CHAPTER 2

Prenatal Development and the Newborn Period

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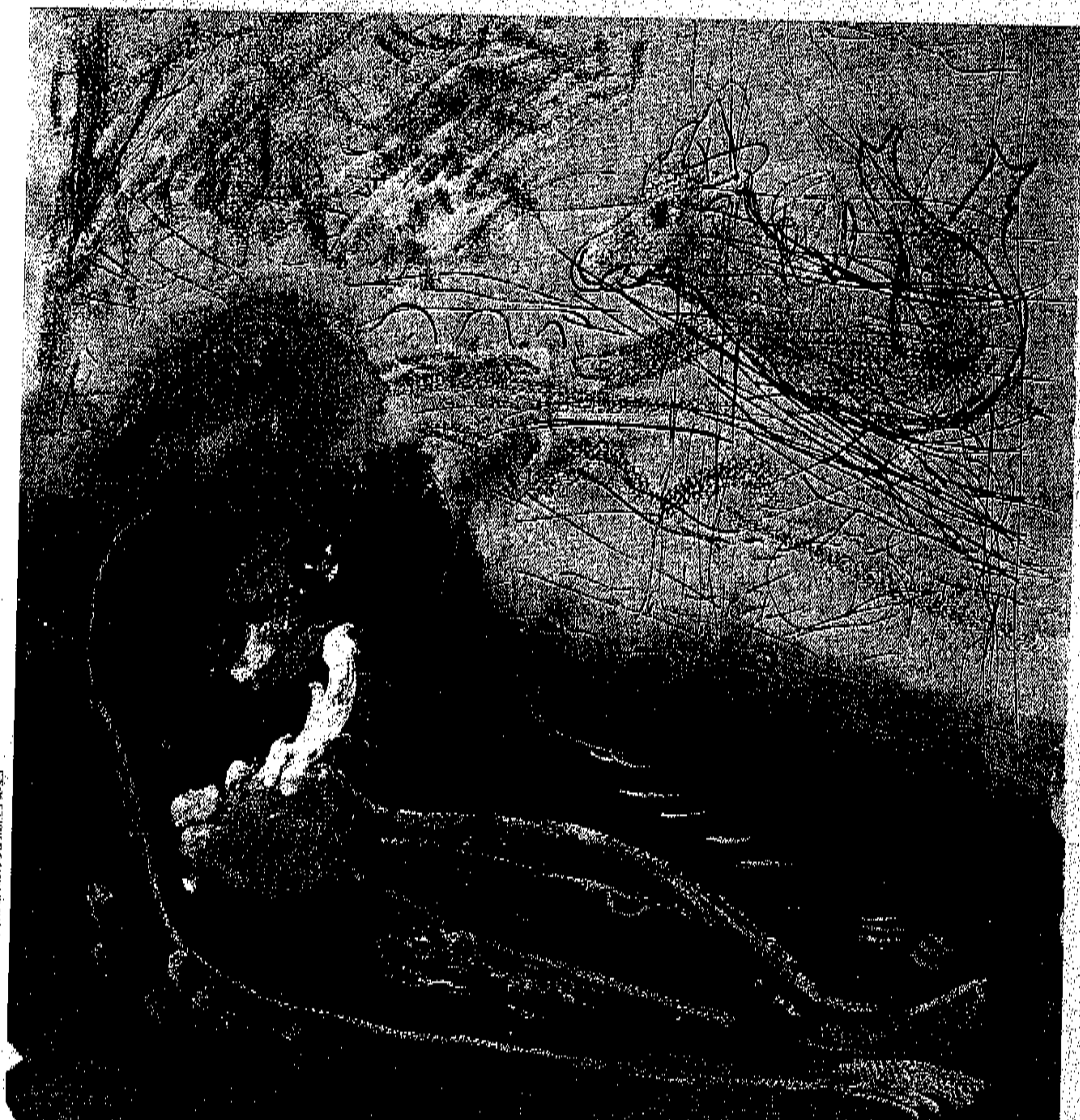


MARC CHAGALL, *Pont Marie,* 1945–50

THEMES

- Nature and Nurture
- The Active Child
- Continuity/Discontinuity
- The Sociocultural Context
- Individual Differences
- Research and Children's Welfare

Picture the following scenario. A developmental psychologist is investigating a young research subject's perceptual capacities and ability to learn from experience. First, she plays a loud sound through a speaker near the subject's ear. She notes that the subject moves vigorously in response and concludes that the subject can hear the sound. Now she continues to play the same tone, over and over. As everyone else in the lab gets tired of repeatedly hearing the same sound, so, apparently, does the subject, who responds less and less to the repetitions of the sound and eventually does not react to it at all. Has the subject learned to recognize the sound or just gone to sleep? To find out, the researcher next presents a different sound, to which the subject responds vigorously. The subject seems to recognize the old sound and to tell that the new sound is different from it, evidence that some simple learning has occurred. Wanting to see if the subject is capable of learning something more complex and in a more natural setting, the researcher sends the subject home, asking the subject's mother to read aloud to the subject from a Dr. Seuss book for several minutes a day for six weeks. The idea is to see whether the subject later shows any recognition of the passages that were read. But before the researcher sees the subject again, something quite dramatic happens: the subject is born!

This scenario is not at all fanciful. Indeed, as you will discover later in this chapter, it is an accurate description of a fascinating and informative study that helped to revolutionize the understanding of prenatal development (DeCasper & Spence, 1986). As you will also discover in this chapter, researchers have been asking many questions about the sensory and learning capabilities of fetuses. And they have been finding that while in the womb, fetuses can detect a range of stimuli coming from the outside world and can learn from their experience and remain affected by it after birth.

In this chapter, we will examine the extraordinary course of prenatal development—a time of astonishingly rapid and dramatic change. In addition to discussing the processes involved in prenatal development, we will discuss some of the environmental hazards that can harm the developing fetus. We will also examine the birth process and what the infant experiences during this dramatic turning point, as well as some of the most salient aspects of neonatal behavior. Finally, we will discuss problems associated with premature birth.

In our discussion of the earliest periods of development, most of the developmental themes we described in Chapter 1 will play prominent roles. The most prominent will be *nature and nurture*, as we emphasize how every aspect of development before birth results from the continual interplay of biological and environmental factors. Our genes provide a set of relatively simple instructions from which very complex forms ultimately emerge. These forms emerge through a cascade of minor events, with each event leading to another minor event and then another. In the end, something very complicated has happened, but not because that end point was specified at the beginning (see Figure 2.1).

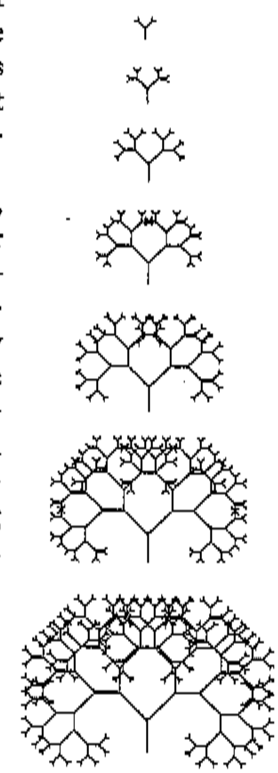


FIGURE 2.1 Emergent structure A structure of great complexity can emerge from a simple starting condition through the repeated application of a few very simple instructions. Can you figure out what rules were used to generate the figure?

The *active child* theme will also be featured, because the activity of the fetus contributes in numerous vital ways to its development. In fact, normal prenatal development depends on fetal behavior, from squirming around in the womb to making breathing motions (both necessary for muscle development) to secreting hormones essential for the differentiation of the sex organs. Another theme we will highlight is the *sociocultural context* of prenatal development and birth, as we note large differences in how people in different societies think about the beginning of life and how the birth process is handled. *Individual differences* come into play at many points throughout the chapter, starting with gender differences in survival rates from conception on. The theme of *continuity/discontinuity* is also prominent: despite the dramatic transition between prenatal and postnatal life, the behavior of newborns shows clear relations to their behavior and experience inside the womb. Finally, the theme of *research and children's welfare* underlies our discussion of the role of poverty in prenatal development and birth outcomes, as well as our description of intervention programs designed to foster the development of preterm infants.

epigenesis the emergence of *new* s tures and functions in the course of deve ment

embryology the scientific study of p tal development

Prenatal Development

Hidden from view, the process of prenatal development has always been mysterious and fascinating, and beliefs about the origins of human life and development before birth have been an important part of the lore and traditions of all societies (see DeLoache & Gottlieb, 2000). Enormous variability exists across as well as within cultures, for example with respect to beliefs about when life begins. (Box 2.1 describes what people in one society believe about this topic.)

When we look back in history, we also see great differences in how people have thought about prenatal development. In the fourth century B.C., Aristotle posed the fundamental question about prenatal development that was to underlie Western thought for the next fifteen centuries: Does prenatal life start with the new individual already preformed, composed of a full set of tiny parts, or do the many parts of the human body develop in succession? Aristotle rejected the idea of preformation in favor of what he termed **epigenesis**—the emergence of new structures and functions during development (a view of development that is highly influential today; Wolpert, 1991). Seeking support for his idea, he took what was then the very unorthodox step of opening fertile chicken eggs to see for himself. He did indeed observe chick organs in various stages of development. Nevertheless, the idea of preformationism persisted long after Aristotle, degenerating into a dispute about whether the miniature, preformed human was lodged inside the mother's egg or the father's sperm (see Figure 2.2).

The notion of preformation may strike you as a bit simpleminded. Remember, however, that our forebears had no way of knowing about the existence of cells and genes, to say nothing of the many discoveries that have led to a recent revolution in **embryology,** the study of prenatal development. Modern scientists have a variety of techniques for studying physical and behavioral development in the womb. Many of the mysteries that perplexed our ancestors have now been solved, but as is always true in science, new mysteries have replaced them.

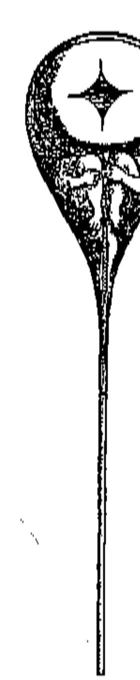


FIGURE 2.2 Preformationism
A seventeenth-century drawing of a preformed being inside a sperm. This drawi was based on the claim of committed pre mationists that when they looked at sam of semen under the newly invented micr scope, they could actually see a tiny fig curled up inside the head of the sperm. 1 believed that the miniature person would enlarge after entering an egg. As this dra ing illustrates, we must always take care not to let our cherished preconceptions s dominate our thinking that we see what v want to see—not what is really there. (Fr Moore & Persaud, 1993, p. 7).

a closer look 2.1

Beng Beginnings

Few topics have generated more intense debate and dispute in the United States in recent years than the issue of what point in development marks the beginning of life—the moment of conception or somewhere between conception and birth. The irony is that few who engage in this debate recognize how complex the issue is or the degree to which societies throughout the world have different views on it.

One example of this variety comes from the Beng, a people in the Ivory Coast of West Africa, who believe that every newborn is a reincarnation of an ancestor (Gottlieb, 2004). According to the Beng, in the first weeks after birth, the ancestor's spirit, its *wru,* is not fully committed to an earthly life and therefore maintains a double existence, traveling back and forth between the everyday world and *wrugbe,* or "spirit village." (The term can be roughly translated as "afterlife," but "before-life" might be just as appropriate.) It is only after the umbilical stump has dropped off that the newborn is considered to have emerged from *wrugbe* and to be a person. If the newborn dies before this, there is no funeral, for the infant's passing is simply conceived as a return in bodily form to the space that the infant was still psychically inhabiting.

These beliefs underlie many aspects of Beng infant-care practices. One is the application, many times a day, of an herbal mixture to the newborn's umbilical stump to hasten its drying out and dropping off. In addition, there is the constant danger that the infant or young child will become homesick for its life in *wrugbe* and decide to leave its earthly existence. To prevent this, parents try to make their babies comfortable and happy so they will want to stay in this life. Among the many recommended procedures is elaborately decorating the infant's face and body so that the infant will be attractive and elicit attention from others. Sometimes diviners are consulted, especially if the baby seems to be unhappy; a common diagnosis for prolonged crying is that the baby wants a different name, one from its previous life in *wrugbe.*

So when does life begin for the Beng? In one sense, a Beng individual's life begins well before birth, since he or she is a reincarnation of an ancestor. In another sense, however, life begins sometime after birth, when the individual is considered to have become a person.

COURTESY OF ALMA GOTTLIEB

The mother of this Beng baby has spent considerable time painting the baby's face in an elaborate pattern. She does this every day in an effort to make the baby attractive so other people will help keep the baby happy in this world.

Conception

Each of us originated as a single cell that resulted from the union of two highly specialized cells—a sperm from our father and an egg from our mother. These **gametes,** or germ cells, are unique not only in their function, but also in the fact that each one contains only half the genetic material found in other cells. Gametes are produced through a special type of cell division in which the eggs and sperm receive only half (23) of the chromosomes present in all other cells of the body. This reduction is necessary for reproduction, because the union of egg and sperm must contain the normal amount of genetic material (23 *pairs* of chromosomes). A major difference in the formation of these two types of gametes is the fact that almost all the eggs a woman will ever have are formed during her own prenatal development, whereas men produce vast numbers of new sperm continuously.

The process of reproduction starts with the launching of an egg (the largest cell in the human body) from one of the woman's ovaries into the fallopian tube (see Figure 2.3). As the egg moves through the tube toward the uterus, it emits a chemical substance that acts as a sort of beacon, a "come hither" signal that attracts sperm toward it. If an act of sexual intercourse takes place near the time the egg is

gametes (germ cells) reproductive cells—egg and sperm—that contain only half the genetic material of all the other cells in the body

conception the union of an egg from the mother and a sperm from the father

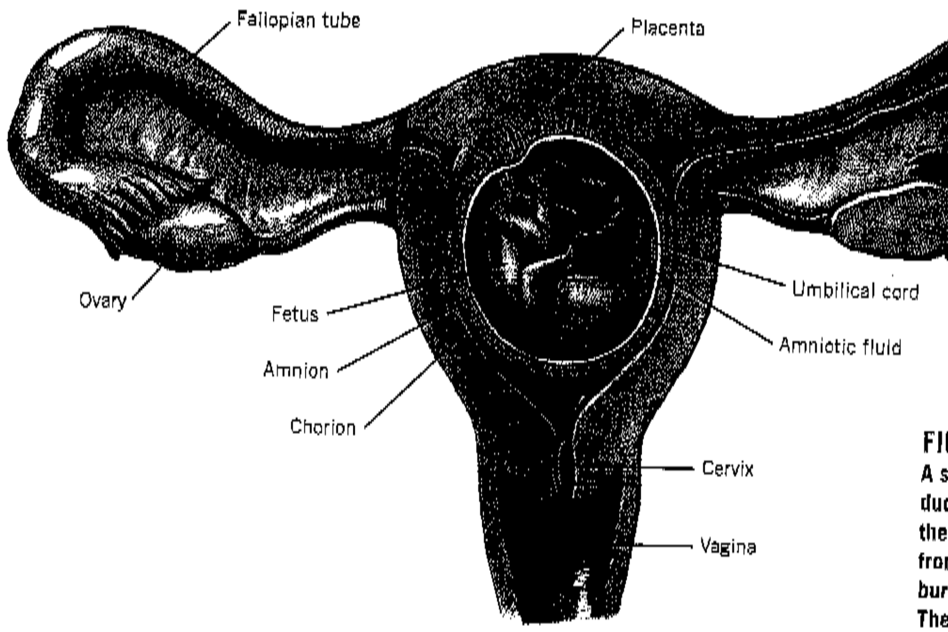


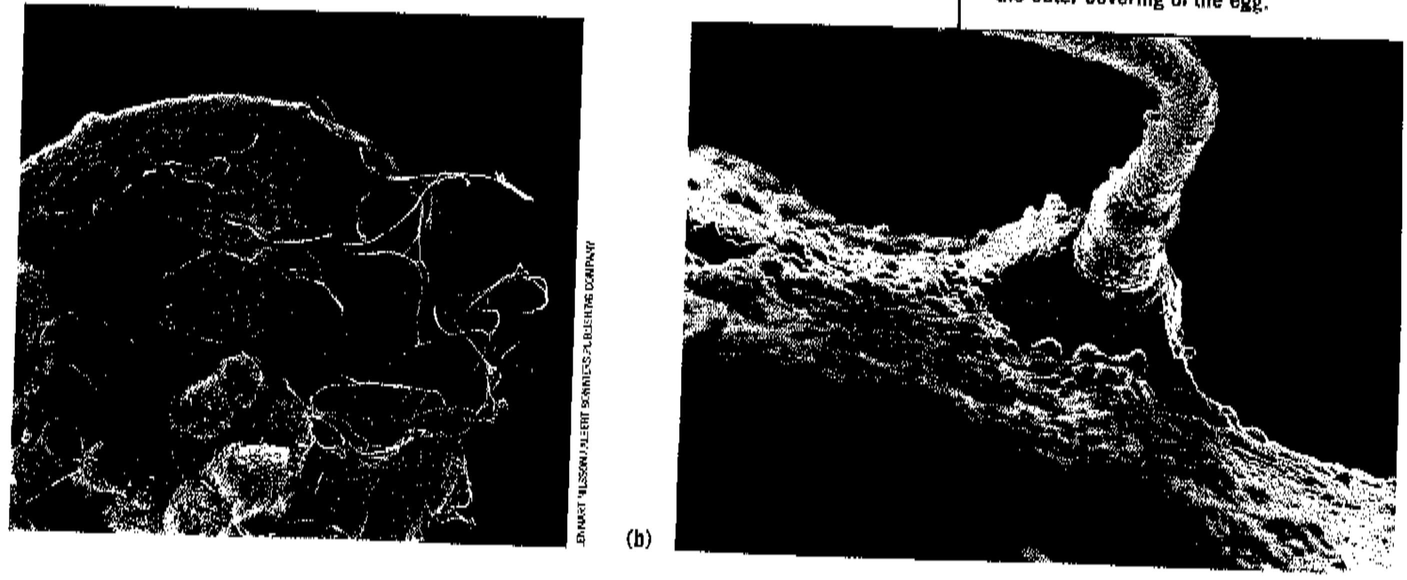
FIGURE 2.3 Female reproductive syste A simplified illustration of the female repr ductive system, with a fetus developing in the uterus (womb). The umbilical cord run from the fetus to the placenta, which is burrowed deeply into the wall of the uterus The fetus is floating in amniotic fluid insid the amniotic sac.

released, **conception,** the union of sperm and egg, will be possible. In every ejaculation, as many as 500 million sperm are pumped into the woman's vagina. Each sperm, a streamlined vehicle for delivering the man's genes to the woman's egg, consists of little more than a pointed head packed full of genetic material (the 23 chromosomes) and a long tail. The sperm's tail whips around to propel it through the woman's reproductive system.

