing organs functioning properly (Trahms & Pipes, 1997).

Breastfeeding versus Bottle-Feeding

Babies need not only enough food but the right kind of food. In early infancy, breastfeeding is ideally suited to their needs, and bottled formulas try to imitate it. Applying What We Know on the following page summarizes major nutritional and health advantages of breastfeeding.

Because of these benefits, breastfed babies in poverty-stricken regions are much less likely to be malnourished and 6 to 14 times more likely to survive the first year of life. The World Health Organization (2008b) recommends breastfeeding until age 2 years, with solid foods added at 6 months—practices that, if widely followed, would save the lives of more than a million infants annually. Even breastfeeding for just a few weeks offers some protection against respiratory and intestinal infections, which are devastating to young children in developing countries (Bellamy, 2005).

Yet many mothers in the developing world give their babies commercial formula or low-grade nutrients, such as rice water or highly diluted cow or goat milk, in place of breast milk. Contamination of these foods as a result of poor sanitation is common and often leads to illness and infant death. The United Nations has encouraged all hospitals and maternity units in...
developing countries to promote breastfeeding as long as mothers do not have viral or bacterial infections (such as HIV or tuberculosis) that can be transmitted to the baby.

Partly as a result of the natural childbirth movement, breastfeeding has become more common in industrialized nations, especially among well-educated women. Today, 74 percent of American mothers breastfeed, but nearly two-thirds of them stop after a few months (U.S. Department of Health and Human Services, 2008c). Not surprisingly, mothers who return to work sooner wean their babies from the breast earlier (Kimbro, 2006). But mothers who cannot be with their infants all the time can still combine breast- and bottle-feeding. The U.S. Department of Health and Human Services advises exclusive breastfeeding for the first 6 months and inclusion of breast milk in the baby’s diet until at least 1 year.

Women who do not breastfeed sometimes worry that they are depriving their baby of an experience essential for healthy psychological development. Yet breastfed and bottle-fed children in industrialized nations do not differ in emotional adjustment (Fergusson & Woodward, 1999). Some studies report a slight advantage in intelligence test performance for children and adolescents who were breastfed, after controlling for many factors. Most, however, find no cognitive benefits (Der, Batty, & Deary, 2006).

As babies transition to solid foods, a nutritious diet is crucial for healthy growth. Yet interviews with more than 3,000 U.S. parents of 4- to 24-month-olds revealed that many routinely served them french fries, pizza, candy, sugary fruit drinks, and soda. On average, infants consumed 20 percent and toddlers 30 percent more calories than they needed. At the same time, one-third ate no fruits or vegetables (Briefel et al., 2004). Recent evidence indicates a strengthening relationship between rapid weight gain in the first two years and later obesity (Botton et al., 2008; Chomtho et al., 2008).

### Malnutrition

In developing countries and war-torn areas where food resources are limited, malnutrition is widespread. About one-third of the world’s children under age 5 are affected (Bellamy, 2005; Pronczuk & Surdu, 2008). The 9 percent who are severely malnourished suffer from two dietary diseases. **Marasmus** is a wasted condition of the body caused by a diet low in all essential nutrients. It usually appears in the first year when a baby’s mother is too malnourished to produce enough breast milk and bottle-feeding is also inadequate. Her starving baby becomes painfully thin and is in danger of dying. **Kwashiorkor** is caused by an unbalanced diet very low in protein. The disease usually strikes after weaning, between 1 and 3 years of age. It is common in regions where children get just enough calories from starchy foods, but little protein. The child’s body responds by breaking down its own protein reserves, which causes swelling of the abdomen and limbs, hair loss, skin rash, and irritable, listless behavior.

Children who survive these extreme forms of malnutrition grow to be smaller in all body dimensions and suffer from lasting damage to the brain, heart, liver, and other organs (Müller & Krawinkel, 2005). When their diets get better, they tend to gain excessive weight (Branca & Ferrari, 2002; Martins et al., 2004). A malnourished body protects itself by establishing a low basal metabolism rate, which may endure after nutrition improves. Also, malnutrition may disrupt appetite control centers in the brain, causing the child to overeat when food becomes plentiful.

Learning and behavior are also seriously affected. One long-term study of marasmic children revealed that an improved diet did not result in catch-up in head size, suggesting permanent loss in brain weight (Stoch et al., 1982). And animal evidence reveals that a deficient diet alters the production of neurotransmitters in the brain—an effect that can disrupt all

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**Table: Nutritional and Health Advantages of Breastfeeding**

<table>
<thead>
<tr>
<th>Nutritional and Health Advantages</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides the correct balance of fat and protein</td>
<td>Compared with the milk of other mammals, human milk is higher in fat and lower in protein. This balance, as well as the unique proteins and fats contained in human milk, is ideal for a rapidly myelinating nervous system.</td>
</tr>
<tr>
<td>Ensures nutritional completeness</td>
<td>A mother who breastfeeding need not add other foods to her infant’s diet until the baby is 6 months old. The milk of all mammals are low in iron, but the iron contained in breast milk is much more easily absorbed by the baby’s system. Consequently, bottle-fed infants need iron-fortified formula.</td>
</tr>
<tr>
<td>Helps ensure healthy physical growth</td>
<td>In the first few months, breastfed infants add weight and length slightly faster than bottle-fed infants, who catch up by the end of the first year. One-year-old breastfed babies are leaner (have a higher percentage of muscle to fat), a growth pattern that may help prevent later overweight and obesity.</td>
</tr>
<tr>
<td>Protects against many diseases</td>
<td>Breast milk transfers antibodies and other infection-fighting agents from mother to child and enhances functioning of the immune system. As a result, compared with bottle-fed infants, breastfed babies have far fewer allergic reactions and respiratory and intestinal illnesses. Breast milk also has anti-inflammatory effects, which ease the severity of illness symptoms. U.S. infant mortality rates are reduced by 21 percent in breastfed infants.</td>
</tr>
</tbody>
</table>

*Sources: American Academy of Pediatrics, 2005; Buescher, 2001; Kramer et al., 2003; Weyermann, Rothermacher, & Brenner, 2006.*
aspects of development (Haller, 2005). These children score low on intelligence tests, show poor fine-motor coordination, and have difficulty paying attention (Galler et al., 1990; Liu et al., 2003). They also display a more intense stress response to fear-arousing situations, perhaps caused by the constant, gnawing pain of hunger (Fernald & Grantham-McGregor, 1998).

Inadequate nutrition is not confined to developing countries. Because government-supported supplementary food programs do not reach all families in need, an estimated 17 percent of U.S. children suffer from food insecurity—uncertain access to enough food for a healthy, active life. Food insecurity is especially high among single-parent and low-income ethnic minority families (U.S. Census Bureau, 2008). Although few of these children have marasmus or kwashiorkor, their physical growth and ability to learn are still affected.

**Emotional Well-Being**

We may not think of affection and stimulation as necessary for healthy physical growth, but they are just as vital as food. Nonorganic failure to thrive, a growth disorder resulting from lack of parental love, is usually present by 18 months of age. Infants who have it show all the signs of marasmus—their bodies look wasted, and they are withdrawn and apathetic. But no organic (or biological) cause for the baby's failure to grow can be found (Black, 2005).

Lana, an observant nurse at a public health clinic, became concerned about 8-month-old Melanie, who was 3 pounds lighter than she had been at her last checkup. Lana noted that Melanie kept her eyes on nearby adults, anxiously watching their every move, rarely smiling, and avoiding her mother's gaze (Steward, 2001). During feeding, diaper changing, and play, Melanie's mother sometimes acted cold and distant, at other times impatient and hostile (Hagekull, Bohlin, & Rydell, 1997). Often an unhappy marriage and parental psychological disturbance contribute to these serious caregiving problems (Drotar, Pallotta, & Eckerle, 1994; Duniz et al., 1996). Sometimes the baby is irritable and displays abnormal feeding behaviors, such as poor sucking or vomiting—circumstances that stress the parent-child relationship further (Linscheid, Budd, & Rasnake, 2005).

In Melanie's case, her alcoholic father was out of work, and her parents argued constantly. Melanie's mother had little energy to meet Melanie's psychological needs. When treated early, by helping parents or placing the baby in a caring foster home, failure-to-thrive infants show quick catch-up growth. But if the disorder is not corrected in infancy, most of these children remain small and show lasting cognitive and emotional difficulties (Drewett, Corbett, & Wright, 2006; Dykman et al., 2001).

**ASK YOURSELF**

**REVIEW**

Explain why breastfeeding can have lifelong consequences for the development of babies born in poverty-stricken regions of the world.

**APPLY**

Ten-month-old Shaun is below average in height and painfully thin. He has one of two serious growth disorders. Name them, and indicate what clues you would look for to tell which one Shaun has.

**REFLECT**

Imagine that you are the parent of a newborn baby. Describe feeding practices you would use, and ones you would avoid, to prevent overweight and obesity.
Learning Capacities

Learning refers to changes in behavior as the result of experience. Babies are capable of two basic forms of learning, which were introduced in Chapter 1: classical and operant conditioning. They also learn through their natural preference for novel stimulation. Finally, shortly after birth, babies learn by observing others; they can imitate the facial expressions and gestures of adults.

Classical Conditioning

Newborn reflexes, discussed in Chapter 3, make classical conditioning possible in the young infant. In this form of learning, a neutral stimulus is paired with a stimulus that leads to a reflexive response. Once the baby’s nervous system makes the connection between the two stimuli, the neutral stimulus produces the behavior by itself. Classical conditioning helps infants recognize which events usually occur together in the everyday world, so they can anticipate what is about to happen next. As a result, the environment becomes more orderly and predictable. Let’s take a closer look at the steps of classical conditioning.

As Carolyn settled down in the rocking chair to nurse Caitlin, she often stroked her baby’s forehead. Soon Carolyn noticed that each time she did this, Caitlin made sucking movements. Caitlin had been classically conditioned. Here is how it happened (see Figure 4.5):

1. Before learning takes place, an unconditioned stimulus (UCS) must consistently produce a reflexive, or unconditioned, response (UCR). In Caitlin’s case, sweet breast milk (UCS) resulted in sucking (UCR).
2. To produce learning, a neutral stimulus that does not lead to the reflex is presented just before, or at about the same time as, the UCS. Carolyn stroked Caitlin’s forehead as each nursing period began. The stroking (neutral stimulus) was paired with the taste of milk (UCS).
3. If learning has occurred, the neutral stimulus by itself produces a response similar to the reflexive response. The neutral stimulus is then called a conditioned stimulus (CS), and the response it elicits is called a conditioned response (CR). We know that Caitlin has been classically conditioned because stroking her forehead outside the feeding situation (CS) results in sucking (CR).

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

Young infants can be classically conditioned most easily when the association between two stimuli has survival value.
Learning which stimuli regularly accompany feeding improves the infant's ability to get food and survive (Blass, Ganchrow, & Steiner, 1984). In contrast, some responses, such as fear, are very difficult to classically condition in young babies. Until infants have the motor skills to escape unpleasant events, they have no biological need to form these associations.

**Operant Conditioning**

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

Many stimuli besides food can also serve as reinforcers of infant behavior. For example, newborns will suck faster on a nipple when their rate of sucking produces interesting sights and sounds, making operant conditioning a powerful tool for finding out what stimuli babies can perceive and which ones they prefer. Operant conditioning also plays a vital role in the formation of social relationships. As the baby gazes into the adult's eyes, the adult looks and smiles back, and then the infant looks and smiles again. The behavior of each partner reinforces the other, so both continue their pleasurable interaction. In Chapter 6, we will see that this contingent responsiveness contributes to the development of infant-caregiver attachment.

**Habituation**

At birth, the human brain is set up to be attracted to novelty. Infants tend to respond more strongly to a new element that has entered their environment. **Habituation** refers to a gradual reduction in the strength of a response due to repetitive stimulation. Looking, heart rate, and respiration rate may all decline, indicating a loss of interest. Once this has occurred, a new stimulus—a change in the environment—causes responsiveness to return to a high level, an increase called **recovery**. Habituation and recovery promote efficient learning by focusing our attention on those aspects of the environment we know least about.

Researchers investigating infants' understanding of the world rely on habituation and recovery more than any other learning capacity. For example, a baby who first habituates to a visual pattern (a photo of a baby) and then recovers to a new one (a photo of a bald man) appears to remember the first stimulus and perceive the second one as new and different from it. This method of studying infant perception and cognition, illustrated in Figure 4.6, can be used with newborns, including preterm infants.

**Recovery to a new stimulus, or novelty preference, assesses infants' recent memory. TAKE A MOMENT...** Think about what happens when you return to a place you have not seen for a long time. Instead of attending to novelty, you are likely to focus on aspects that are familiar: "I've been here before!" Similarly, with passage of time, infants shift from a **novelty preference** to a **familiarity preference**. That is, they recover to the familiar stimulus rather than to a novel stimulus (see Figure 4.6) (Bahrick & Pickens, 1995; Courage & Howe, 1998). By focusing on that shift, researchers can also use habituation to assess remote memory, or memory for stimuli to which infants were exposed weeks or months earlier.

**Imitation**

Newborn babies come into the world with a primitive ability to learn through imitation—by copying the behavior of another person. Figure 4.7 shows infants several weeks old imitating adult facial expressions (Meltzoff & Moore, 1977). The newborn's capacity to imitate extends to certain gestures, such as
head movements, and has been demonstrated in many ethnic groups and cultures (Meltzoff & Kuhl, 1994; Nagy et al., 2005). As the figure reveals, even newborn chimpanzees, our closest primate relatives, imitate some facial expressions (Myowa-Yamakoshi et al., 2004).

Although newborns' capacity to imitate is widely accepted, a few studies have failed to reproduce the findings (see, for example, Anisfeld et al., 2001). And because newborn mouth and tongue movements occur with increased frequency to almost any arousing change in stimulation (such as lively music or flashing lights), some researchers argue that certain newborn "imitative" responses are actually mouthing—a common early exploratory response to interesting stimuli (Jones, 2006). Others claim that newborns imitate a variety of facial expressions and head movements with effort and determination even after short delays—when the adult is no longer demonstrating the behavior (Hayne, 2002; Meltzoff & Moore, 1999).

According to Andrew Meltzoff, newborns imitate much as older children and adults do—by actively trying to match body movements they see with ones they feel themselves make (Meltzoff, 2007). Scientists have identified specialized cells in motor areas of the cerebral cortex in primates—called mirror neurons—that underlie this capacity (Rizzolatti & Craighero, 2004). Mirror neurons fire identically when a primate sees or hears an action and when it carries out that action on its own. Human adults have especially elaborate systems of mirror neurons, which enable us to observe another's behavior (such as smiling or throwing a ball) while simulating the behavior in our own brain. Mirror neurons are believed to be the biological basis of a variety of interrelated, complex social abilities, including imitation, empathic sharing of emotions, and understanding others' intentions (Iacoboni et al., 2005; Schulte-Ruther et al., 2007).

Still, Meltzoff and Moore's view of newborn imitation as a flexible, voluntary capacity remains controversial. Mirror neurons, although possibly functional at birth, undergo an extended period of development (Bertenthal & Longo, 2007; Lepage & Théoret, 2007). Similarly, as we will see in Chapter 5, the capacity to imitate expands greatly over the first two years. But however limited it is at birth, imitation is a powerful means of learning. Using imitation, infants explore their social world and get to know people by matching their behavioral states. As babies notice similarities between their own and others' actions, they learn about themselves. And by tapping into infants' ability to imitate, adults can get infants to express desirable behaviors. Finally, caregivers take great pleasure in a baby who imitates, which helps get the parent–infant relationship off to a good start.

