“Pregnant Mummy”
Eliska Kocová
5 years, Czech Republic

In this painting, the rapidly growing fetus claims a central place in the parent’s world. How is the one-celled organism transformed into a baby with the capacity to participate in family life? What factors support or undermine this earliest period of development? Chapter 3 provides answers to these questions.

Reprinted with permission from the International Museum of Children’s Art, Oslo, Norway
When I met Yolanda and Jay one fall in my child development class, Yolanda was just two months pregnant. Approaching age 30, married for several years and their careers well under way, they had decided to have a baby. To prepare for the transition to parenthood, they enrolled in my evening section, arriving once a week after work 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 wondered 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 the workday 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 a compelling social expectation. 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 far less fear of social criticism and rejection than a generation or two ago (Scott, 2009). In 1950, 78 percent of U.S. 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 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; Langdridge, Connolly, & Sheeran, 2000; O’Laughlin & Anderson, 2001).

Most adults are also aware that having children means years of extra burdens and responsibilities. Among disadvantages of parenthood, they cite “loss of freedom” most often, followed by “financial strain.” According to a conservative estimate, new parents in the United States today will spend about $210,000 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 birthrate in industrialized nations (Lino & Carlson, 2009). Finally, many adults worry greatly about family–work conflict—not having enough time to meet both child-rearing and job responsibilities (Jacobs & Gerson, 2004).

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 increases 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 2.1 in the United States; 1.9 in the United Kingdom; 1.8 in Australia; 1.6 in Sweden; 1.4 in Germany; and 1.3 in Italy and Japan (U.S. Census Bureau, 2010a; 2010b). 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 career. 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 nationally representative sample of several thousand U.S. 14- to 22-year-olds; in 1986 the children of the original participants were added to the investigation. Because both cohorts took intelligence tests, the 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

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

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</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 carry on after one’s own death</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>Having someone to provide care in old age</td>
<td>Reduced time to spend with partner</td>
</tr>
<tr>
<td>Learning to become less selfish and to sacrifice</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>


### Figure 3.1
Relationship of birth order and family size to intelligence. In the U.S. National Longitudinal Survey of Youth, children’s intelligence test scores did not decline with later birth order, as would be predicted if large families diluted the quality of children’s experiences. To the contrary, in the largest families, the youngest children tended to score higher than their siblings. But note the differences among the lines, which indicate that the larger the family, the lower the scores of all siblings. (From J. L. Rodgers, H. H. Cleveland, E. van den Oord, & D. C. Rowe, 2000, “Resolving the Debate over Birth Order, Family Size, and Intelligence,” American Psychologist, 55, p. 607. Copyright © by the American Psychological Association. Reprinted by permission.)
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 & Van Wey, 1999).

Other evidence confirms that rather than parenting quality declining as new children are born, parents reallocate their energies. In a longitudinal study of Canadian two-parent families, new births led to a decrease in maternal affection toward older siblings, though most mothers probably remained generally warm. At the same time, the consistency of parenting—the extent to which mothers insisted older children meet their expectations for mature behavior, such as completing chores, doing homework, and treating others respectfully—rose over time (Strohschein et al., 2008). After a new baby joined the family, mothers seemed to reorganize their parenting practices to best meet all their children’s needs.

In sum, although many good reasons exist for limiting family size, the concern that additional births will reduce parenting quality and, thus, 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 (Amato et al., 2008). Return to the Social Issues: Education box on page 73 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 useful for parents to consider when deciding how many children would best fit their life plans.

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


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 29, 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 several decades. Many people are delaying childbearing until their education is 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 better 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 20 percent of women are affected, a figure that climbs to 34 percent for 35- to 39-year-olds and to 43 percent for 40- to 44-year-olds. Age also affects male reproductive capacity. Amount of semen and concentration of sperm in each ejaculation decline gradually after age 35. 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 (Lambert, Masson, & Fisch, 2006; U.S. Department of Health and Human Services, 2009b). Women with demanding careers are especially likely to delay parenthood (Tough et al., 2007). 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.
- **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 35 or later to conclude that medical advances can overcome fertility problems? (See Chapter 2, pages 66–67.)
- **REFLECT** Ask one of your parents or grandparents to list his or her 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?

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**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, sacks 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 six days and can lie in wait for the ovum, which survives for only one day after being released into the fallopian tube. However, most conceptions result from intercourse during a three-day period—on the day of ovulation or during the two days preceding it (Wilcox, Weinberg, & Baird, 1995).