To be a candidate for initiating conception, a sperm must travel for about 6 hours, journeying 6 to 7 inches from the vagina up through the uterus to the fallopian tube. The rate of attrition on this journey is enormous: of the millions of sperm that enter the vagina, only about 200 ever get near the egg (see Figure 2.4). There are many causes for this high failure rate. Some failures are due to chance: many of the sperm get tangled up with other sperm milling about in the vagina, and others simply happen to travel the wrong way (i.e., into the fallopian tube that

FIGURE 2.4 (a) Sperm nearing the egg Of the millions of sperm that started out together, only a few ever get near the egg. The egg is the largest human cell (the only one visible to the naked eye), but the sperm are among the smallest. **(b) Sperm penetrating the egg** This sperm is whipping its tail around furiously to drill itself through the outer covering of the egg.

(a)



(b)

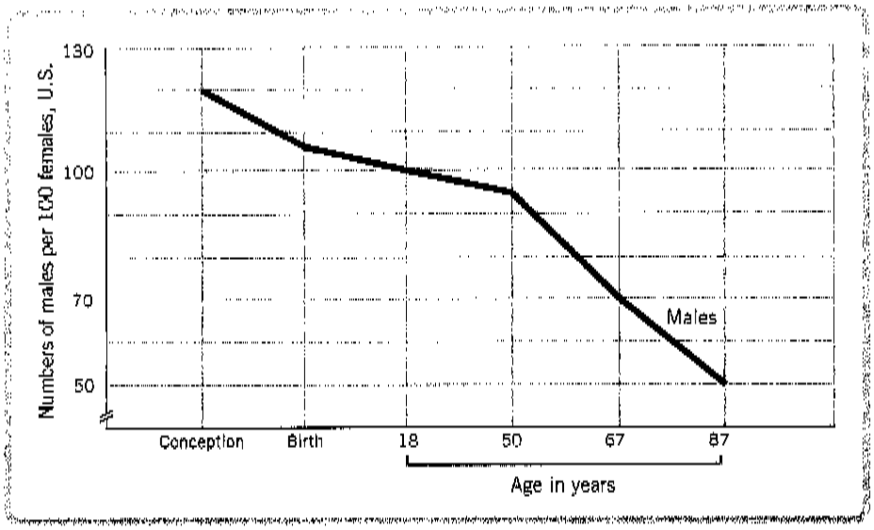
individual differences 2.2

The First Sex Differences

The proverbial competition between the sexes might be said to begin with millions of sperm racing to fertilize the egg, a race won much more often by the "boys." Those sperm that possess a Y chromosome (the genetic basis for maleness) are lighter and swim faster, so they beat those bearing an X chromosome to the egg. As a result, approximately 120 to 150 males are conceived for each 100 females.

The girls win the next big competition—survival. The ratio at birth is only 106 males to 100 females. Where are the missing males? Obviously, they are miscarried at a much greater rate than females. Birth is also more challenging for boys, who are 50% more likely to need a cesarean delivery. This heightened vulnerability is not limited to the prenatal period. Boys also suffer disproportionately from most developmental disorders, including language and learning disorders, dyslexia, attention-deficit disorder, mental retardation, and autism. The greater fragility of males continues throughout life, as reflected in the figure.

Differential survival is not always left in the hands of nature. In many societies, both historically and currently, male offspring are more highly valued than females, and parents resort to infanticide to avoid having daughters. For example, Inuit families in Alaska traditionally depended on male children to help in the hunt for food, and in former times Inuit girls were often killed at birth. Chinese parents, in both the past and present, count on their sons to take care of them in their old age. In modern China, the "one-child" policy, a measure designed to reduce population growth by forbidding couples to have more than one child, has resulted in many female babies being killed or abandoned to make room for a male child. A more technological approach is currently practiced in some countries that place a premium on male offspring: prenatal tests are used to determine the gender of the fetus, and female fetuses are selectively aborted. These cases dramatically illustrate the contextual model of development described in Chapter 1, showing how cultural values, government policy, and available technology all affect developmental outcomes.



Source: Lerner & Libby (1976)

Males are more vulnerable than females across the life span. In the United States, at conception, there are more males than females, but that advantage quickly disappears. The two sexes become equal in number at around 18 years; from then on there are increasingly more females than males in the population, particularly in old age. As Herb Caen, the famous San Francisco columnist, commented: "As of the 1990 census, the number of people aged 80 and over in S.F. was 26,962, broken down to 8,766 broken down males and 18,196 females, all complaining 'Can't live with 'em, can't live without 'em'" (Caen, 1996).

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zygote a fertilized egg cell

does not currently harbor an egg). Other failures have to do with problems wit the sperm themselves: a substantial portion have serious genetic or other defec that prevent them from propelling themselves vigorously enough to reach and fe tilize the egg. Thus, any sperm that do get to the egg are reasonably likely to b healthy and structurally sound, revealing a Darwinian-type "survival of the fittest process operating during fertilization. (Box 2.2 describes the consequences of th selection process for the conception of males and females.)

As soon as one sperm's head penetrates the outer membrane of the egg, a chem ical reaction seals the membrane, preventing other sperm from entering. The ta of the sperm falls off, the contents of its head gush into the egg, and within hou the nuclei of the two cells merge. The fertilized egg, known as a **zygote,** now has

TABLE 2.1

Periods of Prenatal Development

Conception to two weeks	Germinal	Begins with conception and lasts until the zygote becomes implanted in the uterine wall. Rapid cell division takes place.
3rd to 8th week	Embryonic	Following implantation, major development occurs in all the organs and systems of the body. Development takes place through the processes of cell division, cell migration, cell differentiation, and cell death, as well as hormonal influences.
9th week to birth	Fetal	Continued development of physical structures and rapid growth of the body. Increasing levels of behavior, sensory experience, and learning.

full complement of human genetic material, half from the mother and half from the father. The first of the three periods of prenatal development (see Table 2.1) has begun and will, if all goes well, continue for approximately 9 months (on average, 38 weeks or 266 days).

Developmental Processes

Before describing the course of prenatal development, we need to briefly outline four major developmental processes that underlie the transformation of a zygote into an **embryo** and then a **fetus.** The first of these processes is *cell division.* Within 12 hours or so after fertilization, the zygote divides into two equal parts, each containing a full complement of genetic material. These two cells divide into four, those four into eight, those eight into sixteen, and so on. Through continued cell division over the course of 38 weeks, the barely visible zygote becomes a newborn consisting of trillions of cells.

A second major process, which occurs during the embryonic period, is *cell migration,* the movement of newly formed cells from their point of origin in the embryo to somewhere else. Among the many cells that migrate are the neurons in the cortex, the outer layer of the brain. These cells originate deep inside the embryonic brain and then, like pioneers settling new territory, travel to the outer reaches of the developing brain.

The third process that is crucial to further prenatal development is *cell differentiation.* Initially, all embryonic cells, also known as stem cells, are equivalent and interchangeable: none has any fixed fate or function. After several cell divisions, however, cells start to differentiate, or specialize, becoming different from one another in terms of both structure and function. In humans, stem cells develop into roughly 350 different types of cells, which from then on perform a particular function on behalf of the organism. (Because of their flexibility, very early embryonic stem cells offer the hope of treating a variety of illnesses, including Parkinson's disease and Alzheimer's disease. Injected into a person suffering from illness or injury, these cells have the capacity to develop into healthy cells to replace diseased or damaged ones.)

The process of differentiation is one of the major mysteries of prenatal development. Since all cells in the body have the identical set of genes, what determines which type of cell a given stem cell will become? One key determinant is which

embryo the name given to the devel organism from the 3rd to 8th week of pre development

fetus the name given to the developi organism from the 9th week to birth

a closer look 2.3

Phylogenetic Continuity

At various times throughout this book, we will describe research done with nonhuman animals to make some point about human development. In doing so, we subscribe to the principle of **phylogenetic continuity**—the idea that because of our common evolutionary history, humans share some characteristics and developmental processes with other living things. Indeed, you share *most* of your genes with your dog, cat, or hamster. In Chapter 3, we will consider how the part of our genetic heritage that we do not share with other mammals makes us all so different.

The assumption that animal models of behavior and development can be useful and informative for human development underlies a great deal of research. For example, much of our knowledge about the dangers of alcohol consumption by pregnant women comes from research with animals. Because scientists suspected that drinking alcohol while pregnant caused the constellation of defects now known as *fetal alcohol spectrum disorder* (page 63), they experimentally exposed fetal mice to alcohol. One result of this intervention was that the newborn mice had misformed facial features remarkably similar to the facial anomalies of children born to alcoholic mothers. This fact increased researchers' confidence that the problems commonly associated with fetal alcohol syndrome are, in fact, caused by alcohol rather than by some other factor.

One of the most fascinating discoveries in recent years, discussed later in this chapter, is the existence of fetal learning. Well before this phenomenon was demonstrated for human fetuses, it was documented in research on one of comparative psychologists' favorite creatures—the rat. Some natural preferences exhibited by newborn rat pups, including preferences important for survival, are based on learning that took place in the womb. To survive, newborns must find a milk-producing maternal nipple. How do they know where to go? The answer is that they search for something familiar to them. In the birth process, the nipples on the underside of the mother rat's belly get smeared with amniotic fluid. The scent of the amniotic fluid is familiar to the pups from their time in the womb, and it lures the babies to where they need to be—with their noses, and hence their mouths, near a nipple (Blass, 1990).

How do we know that newborn rats' first nipple attachment is based on their recognition of amniotic fluid? For one thing, when researchers washed the mother's belly clean of amniotic fluid, her pups failed to find her nipples, and if half her nipples were washed, the pups were attracted to the unwashed ones with amniotic fluid still on them (Blass & Teicher, 1980). Even more impressive, when researchers introduced odors or flavors into the amniotic fluid, either by directly injecting them or by adding them to the mother's diet, her pups preferred those odors and tastes after birth (Hepper, 1988; Pedersen & Blass, 1982; Smotherman & Robinson, 1987). These and other experimental demonstrations of fetal learning in rodents inspired developmental psychologists to look for similar processes in human fetuses. As you will see later, they found them.

Child and chimp have 99% of their genes in common.

genes in the cell are "switched on" or expressed (see Box 2.3). Another is the cell's location, because its further development is influenced by what is going on in its neighbor cells.

The initial flexibility and subsequent inflexibility of cells, as well as the importance of location, is vividly illustrated by classic research with frog embryos. If the region of a frog embryo that would normally become an eye is grafted onto its belly very early in development, the transplanted region will develop as a normal part of the belly. Thus, although the cells were initially in the right place to become an eye, they had not yet become specialized. If performed later on, the same

phylogenetic continuity the idea that because of our common evolutionary history, humans share many characteristics, behaviors, and developmental processes with other animals, especially mammals operation results in an eye—alone and unseeing—lodged in the frog's belly (Wolpert, 1991).

The fourth developmental process is something you would not normally think of as developmental at all—*death*. However, the selective death of certain cells is the "almost constant companion" to the other developmental processes we have described (Wolpert, 1991). The role of this genetically programmed "cell suicide," known as **apoptosis**, is readily apparent in hand development (see Figure 2.5): the formation of fingers depends on the death of the cells in between the ridges in the hand plate. In other words, dying is part of the developmental program for those cells that selectively disappear from the hand plates.

In addition to these four developmental processes, we need to call attention to the influence of hormones on prenatal development. For example, hormones play a crucial role in sexual differentiation. All human fetuses, regardless of the genes they carry, can develop either male or female genitalia. What causes development to proceed one way or the other is the presence or absence of testosterone, a male hormone. If testosterone is present, male sex organs develop; if it is absent, female genitalia develop. The source of this influential hormone is the male fetus itself. Around the 8th week after conception, the testes begin to produce testosterone, and this self-generated substance changes the fetus forever. This is just one of the many ways in which the fetus acts as an instigator of its own development.

We now turn our attention to the general course of prenatal development that results from all the above influences, as well as other developmental processes.

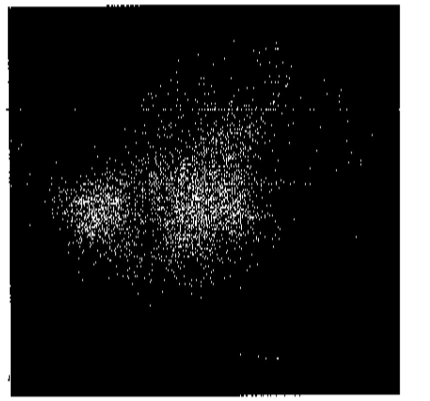

FIGURE 2.5 Embryonic hand plate Fingers will emerge from the hand plate o this 7-week-old embryo. The fingers are formed as a result of the death of the cell between the ridges you can see in the pla If these cells did not expire, the baby wou be born with webbed rather than independ ent fingers.

Early Development

On its journey through the fallopian tube to the womb, the zygote doubles its number of cells roughly twice a day. By the 4th day after conception, the cells arrange themselves into a hollow sphere with a bulge of cells, called the *inner cell mass*, on one side.

This is the stage at which **identical twins** most often originate. They result from a splitting in half of the inner cell mass, and thus they both have exactly the same genetic makeup (Moore & Persaud, 1993). In contrast, **fraternal twins** result when two eggs happen to be released from the ovary into the fallopian tube and both are fertilized. Because they originate from two different eggs and two different sperm, fraternal twins are no more alike genetically than any pairs of siblings.

By the end of the 1st week following fertilization, if all goes well (as it does for fewer than half the zygotes that are conceived), a momentous event occurs—implantation, the process in which the zygote embeds itself in the uterine lining and becomes dependent on the mother for sustenance. Well before the end of the 2nd week, it will be completely embedded within the uterine wall.

After implantation, the embedded ball of cells starts to differentiate. The inner cell mass will become the embryo, and the rest of the cells will become an elaborate support system—including the *placenta* and *amniotic sac*—that enables the embryo to develop. The inner cell mass is initially a single layer thick, but during the 2nd week, it folds itself into three layers, each with a different developmental destiny. The top layer becomes the nervous system, the nails, teeth, inner ear, lens of the eyes, and the outer surface of the skin. The middle layer eventually becomes muscles, bones, the circulatory system, the inner layers of the skin, and other internal organs. The bottom layer develops into the digestive system, lungs, urinary tract, and glands. A few days after the embryo has differentiated into these three layers,

apoptosis genetically programmed cell death

identical twins twins that result from splitting in half of the zygote, resulting in ea of the two resulting zygotes having exactly t same set of genes

fraternal twins twins that result when two eggs happen to be released into the fallopian tube at the same time and are fertiliz by two different sperm. Fraternal twins have only half their genes in common.

FIGURE 2.6 Neural tube In the 4th week, the neural tube begins to develop into the brain and spinal cord. In this photo, the neural groove, which fuses together first at the center and then outward in both directions as if two zippers were being closed, has been "zipped shut" except for one part still open at the top. Spina bifida, a congenital disorder in which the skin over the spinal cord is not fully closed, can originate at this point. After closing, the top of the neural tube will develop into the brain.

a U-shaped groove forms down the center of the top layer. The folds at the top of the groove move together and fuse, creating the **neural tube** (Figure 2.6). One end of the neural tube will swell and develop into the brain, and the rest will become the spinal cord.

The support system that is developing simultaneously with the embryo is elaborate and essential to its development. One key element of this support system is the **placenta,** a unique organ that permits the exchange of materials carried in the bloodstreams of the fetus and its mother. It is an extraordinarily rich network of blood vessels, including minute ones extending into the tissues of the mother's uterus, with a total surface area of about 10 square yards—approximately the amount of driveway covered by the family car (Vaughn, 1996). Blood vessels running from the placenta to the embryo and back again are contained in the **umbilical cord.**

At the placenta, the blood systems of the mother and fetus come extremely close to one another, but the placenta prevents their blood from actually mixing. However, the placental membrane is semipermeable, meaning that some elements can pass through it, but others cannot. Oxygen, nutrients, minerals, and some antibodies—all of which are just as vital to the fetus as they are to you—are transported to the placenta by the mother's circulating blood. They then cross the placenta and enter the fetal blood system. Waste products (e.g., carbon dioxide, urea) from the fetus cross the placenta in the opposite direction and are removed from the mother's bloodstream by her normal excretory processes.