**FIGURE 4.7** Imitation by human and chimpanzee newborns. The human infants in the middle row imitating (left) tongue protrusion and (right) mouth opening are 2 to 3 weeks old. The chimpanzee imitating both facial expressions is 2 weeks old. (From A. N. Meltzoff & M. K. Moore, 1977, "Imitation of Facial and Manual Gestures by Human Neonates," Science, 196, p. 75; and M. Myowa-Yamakoshi et al., 2004, "Imitation in Neonatal Chimpanzees (Pan Troglodytes)," Developmental Science, 7, p. 440. Copyright © 1977 by AAAS, copyright 2004 by Blackwell Publishing. Reprinted by permission.)

**ASK YOURSELF**

**REVIEW**
Provide an example of classical conditioning, of operant conditioning, and of habituation/recovery in young infants.
Why is each type of learning useful?

**APPLY**
Nine-month-old Byron has a toy with large, colored push buttons on it. Each time he pushes a button, he hears a nursery tune. Which learning capacity is the toy's manufacturer taking advantage of? What can Byron's play with the toy reveal about his perception of sound patterns?
Motor Development

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

Babies’ motor achievements have a powerful effect on their social relationships. When Caitlin crawled at 7½ months, Carolyn and David began to restrict her movements. When she walked three days after her first birthday, the first “testing of wills” occurred (Biringen et al., 1995). Despite her mother’s warnings, she sometimes pulled items from shelves that were off limits. “Don’t do that!” Carolyn would say firmly while redirecting Caitlin’s attention. At the same time, newly walking babies more actively attend to and initiate social interaction (Clearfield, Obsborn, & Mullen, 2008). Caitlin frequently toddled over to her parents to express a greeting or hold out a picture book to look at. And Caitlin’s delight as she worked on new motor skills triggered pleasurable reactions in others, which encouraged her efforts. Motor, social, cognitive, and language competencies developed together and supported one another.

The Sequence of Motor Development

Gross-motor development refers to control over actions that help infants get around in the environment, such as crawling, standing, and walking. Fine-motor development has to do with smaller movements, such as reaching and grasping. Table 4.2 shows the average age at which North American infants and toddlers achieve a variety of gross- and fine-motor skills. It also presents the age ranges during which most babies accomplish each skill, indicating large individual differences in rate of motor progress. We would be concerned about a child’s development only if many motor skills were seriously delayed.

Children acquire motor skills in highly individual ways. Many influences—both internal and external to the child—support the vast gains in motor competences of the first two years.

Motor Skills as Dynamic Systems

According to dynamic systems theory of motor development, mastery of motor skills involves acquiring increasingly complex

<table>
<thead>
<tr>
<th>TABLE 4.2</th>
<th>Gross- and Fine-Motor Development in the First Two Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOTOR SKILL</td>
<td>AVERAGE AGE ACHIEVED</td>
</tr>
<tr>
<td>When held upright, holds head erect and steady</td>
<td>6 weeks</td>
</tr>
<tr>
<td>When prone, lifts self by arms</td>
<td>2 months</td>
</tr>
<tr>
<td>Rolls from side to back</td>
<td>2 months</td>
</tr>
<tr>
<td>Grasps cube</td>
<td>3 months, 3 weeks</td>
</tr>
<tr>
<td>Rolls from back to side</td>
<td>4½ months</td>
</tr>
<tr>
<td>Sits alone</td>
<td>7 months</td>
</tr>
<tr>
<td>Crawls</td>
<td>7 months</td>
</tr>
<tr>
<td>Pulls to stand</td>
<td>8 months</td>
</tr>
<tr>
<td>Plays pat-a-cake</td>
<td>9 months, 3 weeks</td>
</tr>
<tr>
<td>Stands alone</td>
<td>11 months</td>
</tr>
<tr>
<td>Walks alone</td>
<td>11 months, 3 weeks</td>
</tr>
<tr>
<td>Builds tower of two cubes</td>
<td>11 months, 3 weeks</td>
</tr>
<tr>
<td>Scribbles vigorously</td>
<td>14 months</td>
</tr>
<tr>
<td>Walks up stairs with help</td>
<td>16 months</td>
</tr>
<tr>
<td>Jumps in place</td>
<td>23 months, 2 weeks</td>
</tr>
<tr>
<td>Walks on tiptoe</td>
<td>25 months</td>
</tr>
</tbody>
</table>

Sources: Bayley, 1969, 1993, 2005
systems of action. When motor skills work as a system, separate abilities blend together, each cooperating with others to produce more effective ways of exploring and controlling the environment. For example, control of the head and upper chest combine into sitting with support. Kicking, rocking on all fours, and reaching combine to become crawling. And standing, stepping, and improved upright postural control unite into walking (Adolph & Berger, 2006; Thelen, 1989).

Each new skill is a joint product of four factors: (1) central nervous system development, (2) the body’s movement capacities, (3) the goals the child has in mind, and (4) environmental supports for the skill. Change in any element makes the system less stable, and the child starts to explore and select new, more effective motor patterns.

When a skill is first acquired, infants must refine it. For example, in learning to walk, toddlers practice six or more hours a day, traveling the length of 29 football fields! Gradually their small, unsteady steps change to a longer stride, their feet move closer together, their toes point to the front, and their legs become symmetrically coordinated (Adolph, Vereijken, & Shrout, 2003). As movements are repeated thousands of times, they promote new connections in the brain that govern motor patterns.

DYNAMIC MOTOR SYSTEMS IN ACTION. To find out how babies acquire motor capacities, some studies have tracked their first attempts at a skill until it became smooth and effortless. In one investigation, researchers held sounding toys alternately in front of infants’ hands and feet, from the time they showed interest until they engaged in well-coordinated reaching and grasping (Galloway & Thelen, 2004). As Figure 4.8 shows, the infants violated the cephalocaudal trend (reaching with hands before feet), long believed to characterize the sequence of motor development. Instead, the babies first reached for the toys with their feet—as early as 8 weeks of age, at least a month before reaching with their hands!

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

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

In contrast, among the Kipsigis of Kenya, babies hold their heads up, sit alone, and walk considerably earlier than North American infants. Kipsigi parents deliberately teach these motor skills. In the first few months, babies are seated in holes...
dug in the ground, with rolled blankets used to keep them upright. Walking is promoted by frequently bouncing babies on their feet (Super, 1981).

By decreasing exposure to “tummy time,” the current Western practice of having babies sleep on their backs to protect them from SIDS (see page 85 in Chapter 3) delays gross-motor milestones of rolling, sitting, and crawling (Majnemer & Barr, 2005). Regularly exposing infants to the tummy-lying position during waking hours prevents these delays.

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

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

Reaching and grasping, like many other motor skills, start out as gross, diffuse activity and move toward mastery of fine movements. Figure 4.9 illustrates some milestones of reaching over the first nine months. Newborns make poorly coordinated swipes, called prereaching, toward an object in front of them, but because of poor arm and hand control, they rarely contact the object. Like newborn reflexes, prereaching drops out around 7 weeks of age. Yet these early behaviors suggest that babies are biologically prepared to coordinate hand with eye in the act of exploring (von Hofsten, 2004).

Around 3 to 4 months, as infants develop the necessary eye, head, and shoulder control, reaching reappears and gradually improves in accuracy (Bhat, Heathcock, & Galloway, 2005; Spencer et al., 2000). By 5 to 6 months, infants reach for an object in a room that has been darkened during the reach by switching off the lights (McCarty & Ashmead, 1999). Early on, vision is freed from the basic act of reaching so it can focus on more complex adjustments. During the next few months, infants become better at reaching with just one arm (rather than both) and reaching for moving objects (Fagard & Pezé, 1997; Wentworth, Benson, & Faith, 2000).

Once infants can reach, they modify their grasp. The newborn’s grasp reflex is replaced by the ulnar grasp, a clumsy motion in which the fingers close against the palm. Still, even 3-month-olds adjust their grasp to the size and shape of an object—a capacity that improves over the first year (Witherington, 2005). Around 4 to 5 months, when infants begin to sit up, they coordinate both hands in exploring objects (Rochat & Goubet, 1995). By the end of the first year, infants use the thumb and index finger opposingly in a well-coordinated pincer grasp. Then the ability to manipulate objects greatly expands. The 1-year-old can pick up raisins and blades of grass, turn knobs, and open and close small boxes.

Finally, the capacity to reach for and manipulate an object increases infants’ attention to the way an adult reaches for and plays with that particular object (Hauf, Aschersleben, & Prinz, 2007). As a result, babies broaden their understanding of others’ behaviors and—as they watch what others do—of the range of actions that can be performed on various objects.

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**ASK YOURSELF**

**REVIEW**

Cite evidence that motor development is a joint product of biological, psychological, and environmental factors.

**APPLY**

List everyday experiences that support mastery of reaching, grasping, sitting, and crawling. Why should caregivers place young infants in a variety of waking-time body positions?

**REFLECT**

Do you favor early, systematic training of infants in motor skills such as crawling, walking, and stair climbing? Why or why not?
Perceptual Development

In Chapter 3, you learned that the senses of touch, taste, smell, and hearing—but not vision—are remarkably well-developed at birth. Now let’s turn to a related question: How does perception change over the first year? Our discussion will address hearing and vision, the focus of almost all research. Recall that in Chapter 3, we used the word sensation to talk about these capacities. It suggests a fairly passive process—what the baby’s receptors detect when exposed to stimulation. Now we use the word perception, which is active: When we perceive, we organize and interpret what we see. As we review the perceptual achievements of infancy, you may find it hard to tell where perception leaves off and thinking begins.

Hearing

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

Between 4 and 7 months, infants display a sense of musical phrasing: They prefer Mozart minuets with pauses between phrases to those with awkward breaks (Krumhansl & Jusczyk, 1990). Around 6 to 7 months, they can distinguish musical tunes on the basis of variations in rhythmic patterns, including beat structure (duple or triple) and accent structure (emphasis on the first note of every beat unit or at other positions) (Hannon & Johnson, 2004). And by the end of the first year, infants recognize the same melody when it is played in different keys (Trehub, 2001). As we will see next, 6- to 12-month-olds make comparable discriminations in human speech.

SPEECH PERCEPTION. Recall from Chapter 3 that newborns can distinguish nearly all sounds in human languages and that they prefer listening to human speech, especially their native tongue. As they listen to people talking, they learn to focus on meaningful sound variations. ERP brain-wave recordings reveal that around 5 months, babies become sensitive to syllable stress patterns in their own language (Weber et al., 2004). Between 6 and 8 months, they start to “screen out” sounds not used in their native tongue (Anderson, Morgan, & White, 2003; Polka & Werker, 1994). As the Biology and Environment box on page 110 explains, this increased responsiveness to native-language sounds is part of a general “tuning” process in the second half of the first year—a possible sensitive period in which infants acquire a range of perceptual skills for picking up socially important information.

Soon after, infants focus on larger speech segments. They recognize familiar words in spoken passages and listen longer to speech with clear clause and phrase boundaries (Jusczyk & Hohne, 1997; Soderstrom et al., 2003). Around 7 to 9 months, infants extend this sensitivity to speech structure to individual words. They begin to divide the speech stream into wordlike units (Jusczyk, 2002; Safran, Werker, & Werner, 2006).

How do infants make such rapid progress in perceiving the structure of language? Research shows that they have an impressive statistical learning capacity. By analyzing the speech stream for patterns—repeatedly occurring sequences of sounds—they acquire a stock of speech structures for which they will later learn meanings, long before they start to talk around age 12 months. For example, when presented with controlled sequences of nonsense syllables, babies listen for statistical regularities: They locate words by distinguishing syllables that often occur together (indicating they belong to the same word) from syllables that seldom occur together (indicating a word boundary) (Safran, Aslin, & Newport, 1996; Safran & Thiessen, 2003).

Once infants locate words, they focus on the words and, around 7 to 8 months, identify regular syllable-stress patterns—for example, in English and Dutch, that the onset of a strong syllable (hap-py, rab-bit) often signals a new word (Safran & Thiessen, 2007). By 10 months, babies can detect words that start with weak syllables, such as “surprise” (Jusczyk, 2001).

Clearly, babies have a powerful ability to extract patterns from complex, continuous speech. Some researchers believe that infants are innately equipped with a general statistical learning capacity for detecting structure in the environment, which they also apply to visual stimulation (Kirkham, Slemmer, & Johnson, 2002).

Vision

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

Visual development is supported by rapid maturation of the eye and visual centers in the cerebral cortex. Around 2 months, infants can focus on objects about as well as adults can, and their color vision is adultlike by 4 months (Kellman & Arterberry, 2006). Visual acuity (fineness of discrimination) improves steadily, reaching a near-adult level of about 20/20 by 6 months (Slater, 2001). Scanning the environment and tracking moving objects also improve over the first half-year as infants better control their eye movements and build an organized perceptual world (Johnson, Slemmer, & Amso, 2004).

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

DEPTH PERCEPTION. Depth perception is the ability to judge the distance of objects from one another and from ourselves. It is important for understanding the layout of the environment and for guiding motor activity.
“Tuning In” to Familiar Speech, Faces, and Music: A Sensitive Period for Culture-Specific Learning

To share experiences with members of their family and community, babies must become skilled at making perceptual discriminations that are meaningful in their culture. As we have seen, at first babies are sensitive to virtually all speech sounds, but around 6 months, they narrow their focus to the language they hear and will soon learn. The ability to perceive faces shows a similar path of development. After habituating to one member of each pair of faces in Figure 4.10, 6-month-olds were shown the familiar and the novel face side by side. For both pairs, they recovered to (looked longer at) the novel face, indicating that they could discriminate individual faces of both humans and monkeys equally well (Pascalis, de Haan, & Nelson, 2002). But at 9 months, infants no longer showed a novelty preference when viewing the monkey pair. Like adults, they could distinguish only the human faces.

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

Several weeks of regular interaction with a foreign-language speaker and of daily opportunities to listen to non-Western music fully restore 12-month-olds' sensitivity to wide-ranging speech sounds and music rhythms (Hannon & Trehub, 2005a; Kuhl, Tsao, & Liu, 2003). Adults given similar extensive experiences, by contrast, show little improvement in perceptual sensitivity.

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

Figure 4.11 shows the visual cliff, designed by Eleanor Gibson and Richard Walk (1960) and used in the earliest studies of depth perception. It consists of a Plexiglas-covered table with a platform at the center, a “shallow” side with a checkerboard pattern just under the glass, and a “deep” side with a checkerboard several feet below the glass. The researchers found that crawling babies readily crossed the shallow side, but most reacted with fear to the deep side. They concluded that around the time infants crawl, most distinguish deep and shallow surfaces and avoid drop-offs.

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

Motion is the first depth cue to which infants are sensitive. Babies 3 to 4 weeks old blink their eyes defensively when an object moves toward their face as if it is going to hit (Nánez & Yonas, 1994). Binocular depth cues arise because our two eyes have slightly different views of the visual field. Sensitivity to
binocular cues emerges between 2 and 3 months and improves rapidly over the first year (Brown & Miracle, 2003). Finally, around 6 to 7 months, babies become sensitive to pictorial depth cues, the ones artists use to make a painting look three-dimensional. Examples include receding lines that create the illusion of perspective, changes in texture (nearby textures are more detailed than faraway ones), and overlapping objects (an object partially hidden by another object is perceived to be more distant) (Sen, Yonas, & Knill, 2001; Yonas, Elieff, & Arterberry, 2002).

