CHAPTER 4

The Prenatal Period and Birth

THE STAGES OF PRENATAL DEVELOPMENT

Fertilization
The Germinal Period
The Embryonic Period
The Fetal Period
Assisted Reproduction

ENVIRONMENTAL FACTORS INFLUENCING PRENATAL DEVELOPMENT

Support Within the Womb
Principles of Teratology
Drugs as Teratogens
CONTROVERSY: *Should a Drug-Abusing Expectant Woman Be Charged with Child Abuse?*
Diseases as Teratogens
Environmental Hazards as Teratogens
Women's Conditions and Prenatal Development
A Final Note on Environment and Prenatal Development

BIRTH AND THE PERINATAL ENVIRONMENT

Preparing for Childbirth
RESEARCH APPLIED TO PARENTING: *Nurturing and Caring During Labor*
Labor and Delivery
Low Birth Weight

NEWBORN ASSESSMENT AND STATES

Assessing Newborns
Newborn States

CHAPTER RECAP

Summary of Developmental Themes
Summary of Topics

Key Themes in the Prenatal Period and Birth

- **Nature/Nurture** What roles do nature and nurture play in prenatal development and birth?
- **Sociocultural Influence** How does the sociocultural context influence prenatal development and birth?
- **Continuity/Discontinuity** Is development before and after birth continuous or discontinuous?
- **Individual Differences** How prominent are individual differences in prenatal development and the newborn?

She was expecting. It was great news. But this time her concerns outweighed the joy. Carole was already caring for two little ones, both under the age of five, and also working full-time to provide income to help ends meet. Her job paid only a little above the minimum wage. Never enough, even when added to her husband's paycheck. However, neither she nor her husband had gone to college. Nor did either have the kinds of skills to permit them to obtain a really high-paying job. It would be a struggle to provide for another child.

Although only four weeks into her pregnancy, Carole knew the embryo was undergoing rapid developmental changes and would continue to do so for many more weeks. She avoided alcohol as soon as she learned of her pregnancy. She had stopped smoking even before her first child was born. But was there enough money for prenatal care? Did she need to make modifications in her diet or adjustments in her work to ensure that her unborn would have a healthy start? Would her persistent anxieties take a toll as well? She wanted the best for this new addition coming into the family. But she wasn't sure she would always be able to give it.

Most women experience both pride and apprehension when they learn they are pregnant. Those feelings are often influenced by a multitude of social and cultural views and ideas about pregnancy. Although societies differ enormously in their specific beliefs, anthropologists report that expectant women around the world are often urged to avoid certain activities and to carry out various rituals for the sake of their unborn. In Western civilizations, admonitions about pregnancy exist as well; obstetricians may advise a pregnant woman to stop smoking, avoid alcohol, and let someone else clean the cat's litterbox, and they may recommend taking supplements containing folic acid and other nutrients.

Fortunately, the mysteries surrounding this remarkable time are beginning to become clearer. Our discussion of prenatal development will open with a brief description of the amazing sequence of events taking place between conception and birth. At no other time does growth take place so rapidly or do so many physical changes occur in a matter of weeks, days, and even hours. Some cultures, such as the Chinese, tacitly acknowledge these dramatic events by granting the baby a year of life when born. In the typical nine months of confinement to the womb, the fetus has indeed undergone an epic journey.

Although fetal growth proceeds in a highly protected environment, we are also discovering the ways in which drugs, diseases, and other factors affect prenatal development. We summarize our current understanding of these influences as well. We then consider the birth process and take a first brief look at the newborn's states and characteristics.

KEY THEME
Continuity/Discontinuity

The Stages of Prenatal Development

Three major overlapping periods define the life of a human organism. **Prenatal development** is launched from the moment of conception and continues to the beginning of labor. All but the first few days of this period are spent within the confines of the womb. The **perinatal period** dawns about the seventh month of pregnancy and extends until twenty-eight days after birth. This phase is associated with the impending birth, the social and physical setting for delivery, and the baby's first adjustments to his or her new world. Among the events included in the perinatal period are the medical and obstetrical practices associated with delivery and the preparations and care provided by parents and others to assist in the transition from the womb to life outside. **Postnatal development** begins after birth. The child's environment now includes the broader physical and social world afforded by caregivers and others responsible for the infant's continued growth.

SEE FOR YOURSELF
psychology.college.hmco.com
Prenatal Development

Prenatal development is further divided into three stages. The **germinal period,** also known as the *period of the zygote,* encompasses the first ten to fourteen days following conception. Cell division and migration of the newly fertilized egg, culminating with its implantation in the uterine wall, characterize the germinal period. The second stage, the **embryonic period,** continues from about two to eight weeks after conception. The formation of structures and organs associated with the nervous, circulatory, respiratory, and most other systems mark the embryonic period. The final stage, the **fetal period,** lasts from about eight weeks after conception to birth. This period is distinguished by substantial physical growth, and organs and systems are refined in preparation for functioning outside the womb. This entire process begins the moment sperm and egg fuse.

Fertilization

Even before her own birth, Carole, like most other human females, had formed approximately 5 million primitive egg cells in her ovaries. Their numbers, however, declined with development; by puberty perhaps only thirty thousand remained. Of this abundant supply, about four hundred will mature and be released for potential fertilization during the childbearing years (Samuels & Samuels, 1986). In contrast, male sperm production begins only at puberty, when an incredible 100 to 300 million sperm may be formed daily.

The opportunity for human conception begins about the fourteenth day after the start of the menstrual period. At this time, a capsulelike *follicle* housing a primitive egg cell in one of the ovaries begins to mature. As it matures and changes position, the follicle eventually ruptures and discharges its valuable contents from the ovary. After being expelled, the egg cell, or *ovum,* is normally carried into the Fallopian tube. This organ serves as a conduit for the egg, which moves toward the uterus at the leisurely rate of about one-sixteenth inch per hour. The Fallopian tube provides a receptive environment for fertilization if sperm are present. If unfertilized, the ovum survives only about twenty-four hours.

Sperm reach the Fallopian tube by maneuvering from the vagina through the cervix and the uterus. Sperm can migrate several inches an hour with the assistance of their tail-like appendages. From 300 to 500 typically negotiate the six- or more hour trip into the Fallopian tube; these usually survive about forty-eight hours and sometimes substantially longer.

If an ovum is present, sperm seem attracted to it (Roberts, 1991). The egg also prepares for fertilization in the presence of sperm. Cells initially surrounding the ovum loosen their protective grip, permitting the egg to be penetrated (Nilsson, 1990). As soon as one sperm cell breaks through the egg's protective linings, enzymes rapidly transform its outer membrane to prevent others from invading. Genetic material from egg and sperm quickly mix to establish a normal complement of forty-six chromosomes. The egg, the body's largest cell, barely visible to the naked eye, weighs about 100,000 times more than the sperm, the body's smallest cell. Despite the enor-

prenatal development Period in development from conception to the onset of labor.

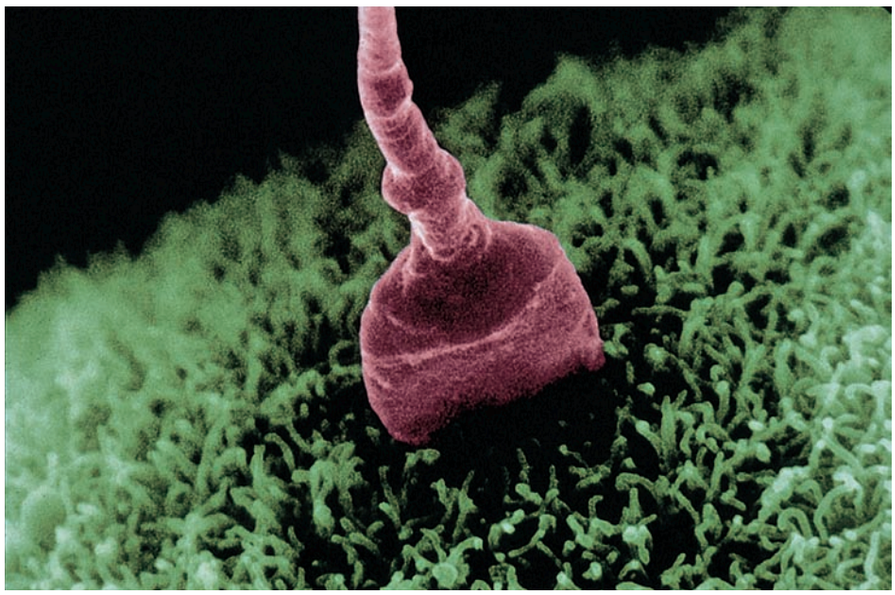
perinatal period Period beginning about the seventh month of pregnancy and continuing until about four weeks after birth.

postnatal development Period in development following birth.

germinal period Period lasting about ten to fourteen days following conception before the fertilized egg becomes implanted in the uterine wall. Also called *period of the zygote.*

embryonic period Period of prenatal development during which major biological organs and systems form. Begins about the tenth to fourteenth day after conception and ends about the eighth week after conception.

fetal period Period of prenatal development, from about the eighth week after conception to birth, marked by rapid growth and preparation of body systems for functioning in the postnatal environment.



Human development begins with the penetration of the egg by a single sperm as shown here (egg and sperm are magnified greatly). Although the egg is the body's largest cell and the sperm its smallest, each contributes twenty-three chromosomes to form the hereditary basis for the development of a new living entity.

mous difference in size, both contribute equivalent amounts of genetic material to the zygote.

The Germinal Period

After fertilization, the zygote continues to migrate down the Fallopian tube (see Figure 4.1). Within twenty-four to thirty hours after conception, the single cell divides into two cells, the first of a series of mitotic divisions called *cleavages*. At roughly twenty-hour intervals these cells divide again to form four, then eight, then sixteen cells. During the cleavages, the zygote remains about the same size; thus individual cells become smaller and smaller.

After three days, about the time the zygote is ready to enter the uterus, it has become a solid sphere of sixteen cells called a *morula*. Each cell is alike in its capacity to generate a separate identical organism. About the fourth day after conception, however, the cells begin to segregate and carry out specific functions. One group forms a spherical outer cellular layer that eventually becomes various membranes providing nutritive support for the embryo. A second, inner group of cells organizes into a mass that will develop into the embryo (Cross, Werb, & Fisher, 1994). This differentiated group of cells is now called a *blastocyst*.

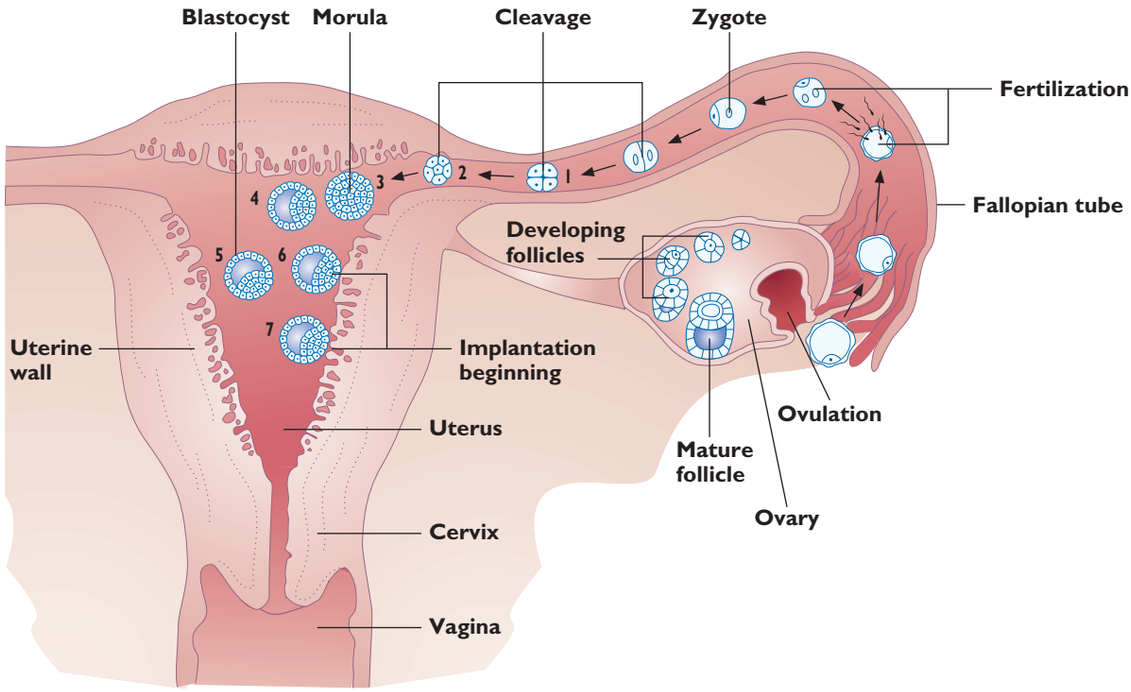
About the sixth day after conception, the blastocyst begins the process of attaching to the uterine wall to tap a critical new supply of nutriments. By about the tenth to fourteenth day after conception, the implantation process is completed. In preparing for this event, the blastocyst began secreting hormones and other substances to inhibit menstruation, or the shedding of the uterine lining, and to keep the woman's immune system from rejecting the foreign object. One of these hormones eventually becomes detectable in the woman's urine as a marker in pregnancy tests.

If the zygote fails to attach to the uterine wall, it is expelled; the frequency of such events is unknown because a woman seldom realizes that a potential pregnancy has terminated. However, the possibility exists for the zygote to also implant and begin development at some location other than in the uterus. Such an event is called an **ectopic pregnancy.** The most likely site is somewhere in the Fallopian tube, although it may implant on occasion within the abdominal cavity, ovary, or cervix. Ectopic pregnancies occur relatively infrequently, but they are the leading cause of maternal death during the first trimester of pregnancy (Grimes, 1995). Thus they pose a serious health risk for a woman. For example, if the embryo continues to grow, it may rupture the narrow Fallopian tube and cause life-threatening hemorrhaging. The rate of

ectopic pregnancy Implantation of the fertilized ovum in a location outside of the uterus.

FIGURE 4.1 Fertilization and the Germinal Period

During the early development of the human embryo, an egg cell is released from a maturing follicle within the ovary, and fertilization takes place in the Fallopian tube, transforming the egg cell or ovum into a zygote. Cleavage and multiplication of cells proceed as the zygote migrates toward the uterus. Differentiation of the zygote begins within the uterus, becoming a solid sixteen-cell sphere known as the *morula,* then a differentiated set of cells known as the *blastocyst,* which prepares for implantation in the uterine wall. Once implanted, it taps a vital source of nutriments to sustain further development. (The numbers indicate days following fertilization.)



ectopic pregnancies has shown a worrisome increase in recent years. For example, in the United States its occurrence increased from 4.5 to 19.7 per 1,000 pregnancies between 1970 and 1992, and in Norway, from 12.5 to 18.0 per 1,000 pregnancies between 1979 and 1993 (Pisarska & Carson, 1999).

Numerous factors may account for the increase in ectopic pregnancies. For example, pelvic infections, many caused by sexually transmitted diseases, and surgery, especially involving the Fallopian tubes, elevate the risk substantially. So, too, although to a lesser extent, do new methods of assisted reproduction (see later in this section) and certain aspects of lifestyle, including multiple sexual partners or early sexual activity and cigarette smoking (Frishmuth, 1998; Pisarska & Carson, 1999). Regardless of its cause, however, ectopic pregnancy is serious for the mother and does not allow for the continued development of the embryo or fetus.

The Embryonic Period

The embryonic period, which begins with the implantation of the blastocyst in the uterine wall and continues until about the eighth week after conception, is marked by the rapid differentiation of cells to form most of the organs and systems within the body. This differentiation, known as *organogenesis,* is achieved by the production and migration of specialized cells having distinctive functions.

● **Formation of Body Organs and Systems** The first step in the formation of various body organs and systems involves the migration of unspecialized embryonic cells to establish a three-layered embryo. The three layers serve as the foundation for all tissues and organs in the body. The *endoderm,* or inner layer, will give rise to many

of the linings of internal organs such as lungs, the gastrointestinal tract, the liver, the pancreas, the bladder, and some glands. The *mesoderm,* or middle layer, eventually develops into skeleton and muscles, the urogenital system, the lymph and cardiovascular systems, and other connective tissues. The *ectoderm,* or outer layer, will form skin, hair, and nails, but its earliest derivatives will be the central nervous system and nerves.

KEY THEME
Nature/Nurture

How, by simply migrating to a layered configuration, do undifferentiated cells come to establish a highly distinctive set of organs and systems? Understanding this process remains one of the most important unresolved issues in prenatal development (Barinaga, 1994). However, the immediate environment surrounding a cell appears to play a major role. Although at first unspecialized, a cell's potential becomes constrained by its association with neighboring tissues. In other words, cells are induced by their surroundings to take on certain forms and functions. For example, if cells from the ectodermal layer are removed and placed in a culture so that they grow in isolation from other cell layers, they form epidermal, or skinlike, tissues. If placed with a layer of mesodermal cells, however, a nervous system will emerge (Abel, 1989).

Because the embryonic period is the major time for development of organs and systems, many possibilities for disruption exist. However, under normal conditions the sequence of primary changes in prenatal development proceeds in a fairly regular pattern, as summarized in the Prenatal Development chronology.

● **Early Brain and Nervous System Development** About the fifteenth day after conception, a small group of cells at one end of the ectoderm starts to grow rapidly. The growth creates a reference point for the cephalo (head) and the caudal (tail) regions of the embryo and helps to distinguish left from right side. The cells induce the development of the *neural* tube, which in turn initiates the formation of the spinal cord, nerves, and eventually the brain.

Rapid changes in the neural tube begin about the third week. At first, the neural tube is open at both ends. The tube begins closing in the brain region and, a few days later, in the caudal region. Its failure to knit shut at either end can have drastic consequences for development. In *anencephaly,* a condition in which the cephalic region of the neural tube does not close, the cerebral hemispheres fail to develop, and most of the cortex is missing at birth. Newborns with such a condition survive only a short time.