The placental membrane also serves as a defensive barrier against a host of dangerous toxins and infectious agents that can inhabit the mother's body and could be harmful or even fatal to the fetus. Unfortunately, being semipermeable, the placenta is not a perfect barrier, and, as we will see later, a variety of harmful elements can cross it and attack the fetus. One other function of the placenta is the production of hormones, including estrogen, which increases the flow of maternal blood to the uterus, and progesterone, which suppresses uterine contractions that could expel the fetus prematurely (Nathanielsz, 1994).

A second vital part of the support system is the **amniotic sac,** a membrane filled with a clear, watery fluid in which the fetus floats. The amniotic fluid operates as a protective buffer for the developing fetus in several ways, such as providing it with a relatively even temperature and cushioning it against jolting. As you will soon see, because the amniotic fluid keeps the fetus afloat, the fetus is able to exercise its tiny, weak muscles relatively unhampered by the effects of gravity.

An Illustrated Summary of Prenatal Development

The course of prenatal development from the 4th week on is illustrated in Figures 2.7 through 2.14, and significant milestones are highlighted in the accompanying text. The fetal behaviors that are mentioned will be discussed in detail in a later section. Notice that earlier development takes place at a more rapid pace than later development and that the areas nearer the head develop earlier than those farther away (e.g., head before body, hands before feet)—a general tendency known as **cephalocaudal development.**

Figure 2.7: At 4 weeks after conception, the embryo's tiny body is curved so tightly that the head and the tail-like structure at the other end are almost touching. Several facial features have their origin in the set of four folds in the front

neural tube a groove formed in the top layer of differentiated cells in the embryo that eventually becomes the brain and spinal cord

placenta a support organ for the fetus; it keeps the circulatory systems of the fetus and mother separate, but as a semipermeable membrane permits the exchange of some materials between them (oxygen and nutrients from mother to fetus and carbon dioxide and waste products from fetus to mother)

umbilical cord a tube containing the blood vessels connecting the fetus and placenta

amniotic sac a transparent, fluid-filled membrane that surrounds and protects the fetus

cephalocaudal development the pattern of growth in which areas near the head develop earlier than areas farther from the head

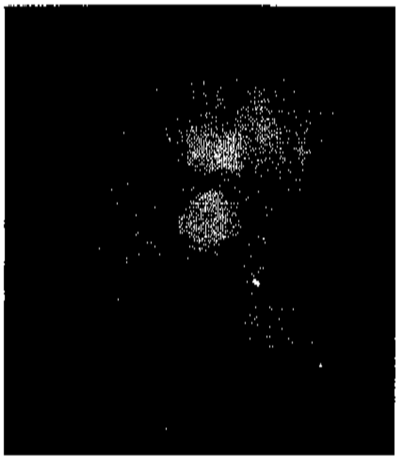

FIGURE 2.7 Embryo at 4 weeks

of the embryo's head; the face gradually emerges as a result of these tissues moving and stretching, as parts of them fuse and others separate. The round area near the top of the head is where the eye will form, and the round gray area near the back of the "neck" is the primordial inner ear. A primitive heart is visible; it is already beating and circulating blood. An arm bud can be seen in the side of the embryo; a leg bud is also present but less distinct.

Figure 2.8: (a) In this 5½-week-old fetus, the nose, mouth, and palate have not yet differentiated as separate structures. (b) Just three weeks later, the nose and mouth are almost fully formed. Cleft palate, one of the most common birth defects worldwide, involves malformations (sometimes minor, sometimes major) of this area. This condition originates sometime between 5½ and 8 weeks prenatally—precisely when these structures are developing.

Figure 2.9: The head constitutes roughly half the length of this 9-week-old fetus, and its bulging forehead reflects the extremely rapid brain growth that has been going on for weeks. Rudimentary eyes and ears are forming. All the internal organs are present, although most must undergo further development. Sexual differentiation has started. Ribs are visible; fingers and toes have emerged, and nails are growing. The umbilical cord connecting the fetus to the placenta is shown (the fetal membranes have been pulled to the side). Spontaneous movements occur, but because the fetus is so small and is floating in amniotic fluid, these movements cannot be felt by the mother.

(a)

(b)

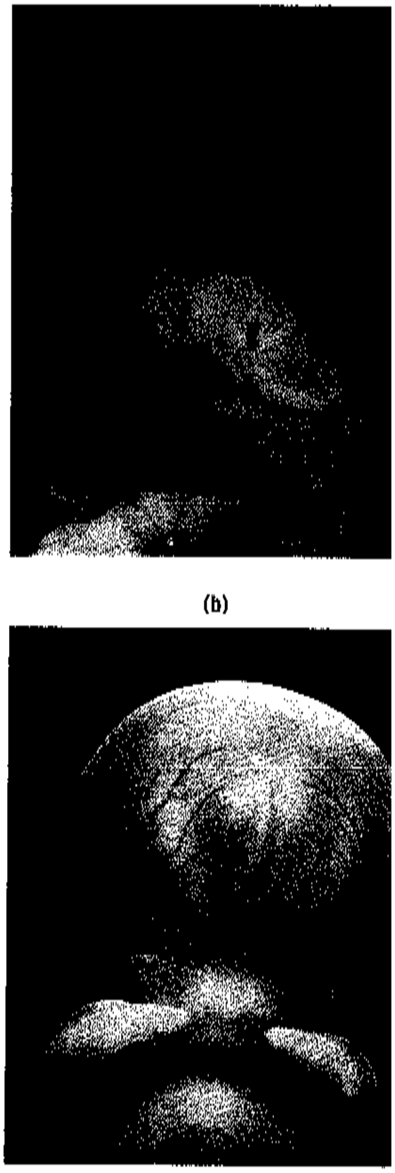

FIGURE 2.8 Face development from 5½ to 8½ weeks

FIGURE 2.9 Fetus at 9 weeks

FIGURE 2.11 Fetus at 16 weeks

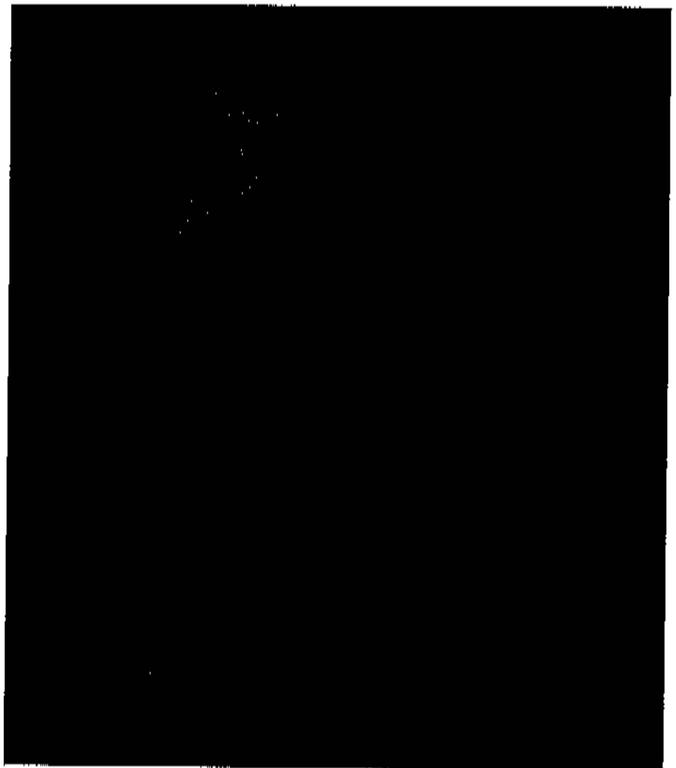

FIGURE 2.10 Fetus at 11 weeks

Figure 2.10: This picture of a 12-week-old fetus was produced by a new noninvasive technique for creating three-dimensional images of the body. The image clearly shows the heart, which has achieved its basic adult structure. You can also see the developing spine and ribs, as well as the major divisions of the brain.

Figure 2.11: During the last 5 months of prenatal development, the growth of the lower part of the body accelerates. The fetus's movements have increased dramatically: the chest makes breathing movements, and some reflexes—grasping, swallowing, sucking—are present. The intense kick dealt by this 16-week-old fetus will be felt by its mother, although only as a mild "flutter." A different camera angle of this fetus would reveal whether it is boy or girl, as the external genitalia are substantially developed at this point.

Figure 2.12: This 18-week-old fetus is clearly sucking its thumb, in much the same way it will do as a newborn. The fetus is covered with very fine hair, and a greasy coating protects its skin from its long immersion in liquid.

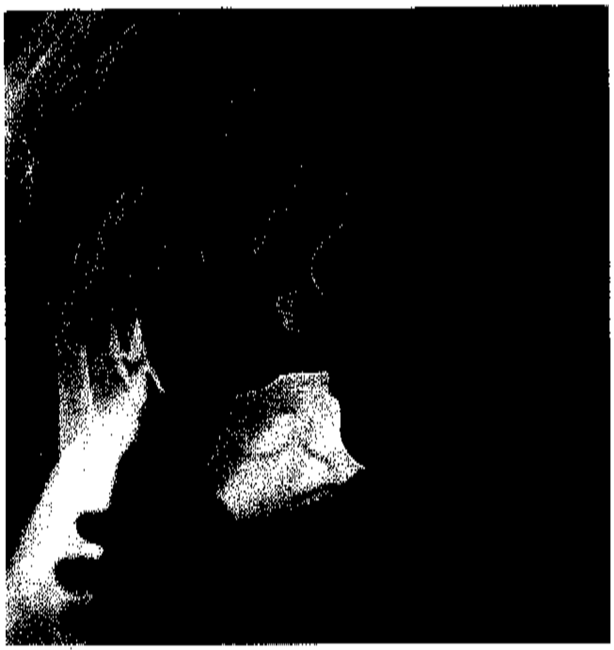

FIGURE 2.12 Fetus at 18 weeks

FIGURE 2.13 Fetus at 20 weeks

FIGURE 2.14 Fetus at 28 weeks

Figure 2.13: By the 20th week, the fetus spends increasingly more time in a head-down position and is rapidly putting on weight. The components of facial expressions are present—the fetus is capable of raising its eyebrows, wrinkling its forehead, and moving its mouth. As the fetus rapidly puts on weight, free space in the amniotic sac decreases and so do fetal movements.

Figure 2.14: The 28th week marks the point at which the brain and lungs are sufficiently developed that, if the fetus were born at this time, it would have a chance of surviving on its own, without medical intervention. The eyes can open, and they move, especially during periods of REM (rapid eye movement) sleep. The auditory system is now functioning, and the fetus hears and reacts to a variety of sounds. At this stage of development, the brain waves of the fetus are very similar to those of a newborn. During the last 3 months of prenatal development, the fetus grows dramatically in size, essentially tripling its weight. The mother becomes increasingly uncomfortable, and so, presumably, does the fetus in the cramped confines of the womb.

The typical result of this 9-month period of rapid and remarkable development is a healthy newborn.

Fetal Behavior

As we have noted, the fetus is an active participant in, and contributor to, its own physical and behavioral development. Indeed, the normal formation of organs and muscles depends on fetal activity, and the fetus rehearses the behavioral repertoire it will need at birth.

Movement

Every mother knows that her baby was active in the womb, but few realize how early their child started moving. From 5 or 6 weeks after conception, the developing organism moves spontaneously, starting with a simple bending of the head and spine that is soon followed by the onset of numerous kinds of increasingly complex movements over the next weeks (De Vries, Visser, & Prechtl, 1982). One of the earliest distinct patterns of movement to emerge (at around 7 weeks) is, remarkably enough, hiccups. Why? According to a scientific paper, hiccups "remain as poorly defined for the fetus as they are for the adult" (Stark & Myers, 1995, p. 61). In other words, no one knows.

The fetus also moves its arms and legs, wiggles its fingers, grasps the umbilical cord, moves its head and eyes, and yawns. Complete changes of position are achieved by a kind of backward somersault. These various movements are initially jerky and uncoordinated but gradually become more integrated. By 12 weeks, most of the movements that will be present at birth have appeared (De Vries et al., 1982), although the mother is still unaware of them. Later on, when mothers can readily feel the movement of their fetuses, their reports reveal that how much a fetus moves—its activity level—is quite consistent over time: some fetuses are characteristically very active, whereas others are more sedentary (Eaton & Saudino, 1992). There is prenatal-to-postnatal *continuity* in these individual differences: more active fetuses are more active infants (DiPietro, Costigan, Shupe, Pressman, & Johnson, 1998). Further, fetuses that have regular periods of sleep and waking are likely to have them as newborns (DiPietro, Bornstein, et al., 2002).

COURTESY JANET DIPIETRO

Developmental psychologist Janet DiPietro is using ultrasound to study the movement patterns of this woman's fetus.

A particularly important form of fetal movement is *swallowing*. The fetus drinks amniotic fluid, which passes through its gastrointestinal system. Most of the fluid is then excreted back out into the amniotic sac. One benefit of this activity is that the tongue movements associated with drinking and swallowing promote the normal development of the palate (Walker & Quarles, 1962). In addition, the passage of amniotic fluid through the stomach and intestines helps those organs mature properly, so that the digestive system is functional at birth. Thus, swallowing amniotic fluid prepares the fetus for survival outside the womb.

A second form of fetal movement anticipates the fact that at birth the newborn must soon start breathing. For that to happen, the lungs and the rest of the respiratory system, including the muscles that move the diaphragm in and out, must be mature and functional. Thus, from as early as 10 weeks, the fetus exercises its lungs through "fetal breathing," moving its chest wall in and out (Nathanielsz, 1994). No air is taken in, of course; rather, small amounts of amniotic fluid are pulled into the lungs and then expelled. Unlike real breathing, which must be continuous, fetal breathing goes on only about 50% of the time (James, Pillai, & Smoleniec, 1995).

Behavioral Cycles

Once the fetus begins to move at 5 to 6 weeks, it is in almost constant motion for the next month or so. Then periods of inactivity gradually begin to occur. Rest-activity cycles—bursts of high activity alternating with little or no activity for a few minutes at a time—emerge as early as 10 weeks and become very stable during the second half of pregnancy (Robertson, 1990). In the latter half of the prenatal period, the fetus moves only about 10% to 30% of the time (DiPietro et al., 1998). Fetuses that are anencephalic (a rare condition in which the cerebral cortex is missing) remain highly active throughout pregnancy, suggesting that the cortex is involved in the inhibition of fetal movement (James et al., 1995).

Longer-term patterns, including daily (circadian) rhythms, also become apparent, with the fetus being less active in the early morning and more active in the late evening (Arduini, Rizzo, & Romanini, 1995). This confirms the impression of most pregnant women that their fetuses wake up and start doing acrobatics just as they themselves are trying to go to sleep.

Near the end of pregnancy, the fetus spends more than three-fourths of its time in quiet and active sleep states like those of the newborn (James et al., 1995) (see page 70). The active sleep state is characterized by REM, just as it is in infants and adults. Sleep states in the last weeks before birth are highly similar to those 2 weeks after birth (Groome, Swiber, Atterbury, Bentz, & Holland, 1997).

"It's a baby. Federal regulations prohibit ou mentioning its race, age, or gender."

Fetal Experience

There is a popular idea—promoted by everyone from scholars to cartoonists—that we spend our lives longing for the peace and quiet we experienced in our mother's womb. But is the womb a haven of peace and quiet? Although the uterus and the amniotic fluid buffer the fetus from much of the stimulation impinging on the mother, research has made it clear that the fetus experiences an abundance of sensory stimulation.

Sight and Touch

Although it is not totally dark inside the womb, the visual experience of the fetus is presumably negligible. The fetus does, however, experience tactile stimulation as a result of its own activity. As it moves around, its hands come into contact with other parts of its body: fetuses have been observed grasping their umbilical cords, rubbing their faces, and, as you saw in Figure 2.12, sucking their thumbs. As the fetus grows larger, it increasingly often bumps against the walls of the uterus.

Taste

The amniotic fluid that the fetus swallows contains a variety of flavors (Maurer & Maurer, 1988). The fetus can detect these flavors and likes some better than others. Indeed, the fetus has a sweet tooth. The first evidence of fetal taste preferences came from a medical study performed over 60 years ago (described by Gandelman, 1992). A physician named DeSnoo devised an ingenious treatment for women with excessive amounts of amniotic fluid. He injected a sweet flavor (saccharin) into their amniotic fluid, hoping that the fetus would help the mother out by ingesting increased amounts of fluid, thereby diminishing the excess. To find out if his procedure worked, DeSnoo also injected into the amniotic fluid a dye that shows up in urine. He reasoned that the more of the sweetened fluid the fetus drank, the more dye it would take in; the more dye it ingested, the more that would pass from the fetus across the placenta to the mother and be excreted in her urine. Thus, all he had to do was assess how much dye showed up in the mother's urine. DeSnoo found that the urine of mothers who had the saccharin-dye combination injected into their amniotic fluid was more tinted than that of mothers who had received only the dye. Thus, the fetuses in this study drank more amniotic fluid when it had been sweetened, showing that taste sensitivity and flavor preferences exist before birth.