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

**INDEPENDENT MOVEMENT AND DEPTH PERCEPTION.**

At 6 months, Timmy started crawling. "He's fearless!" exclaimed Vanessa. "If I put him down in the middle of our bed, he crawls right over the edge. The same thing's happened by the stairs." Will Timmy become more wary of the side of the bed and the staircase as he becomes a more experienced crawler? Research suggests that he will. From extensive everyday experience, babies gradually figure out how to use depth cues in each body position (sitting, crawling, then walking) to detect the danger of falling (Adolph, 2000, 2002; Joh & Adolph, 2006). For example, infants with more crawling experience (regardless of when they start to crawl) are far more likely to refuse to cross the deep side of the visual cliff (Campas et al., 2000).

Independent movement promotes other aspects of three-dimensional understanding. Seasoned crawlers are better than their inexperienced agemates at remembering object locations and finding hidden objects (Campos et al., 2000). Why does crawling make such a difference? **TAKE A MOMENT...** Compare your own experience of the environment when you are driven from one place to another as opposed to walking or driving yourself. When you move on your own, you are much more aware of landmarks and routes of travel, and you take more careful note of what things look like from different points of view. The same is true for infants.

**PATTERN AND FACE PERCEPTION.** Even newborns prefer to look at patterned rather than plain stimuli (Fantz, 1961). But because of their poor vision, very young babies cannot resolve the features in complex patterns, so they prefer, for example, to look at a checkerboard with large, bold squares than one with many small squares. Around 2 months of age, when detection of fine-grained detail has improved, infants spend more time looking at the more complex checkerboard (Gwiazda & Birch, 2001). With age, they prefer increasingly intricate patterns.

In the early weeks of life, infants respond to the separate parts of a pattern, staring at single, high-contrast features (Hunnis & Geuze, 2004a, 2004b). In exploring drawings of human faces, for example, 1-month-olds often limit themselves to the edges of the stimulus and focus on the hairline or chin. At 2 to 3 months, when vision improves and infants can better control their scanning, they thoroughly explore a pattern's internal features (Bronson, 1994).

But babies' inspection of a stimulus varies with pattern characteristics. When exposed to dynamic stimuli, such as the mother's nodding, smiling face, even 6-week-olds fixate more on internal features (the mouth and eyes) than on edges. Nevertheless, thorough scanning of a dynamic stimulus emerges later—after 4 months of age (Hunnis & Geuze, 2004b). Exploring patterns with moving stimuli is more demanding than exploring static patterns.

Once babies can take in all aspects of a pattern, they integrate the parts into a unified whole. Gradually, they become so good at detecting pattern organization that they even perceive subjective boundaries that are not really present. For example, 9-month-olds look much longer at an organized series of moving lights that resembles a human being walking than at upside-down or scrambled versions (Bertenthal, 1993). At 12 months, infants can detect familiar objects represented by incomplete drawings, even when as much as two-thirds of the drawing is...
infants prefer more easily discriminate among female faces than among male faces, probably because they typically spend more time with female adults. And 3-month-olds exposed mostly to members of their own race prefer and more easily detect differences among faces of that race (Bar-Haim et al., 2006; Kelly et al., 2007). In contrast, babies who have frequent contact with members of other races show no own-race face preference.

Around 5 months—and strengthening over the second half of the first year—infants perceive emotional expressions as meaningful wholes. They treat positive faces (happy and surprised) as different from negative ones (sad and fearful) (Bornstein & Arterberry, 2003; Ludemann, 1991). As babies recognize and respond to the expressive behavior of others, face perception supports their earliest social relationships.

missing (see Figure 4.12) (Rose, Jankowski, & Senior, 1997). As these findings reveal, infants' increasing knowledge of objects and actions supports pattern perception.

The tendency to search for structure in a patterned stimulus also applies to face perception. Newborns prefer to look at photos and simplified drawings with facial features arranged naturally (upright) rather than unnaturally (upside-down or sideways) (see Figure 4.13a) (Cassia, Turati, & Simion, 2004; Mondloch et al., 1999). They also track a facial pattern moving across their visual field farther than they track other stimuli (Johnson, 1999). Some researchers claim that these behaviors reflect a built-in capacity to orient toward members of one's own species, just as many newborn animals do (Johnson, 2001; Slater & Quinn, 2001). Others assert that newborns prefer any stimulus in which the most salient elements are arranged horizontally in the upper part of a pattern—like the "eyes" in Figure 4.13b (Turati, 2004). Another conjecture is that newborns are exposed to faces more often than to other stimuli—early experiences that might quickly "wire" the brain to detect faces (Nelson, 2001).

Although newborns respond to a general facelike structure, they cannot discriminate a complex facial pattern from other, equally complex patterns (see Figure 4.13c). But from repeated exposures to their mother's face, they quickly learn to prefer her face to that of an unfamiliar woman, although they are sensitive only to its broad outlines. Around 2 months, when they can combine pattern elements into an organized whole, babies prefer a complex drawing of the human face to other equally complex stimulus arrangements (Dannemiller & Stephens, 1988). They also prefer their mother's detailed facial features to those of another woman (Bartrip, Morton, & de Schonen, 2001).

Early experience influences other aspects of face processing, yielding group biases at a tender age. As early as 3 months,
Intermodal Perception

Our world provides rich, continuous intermodal stimulation—simultaneous input from more than one modality, or sensory system. In intermodal perception, we make sense of these running streams of light, sound, tactile, odor, and taste information by perceiving them as unified wholes.

Babies perceive input from different sensory systems in a unified way by detecting amodal sensory properties—information that overlaps two or more sensory systems. Consider the sight and sound of a bouncing ball or the face and voice of a speaking person. In each event, visual and auditory information occur simultaneously and with the same rate, rhythm, duration, and intensity.

Even newborns are impressive perceivers of amodal properties. After touching an object (such as a cylinder) placed in their palms, they recognize it visually, distinguishing it from a different-shaped object (Sann & Streri, 2007). And they require just one exposure to learn the association between the sight and sound of a toy, such as a rhythmically jangling rattle (Morrongiello, Fenwick, & Chance, 1998). Within the first half-year, infants master a remarkable range of intermodal relationships. For example, 3- and 4-month-olds can link the age of a voice (child versus adult) and its emotional tone (happy or angry) with the appropriate face of a person (Bahrick, Netto, & Hernandez-Reif, 1998; Walker-Andrews, 1997). Between 4 and 6 months, infants can perceive and remember the unique face–voice pairings of unfamiliar adults (Bahrick, Hernandez-Reif, & Flom, 2005). By 8 months, they can match voices and faces on the basis of gender (Patterson & Werker, 2002).

How does intermodal perception develop so quickly? Young infants seem biologically primed to focus on amodal information. Their detection of amodal relations—for example, the common tempo and rhythm in sights and sounds—precedes and seems to provide the basis for detecting more specific intermodal matches, such as the relation between a particular person's face and the sound of her voice or between an object and its verbal label (Bahrick, Hernandez-Reif, & Flom, 2005).

Intermodal sensitivity is crucial for perceptual development. In the first few months, when much stimulation is unfamiliar and confusing, it enables babies to notice meaningful correlations between sensory inputs and rapidly make sense of their surroundings (Bahrick, Lickliter, & Flom, 2004). And as the examples just reviewed suggest, intermodal perception also facilitates social and language processing.

Finally, early parent–infant interaction presents the baby with a rich context—consisting of many concurrent sights, sounds, touches, and smells—for expanding intermodal knowledge (Lickliter & Bahrick, 2000). Intermodal perception is a fundamental ability that fosters all aspects of psychological development.

Understanding Perceptual Development

Now that we have reviewed the development of infant perceptual capacities, how can we put together this diverse array of amazing achievements? Widely accepted answers come from the work of Eleanor and James Gibson. According to the Gibson's differentiation theory, infants actively search for invariant features of the environment—those that remain stable—in a constantly changing perceptual world. In pattern perception, for example, young babies—confronted with a confusing mass of stimulation—search for features that stand out and also orient toward faces. Soon they explore internal features, noticing stable relationships among them. As a result, they detect patterns, such as complex designs and faces. The development of intermodal perception also reflects this principle. Babies seek out invariant relationships—first, amodal properties, such as common rate and rhythm in a voice and face, and later, more detailed associations, such as unique voice–face matches.

The Gibsons described their theory as differentiation (where “differentiate” means “analyze” or “break down”) because over time, the baby detects finer and finer invariant features among stimuli. Thus, one way of understanding perceptual development is to think of it as a built-in tendency to search for order and consistency—a capacity that becomes increasingly fine-tuned with age (Gibson, 1970; Gibson, 1979).

Acting on the environment is vital in perceptual differentiation. TAKE A MOMENT... Think back to the links between motor milestones and perceptual development discussed in this chapter. Infants constantly look for ways in which the environment affords opportunities for action (Gibson, 2000, 2003). By exploring their surroundings, they figure out which things can be grasped, squeezed, bounced, or stroked and when a
surface is safe to cross or presents a risk of falling (Adolph & Eppler, 1998, 1999). And from handling objects, they become more aware of a variety of observable object properties (Perone et al., 2008). As a result, they differentiate the world in new ways and act more competently.

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

**ASK YOURSELF**

**REVIEW**
Using examples, explain why intermodal perception is vital for infants’ developing understanding of their physical and social worlds.

**APPLY**
At 8 months, Ben has just begun to crawl. Can his parents trust him to avoid going headfirst down a steep staircase? Explain.

**REFLECT**
Are young infants more competent than you believed before you read this chapter? List the capacities that most surprised you.

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**Summary**

**Body Growth**

Describe major changes in body growth over the first two years.

- Changes in height and weight are rapid during the first two years. In the first nine months, body fat is laid down quickly, while muscle development is slow and gradual. Skeletal age is the best way to estimate a child’s physical maturity. Body proportions change as growth follows cephalocaudal and proximodistal trends.

**Brain Development**

Describe brain development during infancy and toddlerhood, including appropriate stimulation to support the brain’s potential.

- Early in development, the brain grows faster than any other organ. Once neurons are in place, they rapidly form synapses. To communicate, neurons release neurotransmitters, which cross synapses. To make room for new synaptic connections, many surrounding neurons die. Neurons that are seldom stimulated lose their synapses in a process called synaptic pruning. Glial cells, responsible for myelination, multiply rapidly into the second year, contributing to large gains in brain weight.
- The cerebral cortex is the largest, most complex brain structure and the last to stop growing. The hemispheres of the cerebral cortex specialize, a process called lateralization. In the first few years of life, there is high brain plasticity, with many areas not yet committed to specific functions.

**Influences on Early Physical Growth**

Cite evidence that heredity, nutrition, and affection and stimulation contribute to early physical growth.

- Twin and adoption studies reveal the contribution of heredity to body size and rate of physical growth.
- Breast milk is ideally suited to infants’ growth needs. Breastfeeding protects against disease and prevents malnutrition and infant death in poverty-stricken areas of the world. Breast- and bottle-fed babies do not differ in emotional adjustment, and cognitive benefits of breastfeeding are inconclusive.
- Marasmus and kwashiorkor are dietary diseases caused by malnutrition that affect many children in developing countries and, if prolonged, can permanently stunt body growth and brain development. Nonorganic failure to thrive, which occurs in infants who lack affection and stimulation, illustrates the importance of these factors in normal physical growth.

**Learning Capacities**

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

- Classical conditioning is based on the infant’s ability to associate events that usually occur together in the everyday world. Infants can be classically conditioned most easily when the pairing of an unconditioned stimulus (UCS)
and a conditioned stimulus (CS) has survival value—for example, learning which stimuli regularly accompany feeding.

- In operant conditioning, infants act on their environment and their behavior is followed by either reinforcers, which increase the occurrence of a preceding behavior, or punishment, which either removes a desirable stimulus or presents an unpleasant one to decrease the occurrence of a response. In young infants, interesting sights and sounds and pleasurable caregiver interaction serve as effective reinforcers.

- Habituation and recovery reveal that at birth, babies are attracted to novelty. Novelty preference (recovery to a novel stimulus) assesses recent memory, whereas familiarity preference (recovery to the familiar stimulus) assesses remote memory.

- Newborns have a primitive ability to imitate adults' facial expressions and gestures. Imitation is a powerful means of learning and contributes to the parent-infant bond, though whether it is a voluntary capacity in newborns remains controversial.

**Motor Development**

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

- According to dynamic systems theory of motor development, children acquire new motor skills by combining existing skills into increasingly complex systems of action. Each new skill is a joint product of central nervous system development, movement possibilities of the body, the child's goals, and environmental supports for the skill. Cultural values and rearing customs also contribute to motor development.

- During the first year, infants perfect reaching and grasping. Reaching gradually becomes more accurate and flexible, and the clumsy ulnar grasp is transformed into a refined pincer grasp.

**Perceptual Development**

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

- Infants organize sounds into increasingly complex patterns and, in the middle of the first year, become more sensitive to the sounds of their own language. They have an impressive statistical learning capacity, which enables them to detect regular sound patterns for which they will later learn meanings.

- Rapid maturation of the eye and visual centers in the brain supports gains in focusing, color discrimination, and visual acuity during the first half-year. The ability to scan the environment and track moving objects also improves.

- Research on depth perception reveals that responsiveness to motion cues develops first, followed by sensitivity to binocular and then to pictorial cues. Experience in crawling enhances depth perception and other aspects of threedimensional understanding.

- At first, babies stare at single, high-contrast features and often focus on the edges of a pattern. At 2 to 3 months, they explore a pattern's internal features and start to detect pattern organization. Over time, they discriminate increasingly complex, meaningful patterns.

**Important Terms and Concepts**

- brain plasticity (p. 96)
- cephalocaudal trend (p. 93)
- cerebral cortex (p. 95)
- classical conditioning (p. 103)
- conditioned response (p. 103)
- conditioned stimulus (CS) (p. 103)
- differentiation theory (p. 113)
- dynamic systems theory of motor development (p. 106)
- experience-dependent brain growth (p. 98)
- experience-expectant brain growth (p. 98)
- glial cells (p. 94)
- habituation (p. 104)
- imitation (p. 104)
- intermodal perception (p. 113)
- kwashikor (p. 101)
- lateralization (p. 96)
- mirror neurons (p. 105)
- myelination (p. 94)
- neurons (p. 94)
- neurotransmitters (p. 94)
- nonorganic failure to thrive (p. 102)
- operant conditioning (p. 104)
- proximodistal trend (p. 93)
- punishment (p. 104)
- recovery (p. 104)
- reinforcer (p. 104)
- statistical learning capacity (p. 109)
- synapses (p. 94)
- synaptic pruning (p. 94)
- unconditioned response (UCR) (p. 103)
- unconditioned stimulus (UCS) (p. 103)
This grandmother shares her grandchild’s curiosity and delight in discovery. With the sensitive support of caring adults, infants' and toddlers' cognition and language develop rapidly.
When Caitlin, Grace, and Timmy, each nearly 18 months old, gathered at Ginette's child-care home, the playroom was alive with activity. Grace dropped shapes through holes in a plastic box that Ginette adjusted so the harder ones would fall smoothly into place. Once a few shapes were inside, Grace grabbed the box and shook it, squealing with delight as the lid fell open and the shapes scattered around her. The clatter attracted Timmy, who picked up a shape, carried it to the railing at the top of the basement steps, and dropped it overboard, then followed with a teddy bear, a ball, his shoe, and a spoon.

As the toddlers experimented, I could see the beginnings of spoken language—a whole new way of influencing the world. "All gone baw!" Caitlin exclaimed as Timmy tossed the ball down the basement steps. Later that day, Grace revealed that she could use words and gestures to pretend. "Night-night," she said, putting her head down and closing her eyes.