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

**FIGURE 3.3**
Female reproductive organs, showing fertilization, early cell duplication, and implantation. (From Before We Are Born, 6th ed., by K. L. Moore and T. V. N. Persaud, p. 87. Copyright © 2003, reprinted with permission from Elsevier, Inc.)
### TABLE 3.3 Milestones of Prenatal Development

<table>
<thead>
<tr>
<th>TRIMESTER</th>
<th>PERIOD</th>
<th>WEEKS</th>
<th>LENGTH AND WEIGHT</th>
<th>MAJOR EVENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Zygote</td>
<td>1</td>
<td></td>
<td>The one-celled zygote multiplies and forms a blastocyst.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>The blastocyst burrows into the uterine lining. Structures that feed and protect the developing organism begin to form—amnion, chorion, yolk sac, placenta, and umbilical cord.</td>
</tr>
<tr>
<td>Embryo</td>
<td></td>
<td>3–4</td>
<td>( \frac{1}{4} ) inch ((6 \text{ mm}))</td>
<td>A primitive brain and spinal cord appear. Heart, muscles, ribs, backbone, and digestive tract begin to develop.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5–8</td>
<td>1 inch ((2.5 \text{ cm})); ( \frac{1}{7} ) ounce ((4 \text{ g}))</td>
<td>Many external body structures ( (\text{face, arms, legs, toes, fingers}) ) and internal organs form. The sense of touch begins to develop, and the embryo can move.</td>
</tr>
<tr>
<td>Fetus</td>
<td></td>
<td>9–12</td>
<td>(3 ) inches ((7.6 \text{ cm})); less than 1 ounce ((28 \text{ g}))</td>
<td>Rapid increase in size begins. Nervous system, organs, and muscles become organized and connected, and new behavioral capacities ( (\text{kicking, thumb sucking, mouth opening, and rehearsal of breathing}) ) appear. External genitals are well-formed, and the fetus’s sex is evident.</td>
</tr>
<tr>
<td>Second</td>
<td></td>
<td>13–24</td>
<td>(12 ) inches ((30 \text{ cm})); 1.8 pounds ((820 \text{ g}))</td>
<td>The fetus continues to enlarge rapidly. In the middle of this period, fetal movements can be felt by the mother. Vernix and lanugo keep the fetus’s skin from chapping in the amniotic fluid. Most of the brain’s neurons are present by 24 weeks. Eyes are sensitive to light, and the fetus reacts to sound.</td>
</tr>
<tr>
<td>Third</td>
<td></td>
<td>25–38</td>
<td>(20 ) inches ((50 \text{ cm})); 7.5 pounds ((3,400 \text{ g}))</td>
<td>The fetus has a good chance of survival if born during this time. Size increases. Lungs mature. Rapid brain development causes sensory and behavioral capacities to expand. In the middle of this period, a layer of fat is added under the skin. Antibodies are transmitted from mother to fetus to protect against disease. Most fetuses rotate into an upside-down position in preparation for birth.</td>
</tr>
</tbody>
</table>

*Source: Moore & Persaud, 2008.*


### 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. 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, 2008).

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, 2009).

**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).

The placenta is connected to the developing organism by the **umbilical cord**, which first appears as a primitive body stalk and, during the course of pregnancy, grows to a

---

**FIGURE 3.4**

**Cross-section of the uterus, showing detail of the placenta.** The embryo’s blood flows from the umbilical cord arteries into the chorionic villi and returns via the umbilical cord vein. The mother’s blood circulates in spaces surrounding the chorionic villi. A membrane between the two blood supplies permits food and oxygen to be delivered and waste products to be carried away. The two blood supplies do not mix directly. The umbilical arteries carry oxygen-poor blood (shown in blue) to the placenta, and the umbilical vein carries oxygen-rich blood (shown in red) to the fetus.  
(Adapted from Before We Are Born, 7th ed., by K. L. Moore and T. V. N. Persaud, p. 76. Copyright © 2008, reprinted by permission from Elsevier, Inc.)

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1Recall 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.
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, 2008).

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.

### Period of the Embryo

The period of the **embryo** lasts from implantation through the eighth week of pregnancy. During these brief six 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 the 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 the astounding pace of 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, but many body structures have begun to form.

#### 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 ounce in weight, the embryo can sense its world. It responds to touch, particularly in the mouth area and on the soles of the feet. And it can move, although its tiny flutters are still too light to be felt by the mother (Moore & Persaud, 2008).
Period of the Fetus

The period of the fetus, from the ninth week to the end of pregnancy, is the longest prenatal period. During this “growth and finishing” phase, the 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, turns its head, opens its mouth, and even sucks its thumb, stretches, and yawns. Body position changes are frequent, occurring as often as 25 times per hour (Einspieler, Marschik, & Prechtl, 2008). 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 can be detected with ultrasound (Sadler, 2009). Other finishing touches appear, such as fingernails, toenails, tooth buds, and eyelids that open and close. The heartbeat can now be heard through a stethoscope.

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

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

At the end of the second trimester, many organs are well-developed. And most of the brain's billions of neurons are in place; 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 twentieth 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. Slow eye movements appear, with rapid eye movements following at 22 weeks. And if a doctor looks inside the uterus using fetoscopy (see Chapter 2, page 64), fetuses try to shield their eyes from the light with their hands, indicating that sight has begun to emerge (Moore & Persaud, 2008). Still, a fetus born at this time cannot survive. Its lungs are immature, and the brain cannot yet control breathing 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, 2008). 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.

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 that allows for maximum prenatal brain growth 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, 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). Between 30 and 34 weeks, fetuses show rhythmic alternations between sleep and wakefulness that gradually increase in organization (Rivkees, 2003). Around this time, synchrony between fetal heart rate and motor activity peaks: A rise in heart rate is usually followed within five seconds by a burst of motor activity (DiPietro et al., 2006). These are clear signs that coordinated neural networks are beginning to form in the brain.

