A young painter captures the wide-ranging medical and social supports that help ensure that her twin siblings, floating within her mother's protective womb, will be born healthy. How is the one-celled organism gradually transformed into a baby with the capacity to participate in family life? What factors protect or undermine prenatal development? Chapter 3 answers these questions.

“Mother at the Specialist's”
Sonja Zajcikovska,
7 years old, former Czechoslovakia
Motivations for Parenthood

When I met Yolanda and Jay one fall in my child development class, Yolanda was just two months pregnant. After months of wondering if the time in their lives was right, they had decided to have a baby. Both were full of questions: “How does the baby grow before birth?” “When is each organ formed?” “Has its heart begun to beat?” “Can it hear, feel, or sense our presence?”

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

In this chapter, we answer Yolanda and Jay’s questions, along with a great many more that scientists have asked about the events before birth. We begin our discussion during the time period before pregnancy with these puzzling questions: Why is it that generation after generation, most couples who fall in love and marry want to become parents? And how do they decide whether to have just one child or more than one?

Then we trace prenatal development, paying special attention to environmental supports for healthy growth, as well as damaging influences that threaten the child’s health and survival. Finally, we look at how couples prepare psychologically for the arrival of the baby and start to forge a new sense of self as mother or father.

Motivations for Parenthood

TAKE A MOMENT... What, in your view, are the benefits and drawbacks of having children? How large would your ideal family be, and why? As part of her semester project for my class, Yolanda interviewed her grandmother, asking why she had wanted children and how she had settled on a particular family size. Yolanda’s grandmother, whose children were born in the 1950s, replied:

We didn’t think much about whether or not to have children in those days. We just had them—everybody did. It would have seemed odd not to! I was 22
years old when I had the first of my four children, and I had four because—well, I wouldn’t have had just one because we all thought children needed brothers and sisters, and only children could end up spoiled and selfish. Life is more interesting with children, you know. And now that we’re older, we’ve got family we can depend on and grandchildren to enjoy.

**Why Have Children?**

In some ways, the reasons Yolanda’s grandmother wanted children are much like those of contemporary parents. In other ways, they are very different. In the past, the issue of whether to have children was, for many adults, “a biological given or unavoidable cultural demand” (Michaels, 1988, p. 23). Today, in Western industrialized nations, it is a matter of true individual choice. Effective birth control techniques enable adults to avoid having children in most instances. And changing cultural values allow people to remain childless with much less fear of social criticism and rejection than a generation or two ago. In 1950, 78 percent of North American married couples were parents. Today, 70 percent bear children—a choice affected by a complex array of factors including financial circumstances, career goals, personal and religious values, and health conditions (Theil, 2006).

When North Americans are asked about their desire to have children, they mention a variety of advantages and disadvantages, which are listed in Table 3.1. Although some ethnic and regional differences exist, reasons for having children that are most important to all groups include the warm, affectionate relationship and the stimulation and fun that children provide. Also frequently mentioned are growth and learning experiences that children bring into the lives of adults, the desire to have someone carry on after one’s own death, and feelings of accomplishment and creativity that come from helping children grow (Cowan & Cowan, 2000; Dion, 1995; O’Laughlin & Anderson, 2001).

<table>
<thead>
<tr>
<th><strong>ADVANTAGES</strong></th>
<th><strong>DISADVANTAGES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Giving and receiving warmth and affection</td>
<td>Loss of freedom, being tied down</td>
</tr>
<tr>
<td>Experiencing the stimulation and fun that children add to life</td>
<td>Financial strain</td>
</tr>
<tr>
<td>Being accepted as a responsible and mature member of the community</td>
<td>Family—work conflict—not enough time to meet both child-rearing and job responsibilities</td>
</tr>
<tr>
<td>Experiencing new growth and learning opportunities that add meaning to life</td>
<td>Interference with mother’s employment opportunities and career progress</td>
</tr>
<tr>
<td>Having someone to provide care in old age</td>
<td>Worries over children’s health, safety, and well-being</td>
</tr>
<tr>
<td>Gaining a sense of accomplishment and creativity from helping children grow</td>
<td>Risks of bringing up children in a world plagued by crime, war, and pollution</td>
</tr>
<tr>
<td>Learning to become less selfish and to sacrifice</td>
<td>Reduced time to spend with husband or wife</td>
</tr>
<tr>
<td>Having someone carry on after one’s own death</td>
<td>Loss of privacy</td>
</tr>
<tr>
<td>Having offspring who help with parents’ work or add their own income to the family’s resources</td>
<td>Fear that children will turn out badly, through no fault of one’s own</td>
</tr>
</tbody>
</table>

**TABLE 3.1 Advantages and Disadvantages of Parenthood Mentioned by American Couples**

Most adults are also aware that having children means years of extra burdens and responsibilities. When asked about the disadvantages of parenthood, they mention “loss of freedom” most often, followed by “financial strain.” Indeed, the cost of child rearing is a major factor in modern family planning. According to a conservative estimate, today’s new parents will spend about $190,000 in the United States and $170,000 in Canada to rear a child from birth to age 18, and many will incur substantial additional expense for higher education and financial dependency during emerging adulthood—a reality that has contributed to the declining birth rate in industrialized nations (Child Care Advocacy Association of Canada, 2004; U.S. Department of Agriculture, 2005a). Finally, many adults worry greatly about conflict between family and work—not having enough time to meet both child-rearing and job responsibilities (Hewlett, 2003).

Greater freedom to choose whether, when, and how to have children (see the discussion of reproductive choices in Chapter 2) makes contemporary family planning more challenging than it was in Yolanda’s grandmother’s day. As each partner expects to have equal say, childbearing often becomes a matter of delicate negotiation (Cowan & Cowan, 2000). Yet careful weighing of the pros and cons of having children means that many more couples are making informed and personally meaningful decisions—a trend that should increase the chances that they will have children when ready and will find parenting an enriching experience.

**How Large a Family?**

In contrast to her grandmother, Yolanda plans to have no more than two children. And she and Jay are talking about whether to limit their family to a single child. In 1960, the average number of children per North American couple was 3.1. Currently, it is 1.8 in the United States; 1.7 in Australia, Great Britain, and Sweden; 1.6 in Canada; 1.4 in Japan and Germany; and 1.3 in Italy (U.S. Census Bureau, 2007a; 2007b). In addition to more effective birth control, a major reason for this decline is that a family size of one or two children is more compatible with a woman’s decision to divide her energies between family and work. Marital instability has also contributed to smaller families: More couples today get divorced before their childbearing plans are complete.

Popular advice to prospective parents often recommends limiting family size in the interests of “child quality”—more parental affection, attention, and material resources per child, which enhance children’s intellectual development. Do large families make less intelligent children, as prevailing attitudes suggest? Or do less intelligent parents—as a result of heredity, environment, or both—tend to have larger families? To find out researchers turned to a large, two-generation longitudinal study.

Starting in 1972, the U.S. National Longitudinal Survey of Youth (NLSY) followed a representative sample of more than 3,000 14- to 22-year-olds; in 1986 the children of the original participants were added to the investigation. Because both cohorts took intelligence tests, researchers could (1) examine the relationship of sibling birth order within families to mental test scores, to find out whether having more children depresses children’s intellectual functioning, and (2) correlate maternal scores with family size, for insight into whether mothers who score poorly are prone to have larger families.

As the horizontal lines in Figure 3.1 reveal, children’s mental test performance did not decline with later birth...
order—a finding that contradicts the belief that having more children depresses children’s intellectual ability. At the same time, the differences among the lines show that the larger the family, the lower the scores of all siblings. The researchers found that the link between family size and children’s scores can be explained by the strong trend for mothers who are low in intelligence to give birth to more children (Rodgers et al., 2000). In other NLSY research, among children of bright, economically advantaged mothers, the family size–intelligence correlation disappeared (Guo & VanWey, 1999).

Although many good reasons exist for limiting family size, the concern that additional births will reduce children’s intelligence and life chances is not warranted. Rather, young people with lower mental test scores—many of whom dropped out of school, live in poverty, lack hope for their future, and fail to engage in family planning—are most likely to have large families. Return to the Social Issues: Education box on page 75 in Chapter 2 to review the close link between education and family planning. Both are vital for improving children’s quality of life.

Is Yolanda’s grandmother right when she says that parents who have just one child are likely to end up with a spoiled, selfish youngster? As we will see in Chapter 13, research also challenges this widely held belief. Only children are just as well-adjusted as children with siblings. Still, the one-child family, like all family lifestyles, has both pros and cons. Table 3.2 summarizes results of a survey in which only children and their parents were asked what they liked and disliked about living in a single-child family. The list is a useful one for parents to consider when deciding how many children would best fit their life plans.

**Is There a Best Time During Adulthood to Have a Child?**

Yolanda’s grandmother had her first child in her early twenties. Yolanda, at age 28, is pregnant for the first time. Many people believe that women should, ideally, give birth in their twenties, not only because the risk of having a baby with a chromosomal disorder increases with age (see Chapter 2) but also because younger parents have more energy to keep up with active children.

However, as Figure 3.2 reveals, first births to women in their thirties have increased greatly over the past quarter century. Many people are delaying childbearing until their education is

---

**TABLE 3.2 Advantages and Disadvantages of a One-Child Family**

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mentioned by Parents</strong></td>
<td><strong>Mentioned by Children</strong></td>
</tr>
<tr>
<td>Having time to pursue one’s own interests and career</td>
<td>Having no sibling rivalry</td>
</tr>
<tr>
<td>Less financial pressure</td>
<td>Enjoying greater affluence</td>
</tr>
<tr>
<td>Not having to worry about “playing favorites” among children</td>
<td>Having a closer parent-child relationship</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mentioned by Parents</strong></td>
<td><strong>Mentioned by Children</strong></td>
</tr>
<tr>
<td>Walking a “tightrope” between healthy attention and overindulgence</td>
<td>Not getting to experience the closeness of a sibling relationship</td>
</tr>
<tr>
<td>Having only one chance to “make good” as a parent</td>
<td>Feeling too much pressure from parents to succeed</td>
</tr>
<tr>
<td>Being left childless in case of the child’s death</td>
<td>Having no one to help care for parents when they get old</td>
</tr>
</tbody>
</table>

**Source:** Hawke & Knox, 1978.
complete, their careers are established, and they know they
can support a child. Older parents may be somewhat less
energetic than they once were, but they are financially bet-
ter off and emotionally more mature. For these reasons,
they may be better able to invest in parenting.

Nevertheless, reproductive capacity does decline with
age. Fertility problems among women increase from age 15 to
50, with a sharp rise in the mid-thirties. Between ages 25
and 34, nearly 14 percent of women are affected, a figure
that climbs to 26 percent for 35- to 44-year-olds. Age also
affects male reproductive capacity. Amount of semen and
concentration of sperm in each ejaculation gradually
decline after age 30. Consequently, compared to a 25-year-
old man, a 45-year-old is 12 times as likely to take more than
two years to achieve a conception (Hassan & Killick, 2003;

Women with demanding careers are especially likely to
delay parenthood (Barber, 2001). Many believe, incorrectly,
that if they have difficulty conceiving, they can rely on
reproductive technologies. But recall from Chapter 2 that
the success of these procedures drops steadily with age.
Although no one time during adulthood is best to begin
parenthood, individuals who decide to put off childbirth
until well into their thirties or early forties risk having fewer
children than they desire or none at all.