Over the first two years, the small, reflexive newborn baby becomes a self-assertive, purposeful being who solves simple problems and starts to master the most amazing human ability: language. Parents wonder, How does all this happen so quickly? This question has also captivated researchers, yielding a wealth of findings along with vigorous debate over how to explain the astonishing pace of infant and toddler cognition.

In this chapter, we take up three perspectives on early cognitive development: Piaget's cognitive-developmental theory, information processing, and Vygotsky's sociocultural theory. We also consider the usefulness of tests that measure early intellectual progress. Finally, we look at the beginnings of language. We will see how toddlers' first words build on cognitive achievements and how, very soon, new words and expressions greatly increase the speed and flexibility of thinking.

**Piaget's Cognitive-Developmental Theory**

Swiss theorist Jean Piaget inspired a vision of children as busy, motivated explorers whose thinking develops as they act directly on the environment. According to Piaget, all aspects of cognition develop in an integrated fashion, changing in a similar way at about the same time as children move through four stages between infancy and adolescence.

Piaget’s first stage, the sensorimotor stage, spans the first two years of life. Piaget believed that infants and toddlers “think” with their eyes, ears, hands, and other sensorimotor equipment. They cannot yet carry out many activities inside their heads. But by the end of toddlerhood, children can solve practical, everyday problems and represent their experiences in speech, gesture, and play.

**Piaget's Ideas About Cognitive Change**

According to Piaget, specific psychological structures—organized ways of making sense of experience called schemes—change with age. First schemes are sensorimotor action patterns. For example, at 6 months, Timmy dropped objects in a fairly rigid way, simply letting go of a rattle and watching with interest. By 18 months, his “dropping scheme” had become deliberate and creative. In tossing objects down the basement stairs, he threw some in the air, bounced others off walls, released some gently and others forcefully. Soon, instead of just acting on objects, he will show evidence of thinking before he acts, marking the transition from sensorimotor to preoperational thought.

In Piaget’s theory, two processes, adaptation and organization, account for changes in schemes.

- **Adaptation. Take a Moment...** The next time you have a chance, notice how infants and toddlers tirelessly repeat actions that lead to interesting effects. Adaptation involves building schemes through direct interaction with the environment. It consists of two complementary activities, assimilation and accommodation. During assimilation, we use our current schemes to interpret the external world. For example, when Timmy dropped objects, he was assimilating them to his sensorimotor “dropping scheme.” In accommodation, we create new schemes or adjust old ones after noticing that our current ways of thinking do not capture the environment completely. When Timmy dropped objects in different ways, he modified his dropping scheme to take account of the varied properties of objects.

According to Piaget, the balance between assimilation and accommodation varies over time. When children are not changing much, they assimilate more than they accommodate. Piaget called this a state of cognitive equilibrium, implying a steady, comfortable condition. During rapid cognitive change, however, children are in a state of disequilibrium, or cognitive discomfort. Realizing that new information does not match their current schemes, they shift from assimilation toward accommodation. After modifying their schemes, they move back toward assimilation, exercising their newly changed structures until they are ready to be modified again.

Each time this back-and-forth movement between equilibrium and disequilibrium occurs, more effective schemes are produced. Because the times of greatest accommodation are the earliest ones, the sensorimotor stage is Piaget’s most complex period of development.
In Piaget's theory, first schemes are motor action patterns. As this 11-month-old repeatedly experiments with her "dropping scheme," her dropping behavior will become more deliberate and varied.

**ORGANIZATION.** Schemes also change through organization, a process that takes place internally. Once children form new schemes, they rearrange them, linking them with other schemes to create a strongly interconnected cognitive system. For example, eventually Timmy will relate "dropping" to "throwing" and to "nearness" and "farness." According to Piaget, schemes truly reach equilibrium when they become part of a broad network of structures that can be jointly applied to the surrounding world (Piaget, 1936/1952).

In the following sections, we will first describe infant development as Piaget saw it, noting research that supports his observations. Then we will consider evidence demonstrating that, in some ways, babies' cognitive competence is more advanced than Piaget believed.

**The Sensorimotor Stage**

The difference between the newborn baby and the 2-year-old child is so vast that Piaget divided the sensorimotor stage into six substages, summarized in Table 5.1. Piaget based this sequence on a very small sample: his own three children. He observed his son and two daughters carefully and also presented them with everyday problems (such as hidden objects) that helped reveal their understanding of the world.

According to Piaget, newborns know so little about the world that they cannot purposefully explore it. The **circular reaction** provides a special means of adapting their first schemes. It involves stumbling onto a new experience caused by the baby's own motor activity. The reaction is "circular" because, as the infant tries to repeat the event again and again, a sensorimotor response that first occurred by chance becomes strengthened into a new scheme. Consider Caitlin, who at age 2 months accidentally made a smacking noise after a feeding. Intrigued, she tried to repeat the sound until she became expert at smacking her lips. Infants' difficulty inhibiting new and interesting behaviors may underlie the circular reaction. This immaturity in inhibition seems to be adaptive, ensuring that new skills will not be interrupted before they strengthen (Carey & Markman, 1999). Piaget considered revisions in the circular reaction so important that, as Table 5.1 shows, he named the sensorimotor substages after them.

**REPEATING CHANCE BEHAVIORS.** In Substage 1, babies are reflexive beings who suck, grasp, and look in much the same way, no matter what experiences they encounter. Around 1 month, as they enter Substage 2, infants start to gain voluntary control over their actions through the **primary circular reaction**, by repeating chance behaviors largely motivated by basic needs. This leads to some simple motor habits, such as

**TABLE 5.1 Summary of Piaget's Sensorimotor Stage**

<table>
<thead>
<tr>
<th>SENSORIMOTOR SUBSTAGE</th>
<th>TYPICAL ADAPTIVE BEHAVIORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reflexive schemes (birth-1 month)</td>
<td>Newborn reflexes (see Chapter 3, page 82)</td>
</tr>
<tr>
<td>2. Primary circular reactions (1-4 months)</td>
<td>Simple motor habits centered around the infant's own body; limited anticipation of events</td>
</tr>
<tr>
<td>3. Secondary circular reactions (4-8 months)</td>
<td>Actions aimed at repeating interesting effects in the surrounding world; imitation of familiar behaviors</td>
</tr>
<tr>
<td>4. Coordination of secondary circular reactions (8-12 months)</td>
<td>Intentional, or goal-directed, behavior: ability to find a hidden object in the first location in which it is hidden (object permanence); improved anticipation of events; imitation of behaviors slightly different from those the infant usually performs</td>
</tr>
<tr>
<td>5. Tertiary circular reactions (12-18 months)</td>
<td>Exploration of the properties of objects by acting on them in novel ways; imitation of novel behaviors; ability to search in several locations for a hidden object (accurate A-B search)</td>
</tr>
<tr>
<td>6. Mental representation (18 months-2 years)</td>
<td>Internal depictions of objects and events, as indicated by sudden solutions to problems; ability to find an object that has been moved while out of sight (invisible displacement); deferred imitation; and make-believe play</td>
</tr>
</tbody>
</table>
This 3-month-old sees his hands touch, open, and close. He tries to repeat these movements, in a primary circular reaction that helps him gain voluntary control over his behavior.

Infants of Substage 4, who can better anticipate events, sometimes use their capacity for intentional behavior to try to change those events. At 10 months, Timmy crawled after Vanessa when she put on her coat, whimpering to keep her from leaving. Also, babies can now imitate behaviors slightly different from those they usually perform. After watching someone else, they try to stir with a spoon or push a toy car. Again, they draw on intentional behavior, purposefully modifying schemes to fit an observed action (Piaget, 1945/1951).

In Substage 5, from 12 to 18 months, the tertiary circular reaction, in which toddlers repeat behaviors with variation, emerges. Recall how Timmy dropped objects over the basement steps, trying first one action, then another. Because they approach the world in this deliberately exploratory way, 12- to 18-month-olds become better problem solvers. According to Piaget, this capacity to experiment leads toddlers to look for a hidden toy in several locations, displaying an accurate A–B search. Their more flexible action patterns also permit them to imitate many more behaviors.

**MENTAL REPRESENTATION.** Substage 6 brings the ability to create mental representations—internal depictions of information that the mind can manipulate. Our most powerful mental representations are of two kinds: (1) images, or mental pictures of objects, people, and spaces; and (2) concepts, or categories in which similar objects or events are grouped together. We can use a mental image to retrace our steps when we’ve misplaced something or to imitate someone’s behavior long after we’ve observed it. And by thinking in concepts and labeling them (for example, “ball” for all rounded, movable objects), babies begin to divide their world into meaningful categories. Further development of these concepts leads to the emergence of symbolic thought (Piaget, 1952).

---

**WRITE UP:**

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objects used in play), we can organize our diverse experiences into more manageable units.

Representation enables older toddlers to solve advanced object permanence problems involving invisible displacement—finding a toy moved while out of sight, such as into a small box while under a cover. It also permits deferred imitation—the ability to remember and copy the behavior of models who are not present. And it makes possible make-believe play, in which children act out everyday and imaginary activities. As the sensorimotor stage draws to a close, mental symbols have become major instruments of thinking.

**Follow-Up Research on Infant Cognitive Development**

Many studies suggest that infants display a wide array of understandings earlier than Piaget believed. Recall the operant conditioning research reviewed in Chapter 4, in which newborns sucked vigorously on a nipple to gain access to interesting sights and sounds. This behavior, which closely resembles Piaget’s secondary circular reaction, shows that infants explore and control the external world long before 4 to 8 months. In fact, they do so as soon as they are born.

To discover what young infants know about hidden objects and other aspects of physical reality, researchers often use the violation-of-expectation method. They may habituate babies to a physical event (expose them to the event until their looking declines) to familiarize them with a situation in which their knowledge will be tested. Or they may simply show babies an expected event (one that follows physical laws) and an unexpected event (a variation of the first event that violates physical laws). Heightened attention to the unexpected event suggests that the infant is “surprised” by a deviation from physical reality and, therefore, is aware of that aspect of the physical world.

- **OBJECT PERMANENCE.** In a series of studies using the violation-of-expectation method, Renee Baillargeon and her collaborators claimed to have found evidence for object permanence in the first few months of life (Aguir & Baillargeon, 1999, 2002; Baillargeon, 2004; Wang, Baillargeon, & Paterson, 2005). One of Baillargeon's studies is illustrated and explained in Figure 5.1.

Critics argue that the violation-of-expectation method indicates only a perceptual preference for novelty or, at best, implicit (nonconscious) detection of physical events—not the full-blown understanding that was Piaget’s focus in requiring infants to search for hidden objects (Bremner & Mareschal, 2004; Hood, 2004; Munakata, 2001). But another type of looking behavior suggests that young infants are aware that objects persist when out of view. Four- and 5-month-olds will track a ball’s path of movement as it disappears and reappears from behind a barrier, even gazing ahead to where they expect it to emerge (Bertenthal, Longo, & Kenny, 2007; Rosander & von Hofsten, 2004). With age, babies are more likely to fixate on the predicted place of the ball’s reappearance and wait for it—evidence of an increasingly secure grasp of object permanence.

In related research, investigators recorded 6-month-old’s ERP brain-wave activity as the babies watched two events on a computer screen. In one, a black square moved until it covered an object, then moved away to reveal the object (object permanence). In the other, as a black square began to move across an object, the object disintegrated (object disappearance) (Kaufman, Csibra, & Johnson, 2005). Only while watching the first event did infants show a particular brain-wave pattern in the right temporal lobe—the same pattern adults exhibit when told to sustain a mental image of an object.

**FIGURE 5.1** Testing young infants for understanding of object permanence using the violation-of-expectation method. (a) First, infants were habituated to two events: a short carrot and a tall carrot moving behind a yellow screen, on alternate trials. Next, the researchers presented two test events. The color of the screen was changed to help infants notice its window. (b) In the expected event, the carrot shorter than the window’s lower edge moved behind the blue screen and reappeared on the other side. (c) In the unexpected event, the carrot taller than the window’s lower edge moved behind the screen and did not appear in the window, but then emerged intact on the other side. Infants as young as 2½ to 3½ months recovered to (looked longer at) the unexpected event, suggesting that they had some understanding of object permanence. (From R. Baillargeon & J. DeVos, 1991, “Object Permanence in Young Infants: Further Evidence.” *Child Development*, 62, p. 1230. © The Society for Research in Child Development. Adapted with permission.)
Once 8- to 12-month-olds actively search for hidden objects, they make the A-not-B search error. Some research suggests that after finding the object several times at A, they do not attend closely when it is hidden at B (its most recent location) (Ruffman & Langman, 2002). A more comprehensive explanation is that a dynamic system of factors—having built a habit of reaching toward A, continuing to look at A, having the hiding place at B appear similar to the one at A, and maintaining a constant body posture—increases the chances that the baby will make the A-not-B search error. Disrupting any one of these factors increases 10-month-olds’ accurate searching at B (Thelen et al., 2001).

In sum, mastery of object permanence is a gradual achievement: Babies’ understanding becomes increasingly complex with age (Cohen & Cashon, 2006). Success at object search tasks coincides with rapid development of the frontal lobe of the cerebral cortex (Bell, 1998). Also crucial are a wide variety of experiences perceiving, acting on, and remembering objects.

**Mental Representation.** In Piaget’s theory, infants lead purely sensorimotor lives, unable to mentally represent experience until about 18 months of age. Yet 8-month-olds’ ability to recall the location of a hidden object after delays of more than a minute, and 14-month-olds’ recall after delays of a day or more, indicate that babies construct mental representations of objects and their whereabouts (McDonough, 1999; Moore & Meltzoff, 2004). And in studies of deferred imitation and problem solving, representational thought is evident even earlier.

**Deferred Imitation.** Piaget studied deferred imitation by noting when his three children demonstrated it in their everyday behavior. But laboratory research suggests that it is present at 6 weeks of age! Infants who watched an unfamiliar adult’s facial expression imitated it when exposed to the same adult the next day (Meltzoff & Moore, 1994). As motor capacities improve, infants copy actions with objects. In one study, an adult showed 6- and 9-month-olds a novel series of actions with a puppet: taking its glove off, shaking the glove to ring a bell inside, and replacing the glove. When tested a day later, infants who had seen the novel actions were far more likely to display them (see Figure 5.2 on page 122) (Barr, Marrott, & Rowe-Collier, 2003).

Between 12 and 18 months, toddlers use deferred imitation to enrich their range of sensorimotor schemes. They retain modeled behaviors for at least several months, copy the actions of peers as well as adults, and imitate across a change in context—for example, enact at home a behavior learned at child care or on TV (Barr & Hayne, 1999; Hayne, Boniface, & Barr, 2000; Klein & Meltzoff, 1999). Over the second year, toddlers also gain in ability to imitate an adult’s action on toys in the order in which those actions occurred (Bauer, 2002, 2006). And when toddlers imitate in correct sequence, they remember more modeled behaviors (Knopf, Kraus, & Kressley-Mba, 2006). Toddlers even imitate rationally, by inferring others’ intentions! Fourteen-month-olds are more likely to imitate purposeful than accidental behaviors (Carpenter, Akhtar, & Tomasello, 1998). If 12-month-olds see an adult perform an unusual action for fun (making a toy dog enter a miniature house by jumping through the chimney, even though its door is wide open), they copy the behavior. But if the adult engages in the odd behavior because she must (making the dog go through the chimney only after trying to use the door and finding it locked), 12-month-olds typically imitate the more efficient action (putting the dog through the door) (Schwier et al., 2006).