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, fetuses acquire taste and odor preferences from bathing in and swallowing amniotic fluid (its makeup is influenced by the mother’s diet). Between 23 and 30 weeks, connections form between the cerebral cortex and brain regions involved in pain sensitivity. By this time, painkillers should be used in any surgical procedures performed on a fetus (Lee et al., 2005). Around 28 weeks, fetuses blink their eyes in reaction to nearby sounds (Kisilevsky & Low, 1998; Saffran, Werker, & Werner, 2006). And at 30 weeks, fetuses presented with a repeated auditory stimulus against the mother’s abdomen initially react with a rise in heart rate and body movements. But over the next 5 to 6 minutes, responsiveness gradually declines, indicating habituation (adaptation) to the sound. If the stimulus is reintroduced after a 10-minute delay, heart rate falls off far more quickly (Dirix et al., 2009). This suggests that fetuses can remember for at least a brief period.

Within the next six 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, to a stranger speaking their native language (English) versus a foreign language (Mandarin Chinese), 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, 2009; 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 six 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 stimulation specially designed 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 pages 23–24 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 (Pierson, 1996).

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., 1996). 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.

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, two months pregnant, wonders how the embryo 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 infant 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 parents—and society as a whole—can do a great deal to create a safe environment for development before birth.

Teratogens

The term teratogen refers to any environmental agent that causes damage during the prenatal period. Scientists chose this label (from the Greek word teras, meaning “malformation” or “monstrosity”) 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, you 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 additional teratogens, poor nutrition, and lack of medical care, 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. To understand this last idea, 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 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...
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—one that is 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, 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 high blood pressure, heart disease, stroke, and diabetes in middle adulthood emerged—for both sexes and in diverse countries (Barker, 2008; Kaijser et al., 2009; Whincup et al., 2008). 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 of heart disease. Low birth weight places her at increased risk for breast cancer in adulthood.

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. Furthermore, prenatally exposed children may be less resilient in the face of environmental risks, such as single parenthood, parental emotional disturbance, or maladaptive parenting (Yumoto, Jacobson, & Jacobson, 2008). As a result, their long-term adjustment may be compromised.
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 excess blood glucose, 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 (Hyppönen, Power, & Smith, 2003).

**High Birth Weight and Breast Cancer**

The other prenatal growth extreme—high birth weight—is linked to breast cancer, the most common malignancy in adult women (Ahlgren et al., 2004). 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) (dos Santos Silva et al., 2004). Researchers suspect that the culprit is excessive maternal estrogen in the overweight expectant mother, which promotes large fetal size and alters the makeup of beginning breast tissue so that it may respond to estrogen in adulthood by becoming malignant (Barker et al., 2008).

High birth weight is also associated with increases in prostate cancer in men and digestive, blood, and lymphatic cancers in both genders (Caughey & Michels, 2009; Cnattingius et al., 2009; McCormack et al., 2005). As yet, the reasons are unclear.

**Prevention**

The relationships between prenatal development and later-life illnesses emerging in research do not mean that the illnesses are inevitable. Rather, prenatal environmental conditions influence adult health, and the steps we take to protect our health can prevent prenatal risks from becoming reality. Researchers advise individuals who were low-weight or high-weight at birth to get regular medical checkups and screening tests that increase the odds of early disease detection. They also recommend consistent attention to diet, weight, fitness, and stress—controllable factors that contribute to cardiovascular disease, adult-onset diabetes, and cancer.

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 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 four to six 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, 2008). 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.

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).

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

Indeed, any drug with a molecule small enough to penetrate the placental barrier can enter the embryonic or fetal bloodstream. Yet many pregnant women continue to take over-the-counter medications without consulting their doctors. 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. As amounts exceed 100 milligrams per day (equivalent to one cup of coffee), low birth weight and miscarriage increase (CARE Study Group, 2008; Weng, Odouli, & Li, 2008). And antidepressant medications are linked to increased risk of premature delivery and birth complications, including respiratory distress and persistent high blood pressure in infancy (Alwan & Friedman, 2009; Lund, Pedersen, & Henriksen, 2009; Oberlander et al., 2006).

Because children’s lives are involved, we must take findings like these seriously. At the same time, we cannot be sure that these frequently used drugs actually cause the problems just mentioned. Often mothers take more than one drug. If the embryo or fetus is injured, it is hard to tell which drug might be responsible or whether other factors correlated with drug taking are 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. Nearly 4 percent of U.S. pregnant women take these substances (U.S. Department of Health and Human Services, 2007).

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; Howell, Coles, & Kable, 2008; Schuetze & Eiden, 2006). In addition, these infants are born drug-addicted. They are often feverish and irritable 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 (Cosden, Peerson, & Elliott, 1997). The kind of parenting they receive may explain why problems persist for some but not for others (Hans & Jeremy, 2001).

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 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; brain hemorrhages and seizures; and severe growth retardation (Covington et al., 2002; Feng, 2005; Mayes, 1999). Some studies report perceptual, motor, attention, memory, language, and impulse-control problems that persist into the preschool years (Dennis et al., 2006; Lester et al., 2003; Linares et al., 2006; Noland et al., 2005; Singer et al., 2004).