Spina bifida is a condition that arises when the caudal region of the neural tube fails to close. The resulting cleft in the vertebral column permits spinal nerves to grow outside the protective vertebrae. In more serious cases, the infant may be paralyzed and lack sensation in the legs. Surgery often must be performed. Sometimes it can be done even before birth to keep the condition from getting worse. But lost capacities cannot be restored, and malformations in brain development and impaired intellectual development may accompany spina bifida (Northrup & Volcik, 2000).

The frequency of both neural tube defects, now about one in every one thousand births in the United States, has declined sharply over the last thirty years. This decline, as illustrated in Figure 4.2 for the state of South Carolina, appears to be the consequence of two factors. A better understanding of the benefits of nutritional supplements taken early in pregnancy, particularly of folic acid and other components of the vitamin B complex, have helped to prevent neural tube defects in the first place (Stevenson et al., 2000). In addition, in the case of more serious neural tube defects such as anencephaly, the pregnancy is often not carried to term (Limb & Holmes, 1994).

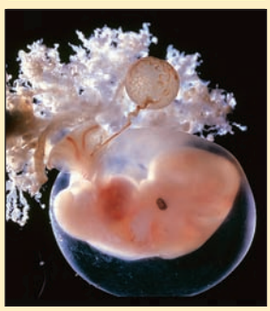
KEY THEME
Nature/Nurture

The second month after conception is marked by continued rapid development of the head and brain. Nerve cells show an explosive increase in number, with as many as 100,000 neurons generated every minute (Nilsson, 1990). Neurons also undergo extensive migration once the neural tube closes and soon make contact with one another. The region of the head greatly enlarges relative to the rest of the embryo to account for about half of total body length. Nevertheless, the embryo is still tiny; it is less than one-and-a-half inches long and weighs only about half an ounce. However, nearly all organs are established by this time, and the embryo is recognizably human.

CHRONOLOGY: *Prenatal Development*

4 Weeks

6–7 Weeks



8–12 Weeks

3 Wks.
6 Wks.
9 Wks.
12 Wks.
15 Wks.
18 Wks.
21 Wks.
24 Wks.
27 Wks.
30 Wks.
33 Wks.
36 Wks.
38 Wks.

Age*	Size and weight	Brain and neural systems	Sensory and facial systems
3 Weeks	Embryo grows to about 2 millimeters in length (about 1/10 inch).	Major segments of brain (hindbrain, midbrain, and forebrain) begin to differentiate.	
4 Weeks	Embryo grows to about 6 millimeters (about 1/4 inch).	Nerves begin to take primitive form. Neural tube begins to fold and knit shut.	Eyes and ears begin to take shape.
5 Weeks	Embryo grows rapidly, about 1 millimeter a day (.04 inches), but is still less than 1/2 inch in length.	Nervous system starts to function and faint brain waves can be recorded.	Basic mouth and esophagus begin to develop.
6–7 Weeks	Embryo grows to nearly 1 inch in length.	Neurons form rapidly, at the rate of thousands per minute.	Upper lip, jaws, teeth, eyelids, nostrils, tip of nose, and tongue are formed. Head size becomes dominant.
8–12 Weeks	The fetus grows from about 1 inch to about 3 inches in length but weighs only about 1 ounce at about 8 weeks.		Fetus appears to have widely separated eyes and ears set lower in head than they eventually will be. Eyelids fuse shut about 9th week.
13–16 Weeks	The fetus becomes about 5 1/2 inches long at the end of this time and weighs about 5 ounces.	Division of the halves of the brain is visible.	Eyelids have closed.
17–20 Weeks	Fetus becomes about 8 to 10 inches long and weighs about 1 pound.	Myelinization of nerve fibers begins. Extremely rapid brain growth begins.	Eyebrows become visible.
21–25 Weeks	Fetus reaches about 14 inches in length and weighs nearly 2 pounds.	Brain wave patterns become similar to those observed in newborns.	Eyes fully formed and may be opened and closed.
26–29 Weeks		Nerve cell formation completed, and brain begins to take on wrinkled and fissured appearance. Myelin begins to sheath increasing numbers of neurons.	
30–38 Weeks	Fetus adds about half of its total weight. Reaches about 20 inches in length and weighs about 7 1/2 pounds.		Sensory systems become increasingly functional. Eye color is usually blue and does not change until exposure to light after birth.

* From conception.

Muscle, skin, and skeletal systems	Other systems	Reflexive and behavioral responses
Precursors to vertebrae begin to organize.	Blood vessels form and connect to precursor of umbilical cord. Primitive one-chambered heart starts to beat by 21st day.	
Stripe of tissue forms on either side of trunk to begin chest and stomach muscle production. Arm buds appear by about 26 days. Similar swelling begins about 2 days later to form early buds for lower limbs. Tail-like cartilage appears to curve under rump.	Rudimentary liver, gall bladder, stomach, intestines, pancreas, thyroid, and lungs created. Red blood cells are formed by yolk sac.	
Elbow, wrist regions, and paddle-shaped plate with ridges for future fingers take shape.	Heart differentiates into upper and lower regions.	
Embryo possesses short webbed fingers, and foot plate has also begun to differentiate. Many muscles differentiate and take final shape. Tail-like cartilage regresses.	Heart divides into four chambers.	Embryo begins to show reflexive responses to touch, first around the facial region. Spontaneous movements of head, trunk, and limbs becomes possible.
Bones start to grow. Fingernails, toenails, and hair follicles form.	Fetus begins to show differentiation of external reproductive organs (if male about 9th week, if female, several weeks later).	Startle and sucking responses first appear. Fetus displays hiccups, flexes arms and legs, and also displays some facial expressions.
Spinal cord begins to form. Fingerprints and footprints established. Fetus sprouts soft, downlike hair at the end of this period.	If female, large numbers of primitive egg cells are created.	Other reflexes, including swallowing, emerge. Begins to display long periods of active movement.
Fetus becomes covered by cheeselike, fatty material secreted by oil glands that probably protects the skin constantly bathed in amniotic fluid. Hair becomes visible.		Fetus often assumes a favorite position and displays sleep/wake cycles.
Skin appears wrinkled and has a pink to reddish cast caused by blood in capillaries, which are highly visible through translucent skin.	Lung functioning becomes possible but uncertain.	Fetus can see and hear and produces crying if born prematurely. Some indicators of stable states of sleep and wakefulness are exhibited.
Fat deposits accumulate beneath surface of skin to give fetus a much less wrinkled appearance. Hair may begin to grow on head, lungs are sufficiently developed to permit breathing of air should birth occur.	Red blood cells now produced by bone marrow.	
Fat continues to accumulate, giving full-term newborn chubby appearance and helping to insulate baby from varying temperatures once born. Skin color turns from red to pink to white to bluish pink for all babies regardless of racial makeup.		Seeing, hearing, and learning are now possible.

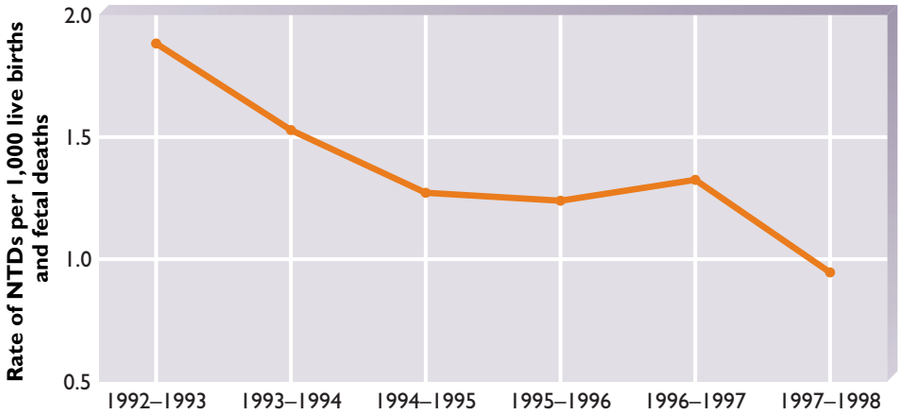
13–16 Weeks

17–20 Weeks

26–29 weeks

FIGURE 4.2
Decline in Neural Tube Defects Associated with the Increased Use of Folic Acid Supplements

Some regions of the United States, including South Carolina, historically have shown relatively high rates of neural tube defects (NTDs) such as spina bifida and anencephaly. However, as shown here, those rates have dropped substantially in South Carolina since 1992. In fact, the rate is now close to that found throughout the United States. During this same period, the use of folic acid supplements by women in their childbearing years in South Carolina increased more than fourfold, a factor that very likely contributed to the substantial decline in neural tube defects.



Source: Stevenson et al., 2000.

One of the most striking milestones is reached about the sixth week after conception, when the nervous system begins to function. Now irregular and faint brain wave activity can be recorded. Soon, if the head or upper body is touched, the embryo exhibits reflex movements. In a few more weeks muscles may flex, but it will still be some time before the woman is able to feel any movement.

The Fetal Period

The change from embryo to fetus is signaled by the emergence of bone tissue at about the eighth week after conception. Organ differentiation continues, particularly in the reproductive system and the brain. However, the fetal period is best known for growth in size and the genesis of processes that assist organs and systems to function. One positive consequence is that the fetus becomes much less susceptible to many potentially damaging environmental factors.

During the third month after conception, the fetus increases to about three-and-a-half inches in length and about one-and-a-half ounces in weight. Its movements become more pronounced. At nine weeks, the fetus opens and closes its lips, wrinkles its forehead, raises and lowers its eyebrows, and turns its head. By the end of twelve weeks, the behaviors have become more coordinated. The fetus can, for example, display sucking and the basic motions of breathing and swallowing. Fingers will bend if the arm is touched, and the thumb can be opposed to fingers, an indication that peripheral muscles and nerves are functioning in increasingly sophisticated ways (Samuels & Samuels, 1986).

● **The Second Trimester** In the second of the three trimesters into which prenatal development is sometimes divided, the fetus's body grows more rapidly than at any other time. By the end of the fourth month, the fetus is about eight to ten inches long, although it still weighs only about six ounces. During the sixth month, the fetus rapidly starts to gain weight, expanding to about one-and-a-half pounds and reaching a length of about fourteen inches.

By the middle of the second trimester, fetal movements known as *quickening* are unmistakable to the woman. The fetus stretches and squirms as well. Near the end of this trimester, brain wave patterns begin to look like those observed in the newborn. Should birth occur at this time, there is some chance of survival if specialized medical facilities are available.

● **The Third Trimester** The final months add finishing touches to the astonishing progression in prenatal development. The cerebral hemispheres, the regions of the brain most heavily involved in complex mental processing, grow rapidly, folding

and developing fissures to give them a wrinkled appearance. *Myelin*, which helps to insulate and speed the transmission of neuronal impulses, begins to form and surround some nerve fibers. Brain wave patterns indicating different stages of sleep and wakefulness can also be observed. The sense organs are developed sufficiently to enable the fetus to smell and taste, as well as to hear, see, feel, and even learn, as we show in the chapter titled "Basic Learning and Perception." The fetus continues to gain weight rapidly (nearly half a pound per week), although growth slows in the weeks just preceding birth. Control of body temperature and rhythmic respiratory activity remain problematic if birth occurs at the beginning of the third trimester. Nevertheless, **viability,** or the ability of the fetus to survive outside the womb, dramatically improves over the course of these three months.

The onset of birth can be expected when the fetus reaches a gestational age of about 277 days. **Gestational age,** commonly employed in the medical profession to gauge prenatal growth, is derived from the date of onset of the woman's last menstrual period before conception. This method of calculation makes the embryo or fetus about fifteen days older than determining age from the date of conception (Reece et al., 1995). However, as any parent knows, variability in the timing of birth is the norm. The average gestational period appears to be a few days shorter for Japanese and African American babies compared to Caucasian babies, for infants born to mothers younger than nineteen or older than thirty-four years, and for second and later children compared with firstborns (Mittendorf et al., 1990, 1993).

KEY THEME
Individual Differences

Assisted Reproduction

For many prospective parents, conceiving and having a baby proceeds as a normal part of the process of establishing a family. However, for many men and women the opportunities to become a parent are limited or require special consideration. For example, an estimated 5 to 6 million couples in the United States alone (Collins, 1995; Wright, 1998) have difficulty conceiving. Other couples who may be carriers of genetic diseases (see the chapter titled "Genetics and Heredity") wish to avoid the risk of passing these disorders to their offspring. For these couples, recent advances in the field of reproductive technology have opened up many alternatives in addition to adoption in their efforts to become parents; these advances also are dramatically affecting traditional notions about what it means to be a mother or father.

If a male is infertile or carries a genetic disorder, for example, couples may elect *artificial insemination by donor* (see Table 4.1). In this procedure, a donor, who is usually anonymous and is often selected because of similarity in physical and other characteristics to a prospective father, contributes sperm that are then artificially provided to the mother when ovulation occurs. If a female is infertile, a carrier of a genetic disease, or unable to complete a pregnancy for various reasons, options may include one or a combination of new reproductive technologies involving *fertility drugs, egg donation*, *in vitro fertilization (IVF)*, *gamete intrafallopian transfer (GIFT), surrogacy,* or other, more experimental techniques currently under investigation. Surrogate motherhood has sometimes been termed the "renting" of another woman's womb, but this concept can be misleading because, in many cases, the surrogate mother may donate an egg for prenatal development, as well as her womb. The surrogate is thus the biological mother, as well as the bearer of the child who has been conceived by artificial insemination using the prospective father's sperm. Alternatively, with in vitro fertilization, eggs can be removed from a woman's ovaries, fertilized in a laboratory dish with the prospective father's sperm, and transferred to another woman's uterus. In this situation, the biological and social mothers may be one and the same except during the gestational period, when the surrogate mother's womb is used. Furthermore, a woman who cannot or chooses not to conceive in the traditional way might undergo in vitro fertilization and carry her own or another woman's fertilized egg during her pregnancy.

Legal, medical, and social controversies swirl around the technologies associated with assisted reproduction (Collins, 1995; Wright, 1998). For one thing, those who

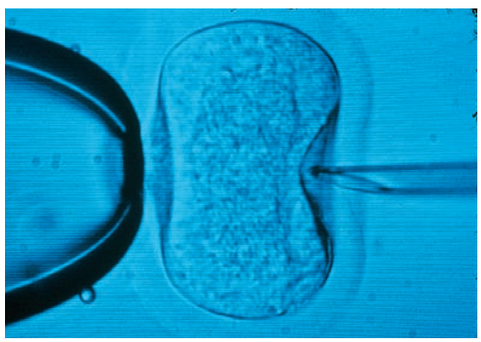
viability Ability of the baby to survive outside the mother's womb.

gestational age Age of fetus derived from onset of mother's last menstrual period.

TABLE 4.1 Examples of New Technologies Associated with Assisted Reproduction

Artificial Insemination by Donor	Sperm from a donor (often anonymous) are artificially provided to a woman during ovulation.
Egg Donation	An egg is harvested from a donor, fertilized, and inserted in another woman's uterus.
Fertility Drugs	Drugs given to stimulate the development and release of egg cells from the ovary to increase the likelihood of conception by traditional means or to increase the harvest of eggs for other assisted reproduction technologies.
Gamete Intrafallopian Transfer (GIFT)	Surgical insertion of both sperm and eggs in the Fallopian tube, where fertilization normally occurs. Zygote intrafallopian transfer (ZIFT) is similar except that fertilization occurs in vitro and the zygote is inserted in the Fallopian tube.
In Vitro Fertilization (IVF)	Eggs harvested from the ovaries and fertilized in a petri dish for subsequent implantation into a woman's uterus.
Surrogacy	A contractual arrangement in which a woman carries a pregnancy to term and in which the pregnancy involves either the surrogate's egg and sperm donated by the father or a couple's zygote established through in vitro fertilization.

In vitro fertilization is one of several reproductive technologies that can assist men and women with fertility problems in their attempts to have healthy offspring. In this procedure, an egg cell is surgically removed from the woman's ovary to permit it to be fertilized by a sperm cell. After cell division begins, the zygote is inserted in the woman's uterus where it can implant and continue to grow. Prior to its insertion in the uterus, individual cells also can be tested to determine whether the zygote carries a hereditary defect.



offer artificial insemination, apart from fertility clinics, are not always licensed, nor are they required to receive special training. Thus the competence of the practitioners, the safety of their various activities, and the frequency of this practice are unknown (Guinan, 1995). In addition, whereas adopted children are often informed of their status, children born as a result of new reproductive technologies may not know about their biological history. And even if told, for example, that their legal and biological fathers may be two different individuals, these offspring typically would be unable to obtain further information, because doctors who draw on sperm banks are not required to keep records linking donors and recipients (Guinan, 1995). In some other countries, however, such as England and Sweden, legislation has been enacted to permit individuals to obtain such information (Daniels & Taylor, 1993). Legal debates can also erupt over who is the rightful father or mother when, for example, a surrogate mother resolves to keep the child she has carried to term.

Medical concerns are linked to the use of fertility drugs because they increase the rate of multiple pregnancies perhaps to as much as 25 percent, compared with 1 or 2 percent in the general population without the use of such drugs (Wright, 1998). Multiple pregnancies, especially when they involve more than two fetuses, increase risks both to the woman and to her offspring. Evidence exists, too, that single children born to mothers who receive assisted reproduction, even with various factors such as maternal age controlled, tend to be of lower birth weight (Dhont et al., 1999; Tough et al., 2000). Controversies further extend to the costly medical procedures associated with assisted reproduction. Should insurance companies be mandated to pay expenses accompanying the repeated efforts often required to conceive (Collins, 1995)?