Around 18 months, toddlers can imitate actions an adult tries to produce, even if these are not fully realized (Meltzoff, 1995). On one occasion, Ginette attempted to pour some raisins into a bag but missed, spilling them onto the counter. A moment later, Grace began dropping the raisins into the bag, indicating that she had inferred Ginette’s goal (Falck-Ytter, Gredebäck, & von Hofsten, 2006).

**Problem Solving.** As Piaget indicated, around 7 to 8 months, infants develop intentional action sequences, which they use to solve simple problems, such as pulling on a cloth to obtain a toy resting on its far end (Willatts, 1999). Soon after, infants’ representational skills permit more effective problem solving than Piaget’s theory suggests.

By 10 to 12 months, infants can solve problems by analogy—apply a solution strategy from one problem to other relevant problems. In one study, 12-month-olds who were repeatedly presented with a spoon in the same orientation (handle to one side) readily adapted their motor actions when the spoon was presented with the handle to the other side, successfully transporting food to their mouths (McCarty & Keen, 2005). With
age, children become better at reasoning by analogy, applying relevant strategies across increasingly dissimilar situations (Goswami, 1996). But even in the first year, infants have some ability to move beyond trial-and-error experimentation, represent solutions mentally, and use them in new contexts.

**Evaluation of the Sensorimotor Stage**

Table 5.2 summarizes the remarkable cognitive attainments we have just considered. **TAKE A MOMENT...** Compare this table with the description of Piaget's account of sensorimotor substages in Table 5.1 on page 118. You will see that infants anticipate events, actively search for hidden objects, master the A-B object search, flexibly vary their sensorimotor schemes, and engage in make-believe play within Piaget's time frame. Yet other capacities—including secondary circular reactions, understanding of object properties, first signs of object permanence, deferred imitation, and problem solving by analogy—emerge earlier than Piaget expected.

These findings show that the cognitive attainments of infancy do not develop together in the neat, stepwise fashion that Piaget assumed. They also reveal that infants comprehend a great deal before they are capable of the motor behaviors that Piaget believed led to those understandings. How can we account for babies' amazing cognitive accomplishments?

**ALTERNATIVE EXPLANATIONS.** Unlike Piaget, who thought young babies constructed all mental representations out of sensorimotor activity, most researchers now believe that infants have some built-in cognitive equipment for making sense of experience. But intense disagreement exists over the extent of this initial understanding. Researchers who lack confidence in the violation-of-expectation method argue that babies' cognitive starting point is limited (Campos et al., 2008; Cohen & Cashon, 2006; Kagan, 2008). For example, some believe that newborns begin life with a set of biases for attending to certain information and with general-purpose learning procedures, such as powerful techniques for analyzing complex perceptual information. Together, these capacities enable infants to construct a wide variety of schemes (Bahrick, Lickliter, & Flom, 2004; Mandler, 2004; Quinn, 2008).

Others, convinced by violation-of-expectation findings, believe that infants start out with impressive understandings. According to this core knowledge perspective, babies are born with a set of innate knowledge systems, or core domains of thought. Each of these prewired understandings permits a ready grasp of new, related information and therefore supports early, rapid development (Carey & Markman, 1999; Leslie, 2004; Spelke, 2004; Spelke & Kinzler, 2007). Core knowledge theorists argue that infants could not make sense of the complex stimulation around them without having been genetically "set up" in the course of evolution to comprehend its crucial aspects.

Researchers have conducted many studies of infants' physical knowledge, including object permanence, object solidity (that one object cannot move through another), and gravity (that an object will fall without support). Violation-of-expectation findings suggest that in the first few months, infants have some awareness of all these basic object properties and quickly build on this knowledge (Baillargeon, 2004; Hespos & Baillargeon, 2001; Luo & Baillargeon, 2005; Spelke, 2000). Core knowledge theorists also assume that an inherited foundation of linguistic knowledge enables swift language acquisition in early childhood—a possibility we will consider later in this chapter. Further, these theorists argue, infants' early orientation toward people initiates rapid development of psychological knowledge—in particular, understanding of mental states, such as intentions, emotions, desires, and beliefs.

Researchers have even examined infants' numerical knowledge! In the best-known study, 5-month-olds saw a screen cover a single toy animal, then watched a hand place a second toy
Table 5.2: Some Cognitive Attainments of Infancy and Toddlerhood

<table>
<thead>
<tr>
<th>AGE</th>
<th>COGNITIVE ATTAINMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth–1 month</td>
<td>Secondary circular reactions using limited motor skills, such as sucking a nipple to gain access to interesting sights and sounds</td>
</tr>
<tr>
<td>1–4 months</td>
<td>Possible awareness of object permanence, object solidity, and gravity, as suggested by violation-of-expectation findings; deferred imitation of an adult’s facial expression over a short delay (one day)</td>
</tr>
<tr>
<td>4–8 months</td>
<td>Improved knowledge of object properties and of basic numerical knowledge, as suggested by violation-of-expectation findings; deferred imitation of an adult’s novel actions on objects over a short delay (one day)</td>
</tr>
<tr>
<td>8–12 months</td>
<td>Ability to search for a hidden object when covered by a cloth; ability to solve simple problems by analogy to a previous problem</td>
</tr>
<tr>
<td>12–18 months</td>
<td>Ability to search for a hidden object when a hand deposits it under a cloth and when it is moved from one location to another (accurate A–B search). Deferred imitation of an adult’s novel actions on an object over a long delay (at least several months) and across a change in situation (from child care to home, from TV to everyday life); rational imitation, taking into account the model’s intentions</td>
</tr>
<tr>
<td>18 months–2 years</td>
<td>Deferred imitation of actions an adult tries to produce, again indicating a capacity to infer others’ intentions; imitation of everyday behaviors in make-believe play</td>
</tr>
</tbody>
</table>

Take a moment... Which of the capacities listed in the table indicate that mental representation emerges earlier than Piaget believed?

Before turning to this alternative point of view, let’s recognize Piaget’s enormous contributions. Piaget’s work inspired a wealth of research on infant cognition, including studies that challenged his theory. His observations also have been of great practical value. Teachers and caregivers continue to look to the sensorimotor stage for guidelines on how to create developmentally appropriate environments for infants and toddlers.
**Information Processing**

Recall from Chapter 1 that the information-processing approach frequently relies on computerlike flowcharts to describe the human cognitive system. Information-processing theorists are not satisfied with general concepts, such as assimilation and accommodation, to describe how children think. Instead, they want to know exactly what individuals of different ages do when faced with a task or problem (Birney et al., 2005; Halford, 2002).

### Structure of the Information-Processing System

Most information-processing researchers assume that we hold information in three parts of the mental system for processing: the sensory register, working, or short-term, memory; and long-term memory (see Figure 5.3). As information flows through each, we can use mental strategies to operate on and transform it, increasing the chances that we will retain information, use it efficiently, and think flexibly, adapting the information to changing circumstances. To understand this more clearly, let's look at each aspect of the mental system.

First, information enters the sensory register, where sights and sounds are represented directly and stored briefly. **TAKE A MOMENT...** Look around you, and then close your eyes. An image of what you saw persists for a few seconds, but then it decays, or disappears, unless you use mental strategies to preserve it. For example, by attending to some information more carefully than to other information, you increase the chances that it will transfer to the next step of the information-processing system.

In the second part of the mind, working, or short-term, memory, we actively apply mental strategies as we "work" on a limited amount of information. For example, if you are studying this book effectively, you are taking notes, repeating information to yourself, or grouping pieces of information together, thereby reducing the number of pieces you must attend to and making room in working memory for more.

To manage its complex activities, a special part of working memory—called the central executive—directs the flow of information. It decides what to attend to, coordinates incoming information with information already in the system, and selects, applies, and monitors strategies (Baddeley, 1993, 2000; Pressley & Hilden, 2006). The central executive is the conscious, reflective part of our mental system. It works closely with working memory to direct such activities as comprehension, reasoning, and problem solving.

The longer we hold information in working memory, the more likely it will transfer to the third, and largest, storage area—long-term memory, our permanent knowledge base, which is unlimited. In fact, we store so much in long-term memory that retrieval—getting information back from the system—can be problematic. To aid retrieval, we apply strategies, just as we do in working memory. Information in long-term memory is categorized according to a master plan based on content, much like a library shelving system that allows us to retrieve items easily by following the same network of associations used to store them.

Information-processing researchers believe that the basic structure of the mental system remains similar throughout life. But the capacity of the system—the amount of information that can be retained and processed at once—and the speed with which it can be processed increases, making more complex forms of thinking possible with age (Case, 1998; Kail, 2003). Gains in information-processing capacity are due in part to brain development and in part to improvements in strategies—such as attending to information and categorizing it effectively—that are already developing in the first two years of life.

### Attention

Recall from Chapter 4 that at 2 to 3 months of age, infants explore objects and patterns more thoroughly. Besides attending to more aspects of the environment, infants gradually take in information more quickly. Preterm and newborn babies require a long time to habituate and recover to novel visual stimuli—about 3 or 4 minutes. But by 4 or 5 months, infants require as little as 5 to 10 seconds to take in a complex visual stimulus and recognize it as different from a previous one (Rose, Feldman, & Janowski, 2001; Slater et al., 1996).

One reason for young babies’ long habituation times is that they have difficulty disengaging their attention from interesting stimuli (Colombo, 2002). The ability to shift attention from one stimulus to another is just as important as attending to a stimulus. By 4 months, infants’ attention becomes more flexible (Posner & Rothbart, 2007).

During the first year, infants attend to novel and eye-catching events. With the transition to toddlerhood, children become increasingly capable of intentional behavior (refer back to Piaget’s Substage 4). Consequently, attraction to novelty declines (but does not disappear) and sustained attention improves. A toddler who engages even in simple goal-directed behavior, such as stacking blocks or putting them in a container, must sustain attention to reach the goal. As plans and activities become more complex, so does the duration of attention (Ruff & Capozzoli, 2003).
Memory

Operant conditioning and habituation provide windows into early memory. Both methods show that retention of visual events increases dramatically over infancy and toddlerhood.

Using operant conditioning, researchers study infant memory by teaching 2- to 6-month-olds to move a mobile by kicking a foot tied to it with a long cord. Three-month-olds still remember how to activate the mobile one week after training. By 6 months, memory increases to two weeks (Rovee-Collier, 1999; Hildreth, Sweeney, & Bhatt, 1993). Even after 3- to 6-month-olds forget an operant response, they need only a brief prompt—an adult who shakes the mobile—to reinstate the memory (Hildreth & Rovee-Collier, 2002). And when 6-month-olds are given a chance to reactivate the response themselves for just a couple of minutes, their memory not only returns but extends dramatically, to about 17 weeks (Hildreth, Sweeney, & Rovee-Collier, 2003). Perhaps permitting the baby to generate the previously learned behavior strengthens memory because it reexposes the child to more aspects of the original learning situation.

Habituation/recovery research shows that infants learn and retain a wide variety of information just by watching objects and events, sometimes for much longer time spans than in operant conditioning studies. Babies are especially attentive to the movement of objects and people. In one investigation, 5-month-olds remembered a woman’s captivating action (such as blowing bubbles or brushing hair) seven weeks later, as indicated by a familiarity preference (see page 104 in Chapter 4) (Bahrick, Gogate, & Ruiz, 2002). The babies were so attentive to the woman’s action that they did not remember her face, even when tested 1 minute later for a novelty preference.

So far, we have discussed only recognition—noticing when a stimulus is identical or similar to one previously experienced. It is the simplest form of memory: All babies have to do is indicate (by kicking or looking) that a new stimulus is identical or similar to a previous one. Recall is more challenging because it involves remembering something not present. But by the end of the first year, infants are capable of recall, as indicated by their ability to find hidden objects and to imitate others’ actions long after observing the behavior (see pages 120–121).

Long-term recall depends on connections among multiple regions of the cerebral cortex, especially with the frontal lobes. During the second year, these neural circuits start to increase rapidly (Bauer et al., 2006; Nelson, Thomas, & de Haan, 2006). Yet older children and adults no longer recall their earliest experiences—a puzzling find discussed in the Lifespan Vista box on page 126.

Categorization

Categorization—grouping similar objects and events into a single representation—helps infants make sense of experience. It reduces the enormous amount of new information they encounter so they can learn and remember (Cohen, 2003; Oakes & Madole, 2003).

Some creative variations of operant conditioning research with mobiles have been used to investigate infant categorization. One such study, of 3-month-olds, is described and illustrated in Figure 5.5. Similar investigations reveal that in the first few months, babies categorize stimuli on the basis of shape, size, color, and other physical properties (Wasserman & Rovee-Collier, 2001). By 6 months of age, they can categorize on the basis of two
Infantile Amnesia

If toddlers remember many aspects of their everyday lives, how do we explain infantile amnesia—that most of us cannot retrieve events that happened to us before age 3? The reason we forget cannot be merely the passage of time because we can recall many personally meaningful one-time events from both the recent and the distant past: the day a sibling was born, a birthday party, or a move to a new house—reollections known as autobiographical memory.

Several explanations of infantile amnesia exist. One theory credits brain development, suggesting that vital changes in the frontal lobes of the cerebral cortex may pave the way for an explicit memory system—one in which children remember deliberately rather than implicitly, without conscious awareness (Boyer & Diamond, 1992). But a growing number of researchers argue that even young infants remember consciously. Their memory processing is not fundamentally different from that of children and adults (Bauer, 2006; Rovee-Collier & Barr, 2001).

Another conjecture is that older children and adults often use verbal means for storing information, whereas infants’ and toddlers’ memory processing is largely nonverbal—an incompatibility that may prevent long-term retention of early experiences. To test this idea, researchers sent two adults to the homes of 2- to 4-year-olds with an unusual toy that the children were likely to remember: the Magic Shrinking Machine, shown in Figure 5.4. One adult showed the child how, after inserting an object in an opening on top of the machine and turning a crank that activated flashing lights and musical sounds, the child could retrieve a smaller, identical object from behind a door on the front of the machine. (The second adult discreetly dropped the smaller object down a chute leading to the door.) The child was encouraged to participate as the machine “shrunk” additional objects.

A day later, the researchers tested the children to see how well they recalled the event. Their nonverbal memory—based on acting out the “shrinking” event and recognizing the “shrunk” objects in photos—was excellent. But even when they had the vocabulary, children younger than age 3 had trouble describing features of the “shrinking” experience. Verbal recall increased sharply between ages 3 and 4—the period during which children “scramble over the amnesia barrier” (Simcock & Hayne, 2003, p. 813). In a second study, preschoolers could not translate their nonverbal memory for the game into language six months to one year later, when their language had improved dramatically. Their verbal reports were “frozen in time,” reflecting their limited language skill at the time they played the game (Simcock & Hayne, 2002).

These findings help us reconcile infants’ and toddlers’ remarkable memory skills with infantile amnesia. During the first few years, children remember largely with nonverbal techniques, such as visual images and motor actions. As language develops, preschoolers can use it to refer to preverbal memories. But their ability to do so is fragile, requiring strong contextual cues, such as direct exposure to the physical setting of the to-be-remembered experience (Morris & Baker-Ward, 2007). Only after age 3 do children often represent events verbally and participate in elaborate conversations with adults about them. As children encode autobiographical events in verbal form, they can use language­based cues to retrieve them, increasing the accessibility of these memories at later ages (Hayne, 2004).