But other investigations reveal no major negative effects of prenatal cocaine exposure (Behnke et al., 2006; Frank et al., 2005; Hurt et al., 2005). These contradictory findings indicate how difficult it is to isolate the precise damage caused by illegal drugs. 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—factors that worsen outcomes for children (Jones, 2006). 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 14 percent of U.S. women smoke during their pregnancies (Tong et al., 2009). 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 (Howell, Coles, & Kable, 2008; Jaakkola & Gissler, 2004). The more cigarettes a mother smokes, the greater the chances that her baby will be affected. If a pregnant woman decides to stop smoking at any time, even during the last trimester, she reduces the likelihood that her infant will be born underweight and suffer from future problems (Klesges et al., 2001).

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). These findings suggest subtle negative effects on brain development (Law et al., 2003; Søndergaard et al., 2002). Consistent with this view, prenatally exposed children and adolescents tend to have shorter attention spans, difficulties with impulsivity and overactivity, poorer memories, lower mental test scores, and more externalizing behavior problems (Fryer, Crocker, & Mattson, 2008; Huizink & Mulder, 2006; Nigg & Breslau, 2007; Rogers, 2009).

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 bloodstream 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. Similar effects may occur in humans. Also, recall from Chapter 2 that nicotine-exposed fetuses with a certain genotype are at high risk for becoming impulsive, overactive, and oppositional children and adolescents (see page 87).
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 attention, learning, and behavior problems (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 College anthropology professor, described what it was like to raise his adopted son Abel (called Adam in the book), whose biological mother drank heavily throughout pregnancy and died of alcohol poisoning shortly after his birth. A Sioux Indian, Abel was born with **fetal alcohol spectrum disorder (FASD)**, a term that encompasses a range of physical, mental, and behavioral outcomes caused by prenatal alcohol exposure. As Table 3.4 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 can alter gene expression (see page 86 in Chapter 2), thereby contributing to symptoms (Ouko et al., 2009).
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 would 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, & Autti-Raemoe, 2003; Mattson, Calarco, & Lang, 2006). In adolescence and early adulthood, FASD is associated with persisting attention and motor-coordination deficits, poor school performance, trouble with the law, inappropriate sexual behavior, alcohol and drug abuse, and lasting mental health problems (Barr et al., 2006; Fryer, Crocker, & Mattson, 2008; Howell et al., 2006; Streissguth et al., 2004).

How does alcohol produce its devastating effects? First, it interferes with production and migration of neurons in the primitive neural tube. Brain-imaging research reveals reduced brain size, damage to many brain structures, and abnormalities in brain functioning, including the electrical and chemical activity involved in transferring messages from one part of the brain to another (Riley, McGee, & Sowell, 2004; Spadoni et al., 2007). 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 25 percent of U.S. mothers reported drinking at some time during their pregnancies. As with heroin and cocaine, alcohol abuse is higher in poverty-stricken women. On some Native-American reservations, the incidence of FAS is as high as 10 to 20 percent (Szlemko, Wood, & Thurman, 2006; U.S. Department of Health and Human Services, 2007). 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. Thus, 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 (Jacobson et al., 2004; Martinez-Frias 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 children born to pregnant women who survived the bombing of Hiroshima and Nagasaki during World War II. Similar abnormalities surfaced in the nine months following the 1986 Chernobyl, Ukraine, nuclear power plant accident. After each disaster, the incidence of miscarriage and babies born with underdeveloped brains, physical deformities, and slow physical growth rose dramatically (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 nonexposed 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 (Loganovskaja & Loganovsky, 1999; Loganovsky et al., 2008). 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  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).

In the 1950s, an industrial plant released waste containing high levels of mercury into a bay providing seafood and water for the town of Minamata, Japan. Many children born at the time displayed physical deformities, mental retardation, abnormal speech, difficulty in chewing and swallowing, and uncoordinated movements. 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 (Boucher, Muckle, & Bastien, 2009; Jacobson & Jacobson, 2003; Stewart et al., 2008).
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 (Bellinger, 2005). In one investigation, unfavorable effects—in the form of increased delinquent and antisocial behaviors—were evident in adolescence (Dietrich et al., 2001).

Finally, prenatal exposure to dioxins—toxic compounds resulting from incineration—is linked to brain, immune system, and thyroid damage in babies and to an increased incidence of breast and uterine cancers in women, perhaps through altering hormone levels (ten Tusscher & Koppe, 2004). Furthermore, even tiny amounts of dioxin in the paternal bloodstream cause a dramatic change in sex ratio of offspring: Affected men father nearly twice as many girls as boys (Ishihara et al., 2007; Mocarell et al., 2000). Dioxin seems to impair the fertility of Y-bearing sperm prior to conception.

**INFECTIOUS DISEASE**  During her first prenatal visit, Yolanda's doctor asked her if she and Jay had already had measles, mumps, chickenpox, 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.** In the mid-1960s, a worldwide epidemic of rubella (three-day, or German, measles) led to the birth of more than 20,000 American babies with serious defects and to 13,000 fetal and newborn deaths. Consistent with the sensitive-period concept, the greatest damage occurs when rubella strikes during the embryonic period. More than 50 percent of infants whose mothers become ill during that time show deafness; eye deformities, including cataracts; heart, genital, urinary, intestinal, bone, and dental defects; and mental retardation. Infection during the fetal period is less harmful, but low birth weight, hearing loss, and bone defects may still

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<th>TABLE 3.5 Effects of Some Infectious Diseases During Pregnancy</th>
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+ = established finding; 0 = no present evidence; ? = possible effect that is not clearly established.