The desire to have their own children is a powerful motive for many couples. This is evident from the large number of fertility clinics—perhaps as many as three hundred operating in the United States alone and probably twenty or so more in Canada (Nemeth, 1997; Wright, 1998). In Western societies about one in every one hundred conceptions involving first-born children may be completed by means of in vitro fertilization (Van Balen, 1998). Studies conducted in Europe, the United States, and Taiwan reveal that children conceived by means of assisted reproduction show few emotional, behavioral, or other problems during their development (Hahn & DiPietro, 2001; Van Balen, 1998). For example, Susan Golombok and her colleagues (Golombok et al., 1995; Golombok, MacCallum, & Goodman, 2001; Golombok et al., 2002) have followed samples of children from the United Kingdom who were conceived by in vitro fertilization or donor insemination and who are now entering

into adolescence. They found no differences between these children and children who were conceived without assistance on scales evaluating ability to function in school, peer relationships, or self-esteem. Parents, especially mothers, of these children are sometimes reported to display greater warmth and more concern than other parents, perhaps an indicator of their commitment to and the value they place on their children (Hahn & DiPietro, 2001). The general conclusion from research is that the risks to children born to parents who have been assisted in their reproductive efforts is low and that their development is similar to that found in the larger population of children.

FOR YOUR REVIEW

- What constitutes the prenatal, perinatal, and postnatal periods of development?
- What are the major changes that take place following conception during the germinal, embryonic, and fetal periods of prenatal development?
- What is an ectopic pregnancy? What factors may account for its increasing frequency in recent decades?
- When are the major organs and systems of the body established? What is the course of brain and nervous system development in the embryo and fetus?
- How can various kinds of assisted reproduction help those couples who have difficulty conceiving or are concerned about the inheritance of genetic disorders in their offspring? What are some of the medical and legal issues associated with various forms of assisted reproduction?

Environmental Factors Influencing Prenatal Development

We can readily imagine that a host of events must occur, and at the right times, for prenatal development to proceed normally. What kinds of environmental support do embryo and fetus receive in their liquid, somewhat buoyant, surroundings, and how well protected are they from intrusions that can disrupt their development?

Support Within the Womb

The embryo and fetus are sustained by a number of major structures, including the placenta, the umbilical cord, and the amniotic sac. The **placenta,** formed by cells from both the blastocyst and the uterine lining, produces essential hormones for the fetus. Just as important, it serves as the exchange site at which oxygen and nutrients are absorbed from the woman's circulatory system and carbon dioxide and waste products are excreted from the embryo's circulatory system (Cross, Werb, & Fisher, 1994). The transfer takes place via a network of intermingling blood-rich capillaries originating in the woman's and the fetus's circulatory systems. Thus blood is not normally exchanged between a woman and the fetus. Although blood cells are too large to cross the membranes separating the two systems, smaller molecules of oxygen, carbon dioxide, nutrients, and hormones can traverse the barrier. So can some chemicals, drugs, and diseases that interfere with fetal development, as we will see shortly.

The **umbilical cord** is the conduit to and from the placenta for the blood of the fetus. The fetus lives in the womb surrounded by the fluid-filled **amniotic sac.** Amniotic fluid helps to stabilize temperature, insulates the fetus from bumps and shocks, and contains substances necessary for the development of the lungs. The fluid is constantly recirculated and renewed as the fetus ingests nutrients and urinates.

placenta Support organ formed by cells from both blastocyst and uterine lining; serves as exchange site for oxygen, nutrients, and waste products.

umbilical cord Conduit of blood vessels through which oxygen, nutrients, and waste products are transported between placenta and embryo.

amniotic sac Fluid-filled, transparent protective membrane surrounding the fetus.

Principles of Teratology

KEY THEME
Nature/Nurture

Most fetuses negotiate the average thirty-eight-week period from conception to birth as healthy, vigorous newborns. Yet, as we discuss in the chapter titled "Genetics and Heredity," genetic factors can modify normal progress. So too can environmental factors. The study of disabilities and problems that arise from environmental influences during the prenatal period is called *teratology*. Environmental agents that cause disruptions in normal development are known as **teratogens.**

The fact that external agents can upset the course of prenatal development in humans was first appreciated in 1941 when McAllister Gregg, an ophthalmologist, confirmed that rubella, commonly called German measles, caused visual anomalies in the fetus. During this same decade, many infants born to women exposed to the atomic bomb were reported to have birth defects. This finding, along with studies involving animals, implicated radiation as a teratogen (Warkany & Schraffenberger, 1947). The import of these early observations became more fully appreciated when researchers documented that women who had taken a presumably harmless antinausea drug called *thalidomide* frequently bore infants with severe arm and leg malformations (McBride, 1961).

The widely publicized thalidomide tragedy made it abundantly clear that human embryos could be harmed seriously by environmental agents without adversely affecting the woman or others during postnatal development (Wilson, 1977). In fact, the embryo may be susceptible to virtually any substance if exposure to it is sufficiently concentrated (Samuels & Samuels, 1986). A number of broad generalizations have emerged from research on teratogens since the 1960s (Abel, 1989; Hanson, 1997; Vorhees, 1986). These principles help to explain the sometimes bewildering array of adverse consequences that specific drugs, diseases, and other agents can have on development.

KEY THEME
Individual Differences

■ ***The Principle of Susceptibility: Individuals within species, as well as species themselves, show major differences in susceptibility to different teratogens.*** Thalidomide provides a good example of this principle. Scientists knew that extremely large amounts of the drug caused abnormal fetal development in rats (Cohen, 1966). However, the doses given to pregnant women in Europe and Canada, where thalidomide was available as an over-the-counter preparation to reduce morning sickness and anxiety, were considerably smaller. For reasons unknown, the embryos of humans between twenty and thirty-five days after conception are extremely sensitive to small amounts of thalidomide. More than ten thousand babies were born without limbs or with limb defects and intellectual retardation. The genotype of an individual woman and her fetus may also affect susceptibility. Some fetuses were exposed to thalidomide during this sensitive period, yet at birth these babies showed no ill effects from the drug (Kajii, Kida, & Takahashi, 1973).

KEY THEME
Continuity/Discontinuity

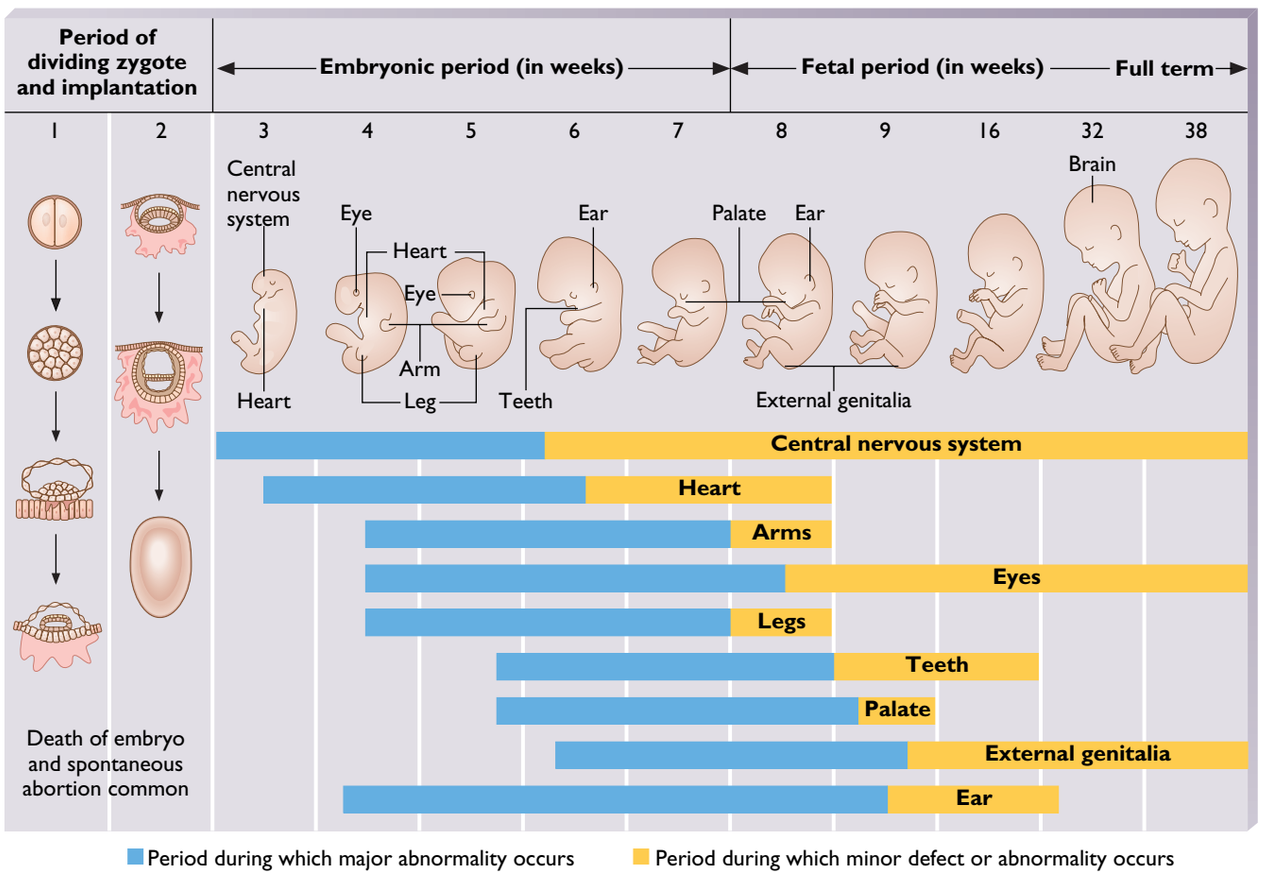
■ ***The Principle of Critical or Sensitive Periods: The extent to which a teratogen affects the fetus depends on the stage of development during which exposure occurs.*** Figure 4.3 shows that many human organs and systems are most sensitive to toxic agents during the third to eighth week after conception, when they are still being formed. However, vulnerability to teratogens exists throughout much of prenatal development. In fact, the brain continues to undergo substantial neural differentiation, migration, and growth during the second and third trimesters of pregnancy, as well as after birth. As a consequence, exposure to teratogens throughout prenatal development may have especially important behavioral consequences.

■ ***The Principle of Access: The accessibility of a given teratogen to a fetus or an embryo influences the extent of its damage.*** Many factors determine when and to what extent an embryo or a fetus is exposed to a teratogen. At one level, cultural and social practices may prevent or encourage a pregnant woman to use drugs, be inoculated for certain diseases, or become exposed to chemicals and other toxins. For example, use of cocaine may be socially approved in one segment of a culture and avoided in another. However, even when a teratogen is present, it must still gain ac-

teratogen Any environmental agent that can cause deviations in prenatal development. Consequences may range from behavioral problems to death.

FIGURE 4.3 Sensitive Periods in Prenatal Development

During prenatal development, organs and systems undergo periods in which they are more or less sensitive to teratogenic influences, environmental agents that can cause deviations in development. The potential for major structural defects (blue-colored sections) is usually greatest during the embryonic period, when many organs are forming. However, many regions of the body, including the central nervous system, continue to have some susceptibility to teratogens (yellow-colored sections) during the fetal period.



Source: Moore & Persaud, 1998.

cess to the uterine environment, for example, by a woman inhaling, ingesting, or injecting a drug intravenously. How a woman has been exposed to the agent, the way she metabolizes it, and how it is transported to the womb influence whether a teratogen reaches a sufficient threshold to have some effect.

KEY THEME
Sociocultural Influence

■ ***The Principle of Dose-Response Relationships: The amount of exposure or dosage level of a given teratogen influences the extent of its damage.*** The severity of a teratogen often is related to level of dosage. The more a woman smokes, for example, the greater the likelihood that her baby will be of low birth weight. The concentration of a toxic agent reaching the fetus, however, cannot always be determined from the woman's exposure to it. The severity of an illness a woman experiences, for example, from rubella, does not always predict the effect of the disease on the fetus.

■ ***The Principle of Teratogenic Response: Teratogens do not show uniform effects on prenatal development.*** Teratogens may cause death or disrupt development of specific organs and systems. They may also have behavioral consequences, impairing sensorimotor, cognitive, social, and emotional development. The principles of species and individual differences, as well as timing, duration, and intensity of exposure

to the teratogen, govern the effect a specific teratogen will have on prenatal development. Alcohol, for example, can cause congenital defects during the embryonic period, but may interfere with prenatal weight gain and contribute to postnatal behavioral problems during the second and third trimesters of pregnancy (Abel, 1989). One other important implication of this principle is that very different teratogenic agents can produce a similar pattern of disabilities. Thus efforts to pinpoint why a baby was born with a given anomaly are not always successful.

■ ***The Principle of Interference with Specific Mechanisms: Teratogens affect prenatal development by interfering with biochemical processes that regulate the differentiation, migration, or basic functions of cells.*** This principle helps to differentiate folk beliefs from scientific explanations of fetal anomalies. A woman's looking at a frightening visual stimulus, for example, has no direct consequence for the fetus. However, hormonal imbalances induced by chronic levels of stress may have an impact on development.

■ ***The Principle of Developmental Delay and "Sleeper Effects": Some teratogens may delay development temporarily with no long-term negative consequences; others may cause developmental problems only late in development.*** Although some teratogenic effects can be observed at birth and are permanent and irreversible, others may be nullified, especially when a supportive caregiving environment is provided. However, the effects of teratogens on later development are probably substantially underestimated because many produce "sleeper effects." These are consequences that go unnoticed at birth but seed problems that become apparent in childhood and even later. For example, women treated with *diethylstilbestrol (DES),* a hormone administered from the 1940s through the 1960s to prevent miscarriages, gave birth to daughters who showed a high rate of genital tract cancers and sons who displayed a high incidence of abnormalities of the testes when they reached adulthood.

Drugs as Teratogens

Now that we have considered general principles involving teratogens, we can examine the effects specific environmental agents have on the embryo or fetus. A number of substances that expectant women may use, either as medicine or as mood-altering devices, frequently become part of the intrauterine world. We focus on their consequences for embryonic and fetal development because the primary impact during the germinal stage is likely to be a disruption in implantation and thus the loss of the zygote.

KEY THEME
Sociocultural Influence

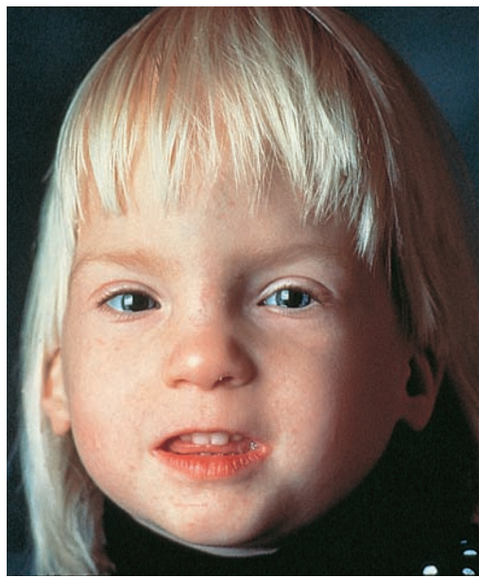
● **Alcohol** Because alcohol readily crosses the placenta, its concentration in the fetus is likely to be similar to that in the woman (Abel, 1981). Moreover, because it lacks some enzymes to effectively degrade alcohol, the fetus may be exposed to it for a longer period of time (Reece et al., 1995). Among pregnant women in the Western world, alcohol is more widely used than any other teratogen and, according to some experts, is the single most frequent cause of mental retardation in industrialized countries (Reece et al., 1995). Although the percentage of pregnant women in the United States indicating that they consume alcohol began to decline in the late 1980s, that percentage now appears to be rising again (Ebrahim et al., 1998). Part of this upturn may stem from recent reports that alcohol, when taken in limited amounts, can have health benefits for adults. Moreover, the percentage of pregnant women who drink and who drink frequently is probably substantially greater in some other Western European nations (such as France and Italy) and in many countries around the world in which alcohol consumption is more generally accepted and in which concerns about its teratogenic effects are less extensively publicized.

Widespread recognition of the dangers of alcohol emerged in the early 1970s, when three sets of characteristics were observed in a number of babies of alcoholic women (Jones & Smith, 1973). They included prenatal and postnatal growth retardation, microcephaly, and abnormal facial features, and mental retardation and other

behavioral problems, such as hyperactivity and poor motor coordination, suggestive of central nervous system dysfunction. This constellation of deficits, known as **fetal alcohol syndrome (FAS),** appears in as many as 6 percent of infants born to alcoholic mothers (Day & Richardson, 1994). *Alcohol-related neurodevelopmental disabilities* (ARND) have been identified in many other children prenatally exposed to alcohol. These children exhibit retardation or learning difficulties, along with other behavioral problems (Mattson et al., 1997; Stratton, Howe, & Battaglia, 1996). Perhaps as many as one in every one hundred births in the United States displays FAS or ARND (Sampson et al., 1997).

Binge drinking, usually identified as five or more drinks within a short time, even if it takes place infrequently, can be especially hazardous because it exposes the fetus to highly concentrated levels of alcohol (Chasnoff, 1986; Streissguth et al., 1994). However, even limited alcohol consumption, some researchers report, is linked to an increase in spontaneous abortions and to reduced alertness, less vigorous body activity, more tremors, and slower learning in newborns compared with babies of women who do not drink (Jacobson & Jacobson, 1996; Streissguth et al, 1994). Work by Anne Streissguth and her colleagues shows that prenatal exposure to relatively moderate amounts of alcohol contributes to measurable deficits in attention and school performance, small declines in IQ, and more frequent behavioral problems in children and adolescents (Bookstein et al., 1996; Streissguth et al., 1994; Streissguth et al., 1999). For example, these children and adolescents tended to be more impulsive and had difficulty organizing their work, especially under stress. Moreover, the tendency to display neurocognitive deficits was related to the amount of alcohol exposure prenatally, an example of the dose-related principle, and was especially evident when the expectant woman engaged in occasional binge drinking. Nevertheless, there was no clear threshold at which negative consequences began to appear. As a result, Streissguth et al. (1999) concluded that even small amounts of alcohol can be harmful.