Smell

Amniotic fluid also takes on odors from what the mother has eaten (Mennella, Johnson, & Beauchamp, 1995). Obstetricians have long reported that during birth they can smell scents like curry and coffee in the amniotic fluid of women who had recently consumed them. Indeed, human amniotic fluid has been shown to be rich in odorants (although many do not sound very appealing—including those described as being pungently rancid, goaty, or having a "strong fecal note") (Schaal, Orgeur, & Rognon, 1995). Through fetal breathing, amniotic fluid comes into contact with the fetus's odor receptors. Hence, scientists have concluded that the fetus has olfactory experience (Schaal et al., 1995).

Hearing

Picture serious scientists hovering over a pregnant woman's bulging abdomen, ringing bells, striking a gong, clapping blocks of wood together, and even sounding an automobile horn—all to see if her fetus reacts to auditory stimulation. (It reminds you of the opening to this chapter, doesn't it?) We know that many sounds originating outside the woman's body are audible in the womb, because miniature recording devices have been inserted in the uterus immediately before birth (Lecanuet, Granier-Deferre, & Busnel, 1995). External sounds that are audible include the voices of people talking to the woman. In addition, the prenatal environment includes many sounds generated internally by the mother—her heartbeat, her blood pumping through her vascular system, her breathing, her swallowing, and various rude noises made by her digestive system. A particularly prominent and frequent source of sound stimulation is the mother's voice as she talks, with the clearest aspects being the general cadence, intonation, and stress pattern of her speech.

The fetus of this pregnant woman may be eavesdropping on her conversation with her friends. (Note that there is no glass of wine for the expectant mother—a wise decision.)

The fetus responds to these various sounds from at least the 6th month of pregnancy on. During the last trimester, external noises elicit changes in fetal movements and heart rate (Kisilevsky, Fearon, & Muir, 1998; Lecanuet et al., 1995; Zimmer, Chao, Guy, Marks, & Fifer, 1993). The fetus's heart rate also changes (decelerates) briefly when the mother starts speaking (Fifer & Moon, 1995). As we will discuss in the next section on fetal learning, the fetus's extensive auditory experience with human voices has some lasting effects.

Fetal Learning

In the preceding sections, we have emphasized the impressive behavioral and sensory capabilities of the fetus in the early stages of development. Even more impressive is the extent to which the fetus learns from many of its experiences in the last 3 months of pregnancy, after the central nervous system is adequately developed to support this learning.

Direct evidence for human fetal learning comes from studies of habituation, one of the simplest forms of learning (Thompson & Spencer, 1966). **Habituation** involves a decrease in response to repeated or continued stimulation (see Figure 2.15). If you shake a rattle beside an infant's head, the baby will likely turn toward it. At the same time, the infant's heart rate may slow momentarily. (Transitory heart-rate deceleration is a sign of interest.) If you repeatedly shake the rattle, however, the head-turning and heart-rate changes will eventually stop. This decreased response is evidence of learning and memory; only if the infant remembers the stimulus from one presentation to the next can the stimulus lose its novelty. When a new stimulus occurs, the habituated response recovers (increases). Shaking a bell, for example, may reinstate the head-turning and heart-rate responses. (Developmental psychologists have exploited habituation to study a great variety of topics that you will read about in later chapters.)

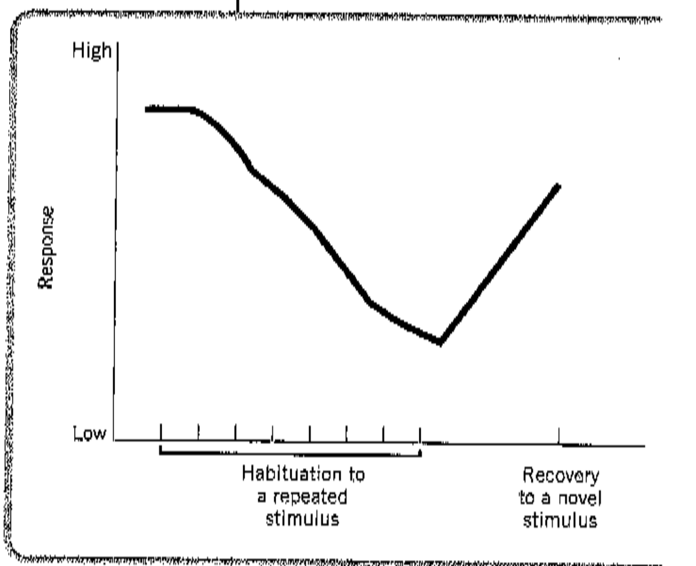

FIGURE 2.15 Habituation Habituation occurs in response to the repeated presentation of a stimulus. As the first stimulus is repeated and becomes familiar, the respon[se] to it gradually decreases. When a novel stimulus occurs, the response recovers. Th[e] decreased response to the repeated stimulus indicates the formation of memory for i[t;] the increased response to the novel stimul[us] indicates discrimination of it from the famil[iar] one, as well as a general preference fo[r] novelty.

In one habituation study of prenatal learning of speech sounds, a team of French investigators (Lecanuet et al., 1995) repeatedly presented fetuses in their 9th month of gestation with a syllable pair—"babi." (A speaker was placed over the mother's abdomen, and a recording of the syllable pair was played through it, loud enough to penetrate the womb.) The initial presentations elicited a brief but noticeable deceleration in the heart rate of the fetus. As the sound was repeated, the amount of change in heart rate grew smaller. Then the order of the two syllables was reversed, creating the new stimulus "biba." At this point, the heart-rate response increased. Thus, the fetus had habituated to the familiar stimulus (i.e., had learned to recognize it) and could discriminate between one syllable pair and another. Fetuses pay attention to and habituate to a wide variety of sounds in addition to human voices (e.g., Kisilevsky & Muir, 1991; Lecanuet et al., 1995). The earliest at which fetal habituation has been observed is 32 weeks, indicating that the central nervous system is sufficiently developed at this point for learning and memory to occur (Sandman, Wadhwa, Hetrick, Porto, & Peeke, 1997).

Long-term learning and retention have also been demonstrated, although with different measures. A group of 37-week-old fetuses who had heard their mothers recite a short rhyme three times a day for four weeks recognized the familiar poem, as shown by the fact that when they were tested at the end of four weeks, their heart-rate deceleration was greater when they heard the familiar poem than when they heard a novel one (DeCasper, Lecanuet, Busnel, Granier-Deferre, & Maugeais, 1994).

The effects of prenatal learning have also been observed after birth. In a classic study, Anthony DeCasper and Melanie Spence (1986) asked pregnant women to read aloud twice a day from *The Cat in the Hat* (or another Dr. Seuss book) during the last 6 weeks of their pregnancy. Thus, the women's fetuses were repeatedly exposed to the same highly rhythmical pattern of speech sounds. The question was

habituation a simple form of learning that involves a decrease in response to repeated or continued stimulation

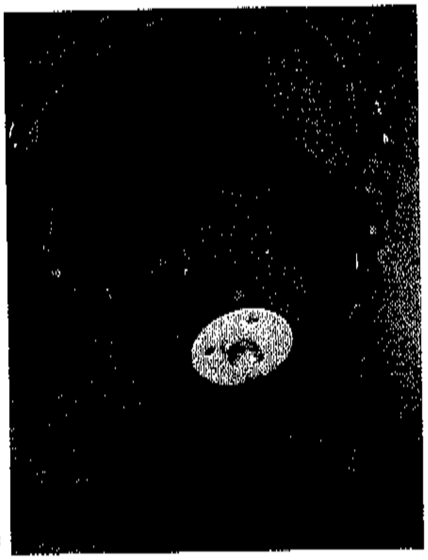

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FIGURE 2.16 Prenatal learning This newborn can control what he gets to listen to. His pacifier is hooked up to a computer, which is in turn connected to a tape player. If the baby sucks in one pattern (predetermined by the researchers), he will hear one tape. If he sucks in a different pattern, he will hear a different tape. Researchers have used this technique to investigate many questions about infant abilities, including the influence of fetal experience on newborn preferences.

whether they would recognize the familiar story after birth. To see, the researchers tested them as newborns. The infants were fitted with miniature headphones and given a special pacifier to suck on (see Figure 2.16). When the infants sucked in one particular pattern, they heard the familiar story through the headphones, but when they sucked in a different pattern, they heard an unfamiliar story. The babies quickly modified their sucking to the pattern that enabled them to hear the familiar story. Thus, these newborns apparently recognized and preferred the story their mothers had read to them while they were still in the womb.

Newborns also have a natural preference for a familiar smell—the scent of the amniotic fluid in which they lived for 9 months. In one set of studies that shows this preference, newborns were presented with two pads, one saturated with their own amniotic fluid and the other saturated with the amniotic fluid of a different baby. With the two pads located on either side of the head, the infants revealed a preference for the scent of their own amniotic fluid by keeping their heads oriented longer toward that scent (Marlier, Schaal, & Soussignon, 1998; Varendi, Porter, & Winberg, 2002).

Long-lasting preferences based on prenatal experience have been demonstrated for taste (Mennella, Jagnow, & Beauchamp, 2001). Pregnant women were asked to drink carrot juice four days a week for three weeks near the end of their pregnancy. When their babies were tested at around 5½ months of age, they reacted more positively to cereal prepared with carrot juice than to the same cereal prepared with water. Thus, the flavor preferences of these babies reflected the influence of their experience in the womb several months earlier. This finding has great theoretical and practical significance. On the theoretical side, it is a very powerful demonstration of a *persistent* effect of prenatal learning. On the practical side, it may shed light on the strength of cultural food preferences. A child whose mother ate a lot of chili peppers, ginger, and cumin, for example, may be more favorably disposed from the beginning to Indian food than a child whose mother's diet was more bland.

Newborns also show numerous auditory preferences based on prenatal experience. To begin with, they prefer to listen to their own mother's voice over the voice of another woman; in other words, the fetus learns to recognize, and subsequently prefers, the particular voice it has heard the most (DeCasper & Fifer, 1980). Further, the newborn prefers a version of its mother's voice that sounds most familiar—one that has been filtered so as to mimic how it sounded in the womb (Moon & Fifer, 1990; Spence & Freeman, 1996). Finally, newborns would rather listen to the language they heard in the womb than to another language (Mehler et al., 1988; Moon, Cooper, & Fifer, 1993). French newborns prefer listening to French over Russian, for example.

There can be little question that the human fetus is listening and learning. Does this mean that parents-to-be should sign up for programs that promise to "educate your unborn child"? Such programs exhort the mother-to-be to talk to her fetus, read books to it, play music for it, and so on. Some also urge the father-to-be to speak through a megaphone aimed at his wife's bulging belly in the hope that the newborn will recognize his voice as well as the mother's. Is there any point in such exercises?

Probably not. Although it seems possible that hearing Dad's voice more clearly and more frequently might lead the newborn to prefer it over unfamiliar voices, such a preference probably develops very quickly after birth anyway. And it is quite clear that some of the advertised advantages of prenatal training would not occur. Because of the level of development of the fetus's brain, it would be impossible for it to learn the meaning of words or any kind of factual knowledge, no matter how much the mother-to-be might read aloud. The fetus will only learn about her voice and the general patterns of her language—not any specific content. We suspect that the craze for "prenatal education" will go the way of other ill-conceived attempts to shape early development to adult desires.

Hazards to Prenatal Development

Thus far, our focus has been on the normal course of development before birth. Unfortunately, prenatal development is not always free of error or misfortune. The most dire, and by far the most common, misfortune is spontaneous abortion (commonly referred to as miscarriage). The best estimate is that around 45% or more of pregnancies end in a spontaneous abortion prior to the 3rd week, before the woman has any idea she is pregnant (Moore & Persaud, 1993). The majority of embryos that miscarry very early have severe defects, such as a missing chromosome or an extra one, that make further development impossible. Of pregnancies that women are aware of, 15% to 20% end in a miscarriage. Few couples realize how common this experience is, making it all the more painful if it happens to them.

Most infants who survive the danger of miscarriage are born fully normal. This is the case for well over 90% of all newborns in the United States today, and most of the rest have only minor defects. There are, however, numerous factors operating before birth that can cause less fortunate outcomes (Lamb & Lang, 1992). Genetic factors, which are the most common, will be discussed in the next chapter. Here, we consider some of the environmental influences that can have harmful effects on prenatal development.

Environmental Influences

In the spring of 1956, two sisters were brought to a Japanese hospital, delirious and unable to talk coherently or even to walk. Their parents and doctors were mystified by the sudden deterioration in the girls, described as having been "the brightest, most vibrant, cutest kids you could imagine." The mystery intensified as more children and adults developed nearly identical symptoms. The discovery that all the disabled patients were from the small coastal town of Minamata suggested a common cause for what was referred to as the "strange disease" (Newland & Rasmussen, 2003; Smith & Smith, 1975).

That cause was eventually traced to the tons of mercury that had been dumped into Minamata Bay by a local petrochemical and plastics factory. For years, the residents of Minamata had been catching and consuming fish that had absorbed mercury from the polluted waters of the bay. By 1993, over 2000 children and adults had been diagnosed with what had come to be

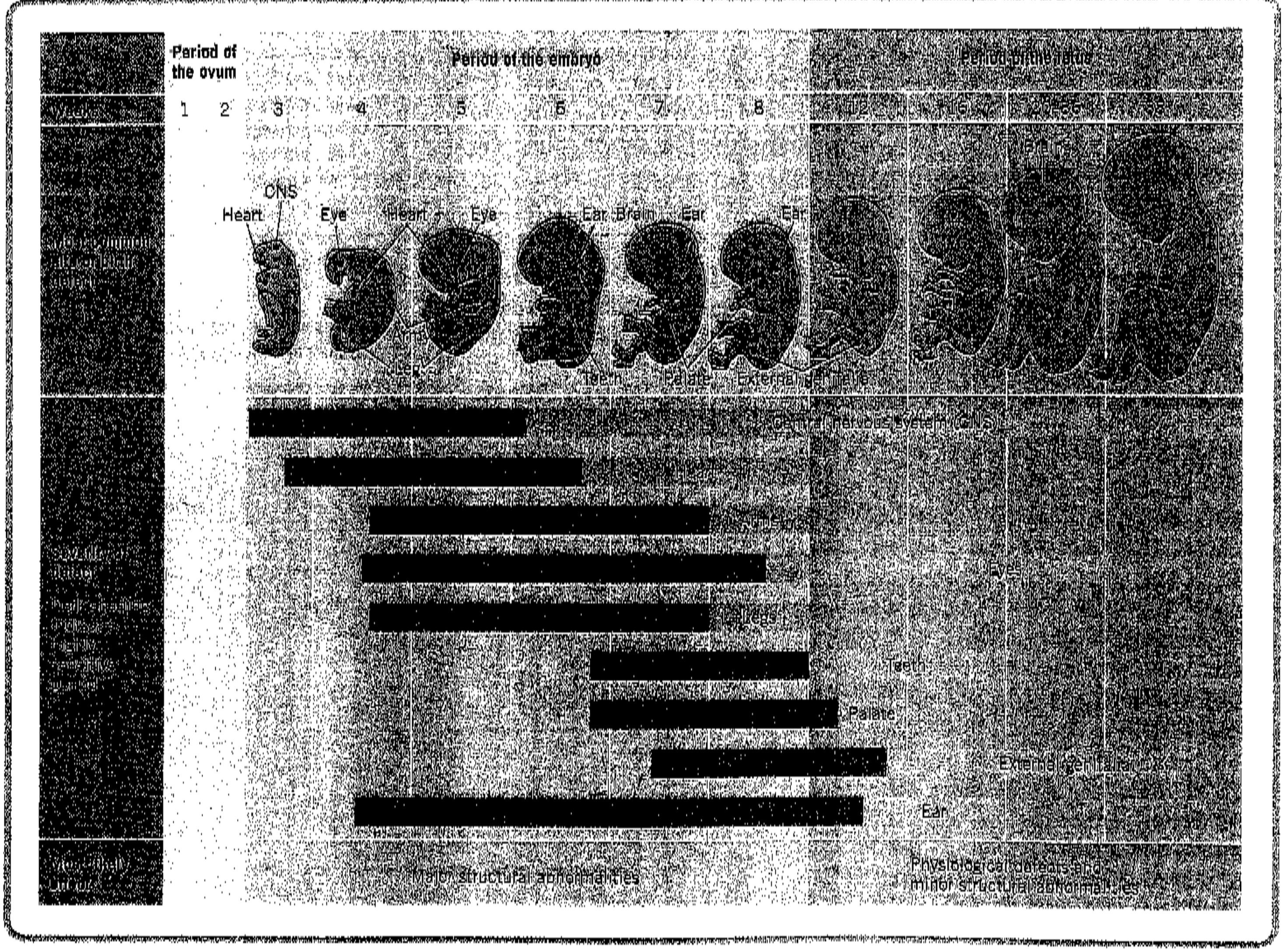
Victims of "Minamata disease" caused by mercury pollution in Minamata Bay.

known as "Minamata disease"—methyl-mercury poisoning (Harada, 1995). At least 40 children had been poisoned prenatally by mercury in the fish eaten by their pregnant mothers and were born with cerebral palsy, mental retardation, and a host of other neurological disorders.

The tragedy of Minamata Bay provided some of the first clear evidence of the seriously detrimental impact that environmental factors can have on prenatal development. As you will see, a vast array of environmental agents have the potential to harm the developing organism during the prenatal period. Such agents are referred to as **teratogens,** a classification that comprises all external agents that can cause prenatal harm, ranging from relatively mild and easily corrected problems to fetal death.