---

**Ask Yourself**

**Review** Using research findings, explain why
the common assumption that larger families make less
intelligent children is incorrect. What accounts for the link
between family size and mental test scores?

**Apply** Rhonda and Mark are career-oriented,
35-year-old parents of an only child. They are thinking
about having a second baby. What factors should they keep
in mind as they decide whether to add to their family at
this time in their lives?

**Connect** Why is it incorrect for couples
who postpone childbearing until age 40 to conclude that
medical advances can overcome fertility problems? (See
Chapter 2, page 00.)

**Reflect** Ask one of your parents or grand-
parents to list their motivations for having children. How do
those motivations compare with your own? What factors—
for example, education or cultural changes—might account
for any differences?

---

**Prenatal Development**

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

About once every 28 days, in the middle of a woman’s menstrual cycle, an ovum bursts from one of her ovaries, two walnut-sized organs located deep inside her abdomen, and is drawn into one of two fallopian tubes—long, thin structures that lead to the hollow, soft-lined uterus (see Figure 3.3). While the ovum is traveling, the spot on the ovary from which it was released, now called the corpus luteum, secretes hormones that prepare the lining of the uterus to receive a fertilized ovum. If pregnancy does not occur, the corpus luteum shrinks, and the lining of the uterus is discarded two weeks later with menstruation.

The male produces sperm in vast numbers—an average of 300 million a day—in the testes, two glands located in the scrotum, sacs that lie just behind the penis. In the final process of maturation, each sperm develops a tail that permits it to swim long distances, upstream in the female reproductive tract, through the cervix (opening of the uterus), and into the fallopian tube, where fertilization usually takes place. The journey is difficult, and many sperm die. Only 300 to 500 reach the ovum, if one happens to be present. Sperm live for up to 6 days and can lie in wait for the ovum, which survives for only 1 day after being released into the fallopian tube. However, most conceptions result from intercourse during a 3-day period—on the day of or during the 2 days preceding ovulation (Wilcox, Weinberg, & Baird, 1995).

With conception, the story of prenatal development begins to unfold. The vast changes that take place during the 38 weeks of pregnancy are usually divided into three phases: (1) the period of the zygote, (2) the period of the embryo, and (3) the period of the fetus. As we look at what happens in each, you may find it useful to refer to Table 3.3 on page 102, which summarizes major milestones of prenatal development.

**FIGURE 3.3**

Female reproductive organs, showing fertilization, early cell duplication, and implantation. (Adapted from K. L. Moore and T. V. N. Persaud, 2003, Before We Are Born, 6th ed., Philadelphia: Saunders, p. 36. Reprinted by permission of the publisher and authors.)
The Period of the Zygote

The period of the zygote lasts about two weeks, from fertilization until the tiny mass of cells drifts down and out of the fallopian tube and attaches itself to the wall of the uterus. The zygote’s first cell duplication is long and drawn out; it is not complete until about 30 hours after conception. Gradually, new cells are added at a faster rate. By the fourth day, 60 to 70 cells exist that form a hollow, fluid-filled ball called a blastocyst (refer again to Figure 3.3). The cells on the inside of the blastocyst, called the embryonic disk, will become the new organism; the thin outer ring of cells, termed the trophoblast, will become the structures that provide protective covering and nourishment.

Implantation

Between the seventh and ninth days, implantation occurs: The blastocyst burrows deep into the uterine lining where, surrounded by the woman’s nourishing blood, it starts to grow in earnest. At first, the trophoblast (protective outer layer) multiplies fastest. It forms a membrane, called the amnion, that encloses the developing organism in amniotic fluid, which helps keep the temperature of the prenatal world constant and provides a cushion against any jolts caused by the woman’s movement. A yolk sac emerges that produces blood cells until the developing liver, spleen, and bone marrow are mature enough to take over this function (Moore & Persaud, 2003).

The events of these first two weeks are delicate and uncertain. As many as 30 percent of zygotes do not survive this period. In some, the sperm and ovum did not join properly. In others, for some unknown reason, cell duplication never begins. By preventing implantation in these cases, nature eliminates most prenatal abnormalities (Sadler, 2006).

The Placenta and Umbilical Cord

By the end of the second week, cells of the trophoblast form another protective membrane—the chorion, which surrounds the amnion. From the chorion, tiny fingerlike villi, or blood vessels, emerge. As these villi burrow into the uterine wall, the placenta starts to develop. By bringing the mother’s and the embryo’s blood close together, the placenta permits food and oxygen to reach the developing organism and waste products to be carried away. A membrane forms that allows these substances to be exchanged but prevents the mother’s and the embryo’s blood from mixing directly (see Figure 3.4 on page 103).

Recall from Chapter 2 that chorionic villus sampling is the prenatal diagnostic method that can be performed earliest, at nine weeks after conception. In this procedure, tissues from the ends of the villi are removed and examined for genetic abnormalities.
The placenta is connected to the developing organism by the **umbilical cord**. In the period of the zygote, it first appears as a primitive body stalk, but during the course of pregnancy, it grows to a length of 1 to 3 feet. The umbilical cord contains one large vein that delivers blood loaded with nutrients and two arteries that remove waste products. The force of blood flowing through the cord keeps it firm, much like a garden hose, so it seldom tangles while the embryo, like a space-walking astronaut, floats freely in its fluid-filled chamber (Moore & Persaud, 2003).

By the end of the period of the zygote, the developing organism has found food and shelter. Already, it is a very complex being. These dramatic beginnings take place before most mothers know they are pregnant.
The Period of the Embryo

The period of the embryo lasts from implantation through the eighth week of pregnancy. During these brief 6 weeks, the most rapid prenatal changes take place, as the groundwork is laid for all body structures and internal organs. Because all parts of the body are forming, the embryo is especially vulnerable to interference with healthy development. But a short time span of embryonic growth helps limit opportunities for serious harm.

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

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

While the nervous system is developing, the heart begins to pump blood, and muscles, backbone, ribs, and digestive tract start to appear. At the end of the first month, the curled embryo—only ¼ inch long—consists of millions of organized groups of cells with specific functions.

THE SECOND MONTH  ■ In the second month, growth continues rapidly. The eyes, ears, nose, jaw, and neck form. Tiny buds become arms, legs, fingers, and toes. Internal organs are more distinct: The intestines grow, the heart develops separate chambers, and the liver and spleen take over production of blood cells so that the yolk sac is no longer needed. Changing body proportions cause the embryo’s posture to become more upright. Now 1 inch long and ½ of an ounce in weight, the embryo can sense its world. It responds to touch, particularly in the mouth area and on the soles of the feet. And it can move, although its tiny flutters are still too light to be felt by the mother (Moore & Persaud, 2003).
The Period of the Fetus

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

THE THIRD MONTH ■ In the third month, the organs, muscles, and nervous system start to become organized and connected. When the brain signals, the fetus kicks, bends its arms, forms a fist, curls its toes, opens its mouth, and even sucks its thumb. The tiny lungs begin to expand and contract in an early rehearsal of breathing movements. By the twelfth week, the external genitals are well-formed, and the sex of the fetus is evident (Sadler, 2006). Using ultrasound, Yolanda’s doctor could see that she would have a boy (although Yolanda and Jay asked not to be told the fetus’s sex). Other finishing touches appear, such as fingernails, toenails, tooth buds, and eyelids that open and close. The heartbeat is now stronger and can be heard through a stethoscope.

Prenatal development is sometimes divided into trimesters, or three equal time periods. At the end of the third month, the first trimester is complete.

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

At the end of the second trimester, many organs are well-developed. And most of the brain’s billions of neurons are in place; few will be produced after this time. However, glial cells, which support and feed the neurons, continue to increase at a rapid rate throughout the remaining months of pregnancy, as well as after birth. Consequently, brain weight increases tenfold from the 20th week until birth (Roelfsema et al., 2004).

Brain growth means new behavioral capacities. The 20-week-old fetus can be stimulated as well as irritated by sounds. And if a doctor looks inside the uterus using fetoscopy (see Chapter 2, page 00), fetuses try to shield their eyes from the light with their hands, indicating that the sense of sight has begun to emerge (Moore & Persaud, 2003). Still, a fetus born at this time cannot survive. Its lungs are immature, and the brain cannot yet control breathing movements or body temperature.

THE THIRD TRIMESTER ■ During the final trimester, a fetus born early has a chance for survival. The point at which the baby can first survive, called the age of viability, occurs sometime between 22 and 26 weeks (Moore & Persaud, 2003). A baby born between the seventh and eighth month, however, usually needs oxygen assistance to breathe. Although the brain’s respiratory center is now mature, tiny air sacs in the lungs are not yet ready to inflate and exchange carbon dioxide for oxygen.
During the last three months, the brain continues to make great strides. The cerebral cortex, the seat of human intelligence, enlarges. Convolutions and grooves in its surface appear, permitting a dramatic increase in surface area without extensive increase in head size. As a result, maximum prenatal brain growth occurs without the full-term baby’s head becoming too large to pass through the birth canal. As neurological organization improves, the fetus spends more time awake. At 20 weeks, the fetal heart rate reveals no periods of alertness. But by 28 weeks, fetuses are awake about 11 percent of the time, a figure that rises to 16 percent just before birth (DiPietro et al., 1996). And between 30 and 34 weeks, fetuses show rhythmic alternations between sleep and wakefulness that gradually increase in organization (Rivkees, 2003).

By the end of pregnancy, the fetus also takes on the beginnings of a personality. Higher fetal activity in the last weeks of pregnancy predicts a more active infant in the first month of life—a relationship that, for boys, persists into early childhood (Groome et al., 1999). Fetal activity is linked in other ways to infant temperament. In one study, more active fetuses during the third trimester became 1-year-olds who could better handle frustration and 2-year-olds who were less fearful, in that they more readily interacted with toys and with an unfamiliar adult in a laboratory (DiPietro et al., 2002). Perhaps fetal activity level is an indicator of healthy neurological development, which fosters adaptability in childhood. The relationships just described, however, are only modest. As we will see in Chapter 7, sensitive caregiving can modify the temperaments of children who have difficulty adapting to new experiences.

The third trimester also brings greater responsiveness to external stimulation. As we will see later when we discuss newborn capacities, from bathing in and swallowing amniotic fluid (its makeup is influenced by the mother’s diet), fetuses acquire taste and odor preferences. Between 23 and 30 weeks, connections form between the cerebral cortex and brain regions involved in pain sensitivity. By this time, painkillers should be used in any surgical procedures (Lee et al., 2005). When Yolanda turned on an electric mixer, the fetus reacted with a forceful startle. And by 28 weeks, fetuses blink their eyes in reaction to nearby sounds (Kisilevsky & Low, 1998; Saffran, Werker, & Werner, 2006).

Within the next 6 weeks, fetuses distinguish the tone and rhythm of different voices and sounds: They show systematic heart rate changes in response to a male versus a female speaker, to the mother’s voice versus a stranger’s, and to a simple familiar melody (descending tones) versus an unfamiliar melody (ascending tones) (Granier-Defere et al., 2003; Huotilainen et al., 2005; Kisilevsky et al., 2003; Lecanuet et al., 1993). And in one clever study, mothers read aloud Dr. Seuss’s lively book The Cat in the Hat each day during the last 6 weeks of pregnancy. After birth, their infants learned to turn on recordings of the mother’s voice by sucking on nipples. They sucked hardest to hear The Cat in the Hat—the sound they had come to know while still in the womb (DeCasper & Spence, 1986).