Sources: Jones, Lopez, & Wilson, 2003; Kliegman et al., 2008; Mardh, 2002; O’Rahilly & Müller, 2001.
occur. The organ damage inflicted by prenatal rubella often leads to lifelong health problems, including severe mental illness, diabetes, cardiovascular disease, and thyroid and immune-system dysfunction in adulthood (Brown, 2006; Duszek, 2009). Routine vaccination in infancy and childhood has made new rubella outbreaks unlikely in industrialized nations. But an estimated 100,000 cases of prenatal infection continue to occur each year, primarily in developing countries in Africa and Asia with weak or absent immunization programs (Robinson et al., 2006).

The human immunodeficiency virus (HIV), which can lead to acquired immune deficiency syndrome (AIDS), a disease that destroys the immune system, has infected increasing numbers of women over the past two decades. 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, nearly 30 percent of all pregnant women are HIV-positive (Quinn & Overbaugh, 2005; South African Department of Health, 2009). 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. Nearly half of prenatal AIDS babies die by 1 year of age and 90 percent by age 3 (Devi et al., 2009). 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). ZDV has led to a dramatic decline in prenatally acquired AIDS in Western nations. Although distribution is increasing, the drug is still not widely available in impoverished regions of the world (UNICEF, 2009).

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.

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 and a reduction in risk for certain complications, such as pregnancy-induced maternal diabetes and high blood pressure (Leiferman & Evenson, 2003; Olson et al., 2009). However, frequent, vigorous, extended exercise—working up a sweat for more than 30 minutes, four or five days a week, especially late in pregnancy—results in lower birth weight than in healthy, nonexercising controls (Clapp et al., 2002; Leet & Flick, 2003). 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 doctor about a physical fitness routine. 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.

**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).

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 104–105).

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, taking a folic acid supplement around the time of conception reduces by more than 70 percent abnormalities of the neural tube, such as anencephaly and spina bifida (see Table 2.5 on page 64). Folic acid supplementation early in pregnancy also reduces the risk of other physical defects, including cleft lip and palate, urinary tract abnormalities, and limb deformities. Furthermore, adequate folic acid intake during the last 10 weeks of pregnancy cuts in half the risk of premature delivery and low birth weight (Goh & Koren, 2008; MCR Vitamin Study Research Group, 1991; Scholl, Hediger, & Belsky, 1996).

Because of these findings, U.S. government guidelines recommend that all women of childbearing age consume 0.4 milligrams of folic acid per day. For women who have previously had a pregnancy affected by neural tube defect, the recommended amount is 4 or 5 milligrams (dosage must be carefully monitored, as excessive intake can be harmful) (American Academy of Pediatrics, 2006). About half of U.S. 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. Adequate magnesium and zinc reduce the risk of many prenatal and birth complications (Durlach, 2004; Kotic-Vucinic, Sulovic, & Radunovic, 2006). 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 (Williams, 2008). 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 (U.S. Department of Agriculture, 2009). But many U.S. women who need nutrition intervention are not eligible for WIC.

EMOTIONAL STRESS When women experience severe emotional stress during pregnancy, their babies are at risk for a wide variety of difficulties. Intense anxiety—especially during the first two trimesters—is associated with higher rates of miscarriage, prematurity, low birth weight, infant respiratory and digestive illnesses, colic (persistent infant crying), sleep disturbances, and irritability during the child's first three years (Field et al., 2007; Huizink, Mulder, & Buitelaar, 2004; Lazinski, Shea, & Steiner, 2008; van der Wal, van Eijsden, & Bonsel, 2007). Prenatal stress is also related to several commonly occurring physical defects, such as cleft lip and palate, heart deformities, and pyloric stenosis (tightening of the infant's stomach outlet, which often must be treated surgically) (Carmichael & Shaw, 2000).

How can maternal stress affect the 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.
Maternal stress hormones also cross the placenta, causing a dramatic rise in fetal stress hormones (evident in the amniotic fluid) and in fetal heart rate, blood pressure, and activity level (Monk et al., 2000, 2004; Weinstock, 2008). Excessive fetal stress may permanently alter neurological functioning, 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. Consistent with this finding, these 9-month-olds showed greater distress when confronted with novel stimuli than did other infants (Brand et al., 2006; Yehuda et al., 2005).

But stress-related prenatal complications are greatly reduced when mothers have partners, other family members, and friends who offer social support (Glover, Bergman, & O’Connor, 2008). The relationship of social support to positive pregnancy outcomes and subsequent child development is particularly strong for low-income women, who often lead highly stressful lives (see the Social Issues: Health box on page 116) (Olds et al., 2002, 2004).