A crucial factor in the severity of the effects of potential teratogens is timing. Many teratogens cause damage only if exposure to them occurs during a **sensitive period** in prenatal development (see Figure 2.17). Each of the major organ systems has its own sensitive period, which is the time when its basic structures are being formed. There is no more dramatic or straightforward illustration of the importance of timing than the thalidomide tragedy that occurred in the 1960s. Many

FIGURE 2.17 Sensitive periods of prenatal development The most sensitive or critical period of prenatal development is the embryonic period. During the first two weeks, before implantation in the uterus, the zygote is generally not susceptible to environmental factors. Every major organ system of the body undergoes all or a major part of its development between the 3rd and the end of the 8th week. The dark green portions of the bars in the figure denote the times of most rapid development when major defects originate. The light green portions indicate periods of continued but less rapid development when minor defects may occur. (Adapted from Moore & Persaud, 1993.)



pregnant women who took this new, presumably safe sedative gave birth to babies with major limb deformities; some babies were born with no arms and with flipperlike hands growing out of their shoulders. However, these serious defects occurred only if the pregnant woman took the drug between the 4th and 6th week after conception, the time when her fetus's limbs were emerging and developing (look again at Figures 2.7 to 2.14). Taking thalidomide either before the arms or legs started to develop or after they were basically formed had no harmful effect.

As you can see in Figure 2.17, the sensitive period for many organ systems—and hence the time when the most significant teratogenic damage can result from something the mother does or experiences—is before the woman might realize she is pregnant. Because a substantial proportion of all births are unplanned, sexually active people of childbearing age need to be aware of behaviors that could compromise the health of a child they might conceive.

Another crucial factor influencing the severity of teratogenic effects is the amount and length of exposure. Most teratogens show a **dose–response relation:** the greater the exposure to a potential teratogen the fetus receives, the more likely it is that damage will occur and the more severe any damage is likely to be.

Avoiding environmental agents that have teratogenic effects is complicated by the fact that they are often very difficult to identify. One reason is that they frequently occur in combination, making it difficult to separate out their effects. For families living in urban poverty, for example, it is hard to tease apart the effects of poor maternal diet, exposure to airborne pollution, inadequate prenatal care, and psychological stress resulting from unemployment, single parenthood, and living in crime-ridden neighborhoods. Furthermore, the presence of multiple factors can have a *cumulative* impact. A given agent may have little discernible effect by itself but might have an impact in combination with other harmful agents. Alcohol, cigarettes, and addictive drugs all carry some risk, but the fetus of a woman who abuses all three is at particularly high risk.

The effects of teratogens can also vary according to *individual differences* in genetic susceptibility (probably in both the mother and the fetus). Thus, a substance that is harmless to most people may trigger problems in a minority whose genes predispose them to be affected by it.

Finally, identifying teratogens is also made difficult by the existence of *sleeper effects*, in which the impact of a given agent may not be apparent for many years. For example, the hormone DES was commonly given between the 1940s and 1960s to prevent miscarriage, with no apparent ill effects on babies born to women who had taken it. However, in adolescence and adulthood, these offspring turned out to have elevated rates of cervical and testicular cancer.

Having discussed some of the basic factors involved in teratogenic influences, we will now briefly examine some specific teratogens. An enormous number of potential teratogens have been identified, but we will focus only on some of the most common ones, emphasizing in particular those that are related to the pregnant woman's behavior. Table 2.2 includes the agents discussed in the text as well as some additional ones, but you should be aware that there are numerous other agents known or suspected to be hazardous to prenatal development.

This young artist was damaged while in th womb—his mother took the drug thalidomide. She must have taken the drug in the second month of her pregnancy, the time when the arm buds develop—an unfortuna example providing clear evidence of the i portance of timing in how environmental agents can affect the developing fetus.

teratogen external agent that can cause damage or death during prenatal developmer

sensitive period the period of time during which a developing organism is most sensitive to the effects of external factors; prenatally, the sensitive period is when the fetus is maximally sensitive to the harmful effects of teratogens

dose–response relation a relation in which the effect of exposure to an element increases with the extent of exposure (prenatally, the more exposure a fetus has to a poter tial teratogen, the more severe its effect is likely to be)

TABLE 2.2

Some Environmental Hazards to Fetus or Newborn

Drugs	**Maternal Disease**
Alcohol	AIDS
Birth control pills (sex hormones)	Chicken pox
Cocaine	Chlamydia
Heroin	Cytomegalovirus
Marijuana	Gonorrhea
Methadone	Herpes simplex (genital herpes)
Tobacco	Influenza
Environmental Pollutants	Mumps
Lead	Rubella (German measles)
Mercury	Syphilis
PCBs	Toxoplasmosis

Note: This list of dangerous elements is *not* comprehensive; there are many other agents in the environment that can have a negative impact on developing fetuses or on newborns during the birth process.

Legal drugs Although many prescription and over-the-counter drugs are perfectly safe for pregnant women to take, some are not. Many (such as thalidomide and DES) that were initially believed to be harmless later turned out to be potent teratogens. Pregnant women (and women who have reason to think they might be or might soon become pregnant) should take drugs only under the supervision of a physician. The two legal "drugs" that cause by far the most havoc for fetal development are cigarettes (nicotine) and alcohol.

CIGARETTE SMOKING We all know that smoking is unhealthy for the smoker, and there is an abundance of evidence that it is not good for the smoker's fetus either. When a pregnant woman smokes a cigarette, she gets less oxygen, and so does her fetus. One sign of this is that the fetus makes fewer breathing movements after Mom lights up. In addition, the fetuses of smokers metabolize some of the cancer-causing agents contained in tobacco. And because the mother-to-be inhales gases even when someone else, such as the father, is doing the smoking, passive smoking can have an indirect effect on fetal oxygen.

■ fetal alcohol spectrum disorder (FASD) ■ the harmful effects of maternal alcohol consumption on a developing fetus. *Fetal alcohol syndrome* (FAS) involves a range of effects, including facial deformities, mental retardation, attention problems, hyperactivity, and other defects. *Fetal alcohol effects* (FAE) is a term used for individuals who show some, but not all, of the standard effects of FAS.

The main consequence that maternal smoking has for the fetus is retarded growth and low birth weight, both of which compromise the health of the newborn. Babies born to heavy smokers weigh on average 200 grams less than babies of nonsmokers (Moore & Persaud, 1993). In addition, evidence suggests that smoking may be linked to increased risk of SIDS (sudden infant death syndrome, discussed in Box 2.4) and a variety of problems, including lower IQ, hearing deficits, and cancer.

In spite of the well-established negative effects of maternal smoking on fetal development, more than 11% of women in the United States smoke during their pregnancies (National Center for Health Statistics, 2003). The rate is especially high (over 18%) for pregnant 18- and 19-year-olds. Most of these women also continue to smoke after giving birth; thus, their children are exposed to a known teratogen before birth, as well as to a known health hazard after birth.

This woman is endangering the health of her fetus.

ALCOHOL Maternal alcohol use is generally considered to be the most common preventable cause of mental retardation and birth defects in the United States. This is partly because approximately 50% of women of childbearing age drink alcohol, and 15% to 20% continue to drink while pregnant (Sokol, Delaney-Black, & Nordstrom, 2003).

When a pregnant woman drinks, the alcohol in her blood crosses the placenta into both the fetus's bloodstream and the amniotic fluid. Thus, the fetus gets alcohol directly and also by drinking an amniotic-fluid cocktail. Concentrations of alcohol in the blood of mother and fetus quickly become equal, but the fetus has less ability to metabolize and remove alcohol from its blood, so it remains in the fetus's system longer. Immediate effects on the fetus include altered activity levels and abnormal startle reflexes (Little, Hepper, & Dornan, 2002).

applications 2.4

Face Up to Wake Up

For parents, nothing is more terrifying to contemplate than the death of their child. New parents are especially frightened by the specter of **SIDS—sudden infant death syndrome.** SIDS refers to the sudden, unexpected, and unexplained death of an infant less than 1 year of age (Hunt, 2001). The most common SIDS scenario is that an apparently healthy baby, usually between 2 and 5 months of age, is put to bed for the night and found dead in the morning. Although SIDS is rare, in developing countries, more children under the age of 1 year die of it than of all other causes combined. In the United States, where the SIDS incidence is 2 to 3 deaths per 1,000 births, victims are more likely to be male, from a low-SES family, and African American or Native American (Task Force on Sleep Position and Sudden Infant Death, 2000).

The causes of SIDS are still not fully understood, but Lewis Lipsitt (2003) has proposed that SIDS may involve an inadequate reflexive response to respiratory occlusion—that is, an inability to remove or move away from something covering the nose and mouth. He believes that infants are particularly vulnerable to SIDS between 2 and 5 months of age because that is when they are making a transition from neonatal reflexes under the control of lower parts of the brain (the brainstem) to deliberate, learned behaviors mediated by higher brain areas (cerebral cortex). A waning and "disorganized" respiratory-occlusion reflex during this transition period may make infants less able to effectively pull their head away from a smothering pillow or to push a blanket away from their face.

In spite of the lack of certainty about the causes of SIDS, researchers have identified several steps that parents can take to decrease the risk to their baby. The most important one is putting infants on their back to sleep, reducing the possibility of anything obstructing their breathing. Research has firmly established that sleeping on the stomach increases the risk of SIDS more than any other single factor (e.g., Willinger, 1995). A campaign encouraging parents to put their infants to sleep on their backs—the "back to sleep movement"—has contributed to a dramatic reduction in the number of SIDS victims.

Second, to lower the risk of SIDS, parents should not smoke. If they do smoke, they should not smoke around the baby. Infants whose mothers smoke during pregnancy and/or after the baby's birth are more than 3½ times more likely to succumb to SIDS than babies not exposed to smokers in their home (Klonoff-Cohen et al., 1995).

Third, babies should sleep on a firm mattress with no pillow. Soft bedding can trap air around the infant's face, causing the baby to breathe in its own carbon dioxide instead of oxygen.

Fourth, infants should not be wrapped in lots of blankets or clothes. Being overly warm is associated with SIDS.

One unanticipated consequence of the "back to sleep" movement has been that infants today start crawling slightly later than those in previous generations, presumably because of reduced opportunity to strengthen their muscles by pushing up off their mattress. Parents are now encouraged to give their babies supervised play time on their tummies to exercise their muscles during the day.

"Face Up to Wake Up." The parents of this infant are following the good advice of the foundation dedicated to lowering the incidence of SIDS worldwide. Since the inauguration of this campaign, SIDS in the United States has declined to half its previous rate (Task Force on Sleep Position and Sudden Infant Death, 2000).

In the long run, maternal drinking can result in various forms of **fetal alcohol spectrum disorder** (FASD) (Sokol et al., 2003). The most dramatic form of FASD occurs when a fetus is exposed to large amounts of alcohol over a long period of time. Babies born to alcoholic women often exhibit a condition known as *fetal alcohol syndrome* (FAS) (Jacobson & Jacobson, 2002; Jones & Smith, 1973; Streissguth, 2001; Streissguth, Bookstein, Sampson, & Barr, 1993). The most obvious symptoms of FAS are facial deformities like those shown in Figure 2.18.

SIDS (sudden infant death syndrome) the sudden, unexpected death of an infant les than 1 year of age that has no identifiable cause

FIGURE 2.18 Effects of FAS This child of an alcoholic mother, shown as an infant, a preschooler, and a school-age child, displays the symptoms of fetal alcohol syndrome (FAS). The characteristic features caused by extensive exposure to alcohol in the womb include facial abnormalities (a smooth upper lip, short nose, and narrow, widely spaced eyes), as well as neuropsychological deficits (including attention, learning, and memory problems). Roughly 1 in every 1000 infants born in the United States has FAS.

Other FAS effects can include varying degrees of mental retardation, attention problems, and hyperactivity. Many children who were prenatally exposed to alcohol and show similar but fewer symptoms are diagnosed with *fetal alcohol effects* (FAE) (Mattson, Riley, Delis, & Jones, 1998). Even moderate drinking during pregnancy (i.e., less than one drink per day) can have both short- and long-term negative effects on development. So can occasional drinking if it involves binge drinking (more than five drinks per episode) (e.g., Hunt, Streissguth, Kerr, & Olson, 1995; Sokol et al., 2003; Streissguth, Barr, & Martin, 1983).

Given the potential outcomes and the fact that no one knows if there is a safe level of alcohol consumption for a pregnant woman, the best approach for expectant mothers is to avoid alcohol altogether.

Illegal drugs Almost all commonly abused illegal drugs have been shown or are suspected to be dangerous for prenatal development. It has proved difficult to pin down exactly how dangerous various ones are, because, as we discussed earlier, pregnant women who use one illegal substance often use others and often smoke cigarettes and drink alcohol as well (Lester, 1998).

Marijuana, the illegal substance most commonly used by women of reproductive age in the United States, is suspected of affecting memory, learning, and visual skills after birth (Mereu et al., 2003). Cocaine in its various forms is the second most common illegal drug abused by young American women (Substance Abuse and Mental Health Services Administration, 2004). Although some early reports of devastating effects from cocaine use during pregnancy turned out to be exaggerated, it is well established that cocaine use is associated with growth retardation and premature birth (Hawley & Disney, 1992; March of Dimes, 2004). Newborn and older infants of coke addicts have impaired ability to regulate arousal and attention (e.g., DiPietro, Suess, Wheeler, Smouse, & Newlin, 1995; Lester & Tronick, 1994; Lewkowicz, Karmel, & Gardner, 1998). Some tend to be lethargic and underaroused; others are highly excitable and irritable, with a characteristic high-pitched cry that adults find very grating. Longitudinal studies of the development of cocaine-exposed children have reported persistent, although sometimes subtle, cognitive and social deficits (Lester, 1998). These deficits can be ameliorated to some degree, as suggested by improved outcomes among affected children who were adopted into supportive middle-class families (Koren, Nulman, Rovet, Greenbaum, Loebstein, & Einarson, 1998).

Environmental pollutants The bodies and bloodstreams of most Americans (including women of childbearing age) contain a noxious mix of toxic metals, synthetic hormones, and various ingredients of plastics, pesticides, and herbicides that can be teratogenic (Harder, 2003). Echoing the story of Minamata disease, evidence has accumulated that mothers whose diet was high in Lake Michigan fish with high levels of PCBs (polychlorinated biphenyls) had newborns with small heads. The children with the highest prenatal exposure to PCBs had slightly lower IQ scores as long as 11 years later (Jacobson & Jacobson, 1996; Jacobson, Jacobson, Padgett, Brumitt, & Billings, 1992).

Occupational hazards Another category of worrisome environmental agents are those in the workplace. Many women have jobs that bring them into contact with a variety of potentially hazardous elements. Tollbooth collectors, for example, are exposed to high levels of automobile exhaust; farmers, to pesticides; and factory workers, to numerous chemicals. Employers and employees alike are grappling with how to protect pregnant women from potential teratogens without subjecting them to job discrimination.

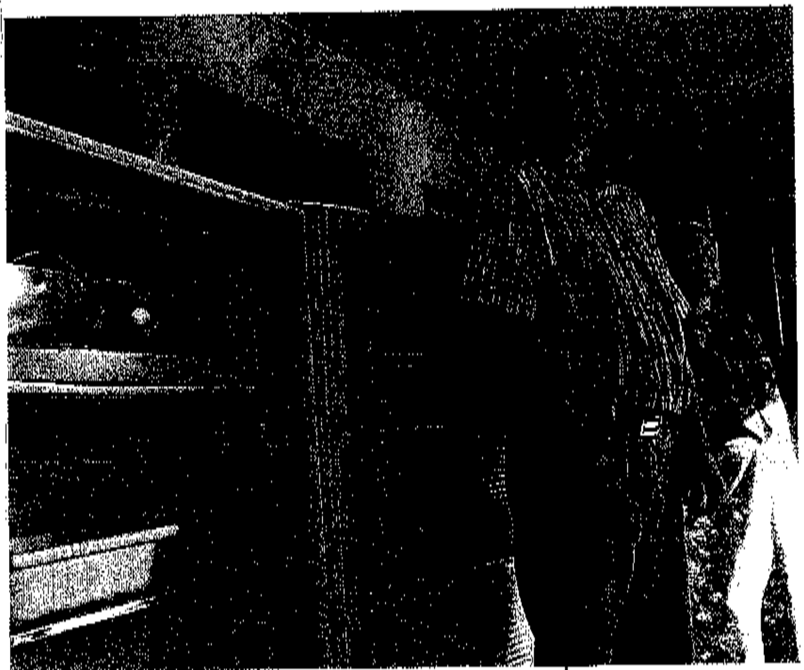
Maternal Factors

Because the mother-to-be constitutes the most immediate environment for her fetus, certain of her characteristics can affect prenatal development. These characteristics include age, nutritional status, health, and stress level.

Age The age of the pregnant woman is related to the outcome of her pregnancy. Infants born to girls 15 years or younger are three to four times more likely to die before their first birthday than are those whose mothers are between 23 and 29 (Phipps, Blume, & DeMonner, 2002). Although the high rate of pregnancies among young teenagers in the United States has declined in recent years, it remains a cause for concern for this and many other reasons.

Nutrition The fetus depends on its mother for all its nutritional requirements. If a pregnant woman has an inadequate diet, her unborn child may also be nutritionally deprived (Pollitt et al., 1996). An inadequate supply of specific nutrients or vitamins can have dramatic consequences. For example, women who get too little folic acid (a form of B vitamin) are at high risk for having an infant with a neural-tube defect such as spina bifida (see Figure 2.6). General malnutrition affects the growth of the fetal brain: malnourished newborns have smaller brains containing fewer brain cells than do well-nourished newborns. They also tend to be unresponsive and irritable (Lozoff, 1989).