Other findings suggest that the advent of a clear self-image contributes to the end of infantile amnesia. Toddlers who were advanced in development of a sense of self demonstrated better verbal memories a year later while conversing about past events with their mothers (Harley & Reese, 1999). Very likely, both biology and social experience contribute to the decline of infantile amnesia. Brain development and adult–child interaction may jointly foster self-awareness, language, and improved memory, which enable children to talk with adults about significant past experiences (Bauer, 2007). As a result, preschoolers begin to construct a long­lasting autobiographical narrative of their lives and enter into the history of their family and community.

**FIGURE 5.4** The Magic Shrinking Machine, used to test young children’s verbal and nonverbal memory of an unusual event. After being shown how the machine worked, the child participated in selecting objects from a polka-dot bag, dropping them into the top of the machine (a) and turning a crank, which produced a “shrunk” object (b). When tested the next day, 2- to 4-year-olds’ nonverbal memory for the event was excellent. But below 36 months, verbal recall was poor, based on the number of features recalled about the game during an open-ended interview (c). Recall improved between 36 and 48 months, the period during which infantile amnesia subsides. (From G. Simcock & H. Hayne, 2003, “Age-Related Changes in Verbal and Nonverbal Memory During Early Childhood,” Developmental Psychology, 39, pp. 807, 809. Copyright © 2003 by the American Psychological Association. Reprinted with permission of the American Psychological Association.) Photos: Ross Coombes/Courtesy of Harlene Hayne.
correlated features—for example, the shape and color of the alphabet letter (Bhatt et al., 2004). This ability to categorize using clusters of features prepares babies for acquiring many complex everyday categories.

Habituation has also been used to study infant categorization. Researchers show babies a series of pictures belonging to one category and then see whether they recover to (look longer at) a picture that does not belong to the category. Findings reveal that 6- to 12-month-olds structure objects into an impressive array of meaningful categories—food items, furniture, animals, plants, vehicles, kitchen utensils, and spatial location (“above” and “below,” “on” and “in”) (Casasola, Cohen, & Chiarello, 2003; Mandler & McDonough, 1998; Oakes, Coppage, & Dingel, 1997). Besides organizing the physical world, infants of this age categorize their emotional and social worlds. Their looking responses reveal that they sort people and their voices by gender and age, have begun to distinguish emotional expressions, and can separate people’s natural movements from other motions (see Chapter 4, pages 111, 112, and 113).

Compared with habituation/recovery, toddlers’ play behaviors better reveal the meanings they attach to categories. After watching an adult give a toy dog a drink from a cup, 14-month-olds shown a rabbit and a motorcycle usually offer the drink only to the rabbit (Mandler & McDonough, 1998). They clearly understand that certain actions are appropriate for some categories of items (animals) but not others (vehicles). By the end of the second year, toddlers’ grasp of the animate—inanimate distinction expands. Nonlinear motions are typical of animates (a person or a dog jumping), linear motions of inanimates (a car or a table pushed along a surface). At 22 months, toddlers imitate a nonlinear motion only with toys in the animate category (e cat but not a bed) (Rakison, 2005, 2006). They seem to grasp that whereas animates are self-propelled and, therefore, have varied paths of movement, inanimates move only when acted on, in highly restricted ways.

Notice in the findings just reviewed that babies’ earliest categories are perceptual—based on similar overall appearance. But from the second half-year on, more categories are conceptual—based on common functions or behaviors (Cohen, 2003; Mandler, 2004; Quinn, 2008). How does this perceptual-to-conceptual shift occur? Although researchers disagree on whether it requires a new approach to analyzing experience, all acknowledge that exploration of objects and expanding knowledge of the world contribute greatly (Mandler, 2004; Oakes & Madole, 2003). In addition, language both builds on and facilitates categorization. Adult labeling of objects (“This one’s a car, and that one’s a bicycle”) helps toddlers refine their categories (Gelman & Kalish, 2006).

**Evaluation of Information-Processing Findings**

The information-processing perspective underscores the continuity of human thinking from infancy into adult life. In attending to the environment, remembering everyday events, and categorizing objects, children, Grace, and Timmy think in ways that are remarkably similar to our own, though their mental processing is far from proficient. Findings on infant memory and categorization join other evidence that challenges Piaget’s view of early cognitive development. If 3-month-olds can remember events for as long as three months and can categorize stimuli, then they must have some ability to represent their experiences.

Information-processing research has contributed greatly to our view of young babies as sophisticated cognitive beings. But its central strength—analyzing cognition into its components, such as perception, attention, and memory—is also its greatest drawback. Information processing has had difficulty putting these components back together into a broad, comprehensive theory.

One approach to overcoming this weakness has been to combine Piaget’s theory with the information-processing approach, an effort we will explore in Chapter 9. A more recent
trend has been the application of a *dynamic systems view*. Researchers analyze each cognitive attainment to see how it results from a complex system of prior accomplishments and the child's current goals (Spencer & Perone, 2008; Thelen & Smith, 2006). Once these ideas are fully tested, they may move the field closer to a more powerful view of how the minds of infants and children develop.

**The Social Context of Early Cognitive Development**

Recall the description at the beginning of this chapter of Grace dropping shapes into a container. Notice that she learns about the toy with Ginette's support. According to Vygotsky's sociocultural theory, complex mental activities have their origins in social interaction (Bodrova & Leong, 2007; Rogoff, 2003). Through joint activities with more mature members of their society, children master activities and think in ways that have meaning in their culture.

A special Vygotskian concept explains how this happens. The *zone of proximal (or potential) development* refers to a range of tasks that the child cannot yet handle alone but can do with the help of more skilled partners. To understand this idea, think about how a sensitive adult (such as Ginette) introduces a child to a new activity. The adult picks a task that the child can master but that is challenging enough that the child cannot do it alone. As the adult guides and supports, the child joins in the interaction and picks up mental strategies. As her competence increases, the adult steps back, permitting the child to take more responsibility for the task.

A study by Barbara Rogoff and her collaborators (1984) illustrates this process. Placing a jack-in-the-box nearby, the researchers watched how several adults played with Rogoff's son and daughter over the first two years. In the early months, the adults tried to focus the baby's attention by working the toy and, as the bunny popped out, saying something like "My, what happened?" By the end of the first year, when the child's cognitive and motor skills had improved, interaction centered on how to use the toy. The adultos guided the baby's hand in turning the crank and putting the bunny back in the box. During the second year, the adults helped from a distance, using gestures and verbal prompts, such as making a turning motion with the hand near the crank. Research indicates that this fine-tuned support is related to advanced play, language, and problem solving in toddlerhood and early childhood (Bornstein et al., 1992; Charman et al., 2001; Tamis-LeMonda & Bornstein, 1989).

As early as the first year, cultural variations in social experiences affect mental strategies. In the jack-in-the-box example, adults and children focused their attention on a single activity—a strategy common in Western middle-SES infant and toddler play. In contrast, Guatemalan Mayan babies often attend to several events at once. For example, one 12-month-old skillfully put objects in a jar while also watching a passing truck and blowing a toy whistle (Chavajay & Rogoff, 1999). Processing several competing events simultaneously may be vital in cultures where children learn largely through keen observation of others' ongoing activities. Mexican children from low-SES families continue to display this style of attention well into middle childhood (Correa-Chavez, Rogoff, & Mejia-Arauz, 2005).

Earlier we saw how infants and toddlers create new schemes by acting on the physical world (Piaget) and how certain skills become better developed as children represent their experiences more efficiently and meaningfully (information processing). Vygotsky adds a third dimension to our understanding by emphasizing that many aspects of cognitive development are socially mediated. The Cultural Influences box on the following page presents additional evidence for this idea, and we will see even more in the next section.
Social Origins of Make-Believe Play

One of the activities my husband, Ken, used to do with our two sons when they were young was to bake pineapple upside-down cake, a favorite treat. One Sunday afternoon as 4-year-old David stirred the cake batter, Ken poured some into a small bowl for 21-month-old Peter and handed him a spoon.

"Here's how you do it, Petey," instructed David, with a superior air. Peter watched as David stirred, then tried to copy his motion. When it was time to pour the batter, Ken helped Peter hold and tip the small bowl.

"Time to bake it," said Ken.

"Bake it, bake it," repeated Peter, watching Ken slip the pan into the oven.

Several hours later, we observed one of Peter's earliest instances of make-believe play. He got his pile from the sandbox and, after filling it with a handful of sand, carried it into the kitchen and put it down on the floor in front of the oven. "Bake it, bake it," Peter called to Ken. Together, father and son placed the pretend cake in the oven.

Vygotsky believed that society provides children with opportunities to represent culturally meaningful activities in play. Make-believe, he claimed, is first learned under the guidance of experts (Berk, Mann, & Ogan, 2006). In the example just described, Peter extended his capacity to represent daily events when Ken drew him into the baking task and helped him act it out in play.

Current evidence supports the idea that early make-believe is the combined result of children's readiness to engage in it and social experiences that promote it. In a study of U.S. middle-SES toddlers, 75 to 80 percent of make-believe involved mother-child interaction (Haight & Miller, 1993). At 12 months, almost all play episodes were initiated by mothers, but by the end of the second year, half of pretend episodes were initiated by each.

During make-believe, mothers offer toddlers a rich array of cues that they are pretending—looking and smiling at the child more, making more exaggerated movements, and using more "we" talk (acknowledging that pretending is a joint endeavor) than they do during the same real-life event (Lillard, 2007). When adults participate, toddlers' make-believe is more elaborate (Keren et al., 2005). And the more parents pretend with their toddlers, the more time their children devote to make-believe.

But in some cultures, such as those of Indonesia and Mexico, where extended-family households and sibling caregiving are common, make-believe is more frequent and more complex with older siblings than with mothers. These Kenyan brothers pretend with sand and rocks—"toys" that are plentiful in their surroundings. The older boy easily engages his toddler sibling, teaching him how to play.

Individual Differences in Early Mental Development

Because of Grace's deprived early environment, Kevin and Monica had a psychologist give her one of many tests available for assessing mental development in infants and toddlers. Worried about Timmy's progress, Vanessa also arranged for him to be tested. At age 22 months, he had only a handful of words in his vocabulary, played in a less mature way than Caitlin and Grace, and seemed restless and overactive.

The cognitive theories we have just discussed try to explain the process of development—how children's thinking changes. Mental tests, in contrast, focus on cognitive products. Their goal is to measure behaviors that reflect development and to arrive at scores that predict future performance, such as later intelligence and school achievement.
Infant and Toddler Intelligence Tests

Accurately measuring infants’ intelligence is a challenge because babies cannot answer questions or follow directions. As a result, most infant tests emphasize perceptual and motor responses. But new tests are being developed that also tap early language, cognition, and social behavior. One commonly used test, the Bayley Scales of Infant and Toddler Development, is suitable for children between 1 month and 3½ years. The most recent edition, the Bayley-III, has three main subtests: (1) the Cognitive Scale, which includes such items as attention to familiar and unfamiliar objects, looking for a fallen object, and pretend play; (2) the Language Scale, which assesses understanding and expression of language—for example, recognition of objects and people, following simple directions, and naming objects and pictures; and (3) the Motor Scale, which includes gross and fine motor skills, such as grasping, sitting, stacking blocks, and climbing stairs (Bayley, 2005).

Two additional Bayley-III scales depend on parental report: (4) the Social-Emotional Scale, which asks caregivers about such behaviors as ease of calming, social responsiveness, and imitation in play; and (5) the Adaptive Behavior Scale, which asks about adaptation to the demands of daily life, including communication, self-control, following rules, and getting along with others.

Computing Intelligence Test Scores. Intelligence tests for infants, children, and adults are scored in much the same way—by computing an intelligence quotient (IQ), which indicates the extent to which the raw score (number of items passed) deviates from the typical performance of same-age individuals. To make this comparison possible, test designers engage in standardization—giving the test to a large, representative sample and using the results as the standard for interpreting scores.

Within the standardization sample, performances at each age level form a normal distribution in which most scores cluster around the mean, or average, with progressively fewer falling toward the extremes (see Figure 5.6). This bell-shaped distribution results whenever researchers measure individual differences in large samples. When intelligence tests are standardized, the mean IQ is set at 100. An individual’s IQ is higher or lower than 100 by an amount that reflects how much his or her test performance deviates from the standardization-sample mean. In this way, the IQ indicates whether the individual is ahead, behind, or on time (average) in mental development in relation to others of the same age. The IQs of 96 percent of individuals fall between 70 and 130; only a few achieve higher or lower scores.

Predicting Later Performance from Infant Tests. Despite careful construction, infant tests—including previous editions of the Bayley—predict later intelligence poorly. Because infants and toddlers easily become distracted, fatigued, or bored during testing, their scores often do not reflect their true abilities. And infant perceptual and motor items differ from the tasks given to older children, which increasingly emphasize verbal, conceptual, and problem-solving skills. In contrast, the Bayley-III Cognitive and Language Scales, which better dovetail with childhood tests, are good predictors of preschool mental test performance (Albers & Grieve, 2007).

Most infant tests are better at making long-term predictions for extremely low-scoring babies. Today, they are largely used for screening—helping to identify for further observation and intervention babies who are likely to have developmental problems.

As an alternative to infant tests, some researchers have turned to information-processing measures, such as habituation, to assess early mental progress. Their findings show that speed of habituation and recovery to novel visual stimuli are among the best available infant predictors of IQ from early childhood through early adulthood (Fagan, Holand, & Wheeler, 2007; Kavsek, 2004; McCall & Carriger, 1993). These measures assess memory as well as quickness and flexibility of thinking, which underlie intelligent behavior at all ages (Colombo, 1995; Rose & Feldman, 1997). The consistency of these findings has prompted designers of the Bayley-III to include items that tap such cognitive skills as habituation/recovery, problem-solving, and categorization.

Early Environment and Mental Development

In Chapter 2, we indicated that intelligence is a complex blend of hereditary and environmental influences. Many studies have examined the relationship of environmental factors to early
mental test scores. As we consider this evidence, you will encounter findings that highlight the role of heredity as well.

**HOME ENVIRONMENT.** The Home Observation for Measurement of the Environment (HOME) is a checklist for gathering information about the quality of children's home lives through observation and parental interview (Caldwell & Bradley, 1994). Factors measured by HOME during the first three years include an organized, stimulating physical setting and parental affection, involvement, and encouragement. Regardless of SES and ethnicity, each predicts better language and IQ scores in toddlerhood and early childhood (Fuligni, Han, & Brooks-Gunn, 2004; Linver, Martin, & Brooks-Gunn, 2004; Tamis-LeMonda et al., 2004). The extent to which parents talk to infants and toddlers is particularly important. It contributes strongly to early language progress, which, in turn, predicts intelligence and academic achievement in elementary school (Hart & Risley, 1995).

Yet we must interpret these correlational findings cautiously. Parents who are genetically more intelligent may provide better experiences while also giving birth to genetically brighter children, who evoke more stimulation from their parents. Research supports this hypothesis, which refers to genetic-environmental correlation (see Chapter 2, page 55) (Saudino & Plomin, 1997). But heredity does not account for the entire association between home environment and mental test scores. Family living conditions—both HOME scores and affluence of the surrounding neighborhood—continue to predict children's IQ beyond the contribution of parental IQ and education (Chase-Lansdale et al., 1997; Klebanov et al., 1998).

How can the research summarized so far help us understand Vanessa's concern about Timmy's development? Ben, the psychologist who tested Timmy, found that he scored only slightly below average. Ben also noticed that Vanessa, anxious about Timmy's progress, tended to pressure him, dampening his active behavior and bombarding him with directions: "That's enough ball play. Stack these blocks."