**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 Rh blood 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.

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

**MATERNAL AGE AND PREVIOUS BIRTHS** In Chapter 2, we noted that women who delay childbearing until their thirties or forties face increased risk of infertility, miscarriage, and babies born with chromosomal defects. Are other pregnancy complications also more common for older mothers? Research consistently indicates that healthy women in their thirties have about the same rates of prenatal and birth complications as those in their twenties (Bianco et al., 1996; Dildy et al., 1996; Prysak, Lorenz, & Kisly, 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; Usta & Nassar, 2008).

![Figure 3.7](image-url) Relationship of maternal age to prenatal and birth complications. Complications increase after age 40, with a sharp rise between 50 and 55 years. See page 117 for a description of preeclampsia. (Adapted from Salihu et al., 2003.)
The Nurse–Family Partnership: Reducing Maternal Stress and Enhancing Child Development Through Social Support

At age 17, Denise—an unemployed high-school dropout living with her disapproving parents—gave birth to Tara. Having no one to turn to for help during pregnancy and beyond, Denise felt overwhelmed and anxious much of the time. Tara was premature and cried uncontrollably, slept erratically, and suffered from frequent minor illnesses throughout her first year. When she reached school age, she had trouble keeping up academically, and her teachers described her as distractible, unable to sit still, angry, and uncooperative.

The Nurse–Family Partnership, currently implemented in hundreds of counties across 29 U.S. states, is a voluntary home visiting program for first-time, low-income expectant mothers like Denise. Its goals are to reduce pregnancy and birth complications, promote competent early caregiving, and improve family conditions, thereby protecting children from lasting adjustment difficulties. A registered nurse visits the home seven times during pregnancy and once a month until she was seven months pregnant, infant referral for developmental problems. Families were followed through their child’s first three years of elementary school (Olds et al., 2004, 2007).

As kindergartners, Nurse–Family Partnership children obtained higher language and intelligence test scores. And at both ages 6 and 9, children of home-visited mothers in the poorest mental health during pregnancy exceeded comparison children in academic achievement and displayed fewer behavior problems. Furthermore, from their baby’s birth on, home-visited mothers were on a more favorable life course: They had fewer subsequent births, longer intervals between their first and second births, more frequent contact with the child’s father, more stable intimate partnerships, less welfare dependence, and a greater sense of control over their lives—key factors in reducing subsequent prenatal stress and in protecting children’s development.

In another experiment involving over 700 at-risk mothers and babies, professional nurses were far more effective than trained paraprofessionals in preventing outcomes associated with prenatal stress, including high infant fearfulness to novel stimuli and delayed mental development (Olds et al., 2002). Nurses were probably more proficient in individualizing program guidelines to fit the strengths and challenges faced by each family. They also might have had unique legitimacy as experts in the eyes of stressed mothers, more easily convincing them to take steps to reduce pregnancy complications that can trigger persisting developmental problems—such as those Tara displayed.

Through the Nurse–Family Partnership, this 15-year-old first-time mother-to-be receives regular home visits from a registered nurse, which will continue after her baby is born. In follow-up research, the children of home-visited mothers developed more favorably—cognitively, emotionally, and socially—than did comparison children whose mothers did not receive this individualized intervention.

In the case of teenage mothers, does physical immaturity cause prenatal problems? 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, 2009a).

The Importance of Prenatal Health Care

Yolanda had her first prenatal appointment three weeks after missing her menstrual period. After that, she visited the doctor’s office once a month until she was seven months pregnant,
then twice during the eighth month. 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 increases the risk of pregnancy and birth problems, as well as brain damage and later learning difficulties (see the Biology and Environment box on page 118). Another complication, experienced by 5 to 10 percent of pregnant women, is preeclampsia (sometimes called toxemia), in which blood pressure increases sharply and the face, hands, and feet swell in the second half of pregnancy. If untreated, preeclampsia can cause convulsions in the mother and fetal death. Usually, hospitalization, bed rest, and drugs can lower blood pressure to a safe level (Vidaeff, Carroll, & Ramin, 2005). If not, the baby must be delivered at once.

Unfortunately, 8 percent of pregnant women in the United States wait until after the first trimester to seek prenatal care or receive none at all. As Figure 3.8 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 them 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 nations where affordable medical care is universally available, such as Australia, Canada, Japan, and 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. These include 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 also engage in high-risk behaviors, such as smoking and drug abuse, which they do not want to reveal to health professionals (Maupin et al., 2004). These women, who receive little or no prenatal care, are among those who need 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.

Culturally sensitive health-care practices are also helpful. Low-SES minority women often report depersonalizing experiences during prenatal appointments, including condescending interactions with medical staff and hurried

**Figure 3.8**

Expectant mothers in the United States with late (after the first trimester) or no prenatal care. More than 10 percent of low-income minority mothers, and nearly 30 percent of adolescent mothers, receive inadequate prenatal care. (From Hueston et al., 2009; U.S. Department of Health and Human Services, 2009a.)
Prenatal Iron Deficiency and Memory Impairments in Infants of Diabetic Mothers

Diabetes affects nearly 11 percent of Americans age 20 and older—a rate that has risen sharply over the past quarter century as a result of widespread overweight and obesity. Although it is increasingly prevalent among all sectors of the population, diabetes is at least twice as likely to affect low-income ethnic minority as white adults. Today, about 5 percent of pregnant mothers are diabetic—a 50 percent increase over the past decade. Most had the disease before becoming pregnant; others developed it during pregnancy (American Diabetes Association, 2010). In either case, their newborn babies are at risk for long-term developmental problems.