How does alcohol produce such effects? One way is by directly modifying cell functioning, including cell differentiation, migration, and growth. Examination of infants with fetal alcohol syndrome who died shortly after birth reveals structural changes in the brain caused by delays and errors in the way neurons migrate to form the cortex, or outer layer, of the brain (Clarren et al., 1978). Greater alcohol consumption has also been linked to delayed growth of the frontal cotex (Wass, Persutte, & Hobbins, 2001). The metabolism of alcohol also requires substantial amounts of oxygen so less oxygen may be available for normal cell functions. These findings provide further justification for the recommendation of the American Academy of Pediatrics for complete abstinence during pregnancy because no "safe dose for alcohol has been established" (American Academy of Pediatrics, 1993).



This young Swedish girl, displaying features often associated with fetal alcohol syndrome, was born to a mother who was alcoholic. Physical characteristics, including microcephaly (small head size), eyes widely set apart, and flat thin upper lip are often accompanied by delayed physical growth and mental retardation.

● **Cigarette Smoking** About 13 percent of women in the United States smoke during pregnancy, a percentage that has been declining in recent years (Hoyert et al., 2001). The percentage is higher among Caucasian (15 percent) and African American women (10 percent) than among Hispanic women (5 percent). It may also be far higher in other countries in which less effort has been directed at publicizing the negative health consequences of smoking.

No evidence exists to indicate that smoking during pregnancy causes major congenital defects. However, nicotine and some other of the more than twenty-five hundred chemicals found in tobacco smoke (American College of Obstetricians, 1994) do have serious consequences for fetal and infant mortality, birth weight, and possibly postnatal development. Spontaneous abortions, stillbirths, and neonatal deaths increase in pregnant women who smoke (Streissguth et al., 1994). The most consistent finding from studies of babies born to smokers compared with nonsmokers, however, is their smaller size (Ernst, Moolchan, & Robinson, 2001; Secker-Walker et al., 1997). The more and the longer a woman smokes during pregnancy, the lower her baby's average weight at birth, even when equated for length of gestation, because babies of women who smoke are also likely to be born a few days early (Pollard, 2000; Shah & Bracken, 2000). Babies of women who smoke ten to twenty cigarettes a day

fetal alcohol syndrome (FAS) Cluster of fetal abnormalities stemming from mother's consumption of alcohol; includes growth retardation, defects in facial features, and intellectual retardation.

weigh an average of nearly three hundred grams (about ten ounces) less than other babies.

As with alcohol consumption, a reduction in oxygen may account for the effects. Smoking increases carbon monoxide, which displaces oxygen, in the red blood cells of both woman and fetus. Nicotine also reduces blood flow to the placenta. Moreover, a fetus's heart rate goes up when a woman smokes, a reaction that may be designed to maintain adequate oxygen (Samuels & Samuels, 1986). Babies of women who use tobacco have larger placentas and more frequent placental abnormalities than babies of the same weight born to nonsmoking women (Meyer & Tonascia, 1977; Weinberger & Weiss, 1988). Nicotine may also interfere with metabolic activity important to cell regulation and differentiation.

KEY THEME
Individual Differences

The long-term behavioral consequences of prenatal exposure to smoke are less well understood (Ernst et al., 2001). Some researchers have failed to find evidence of poorer performance on cognitive, academic, or other tasks for children exposed to smoke prenatally. However, other researchers have reported that infants born to smokers display poorer learning (Martin et al., 1977), a higher-pitched cry (Nugent et al., 1996), and reduced visual and auditory alertness (Franco et al., 1999; Landesman-Dwyer, Keller, & Streissguth, 1978). Moreover, studies carried out in the United States, the Netherlands, and New Zealand reveal a small but significant increase in behavioral problems in children and adolescents whose mothers smoked during pregnancy (Fergusson, Woodward, & Horwood, 1998; Orlebeke, Knol, & Verhulst, 1999; Weitzman, Gortmaker, & Sobel, 1992). Although efforts to control other factors potentially contributing to these observations have often been undertaken, genetic, family differences, continued passive exposure to smoke from a caregiver or others in the family, and transmission of smoking-related substances during breastfeeding cannot be eliminated as possible causal contributors to these outcomes (Becker et al., 1999; American Academy of Pediatrics Committee on Drugs, 2001; Orlebeke et al., 1999). For example, passive exposure to environmental tobacco smoke created by others in the child's household is associated with significantly increased health risks such as sudden infant death (see the chapter titled "Brain, Motor Skill, and Physical Development") and other respiratory problems (American Academy of Pediatrics Committee on Environmental Health, 1997; Brown, 2001).

● **Prescription and Over-the-Counter Drugs** Legal drugs in addition to alcohol and tobacco can be hazardous for fetal development. Some are known teratogens (see Table 4.2), but knowledge of the effects of many remains perilously limited. Aspirin, for example, has been demonstrated to impair behavioral competence in the offspring of lower animals. One well-controlled study found that aspirin may also be associated with lower IQ in early childhood (Streissguth et al., 1984). Certainly large doses of aspirin, but also alternative pain relievers such as acetominophen, may increase risk to the fetus (Reece et al., 1995).

Caffeine too has been implicated in birth defects in animals, although studies have failed to reveal any consistent link in humans. However, babies born to mothers who consume higher amounts of caffeine tend to have lower birth weight than babies of mothers who drink less coffee (Eskenazi et al, 1999). Caffeine also has a behavioral impact on the fetus. Lawrence Devoe and his colleagues (1993) used ultrasound to record biweekly two-hour observations of fetal activity during the final ten weeks of pregnancy in ten heavy caffeine consumers (>500 milligrams, or five cups of coffee, daily) and ten low caffeine consumers (<200 milligrams, or two cups of coffee, daily). Fetuses exhibited considerably more arousal (defined by irregular heart rate and breathing activity, frequent body movements, and rapid eye movements) when exposed to the higher amounts of caffeine. The more highly aroused infants may have consumed more energy, a factor that could contribute to their lower birth weight. However, the long-term implications of this difference in activity remain unknown.

KEY THEME
Individual Differences

Perhaps an even greater concern is the number of prescription and over-the-counter drugs consumed during pregnancy. Most expectant women use at least one medication, and the average is more than three (Buitendijk & Bracken, 1991). Little is

TABLE 4.2 Prescription and Other Frequently Used Drugs and Their Effects on Prenatal Development

Drug	Description and Known or Suspected Effects
Alcohol	See text.
Amniopterin	Anticancer agent. Facial defects and a number of other congenital malformations as well as mental retardation (Hanson, 1997).
Amphetamines	Stimulants for the central nervous system, some types frequently used for weight control. Readily cross placental barrier. Fetal intrauterine growth retardation often reported but may be a result of accompanying malnutrition or multiple-drug use. Increased amounts and duration of exposure prenatally found to be correlated with aggressive behavior in 8-year-olds (Billing et al., 1994).
Antibiotics (streptomycin, tetracycline)	Streptomycin associated with hearing loss. Tetracycline associated with staining of baby's teeth if exposure occurs during second or third trimester (Friedman & Polifka, 1996).
Aspirin	Possibility of increased bleeding in both mother and infant (Hanson, 1997). See text for other complications that can arise.
Barbiturates (pentobarbital, phenobarbital, secobarbital)	Sedatives and anxiety reducers. Considerable evidence of neurobiological and behavioral complications in rats. Readily cross human placenta; concentrations in fetus may be greater than in woman. Newborns may show withdrawal symptoms (Friedman & Polifka, 1996). No consistent evidence of long-term effects in humans.
Benzodiazepines (chlordiazepoxide, diazepam)	Tranquilizers. Not shown to have teratogenic effects although newborns may display withdrawal symptoms with diazepam (Friedman & Polifka, 1996).
Caffeine	See text.
Hydantoins (Anticonvulsants)	Treatment for epilepsy. Produce *fetal hydantoin syndrome*, including heart defects, cleft lip or palate, decreased head size, and mental retardation. Controversy continues over whether effects are entirely caused by drug or by conditions associated with the mother, including her epilepsy (Hanson, 1986).
Lithium	Treatment for bipolar disorder. Crosses placenta freely. Known to be teratogenic in premammalian animals. Strong suggestive evidence of increased cardiovascular defects in human infants. Behavioral effects unknown. Administration at time of delivery markedly reduces infant responsivity (Friedman & Polifka, 1996).
Retinoids	Antiacne medicine. Effects similar to large amounts of vitamin A.
Sex Hormones (androgens, estrogens, progestins)	Contained in birth control pills, fertility drugs, and other drugs to prevent miscarriages. Continued use of birth control pills during pregnancy associated with heart and circulatory disorders. Behavioral and personality implications suspected. Masculinization of female embryo from exposure to high doses of androgens or progestins.
Thalidomide	Reduces morning sickness and anxiety. Deformities of the limbs, depending on time of exposure, often accompanied by mental retardation (Friedman & Polifka, 1996).
Tobacco	See text.
Tricyclics (imipramine, desimipramine)	Antidepressants. Some tricyclics cross the placenta. Studies with rats reveal developmental and behavioral disturbances. Studies with humans reveal no consistent findings (Friedman & Polifka, 1996).
Vitamins	Large amounts of vitamin A known to cause major birth defects. Excessive amounts of other vitamins may also cause prenatal malformations (Reece et al., 1995).

Note: This listing is not meant to be exhaustive, and other drugs may have teratogenic effects. No drug should be taken during pregnancy without consultation with a qualified physician.

known about the effects of many of these products, and even less is known about the interactive consequences when multiple drugs are used. For these reasons expectant women are often advised to take *no* drugs during pregnancy, including over-the-counter remedies, or to take them only under the close supervision of their physicians.

● **Illegal Drugs** The effects of illegal drugs such as marijuana, heroin, and cocaine on prenatal development are even more difficult to untangle than the effects of prescription and over-the-counter medications. Drug users are rarely certain of the contents or concentrations of the drugs they consume. Wide variation in frequency of use, the possibility of interactions from exposure to multiple drugs, poor nutritional status, inadequate or no prenatal care, and potential psychological and physiological differences both before and after taking such drugs compound the problem of isolating their teratogenic effects. The lifestyles of many illegal-drug users can be described as essentially chaotic (Chasnoff, 1992), so that conclusions about the impact of the drug itself are often difficult to make.

Research with animals has shown that the psychoactive ingredients associated with marijuana cross the placenta and are stored in the amniotic fluid (Harbison & Mantilla-Plata, 1972). They may also be transferred postnatally through the mother's milk (Dalterio & Bartke, 1979). Still, efforts to determine the effects of marijuana on the human fetus and postnatal development reveal few consistent findings (Zuckerman & Bresnahan, 1991). As with tobacco, fetal weight and size appear to be reduced. Length of gestation may also be shorter for heavy marijuana users, a finding consistent with giving marijuana to speed labor, a practice carried out at one time in Europe.

KEY THEME
Individual Differences

A higher pitched cry, visual problems, lower scores on memory and verbal tasks, and more restless sleep patterns in early childhood are reported with prenatal exposure to marijuana (Dahl et al., 1995; Fried, Watkinson, & Gray, 1998; Lester & Dreher, 1989). However, social and economic differences in the backgrounds of the children could account for these findings. In fact, in some cultures, such as Jamaica, marijuana use correlates positively with neonatal test performance (Dreher, Nugent, & Hudgins, 1994).

KEY THEME
Sociocultural Influence

The effects of heroin and morphine became a public concern as early as the late 1800s when doctors reported withdrawal symptoms in newborns whose mothers used these substances (Zagon & McLaughlin, 1984). By the early 1900s, heroin and morphine were known to be transmitted through the placenta, as well as through the mother's milk. Today an estimated nine thousand infants born in the United States each year are exposed to heroin or *methadone,* a pharmacologically similar product (Sprauve, 1996). Often given under regulated conditions as a heroin substitute, methadone's effects on fetal development are just as powerful as heroin's. So, too, may be the effects of a newer synthetic form of heroin, OxyContin, a prescribed pain killer that has recently achieved the status of a widely sought after street drug.

Although congenital defects have not been positively linked to heroin and methadone, stillbirths and infant deaths are more frequent and lower birth weight is common (American College of Obstetricians and Gynecologists, 1994). About 60 to 70 percent of infants born to heroin- and methadone-addicted women also undergo withdrawal symptoms such as diarrhea, sweating, a distinctive high-pitched cry, tremors, and irritability (Sprauve, 1996). Developmental difficulties continue to be observed in infants and children exposed to heroin and methadone. However, high quality caregiving can play a powerful role in lessening the negative impact of prenatal exposure to heroin in children, at least for those who do not experience neurological damage (Orney et al., 1996).

Each year in the United States alone, more than 200,000 infants are estimated to be born to mothers who use illegal drugs (National Institute on Drug Abuse, 1995). However, probably none of these drugs has received more widespread attention than cocaine. Cocaine in its many forms—including *crack*, an especially potent and addictive variation—readily crosses the placenta. Once it reaches the fetus, it stays longer than in adults because the immature organs of the fetus have difficulty breaking it down. Cocaine also can continue to influence the baby after birth through the mother's milk.

Dire effects for the fetus and subsequently for postnatal development as a result of exposure to cocaine have been widely publicized (Chavkin, 2001; Frank et al., 2001). Indeed, evidence exists that cocaine may be associated with premature and low birth weight (Bendersky & Lewis, 1999), as well as attentional, motor, and some early neurobehavioral difficulties (Eyler et al., 1998; Fried et al., 1998; Singer, Arendt, et al., 1999; Stanwood & Levitt, 2001). However, these observed relationships often can be explained by other factors known to interfere with development. In fact, a recent detailed review of the results of a number of well-controlled studies by Deborah Frank and her colleagues concluded that exposure to cocaine for those undergoing a normal gestational period is *not* a factor that leads to poor physical growth or delayed acquisition of motor skills, lowered cognitive abilities, or behavioral, attentional, or affective disturbances in young children (Frank et al., 2001).

The primary position of Deborah Frank and her colleagues, and a common thread of agreement emerging among researchers, is that other risk factors regularly associated with the use of cocaine—such as increased exposure to tobacco and alcohol, poor nutrition, diminished parental responsiveness, abuse and neglect, social isolation of the family, and the increased stress typically accompanying poverty—play a *far more important* role in negative outcomes for development during early childhood than does cocaine itself (Bendersky & Lewis, 1999; Frank et al., 2001; Miller & Boudreaux, 1999). Thus the prognosis for children subjected to cocaine and other illegal drugs in utero should and does improve substantially when interventions are undertaken to reduce or eliminate these other risk factors (Butz et al., 2001; Field et al., 1998; Kilbride et al., 2000). In other words, although the potential for negative consequences of prenatal exposure to cocaine cannot be ruled out, intervention at other levels appears to be the key to improving the developmental outlook for children exposed to this and other drugs. So, too, may be the need to educate the public, as well as professionals, about the known consequences of exposure to cocaine for development.

Nancy Stewart Woods and her colleagues (Stewart Woods et al., 1998) asked college students to rate a videotape of infants who were described as having been exposed to cocaine. Their assessments of the infants were significantly more negative than assessments of these same infants not described as cocaine-exposed. Perhaps the heavily promoted image of alarming consequences for development as a result of exposure to cocaine needs to be brought into greater accord with recent research findings in order to prevent the potential self-fulfilling prophecy of continued difficulties for such children.

Because prenatal development is so closely tied to the intrauterine environment, little research has been conducted on the father's abuse of drugs or other teratogens and their effects on the fetus. Studies with lower animals, and some with humans, suggest that the sperm of men who consume alcohol or use cocaine or other drugs may carry toxic substances that can disrupt normal prenatal development (Yazigi, Odem, & Polakoski, 1991). However, the woman is regularly assigned far greater responsibility for prenatal events, as the following controversy reveals.

Controversy: Thinking It Over

Should a Drug-Abusing Expectant Woman Be Charged with Child Abuse?

Consider the circumstances surrounding the prosecution of Cornelia Whitner of South Carolina. Her son was born with cocaine in his system. In 1992 Cornelia pled guilty to a charge of child neglect after admitting to the use of cocaine in her third trimester of pregnancy. She was sentenced to eight years in prison.

What Is the Controversy?

Although the conviction of Cornelia Whitner has since been overturned, the issues surrounding this and similar cases deeply divide law enforcement, medical, and

social service agencies in the United States, Canada, and many Western European countries (Capron, 1998; Peak & Del Papa, 1993). Since the mid-1980s, more than two hundred American women in thirty states have been prosecuted on charges of child abuse and neglect, delivery of drugs to a minor, or assault with a deadly weapon for allegedly harming their offspring through prenatal exposure to cocaine or other illegal drugs (Paltrow et al., 2000). Court cases with policy implications for whether a woman can or should be arrested if she exposes a fetus to illegal drugs are continuing to be debated at the highest judicial levels including the Supreme Court in the United States (Greenhouse, 2000; Paltrow et al., 2000). Is this an effective way to reduce the likelihood of drug use and any of its accompanying risks for the fetus?

What Are the Opposing Arguments?

Some say a concerned society should impose criminal or other charges on a pregnant woman who uses a drug that may be dangerous to the fetus. A number of jurisdictions in the United States and provinces in Canada have implemented laws permitting a newborn to be removed from a parent on the grounds of child abuse or neglect because of drug exposure during pregnancy. In some cases, the woman has been ordered to be confined to a drug-treatment facility during pregnancy. After all, anyone found to provide such illegal substances to a child would certainly expect to face criminal or other charges. Are the circumstances that much different in the case of a pregnant woman and her fetus?

Others believe the situation is vastly different and further claim that criminal charges, imprisonment, or mandatory treatment are counterproductive (Beckett, 1995; Farr, 1995). Legislation specifically targeted to pregnant drug users might actually drive prospective mothers, out of fear of being prosecuted, away from the care and treatment needed for both themselves and their fetuses. Moreover, the tendency to rely on criminal procedures could limit the resources available for the implementation of innovative, well-funded public health efforts for treating addiction and its consequences for the fetus (Chavkin, 2001).