**TAKE A MOMENT...** On the basis of these findings, would you recommend that expectant mothers provide fetuses with certain kinds of stimulation to enhance later mental development? Notice how risky it is to draw such conclusions. First, specific forms of fetal stimulation, such as reading aloud or playing classical music, are unlikely to have a long-lasting impact on cognitive development because of the developing child’s constantly changing capacities and experiences, which can override the impact of fetal stimulation (Lecanuet, Granier-Deferre, & DeCasper, 2005). Second, although ordinary stimulation contributes to the functioning of sensory systems, excessive input can be dangerous. For example, animal studies indicate that a sensitive period (see page 23 in Chapter 1) exists in which the fetal ear is highly susceptible to injury. During that time, prolonged exposure to sounds that are harmless to the mature ear can permanently damage fetal inner-ear structures (Rubel & Ryals, 1982, 1983).

In the final three months, the fetus gains more than 5 pounds and grows 7 inches. As it fills the uterus, it gradually moves less often. In addition, brain development, which enables the organism to inhibit behavior, contributes to a decline in physical activity (DiPietro et al., 2006).
Ask Yourself

**Review** Why is the period of the embryo regarded as the most dramatic prenatal phase? Why is the period of the fetus called the “growth and finishing” phase?

**Apply** Amy, who is two months pregnant, wonders how the developing organism is being fed and what parts of the body have formed. “I don’t look pregnant yet, so does that mean not much development has taken place?” she asks. How would you respond to Amy?

**Connect** How is brain development related to fetal capacities and behavior? What implications do individual differences in fetal behavior have for the baby’s temperament after birth?

---

### Prenatal Environmental Influences

Although the prenatal environment is far more constant than the world outside the womb, a great many factors can affect the embryo and fetus. Yolanda and Jay learned that they could do a great deal to create a safe environment for development before birth. Let’s look at some factors that can influence the prenatal environment.

---

1. In the eighth month, a layer of fat is added to assist with temperature regulation. The fetus also receives antibodies from the mother’s blood to protect against illnesses, since the newborn’s own immune system will not work well until several months after birth. In the last weeks, most fetuses assume an upside-down position, partly because of the shape of the uterus and partly because the head is heavier than the feet. Growth slows, and birth is about to take place.
The term *teratogen* refers to any environmental agent that causes damage during the prenatal period. It comes from the Greek word *teras*, meaning “malformation” or “monstrosity.” Scientists selected this label because they first learned about harmful prenatal influences from cases in which babies had been profoundly damaged. But the harm done by teratogens is not always simple and straightforward. It depends on the following factors:

- **Dose.** As we discuss particular teratogens, we will see that larger doses over longer time periods usually have more negative effects.
- **Heredity.** The genetic makeup of the mother and the developing organism plays an important role. Some individuals are better able than others to withstand harmful environments.
- **Other negative influences.** The presence of several negative factors at once, such as poor nutrition, lack of medical care, and additional teratogens, can worsen the impact of a single harmful agent.
- **Age.** The effects of teratogens vary with the age of the organism at time of exposure. We can best understand this last idea if we again think of the sensitive period concept. Recall that a sensitive period is a limited time span in which a part of the body or a behavior is biologically prepared to develop rapidly. During that time, it is especially sensitive to its surroundings. If the environment is harmful, then damage occurs, and recovery is difficult and sometimes impossible.

Figure 3.5 summarizes prenatal sensitive periods. Look at it carefully, and you will see that some parts of the body, such as the brain and eye, have long sensitive periods that extend
When Michael entered the world 55 years ago, 6 weeks premature and weighing only 4 pounds, the doctor delivering him wasn’t sure he would make it. Michael not only survived but enjoyed good health until his mid-forties, when, during a routine medical checkup, he was diagnosed with high blood pressure and type 2 diabetes. Michael had no apparent risk factors for these conditions: He wasn’t overweight, didn’t smoke, and didn’t eat high-fat foods. Nor did the illnesses run in his family. Could the roots of Michael’s health problems date back to his prenatal development?

Increasing evidence suggests that prenatal environmental factors—ones that are not toxic (as are tobacco or alcohol) but rather fairly subtle, such as the flow of nutrients and hormones across the placenta—can affect an individual’s health decades later.

**Low Birth Weight and Heart Disease, Stroke, and Diabetes**

Carefully controlled animal experiments reveal that a poorly nourished, underweight fetus experiences changes in body structure and function that greatly increase the risk of cardiovascular disease in adulthood (Franco et al., 2002). To explore this relationship in humans, researchers tapped public records, gathering information on the birth weights of 15,000 British men and women and the occurrence of disease in middle adulthood. Those weighing less than 5 pounds at birth had a 50 percent greater chance of dying of heart disease and stroke later in life.

**FIGURE 3.6**

**Relationship of birth weight to breast cancer risk in adulthood.** In a study of more than 2,000 British births with follow-ups in adulthood, birth weight predicted breast cancer incidence after many other prenatal and postnatal health risks were controlled. The breast cancer risk was especially high for women whose birth weights were greater than 3,999 grams, or 8.8 pounds. (Adapted from Silva et al., 2004.)

Throughout prenatal development. Other sensitive periods, such as those for the limbs and palate, are much shorter. Figure 3.5 also indicates that we can make some general statements about the timing of harmful influences. In the period of the zygote, before implantation, teratogens rarely have any impact. If they do, the tiny mass of cells is usually so completely damaged that it dies. The embryonic period is the time when serious defects are most likely to occur because the foundations for all body parts are being laid down. During the fetal period, teratogenic damage is usually minor. However, organs such as the brain, ears, eyes, teeth, and genitals can still be strongly affected.

The effects of teratogens go beyond immediate physical damage. Some health effects are subtle and delayed. As the Biology and Environment box above illustrates, they may not show up for decades. Furthermore, psychological consequences may occur indirectly, as a result of physical damage. For example, a defect resulting from drugs the mother took during pregnancy can affect others’ reactions to the child as well as the child’s ability to explore the environment. Over time, parent–child interaction, peer relations, and opportunities to explore may suffer. These experiences, in turn, can have far-reaching consequences for cognitive, emotional, and social development.
stroke, even after SES and a variety of other health risks were controlled. The connection between birth weight and cardiovascular disease was strongest for people whose weight-to-length ratio at birth was very low—a sign of prenatal growth stunting (Godfrey & Barker, 2000; Martyn, Barker, & Osmond, 1996).

In other large-scale studies, a consistent link between low birth weight and heart disease, stroke, and diabetes in middle adulthood has emerged—for both sexes and in diverse countries, including Finland, India, Jamaica, and the United States (Barker, 2002; Fowden, Giussani, & Forhead, 2005; Godfrey & Barker, 2001). Smallness itself does not cause later health problems; rather, researchers believe, complex factors associated with it are involved.

Some speculate that a poorly nourished fetus diverts large amounts of blood to the brain, causing organs in the abdomen, such as the liver and kidneys (involved in controlling cholesterol and blood pressure), to be undersized (Hales & Ozanne, 2003). The result is heightened later risk for heart disease and stroke. In the case of diabetes, inadequate prenatal nutrition may permanently impair functioning of the pancreas, leading glucose intolerance to rise as the person ages (Wu et al., 2004). Yet another hypothesis, supported by both animal and human research, is that the malfunctioning placentas of some expectant mothers permit high levels of stress hormones to reach the fetus, which retards fetal growth, increases fetal blood pressure, and promotes hyperglycemia (excess blood sugar), predisposing the developing person to later disease (Stocker, Arch, & Cawthorne, 2005).

Finally, prenatally growth-stunted babies often gain excessive weight in childhood, once they have access to plentiful food. This excess weight usually persists, greatly increasing the risk of diabetes (Hypponen, Power, & Smith, 2003).

High Birth Weight and Breast Cancer

The other prenatal growth extreme—high birth weight—is related to breast cancer, the most common malignancy in adult women (Ahlgren et al., 2004; Vatten et al., 2002). In one study of more than 2,000 British women, high birth weight—especially weight above 8.8 pounds—was associated with a greatly increased incidence of breast cancer, even after other cancer risks were controlled (see Figure 3.6) (Silva et al., 2004). Researchers suspect that the culprit is excessive maternal estrogen during pregnancy, which promotes large fetal size and alters beginning breast tissue so that it may respond to estrogen in adulthood by becoming malignant.

High birth weight is also associated with increases in digestive and lymphatic cancers in both men and women (McCormack et al., 2005). As yet, the reasons are unclear.

Notice how an important idea about development that we discussed in earlier chapters is at work here: bidirectional influences between child and environment. Now let’s take a look at what scientists have discovered about a variety of teratogens.

**PRESCRIPTION AND NONPRESCRIPTION DRUGS**

In the early 1960s, the world learned a tragic lesson about drugs and prenatal development. At that time, a sedative called thalidomide was widely available in Canada, Europe, and South America. When taken by mothers 4 to 6 weeks after conception, thalidomide produced gross deformities of the embryo’s developing arms and legs and, less frequently, damage to the ears, heart, kidneys, and genitals. About 7,000 infants worldwide were affected (Moore & Persaud, 2003). As children exposed to thalidomide grew older, many scored below average in intelligence. Perhaps the drug damaged the central nervous system directly. Or the child-rearing conditions of these severely deformed youngsters may have impaired their intellectual development.
Currently, thalidomide is being prescribed to treat *erythema nodosum*, a rare but painful skin inflammation associated with flu-like symptoms. It also may prove useful for a variety of other diseases. Consequently, some researchers worry about a resurgence of thalidomide-caused birth defects (Ances, 2002). Turn to the Social Issues: Health box on the following page to find out about a drug, prescribed to treat severe acne, that has sparked similar concerns.

Another medication, a synthetic hormone called *diethylstilbestrol (DES)*, was widely prescribed between 1945 and 1970 to prevent miscarriages. As daughters of these mothers reached adolescence and young adulthood, they showed unusually high rates of cancer of the vagina, malformations of the uterus, and infertility. When they tried to have children, their pregnancies more often resulted in prematurity, low birth weight, and miscarriage than those of non-DES-exposed women. Young men showed an increased risk of genital abnormalities and cancer of the testes (Hammes & Laitman, 2003; Palmer et al., 2001).

Any drug with a molecule small enough to penetrate the placental barrier can enter the embryonic or fetal bloodstream. Nevertheless, many pregnant women continue to take over-the-counter medications without consulting their doctors. Aspirin is one of the most common. Several studies suggest that regular aspirin use is linked to low birth weight, infant death around the time of birth, poorer motor development, and lower intelligence test scores in early childhood, although other research fails to confirm these findings (Barr et al., 1990; Kozer et al., 2003; Streissguth et al., 1987). Coffee, tea, cola, and cocoa contain another frequently consumed drug, caffeine. Heavy caffeine intake (more than three cups of coffee per day) is associated with low birth weight, miscarriage, and newborn withdrawal symptoms, such as irritability and vomiting (Klebanoff et al., 2002; Vik et al., 2003). And antidepressant medication taken during the third trimester is linked to increased risk of birth complications, including respiratory distress (Lattimore et al., 2005).