Ben explained that when parents are intrusive in these ways, infants and toddlers are likely to be distractible, play immaturely, and do poorly on mental tests (Bono & Stifter, 2003; Stilson & Harding, 1997). He coached Vanessa in how to interact sensitively with Timmy, while also assuring her that warm, responsive parenting is a much better indicator of how children will do later than an early mental test score.

**INFANT AND TODDLER CHILD CARE.** Today, more than 60 percent of U.S. mothers with a child under age 2 are employed (U.S. Census Bureau, 2009b). Child care for infants and toddlers has become common, and its quality has a major impact on mental development. Infants and young children exposed to poor-quality child care—whether they come from middle-class or from low-SES homes—score lower on measures of cognitive and social skills (Hausfather et al., 1997; NICHD Early Child Care Research Network, 2000b, 2001, 2003, 2006). In contrast, good child care can reduce the negative impact of a parent who worked long hours, Vanessa had little energy for Timmy at the end of the day. Ben also noticed that Vanessa, anxious about Timmy's progress, tended to pressure him, dampening his active behavior and bombarding him with directions: "That's enough ball play. Stack these blocks."

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PART III Infancy and Toddlerhood: The First Two Years

Applying What We Know

**Signs of Developmentally Appropriate Infant and Toddler Child Care**

<table>
<thead>
<tr>
<th>Program Characteristics</th>
<th>Signs of Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical setting</td>
<td>Indoor environment is clean, in good repair, well-lit, well-ventilated, and not overcrowded. Fenced outdoor play space is available.</td>
</tr>
<tr>
<td>Toys and equipment</td>
<td>Play materials are appropriate for infants and toddlers and are stored on low shelves within easy reach. Cribs, highchairs, infant seats, and child-sized tables and chairs are available. Outdoor equipment includes small riding toys, swings, slide, and sandbox.</td>
</tr>
<tr>
<td>Caregiver–Child ratio</td>
<td>In child-care centers, caregiver–child ratio is no greater than one to three for infants and one to six for toddlers. Group size (number of children in one room) is no greater than six infants with two caregivers and 12 toddlers with two caregivers. In family child care, caregiver is responsible for no more than six children; within this group, no more than two are infants and toddlers.</td>
</tr>
<tr>
<td>Daily activities</td>
<td>Daily schedule includes times for active play, quiet play, naps, snacks, and meals. Atmosphere is warm and supportive, and children are never left unsupervised.</td>
</tr>
<tr>
<td>Interactions among adults and children</td>
<td>Caregivers respond promptly to infants’ and toddlers’ distress; hold, talk to, sing to, and read to them; and interact with them in a manner that respects the individual child’s interests and tolerance for stimulation. Staffing is consistent, so infants and toddlers can form relationships with particular caregivers.</td>
</tr>
<tr>
<td>Caregiver qualifications</td>
<td>Caregivers have some training in child development, first aid, and safety.</td>
</tr>
<tr>
<td>Relationships with parents</td>
<td>Parents are welcome anytime. Caregivers talk frequently with parents about children’s behavior and development.</td>
</tr>
<tr>
<td>Licensing and accreditation</td>
<td>Child-care setting, whether a center or a home, is licensed by the state. In the United States, voluntary accreditation by the National Academy of Early Childhood Programs (<a href="http://www.naeyc.org/accreditation">www.naeyc.org/accreditation</a>) or the National Association for Family Child Care (<a href="http://www.nafcc.org">www.nafcc.org</a>) is evidence of an especially high-quality program.</td>
</tr>
</tbody>
</table>

Sources: Copple & Bredekamp, 2009.

stressed, poverty-stricken home life, and it sustains the benefits of growing up in an economically advantaged family (Lamb & Ahnert, 2006; McCartney et al., 2007; NICHD Early Child Care Research Network, 2003).

**TAKE A MOMENT...** Visit several child-care settings, and take notes on what you see. Unlike most European countries and Australia and New Zealand, where child care is nationally regulated and funded to ensure its quality, U.S. child care is cause for concern. Standards are set by the states and vary widely. In studies of U.S. child care, only 20 to 25 percent of child-care centers and family child-care homes provided infants and toddlers with sufficiently positive, stimulating experiences to promote healthy psychological development (NICHD Early Childhood Research Network, 2000a, 2004). U.S. settings providing the very worst care tend to serve middle-SES families. These parents are especially likely to place their children in for-profit centers, where quality tends to be lowest. Low-SES children more often attend publicly subsidized, nonprofit centers, which have smaller group sizes and better teacher–child ratios (Lamb & Ahnert, 2006). Still, child-care quality for low-SES children varies widely. And probably because of greater access to adult stimulation, infants and toddlers in high-quality family child care score higher than those in center care in cognitive and language development (NICHD Early Child Care Research Network, 2000b).

See Applying What We Know above for signs of high-quality care for infants and toddlers, based on standards for developmentally appropriate practice. These standards, devised by the U.S. National Association for the Education of Young Children, specify program characteristics that serve young children’s developmental and individual needs, based on both current research and expert consensus.

High-quality child care, with a generous caregiver–infant ratio, well-trained caregivers, and developmentally appropriate activities, can be especially beneficial to children from low-SES homes.
Child care in the United States is affected by a macrosystem of individualistic values and weak government regulation and funding. Recognizing that child care is in a state of crisis, the U.S. federal government and some states have allocated additional funds to subsidize it, especially for low-income families. Though far from meeting the need, this increase in resources has had a positive impact on child-care quality and accessibility (Children's Defense Fund, 2008).

Good child care is a cost-effective means of protecting children's well-being. And much like the programs we are about to consider, it can serve as effective early intervention for children whose development is at risk.

**Early Intervention for At-Risk Infants and Toddlers**

Children living in poverty are likely to show gradual declines in intelligence test scores and to achieve poorly when they reach school age (Bradley et al., 2001; Gutman, Sameroff, & Cole, 2003). These problems are largely due to stressful home environments that undermine children's ability to learn and that increase their likelihood of remaining poor throughout their lives (McLoyd, Aikens, & Burton, 2006). A variety of intervention programs have been developed to break this tragic cycle of poverty. Although most begin in the preschool years, a few start during infancy and continue through early childhood.

In center-based interventions, children attend an organized child-care or preschool program where they receive educational, nutritional, and health services, and their parents receive child-rearing and other social-service supports. In home-based interventions, a skilled adult visits the home and works with parents, teaching them how to stimulate young children's development. In most programs of either type, participating children score higher than untreated controls on mental tests by age 2.

The earlier intervention begins, the longer it lasts, and the greater its scope and intensity, the better participants' cognitive and academic performance is throughout childhood and adolescence (Brooks-Gunn, 2004; Ramey, Ramey, & Lanzi, 2006).

The Carolina Abecedarian Project illustrates these favorable outcomes. In the 1970s, more than 100 infants from poverty-stricken families, ranging in age from 3 weeks to 3 months, were randomly assigned to either a treatment group or a control group. Treatment infants were enrolled in full-time, year-round child care through the preschool years. There they received stimulation aimed at promoting motor, cognitive, language, and social skills and, after age 3, literacy and math concepts. Special emphasis was placed on rich, responsive adult-child verbal communication. All children received nutrition and health services; the primary difference between treatment and control groups was the intensive child-care experience.

As Figure 5.7 shows, by 12 months, the IQs of the two groups diverged. Treatment children sustained their advantage until last tested—at age 21. In addition, throughout their school years, treatment youths achieved considerably better in reading and math. These gains translated into more years of schooling completed, higher rates of college enrollment and employment in skilled jobs, and lower rates of drug use and adolescent parenthood (Campbell et al., 2001, 2002; Ramey & Ramey, 1999).

Without early intervention, many children born into economically disadvantaged families will not reach their potential. Recognition of this reality led the U.S. Congress to provide limited funding for intervention directed at infants and toddlers at risk for developmental problems. Early Head Start, begun in 1995, currently has 700 sites serving 65,000 low-income families. A recent evaluation, conducted when children reached age 3, showed that intervention led to warmer, more stimulating parenting, a reduction in harsh discipline, gains in cognitive and language development, and lessening of child aggression (Love et al., 2005; Love, Chazan-Cohen, & Raikes, 2007). The strongest effects occurred at sites offering a mix of center- and home-based services. Though not yet plentiful enough to meet the need, such programs are a promising beginning.
Language Development

Improvements in perception and cognition during infancy pave the way for an extraordinary human achievement—language. In Chapter 4, we saw that by the second half of the first year, infants make dramatic progress in distinguishing the basic sounds of their language and in segmenting the flow of speech into word and phrase units. They also start to comprehend some words and, around 12 months, say their first word. Between 1½ and 2 years, toddlers combine two words (MacWhinney, 2005). By age 6, children have a vocabulary of about 10,000 words and speak in elaborate sentences.

How do infants and toddlers make such remarkable progress in launching these skills? To address this question, let’s examine several prominent theories of language development.

Theories of Language Development

In the 1950s, researchers did not take seriously the idea that very young children might be able to figure out important properties of language. As a result, the first two theories of how children acquire language were extreme views. One, behaviorism, regards language development as entirely due to environmental influences. The second, nativism, assumes that children are “prewired” to master the intricate rules of their language.

The Behaviorist Perspective. Behaviorist B. F. Skinner (1957) proposed that language, like any other behavior, is acquired through operant conditioning (see Chapter 4, page 104). As the baby makes sounds, parents reinforce those that are most like words with smiles, hugs, and speech in return. Some behaviorists believe that children rely on imitation to rapidly acquire complex utterances, such as whole phrases and sentences (Moerke, 2000). Imitation can combine with reinforcement to promote language, as when a parent coaxes, “Say, ‘I want a cookie!’” and delivers praise and a treat after the toddler responds, “Wanna cookie!”

Although reinforcement and imitation contribute to early language development, they are best viewed as supporting rather than fully explaining it. “It’s amazing how creative Caitlin is with language,” Carolyn remarked one day. “She combines words in ways she’s never heard before, like ‘needle it’ when she wants me to sew up her teddy bear and ‘all gone outside’ when she has to come in,” Carolyn’s observations are accurate: Young children create many novel utterances that are not reinforced by or copied from others (Owens, 2005).

The Nativist Perspective. Linguist Noam Chomsky (1957) proposed a nativist theory that regards the young child’s amazing language skill as etched into the structure of the human brain. Focusing on grammar, Chomsky reasoned that the rules of sentence organization are too complex to be directly taught to or discovered by even a cognitively adept young child. Rather, he argued, all children have a language acquisition device (LAD), an innate system that contains a universal grammar, or set of rules common to all languages. It enables children, no matter which language they hear, to understand and speak in a rule-oriented fashion as soon as they pick up enough words.

Are children biologically primed to acquire language? Recall from Chapter 4 that newborn babies are remarkably sensitive to speech sounds. And children the world over reach major language milestones in a similar sequence (Gleitman & Newport, 1996).

Furthermore, evidence that childhood is a sensitive period for language acquisition is consistent with Chomsky’s idea of a biologically based language program. Researchers have examined the language competence of deaf adults who acquired their first language—American Sign Language (ASL), a gestural system used by the deaf—at different ages. The late learners, whose parents chose to educate them through speech and lip-reading, did not acquire spoken language because of their profound deafness. Consistent with the sensitive period notion, those who learned ASL in adolescence or adulthood never became as proficient as those who learned in childhood (Mayberry, 1994; Newport, 1991; Singleton & Newport, 2004).

But challenges to Chomsky’s theory suggest that it, too, provides only a partial account of language development. First, researchers have had great difficulty identifying the single system of grammar that Chomsky believes underlies all languages (Maratsos, 1998; Tomasello, 2003, 2005). Second, children’s progress in mastering many sentence constructions is gradual, with errors along the way, indicating more learning and discovery than Chomsky assumed (Tomasello, 2003, 2006).

The Interactionist Perspective. Recent ideas about language development emphasize interactions between inner capacities and environmental influences. One type of interactionist theory applies the information-processing perspective to language development. A second type emphasizes social interaction.

Some information-processing theorists assume that children make sense of their complex language environments by applying powerful cognitive capacities of a general kind (Bates, 2004; Elman, 2001; Munakata, 2006). These theorists note that brain regions housing language also govern similar perceptual and cognitive abilities, such as the capacity to analyze musical and visual patterns (Koelsch et al., 2002; Saygin et al., 2004).

Other theorists blend this information-processing view with Chomsky’s nativist perspective. They agree that infants are amazing analyzers of speech and other information. But, they argue, these capacities probably are not sufficient to account for mastery of higher-level aspects of language, such as intricate grammatical structures (Newport & Aslin, 2000). They also point out that grammatical competence may depend more on specific brain structures than the other components of language. When 2- to 2½-year-olds and adults listened to short sentences—some grammatically correct, others with phrase-structure violations—both groups showed similarly distinct ERP brain-wave patterns for each sentence type in the left frontal and temporal lobes of the cerebral cortex (Oberecker &
Friederici, 2006; Oberecker, Friedrich, & Friederici, 2005). This suggests that 2-year-olds process sentence structures using the same neural system as adults do.

Still other interactionists emphasize that children’s social skills are central to language development. In this social-interactionist view, an active child strives to communicate, cueing caregivers to provide appropriate language experiences, which help the child relate the content and structure of language to its social meanings (Bohannon & Bowvillian, 2009). Among social interactionists, disagreement continues over whether or not children are equipped with specialized language abilities (Lidz, 2007; Shatz, 2007; Tomasello, 2006). Nevertheless, as we chart the course of language development, we will encounter much support for their central premise—that children’s social competencies and language experiences greatly affect their progress.

**Getting Ready to Talk**

Before babies say their first word, they make impressive progress toward understanding and speaking their native tongue. They listen attentively to human speech, and they make speechlike sounds. As adults, we can hardly help but respond.

**COOING AND BABBLING.** Around 2 months, babies begin to make vowel-like noises, called cooing because of their pleasant “oo” quality. Gradually, consonants are added, and around 6 months, babbling appears, in which infants repeat consonant-vowel combinations in long strings, such as “bababababa” or “nanananana.”

Babies everywhere (even those who are deaf) start babbling at about the same age and produce a similar range of early sounds. But for babbling to develop further, infants must be able to hear human speech. In hearing-impaired babies, these speechlike sounds are greatly delayed. And a deaf infant not exposed to sign language will stop babbling entirely (Oller, 2000).

As infants listen to spoken language, babbling expands to include a broader range of sounds. Around 7 months, it includes many sounds common in spoken languages. By 10 months, it reflects the sound and intonation patterns of infants’ language community, some of which are transferred to their first words (Boysson-Bardies & Vihman, 1991).

Deaf infants exposed to sign language from birth and hearing babies of deaf, signing parents produce babblelike hand motions with the rhythmic patterns of natural sign languages (Petitto et al., 2001, 2004; Petitto & Marentette, 1991). This sensitivity to language rhythm—evident in both spoken and signed babbling—supports both discovery and production of meaningful language units.

**BECOMING A COMMUNICATOR.** At birth, infants are prepared for some aspects of conversational behavior. For example, they initiate interaction through eye contact and terminate it by looking away. By 3 to 4 months, infants start to gaze in the same direction adults are looking, a skill that becomes more accurate at 10 to 11 months, as babies realize that others’ focus provides information about their communicative intentions (Brooks & Meltzoff, 2005). Adults also follow the baby’s line of vision and comment on what the infant sees. This joint attention, in which the child attends to the same object or event as the caregiver, contributes greatly to early language development. Infants and toddlers who often experience it sustain attention longer, comprehend more language, produce meaningful gestures and words earlier, and show faster vocabulary development (Carpenter, Nagell, & Tomasello, 1998; Flom & Pick, 2003; Silven, 2001).