What Answers Exist? What Questions Remain?

At the present time no research has been carried out on whether threats of criminal procedures or other forms of punishment dissuade a woman from using drugs during her pregnancy. If studies with this or other populations demonstrate that these kinds of actions are effective in reducing drug use, perhaps greater justification would exist for the extension of this approach to expectant women. But given the recent findings that the negative consequences for the fetus often stem less from the illegal drugs themselves than from the myriad of other factors that are associated with drug use, would such actions be helpful? In other words, are poor nutrition and a host of other social and economic factors, as well as the chaotic lifestyle that often accompanies drug use and over which a woman may not always have control, the primary culprits in impaired fetal development? If so, then intervention must take place at the public health level. And do your views about how to address this issue change given that alcohol and tobacco have been shown to have more serious consequences for fetal development than many illegal drugs (Bendersky & Lewis, 1999; Frank et al., 2001; Miller & Boudreaux, 1999; Streissguth et al., 1999)? If laws are introduced to protect the fetus from illegal drugs, should these laws not also be extended and applied to those who use readily available, heavily advertised, and common drugs that are known to have even more serious teratogenic effects? Research has begun to shed light on some of these issues by providing knowledge about the effects of exposure to drugs on fetal development. What other kinds of developmental research would be useful in helping to resolve these competing views? Are there alternatives that might be proposed to help solve a very complex problem, that of ensuring an optimal start for every child at birth?

Diseases as Teratogens

Somewhere between 2 and 8 percent of babies born to American women are exposed to one or more diseases or other forms of illness during pregnancy (Saltzman & Jordan, 1988). Fortunately, most babies are unaffected. Moreover, significant progress has been made in eliminating the potential negative fetal consequences of several diseases, such as mumps and rubella (German measles), at least in some countries. Unfortunately, rubella, for example, a highly preventable illness, continues to be a major cause of fetal malformations and death worldwide because vaccination programs are limited in some regions of the world. Other diseases, some of which are described in Table 4.3, continue to pose risks for the fetus in even the most medically advanced countries. Their impact on the fetus can be serious, sometimes devastating, even when a woman is completely unaware of illness.

● **Toxoplasmosis** Toxoplasmosis is caused by a parasite found in many mammals and birds. Twenty to 40 percent of adults in the United States and Great Britain have been exposed to it (Feldman, 1982; Peckham & Logan, 1993). However, the disease is found with greater frequency in some European countries, including France and Austria, and in tropical regions. An unusual aspect of the parasite is that part of its life cycle can be completed only in cats. Humans occasionally contract the disease by touching cat feces containing the parasite or, even more frequently, by eating raw or partially infected cooked meat, especially pork and lamb. Children and adults are often unaware of their exposure, because the infection may have no symptoms or cause only a minor fever or rash.

Infections early in pregnancy can have devastating consequences; fortunately, risk of transmission to the fetus at this time is lowest (Foulon et al., 1999). Growth retardation, jaundice, accumulation of fluid in the brain, and visual and central nervous system damage are the most frequent teratogenic outcomes. Some infants show no symptoms at birth; only later may mental retardation, neuromuscular abnormalities, impaired vision, and other eye problems become apparent. Research carried out in Europe indicates that early treatment with antibiotics can help to reduce some of its more devastating consequences (Foulon et al., 1999).

● **Cytomegalovirus** Cytomegalovirus (CMV), a member of the herpes family of viruses, causes swelling of the salivary glands and mononucleosis-like symptoms in adults. It is the single most frequent infection found in newborns today, affecting one to two of every one hundred babies. As many as 10 percent of infected infants can be expected to sustain some congenital damage (Demmler, 1991). No effective treatment exists.

KEY THEME
Sociocultural Influence

CMV is most frequently reported in Asia and Africa and among lower socioeconomic groups, in which up to 85 percent of the population may be infected. Yet 45 to 55 percent of middle- and high-income groups in Europe and the United States are infected as well (Hagay et al., 1996). Transmission occurs through various body fluids. CMV can be passed easily between children playing together, for example, in daycare centers and in family daycare settings (Bale et al., 1999) and from child to adult through physical contact.

Fortunately, the aftermath of contracting the virus in early childhood is generally not serious. Infection can occur within the womb, during birth, and through breastfeeding with more severe consequences (Adler, 1992; Stagno & Cloud, 1994). The negative outcomes are typically greatest for the fetus if a woman contracts the disease for the first time during her pregnancy (Guerra et al., 2000). For example, growth retardation, jaundice, skin disorders, and small head size are common consequences. About one-third of infants showing these characteristics at birth will die in early infancy; a large percentage of those who survive will be mentally retarded. About half of infants sustaining congenital damage from CMV show no symptoms at birth, but many will subsequently display progressive loss of hearing or other,

TABLE 4.3 Diseases and Maternal Conditions That May Affect Prenatal Development

Disease	Physical and Behavioral Consequences for the Fetus
Sexually Transmitted Diseases	
Acquired Immunodeficiency Syndrome (AIDS)	See text.
Chlamydia	Nearly always transmitted to infant during delivery via infected birth canal. Estimated 100,000 (of 155,000 exposed in the United States) become infected. Often causes eye infection in infant and some increased risk of pneumonia. Other adverse effects suspected (McGregor & French, 1991).
Gonorrhea	If acquired prenatally, may cause premature birth (Reece et al., 1995). Most frequently contracted during delivery through infected birth canal and may then attack eyes. In the United States and many other countries, silver nitrate eye drops are administered to all newborns to prevent blindness.
Hepatitis B	Associated with premature birth, low birth weight, increased neonatal death, and liver disorders (Pass, 1987). Most frequently contracted during delivery through birth canal or postnatally.
Herpes Simplex	Of its two forms, only one is transmitted primarily through sexual activity. Both forms, however, can be transmitted to the fetus, causing severe damage to the central nervous system (Pass, 1987). Most infections occur during delivery through birth canal containing active herpes lesions. The majority of infants will die or suffer central nervous system damage (Nahmias, Keyserling, & Kernick, 1983). If known to carry the virus, women may need to be tested frequently during pregnancy to determine if the disease is in its active, contagious state because symptoms may not be present even when active. If the disease is active, cesarean delivery is used to avoid infecting the baby.
Syphilis	Damage to fetus does not begin until about 18 weeks after conception. May then cause death, mental retardation, and other congenital defects (Reece et al., 1995). Infected newborns may not show signs of disease until early childhood.
Other Diseases	
Cytomegalovirus	See text.
Influenza	Some forms linked to increased heart and central nervous system abnormalities, as well as spontaneous abortions (Reece et al., 1995).
Mumps	Increased risk of spontaneous abortion and stillbirth.
Rubella	Increased risk of spontaneous abortion and stillbirth. Growth retardation, cataracts, hearing impairment, heart defects, mental retardation also common and especially if exposure occurs in the first or second month of pregnancy.
Toxoplasmosis	See text.
Varicella-zoster (chicken pox)	Skin and muscle defects, intrauterine growth retardation, limb reduction.
Other Maternal Conditions	
Diabetes	Risk of congenital malformations and death to fetus two to three times higher than for babies born to nondiabetic women (Coustan & Felig, 1988). Excessive size at birth also common. Effects are likely to be a consequence of metabolic disturbances rather than of insulin. Rapid advances in care have helped reduce risks substantially for diabetic women.
Hypertension (chronic)	Probability of miscarriage or infant death increased.
Obesity	Increased risk of diabetes and large-for-gestational-age babies (Lu et al., 2001).

TABLE 4.3 Diseases and Maternal Conditions That May Affect Prenatal Development *(continued)*

Disease	Physical and Behavioral Consequences for the Fetus
Other Maternal Conditions (continued)	
Pregnancy-Induced Hypertension	5%–10% of expectant women experience significant increase in blood pressure, often accompanied by *edema* (swelling of face and extremities as a result of water retention), rapid weight gain, and protein in urine during later months of pregnancy. Condition is also known as *pre-eclampsia* (or *eclampsia,* if severe) and *toxemia.* Under severe conditions, woman may suffer seizures and coma. The fetus is at increased risk for death, brain damage, and lower birth weight. Adequate protein consumption helps minimize problems. Drugs used to treat high blood pressure may be just as hazardous to fetus as the condition itself.
Rh Incompatibility	Blood containing a certain protein is Rh positive, Rh negative if it lacks that protein. Hereditary factors determine which type the individual possesses. If fetus's blood is Rh positive, it can cause formation of antibodies in blood of woman who is Rh negative. These antibodies can cross the placental barrier to destroy red blood cells of fetus. May result in miscarriage or stillbirth, jaundice, anemia, heart defects, and mental retardation. Likelihood of birth defects increases with succeeding pregnancies because antibodies are usually not present until after birth of first Rh-positive child. A vaccine (Rhogam) can be administered to the mother within 3 days after childbirth, miscarriage, or abortion to prevent antibody formation.

subtler defects, including minimal brain dysfunction, visual or dental abnormalities, or motor and neural problems (Pass, 1987; Saltzman & Jordan, 1988).

● **Sexually Transmitted and Other Diseases** Several diseases identified as teratogenic are transmitted primarily through sexual contact, or the infection and its symptoms are usually concentrated in the genitourinary tract (see Table 4.3). Syphilis and certain strains of herpes simplex, for example, are virtually always contracted from infected sexual partners. On the other hand, some diseases, such as acquired immunodeficiency syndrome (AIDS) and hepatitis B, can be acquired through exposure to infected blood as well.

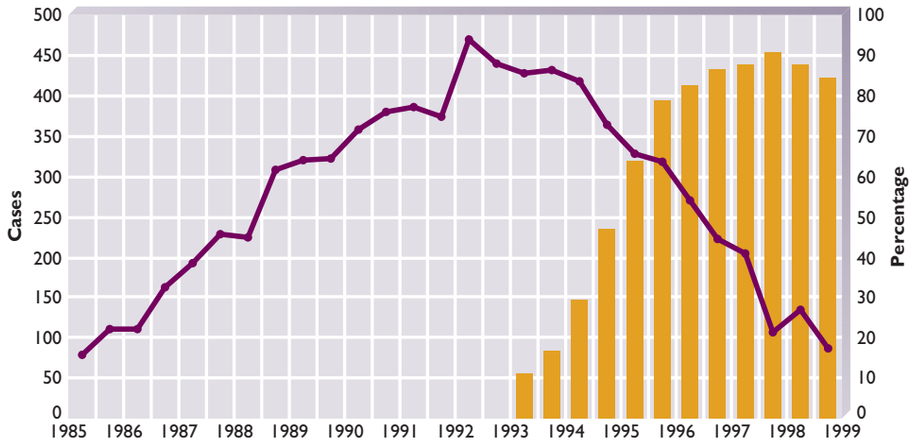
Sexually transmitted diseases (STDs) can interfere with reproduction in a number of ways. They may compromise the woman's health (AIDS, gonorrhea, hepatitis B, herpes simplex, syphilis), scar or disturb reproductive organs so that conception and normal pregnancy cannot proceed (chlamydia, gonorrhea), directly infect the fetus (AIDS, herpes simplex, syphilis), and interfere with healthy postnatal development (AIDS, hepatitis B, herpes simplex, syphilis) (Lee, 1988). In recent years, their frequency has risen rapidly in populations around the world. None, however, has had as dramatic an impact as AIDS.

Of the estimated 16,000 children having human immunodeficiency virus type 1 (HIV) in the United States and the more than 1.1 million children currently living with the disease worldwide, most were infected prenatally, during birth, or shortly after birth through an infected mother's breast milk (Burgess, 2001; Lindegren, Steinberg, & Byers, 2000). Prior to 1995, about 25 percent of infants born to HIV-positive women could be expected to eventually acquire AIDS. However, as can be seen in Figure 4.4, new medical treatments have reduced the transmission rate by more than one-third, at least in countries in which expensive drugs such as zidovudine are available (Lindegren et al., 2000).

Of those infants who do become infected with HIV, about 20 percent show rapid progression to AIDS and death in early childhood. However, with new advances in treatment, about two-thirds live more than five years; the average length of survival in Western countries is now greater than nine years; and about 25 percent of children do not show severe symptoms of AIDS until after ten years (Barnhart et al., 1996; Brown, Lourie, & Pao, 2000; European Collaborative Study, 2001). Children

FIGURE 4.4
Decline in HIV/AIDS Transmitted to Offspring Via HIV-Infected Women

The transmission of HIV/AIDS infection to infants and children via HIV-infected women has declined dramatically in the United States in recent years. The data from thirty-two reporting states reveal that introducing treatment with zidovudine (represented by the shaded bars as the percentage of women receiving treatment with the drug) has been an important factor in reducing the number of cases of infants and children reported with HIV/AIDS. Unfortunately, about 90% of the approximately 1.1 million children around the world with HIV/AIDS are born in sub-Saharan Africa, where this method of treatment is often too expensive or unavailable.



Source: Lindegren, Steinberg, & Byers, 2000.

receiving medication for HIV also show substantial benefits in terms of maintaining more normal levels of cognitive functioning throughout much of their childhood (Brown et al., 2000). Thus the negative course of the disease can be slowed for cognitive and other aspects of development (Tardieu et al., 1995). Unfortunately, however, for many children around the world, limited medical services, poverty, and the absence of social support will adversely affect their development while living with the disease.

KEY THEME
Nature/Nurture

Environmental Hazards as Teratogens

Radiation was one of the earliest confirmed teratogens, and it can cause genetic mutation as well. Radiation's effects include spontaneous abortion, small head size, and other defects associated with the skeleton, genitals, and sensory organs. Even low doses of radiation have been linked to increased risks of cancer and neural damage; pregnant women are urged to avoid unnecessary x-rays and other circumstances in which exposure might occur.

Chemicals and other elements in the environment pose another significant source of potential risks. Known teratogens include lead, mercury, and polychlorinated biphenyls or PCBs (a synthetic hydrocarbon once used in transformers, hydraulic fluids, and other industrial equipment), as well as many elements found in paints, dyes and coloring agents, solvents, oven cleaners, pesticides, herbicides, food additives, artificial sweeteners, and cosmetic products (cf. Needleman & Bellinger, 1994). Careless handling and disposal of such elements and their excessive production and use—they pervade the foods we eat and the air we breathe—are one problem. In addition, many women of childbearing age are exposed to hazardous substances in the workplace (see Table 4.4).

Women's Conditions and Prenatal Development

In addition to teratogens, a number of health conditions are associated with increased risk during pregnancy. Several of these conditions (diabetes, pregnancy-induced and chronic hypertension, Rh incompatibility) and their consequences for the fetus are summarized in Table 4.3. Additional factors influencing the prenatal environment include the age of the woman, her nutritional status, and her emotional state.

TABLE 4.4 Occupational Hazards for Women of Childbearing Age

Occupation	Hazardous Substances
Cleaning personnel	Soaps, detergents, solvents
Electronic assemblers	Lead, tin, antimony, trichloroethylene, methyl chloride, resins
Hairdressers and cosmetologists	Hair-spray resins, aerosol propellants, solvents, dyes
Health personnel	Anesthetic gases, x-rays, laboratory chemicals
Painters	Lead, titanium, toluene
Photographic processors	Caustics, bromides, iodides, silver nitrate
Plastic workers	Formaldehyde, vinyl chloride
Printing personnel	Ink mists, methanol, carbon tetrachloride, lead, solvents, trichloroethylene
Textile and garment workers	Formaldehyde, dyes, asbestos, solvents, flame retardants
Transportation personnel	Carbon monoxide, lead

Source: Adapted from Samuels & Bennett, 1983.

● **Age** The number of older mothers is on the rise in industrialized countries as women postpone pregnancy to establish careers or for other reasons. Is pregnancy riskier as women become older? As we show in the chapter titled "Genetics and Heredity," the likelihood of having a child with Down syndrome increases markedly during the later childbearing years, especially after age thirty-five. Some studies also report increased prematurity, mortality, and greater difficulty during labor for women over thirty-five having their first child (Gilbert, Nesbitt, & Danielsen, 1999; Reece et al., 1995). The findings are likely due, in large part, to greater health-related problems (hypertension, diabetes, and others) that can accompany increased age. Despite these elevated risks, healthy women older than thirty-five routinely deliver healthy infants, just as do women between twenty and thirty-five years of age.

Teenagers, on the other hand, may be at considerably greater risk for delivering less healthy babies (McAnarney, 1987). Lack of adequate prenatal care is one reason; pregnant teenagers in the United States, particularly those who are very young and unmarried, often do not seek medical services. Another reason pregnancy at these early ages poses more problems is the complicated nutritional needs of adolescents; many teenagers are still growing themselves. Although the rate of births to teenagers has declined steadily throughout the 1990s in the United States (Hoyert et al., 2001), it is still substantially higher than in other industrialized nations and double or even triple those of most Western European countries. In any given year, about one in twenty-five teenagers is likely to bear a child; over 90 percent of the nearly 500,000 births to teenagers each year will be to unmarried teens (Children's Defense Fund, 2001).

● **Nutrition** What foods are needed for the health of the woman and her fetus? The seemingly obvious but important answer is a well-balanced diet. Extreme malnutrition during prenatal development can be especially detrimental. During World War II, famines occurred in parts of Holland and in Leningrad in the former Soviet Union. When the malnutrition occurred during the first few months of pregnancy, death, premature birth, and nervous system defects were especially frequent. When famine occurred later in prenatal development, retardation in fetal growth and low

KEY THEME
Sociocultural Influence

Teenage mothers give birth to nearly 500,000 babies in the United States each year. Many of them will be unmarried teens who have received little or even no prenatal care, factors that increase the risk for delivering less healthy babies.

birth weights were more likely (Antonov, 1947). Although not everyone agrees about the guidelines, women of normal weight for their height are typically advised to gain about twenty-five to thirty-five pounds during pregnancy.