Because children’s lives are involved, we must take findings like these seriously. At the same time, we cannot be sure that these frequently used drugs actually cause the problems just mentioned. Often mothers take more than one drug. If the embryo or fetus is injured, it is hard to tell which drug might be responsible or whether other factors correlated with drug taking are really at fault. Until we have more information, the safest course is the one Yolanda took: Avoid these drugs entirely. Unfortunately, many women do not know that they are pregnant during the early weeks of the embryonic period, when exposure to medications (and other teratogens) can be of greatest threat.

**Illegal Drugs**

The use of highly addictive mood-altering drugs, such as cocaine and heroin, has become more widespread, especially in poverty-stricken inner-city areas, where these drugs provide a temporary escape from a daily life of hopelessness. As many as 3 to 7 percent of American and Canadian babies born in large cities, and 1 to 2 percent of all North American newborns, have been exposed to cocaine prenatally (British Columbia Reproductive Care Program, 2003; Lester et al., 2001).

Babies born to users of cocaine, heroin, or methadone (a less addictive drug used to wean people away from heroin) are at risk for a wide variety of problems, including prematurity, low birth weight, physical defects, breathing difficulties, and death around the time of birth (Behnke et al., 2001; Schuetze & Eiden, 2006; Walker, Rosenberg, & Balaban-Gil, 1999). In addition, these infants arrive drug-addicted. They often are feverish and irritable at birth and have trouble sleeping, and their cries are abnormally shrill and piercing—a common symptom among stressed newborns (Bauer et al., 2005). When mothers with many problems of their own must care for these babies, who are difficult to calm, cuddle, and feed, behavior problems are likely to persist.

Throughout the first year, heroin- and methadone-exposed infants are less attentive to the environment than nonexposed babies, and their motor development is slow. After infancy, some children get better, while others remain jittery and inattentive. The kind of parenting they receive seems to explain why problems last for some of these youngsters but not for others (Cosden, Peerson, & Elliott, 1997).

Evidence on cocaine suggests that some prenatally exposed babies develop lasting difficulties. Cocaine constricts the blood vessels, causing oxygen delivered to the developing organism to fall for 15 minutes following a high dose. It also can alter the production and functioning of
Social Issues: Health

Can a Thalidomide-Like Tragedy Occur Again? The Teratogenic Effects of Accutane

Twenty-five-year-old Corrine, several weeks pregnant, suffered from severe, disfiguring acne. After several milder medications failed to clear up the inflamed, hard bumps covering her face, Corrine’s dermatologist prescribed the drug Accutane, also known by the generic name isotretinoin—a vitamin A derivative. Within days, Corrine’s acne receded.

We depend on vitamin A for the health of our skin, hair, mucous membranes, and immune system. But in excess, vitamin A and its derivatives are toxic to the developing organism. Taken during the first trimester of pregnancy, Accutane causes extensive damage, including eye, ear, skull, brain, heart, central nervous system, and immune system abnormalities (Honein, Paulozzi, & Erickson, 2001). Corrine’s baby was born with multiple defects, including heart disease, facial deformities, and hydrocephalus (accumulation of excess fluid, which compresses and damages the brain). After extensive treatment, including heart surgery, he died at 9 weeks of age.

Accutane is the most widely used teratogenic drug since the thalidomide disaster of nearly a half-century ago (Accutane Action Group Forum, 2003). Since its release in the early 1980s, 12 million people in some 100 countries have been treated with it. Hundreds of thousands of U.S. and Canadian women of childbearing age currently take Accutane, and the number of prescriptions is increasing. Despite its established harmful effects, more than 2,300 reports of drug-exposed pregnancies have occurred in the United States alone. Miscarriage rates among affected women are high, and many others choose to end their pregnancies once they learn about possible prenatal damage. Although the number of babies born with Accutane-caused malformations is not known, at least 162 documented American cases exist (Andresen, 2006).

Accutane’s packaging warns users to avoid pregnancy and also states that the drug must not be used by women who are pregnant. Furthermore, early case reports of infants damaged by the drug caused the manufacturer to step up efforts to get doctors to inform patients about the importance of abstaining from intercourse or using two methods of birth control if taking Accutane. The drug company will even pay for birth control counseling and contraceptives. Why, then, do Accutane-exposed pregnancies continue to occur?

To find out, researchers interviewed women who became pregnant while taking Accutane. Findings revealed that most did not use two forms of contraception, and more than half reported at least one instance in which they used none at all! Either their doctors had failed to communicate the risks, or the patients had not been receptive to the warnings. Furthermore, only half the women had acne severe enough to warrant Accutane treatment (Honein, Paulozzi, & Erickson, 2001). Doctors were overprescribing the drug, using it even to treat mild skin inflammations. Other evidence indicates that some women purchase the medication in foreign countries, use a “leftover” prescription, or “borrow” medication from a friend, without following manufacturer recommendations for monthly pregnancy testing and effective birth control (Robertson et al., 2002).

Unlike thalidomide, which was released before its catastrophic consequences were known, Accutane’s teratogenic effects were established when the drug was first marketed. Yet barriers to preventing prenatal exposure persist. Women who become pregnant without planning (about half of all U.S. and Canadian expectant mothers) are less likely to avoid drug taking and less responsive to teratogen counseling (Atanackovic & Koren, 1999). And some patients misinterpret the teratogen symbol that appears on bottles of Accutane and thalidomide: They take it to mean that a woman cannot get pregnant while taking the drug—a conclusion that increases the risk of exposures during pregnancy (Honein et al., 2002).

Notice how a combination of factors—biological, psychological, and environmental—jointly contribute to Accutane prenatal risks. Consequently, multifaceted efforts are needed to prevent Accutane from spiraling into a thalidomide-like tragedy. These include:

- Restriction of teratogenic drugs to treatment of severe medical conditions, for which there are no alternatives
- Improved public and patient education about teratogenic effects and protective strategies
- Interventions that promote widespread, effective contraceptive use

In 2005, the U.S. federal government required that doctors enter every patient who takes Accutane into an Internet database. Before a prescription can be filled, patients must verify that their doctors counseled them about risks and performed pregnancy tests. Patients must also pledge that they will not share Accutane with anyone and will stop taking it if they get pregnant, miss a menstrual period, or stop using two birth control methods (Healy, 2005).

Accutane is the most widely used, potent teratogenic drug in the industrialized world. If a woman becomes pregnant and takes the drug during the first trimester, her baby is likely to suffer from multiple, severe physical defects. Accutane-exposed pregnancies continue to occur because doctors sometimes fail to communicate the risks and patients are not always receptive to warnings. And many women misinterpret the teratogen symbol that appears on Accutane bottles as indicating that a woman cannot get pregnant while using the drug!
prematurely are at increased risk for later physical, emotional, and pregnancy, including maternal drug use and cigarette smoking. Babies born birth weight can result from a variety of environmental influences during is underweight, breathes with the aid of a respirator. Prematurity and low exposure.

caused by prenatal alcohol behavioral outcomes of physical, mental, and abnormalities, and brain injury; usually seen in children whose mothers consumed large amounts of alcohol during most or all of pregnancy.

facial abnormalities. Prematurity and low exposure. The most severe form of fetal alcohol spectrum disorder, distinguished by slow physical growth, facial abnormalities, and brain injury; usually seen in children whose mothers consumed large amounts of alcohol during most or all of pregnancy.

symptoms of fetal alcohol spectrum disorder characterized by facial abnormalities and brain injury, but less severe than fetal alcohol syndrome; usually seen in children whose mothers drank alcohol in smaller quantities during pregnancy.

alcohol-related neurodevelopmental disorder (ARND) The least severe form of fetal alcohol spectrum disorder, involving brain injury, but with typical physical growth and absence of facial abnormalities.

neurons and the chemical balance in the fetus’s brain. These effects may contribute to an array of cocaine-associated physical defects, including eye, bone, genital, urinary tract, kidney, and heart deformities; hemorrhages and seizures; and severe growth retardation (Covington et al., 2002; Feng, 2005; Mayes, 1999). Several studies report perceptual, motor, attention, memory, and language problems in infancy that persist into the preschool years (Lester et al., 2003; Noland et al., 2005; Singer et al., 2002a, 2002b, 2004).

but other investigations reveal no major negative effects of prenatal cocaine exposure (Behnke et al., 2006; Frank et al., 2005; Hurt et al., 2005). These contradictory findings indicate how difficult it is to isolate the precise damage caused by illegal drugs. Cocaine users vary greatly in the amount, potency, and purity of the cocaine they ingest. Also, they often take several drugs, display other high-risk behaviors, suffer from poverty and other stresses, and engage in insensitive caregiving. The joint impact of these factors worsens outcomes for children (Alessandri, Bendersky, & Lewis, 1998; Carta et al., 2001). But researchers have yet to determine exactly what accounts for findings of cocaine-related damage in some studies but not in others.

Another illegal drug, marijuana, is used more widely than heroin and cocaine. Studies examining its relationship to low birth weight and prematurity reveal mixed findings (Fried, 1993). Several researchers have linked prenatal marijuana exposure to smaller head size (a measure of brain growth); to sleep, attention, memory, and academic achievement difficulties and to depression in childhood; and to poorer problem-solving performance in adolescence (Dahl et al., 1995; Goldschmidt et al., 2004; Gray et al., 2005; Huizink & Mulder, 2006). As with cocaine, however, lasting consequences are not well-established. Overall, the effects of illegal drugs are far less consistent than the impact of two legal substances to which we now turn: tobacco and alcohol.

**Tobacco** Although smoking has declined in Western nations, an estimated 12 percent of American women and 17 percent of Canadian women smoke during their pregnancies (Martin et al., 2006; Millar & Hill, 2004). The best-known effect of smoking during the prenatal period is low birth weight. But the likelihood of other serious consequences, such as miscarriage, prematurity, impaired heart rate and breathing during sleep, infant death, and asthma and cancer later in childhood, is also increased (Franco et al., 2000; Jaakkola & Gissler, 2004). The more cigarettes a mother smokes, the greater the chances that her infant will be affected. If a pregnant woman decides to stop smoking at any time, even during the last trimester, she immediately reduces the likelihood that her infant will be born underweight and suffer from future problems (Klesges et al., 2001).

Even when a baby of a smoking mother appears to be born in good physical condition, slight behavioral abnormalities may threaten the child’s development. Newborns of smoking mothers are less attentive to sounds, display more muscle tension, are more excitable when touched and visually stimulated, and more often have colic (persistent crying)—findings that suggest subtle negative effects on brain development (Law et al., 2003; Søndergaard et al., 2002). Furthermore, an unresponsive, restless baby may not evoke the kind of interaction from adults that promotes healthy psychological development. Some studies report that prenatally exposed children and adolescents have shorter attention spans, poorer memories, lower mental test scores, and more behavior problems (Fried, Watkinson, & Gray, 2003; Huizink & Mulder, 2006; Thapar et al., 2003). However, other factors closely associated with smoking, such as lower maternal education and income levels, may contribute to these outcomes (Ernst, Moolchan, & Robinson, 2001).
Exactly how can smoking harm the fetus? Nicotine, the addictive substance in tobacco, constricts blood vessels, lessens blood flow to the uterus, and causes the placenta to grow abnormally. This reduces the transfer of nutrients, so the fetus gains weight poorly. Also, nicotine raises the concentration of carbon monoxide in the bloodstreams of both mother and fetus. Carbon monoxide displaces oxygen from red blood cells, damaging the central nervous system and slowing body growth in the fetuses of laboratory animals (Friedman, 1996). Similar effects may occur in humans.