In the early weeks of pregnancy, when organs are forming, a diabetic mother’s out-of-control blood glucose increases the risk of birth defects. Later in pregnancy, excess blood glucose causes the fetus to be “overfed” and to grow unusually large, often causing birth complications. Furthermore, to metabolize this flood of maternal glucose, the fetus secretes abnormally high levels of insulin—a circumstance that greatly increases demand for oxygen. To extract extra oxygen from the mother’s system, the fetus increases production of oxygen-carrying red blood cells. This expanding red-cell mass requires extra iron, which the fetus can obtain only by taxing its own iron stores in the liver, muscles, heart, and brain.

In animal research on maternal diabetes, by late pregnancy iron stores decline sharply in the brain’s temporal lobes (located on each side of the brain, just above the ears), which house structures centrally involved in memory development—specifically, the hippocampus, which plays a crucial role in the formation of new memories. Prenatal iron depletion interferes with growth of brain cells and their connections, permanently reducing the size and altering the structure of the hippocampus in laboratory rats (deUngria et al., 2000).

In human research, diabetic mothers bear children who, at school age, tend to score lower than their agemates on intelligence tests (Rizzo, 1997). Is prenatal iron deficiency and resulting early damage to the brain’s memory areas responsible? In a series of studies, Charles Nelson (2007) and his collaborators recorded electrical brain waves to assess young infants’ memory performance, focusing on a particular slow brain wave in the temporal lobes believed to reflect memory processing.

Typically developing newborns come to recognize their mother’s voice through repeated exposure during pregnancy; they suck more on a nipple to hear a recording of it than the voice of an unfamiliar woman (DeCasper & Spence, 1988). In a comparison of newborns of diabetic mothers likely to have a brain iron deficiency (based on a measure of body iron stores) with normal-iron controls, brain waves were recorded as the babies listened to sound clips of their mother’s or a stranger’s voice (Sidappa et al., 2004). The controls showed a distinctive slow wave to each stimulus, indicating recognition of the mother’s voice. The brain iron–deficient babies showed no difference in brain waves to the two stimuli, suggesting memory impairment of prenatal origin.

Do these memory deficits persist beyond the newborn period—evidence that diabetes-linked prenatal brain damage has lasting consequences? At 6 months, the researchers recorded brain waves while infants alternately viewed a videotaped image of their mother’s face and that of an unfamiliar woman. Consistent with the newborn findings, control infants responded with distinct slow waves in the temporal lobes to the two faces, while infants of diabetic mothers displayed no difference. Even after months of experience, they could not recognize their mother’s facial image (Nelson et al., 2000).

At an 8-month follow-up, babies were given a more challenging memory task. After feeling a novel object (an unusually shaped wooden block) held beneath an apron so they could not see it, the infants were tested visually: They viewed photos of the novel object interspersed with photos of familiar objects (Nelson et al., 2003). Again, infants of diabetic mothers showed no evidence of distinguishing the novel object from other stimuli. The control babies, in contrast, responded to the novel object with a stronger temporal-lobe slow wave, suggesting an ability to recognize the novel stimulus, even when presented in a different sensory modality.

Nelson and his colleagues have followed their research participants through the preschool years, amassing additional evidence for poorer memory (especially more rapid forgetting) in children born to diabetic mothers than in controls (deRegnier et al., 2007). The findings highlight a previously hidden pregnancy complication: As a result of iron depletion in critical brain areas, a diabetic pregnancy places the fetus at risk for lasting memory deficits and thus for long-term learning and academic problems. The researchers believe that damage to the hippocampus, located deep inside the temporal lobes, is responsible.

Nelson’s research underscores the need to find more effective ways of intervening with iron supplementation in diabetic pregnancies, as well as the importance of sufficient dietary iron for every expectant mother and her developing fetus. Diabetes prevention is also vital, through weight control, increased exercise, and improved diet beginning in childhood.
checkups with no opportunity to ask questions. These behaviors are especially disturbing to women whose cultures emphasize warm, personalized interaction styles and a relaxed sense of time—causing many to avoid returning (Daniels & Mayberry, 2006; Downe et al., 2009). In a strategy called group prenatal care, after each medical checkup, trained leaders provide minority expectant mothers with a group discussion session which is conducted in their native language and encourages them to talk about important health issues (Massey, Rising, & Ickovics, 2006). Compared to mothers receiving traditional brief appointments, participants engaged in more health-promoting behaviors and also gave birth to babies with a reduced incidence of prematurity and low birth weight—major predictors of newborn survival and healthy development. Applying What We Know above lists “do’s and don’ts” for a healthy pregnancy, based on our discussion of the prenatal environment.