Diets must not only be sufficient in number of calories but also balanced with respect to adequate protein, vitamins, and other nutrients. In fact, intake of many nutrients should be increased during pregnancy, as Table 4.5 indicates. Fortunately, unless deficiencies are so severe that malformations and deficits in neuron formation cannot be overcome, many cognitive problems associated with prenatal undernutrition and the lowered birth weight that often accompanies it may still be reversed when adequate nourishment and stimulation are provided following birth (Pollitt, 1996).

KEY THEME
Sociocultural Influence

● **Stress** Cultural beliefs about potentially harmful consequences of frightening or stressful events on fetal development are pervasive, and many societies encourage a calm atmosphere for pregnant women (Samuels & Samuels, 1986). In studies in which researchers have carefully measured anxiety, family conflict, positive and negative life events, and the availability of physical and social support for the woman, stress has been linked to greater complications during both pregnancy and birth. Anxiety appears to lengthen labor, increase the need for more anesthesia during delivery, and produce more birthing complications. High stress, particularly early in pregnancy, seems to contribute to a shorter length of gestation and therefore to more frequent preterm births and more infants with lower birth weight (Wadhwa et al., 1993). For example, women who had experienced an earthquake in the first trimester of pregnancy viewed the event as more stressful and also delivered their infants sooner than those who had experienced the earthquake in the second or third trimester (Glynn et al., 2001). In addition, fatigue associated with long hours at work, especially work that involves prolonged standing, increases preterm birth and health problems for a pregnant woman (Gabbe & Turner, 1997; Luke et al., 1999). Stress also may indirectly affect prenatal development by leading a woman to increase smoking, consume more alcohol, or engage in other activities known to have negative effects on the fetus (McAnarney & Stevens-Simon, 1990).

TABLE 4.5 Nutritional Need Differences Between Nonpregnant and Pregnant Women 24 Years of Age

Nutrient	Nonpregnant	Pregnant	Percent Increase	Dietary Sources
Folic acid	180 mcg	400 mcg	+ 122	Leafy vegetables, liver
Vitamin D	5 μg	10 μg	+ 100	Fortified dairy products
Iron	15 mg	30 mg	+ 100	Meats, eggs, grains
Calcium	800 mg	1200 mg	+ 50	Dairy products
Phosphorus	800 mg	1200 mg	+ 50	Meats
Pyridoxine	1.6 mg	2.2 mg	+ 38	Meats, liver, enriched grains
Thiamin	1.1 mg	1.5 mg	+ 36	Enriched grains, pork
Zinc	12 mg	15 mg	+ 25	Meats, seafood, eggs
Riboflavin	1.3 mg	1.6 mg	+ 23	Meats, liver, enriched grains
Protein	50 g	60 g	+ 20	Meats, fish, poultry, dairy
Iodine	150 mcg	175 mcg	+ 17	Iodized salt, seafood
Vitamin C	60 mg	70 mg	+ 17	Citrus fruits, tomatoes
Energy	2200 kcal	2500 kcal	+ 14	Proteins, fats, carbohydrates
Magnesium	280 mg	320 mg	+ 14	Seafood, legumes, grains
Niacin	15 mg	17 mg	+ 13	Meats, nuts, legumes
Vitamin B-12	2.0 mcg	2.2 mcg	+ 10	Animal proteins
Vitamin A	800 μg	800 μg	0	Dark green, yellow, or orange fruits and vegetables, liver

Source: Reece et al., 1995.

The social support a pregnant woman receives from family and friends is an important factor that can lessen the consequences of stress during pregnancy (Feldman et al., 2000). Among women who experience a variety of life changes before and during pregnancy, those with strong social and personal assistance—for example, those who can obtain a ride to work, get help when sick, or borrow needed money—have far fewer complications than women without such resources (Norbeck & Tilden, 1983). In fact, women who receive as little as twenty minutes of psychosocial support addressing their concerns and offering encouragement during regular prenatal visits have babies who weigh more than the babies of women who do not receive this benefit (Rothberg & Lits, 1991). How well a family functions during stressful times may be a more important predictor of complications during and after pregnancy than how many stressful events are actually experienced (Smilkstein et al., 1984).

In the chapter-opening vignette, Carole expressed concern about the considerable pressure of her work and caring for her other children. She, like many other women, is unable to completely eliminate stress from her life. Pregnant women must juggle work, family, and many other obligations. Perhaps additional support from family and friends could help Carole manage her stress and minimize the potentially negative outcomes. Efforts that families initiate to reduce stress or respond to it in adaptive ways can be effective preventive medicine both during pregnancy and after (Samuels & Samuels, 1986).

A Final Note on Environment and Prenatal Development

After learning about the many teratogens and other factors that can affect prenatal development, we may be surprised that babies manage to be born healthy at all. But they do so every day. We should wonder, rather, at the rich complexity of prenatal development and appreciate more deeply that it proceeds normally so much of the time. Ninety to 95 percent of babies born in the United States are healthy and fully prepared to adapt to their new environment. Knowledge of teratogens allows prospective parents as well as others in the community to maximize the chances that all infants will be equipped to enter the world with as many resources as possible.

FOR YOUR REVIEW

- What kinds of supportive functions do the placenta, umbilical cord, and amniotic sac provide for the embryo and the fetus?
- What are teratogens? What principles apply to how teratogens have their effects?
- How do alcohol, cigarette smoke, prescription and over the counter drugs, and illegal drugs affect prenatal development? What are the methodological difficulties associated with determining the consequences of use of such drugs on the embryo, the fetus, and the child?
- How should society treat women charged with using drugs during their pregnancy?
- What maternal conditions affect the well-being of the fetus and embryo?

Birth and the Perinatal Environment

KEY THEME
Sociocultural Influence

Societies vary enormously in the techniques and rituals that accompany the transition from fetus to newborn. Some interpret pregnancy and birth as natural and healthy, others, as an illness requiring medical care and attention (Newton, 1955). The !Kung, a hunting-and-gathering people living in the Kalahari Desert of Africa, build no huts or facilities for birthing. They view birth as part of the natural order of events, requiring no special intervention (Shostak, 1981). In contrast, pregnancy and childbirth in the United States and many other countries throughout much of the twentieth century has been regarded more as an illness to be managed by professionally trained medical personnel (Dye, 1986). In 1900 fewer than 5 percent of babies were born in hospitals in the United States. Today about 99 percent of all babies in the United States are born in hospitals (Declercq, 1993; Hosmer, 2001).

Preparing for Childbirth

With the shift from childbirth at home to childbirth in the hospital came an increase in the use of medication during delivery. Concerns about the impact of these medications, along with reports of unmedicated but seemingly pain-free delivery by women in other cultures, prodded professionals and expectant parents alike to reconsider how best to prepare for the birth of a baby. After observing one woman who reported a pain-free delivery, Grantley Dick-Read, a medical practitioner in Great Britain, concluded that difficult childbirth was fostered largely by the tension and anxiety in which Western civilization cloaked the event. Dick-Read (1959) proposed that women be taught methods of physical relaxation, given information about the process of childbirth, and encouraged to cultivate a cooperative relationship with their doctors to foster a more natural childbirth experience. Others, including Fernand Lamaze (1970), adopted similar ideas, adding procedures to divert thoughts from pain and encouraging breathing activities to support the labor process.

In recent years, **prepared** (or **natural**) **childbirth,** which involves practicing procedures designed to minimize pain and reduce the need for medication during delivery, has become a popular alternative for prospective mothers. Women who attend classes and adhere to the recommendations of Lamaze and other childbirth education programs (including the National Childbirth Trust in the United Kingdom) generally require fewer and lower amounts of drugs during delivery than women who have not participated in prepared childbirth. Women who attend childbirth classes may experience no less pain, but relaxation techniques and an additional element frequently promoted in these programs—the assistance of a coach or trainer, sometimes the father—seem to help counter the discomfort and lead to a more positive evaluation of childbirth (Waldenström, 1999).

prepared childbirth Type of childbirth that involves practicing procedures during pregnancy and childbirth that are designed to minimize pain and reduce the need for medication during delivery. Also called *natural childbirth*.

Societies differ enormously in their approach to the birth of a baby. In the United States, most births occur in hospitals. In contrast, more than four of every five births in the Trobriand Islands (part of Papua New Guinea) take place in villages where a midwife is in charge.

Research Applied to Parenting

Nurturing and Caring During Labor

Carole knew the signs for the onset of labor; after all, she had already gone through two deliveries. Birthing had proceeded smoothly for her other two children despite her anxieties about the whole process, especially the first time. Maybe it helped to have her husband participate with her in childbirth classes. During those pregnancies she had learned about the various options, ranging from massage to hypnosis to traditional medication, even delivering the baby in water, an alternative the birthing center offered for those who wished to do so. One other thing had been extremely helpful: the presence of a doula, *another woman to accompany her throughout the entire period of labor. Carole was not certain about some of the other alternatives for making the delivery easier and more comfortable. But of one thing she was very sure: she would have a doula with her throughout the birthing process this time as well.*

In addition to exhilaration, most women delivering a baby go through a lot of hard work and some, perhaps considerable, discomfort. It can be a very anxious time. Human birth differs from that of other species of mammals in that it typically requires some form of assistance (Rosenberg & Trevathen, 2001). In many cultures, the help comes from friends and relatives or from midwives, just as it did in the United States many decades ago. With the relocation of childbirth to hospitals, however, women became isolated from family and friends, and a more private and impersonal procedure emerged. Perhaps with that change something very important was lost. Research has helped to identify this loss and has led to alternatives in birthing practices that may benefit both men and women as they become new parents.

KEY THEME
Sociocultural Influence

1. *Include a partner or some other trusted companion in preparing for and assisting during childbirth.* Studies carried out in Botswana, Guatemala, several European countries, and the United States demonstrate that having a continuously supportive companion during delivery is helpful to women and their newborns (Kayne, Greulich, & Albers, 2001; Madi et al., 1999; Scott, Berkowitz, & Klaus, 1999). For example, in the Guatamalan studies, first-time mothers were assigned a *doula*, a

Today, fathers, and sometimes other friends and family members, are encouraged to furnish social and emotional support to women who are about to deliver a baby. When such support is provided by a trusted companion, labor is shorter, fewer drugs are required, and babies are born exhibiting less distress. Nurse midwives, such as the one here discussing the progress of labor with this expectant woman, also have demonstrated an excellent record in helping with the delivery of newborns.

woman experienced with delivery who stayed with the mother to provide emotional support, increase her physical comfort, inform her about what was happening during labor, and advocate for her needs (Klaus & Kennell, 1982). Women given these personal attendants spent far shorter times in labor, required drugs or forceps less frequently, and delivered babies who showed less fetal distress and difficulty breathing than women who received only routine nursing care. Sometimes fathers or other partners are actively encouraged to take on some of these functions as well and can be very effective (Cunningham, 1993), although a doula may be able to provide a more balanced and informative perspective on the sequence of unfolding events.

2. *Consider what type of practitioner might be most beneficial during childbirth.* Of course, fathers or other partners who assist in labor are not likely to be experts in the process. Midwives, nurses, or others far more experienced in childbirth, whose additional primary function is to provide personal assistance while managing labor, have received positive evaluations as well. Compared with physicians, midwives who oversee birthing produce, for example, lower rates of deliveries undergoing cesarean births or other surgical procedures, less use of medication by the mother, and greater satisfaction with care (Butler et al., 1993; Oakley et al., 1996; Sakala, 1993). Whereas about 5 percent of births in the United States are now accompanied by midwives, this figure is nearly 75 percent in many European countries (Alan Guttmacher Institute, 1993).

3. *Explore the different alternatives available to assist in delivering a baby.* The positive outcomes achieved by midwives appear to stem from an attitude that inspires women to not just deliver babies but also draw on their own inner resources, as well as their support networks, for giving birth. For example, midwives are likely to suggest greater flexibility in positioning and moving about during labor, perhaps even soaking in a tub. Standing, squatting, or sitting in special chairs, or even hanging from a bar, are increasingly being offered as alternatives to the traditional recumbent position for delivery. These choices can increase a woman's comfort through the natural benefits of gravity and thus reduce stress for both mother and baby. In fact, in nonwestern cultures, these alternative positions for childbirth are the norm (Rosenberg & Trevathen, 2001).

Labor and Delivery

When labor begins, the wet, warm, and supportive world within the uterus undergoes a rapid transformation, and the fetus must adjust to an earthshaking series of changes. During normal birth, the fetus begins to be subjected to increasingly

stronger pressure. Because the birth canal is typically smaller than the size of the head, pressure—as great as thirty pounds of force—will probably cause the head to become somewhat elongated and misshapen (Trevathen, 1987). This is possible because the cerebral plates are not yet knitted together, allowing them to slide up and over one another. At times the fetus may experience brief disruptions in oxygen as the flow of blood in the umbilical cord is temporarily obstructed. And then the infant emerges head first into a strange, new world, one drier, possibly colder, and often much brighter and noisier. Within minutes the new arrival must begin to take in oxygen. The baby must also soon learn to coordinate sucking, swallowing, and breathing to obtain sufficient nutrients.

Labor is a complicated, interactive process involving the fetus, the placenta, and the woman. What brings about its onset? The answer begins with the hypothalamus, pituitary, and adrenal glands of the fetus. When these become mature enough, they help to produce a cascading sequence of hormones and other events, including some in the placenta, that are especially important in initiating labor (Nathanielsz, 1996). In fact, measurement of one hormone in the placenta as early as the sixteenth to twentieth week of pregnancy can predict whether a delivery will occur somewhat before, somewhat after, or about the time of the anticipated due date (Smith, 1999).

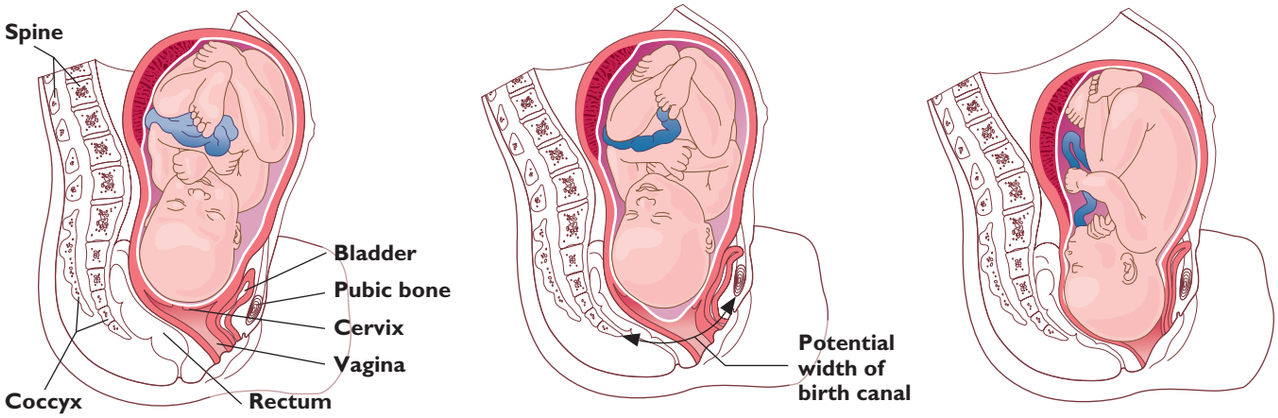
The first of the three traditional stages of labor (see Figure 4.5) begins with brief, mild contractions perhaps ten to fifteen minutes apart. These contractions become increasingly frequent and serve to alter the shape of the cervix, preparing it for the fetus's descent and entry into the narrow birth canal. Near the end of the first stage, which on average lasts about eleven hours for firstborns and about seven hours for later-borns, dilation of the cervix proceeds rapidly to allow passage through the birth canal. The second stage consists of the continued descent and the birth of the baby. This stage usually requires a little less than an hour for firstborns and about twenty minutes for later-borns. It also normally includes several reorientations of both the head and shoulders to permit delivery through the tight-fitting passageway (Rosenberg & Trevathen, 2001). In the third stage, which lasts about fifteen minutes, the placenta is expelled. These durations are, however, averages; enormous variation exists from one woman to another.

This woman, who has just given birth, now has the opportunity to see and hold her infant for the first time. In contrast to earlier practices, parents in most hospital settings today are allowed ample time to become acquainted with their newborns immediately after birth.

Are Home Deliveries a Safe Alternative?
psychology.college.hmco.com

FIGURE 4.5 The Three Stages of Childbirth

In the first stage of labor the cervix, the neck of the uterus, dilates and thins to open a passage through the birth canal. The amniotic fluid, if not already lost, helps by exerting firm, even pressure on the cervix. When the pressure becomes too great, the sac containing the amniotic fluid will rupture, a process known as "breaking the water." The head of the fetus will soon enter the birth canal, and the second stage of labor begins. During the second stage of labor, each contraction continues to push the fetus farther along the approximately four inches of the birth canal. During a normal delivery, the head emerges first (known as *crowning*), much as though pushing through the neck of a tight turtleneck sweater. The orientation of the head toward the mother's back is one of the reasons birthing for humans often needs the assistance of others (Rosenberg & Trevathen, 2001). Once the head has emerged, shoulders twist around in the birth canal, and the head turns sideways to permit delivery of the rest of the body. In the final stage of labor, the placenta is delivered.