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

**ALCOHOL**  
In his moving book *The Broken Cord*, Michael Dorris (1989), a Dartmouth University anthropology professor, described what it was like to raise his adopted son Abel (called Adam in the book), whose biological mother died of alcohol poisoning shortly after his birth. A Sioux Indian, Abel was born with fetal alcohol spectrum disorder (FASD), a term that encompasses a range of physical, mental, and behavioral outcomes caused by prenatal alcohol exposure. As Table 3.4 on page 114 shows, children with FASD are given one of three diagnoses, which vary in severity:

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

2. **Partial fetal alcohol syndrome** (p-FAS), characterized by (a) two of the three facial abnormalities just mentioned and (b) brain injury, again evident in at least three areas of impaired functioning. Mothers of children with p-FAS generally drank alcohol in smaller quantities, and children’s defects vary with the timing and length of alcohol exposure. Furthermore, recent evidence suggests that paternal alcohol use around the time of conception may alter gene expression (see page 00 in Chapter 2), thereby contributing to symptoms (Abel, 2004).

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

Even when provided with enriched diets, FAS babies fail to catch up in physical size during infancy or childhood. Mental impairment associated with all three FASD diagnoses is also permanent: In his teens and twenties, Abel Dorris had trouble concentrating and keeping a routine job, and he suffered from poor judgment. For example, he would buy something and not wait for change or wander off in the middle of a task. He died in 1991, at age 23, after being hit by a car.

The more alcohol a woman consumes during pregnancy, the poorer the child’s motor coordination, speed of information processing, reasoning, and intelligence and achievement test scores during the preschool and school years (Burden, Jacobson, & Jacobson, 2005; Korkman, Kettunen, & Autilia-Raemoe, 2003). In adolescence and early adulthood, FASD is associated with...
TABLE 3.4  Fetal Alcohol Spectrum Disorder: Criteria for Diagnosis

<table>
<thead>
<tr>
<th>Criteria</th>
<th>FAS</th>
<th>p-FAS</th>
<th>ARND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow physical growth</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Facial abnormalities:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Short eyelid openings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Thin upper lip</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Smooth or flattened philtron</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brain injury</td>
<td>Impairment in a minimum of three areas of functioning</td>
<td>Impairment in a minimum of three areas of functioning</td>
<td>Impairment in a minimum of three areas of functioning</td>
</tr>
</tbody>
</table>

Source: Loock et al., 2005.

Persisting motor coordination deficits, poor school performance, trouble with the law, inappropriate sexual behavior, alcohol and drug abuse, and lasting mental health problems (Baer et al., 2003; Connor et al., 2006; Howell et al., 2006; Streissguth et al., 2004).

How does alcohol produce its devastating effects? First, it interferes with cell duplication and migration in the primitive neural tube. Brain-imaging research reveals arrested brain growth, structural damage, and abnormalities in the electrical and chemical activity involved in transferring messages from one part of the brain to another (Bookstein et al., 2002; Riley, McGee, & Sowell, 2004). Second, the body uses large quantities of oxygen to metabolize alcohol. A pregnant woman’s heavy drinking draws away oxygen that the developing organism needs for cell growth.

About one-fourth of American and Canadian mothers reported drinking some alcohol during their pregnancies. As with heroin and cocaine, alcohol abuse is higher in poverty-stricken women (Bearer et al., 2005; Health Canada, 2006b). On some Native American and Canadian First Nations reservations, the incidence of FAS is as high as 10 percent (Silverman et al., 2001). Unfortunately, when affected girls later become pregnant, the poor judgment caused by the syndrome often prevents them from understanding why they themselves should avoid alcohol. As a result, the tragic cycle is likely to be repeated in the next generation.

How much alcohol is safe during pregnancy? Even mild drinking, less than one drink per day, is associated with reduced head size and body growth among children followed into adolescence (Day et al., 2002; Jacobson et al., 2004). Recall that other factors—both genetic and environmental—can make some fetuses more vulnerable to teratogens. Therefore, no amount of alcohol is safe. Couples planning a pregnancy and expectant mothers should avoid alcohol entirely.

RADIATION In Chapter 2, we saw that ionizing radiation can cause mutation, damaging DNA in ova and sperm. When mothers are exposed to radiation during pregnancy, the embryo or fetus can suffer additional harm. Defects due to radiation were tragically apparent in the children born to pregnant Japanese women who survived the bombing of Hiroshima and Nagasaki during World War II. Similar abnormalities surfaced in the nine months following the 1986 Chernobyl, Ukraine, nuclear power plant accident. After each disaster, the incidence of miscarriage and babies born with underdeveloped brains, physical deformities, and slow physical growth rose dramatically (Hoffmann, 2001; Schull, 2003).

Even when a radiation-exposed baby seems normal, problems may appear later. For example, even low-level radiation, as the result of industrial leakage or medical X-rays, can increase the risk of childhood cancer (Fattibene et al., 1999). In middle childhood, prenatally exposed Chernobyl children had abnormal brain-wave activity, lower intelligence test scores, and rates of language and emotional disorders two to three times greater than those of non-
exposed Russian children. Furthermore, the more tension parents reported, due to forced evacuation from their homes and worries about living in irradiated areas, the poorer their children’s emotional functioning (Kolominsky, Igumnov, & Drozdovitch, 1999; Loganovskaja & Loganovsky, 1999). Stressful rearing conditions seemed to combine with the damaging effects of prenatal radiation to impair children’s development.

Women should do their best to avoid medical X-rays during pregnancy. If dental, thyroid, chest, or other X-rays are necessary, insisting on the use of an abdominal X-ray shield is a key protective measure.

**ENVIRONMENTAL POLLUTION**

Yolanda and Jay like to refinish antique furniture in their garage, and Jay enjoys growing fruit trees in the backyard. When Yolanda became pregnant, they postponed work on several pieces of furniture, and Jay did not spray the fruit trees in the fall or spring of that year. Continuing to do so, they learned, might expose Yolanda and the embryo or fetus to chemical levels thousands of times greater than judged safe by the federal government.

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

One established teratogen is mercury. In the 1950s, an industrial plant released waste containing high levels of mercury into a bay providing food and water for the town of Minimata, Japan. Many children born at the time displayed physical deformities, mental retardation, abnormal speech, difficulty in chewing and swallowing, and uncoordinated movements. Autopsies of those who died revealed widespread brain damage. High levels of prenatal mercury exposure disrupt production and migration of neurons, causing widespread brain damage (Clarkson, Magos, & Myers, 2003; Hubbs-Tait et al., 2005). Pregnant women are wise to avoid eating long-lived predatory fish, such as swordfish, albacore tuna, and shark, which are heavily contaminated with mercury.

For many years, polychlorinated biphenyls (PCBs) were used to insulate electrical equipment, until research showed that, like mercury, they found their way into waterways and entered the food supply. In Taiwan, prenatal exposure to very high levels of PCBs in rice oil resulted in low birth weight, discolored skin, deformities of the gums and nails, brain-wave abnormalities, and delayed cognitive development (Chen & Hsu, 1994; Chen et al., 1994). Steady, low-level PCB exposure is also harmful. Women who frequently ate PCB-contaminated fish, compared with those who ate little or no fish, had infants with lower birth weights, smaller heads, persisting attention and memory difficulties, and lower intelligence test scores in childhood (Jacobson & Jacobson, 2003; Stewart et al., 2000; Walkowiak et al., 2001).

Another teratogen, lead, is present in paint flaking off the walls of old buildings and in certain materials used in industrial occupations. High levels of prenatal lead exposure are consistently related to prematurity, low birth weight, brain damage, and a wide variety of physical defects. Even low levels may be dangerous. In some studies, affected babies showed slightly poorer mental and motor development. In one investigation, unfavorable effects—in the form of increased delinquent and antisocial behaviors—were evident in adolescence (Bellinger, 2005; Dietrich et al., 2001).
Part Two: Foundations of Development

INFECTIOUS DISEASE During her first prenatal visit, Yolanda’s doctor asked her if she and Jay had already had measles, mumps, chicken pox, and several other illnesses. In addition, Yolanda was checked for the presence of several infections—and for good reason. As you can see in Table 3.5, certain diseases are major causes of miscarriage and birth defects.

Viruses. Five percent of women catch a virus of some sort while pregnant. Most of these illnesses, such as the common cold and various strains of the flu, have no impact on the embryo or fetus. A few, however, can result in extensive damage. The best known of these is rubella, otherwise known as three-day, or German, measles. In the mid-1960s, a worldwide rubella epidemic led to the birth of more than 20,000 North American babies with serious defects. Consistent with the sensitive-period concept, the greatest damage occurs when rubella strikes during the embryonic period. Over 50 percent of infants whose mothers become ill during that time show eye cataracts; deafness; heart, genital, urinary, and intestinal defects; and mental retardation (Eberhart-Phillips, Frederick, & Baron, 1993). Infection during the fetal period is less likely to be harmful, but low birth weight, hearing loss, and bone defects may still occur. And the brain abnormalities resulting from prenatal rubella increase the risk of severe mental illness, especially schizophrenia, in adulthood (Brown & Susser, 2002).

Although vaccination against rubella in infancy and childhood is now routine, about 10 to 20 percent of women in North America and Western Europe lack the rubella antibody. Thus, new disease outbreaks are possible (Health Canada, 2002f; Pebody et al., 2000).

The human immunodeficiency virus (HIV), which can lead to acquired immune deficiency syndrome (AIDS), a disease that destroys the immune system, has infected increasing numbers of women over the past two decades. Currently, women account for one-fourth of cases in North America, Western Europe, and East Asia. Although the incidence of AIDS has declined in industrialized nations, the disease is rampant in developing countries, where 95 percent of new infections occur, more than half of which affect women. In South Africa, for example, one-fourth of all pregnant women are HIV-positive (Kasmauski & Jaret, 2003; Quinn & Overbaugh, 2005). HIV-infected expectant mothers pass the deadly virus to the fetus 20 to 30 percent of the time.

AIDS progresses rapidly in infants. By 6 months, weight loss, diarrhea, and repeated respiratory illnesses are common. The virus also causes brain damage, as indicated by seizures, gradual loss in brain weight, and delayed mental and motor development. Most prenatal AIDS babies survive for only 5 to 8 months after the appearance of these symptoms (O’Rahilly & Müller, 2001). The antiviral drug zidovudine (ZDV) reduces prenatal AIDS transmission by as much as 95 percent, with no harmful consequences of drug treatment for children (Culnane et al., 1999). It has led to a dramatic decline in prenatally acquired AIDS in Western nations, but ZDV is not widely available in impoverished regions of the world (United Nations, 2006).