Between 4 and 6 months, interactions between caregivers and babies begin to include give-and-take, as in pat-a-cake and peekaboo games. At first, the parent starts the game, and the baby is an amused observer. By 12 months, babies participate actively, practicing the turn-taking pattern of conversation. Infants’ play maturity and vocalizations during games predict advanced language progress in the second year (Rome-Flanders & Cronk, 1995).

At the end of the first year, babies extend their joint attention and social interaction skills. They use preverbal gestures to influence others’ behavior (Liszkowski et al., 2004). For example, while looking at her mother, Caitlin held up a toy to show it and pointed to the cupboard when she wanted a cookie. Carolyn responded to these gestures and also labeled them (“Oh, you want a cookie!”). In this way, toddlers learn that using language leads to desired results. Soon they integrate words with gestures, using the gesture to expand their verbal message, as in pointing to a toy while saying “give” (Capirci et al., 2005). The earlier toddlers form word-gesture combinations, the sooner they produce two-word utterances at the end of the second year (Özçaliskan & Goldin-Meadow, 2005).

Infants communicate from the very beginning of life, as seen in this interchange between a father and his baby. How will this child accomplish the impressive task of becoming a fluent speaker of his native language within just a few years? Theorists disagree sharply on answers to this question.
The baby uses a preverbal gesture to draw his father's attention to the birdhouse. His father's verbal response promotes the baby's transition to spoken language.

First Words

In the second half of the first year, infants begin to understand word meanings. When 6-month-olds listened to the word "Mommy" or "Daddy" while looking at side-by-side videos of their parents, they looked longer at the video of the named parent (Tincoff & Jusczyk, 1999). First spoken words, around 1 year, build on the sensorimotor foundations Piaget described and on categories children form during their first two years. Usually they refer to important people ("Mama," "Dada"), animals ("doggie," "kitty"), objects that move ("car," "ball"), foods ("milk," "apple"), familiar actions ("bye-bye," "more"), or outcomes of familiar actions ("wet," "hot") (Hart, 2004; Nelson, 1973).

When toddlers first learn words, they often apply them too narrowly, an error called underextension. At 16 months, Caitlin used "bear" only to refer to the worn and tattered bear she carried nearly constantly. As vocabulary expands, a more common error is overextension—applying a word to a wider collection of objects and events than is appropriate. For example, Grace used "car" for buses, trains, trucks, and fire engines. Toddlers' overextensions reflect their sensitivity to categories (MacWhinney, 2005). They apply a new word to a group of similar experiences, often overextending deliberately because they have difficulty recalling or have not acquired a suitable word.

Overextensions illustrate another important feature of language development: the distinction between language production (the words children use) and language comprehension (the words they understand). At all ages, comprehension develops ahead of production. Still, the two capacities are related. The speed and accuracy of toddlers' comprehension of spoken language increase dramatically over the second year. And toddlers who are faster and more accurate in comprehension tend to show more rapid growth in words understood and produced (Fernald, Perfors, & Marchman, 2006). Quick comprehension frees space in working memory for picking up new words and for the more demanding task of using them to communicate.

The Two-Word Utterance Phase

Young toddlers add to their spoken vocabularies at a rate of one to three words per week. Because gains in word production between 18 and 24 months are so impressive (one or two words per day), many researchers concluded that toddlers undergo a spurt in vocabulary—a transition from a slower to a faster learning phase. But recent evidence indicates that most children show a steady, continuous increase in rate of word learning that continues through the preschool years (Ganger & Brent, 2004).

Once toddlers produce about 200 words, they start to combine two words: "Mommy shoe," "go car," "more cookie." These two-word utterances are called telegraphic speech because, like a telegram, they focus on high-content words, omitting smaller, less important ones. Children the world over use them to express an impressive variety of meanings.

Two-word speech consists largely of simple formulas ("more + X," "eat + X"), with different words inserted in the X position. Rather than following grammatical rules, toddlers' word-order regularities are usually copies of adult word pairings, as when the parent says, "How about more sandwich?" (Tomasello, 2006).

Individual and Cultural Differences

Although, on average, children produce their first word around their first birthday, the range is large, from 8 to 18 months—variation due to a complex blend of genetic and environmental influences. Earlier we saw that Timmy's spoken language was delayed, in part because of Vanessa's tense, directive communication with him. But Timmy is also a boy, and many studies show that girls are slightly ahead of boys in early vocabulary growth (Fenson et al., 1994). The most common explanation is girls' faster rate of physical maturation, believed to promote earlier development of the left cerebral hemisphere.

Temperament matters, too. Shy toddlers often wait until they understand a great deal before trying to speak. Once they do speak, their vocabularies increase rapidly, although they remain slightly behind their agemates (Spere et al., 2004). Temperamentally negative toddlers also acquire language more
slowly because their high emotional reactivity diverts them from processing linguistic information (Salley & Dixon, 2007).

Also, the more words caregivers use, the more children learn (Weizman & Snow, 2001). Mothers talk much more to toddler-age girls than to boys, and parents converse less often with shy than with sociable children (Leaper, Anderson, & Sanders, 1998; Patterson & Fisher, 2002). Because low-SES children receive less parental verbal stimulation (both conversation and book reading), their vocabularies are, on average, only one-fourth as large as their higher-SES agemates' at kindergarten age (Hoff, 2004; Lee & Burkam, 2002).

Young children have distinct styles of early language learning. Caitlin and Grace, like most toddlers, used a referential style; their vocabularies consisted mainly of words that refer to objects. A smaller number of toddlers use an expressive style; compared with referential children, they produce many more social formulas and pronouns ("thank you," "done," "I want it"). These styles reflect early ideas about the functions of language. Grace, for example, thought words were for naming things. In contrast, expressive-style children believe words are for talking about people's feelings and needs. The vocabularies of referential-style toddlers grow faster because all languages contain many more object labels than social phrases (Bates et al., 1994).

What accounts for a toddler's language style? Rapidly developing referential-style children eagerly imitate their parents' frequent naming of objects, and their parents imitate back—a strategy that supports swift vocabulary growth by helping children remember new labels (Masur & Rodemaker, 1999). Expressive-style children tend to be highly sociable, and their parents more often use verbal routines ("How are you?" "It's no trouble") that support social relationships (Goldfield, 1987).

The two language styles are also linked to culture. Whereas object words are common in the vocabularies of English-speaking toddlers, words for social routines are more numerous among Chinese, Japanese, and Korean toddlers. Mothers' speech reflects this difference: Asian mothers, perhaps because of a cultural emphasis on group membership, teach social routines as soon as their children begin to speak (Choi & Gopnik, 1995; Fernald & Morikawa, 1993; Tardif, Gelman, & Xu, 1999).

Deaf parents use a similar style of communication when signing to their deaf babies (Masataka, 1996). CDS builds on several communicative strategies we have already considered: joint attention, turn-taking, and caregivers' sensitivity to toddlers' preverbal gestures. In this example, Carolyn uses CDS with 18-month-old Caitlin:

**Caitlin:** "Go car."

**Carolyn:** "Yes, time to go in the car. Where's your jacket?"

**Caitlin:** [Looks around, walks to the closet.] "Dacket!" [Points to her jacket.]

**Carolyn:** "There's that jacket! [She helps Caitlin into the jacket.] Now, say bye-bye to Grace and Timmy."

**Caitlin:** "Bye-bye, G-ace. Bye-bye, Te-te."

**Carolyn:** "Where's your bear?"

**Caitlin:** [Looks around.]

**Carolyn:** [Pointing.] "See? Go get the bear. By the sofa."

From birth onward, infants prefer CDS over other adult talk, and by 5 months they are more emotionally responsive to it (Aslin, Jusczyk, & Pisoni, 1998). Parents constantly fine-tune the length and content of their utterances to fit their children's needs—adjustments that foster word learning and enable toddlers to join in (Cameron-Faulkner, Lieve, & Tomasello, 2003; Fernald & Hurtado, 2006). As we saw earlier, parent-toddler conversation—especially reading and talking about picture books—strongly predicts language development and academic success during the school years.

Do social experiences that promote language development remind you of those that strengthen cognitive development in general? CDS and parent-child conversation create a zone of proximal development in which children's language skills expand. In the next chapter, we will see that sensitivity to children's needs and capacities supports their emotional and social development as well.

**Supporting Early Language Development**

Consistent with the interactionist view, a rich social environment builds on young children's natural readiness to acquire language. Adults in many cultures speak to young children in child-directed speech (CDS), a form of communication made up of short sentences with high-pitched, exaggerated expression, clear pronunciation, distinct pauses between speech segments, and repetition of new words in a variety of contexts ("See the ball." "The ball bounced!") (Fernald et al., 1989; O'Neill et al., 2005).
**Piaget's Cognitive-Developmental Theory**

According to Piaget, how do schemes change over the course of development?

» By acting on the environment, children move through four stages in which psychological structures, or *schemes*, achieve a better fit with external reality.

» Schemes change in two ways: through adaptation, which is made up of two complementary activities—assimilation and accommodation—and through organization.

Describe the major cognitive achievements of the sensorimotor stage.

» In the sensorimotor stage, the *circular reaction* provides a means of adapting first schemes, and the newborn's reflexes are transformed into the flexible action patterns of the older infant. Around 8 months, infants develop intentional, or goal-directed, *behavior* and begin to understand object permanence. Between 18 and 24 months, *mental representation* is evident in sudden solutions to sensorimotor problems, mastery of object permanence problems involving invisible displacement, deferred imitation, and make-believe play.

» Many studies suggest that infants display certain understandings earlier than Piaget believed. Some awareness of object permanence, as revealed by the *violation-of-expectation method* and object-tracking research, may be evident in the first few months. In addition, young infants display deferred imitation and analogical problem solving, which suggests that they are capable of mental representation.

Today, researchers believe that newborns have more built-in equipment for making sense of their world than Piaget assumed. According to the *core knowledge perspective*, infants begin life with core domains of thought that support early, rapid cognitive development. Although findings on early, ready-made knowledge are mixed, there is broad agreement that many cognitive changes are continuous rather than stage-like and that cognition develops unevenly rather than in an integrated fashion.

**Information Processing**

Describe the information-processing view of cognitive development.

» Information-processing researchers regard development as gradual and continuous and study many aspects of thinking. Most assume that we hold information in three parts of the system, the *sensory register*; working, or *short-term*; *memory*; and *long-term memory*. As information flows through the system, *mental strategies* operate on it so that it can be retained and used efficiently. To manage the complex activities of working memory, the *central executive* directs the flow of information.

What changes in attention, memory, and categorization take place during the first two years?

» With age, infants attend to more aspects of the environment and take information in more quickly. In the second year, attention to novelty declines and sustained attention improves.

» Young infants are capable of *recognition memory*. By the end of the first year, they can *recall* past events.

» During the first year, infants group stimuli into increasingly complex categories, and categorization shifts from a perceptual to a conceptual basis.

Describe contributions and limitations of the information-processing approach to our understanding of early cognitive development.

» Information-processing findings challenge Piaget's view of babies as purely sensorimotor beings who cannot mentally represent experiences. But information processing has not yet provided a broad, comprehensive theory of children's thinking.

The Social Context of Early Cognitive Development

How does Vygotsky's concept of the zone of proximal development expand our understanding of early cognitive development?

» Vygotsky believed that infants master tasks within the *zone of proximal development*—that is, tasks just ahead of their current capacities—through the support and guidance of more skilled partners. As early as the first year, cultural variations in social experiences affect mental strategies.

**Individual Differences in Early Mental Development**

Describe the mental testing approach and the extent to which infant tests predict later performance.

» The mental testing approach measures intellectual development in an effort to predict future performance. Scores are arrived at by computing an *intelligence quotient* (IQ), which compares an individual's test performance with that of a *standardization* sample of same-age individuals.
Most infant tests, which consist largely of perceptual and motor responses, predict later intelligence poorly. Speed of habituation and recovery to visual stimuli are better predictors of future performance.

Discuss environmental influences on early mental development, including home, child care, and early intervention for at-risk infants and toddlers.

An organized, stimulating home environment and parental encouragement, involvement, and affection repeatedly predict early mental test scores. Although the home environment–IQ relationship is partly due to heredity, family living conditions also affect mental development.

Quality of infant and toddler child care has a major impact on mental development. Standards for developmentally appropriate practice specify program characteristics that meet young children’s developmental needs.

Intensive intervention beginning in infancy and extending through early childhood can prevent the declines in intelligence and poor academic performance seen in many poverty-stricken children.

Language Development

Describe theories of language development, and indicate how much emphasis each places on innate abilities and environmental influences.

According to the behaviorist perspective, parents train children in language skills through operant conditioning and imitation. Behaviorism, however, has difficulty accounting for children’s novel utterances.

In contrast, Chomsky’s nativist view regards children as naturally endowed with a language acquisition device (LAD). Although evidence that mastery of a complex language system is unique to humans and that childhood is a sensitive period for language acquisition is supportive, Chomsky’s theory provides only a partial account of language development.

Recent theories suggest that language development results from interactions between inner capacities and environmental influences. Some interactionists apply the information-processing perspective to language development. Others emphasize children’s social skills and language experiences.

In the second half of the first year, infants begin to understand word meanings. At the end of the first year, they use preverbal gestures, such as pointing, to influence others’ behavior.

Around 12 months, toddlers say their first word. Young children often make errors of underextension and overextension. Rate of word learning increases steadily, and once vocabulary reaches about 200 words, two-word utterances called telegraphic speech appear. At all ages, language comprehension is ahead of production.

Girls show faster language progress than boys, and reserved, cautious toddlers may wait before trying to speak. Most toddlers use a referential style of language learning; their early words consist largely of names for objects. A few use an expressive style, in which pronouns and social formulas are common and vocabulary grows more slowly.

Adults in many cultures speak to young children in child-directed speech (CDS), a simplified form of language that is well-suited to their learning needs. Conversation between parent and toddler is one of the best predictors of early language development and academic success during the school years.

Describe major language milestones in the first two years, individual differences, and ways adults can support early language development.

Infants begin cooing at 2 months and babbling at about 6 months. Around 10 to 11 months, their skill at establishing joint attention improves. Adults can encourage language progress by responding to infants’ coos and babbles, establishing joint attention and labeling what babies see, playing turn-taking games, and acknowledging infants’ preverbal gestures.

Important Terms and Concepts

accommodation (p. 117)
adaptation (p. 117)
assimilation (p. 117)
autobiographical memory (p. 126)
babbling (p. 135)
central executive (p. 124)
child-directed speech (CDS) (p. 137)
circular reaction (p. 118)
coung (p. 135)
core knowledge perspective (p. 122)
deferred imitation (p. 120)
developmentally appropriate practice (p. 132)
expressive style of language learning (p. 137)
Home Observation for Measurement of the Environment (HOME) (p. 131)
infantile amnesia (p. 126)
intelligence quotient (IQ) (p. 130)
intentional, or goal-directed, behavior (p. 119)
joint attention (p. 135)
language acquisition device (LAD) (p. 134)
long-term memory (p. 124)
make-believe play (p. 120)
mental representation (p. 119)
mental strategy (p. 124)
ormal distribution (p. 130)
object permanence (p. 119)
or ganization (p. 118)
overextension (p. 136)
recall (p. 125)
recognition (p. 125)
referential style of language learning (p. 137)
scheme (p. 117)
sensorimotor stage (p. 117)
sensory register (p. 124)
standardization (p. 130)
telegraphic speech (p. 136)
underextension (p. 136)
violation-of- expectation method (p. 126)
working, or short-term, memory (p. 124)
one of proximal development (p. 128)