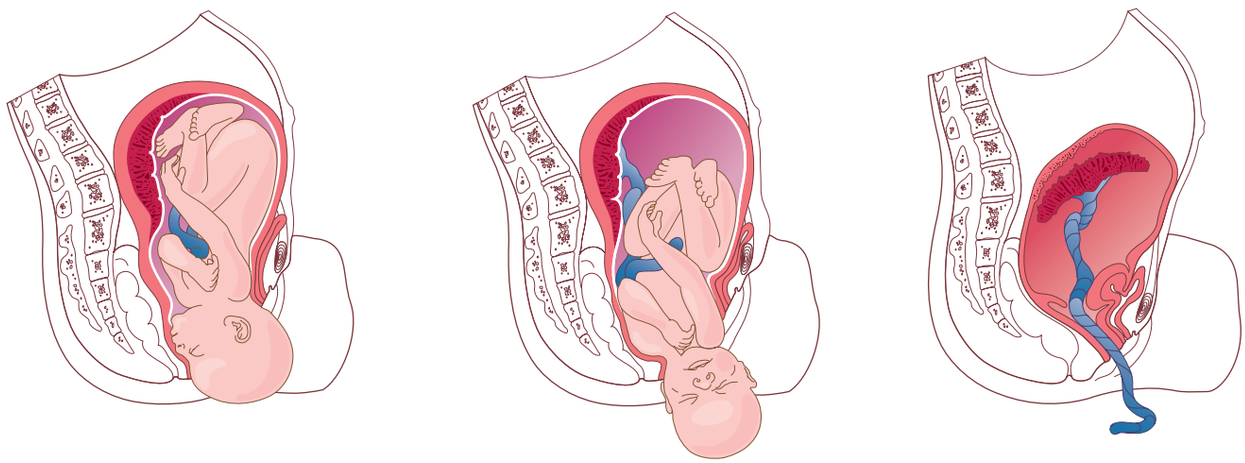


The baby in the uterus before labor

Water about to break (the baby's head now rests inside the cervix)

Transition: The baby in the birth canal

STAGE 1



The baby about to be born

The head rotates sideways after it emerges

The delivery of the placenta

STAGE 2

STAGE 3

● **Medication During Childbirth** In Western societies, births are often accompanied by some form of medication. Anesthesia blocks the transmission of pain, analgesics lessen feelings of discomfort, and sedatives help the woman to relax. All of these drugs readily pass through the placenta and enter the fetus's circulatory system. Critics of the routine use of drugs point out that babies whose mothers receive high doses during labor are less attentive and responsive to caregivers, are more irritable, and gain weight more slowly than babies exposed to small amounts or no drugs at all (Brazelton, Nugent, & Lester, 1987; Emory, Schlackman, & Fiano, 1996). Moreover, some behavioral differences may persist well beyond infancy. Heavy use of drugs

during labor has been associated, for example, with an increased incidence of learning disorders among school-age children (Brackbill, McManus, & Woodward, 1985).

Developmental differences between babies born to medicated and nonmedicated women, however, are not consistent. Some experts believe the negative effects of exposure to drugs at birth have been markedly overstated and occur only when medications are used excessively (Kraemer et al., 1985). Thus women need not experience unreasonable pain or feel guilty if drugs are administered. Efforts to make the birth process gentler, such as by reducing illumination and noise or delivering the baby under water, have also been proposed (Daniels, 1989; LeBoyer, 1975), although the advantages of these practices for either women or infants have not been documented. Furthermore, the use of other complementary and alternative medical procedures, such as acupuncture and various relaxation techniques, remain unproven with respect to benefits to mother or newborn as well (Allaire, 2001). However, as we have already discussed, providing a network of social support does help.

KEY THEME
Individual Differences

● **Cesarean Birth** A *cesarean birth* is the delivery of a baby through a surgical incision in the woman's abdomen and uterus. Cesarean births are recommended, for example, when labor fails to progress normally, when the baby's head is very large, or when birth is *breech* (foot or rump first) rather than head first. Concerns about stress on the fetus that might lead to increased risk of brain damage, vaginal infections that might be transmitted to the baby, and expensive malpractice suits (should things go awry during vaginal delivery) have led to more than a fivefold increase in the frequency of cesarean sections in the past thirty years in the United States. Today nearly 23 percent of deliveries in the United States are cesarean rather than vaginal (Hoyert et al., 2001), a rate that is far higher than in all other countries except Brazil and Puerto Rico (Centers for Disease Control, 1993).

KEY THEME
Sociocultural Influence

Women who undergo cesarean section face an increased risk of infection and a longer hospital stay than women who give birth vaginally. Moreover, cesarean babies are likely to be exposed to greater maternal medication. Other concerns center on the different experiences both mother and infant receive under such circumstances. For example, when cesarean babies are delivered before labor begins, they do not have a misshapen head and appear perfectly healthy. However, they have substantially lower levels of two stress hormones, adrenaline and noradrenaline, known to facilitate respiration by helping to keep the lungs open and clear. The hormones also enhance cell metabolism, circulation of the blood to the brain, and activity level, factors that help the infant make the transition to his or her new environment and to become responsive to caregivers. Thus cesarean babies generally tend to have more trouble breathing, are less active, sleep more, and cry less than other babies (Trevathen, 1987). Mothers, too, tend to evaluate their experience of a cesarean delivery, especially if unplanned, less positively than those who deliver vaginally. Nevertheless, the quality of mother-infant interactions and the psychosocial functioning of the infants a year after their births appear quite similar regardless of type of delivery, suggesting that there are few long-term negative consequences of cesarean births (DiMatteo et al., 1996; Durik, Hyde, & Clark, 2000).

● **Birth Trauma** The increase in the frequency of cesarean sections in the United States has come about partly because of concerns about birth trauma, or injuries sustained at birth. A potentially serious consequence is *anoxia,* or deprivation of oxygen. Anoxia can result from, for example, damage to or lengthy compression of the umbilical cord or head during birth, problems associated with the placenta, or failure of the baby to begin regular breathing after birth. If oxygen deprivation lasts more than a few minutes, severe damage to the central nervous system, including cerebral palsy, can result.

Fortunately, brief periods of anoxia have few long-lasting effects. Furthermore, an adequate postnatal caregiving environment can help to counter potentially negative outcomes for infants experiencing periods without oxygen (Sameroff & Chandler, 1975). Concerns about anoxia and other birth traumas, however, have led to the

widespread use of **fetal monitoring devices** during labor. Most of these devices record fetal heartbeat to determine whether the fetus is undergoing stress during delivery. However, some experts argue that reliance on medically sophisticated equipment promotes a cascading series of interventions that only exacerbate the difficulty of delivery. In fact, by focusing on a supportive context to reduce anxiety, less birth trauma will occur than that which the technology was designed to prevent (Hafner-Eaton & Pearce, 1994; Sakala, 1993).

KEY THEME
Individual Differences

Low Birth Weight

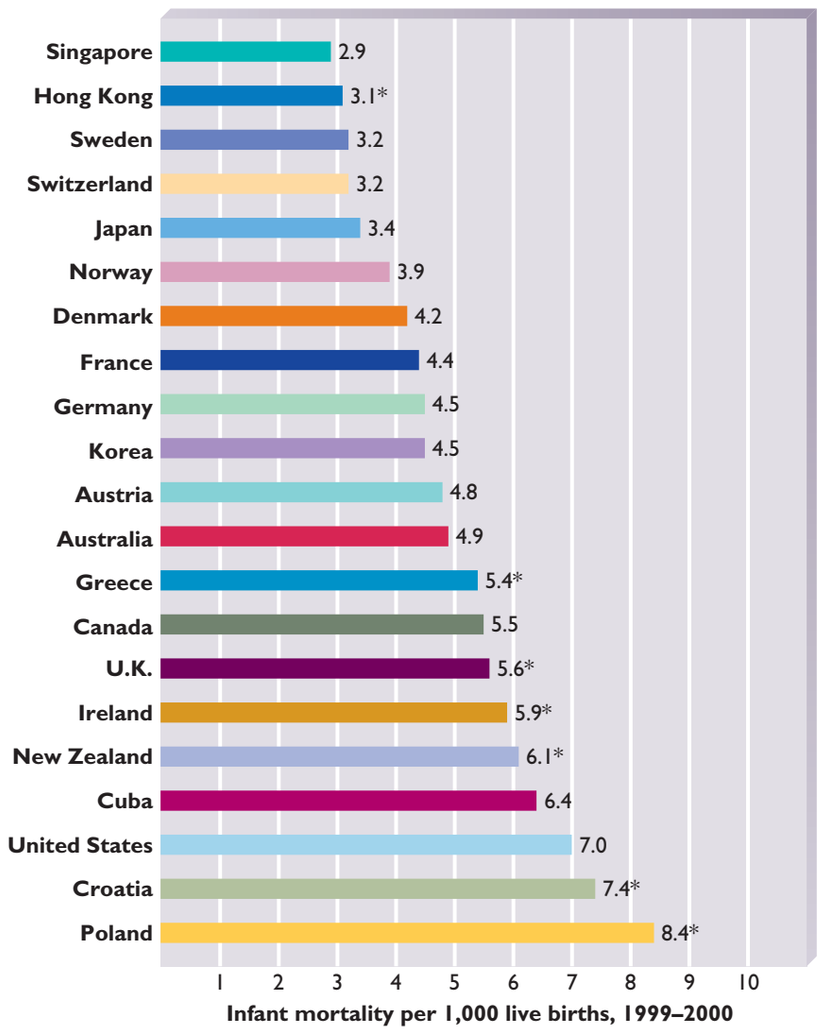
As infant and childhood diseases have come under greater control in recent decades, the treatment and prevention of low-birth-weight infants (those weighing less than twenty-five hundred grams, or five-and-a-half pounds) has gained increased attention. Mortality rate rapidly declines as birth weight increases to near normal levels. The United States has a higher proportion of infants born with low birth weight than many other developed countries, a major reason that its infant mortality rate is also higher than in many other industrialized countries (see Figure 4.6).

KEY THEME
Sociocultural Influence

Babies with low birth weight fall into two major groups: those born preterm (less than thirty-five weeks conceptual age) whose development has generally proceeded

FIGURE 4.6
Infant Mortality in Selected Developed Countries

The infant mortality rate (deaths before one year of age per thousand live births) is a measure that provides an indication of the overall health of a nation. A number of countries have a lower infant mortality rate than the United States.



* Provisional

Source: Data from United Nations, *Population and Vital Statistics Report,* 2001.

fetal monitoring device Medical device used to monitor fetal heartbeat during delivery.

normally but has been cut short by early delivery, and those born near their expected arrival date but are *small for gestational age (SGA)*, that is, who display intrauterine growth retardation. Thus, low-birth-weight infants compose a heterogeneous group, perhaps needing separate types of medical treatment and intervention and facing different developmental outcomes. Congenital anomalies are somewhat more frequent in SGA infants, for example, whereas respiratory distress is more likely among infants who are born preterm.

● **Caring for Infants with Low Birth Weight** In general, infants born with low birth weight face numerous obstacles, not only in terms of survival but also throughout subsequent development (Agustines et al., 2000; Chan et al., 2000). Cerebral palsy, seizure disorders, neurological difficulties that include hemorrhaging associated with regions of the brain, respiratory difficulties, and eye disorders are some examples of the problems observed. These difficulties are found especially frequently among infants born with very low birth weight (less than fifteen hundred grams) and even more so among those with extremely low birth weight (less than 1,000 grams) or who are born at less than twenty-seven weeks gestational age. In addition to these problems, all low-birth-weight and premature infants face the major task of maintaining physiological stability and achieving regular cycles of activity involving sleep and wakefulness. To deal with these problems, premature infants spend much of their time in an isolette, a small plexiglass chamber that carefully controls temperature and air flow with the aid of a respirator. They may be fed via a stomach tube and are often given painful heel pricks and other interventions to monitor the effects of medication and treatment.

The types of experience that premature infants have typically received has been of considerable concern in terms of their social and psychological consequences for development. At one time parents were either excluded completely from neonatal intensive care units (NICUs), the specialized medical facilities designed to care for low-birth-weight infants (called *special care baby units* in Great Britain), or were given little opportunity to see or care for their newborns. However, that policy has changed substantially as evidence emerged showing the importance of appropriate stimulation for postnatal development (Ramey, Bryant, & Suarez, 1987; Thoman, 1993). NICUs and parents now sometimes provide *compensatory stimulation.* This experience attempts to duplicate what the baby would have gained while still in the womb. For instance, the baby might be exposed to oscillating devices or waterbeds to simulate the movements the fetus experiences prenatally; muffled recordings of a human voice, a

KEY THEME
Nature/Nurture

The opportunity to interact with each other shortly after birth typically has positive consequences for both mother and child. For children born with low birth weight these occasions may be more difficult to arrange. Nevertheless, research reveals that encouraging parents to engage in these kinds of experiences are beneficial to all children.

heartbeat, or other sounds to match those usually heard in the womb; reduced light and exposure to noise; and opportunities for nonnutritive sucking, an activity in which the fetus occasionally engages (Thoman, 1993). Caregivers and others may also be encouraged to provide suitable *enriching* visual and auditory experiences, prudent handling, and social and body contact more akin to the environment to which normal newborns are exposed. Researchers have identified benefits from both compensatory and enriching stimulation: more rapid weight gain, shorter hospital stays, fewer medical and eating problems, more regular breathing and heart rate, improvements in sensorimotor development, more stable and longer periods in quiet states, and smoother transitions from one state to another (Gorski, 1991; Thoman, 1993).

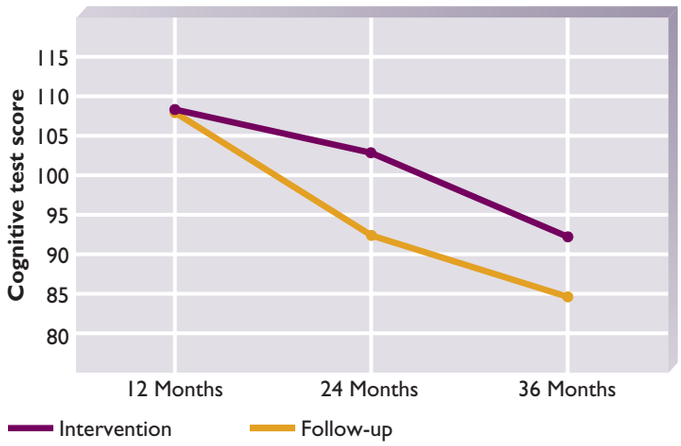
More recently, many hospitals have begun to implement *kangaroo care,* another kind of caregiving that combines both compensatory and enriching elements. First used in Bogotá, Colombia, about a decade ago, kangaroo care involves resting the unclothed premature infant on the mother's body between her breasts for an hour or longer each day. This procedure helps the mother's own body temperature regulate the infant's body temperature, permits opportunity for nursing activity, and assists mother and child to establish a social relationship with one another (Charpak et al., 1997; Ludington-Hoe & Swinth, 1996). Research has revealed that this experience, given to premature infants in the NICU for as little as an hour a day for fourteen days, facilitates infants' ability to regulate arousal, maintain a more consistent sleep-wake pattern, and engage in more mature attentional and exploratory behaviors as much as six months later, compared with premature infants not receiving kangaroo care (Feldman et al., 2002). In addition, the experience appears to positively affect how mothers view their infants and their role as a parent (Neu, 1999).

● **Promoting Development in Low-Birth-Weight Children** In general, low-birth-weight infants lag behind other children in later development. A higher proportion, especially those with extremely low birth weights, display visuomotor and language deficits, learning disabilities, behavior problems, and fewer social skills, and suffer more peer rejection as children (Bregman, 1998; Taylor, Klein, & Hack, 2000; Vohr et al., 2000). The problems are likely to culminate in poorer school achievement and the need for more special education intervention (Klebanov, Brooks-Gunn, & McCormick, 1994; Saigal et al., 2000). Fortunately, many low-birth-weight children still do surprisingly well, as revealed by an analysis of data from more than eighty studies conducted in North America, Europe, Australia, and New Zealand (Aylward et al., 1989). Indeed, the enormous, although justified, concern about the development of some of these children often overshadows the fact that the ones who display disabilities represent only a proportion of all very low-birth-weight children (McCormick, 1997).

KEY THEME
Nature/Nurture

As we have begun to see in other examples of children with special needs, one very important factor contributing to positive developmental outcomes appears to be the support and encouragement of parents. Providing parents with opportunities to engage in suitable caregiving in the hospital setting, instructing them to recognize the specific needs of their infant and what behaviors to expect, and extending the emotional support of professional staff and other parents are types of assistance that have proven beneficial to low-birth-weight children (Achenbach et al., 1993; McCormick et al., 1993; Ramey et al., 1992). For example, Jeanne Brooks-Gunn and her colleagues (1993) found that low-birth-weight children who participated in educational daycare programs and whose families received regular home visits and joined in frequent parent group meetings were able to maintain higher levels of performance on cognitive tests than children in families for whom these resources were unavailable (see Figure 4.7).

Parenting a low-birth-weight infant, especially one who shows medical complications, can be very stressful (Taylor et al., 2001). Despite the continuing demands and increased burdens that are often a part of such child rearing, mothers of very low-birth-weight children report similar levels of satisfaction and positive feelings with respect to their parenting as mothers of normal-birth-weight children by the time their offspring reach three years of age (Singer, Salvator, et al., 1999). Moreover, the caregivers of children born with extremely low birth weight are as enthusiastic and



Source: Brooks-Gunn et al., 1993.

FIGURE 4.7
Low-Birth-Weight Children's Cognitive Development as a Function of Intervention

In a large-scale study investigating the effects of providing home visits and educational child care for low-birth-weight infants and their families, Brooks-Gunn and her colleagues (1993) found that performance on measures of intellectual development was substantially better for those who received the intervention than for those who did not. Although some decline in scores occurred even for the group receiving intervention, it was far less than for those who did not receive the intervention. Both groups performed similarly at the youngest age (twelve months), perhaps because tests measuring cognitive skills often are not very sensitive to differences at that age.

supportive of making every effort to provide the best medical care possible for these children as parents of children born with normal birth weights (Streiner et al., 2001). In bringing up a low-birth-weight child, however, providing family- and child-oriented services appears to be especially important in helping to reduce stress, especially for those mothers who are less educated and may have fewer other resources available (Klebanov, Brooks-Gunn, & McCormick, 2001).