Because malnutrition is more common in impoverished families, it often coincides with the host of other risk factors associated with poverty, making it difficult to isolate its effects on prenatal development (Lozoff, 1989; Sigman, 1995). However, one study of development in very extreme circumstances was able to assess the effects of malnutrition independent of socioeconomic status (SES)



These poor Brazilian parents are worrying about how they are going to feed their children—a situation all too common throughout the world.

(Stein et al., 1975). In parts of Holland during World War II, people of all income and education levels suffered severe famine. Examination of health records of Dutch women who were pregnant at that time revealed that women who became malnourished only in the last few months of pregnancy tended to have underweight babies with small heads, but mothers whose malnutrition started early in pregnancy often had babies with serious physical defects.

Long-term insidious effects of maternal malnutrition can also occur. A malnourished woman may biologically signal her fetus to "expect" a shortage of food, stimulating metabolic adaptations. After birth, the baby's metabolism may continue its famine-survival orientation. As a consequence, adequate nutrition later in life can put the individual at higher risk for obesity, heart disease, and diabetes (Bateson et al., 2004).

Disease Although most maternal illnesses that occur during a pregnancy have no impact on the fetus, some do. For example, if contracted early in pregnancy, rubella (the three-day measles) can have devastating developmental effects, including major malformations, deafness blindness, and mental retardation. Any woman of childbearing age who does no have immunities against rubella should be vaccinated before becoming pregnant.

The sexually transmitted diseases (STDs) that have become increasingly common throughout the world are quite hazardous to the fetus. Cytomegalovirus, currently the most frequent prenatal source of infection, can damage the fetus's centra nervous system and cause other defects. Genital herpes can also be very dangerous if the infant comes into contact with active lesions in the birth canal, blindness o even death can result. HIV infection is sometimes passed to the fetus in the woml or during birth, but the majority of infants born to women with HIV or AIDS d not have the disease. HIV can also be transmitted through breast milk after birth.

Evidence has been accumulating for effects of maternal illness on the development of *psychopathology* later in life. For example, the incidence of schizophrenia i higher for individuals whose mothers had influenza (flu) during the first trimeste of pregnancy (Brown et al., 2004). Maternal flu may interact with genetic or othe factors to lead to mental illness.

Maternal emotional state For centuries, people have believed that a woman' emotions can affect her fetus. Current research suggests that the behavior of fetus can indeed be influenced by the mother's emotional state (DiPietro, 2004 Huizink, Mulder, & Buitelaar, 2004). For example, the fetuses of women who reported higher levels of stress during pregnancy were more physically activ throughout their gestation than were the fetuses of women who felt less stresse (DiPietro, Hilton, Hawkins, Costigan, & Pressman, 2002). Such effects can continue after birth. In a study that involved more than 7000 pregnant women an their infants, maternal anxiety and depression during pregnancy were assessed The higher the level of distress the pregnant women reported, the higher the incidence of behavior problems in their children at 4 years of age—including hyperactivity and inattention in boys, conduct problems in girls, and emotional problem in both boys and girls (O'Connor, Heron, Golding, Beveridge, & Glover, 2002). The specific reasons for these relations between maternal depression during pregnancy and the outcome for children are not fully clear at this point, but it is a topic of intense interest.

review:

The most rapid period of development starts at conception, with the union of egg and sperm, and continues for roughly 9 months, divided into three developmental periods—germinal, embryonic, and fetal. The processes through which prenatal development occurs include cell division, cell migration, cell differentiation, and cell death. Every major organ system undergoes all or a substantial part of its development between the 3rd and 8th week following conception, making this a sensitive period for potential damage from environmental hazards.

Scientists have recently learned an enormous amount about the behavior and experience of the developing organism, which begins to move at 5 to 6 weeks. Some behaviors of the fetus contribute to its development, including swallowing amniotic fluid and breathing motions. The fetus has relatively rich sensory experience from stimulation both within and outside the womb, and this experience is the basis for fetal learning. Researchers have recently established some persistent effects of fetal learning after birth.

Many environmental agents can have a negative impact on prenatal development, with cigarette smoking, alcohol consumption, and environmental pollution being the most common problems in the United States. Maternal factors (malnutrition, illness, emotional state, etc.) can also cause problems for the developing fetus and child. Timing is crucial for some teratogens; the severity of effects is generally related to the amount and length of exposure, as well as to the number of different negative factors with which a fetus has to contend.

The Birth Experience

Approximately 38 weeks after conception, contractions of the muscles of the uterus begin, initiating the birth of the baby. Typically, the baby has already contributed to the process by rotating itself into the normal head-down position. In addition, the maturing lungs of the fetus may release a protein that triggers the onset of labor. Uterine contractions, as well as the baby's progress through the birth canal, are painful for the mother, so women in labor are often given pain-relieving drugs. Although these drugs can help the mother get through childbirth more comfortably, they do not help her baby. Many obstetric medications slow labor, and anything that prolongs labor increases the chance of oxygen deprivation, thereby increasing the risk of brain damage. Also, delivery drugs given to the mother can result in a "drugged" baby—a newborn with a decreased supply of oxygen who is less attentive, has poorer muscle tone, exhibits less vigorous reflexes, and so forth (Brackbill, McManus, & Woodward, 1985; Brazelton, Nugent, & Lester, 1987). The extent of these effects depends on which particular drugs are used and how high the dosage is. Fortunately, the effects are generally not long-lasting.

Is being born as painful as giving birth? There is good reason to doubt that birth is either traumatic or even particularly painful for the baby. Compare how much pain you feel when you pinch and pull on a piece of skin on your forearm versus when you wrap your hand around your forearm and squeeze as tightly as you can. The stretching is painful, but the squeezing is not. The mother's pain comes from her tissues being greatly stretched, but the baby experiences squeezing.

Hence, the experiences of the two participants are not really comparable (Maurer & Maurer, 1988). Childbirth programs based on the assumption that birth is painful and traumatic for newborns are probably based on faulty premises.

Further, the squeezing that the fetus experiences during birth serves several important functions. First, it temporarily reduces the overall size of the head, allowing the disproportionately large head of the fetus to pass safely through the mother's pelvic bones. This is possible because the skull is composed of separate plates that can overlap one another slightly during birth (see Figure 2.19). The squeezing of the baby's head during birth also serves to stimulate the production of hormones that help the fetus withstand mild oxygen deprivation during birth and to regulate breathing after birth. The squeezing of the infant's body also forces amniotic fluid out of the lungs, in preparation for the newborn's first, crucial gasp of air (Lagercrantz & Slotkin, 1986; Nathanielsz, 1994). This first breath usually comes by way of the birth cry, which is a very efficient mechanism for jump-starting respiration: a good, lusty cry not only obtains some essential oxygen but also forces open the small air sacs in the lungs, making subsequent breaths easier.

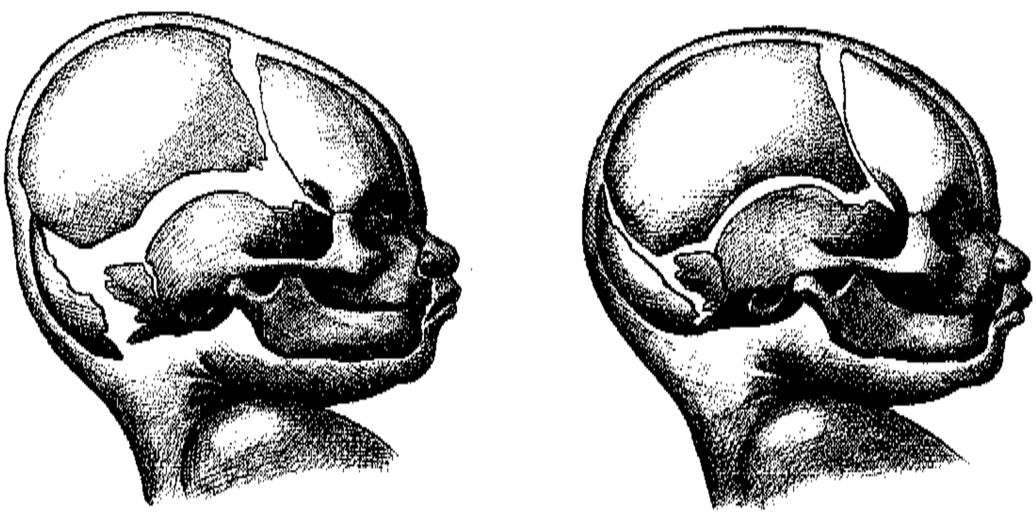


FIGURE 2.19 Head plates Pressure on the head during birth can cause the separate plates of the skull to overlap, resulting in a temporarily misshapen head. Fortunately, the condition rapidly corrects itself after birth. The "soft spot," or fontanel, is simply the temporary space between separate skull plates in the top of the baby's head.

Diversity of Childbirth Practices

Although the biological aspects of birth are pretty much the same everywhere, childbirth practices vary enormously. As with many human behaviors, what is considered a normal and desirable birth custom in one society may seem strange or deviant—or even dangerous—in another.

All cultures pursue the dual goals of safeguarding the *survival and health* of both the mother and the baby and ensuring the *social integration* of the new person. Groups differ, however, regarding the relative importance they give to these goals. An expectant mother on the South Pacific island of Bali assumes that her husband and other kin, along with any children she may already have, will all want to be present at the joyous occasion of the birth of a new child. Her female relatives, as well as a midwife, actively help her throughout the birth, which occurs in her home. Having already been present at many births, the Balinese woman knows what to expect from childbirth, even when it is her first child (Diener, 2000).

A very different scenario has been traditional in the United States, where the woman in labor usually withdraws almost totally from her everyday life. In most cases, she enters a hospital to give birth, typically attended by only one person or the very few people most emotionally close to her. The birth is supervised by a variety of medical personnel, most of whom are strangers. Unlike her Balinese counterpart, the first-time mother has probably never witnessed a birth, so she may not have very realistic expectations about the birth process. Also, unlike the situation in most other societies, the woman has a 26% chance of having her infant surgically removed from her uterus in a cesarean delivery.

The medical model of childbirth prevails in the United States.

Underlying the Balinese approach to childbirth is great emphasis on the social goal of immediately integrating the newborn into the family and community—hence the presence of many kin and friends to support mother and baby. In contrast, modern Western groups have elevated the physical health of the mother and newborn above all other concerns. The belief that childbirth is safer in a hospital setting outweighs the resulting social isolation of mother and baby.

This childbirth in Brazil is quite different from the norm in the United States. The baby was born at home, welcomed by his father, older brother, and grandmother. Also present are an obstetrician and midwife who assisted with the birth.

The practices of both societies have changed to some degree. In the United States, the social dimensions of birth are increasingly recognized by doctors and hospitals. As in Bali, various family members—sometimes even including the parents' other children—are encouraged to be present to support the laboring mother and to share a family experience. This shift has been accompanied by more moderate use of delivery drugs, thereby enhancing the woman's participation in childbirth and her ability to interact with her newborn. In addition, many expectant parents attend childbirth education classes, where they learn some of what their Balinese counterparts picked up through routine attendance at births. Social support is a key component of these programs; the pregnant woman's husband or some other supportive person is trained to assist her during the birth. Such childbirth programs are generally beneficial (Lindell, 1988), and obstetricians routinely advise expectant couples to enroll in them. At the same time that these changes are occurring in the United States, in traditional, nonindustrialized societies like Bali, Western medical practices are increasingly adopted in an effort to improve newborn survival rates.

review:

Research on the birth process has revealed that many aspects of the experience of being born, including squeezing in the birth canal, have adaptive value and increase the likelihood of survival for the newborn. Great differences exist across cultures in beliefs and practices related to childbirth, with one clear difference having to do with the emphasis on the social aspects of birth.

state level of arousal and engagement in the environment, ranging from deep sleep to intense activity

REM (rapid eye movement) sleep an active sleep state characterized by quick, jerky eye movements under closed lids and associated with dreaming in adults

non-REM sleep a quiet or deep sleep state characterized by the absence of motor activity or eye movements and regular, slow brain waves, breathing, and heart rate

autostimulation theory the idea that brain activity during REM sleep in the fetus and newborn facilitates the early development of the visual system

The Newborn Infant

A healthy newborn is ready and able to continue the developmental saga in a new environment. The baby begins interacting with that environment right away, exploring and learning about both the physical and social entities in it. Newborns' exploration of this uncharted territory is very much influenced by their state of arousal.

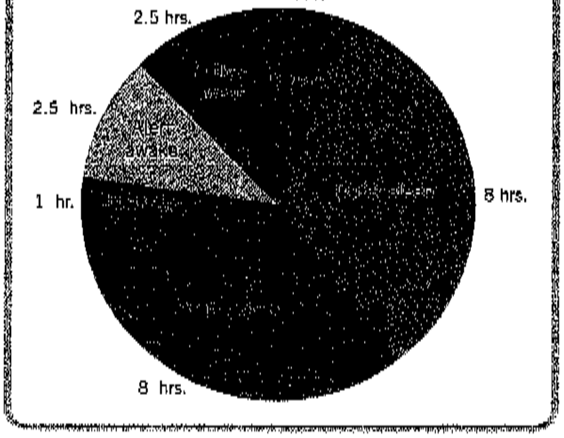
State of Arousal

State refers to a continuum of arousal, ranging from deep sleep to intense activity. As you well know, your state dramatically affects your interaction with the environment—with what you notice, do, learn, and think about. It also affects the ability of others to interact with you. State is an even more important mediator of young infants' experience of the world around them.

Figure 2.20 depicts the average amount of time in a 24-hour period that Western newborns typically spend in each of six states, ranging from quiet sleep to crying. Within this general pattern, however, there is a great deal of variation. Some infants cry relatively rarely, whereas others cry for hours every day; some babies sleep much more, and others much less, than the 16-hour average shown in the figure. Some infants spend more than the average of 2½ hours in the awake-alert state, in which they are fairly inactive but attentive to the environment. To appreciate how these differences might affect parent–infant interaction, imagine yourself as the parent of a newborn who cries more than the average, sleeps little, and spends less time in the awake-alert state. Now imagine yourself with a baby who cries relatively little, sleeps well, and spends an above-average amount of time quietly attending to you and the rest of his or her environment (see Figure 2.21). Clearly, you would have many more opportunities for pleasurable interactions with the second newborn.

The two newborn states that are of particular concern to parents—sleeping and crying—have both been studied extensively.

FIGURE 2.20 Newborn states This figure shows the average proportion of time, in a 24-hour day, that Western newborns spend in each of six states of arousal. There are substantial individual and cultural differences in how much time babies spend in the different states.



Sleep

Figure 2.22 summarizes several important facts about sleep and its development, two of which are of particular importance. First, "sleeping like a baby" means, in part, sleeping a lot; on average, newborns sleep twice as much as young adults do. Total sleep time declines regularly during childhood and continues to decrease, although more slowly, throughout life.

Second, the pattern of two different sleep states—**REM sleep** and **non-REM sleep**—changes dramatically with age. *REM (rapid eye movement) sleep* is an active sleep state that is associated with dreaming in adults and is characterized by quick, jerky eye movements under closed lids; a distinctive pattern of brain activity; body movements; and irregular heart rate and breathing. *Non-REM sleep*, in contrast, is a quiet or deep sleep state characterized by the absence of motor activity or eye movements and regular, slow brain waves, breathing, and heart rate. As you can see in Figure 2.22, at birth, REM sleep constitutes fully 50% of a newborn's total sleep time. The proportion of REM sleep declines quite rapidly to only 20% by 3 or 4 years of age and remains low for the rest of life.

Why do infants spend so much time in REM sleep? Some researchers believe that it helps develop the infant's visual system. The normal development of the human visual system, including the visual area of the brain, depends on visual stimulation, but relatively little visual stimulation is experienced by either the fetus in the womb or by the newborn in its bed. According to the **autostimulation theory** of REM sleep, the high level of internally generated brain activity that occurs during REM sleep helps to make up for the natural deprivation of visual stimulation and hence facilitates the early development of the visual system in both fetus and newborn (Roffwarg, Muzio, & Dement, 1966). This theory is supported by a study showing that newborns who had been given a high level of extra visual stimulation during the day spent less of their subsequent sleep time in REM sleep than did infants exposed to lower levels of visual stimulation (Boismeyer, 1977).

FIGURE 2.21 Quiet-alert state The pare of this quiet-alert newborn have a good chance of having a pleasurable interactio with the baby.