As Table 3.5 reveals, the developing organism is especially sensitive to the family of herpes viruses, for which no vaccine or treatment exists. Among these, cytomegalovirus (the most frequent prenatal infection, transmitted through respiratory or sexual contact, often without symptoms) and herpes simplex 2 (which is sexually transmitted) are especially dangerous. In both, the virus invades the mother’s genital tract, infecting babies either during pregnancy or at birth. Both diseases often have no symptoms, very mild symptoms, or symptoms with which people are unfamiliar, thereby increasing the likelihood of contagion. Pregnant women who are not in a mutually monogamous relationship are at greatest risk.

rubella Three-day, or German, measles; responsible for a wide variety of prenatal abnormalities, especially when it strikes during the embryonic period.

acquired immune deficiency syndrome (AIDS) A viral infection that destroys the immune system and is spread through transfer of body fluids from one person to another; it can be transmitted prenatally.
Bacterial and Parasitic Diseases. Table 3.5 also includes several bacterial and parasitic diseases. Among the most common is toxoplasmosis, an infection caused by a parasite found in many animals. Pregnant women may become infected from eating raw or undercooked meat or from contact with the feces of infected cats. About 40 percent of women who have the disease transmit it to the developing organism. If it strikes during the first trimester, it is likely to cause eye and brain damage. Infection during the second and third trimesters is linked to mild visual and cognitive impairments. And about 80 percent of affected newborns with no obvious signs of damage develop learning or visual disabilities in later life (Jones, Lopez, & Wilson, 2003). Expectant mothers can avoid toxoplasmosis by making sure that the meat they eat is well-cooked, having pet cats checked for the disease, and turning over the care of litter boxes to other family members.

Other Maternal Factors

Besides avoiding teratogens, expectant parents can support the embryo and fetus in other ways. Regular exercise, good nutrition, and emotional well-being of the mother are essential. Problems that may result from maternal and fetal blood type differences can be prevented. Finally, many prospective parents wonder how a mother’s age affects the course of pregnancy. We examine each of these factors in the following sections.

EXERCISE ■ Yolanda continued her half-hour of aerobics three times a week into the third trimester, although her doctor cautioned against bouncing, jolting, and jogging movements that might subject the fetus to too many shocks and startles. In healthy, physically fit women, regular moderate exercise, such as walking, swimming, biking, or an aerobic workout, is related to increased birth weight (Leiferman & Evenson, 2003). However, very frequent, vigorous, extended exercise—working up a sweat for more than 30 minutes, four or five days a

### Table 3.5 Effects of Some Infectious Diseases During Pregnancy

<table>
<thead>
<tr>
<th>DISEASE</th>
<th>PHYSICAL MISCARRIAGE</th>
<th>MENTAL MALFORMATIONS</th>
<th>RETARDATION</th>
<th>LOW BIRTHWEIGHT AND PREMATURITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Viral</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acquired immune deficiency syndrome (AIDS)</td>
<td>0</td>
<td>?</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>Chicken pox</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Cytomegalovirus</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Herpes simplex 2 (genital herpes)</td>
<td>+</td>
<td>?</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mumps</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rubella (German measles)</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>?</td>
</tr>
<tr>
<td><strong>Bacterial</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlamydia</td>
<td>+</td>
<td>?</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Syphilis</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>+</td>
<td>?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Parasitic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaria</td>
<td>+</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Toxoplasmosis</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>+</td>
</tr>
</tbody>
</table>

+ = established finding, 0 = no present evidence, ? = possible effect that is not clearly established.


**Toxoplasmosis** A parasitic disease caused by eating raw or undercooked meat or through contact with the feces of infected cats; during the first trimester, it leads to eye and brain damage.
Part Two: Foundations of Development

Exercise During Pregnancy. Exercise during pregnancy—especially late in pregnancy—results in lower birth weight than in healthy controls (Clapp et al., 2002; Pivarnik, 1998). Hospital-sponsored childbirth education programs frequently offer exercise classes and suggest appropriate routines that help prepare for labor and delivery.

During the last trimester, when the abdomen grows very large, mothers have difficulty moving freely and often must cut back on exercise. Most women, however, do not engage in sufficient moderate exercise during pregnancy to promote their own and their baby’s health (Hausenblas & Downs, 2005). An expectant mother who remains fit experiences fewer physical discomforts, such as back pain, upward pressure on the chest, or difficulty breathing in the final weeks.

Pregnant women with health problems, such as circulatory difficulties or a history of miscarriages, should consult their doctors about fitness routines. For these mothers, exercise (especially the wrong kind) can endanger the pregnancy.

NUTRITION

During the prenatal period, when children are growing more rapidly than at any other time, they depend totally on the mother for nutrients. A healthy diet, consisting of a gradual increase in calories—an extra 100 calories a day in the first trimester, 265 in the second, and 430 in the third—resulting in a weight gain of 25 to 30 pounds (10 to 13.5 kilograms), helps ensure the health of mother and baby (Reifsnider & Gill, 2000).

Consequences of Prenatal Malnutrition. During World War II, a severe famine occurred in the Netherlands, giving scientists a rare opportunity to study the impact of nutrition on prenatal development. Findings revealed that the sensitive-period concept operates with nutrition, just as it does with teratogens. Women affected by the famine during the first trimester were more likely to have miscarriages or give birth to babies with physical defects. When women were past the first trimester, fetuses usually survived, but many were born underweight and had small heads (Stein et al., 1975).

We now know that prenatal malnutrition can cause serious damage to the central nervous system. The poorer the mother’s diet, the greater the loss in brain weight, especially if malnutrition occurred during the third trimester. During that time, the brain is increasing rapidly in size, and for it to reach its full potential, the mother must have a diet high in all the basic nutrients (Morgane et al., 1993). An inadequate diet during pregnancy can also distort the structure of other organs, including the liver, kidney, and pancreas, resulting in lifelong health problems (refer again to the Biology and Environment box on pages 109–110).

Because poor nutrition suppresses development of the immune system, prenatally malnourished babies frequently catch respiratory illnesses (Chandra, 1991). In addition, they often are irritable and unresponsive to stimulation. Like drug-addicted newborns, they have a high-pitched cry that is particularly distressing to their caregivers. In poverty-stricken families, these effects quickly combine with a stressful home life. With age, low intelligence test scores and serious learning problems become more apparent (Pollitt, 1996).

Prevention and Treatment. Many studies show that providing pregnant women with adequate food has a substantial impact on the health of their newborn babies. Yet the growth demands of the prenatal period require more than just increased quantity of food. Vitamin–mineral enrichment is also crucial.

For example, folic acid can prevent abnormalities of the neural tube, such as anencephaly and spina bifida (see Table 2.6 on page 68). In a study of nearly 2,000 women in seven coun-
tries who had previously given birth to a baby with a neural tube defect, half were randomly selected to receive a daily folic acid supplement around the time of conception, and half received a mixture of other vitamins or no supplement. The folic acid group showed 72 percent fewer neural tube defects (MCR Vitamin Study Research Group, 1991). In addition, adequate folate intake during the last 10 weeks of pregnancy cuts in half the risk of premature delivery and low birth weight (Scholl, Hediger, & Belsky, 1996).

Because of these findings, U.S. and Canadian government guidelines recommend that all women of childbearing age consume 0.4 milligrams of folic acid per day. For women who have previously had a pregnancy affected by neural tube defect, the recommended amount is 4 milligrams of folate per day beginning one month before conception and continuing through the first trimester, with some experts recommending 5 milligrams (dosage must be carefully monitored, as excessive intake can be harmful) (American Academy of Pediatrics, 2006). About half of North American pregnancies are unplanned, so government regulations mandate that bread, flour, rice, pasta, and other grain products be fortified with folic acid.

Other vitamins and minerals also have established benefits. Enriching women’s diets with calcium helps prevent maternal high blood pressure and premature births (Repke, 1992). Adequate magnesium and zinc reduce the risk of many prenatal and birth complications (Durlach, 2004; Kontic-Vunicic, Sulovic, & Radunovic, 2006; Späfling & Späfling, 1988). Fortifying table salt with iodine virtually eradicates cretinism—a condition of stunted growth and cognitive impairment, caused by prenatal iodine deficiency, that is a common cause of mental retardation in many parts of the world (Maberly, Haxton, & van der Haar, 2003). And sufficient vitamin C and iron beginning early in pregnancy promote growth of the placenta and healthy birth weight (Mathews, Yudkin, & Neil, 1999). Nevertheless, a supplement program should complement, not replace, efforts to improve maternal diets during pregnancy. For women who do not get enough food or an adequate variety of foods, multivitamin tablets are a necessary, but not a sufficient, intervention.

When poor nutrition continues throughout pregnancy, infants usually require more than dietary improvement. In response to their tired, restless behavior, parents tend to be less sensitive and stimulating. The babies, in turn, become even more passive and withdrawn. Successful interventions must break this cycle of apathetic caregiver–baby interaction. Some do so by teaching parents how to interact effectively with their infants; others focus on stimulating infants to promote active engagement with their physical and social surroundings (Grantham-McGregor et al., 1994; Grantham-McGregor, Schofield, & Powell, 1987).

Although prenatal malnutrition is highest in poverty-stricken regions of the world, it is not limited to developing countries. The U.S. Special Supplemental Food Program for Women, Infants, and Children (WIC), which provides food packages and nutrition education to low-income pregnant women, reaches about 90 percent of those who qualify because of their extremely low incomes. But many U.S. women who need nutrition intervention are not eligible (U.S. Department of Agriculture, 2005b). The Canadian Prenatal Nutrition Program (CPNP), which provides counseling, social support, access to health care, and shelter, as well as food, to all pregnant women in need, regardless of income, reaches nearly 10 percent of expectant mothers in Canada (Health Canada, 2006a).

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

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

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

But stress-related prenatal complications are greatly reduced when mothers receive support from husbands, other family members, and friends (Federenko & Wadhwa, 2004). The link between social support and positive pregnancy outcomes is particularly strong for low-income women, who often lead highly stressful lives (Hoffman & Hatch, 1996). Enhancing supportive social networks for pregnant mothers can help prevent prenatal complications.

**BLOOD INCOMPATIBILITY**

When the inherited blood types of mother and fetus differ, serious problems sometimes result. The most common cause of these difficulties is Rh factor incompatibility. When the mother is Rh-negative (lacks the protein) and the father is Rh-positive (has the protein), the baby may inherit the father’s Rh-positive blood type. (Recall from Table 2.2 on page 57 that Rh-positive blood is dominant and Rh-negative blood is recessive, so the chances are good that a baby will be Rh-positive.) If even a little of a fetus’s Rh-positive blood crosses the placenta into the Rh-negative mother’s bloodstream, she begins to form antibodies to the foreign Rh protein. If these enter the fetus’s system, they destroy red blood cells, reducing the oxygen supply to organs and tissues. Mental retardation, miscarriage, heart damage, and infant death can occur.

Because it takes time for the mother to produce Rh antibodies, firstborn children are rarely affected. The danger increases with each additional pregnancy. Fortunately, Rh incompatibility can be prevented in most cases. After the birth of each Rh-positive baby, Rh-negative mothers are routinely given a vaccine to prevent the buildup of antibodies. In emergency cases, blood transfusions can be performed immediately after delivery or, if necessary, even before birth.