### Applying What We Know

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

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<thead>
<tr>
<th><strong>DO</strong></th>
<th><strong>DON’T</strong></th>
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<tr>
<td>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.</td>
<td>Don’t take any drugs without consulting your doctor.</td>
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<tr>
<td>Do see a doctor as soon as you suspect that you are pregnant, and continue to get regular medical checkups throughout pregnancy.</td>
<td>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 smoke, ask them to quit or to smoke outside.</td>
</tr>
<tr>
<td>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.</td>
<td>Don’t drink alcohol from the time you decide to get pregnant.</td>
</tr>
<tr>
<td>Do obtain literature from your doctor, local library, and bookstore about prenatal development and care, and ask questions about anything that concerns you.</td>
<td>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.</td>
</tr>
<tr>
<td>Do keep physically fit through moderate exercise. If possible, join a special exercise class for expectant mothers.</td>
<td>Don’t engage in activities that might expose your embryo or fetus to harmful infectious diseases, such as toxoplasmosis.</td>
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<tr>
<td>Do avoid emotional stress. If you are a single expectant mother, find a relative or friend on whom you can count for emotional support.</td>
<td>Don’t choose pregnancy as a time to go on a diet.</td>
</tr>
<tr>
<td>Do get plenty of rest. An overtired mother is at risk for pregnancy complications.</td>
<td>Don’t gain too much weight during pregnancy. A very large weight gain is associated with complications.</td>
</tr>
<tr>
<td>Do enroll in a prenatal and childbirth education class with your partner or other companion. When you know what to expect, the nine months before birth can be one of the most joyful times of life.</td>
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**ASK YOURSELF**

- **REVIEW** Why is it difficult to determine the prenatal effects of many environmental agents, such as drugs and pollution?
- **APPLY** Nora, pregnant for the first time, believes that a few cigarettes and a glass of wine a day won’t be harmful. Provide Nora with research-based reasons for not smoking or drinking.
- **CONNECT** How do teratogens illustrate the notion of epigenesis, presented in Chapter 2, that environments can affect gene expression? (See page 86 to review.)
- **REFLECT** If you had to choose five environmental influences to publicize in a campaign aimed at promoting healthy prenatal development, which ones would you choose, and why?
Preparing for Parenthood

Although we have discussed many ways that development can be thrown off course during the prenatal period, more than 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. But gradually, the woman’s 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’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 partner (and siblings) can participate by touching her abdomen.
Parents get to know the fetus as an individual through these signs of life. And both are likely to form an emotional attachment to the new being, especially when their relationship is positive, extended family members are supportive, and the mother reports favorable psychological well-being (Alhusen, 2008). 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 wish there had been more connection and closeness and a lot more respect for who I was. For me, my father-in-law… 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 (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, communicate more effectively, feel more competent as parents after the baby arrives, and adapt more easily when family problems arise (Glade, Bean, & Vira, 2005; Petch & Halford, 2008).

**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 childbirth (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 distressed 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 plan for the baby, the excitement of a first pregnancy may bring husband and wife closer (Feeney et al., 2001). Parents who have forged a solid foundation of love and respect 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 their baby is born.
**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. 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.

- 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 of the blastocyst in the uterine lining. During this time, structures that will support prenatal growth begin to form, including the **placenta and the umbilical cord**.

- 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**, 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**, lasting until the end of pregnancy, involves a dramatic increase in body size and completion of physical structures. At the end of the second trimester, most of the brain’s neurons are in place. At the beginning of the third trimester, between 22 and 26 weeks, the fetus reaches the **age of viability**. The brain continues to develop rapidly, and new sensory and behavioral capacities emerge. 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 impact varies with the amount and length of exposure, the genetic makeup of mother and fetus, the presence or absence of other harmful agents, and the age of the organism at time of exposure. The developing organism is especially vulnerable during the embryonic period. 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. Currently, the most widely used potent teratogen is Accutane, a drug used to treat severe acne. The prenatal impact of many other commonly used medications, such as aspirin and caffeine, is hard to separate from other factors correlated with drug taking. Babies born to users of heroin, methadone, or cocaine are at risk for a wide variety of problems, including prematurity, low birth weight, physical defects, and breathing difficulties around the time of birth.
Infants whose parents use tobacco are often born underweight and have attention, learning, and behavior problems in early childhood. Maternal alcohol consumption can lead to fetal alcohol spectrum disorder (FASD). Fetal alcohol syndrome (FAS) involves slow physical growth, facial abnormalities, and impairment in mental functioning. Milder forms—partial fetal alcohol syndrome (p-FAS) or alcohol-related neurodevelopmental disorder (ARND)—affect children whose mothers consumed smaller quantities of alcohol.

Prenatal exposure to high levels of radiation, mercury, lead, dioxins, 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 deficits and emotional and behavior disorders.

Among infectious diseases, rubella causes a wide variety of abnormalities. Babies with prenatally transmitted HIV rapidly develop AIDS, leading to brain damage and early death. Cytomegalovirus, herpes simplex 2, and toxoplasmosis can also be devastating to the embryo and fetus.

When the mother’s diet is inadequate, low birth weight and damage to the brain and other organs are major concerns. Vitamin-mineral supplementation, including folic acid, 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, resulting in anxiety, short attention span, behavior problems, and lower mental tests scores in childhood. The negative impact of prenatal stress 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. 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 preeclampsia, 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 and fetal movements 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 positive images of themselves as mothers and fathers.

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

Describe the impact of other maternal factors on prenatal development.

Regular moderate exercise during pregnancy contributes to general health and readiness for childbirth and is related to higher birth weight. However, very vigorous exercise results in lower birth weight.