Another distinctive feature of sleep in the newborn period is that napping newborns may actually be learning while they sleep. Infants were exposed to recordings of Finnish vowel sounds while they slumbered in the newborn nursery. When

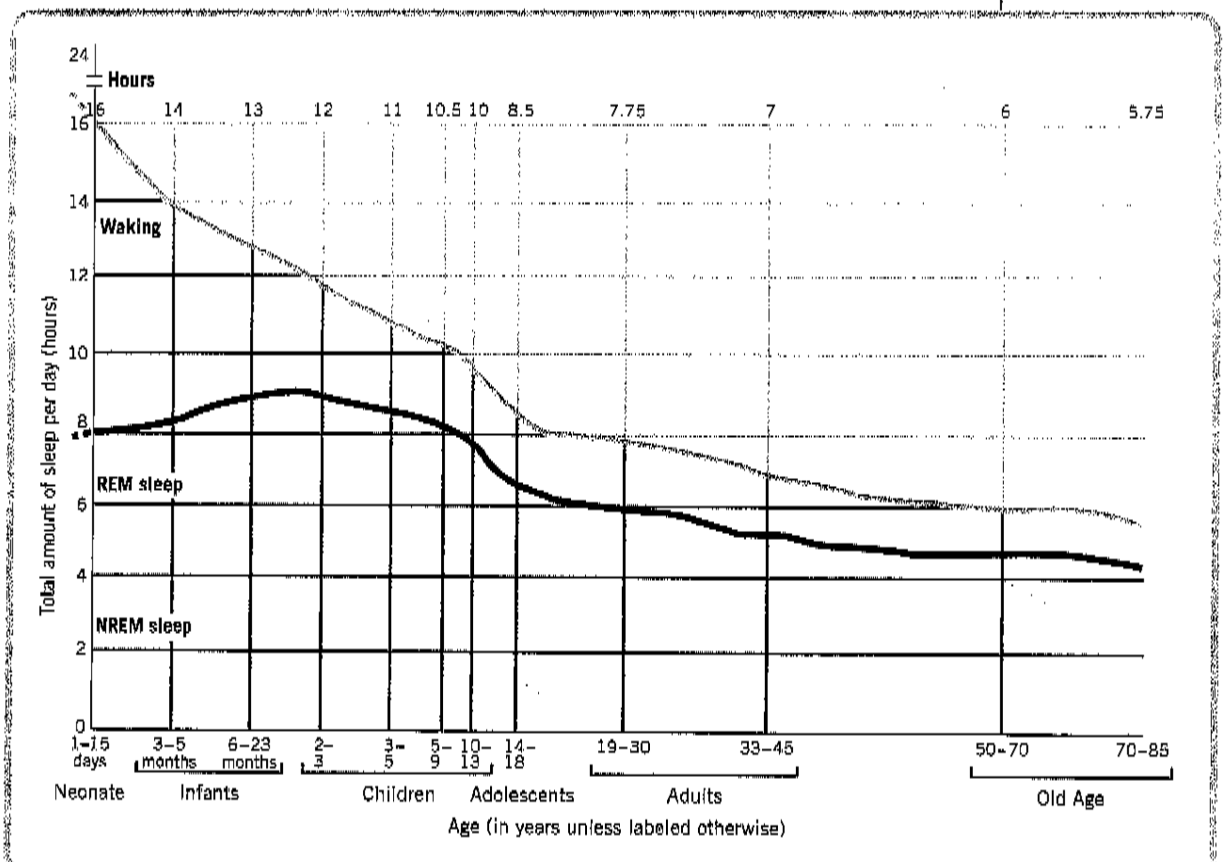


FIGURE 2.22 Total sleep and proportion of REM and non-REM sleep across the life span Newborns average a total of 16 hours of sleep, roughly half of it in REM sleep. The total amount of sleep declines sharply throughout early childhood and continues to decline much more slowly throughout life. From adolescence on, REM sleep constitutes only about 20% of total sleep time. (Adapted from Roffwarg, Muzio, & Dement, 1966, and from a later revision by these authors.)

Most American parents want to avoid the 2 A.M. fate of this young father. They regard their baby's sleeping through the night as a developmental triumph—the sooner, the better.

tested in the morning, their brain activity revealed that they recognized the sounds they had heard while asleep (Cheour et al., 2002). The reason newborns can learn to recognize speech sounds, and presumably other forms of auditory stimulation, in their sleep is that during sleep their brains do not become disconnected from external stimulation to the same extent as the brains of older individuals do.

Another difference between the sleep of young infants and older individuals (not reflected in Figure 2.22) is in sleep–wake cycles. Newborns generally cycle between sleep and waking states several times in a 24-hour period, sleeping slightly more at night than during the day (Whitney & Thoman, 1994). Although newborns are likely to be awake during part of their parents' normal sleep time, they gradually develop the more mature pattern of sleeping through the night.

The age at which infants' sleep patterns come to match those of adults depends very much on cultural practices and pressures. For example, most infants in the United States sleep through the night by around 4 months of age (Berg & Berg, 1987). This change is actively encouraged by most parents, who find the infant's initial sleep pattern disruptive, stressful, and exhausting (Halpern, Anders, Garcia-Coll, & Hua, 1994). Many different strategies are employed by tired parents, from the adoption of elaborate, often extended bedtime rituals to gritting their teeth and letting the baby cry himself or herself to sleep. In contrast, the parents of Kipsigis infants in rural Kenya put little or no pressure on their infants to sleep through the night. Babies are almost always with their mothers. During the day they are often carried on her back as she goes about her daily activities, and at night they sleep with her and are allowed to nurse whenever they awaken. As a consequence, these babies distribute their sleeping throughout the night and day for several months (Harkness & Super, 1995; Super & Harkness, 1986). Thus, cultures vary not only in terms of where babies sleep, as you learned in Chapter 1, but also in terms of how strongly parents attempt to influence when their babies sleep.

Crying

How do you feel when you hear a baby cry? We imagine that, like most people, you find the sound of a crying infant extremely unpleasant. Why is crying so aversive for us?

From an evolutionary point of view, adults' aversion to infants' crying could have adaptive value. Infants cry for many reasons—including illness, pain, and hunger—that require the attention of caregivers. Adults' high level of motivation to stop an infant's crying leads them to take care of the infant's needs and hence would promote the infant's survival. Indeed, some have suggested that in times of hardship, such as famine, cranky babies are more likely to survive than more placid ones, possibly because they elicit adult attention and consequently get more than their share of scarce food resources (DeVries, 1984).

Parents, especially novice parents, are often puzzled and anxious about why their baby is crying. Indeed, one of the most frequent complaints pediatricians hear is about what parents judge to be excessive crying (Barr, 1998; Harkness et al., 1996). With experience, parents become better at interpreting characteristics of the cry itself (a sharp, piercing cry usually signals pain, for example) and at using context (when the last feeding was) (Green, Jones, & Gustafson, 1987).

Crying increases from around 2 weeks of age to a peak at 6 weeks, but then declines to about an hour a day for the rest of the first year (St. James-Roberts & Halil, 1991). On a daily basis, the peak time for crying is late afternoon or evening. The phenomenon of "evening crying," which can be quite disappointing to parents looking forward to interacting with their baby at the end of the workday, may be due to an accumulation of excess stimulation over the course of the day.

The nature of crying and the reasons for it change with development. Early on, crying reflects discomfort from pain, hunger, cold, or overstimulation, although from the beginning infants also cry from frustration (Lewis, Alessandri, & Sullivan, 1990; Stenberg, Campos, & Emde, 1983). Crying gradually becomes more of a communicative act; the crying of older babies often seems geared to "tell" caregivers something and to get them to respond (Gustafson & Green, 1988).

swaddling a soothing technique, use many cultures, that involves wrapping a b tightly in cloths or a blanket

Soothing What works best to console a crying baby? Most of the traditional standbys—rocking, singing lullabies, holding the baby up to the shoulder, giving a pacifier—work reasonably well (R. Campos, 1989; Korner & Thoman, 1970). In general, many effective soothing techniques involve moderately intense and continuous or repetitive stimulation. The combination of holding, rocking, and talking or singing relieves an infant's distress better than any one of them alone (Jahromi, Putnam, & Stifter, 2004).

One very common soothing technique is **swaddling,** which involves wrapping a baby tightly in cloths or a blanket, thereby restricting limb movement. The tight wrapping provides a constant high level of tactile stimulation and warmth. This technique is practiced in cultures as diverse and widespread as those of the Navajo and Hopi in the American Southwest (Chisolm, 1963), the Quechua in Peru (Tronick, Thomas, & Daltabuit, 1994), and rural villagers in Turkey (Delaney, 2000). Another traditional approach, distracting an upset infant with interesting objects or events, can also have a soothing effect, but the distress often resumes as soon as the interesting stimulus is removed (Harman, Rothbart, & Posner, 1997).

Touch can also have a soothing effect on infants, which may be one reason mothers so often touch their babies when interacting with them (Stack & Muir, 1990). In interactions with an adult, infants fuss and cry less, and they smile and vocalize more, if the adult pats, rubs, or strokes them (Field et al., 1996; Peláez-Nogueras, Field, Hossain, & Pickens, 1996; Stack & Arnold, 1998; Stack & Muir, 1992). Carrying young infants, as is routinely done in many societies around the world, reduces the amount of crying that young babies do (Hunziker & Barr, 1986).

In laboratory studies, placing a small drop of something sweet on a distressed newborn's tongue has been shown to have a dramatic calming effect (Barr, Quek, Cousineau, Oberlander, Brian, & Young, 1994; Blass & Camp, 2003; Smith & Blass, 1996). A taste of sucrose has an equally dramatic effect on pain sensitivity; newborn boys who are given a sweetened pacifier to suck during circumcision cry much less than babies who do not receive this simple intervention (Blass & Hoffmeyer, 1991).

Carrying infants close to the parent's body results in less crying. Many Western paren are now emulating the traditional carrying methods of other societies around the worl

Response to distress One question that often concerns parents is whether they should respond as quickly and consistently as possible to a distressed infant. Will that strategy reward the infant for crying and hence increase how much he or she cries, or will it instill a sense of confidence and actually lead to less fussing and

colic excessive, inconsolable crying by a young infant for no apparent reason

crying? It appears that, as is so often the case, the middle road is probably best. In a longitudinal study, Hubbard and van IJzendoorn (1991) found that infants whose mothers waited for a few minutes before responding to their cries tended to cry less often than did infants whose mothers responded more rapidly. The key may be taking into account the severity of the infant's distress. If a parent responds quickly to severe distress but delays responding to minor upset, the infant may learn to cope with less serious problems on his or her own and hence end up crying less overall.

Colic No matter how hard their parents try to soothe them, some infants are impervious to their efforts. Excessive, inconsolable crying for no apparent reason during the first few months of life is known as **colic** (Wessel, Cobb, Jackson, Harris, & Detwiler, 1954). Not only do "colicky" babies cry a lot, but they also tend to have high-pitched, particularly unpleasant cries (Stifter, Bono, & Spinrad, 2003). Unfortunately, colic is not a rare condition: more than one in ten young infants in the United States suffer (along with their parents) from it. Fortunately, it typically ends by around 3 months of age and leaves no ill effects (Stifter & Braungart, 1992; St. James-Roberts, Conroy, & Wilsher, 1998). One of the best things parents with a colicky infant can do is to seek social support and relief from the stress, frustration, and feelings of inadequacy and incompetence resulting from being unable to relieve their baby's distress.

Negative Outcomes at Birth

Although the most common outcome of a recognized pregnancy for a woman in an industrialized society is the full-term birth of a healthy baby, the outcome is sometimes less positive. The most dire result is the death of an infant. The most common less dire negative outcome is low birth weight, which, if extreme, can have long-term consequences.

Infant Mortality

Infant mortality—death during the first year after birth—has become a relatively rare event in the Western industrialized world, thanks to decades of improvements in public health and general economic levels. In the United States, the 2002 infant mortality rate was 6.8 deaths per 1000 live births, the lowest in American history.

Although the infant mortality rate in the United States is low in absolute terms, it is high in comparison with that of other industrialized nations. In 2002, the United States ranked 24th in the world in terms of the number of infants who failed to survive their first year after birth (Table 2.3). As you can see from the table, this rate is double or more the rates in five other countries. The relative ranking of the United States has gotten steadily worse over the past several decades, because the infant mortality rates in many other countries have improved faster and further.

The rates of infant mortality are starkly different for subsets of the U.S. population. African-American infants are more than twice as likely to die before their first birthday as Euro-American infants are. Indeed, the infant mortality rate for African Americans is similar to that in many underdeveloped countries.

Why do more babies die in the United States—the richest country in the world—than in 23 other countries? Why are African-American infants' chances of survival so much poorer than those of Euro-American infants? There are many reasons, most having to do with poverty. For example, many low-income mothers-to-be, including a disproportionate number of African Americans, have no health insurance and have limited access to good health and prenatal care (Kopp & Kaler, 1989; National Center for Health Statistics, 1998). In contrast, all the countries that rank above the United States with respect to infant mortality have some form of government-sponsored health care that guarantees pregnant women prenatal care at low or minimal cost.

In less developed countries, especially those suffering from a breakdown in social organization due to war, famine, major epidemics, or persistent extreme poverty, the infant mortality rates can be staggering. A particularly poignant example comes from the poorest areas of a small city in northeast Brazil, where extreme poverty, chaotic social services, disrupted families, and an infant mortality rate as high as 90% set up conditions for a vicious cycle (Scheper-Hughes, 1992). Because any baby born in this area had a very high risk of dying and family resources were so slim, mothers looked for some evidence that a new baby "wants to live" before investing very much in the child, either economically or emotionally. They tended to feed and care for the infant only minimally while engaging in "watchful waiting" for signs of "child sickness" (symptoms of which are the same as those of malnutrition and dehydration). Thus, underfeeding and neglect produced an infant displaying evidence that he or she "has no knack for life" or "wants to die," leading to further deprivation and neglect. When the almost inevitable occurred and the baby died, the mother was not supposed to express grief, for a mother's tears "will make the road from heaven to earth slippery and [the baby] will lose his footing and fall."

TABLE 2.3

Infant Mortality Worldwide—2002

Country	Deaths per 1000 births	Country	Deaths p[er] 1000 birt[hs]
Iceland	2.2	Netherlands	5.0
Sweden	2.8	Portugal	5.0
Finland	3.0	Ireland	5.1
Japan	3.0	Luxembourg	5.1
Spain	3.4	Canada	5.2
Norway	3.9	United Kingdom	5.3
Austria	4.1	Greece	5.9
Czech Republic	4.2	New Zealand	6.3
France	4.2	United States	6.8
Germany	4.3	Hungary	7.2
Denmark	4.4	Poland	7.5
Switzerland	4.5	Slovak Republic	7.6
Italy	4.7	Mexico	20.1
Belgium	4.9	Turkey	38.3
Australia	5.0		

Source: Organization for Economic Co-operation and Development (2004)

Low Birth Weight

The average newborn in the United States weighs 7½ pounds (most are between 5½ and 10 pounds). Infants who weigh less than 5½ pounds (2500 grams) at birth are considered to be of **low birth weight (LBW)**. Some LBW infants are referred to as **premature** or preterm, because they are born at 35 weeks after conception or earlier, instead of the normal term of 38 weeks. Other LBW infants are referred to as **small for gestational age**: they may be either preterm or full-term, but they weigh substantially less than is normal for whatever their gestational age.

Approximately 8% of U.S. newborns are of low birth weight (National Center for Health Statistics, 2003). The rate is much higher for African Americans (13.3%) and is strongly associated with poverty. Worldwide, 93% of LBW infants are in developing countries (UNICEF, 2001). As a group, LBW newborns have a heightened level of medical complications, including brain damage incurred before or after birth (Beckwith & Rodning, 1991; Goldson, 1996). Very LBW babies (those weighing less than 1500 grams, or 3.3 pounds) are particularly vulnerable.

There are numerous causes of LBW and prematurity, including many of the infant mortality risk factors discussed earlier. In addition, simultaneous pregnancies—twins, triplets, and the multiple births that have become more common due to increased use of fertility drugs—are another cause of early births and LBW. (Box 2.5 discusses some of the challenges faced by parents of LBW infants.)

low birth weight (LBW) a birth weight less than 5½ pounds (2500 grams)

premature any child born at 35 weeks after conception or earlier (as opposed to the normal term of 38 weeks)

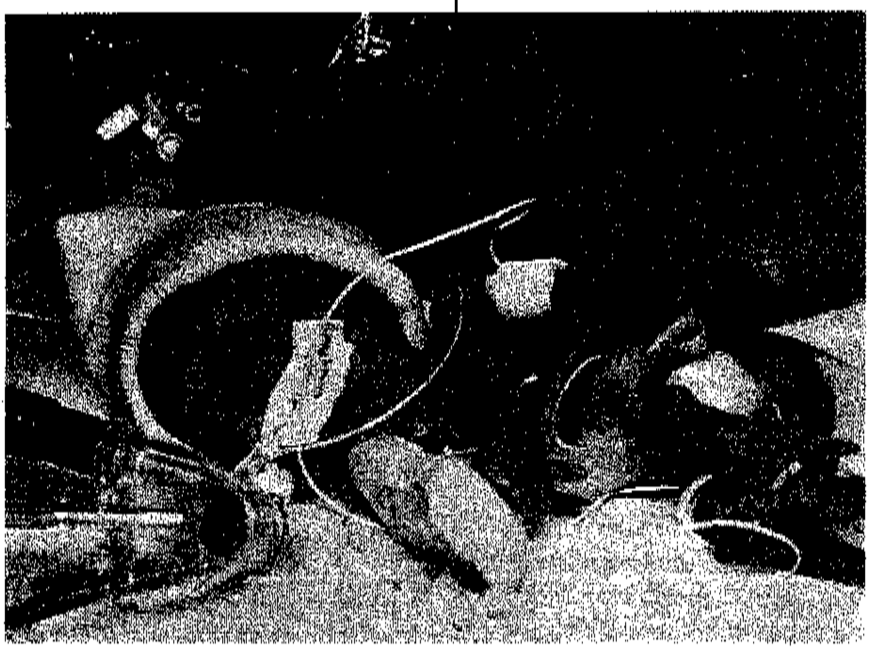
small for gestational age babies that weigh substantially less than is normal for whatever their gestational age

Long-term outcomes What outcome can be expected for LBW newborns who survive? This question becomes increasingly important as newborns of ever lower birth weights—often as low as 1000 grams (about 2¼ pounds)—are kept alive by modern medical technology. The answer includes both bad news and good news.