**MATERNAL AGE AND PREVIOUS BIRTHS**

Recall that women who delay having children until their thirties or forties face increased risk of infertility, miscarriage, and babies born with chromosomal defects (see Chapter 2). Are other pregnancy complications also more common for older mothers? Research consistently indicates that healthy women in their thirties have about the same rates of prenatal and birth problems as those in their twenties (Bianco et al., 1996; Dildy et al., 1996; Prysak, Lorenz, & Kisy, 1995). Thereafter, as Figure 3.7 reveals, complication rates increase, with a sharp rise among women age 50 to 55—an age at which, because of menopause (end of menstruation) and aging reproductive organs, few women can conceive naturally (Salihu et al., 2003).
In the case of teenage mothers, does physical immaturity cause prenatal problems? Again, research shows that it does not. As we will see in Chapter 14, nature tries to ensure that once a girl can conceive, she is physically ready to carry and give birth to a baby. Infants born to teenagers have a higher rate of problems, but not directly because of maternal age. Most pregnant teenagers come from low-income backgrounds, where stress, poor nutrition, and health problems are common. Also, many are afraid to seek medical care or, in the United States, do not have access to care because they lack health insurance (U.S. Department of Health and Human Services, 2006b).

The Importance of Prenatal Health Care

Yolanda had her first prenatal appointment 3 weeks after missing her menstrual period. After that, she visited the doctor’s office once a month until she was 7 months pregnant, then twice during the eighth month. As birth grew near, Yolanda’s appointments increased to once a week. The doctor kept track of her general health, her weight gain, and the capacity of her uterus and cervix to support the fetus. The fetus’s growth was also carefully monitored.

Yolanda’s pregnancy, like most others, was free of complications. But unexpected difficulties can arise, especially if mothers have health problems. For example, women with diabetes need careful monitoring. Extra sugar in the diabetic mother’s bloodstream causes the fetus to grow larger than average, making pregnancy and birth problems more common. Another complication, experienced by 5 to 10 percent of pregnant women, is toxemia (sometimes called preeclampsia), in which blood pressure increases sharply and the face, hands, and feet swell in the second half of pregnancy. If untreated, toxemia can cause convulsions in the mother and fetal death. Usually, hospitalization, bed rest, and drugs can lower blood pressure to a safe level (Vidaeff, Carroll, & Ramin, 2005). If not, the baby must be delivered at once.

Despite steady improvement over the past decade, unfortunately, 16 percent of pregnant women in the United States wait until after the first trimester to seek prenatal care, and nearly 4 percent receive none at all. As Figure 3.8 on page 122 shows, inadequate care is far more common among adolescent and low-income, ethnic minority mothers. Their infants are three times as likely to be born underweight and five times as likely to die as are babies of mothers who receive early medical attention (Child Trends, 2007). Why do these mothers delay going to the doctor? One reason is that they lack health insurance. Although the very poorest of these mothers are eligible for government-sponsored health services, many low-income women do not qualify. As we will see when we take up birth complications in Chapter 4, in countries where affordable medical care is universally available, such as Australia, Canada, Japan, and the Western European countries, late-care pregnancies and maternal and infant health problems are greatly reduced.

Besides financial hardship, some mothers have other reasons for not seeking early prenatal care. When researchers asked women who first went to the doctor late in pregnancy why they waited so long, they mentioned a wide variety of obstacles. These included both situational barriers—difficulty finding a doctor, getting an appointment, and arranging transportation, and insensitive or unsatisfying experiences with clinic staff—and personal barriers—psychological stress, the demands of taking care of other young children, family crises, lack of knowledge about signs of pregnancy and benefits of prenatal care, and ambivalence about the pregnancy. Many were also engaging in high-risk behaviors, such as smoking and drug abuse, and did not want to reveal those behaviors to health professionals (Daniels, Noe, & Mayberry,
2006; Maupin et al., 2004). These women, who had little or no prenatal care, were among those who needed it most!

Clearly, public education about the importance of early and sustained prenatal care for all pregnant women is badly needed. For women who are young, less educated, low-income, or under stress and therefore at risk for inadequate prenatal care, assistance in making appointments, drop-in child-care centers, and convenient, free or low-cost transportation—are vital. See also the Cultural Influences box on the following page, about the importance of culturally sensitive health-care practices. Finally, Applying What We Know below lists “do’s and don’ts” for a healthy pregnancy, based on our discussion of the prenatal environment.

**FIGURE 3.8**

Expectant mothers in the United States with late (after the first trimester) or no prenatal care. Nearly one-fourth of low-income, ethnic minority mothers, and more than 40 percent of adolescent mothers, receive inadequate prenatal care. Weak health insurance policies and lack of culturally sensitive prenatal care contribute to this dire situation. (From U. S. Department of Health and Human Services, 2006b.)

---

### Applying What We Know

**Do’s and Don’ts for a Healthy Pregnancy**

**DO**

- Do make sure that you have been vaccinated against infectious diseases dangerous to the embryo and fetus, such as rubella, before you get pregnant. Most vaccinations are not safe during pregnancy.
- Do see a doctor as soon as you suspect that you are pregnant—within a few weeks after a missed menstrual period.
- Do continue to get regular medical checkups throughout pregnancy.
- Do obtain literature from your doctor, local library, and bookstore about prenatal development and care. Ask questions about anything you do not understand.
- Do eat a well-balanced diet and take vitamin–mineral supplements, as prescribed by your doctor, both prior to and during pregnancy. On average, a woman should increase her intake by 100 calories a day in the first trimester, 265 in the second, and 430 in the third. Gain 25 to 30 pounds gradually.
- Do keep physically fit through mild exercise. If possible, join a special exercise class for expectant mothers.
- Do avoid emotional stress. If you are a single parent, find a relative or friend on whom you can count for emotional support.
- Do get plenty of rest. An overtired mother is at risk for pregnancy complications.
- Do enroll in a prenatal and childbirth education class along with your partner. When parents know what to expect, the 9 months before birth can be one of the most joyful times of life.

**DON’T**

- Don’t take any drugs without consulting your doctor.
- Don’t smoke. If you have already smoked during part of your pregnancy, cut down or (better yet) quit. If other members of your family are smokers, ask them to quit or to smoke outside.
- Don’t drink alcohol from the time you decide to get pregnant. If you find it difficult to give up alcohol, ask for help from your doctor, local family service agency, or nearest chapter of Alcoholics Anonymous.
- Don’t engage in activities that might expose your embryo or fetus to environmental hazards, such as radiation or chemical pollutants. If you work in an occupation that involves these agents, ask for a safer assignment or a leave of absence.
- Don’t engage in activities that might expose your embryo or fetus to harmful infectious diseases, such as toxoplasmosis.
- Don’t choose pregnancy as a time to go on a diet.
- Don’t gain too much weight during pregnancy. A very large weight gain is associated with complications.
Chapter Three: Prenatal Development

Cultural Influences

Culturally Sensitive Prenatal Care Promotes Healthy Pregnancies

Jasmine, three months pregnant, arrived at a public health clinic for her first prenatal visit despite a host of barriers: She was a 19-year-old single mother of an 8-month-old and felt overwhelmed at discovering that she was pregnant again. Unfortunately, Jasmine’s experience discouraged her from returning for additional checkups. The nurse at the reception desk remarked insensitively, “You pregnant again?” And the doctor rushed through the exam and spoke rapidly in English to Jasmine, a native Spanish speaker, who comprehended little of what he said. Jasmine did not make another appointment until she was within two weeks of giving birth.

In several studies, low-SES ethnic minority expectant and new mothers were asked to describe their prenatal-care visits. Many mentioned long hours sitting in waiting rooms; harsh, belittling interactions with medical staff; and impersonal, hurried checkups that discouraged them from asking questions—events that discouraged them from sustaining regular prenatal health care (Daniels & Mayberry, 2006). One mother commented:

“Sometimes they check you really fast and really rough, and they don’t ask you anything. They just check rudely and quickly and they do it so fast . . . after a few visits I stopped trying to ask anything and just wanted to get it over as quickly as possible.” (Tandon, Parillo, & Keefer, 2005, pp. 315–316)

Hispanic women who had recently immigrated to the United States reported communication difficulties that prevented them from fully grasping health information. As one woman stated, “It took a lot of effort asking where I needed to go to get something or to understand what they were saying . . . but nobody would try to help me. I never want to go back” (p. 316).

Lack of patient-sensitive care is particularly disturbing to ethnic minority women from cultures that emphasize warm, personalized styles of interaction and a relaxed sense of time. Consequently, even when these mothers have ready access to health care, they are likely to avoid it. A great need exists for prenatal care that is responsive to cultural values and practices.

A recently devised strategy known as group prenatal care is highly effective in serving minority expectant mothers (Massey, Rising, & Ickovics, 2006). It provides 8 to 12 women, whose babies are due at about the same time, with a half-hour medical checkup, the women bring their questions to a group discussion that focuses on important health issues, such as nutrition, exercise, stress management, and childbirth preparation. A trained group leader conducts group activities in the participants’ native language and encourages them to develop a social network for information and emotional support.

Group prenatal care is responsive to minority women who have culturally based expectations for a relaxed, informal communication atmosphere that allows ample time to build trusting relationships. Evaluations reveal that compared with mothers receiving a series of traditional 15-minute appointments, those in group care engage in more health-promoting and fewer health-damaging behaviors. They also give birth to babies with a reduced incidence of prematurity and low birth weight—major predictors of newborn survival and healthy development (Grady & Bloom, 2004; Ickovics et al., 2003).
Part Two: Foundations of Development

Preparing for Parenthood

Although we have discussed many ways that development can be thrown off course during the prenatal period, over 90 percent of pregnancies in industrialized nations result in healthy newborn babies. For most expectant parents, the prenatal period is not a time of medical hazard. Rather, it is a period of major life change accompanied by excitement, anticipation, and looking inward. The nine months before birth not only permit the fetus to grow but also give men and women time to develop a new sense of themselves as mothers and fathers.

This period of psychological preparation is vital. In one study, more than 100 first-time expectant married couples, varying widely in age and SES, were interviewed about their pregnancy experiences. Participants reported a wide range of reactions to learning they were expecting. Nearly two-thirds were positive, about one-third mixed or neutral, and only a handful negative (Feeney et al., 2001). An unplanned pregnancy was especially likely to spark negative or ambivalent feelings. But as the pregnancy moved along, these reactions subsided. By the third trimester, no participants felt negatively, and only about 10 percent remained mixed or neutral. Couples’ increasingly upbeat attitudes reflected acceptance of parenthood—a coming to terms with this imminent, radical change in their lives.

How effectively individuals construct a parental identity during pregnancy has important consequences for the parent–child relationship. A great many factors contribute to the personal adjustments that take place.

Seeking Information

We know most about how mothers adapt to the psychological challenges of pregnancy, although some evidence suggests that fathers use many of the same techniques. One common strategy is to seek information, as Yolanda and Jay did when they read books on pregnancy and childbirth and enrolled in my class. In fact, expectant mothers regard books as an extremely valuable source of information, rating them as second in importance only to their doctors. And the more a pregnant woman seeks information—by reading, accessing relevant websites, asking friends, consulting her own mother, or attending a prenatal class—the more confident she tends to feel about her own ability to be a good mother (Cowan & Cowan, 2000; Deutsch et al., 1988).
The Baby Becomes a Reality

At the beginning of pregnancy, the baby seems far in the future. Except for a missed period and some morning sickness (nausea that most women experience during the first trimester), the woman’s body has not changed much. But gradually, her abdomen enlarges, and the baby starts to become a reality. A major turning point occurs when expectant parents have concrete proof that a fetus is, indeed, developing inside the uterus. For Yolanda and Jay, this happened 13 weeks into the pregnancy, when their doctor showed them an ultrasound image. As Jay described the experience, “We saw it, these little hands and feet waving and kicking. It had the cord and everything. It’s really a baby in there!” Sensing the fetus’s movements for the first time can be just as thrilling. Of course, the mother feels these “kicks” first, but soon after, the father (and siblings) can participate by touching her abdomen.