Attempts to reduce complications associated with low birth weight have proceeded on two fronts. Improved medical care in NICUs and supportive caregiving have permitted more low-birth-weight, especially extremely low-birth-weight, infants to survive and develop normally. These positive findings reflect more effective treatment (e.g., for respiratory distress) and management of the NICU (e.g., reductions in bright light, loud noise, and sleep interruptions) designed to reduce stress in individuals who are among the least capable of responding to stress (Als et al., 1994; Bregman, 1998). Yet despite this increased number of survivors, the proportion of children showing neurological or cognitive problems has remained stable (Lorenz et al., 1997; O'Shea et al., 1997; Piecuch, Leonard, & Cooper, 1998; Stevenson et al., 1998). Thus, a second major assault on the problem has been in the form of prevention. Researchers have catalogued a long list of demographic, medical, and behavioral factors associated with low birth weight, for example, inadequate prenatal care and nutrition, heavy smoking, and drug use. Because many of these factors are preventable, educational programs targeted to pregnant women at high risk, including teenagers, have become increasingly important. These programs can reduce the incidence of low birth weight, especially when offered consistently and early in the course of pregnancy (Fangman et al., 1994; Seitz & Apfel, 1994). Indeed, future progress in addressing the problems that accompany low birth weight is likely to be closely tied to improved and more widespread programs of prevention as much as to new medical advances.

FOR YOUR REVIEW

- What are the benefits of prepared childbirth and a supportive relationship with another individual for both parent and newborn child?
- What are the stages of delivery? How does medication during delivery affect the newborn?
- What are the benefits and disadvantages of cesarean births for mother and child? Why is this procedure often carried out?
- How do premature and small for gestational age infants differ? What are the factors that increase the likelihood of low birth weight? What practices help children born with low birth weight?

Newborn Assessment and States

Even parents of a healthy infant may be in for a surprise when they see their baby for the first time. Unless delivered by cesarean section, the baby is likely to have a flattened nose and a large, distorted head from the bones of the skull overriding one another during passage through the narrow birth canal. The skin of all babies, regardless of racial background, is a pale pinkish color and often is covered by an oily, cheeselike substance (the vernix caseosa) that protects against infection. Sex organs are swollen due to high levels of sex hormones.

An infant's most immediate need after emerging from the womb is to breathe. Pressure on the chest during delivery probably helps to clear the baby's fluid-filled lungs, but the shock of cool air, perhaps accompanied by jiggling, a slap, or some other less than gentle activity by a birth attendant, makes the first breath more like a gasp, quickly followed by a reflexive cry. The umbilical cord may continue to pulse for several minutes after birth, and in many societies the cord is not cut until after it ceases to do so (Trevathen, 1987).

The second major task the baby must accomplish upon entering the world is to regulate body temperature. Babies lose body heat about four times more rapidly than adults because of their lower fat reserve and relatively large body surface (Bruck, 1962). As a consequence, newborns, although they can effectively maintain their temperature when held close to a caregiver's body, are often quickly placed under heaters.

Assessing Newborns

KEY THEME
Individual Differences

Newborns typically weigh five-and-a-half to ten pounds and measure eighteen to twenty-two inches in length. Many procedures for evaluating their health have become available in recent years, but one routinely administered is the *Apgar Scale* (Apgar, 1953). Typically assessed at both one and five minutes after birth, the Apgar measures five vital signs: heart rate, respiratory effort, muscle tone, reflex responsivity, and color. Each vital sign is scored 0, 1, or 2 based on the criteria described in Table 4.6. In the United States, 90 percent of infants receive a total score of 7 or better; those who score less than 4 are considered to be at risk.

A more extensive measure, developed by T. Berry Brazelton (1973) and given several days after birth, is the *Neonatal Behavioral Assessment Scale (NBAS)*. The NBAS evaluates, for example, the baby's ability to interact with the tester, responsiveness to objects in the environment, reflex motor capacities, and ability to control behavioral state. Newborn performance on the NBAS has been used to assess neurological con-

This two-day-old baby, holding her father's hand, has entered a world in which new forms of physical and social stimulation can be experienced. Although newborns and young infants spend much of their time sleeping, this infant is engaged in alert inactivity, a time in which she may be learning much about her environment.

dition and can indicate whether certain prenatal or perinatal conditions, as well as intervention programs, have had an effect (Korner, 1987; Tronick, 1987). An NBAS score can also predict later developmental outcomes. Babies who score poorly on the scale continue to be somewhat less responsive to caregivers in the first few months after birth (Vaughn et al., 1980). In general, however, the predictive validity of the NBAS (along with other infant tests) for long-term development is only modest at best (Brazelton, Nugent, & Lester, 1987). Nevertheless, parents who observe while examiners give the NBAS or who are trained to give it themselves seem to become more responsive to and effective in interactions with their infants (Worobey, 1985).

Newborn States

Babies sleep. They sleep a lot. But newborns and young infants display a wide variety of states: regular and irregular sleep, drowsiness, alert inactivity, alert activity, and crying. Crying or distress usually begins with whimpering but swiftly shifts to full-scale cries, often accompanied by thrashing of arms and legs. During alert activity the infant also exhibits vigorous, diffuse motor activity, but such exertions are not accompanied by signs of distress. During alert inactivity the baby is relatively quiet, at least in terms of motor activity, but actively engages in visual scanning of the environment. In this state, the baby appears to be most responsive to sensory stimulation and may be learning a great deal.

Although individual differences are great, newborns average sixteen to seventeen hours of sleep a day. Sleep and wake cycles are extremely short, and babies are easily disrupted by external stimulation. As the weeks pass, infants gradually sleep less but for longer periods; by about three to five weeks of age, a pattern begins to emerge in which the longest sleep periods take place at night (Thompson, 1982). But naps during the day continue to be a regular occurrence through the preschool years. In fact, in some cultures, such naps are never eliminated.

KEY THEME
Individual Differences

The development of sleep patterns differs substantially across various cultures. In most industrialized countries, parents eagerly look forward to having their infants adopt a routine that matches their own. A significant milestone is reached when the baby of three or four months finally sleeps through the night. In some cultures, such as the Kipsigi of rural Kenya, however, infants are permitted more flexibility and will not sleep through the night until much older (Super & Harkness, 1982).

KEY THEME
Sociocultural Influence

Like adults, infants (even before they are born) display two distinct sleep states (Groome et al., 1997). During active or *REM (rapid-eye-movement)* sleep, eye movements and muscle jerks are frequent and breathing and heart rate are irregular. During quiet sleep *(NREM),* eye and muscle movements are few and physiological activity is more regular. The proportion of time spent in the two states, however,

TABLE 4.6
The Apgar Scoring System

The Apgar Scale is used at and shortly after birth to diagnose the physical condition of a newborn. The ratings for each vital sign are added for a total score ranging from 0 to 10. An infant who scores less than 4 is considered to be at risk.

	Ratings		
Vital Sign	***0***	***1***	***2***
Heart rate	Absent	Slow (below 100)	Over 100
Respiratory effort	Absent	Slow, irregular	Good, crying
Muscle tone	Flaccid	Some flexion of extremities	Active motion
Reflex responsivity	No response	Grimace	Vigorous cry
Color	Blue, pale	Body pink, extremities blue	Completely pink

Source: Adapted from Apgar, 1953. From V. Apgar, "A Proposal for a New Method of Evaluation of the Newborn Infant," *Anesthesia and Analgesia: Current Researches, 32,* 260–267. Copyright © 1953. Used by permission of Lippincott Williams & Wilkins. www.anesthesia-analgesia.org

shifts dramatically with development. About eight in sixteen hours of sleep is spent in REM sleep as a newborn, but only about two in seven hours of sleep as an adult.

Active or REM sleep has been linked to dreaming, but it is not clear whether young infants dream. However, REM sleep is believed to be important for normal brain activity (Roffwarg, Muzio, & Dement, 1966). *Autostimulation theory* proposes that REM sleep provides powerful stimulation to the central nervous system, which in adults is interpreted as sensory and motor activity associated with dreaming. According to this theory, stimulation during REM sleep compensates for the relatively brief number of hours each day the infant is awake. Infants kept awake for relatively lengthy periods of time show reduced amounts of REM sleep, and premature infants, whose wakeful periods are even shorter, show more REM sleep than full-term babies (Halpern, MacLean, & Baumeister, 1995). If autostimulation theory is correct, it is a further demonstration of how important stimulation is for development, even at those times when a large amount of sleep is essential as well.

FOR YOUR REVIEW

- What are the first tasks for the newborn following birth?
- Why are scores on the Apgar and Neonatal Behavioral Assessment Scale important?
- What states do newborns display? What kinds of sleep patterns are found in newborns?

CHAPTER RECAP

Summary of Developmental Themes

Nature/Nurture ***What roles do nature and nurture play in prenatal development and birth?***

Prenatal development is the product of complex interactions involving genetic instructions inherited from parents (see the chapter titled "Genetics and Heredity") and the expectant woman's physical and emotional conditions, as well as exposure to drugs, diseases, hazardous chemicals, and medications before and during pregnancy and during labor. We have seen, for example, that differentiation of organs and systems in the embryo typically obeys principles established by biochemical and physiological processes. Yet these processes do not operate in a vacuum. Teratogens and various intrauterine conditions can radically alter the normal developmental path. Thus events in the life of the woman may change the immediate environment within her womb, with drastic consequences for the fetus. The reactions, attitudes, and availability of the newborn's caregivers and the stimulation they provide are other major sources of potential influence on the baby's development.

Sociocultural Influence ***How does the sociocultural context influence prenatal development and birth?***

The immediate internal environment of the fetus and the perinatal environment provided for the newborn can be influenced dramatically by the larger social, economic, and cultural settings in which pregnancy and birth take place. The woman's actions during pregnancy are often modified or regulated by a network of expectations, advice, and resources within the culture in which she lives. An expectant woman in one community, for example, may have access to medical and other kinds of care that provide a more or less healthy environment for the fetus than a woman in another community. Industry or governing units may legislate controls on chemical pollution in one country and ignore them in another. Scientific and technological advances in prenatal testing, birthing practices, and newborn care may be available in one region of the world but not another; even when available, however, not all parents may have the economic resources or desire to use them.

Continuous/Discontinuous ***Is development before and after birth continuous or discontinuous?***

When the zygote attaches to the uterine wall and taps a new source of nourishment, its course of development changes dramatically. Once the various organs and systems are formed and become less susceptible to environmental disruptions, the fetus achieves a vastly different status. The process of birth itself is a major transition. Such spectacular changes fit with discontinuous or stagelike descriptions of development. So do the marked shifts in vulnerability to teratogens observed during prenatal development. Underlying the progressions, however, are biochemical and physiological processes governing cell proliferation, differentiation, and the emergence and functioning of biological systems that can be seen as continuous. Many dramatic changes are essentially the product of modest accumulative modifications in the multifaceted, complex environment that promotes development.

■ **Individual Differences** ***How prominent are individual differences in prenatal development and the newborn?***

Newborns everywhere undergo many common gestational experiences; however, individual differences already have begun to surface. Many differences arise because, contrary to once widely held beliefs, the fetus is not immune to the influences of the larger world. Because of exposure to teratogens and other maternal conditions, babies will differ in their physical and behavioral qualities and their ability to cope with and adapt to their new environment. Greater knowledge of and sensitivity to those differences by caregivers, whether exhibited by a newborn with special needs such as one with low birth weight or by an infant who falls within the typical range for newborns, can help to ensure success for the continued development of every child.

Summary of Topics

The Stages of Prenatal Development

- *Prenatal development* is the period that extends from conception to birth. During this time, a single-celled *zygote* is transformed into the complex, active organism that is the newborn.

Fertilization

- Fertilization normally takes place in the Fallopian tube when an ovum, or egg cell, is penetrated by a single sperm cell.

The Germinal Period

- During the *germinal period*, about the first ten to fourteen days after conception, the zygote migrates from the Fallopian tube to the uterus, becomes multicelled, and implants itself in the uterine wall to gain access to a new source of nutrients obtained from the mother.
- If implantation of the zygote occurs in a location other than the uterus, an *ectopic pregnancy* has occurred. Such a pregnancy is potentially life threatening to a woman.

The Embryonic Period

- The *embryonic period* begins after implantation and continues until about the eighth week after conception.
- The embryonic period is marked by development of the *placenta* and other supportive structures within the uterine environment and by the differentiation of cells into tissues that form the major organs and systems of the embryo.

The Fetal Period

- The *fetal period*, beginning in about the eighth week after conception and lasting until birth, is marked by substantial growth and by refinement of organs and systems.
- Neurons continue to form and migrate during the fetal period. Brain activity, sensory reactions, and movement are exhibited by the fetus. *Viability,* that is, the ability to survive outside the womb, improves rapidly over the last three months of pregnancy.
- *Gestational age* differs from conceptual age by about two weeks, because it is based on the woman's last menstrual period rather than the time at which conception occurs.

Assisted Reproduction

- Various forms of assisted reproduction offer couples who are unable to conceive naturally the opportunity to have their own biological children. Among the technologies associated with these procedures are artificial insemination by donor, egg donation, fertility drugs, gamete intrafallopian transfer, in vitro fertilization, and maternal surrogacy.
- Medical concerns, as well as legal and social issues concerning the many different categories of parenting offered by these new technologies, continue to be debated. Nevertheless, children born as a result of assisted reproduction typically appear to show normal psychological and social development.

Environmental Factors Influencing Prenatal Development

- Many environmental circumstances influence prenatal development.

Support Within the Womb

- The placenta serves as the major organ for transfer of nutrients from the mother's circulatory system and for the expelling of waste products from the fetus. The *umbilical cord* connects the fetus to the placenta. The *amniotic sac* provides a fluid-filled, protective surrounding in which development of the fetus occurs.

Principles of Teratology

- During both embryonic and fetal development, *teratogens*, or environmental agents harmful to the organism, can disrupt development and interfere with later behavior.
- The effects of teratogens differ depending on the genetic susceptibility of the embryo or fetus, how the teratogen reaches the prenatal environment, its level of dosage and manner of exposure, and where it interferes with cellular activity. A teratogen's effects also differ depending on the time at which exposure occurs during prenatal development. Not all the consequences are observed immediately; they may not even be evident until well into the postnatal years.

Drugs as Teratogens

- Many different drugs are able to cross the placental barrier and can have teratogenic effects. Among those known to have the greatest impact on fetal development are alcohol, which can result in *fetal alcohol syndrome,* and cigarette smoke.
- The effects of prescription and over-the-counter drugs on prenatal development are not always well known. Of considerable concern is the potential harmful outcome from interactions involving the use of many such drugs.
- Teratogenic effects are linked to the use of illegal drugs. However, their effects are often confounded with other factors known to have significant negative consequences for the fetus. These factors include lack of proper nutrition, poor health of the mother, absence of medical care, lack of emotional and social support, and high levels of stress. These factors may well be more damaging to the fetus than the drugs themselves.

Diseases as Teratogens

- Although some diseases known to have teratogenic effects are no longer common, at least in some regions of the world, others, including sexually transmitted diseases such as HIV, can have serious repercussions on both prenatal and postnatal development.

Environmental Hazards as Teratogens

- Certain chemicals found in the environment, as well as in various workplaces, can have teratogenic effects.

Women's Conditions and Prenatal Development

- Being either very young or in the late childbearing years, poor nutrition, a high level of stress, and lack of social support, in addition to certain conditions such as diabetes, obesity, and pregnancy-induced hypertension, are associated with less positive outcomes in prenatal development.

A Final Note on Environment and Prenatal Development

- Despite the possibility of negative consequences from teratogens, most infants in technologically advanced countries are born healthy and normal.

Birth and the Perinatal Environment

- The practices and procedures surrounding the birth and initial care of a baby are part of the *perinatal period* of development.

Preparing for Childbirth

- Cultures differ enormously in the support and types of assistance provided for the delivery of a child. These preparations may include the prospective parent engaging in *prepared* or *natural childbirth* designed to make birthing easier. Other social and cultural differences include place of delivery (home, hospital, or some other facility specifically designed for birthing), who is present and assists in the birth, and what function those assistants serve.
- The presence of a *doula*, someone familiar with the birth process but continuously present to provide emotional support and information to the mother, appears to have benefits for both mother and newborn.

Labor and Delivery

- Childbirth proceeds through three stages. In the first and longest stage, labor helps to initiate preparation of the birth canal. Passage of the fetus through the birth canal makes up the second stage. During the third stage, the placenta is delivered. Labor appears to be initiated by hormones produced by the fetus and the placenta.
- Concerns about too much reliance on medication during labor have led to efforts to initiate procedures that permit delivery with the use of fewer pain-relieving drugs.
- Cesarean deliveries continue to be relatively common in the United States, despite their greater expense and the fact that vaginal births may produce some benefits for the infant. The large number of cesarean births in the United States may stem, in part, from the extensive use of *fetal monitoring devices* that signal distress to the fetus during delivery and concerns about the long-term negative consequences of birth trauma.

Low Birth Weight

- As infant and childhood diseases have come under increasing control, researchers have directed attention to the prevention and treatment of small-for-gestational-age and low-birth-weight infants. Although many low-birth-weight infants develop into healthy children and adults, a significant number, especially among those with very or extremely low birth weight, experience various developmental disorders.
- Compensatory and enrichment programs for low-birth-weight infants increase early weight gains and other developmental outcomes. They also help to reduce stress among mothers, especially those for whom other support from family and community may be limited.

Newborn Assessment and States

- The newborn's initial appearance may be far different from what most parents expect. Respiration and maintenance of body temperature are two immediate critical goals for the newborn.

Assessing Newborns

- Tests given to the newborn shortly after birth, such as the Apgar Scale and Neonatal Behavioral Assessment Scale, provide some indication of the baby's physiological state and ability to interact with caregivers and respond to stimulation.

Newborn States

- Newborns display a number of states ranging from deep sleep to intense crying. A relatively large proportion of an infant's time involves REM sleep, a state that may provide them with stimulation even when asleep.