The bad news is that, as a group, children who were LBW infants have a higher incidence of developmental problems; the lower their birth weight, the more likely they are to have persistent difficulties (Goldson, 1996; Wallace & McCarton, 1997). They suffer from somewhat higher levels of hearing, language, and cognitive impairments. In preschool and elementary school, they are more likely to be distractible and hyperactive and to have learning disabilities. This group is also more likely to experience a variety of social problems, including poor peer and parent–child relations (Landry et al., 1990). Finally, adolescents who were LBW babies are less likely to complete high school than their siblings (Conley & Bennett, 2002).

The good news, which is vividly illustrated in Figure 2.23, is that the *majority* of LBW children turn out quite well. The negative effects of their birth status gradually diminish so that children who were slightly to moderately underweight as newborns generally end up within the normal range on most developmental measures (Kopp & Kaler, 1989; Liaw & Brooks-Gunn, 1993; Meisels & Plunkett, 1988; Vohr & Garcia-Coll, 1988).

Intervention programs What can be done to improve the chances that a given LBW infant will overcome his or her poor start in life? Developmental specialists have designed a variety of intervention programs to try to improve the current status and future outcome of LBW newborns. Parents are active participants in many



(a)

ASSOCIATED PRESS

(b)

AP/WIDE WORLD PHOTOS

FIGURE 2.23 Small miracles Shown here is (a) the smallest newborn ever to survive and (b) the same child at 14 years of age. Born in 1989 after just 27 weeks of gestation, Madeline weighed a mere 9.9 ounces—approximately the equivalent of three bars of soap. Extremely low-birth-weight infants tend to suffer serious disabilities, but Madeline is remarkably healthy, other than being a bit small for her age and having asthma. She recently entered high school as an honor student and enjoys playing her violin and rollerblading.

applications 2.5

Parenting a Low-Birth-Weight Baby

Parenthood is challenging under the best of circumstances, but it is especially so for the parents of a preterm or LBW baby. First, they have to accept their disappointment over the fact that they do not have the perfect baby they imagined, and they may also have to cope with feelings of guilt ("What did I do wrong?"), inadequacy ("How can I take care of such a tiny, fragile baby?"), and fear ("Will my baby survive?"). Caring for a healthy baby takes a great deal of time, but caring for an LBW baby can be especially time-consuming and stressful and, if the infant requires extended intensive care treatment, very expensive.

Parents of an LBW baby have a great deal to learn. In the hospital, they need to learn how to interact successfully with a fragile baby confined to an isolette, with its tiny body hooked up to life-support equipment. When their infant comes home, the parents have to cope with a baby that is relatively passive and unresponsive, without overstimulating the infant in an effort to get some response (Brazelton et al., 1987; Patteson & Barnard, 1990). LBW infants also tend to be more fussy than the average baby and more difficult to soothe when they become upset (Greene, Fox, & Lewis, 1983). To compound matters, they often have a high-pitched cry that is particularly unpleasant (Lester et al., 1989).

Another problem for parents is the fact that LBW infants have more trouble falling asleep, waking up, and staying alert than do infants of normal birth weight, and their feeding schedules are less regular (DiVitto & Goldberg, 1979; Meisels & Plunkett, 1988). Thus, it takes longer for the baby to get on a predictable schedule, making the parents' life more hectic.

Parents need to understand that their preterm baby's early development will not follow the same timetable as a full-term infant. Developmental milestones will be delayed. For example, their infant will not begin to smile at them at around 6 weeks; instead, they may have to wait several more weeks for their baby to look them in the eye and break into a heart-melting smile. Thus, preterm infants are not only more challenging to care for, but in many ways they are also less rewarding to interact with. One consequence is that children who were born preterm are more often victims of parental child abuse (Bugental, 2003; Frodi & Lamb, 1980; Parke & Collmer, 1975).

One step that can be helpful to parents of an LBW or preterm infant is learning more about infant development. An intervention program that trained mothers how to interpret their preterm babies' signals resulted in gains in the children's mental-test performance (Achenbach, Phares, Howell, Rauh, & Nurcombe, 1990). More general knowledge about infants can also be helpful. Preterm infants whose mothers had a relatively high level of knowledge about infancy performed better on a developmental test than did a group of preterm infants whose mothers were less knowledgeable about babies (but were otherwise comparable) (Dichtelmiller, Meisels, Plunkett, Bozynski, & Mangelsdorf, 1992).

In addition, any parent who is trying to deal with an LBW baby or an infant with other problems would do well to seek social support— from a spouse or partner, other family members, friends, or a formal support group. One of the best-documented phenomena in psychology is that we all cope better with virtually any life problem when we have support from other people.

Parents of an LBW baby usually have to wait longer for the joy of being the target of their child's first social smile.

of these programs, a marked change from past practice. Hospitals formerly did not allow parents to have any contact with their LBW infants, mainly because of fear of infection. Parents are now encouraged to have as much physical contact and social interaction as their hospitalized infant's physical condition allows.

One widely implemented intervention for hospitalized newborns is based on the idea that touch is a vital part of the life of newborns as they are picked up, cuddled, carried around, poked, and prodded. Many LBW infants experience little tactile stimulation because of the precautions that must be taken with them,

FIGURE 2.24 Infant massage Everybody enjoys a good massage, but hospitalized newborns particularly benefit from extra touching.

including keeping them in special isolettes, hooked up to various life-support machines. To compensate, Tiffany Field and her colleagues (Field, 2001; Field, Hernandez-Reif, & Freedman, 2004) developed a special therapy that involves massaging the babies and flexing their arms and legs (Figure 2.24). LBW babies who receive this therapy are more active and alert and gain weight faster than those who are not massaged. As a consequence, they get to go home earlier.

A large number of intervention programs with LBW newborns extend beyond their hospital stay, some for several years (e.g., Ramey & Campbell, 1992). One successful approach was demonstrated in the Infant Health and Development Project (IHDP) (Brooks-Gunn, 2003; Gross, Spiker, & Haynes, 1997; McCarton, Brooks-Gunn, Wallace, & Bauer, 1997). All the LBW infants received good health care, with half randomly assigned to the intervention group and half to a control group. The three-year intervention included home visits and an intensive early childhood education program administered at a day-care center.

The IHDP intervention group benefited from the program in terms of IQ, although the effect was more pronounced for LBW children who had been heavier at birth (2000 to 2500 grams). The intervention group had an advantage of 14 IQ points over the control-group children at 3 years of age, but a difference of only 4 points at age 8. The IQ scores of lighter LBW children (less than 2000 grams) were higher than those of the control group at 3 years of age, but not at later ages. Similar results occurred for measures of behavioral problems.

The IHDP story illustrates three important general points relevant to intervention efforts designed for high-risk infants. First, many intervention programs produce gains, but often they are relatively modest and diminish over time. Second, the success of any intervention depends on the initial health status of the infant. Many programs for LBW babies have been of more benefit to those infants who are less tiny to begin with. This fact is cause for concern, as modern medical technology makes it possible to save the lives of ever-smaller infants who have a high risk of permanent, serious impairment. The third point is the importance of cumulative risk: the more risks the infant endures, the lower the chances of a good outcome. Because this principle is so important for all aspects of development, we will examine it in greater detail in the next section.

Multiple-Risk Model

Risk factors tend to occur together. For example, a woman who is so addicted to alcohol, cocaine, or heroin that she continues to abuse the substance even though she is pregnant is likely to be under a great deal of stress and unlikely to eat well, take vitamins, earn a good income, seek prenatal care, or take good care of herself in other ways. Further, whatever the cumulative effects of these prenatal risk factors, they will likely be compounded by the mother's continuation of her unhealthy lifestyle and by her resulting inability to provide good care for her child (e.g., Weston, Ivins, Zuckerman, Jones, & Lopez, 1989).

As you will see repeatedly throughout this book, a negative developmental outcome—whether in terms of prenatal or later development—is more likely when there are multiple risk factors. In a classic demonstration of this fact, Michael Rutter (1979) reported a heightened incidence of psychiatric problems among English children growing up in families with four or more risk factors (including marital distress, low SES, paternal criminality, and maternal psychiatric disorder) (Figure 2.25). Thus, the likelihood of developing a disorder is slightly elevated for the child of parents who fight a lot; but if the child's family is also poor, if the father engages in criminal behavior, and if the mother suffers from emotional problems, the child's risk is multiplied nearly tenfold. Similar patterns have been reported for IQ (Sameroff, Seifer, Baldwin, & Baldwin, 1993) and social-emotional competence (Sameroff, Seifer, Zax, & Barocas, 1987).

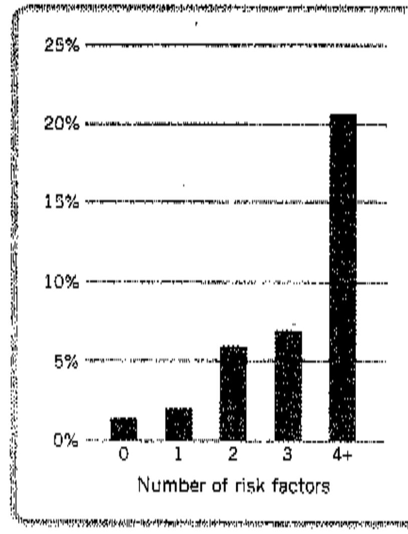


FIGURE 2.25 Multiple risk factors Children who grow up in families with multiple risk factors are more likely to develop psychiatric disorders than children from families with only one or two problematic characteristics (Rutter, 1979).

Poverty as a Developmental Hazard

Because it is such an important point, we cannot emphasize enough that the existence of multiple risks is strongly related to socioeconomic status. Consider some of the factors we have discussed that are known to be dangerous for fetal development: inadequate prenatal care, poor nutrition, illness, emotional stress, cigarette smoking, drug abuse, and exposure to environmental and occupational hazards. All these factors are more likely to be experienced by a woman living below the poverty line than by a middle-class woman. It is no wonder, then, that the outcome of pregnancy on the whole is less positive for lower-SES infants than for babies born to middle-class parents (Kopp, 1990; Minde, 1993; Sameroff, 1986). Nor should it be surprising that among LBW infants, the eventual developmental outcome is poorer for those in lower-SES families (Drillien, 1964; Gross et al., 1997; Kalmar, 1996; Largo et al., 1989; Lee & Barratt, 1993; McCarton et al., 1997; Meisels & Plunkett, 1988).

An equally sad fact is that in many countries, minority families are overrepresented in the lowest SES levels. Although 16% of all children in the United States grow up in families whose income places them below the poverty line, 58% of African-American and 62% of Latino children live in poverty (National Center for Children in Poverty, 2004). Thus, their socioeconomic status places many minority fetuses, newborns, and children at increased risk for developmental difficulties.

Risk and Resilience

There are, of course, individuals who, faced with multiple and seemingly overwhelming developmental hazards, nevertheless do well. In studying such children, researchers employ the concept of **developmental resilience** (Garmezy, 1983; Masten, Best, & Garmezy, 1990). Resilient children often have two factors in their favor: (1) certain personal characteristics, especially intelligence, responsiveness to others, and a sense of being capable of achieving their goals, and (2) responsive care from someone. Recall that in Werner's (1989) study of the children of Kauai (Chapter 1), a crucial factor in the outcome of children who had a problematic start in life was whether some person took an active interest in their welfare.

In summary, development is highly complex, right from the moment of conception on. As you will see throughout this book, that complexity continues. Although early events and experiences can profoundly affect later development, developmental outcomes are never a foregone conclusion.

developmental resilience successful development in spite of multiple and seemingly overwhelming developmental hazards

review:

The experience of newborn infants is mediated by internal states of arousal, ranging from deep sleep to intense crying, with large individual differences in the amount of time spent in the different states. Newborns spend roughly half their time asleep, and the amount of sleep declines steadily for many years. Researchers believe that the large proportion of their sleep time that newborns spend in REM sleep is important for the development of the visual system and brain. Infants' crying is a particularly salient form of behavior for parents, and it generally elicits attention and caretaking. Effective soothing techniques provide moderately intense, continuous, or repetitive stimulation. How parents respond to their young infant's distress is related to later crying.

Negative outcomes of pregnancy are higher for minorities and for families living in poverty. The United States ranks 24th in the world in terms of infant mortality. Almost 8% of all babies born in the United States are of low birth weight. Although most will suffer few lasting effects, the long-term outcome of severely LBW babies is often problematic. Several large-scale intervention programs have successfully improved the outcome of LBW infants.

According to the multiple-risk model, the more risks that a fetus or child faces, the more likely the child is to suffer from a variety of developmental problems. Low SES is associated with many developmental hazards. Despite multiple risks that many children experience, some show remarkable resiliency and thrive.

Chapter Summary

Prenatal Development

- Nature and nurture combine forces in prenatal development. Much of this development is generated by the fetus itself, making the fetus an active player in its own progress. Substantial continuity exists between what goes on before and after birth in that infants demonstrate the effects of what has happened to them in the womb.
- Prenatal development begins at the cellular level with conception, the union of an egg from the mother and a sperm from the father to form a zygote. The zygote multiplies and divides on its way through a fallopian tube.
- The zygote undergoes the processes of cell division, cell migration, cell differentiation, and cell death, all to further the development of the organism. These processes continue throughout prenatal development.
- When the zygote becomes implanted on the uterine wall, it becomes an embryo. From that point, it is dependent on the mother to obtain nourishment and oxygen and to get rid of waste products through the placenta.
- Fetal behavior begins 5 or 6 weeks after conception with simple movements, undetected by the mother, that become increasingly complex and organized into patterns. Later, the fetus practices behaviors vital to independent living, including swallowing and a form of intrauterine "breathing."
- The fetus experiences a wealth of stimulation both from within the womb and from the external environment. The fetus learns from this experience, as demonstrated by studies showing that both fetuses and newborns can discriminate between familiar and novel sounds, especially in language, and exhibit persistent taste preferences developed in the womb.
- There are many hazards to prenatal development. The most common fate of a fertilized egg is spontaneous abortion (miscarriage). A wide range of environmental factors can be hazardous to prenatal development. These include teratogens from the external world and certain maternal characteristics and habits, such as maternal age, nutritional status, use of legal and illegal drugs, and emotional state.

The Birth Experience

- Approximately 38 weeks after conception, the baby is ready to be born. Usually, the behavior of the fetus helps to initiate the birth process.
- Being squeezed through the birth canal has several beneficial effects on the newborn, including preparing the infant to take his or her first breath.
- How the process of childbirth is managed varies greatly from one society to another and is in part related to which goals and values are emphasized by the culture.

The Newborn Infant

- Newborns' state of arousal ranges from deep sleep to active crying.
- The amount of time infants spend in the different arousal states varies greatly, both across individuals and across cultures.

- REM sleep seems to compensate for the lack of visual stimulation that results from the newborn's sleeping many hours a day.
- The sound of a baby crying is a very aversive stimulus for others, and adults employ many strategies to soothe distressed infants.
- Infants born weighing less than 5½ pounds (2500 grams) are referred to as being of low birth weight. LBW infants are at risk for a variety of developmental problems, and the lower the birth weight, the greater the risk of enduring difficulties.
- A variety of intervention programs have been designed to improve the course of development of LBW babies, but the success of such programs depends very much on the numbe of risk factors that threaten the baby.
- The multiple-risk model refers to the fact that infants with number of risk factors have a heightened likelihood of conti ued developmental problems. Poverty is a particularly insidi risk to development, in part because it is inextricably linked with numerous negative factors.
- Some children display resilience even in the face of substant risk factors. Resilience seems to result from certain personal characteristics and from attention and emotional support fro other people.

Critical Thinking Questions

1. A recent cartoon showed a pregnant woman walking down a street carrying a tape player with a set of very large headphones clamped around her protruding abdomen. What point was it making? What research might provide the basis for her behavior, and what assumptions is she making about what the result might be? If you or your partner were pregnant, do you think you would do something like this?
2. There is a great deal of controversy today about the use of stem cells for the treatment of various diseases. What is it about stem cells that would make it possible for them to be used in this way?
3. We hear a great deal about the terrible and tragic effects that illegal drugs like cocaine and diseases like AIDS can have on fetal development. But what two maternal behaviors associated with prenatal harm are actually the *most common* in the United States today, and what effects can they have?
4. Suppose you were in charge of a public health campaign to improve prenatal development in the United States and you could focus on only one factor. What would you target and why?
5. Describe some of the cultural differences that exist in belief and practices with respect to conception, pregnancy, and childbirth. Is there any practice of another culture that appeals to you more than practices with which you are familia
6. Are you more encouraged or more discouraged by the result of intervention programs such as the IHDP? What would i take to make their gains larger and longer lasting?
7. Explain the basic idea of the multiple-risk model and how i relates to poverty in terms of prenatal development and birt outcomes.

Key Terms

epigenesis, p. 43
embryology, p. 43
gametes (germ cells), p. 44
conception, p. 45
zygote, p. 46
embryo, p. 47
fetus, p. 47
phylogenetic continuity, p. 48
apoptosis, p. 49
identical twins, p. 49
fraternal twins, p. 49
neural tube, p. 50
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sensitive period, p. 60
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