Parents get to know the fetus as an individual through these signs of life. And both may form an emotional attachment to the new being, dream about the future parent–infant relationship, and discuss names. In a Swedish study, the stronger mothers’ and fathers’ attachment to their fetus, the more positively they related to each other and to their baby after birth, and the more upbeat the baby’s mood at age 8 months (White et al., 1999).

Models of Effective Parenthood

As pregnancy proceeds, expectant parents think about important models of parenthood in their own lives. When men and women have had good relationships with their own parents, they are more likely to develop positive images of themselves as parents during pregnancy (Deutsch et al., 1988). These images, in turn, predict harmonious marital communication and effective parenting during infancy and early childhood (Curran et al., 2005; Klitzing et al., 1999; McHale et al., 2004).

If their own parental relationships are mixed or negative, expectant mothers and fathers may have trouble building a healthy picture of themselves as parents. Some adults handle this challenge by seeking other examples of effective parenthood. One expectant father named Roger shared these thoughts with his wife and several couples, who met regularly with a counselor to talk about their concerns during pregnancy:

I rethink past experiences with my father and my family and am aware of how I was raised. I just think I don’t want to do that again, I want to change that; I don’t want to be like my father in that way. I wish there had been more connection and closeness and a lot more respect for who I was. For me, my father-in-law combines spontaneity, sincerity, and warmth. He is a mix of empathy and warmth plus stepping back and being objective that I want to be as a father. (Colman & Colman, 1991, p. 148)

Like Roger, many people come to terms with negative experiences in their own childhood, recognize that other options are available to them, and build healthier and happier relationships with their children (Main, 2000; Thompson, 2006). Roger achieved this understanding after participating in a special intervention program for expectant mothers and fathers.
Couples who take part in such programs feel better about themselves and their marital relationships, regard the demands of caring for the new baby as less stressful, and adapt more easily when family problems arise (Glade, Bean, & Vira, 2005).

The Parental Relationship

The most important preparation for parenthood takes place in the context of the parents’ relationship. Expectant couples who are unhappy in their marriages and who have difficulty working out their differences continue to be distant, dissatisfied, and poor problem solvers after the baby is born (Cowan & Cowan, 2000; Curran et al., 2005). Deciding to have a baby in hopes of improving a troubled relationship is a serious mistake. In a troubled marriage, pregnancy adds to rather than lessens family conflict (Perren et al., 2005).

When a couple’s relationship is faring well and both partners want and planned for the baby, the excitement of a first pregnancy may bring husband and wife closer (Feeney et al., 2001). At the same time, pregnancy does change a marriage. Expectant parents must adjust their established roles to make room for children. In addition, each partner is likely to develop new expectations of the other. Women look for greater demonstrations of affection, interest in the pregnancy, and help with household chores. They see these behaviors as important signs of continued acceptance of themselves, the pregnancy, and the baby to come. Similarly, men are particularly sensitive to expressions of warmth from their partner. These reassure them of a central place in the new mother’s emotional life after the baby is born (Cowan & Cowan, 2000).

When a relationship rests on a solid foundation of love and respect, parents are well-equipped for the challenges of pregnancy. They are also prepared to handle the much more demanding changes that will take place as soon as the baby is born.

Ask Yourself

Apply

Muriel, who is expecting her first child, recalls her own mother as cold and distant. Muriel is worried about whether she will be effective at caring for her new baby. What factors during pregnancy are related to maternal behavior?

Reflect

Ask your parents and/or your grandparents to describe attitudes and experiences that fostered or interfered with their capacity to build a positive parental identity when they were expecting their first child. Do you think building a healthy picture of oneself as a parent is more challenging today than it was in your parents’ or grandparents’ generation?
Motivations for Parenthood

How has decision making about childbearing changed over the past half-century, and what are the consequences for child rearing and child development?

Today, adults in Western industrialized nations have greater freedom to choose whether, when, and how to have children, and they are more likely to weigh the advantages and disadvantages of becoming parents. In industrialized nations, family size has declined over the past half-century. But no link has been found between later birth order and lower mental test performance. Rather, less intelligent parents—as a result of heredity, environment, or both—tend to have larger families.

When couples limit their families to just one child, their children are just as well-adjusted socially as children with siblings. Although reproductive capacity declines with age, adults who delay childbearing until their education is complete, their careers are established, and they are emotionally more mature may be better able to invest in parenting.

Prenatal Development

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

The first prenatal phase, the period of the zygote, lasts about two weeks, from fertilization through implantation: the blastocyst becomes deeply embedded in the uterine lining. During this time, structures that will support prenatal growth begin to form. The embryonic disk is surrounded by the trophoblast, which forms structures that protect and nourish the organism. The amnion fills with amniotic fluid to regulate temperature and cushion against the mother’s movements. From the chorion, villi emerge that burrow into the uterine wall, and the placenta starts to develop. The umbilical cord connects the developing organism to the placenta.

During the period of the embryo, from weeks 2 to 8, the foundations for all body structures are laid down. The nervous system develops fastest, starting with the formation of the neural tube, or spinal cord, the top of which swells to form the brain. Other organs follow and grow rapidly. At the end of this phase, the embryo responds to touch and can move.

The period of the fetus, from the ninth week until the end of pregnancy, involves a dramatic increase in body size and completion of physical structures. By the middle of the second trimester, the mother can feel movement. The fetus becomes covered with vernix, which protects the skin from chapping. White, downy hair called lanugo helps the vernix stick to the skin. At the end of the second trimester, production of neurons in the brain is complete.

Between 22 and 26 weeks, at the beginning of the third trimester, the baby reaches the age of viability and is able to survive if born early. The brain continues to develop rapidly, and new sensory and behavioral capacities emerge. Gradually the lungs mature, the fetus fills the uterus, and birth is near.

Prenatal Environmental Influences

What are teratogens, and what factors influence their impact?

Teratogens are environmental agents that cause damage during the prenatal period. Their effects conform to the sensitive period concept. The developing organism is especially vulnerable during the embryonic period, when all essential body structures are emerging rapidly.

The impact of teratogens varies with the amount and length of exposure, the genetic makeup of mother and fetus, the presence or absence of other harmful agents, and the age of the organism at time of exposure. In addition to immediate physical damage, some health outcomes may appear later in development, and physical defects may lead to psychological consequences as well.

List agents known to be or suspected of being teratogens, and discuss evidence supporting their harmful impact.

Drugs, cigarettes, alcohol, radiation, environmental pollution, and infectious diseases are teratogens that can endanger the developing organism. Thalidomide, a sedative widely available in the early 1960s, showed that drugs could cross the placenta, causing serious damage. Other medications, including diethylstilbestrol (DES) and Accutane (used to treat severe acne), are also known teratogens.
Babies born to users of heroin, methadone, or cocaine are at risk for prematurity, low birth weight, and physical defects, and are born drug-addicted, displaying withdrawal symptoms. In some studies, cocaine is associated with lasting difficulties, while others show no major negative effects. Findings are also mixed on the effects of marijuana use during pregnancy.

Infants whose parents use tobacco are often born underweight and may have attention, learning, and behavior problems in early childhood. When mothers consume alcohol in large quantities, children may be born with fetal alcohol spectrum disorder (FASD), a term that includes a range of physical, mental, and behavioral outcomes caused by prenatal alcohol exposure. In the most severe form, fetal alcohol syndrome (FAS), effects include slow physical growth, facial abnormalities, and impairment in mental functioning. Pregnant women who consume smaller quantities of alcohol may bear children with less severe forms of FASD—partial fetal alcohol syndrome (p-FAS) or alcohol-related neurodevelopmental disorder (ARND).

Prenatal exposure to high levels of radiation, mercury, lead, and PCBs leads to physical malformations and severe brain damage. Low-level exposure to these teratogens has also been linked to diverse impairments, including cognitive and language deficits and emotional and behavior disorders.

Among infectious diseases, rubella causes a wide variety of abnormalities, which vary with its time of occurrence during pregnancy. The human immunodeficiency virus (HIV), responsible for acquired immune deficiency syndrome (AIDS), can be transmitted prenatally, resulting in brain damage and early death. Cytomegalovirus (the most frequent prenatal infection) and herpes simplex 2 are also devastating to the fetus. Toxoplasmosis, a parasitic infection, may lead to eye and brain damage when a mother contracts it in the first trimester; in the second and third trimesters it can cause mild visual and cognitive impairments.

Vitamin–mineral supplementation, including folate, beginning before conception and continuing during pregnancy can prevent prenatal and birth complications.

Severe emotional stress is linked to many pregnancy complications and may permanently alter fetal neurological functioning. Its impact can be reduced by providing the mother with emotional support.

Rh factor incompatibility—an Rh-positive fetus developing within an Rh-negative mother—can lead to oxygen deprivation, brain and heart damage, and infant death.

Aside from the risk of chromosomal abnormalities in older women, maternal age through the early forties is not a major cause of prenatal problems. Rather, poor health and environmental risks associated with poverty are the strongest predictors of pregnancy complications in both teenagers and older women.

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

Unexpected difficulties, such as toxemia, can arise, especially when pregnant women have health problems to begin with. Prenatal care is especially crucial for those women least likely to seek it—in particular, those who are young or poverty-stricken. Among low-SES ethnic minority mothers, culturally sensitive health-care practices—such as group prenatal care—can lead to more health-promoting behaviors.

Preparing for Parenthood

What factors contribute to preparation for parenthood during the prenatal period?

Over the course of pregnancy, reactions to expectant parenthood become increasingly positive. Mothers and fathers prepare for their new role by seeking information from books and other sources. Ultrasound images, fetal movements, and the mother’s enlarging abdomen make the baby a reality, and parents may form an emotional attachment to the new being. They also rely on effective models of parenthood to build images of themselves as mothers and fathers.

The most important preparation for parenthood takes place in the context of the couple’s relationship. During the nine months preceding birth, parents adjust their roles and their expectations of each other as they prepare to welcome the baby into the family.
Important Terms and Concepts

acquired immune deficiency syndrome (AIDS) (p. 116)
age of viability (p. 104)
alcohol-related neurodevelopmental disorder (ARND) (p. 112)
amnion (p. 101)
amniotic fluid (p. 101)
blastocyst (p. 101)
chorion (p. 101)
embryo (p. 103)
embryonic disk (p. 101)
fetal alcohol spectrum disorder (FASD) (p. 112)
fetal alcohol syndrome (FAS) (p. 112)
fetus (p. 104)
implantation (p. 101)
lanugo (p. 104)
neural tube (p. 103)
partial fetal alcohol syndrome (p-FAS) (p. 112)
placenta (p. 101)
Rh factor incompatibility (p. 120)
rubella (p. 116)
teratogen (p. 107)
thalidomide (p. 109)
toxemia (p. 121)
toxoplasmosis (p. 117)
trimesters (p. 104)
trophoblast (p. 101)
umbilical cord (p. 102)
vernix (p. 104)