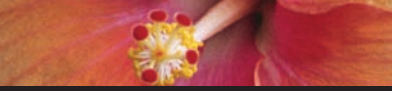


CHAPTER 15

Continuance of Human Life

Reflecting Questions

- How do male and female human hormones interact with reproductive structures?
- How do human limbs, bones, and tissues form from only one cell?
- How do issues related to fertility and infertility affect individuals and society? How has technology dealt with these issues?

Life reproduces itself. "Life" includes all living species, from streptococci to oak trees to salamanders to human beings. The method of reproduction, however, is quite different for different species. Streptococci, for example, reproduce by replicating their genetic material and splitting in two. Oak trees self-pollinate and produce acorns, some of which become new oak trees.

For all mammals, life begins as a tiny fertilized egg about the size of the period at the end of this sentence. Over weeks and months, the new life grows and develops, eventually becoming the collection of cells, tissues, and organs that make up a baby elephant or a baby human. As the baby grows, she or he, in turn, becomes capable of reproducing.

Like all mammals, male and female humans have specialized systems that allow reproduction to take place. The male has specialized structures that produce and deliver sperm, while the female has structures that produce eggs and receive sperm. As you can see in the photo, the female also supports and nourishes a developing human embryo until it is ready to be born. Even after birth, her body produces nourishment for the infant.

In this chapter, you will learn about the reproductive systems of male and female humans. You will learn about the role that hormones play in human reproductive function. You will learn how a pregnant woman's body changes to protect and help a new life grow and how a single cell eventually becomes an independent living organism. You will investigate technologies that help to solve fertility problems and control birth rates, and you will identify factors that can affect the health of a developing fetus.

Does this photograph show a chick embryo or a human embryo? Perhaps it is an elephant embryo? At four weeks, all embryos look much the same.

Chapter Contents

15.1 The Human Reproductive System

OUTCOMES

- **Identify the structures of the male human reproductive system, and describe their functions.**
- **Identify the structures of the female human reproductive system, and describe their functions.**
- **Identify the reproductive hormones of the human male and female, and explain their interactions in the maintenance and functioning of the male and female reproductive systems.**
- **Research and evaluate the uses and effects of estrogen and progesterone treatments for women, including hormone therapy for menopausal women and birth control pills.**
- **Research and evaluate the potential health risks, for individuals and society, associated with exposure to sexually transmitted diseases.**

In Chapter 14, you learned that sexual reproduction is the result of the combination of gametes, one from a male and one from a female. This process is necessary for the survival of the species. Sexual reproduction produces the variations that are necessary to maintain homeostasis as a species. As the environment changes, natural selection determines which individuals will survive to breed and pass on their variations to the next generation. A species with few variations faces possible extinction. The human species, with its reasonably high degree of variation, has proven to be very adaptable as it has populated the globe. In fact, the incredible reproductive success of the billions of *Homo sapiens* will be at the heart of many of the challenges of the twenty-first century.

Figure 15.1 As a species, *Homo sapiens* is characterized by a relatively high degree of variation.

The biology of human reproduction is one of the factors that has allowed us to inhabit almost every part of Earth. In most mammals, reproductive cycles are seasonal and mating occurs so that the offspring are born when environmental conditions are most favourable. Humans, along with some non-human primates, elephants, and giraffes, are examples of continuous breeders. That is, human reproduction is not influenced by the seasons or by location. As you will see, however, human reproduction does have a cyclical component, which is controlled by reproductive hormones.

The Male Reproductive System

The male reproductive system begins to form when the fetus is eight weeks old. It becomes functional at the end of puberty, when a boy is about 13 years old. **Puberty** in males is the stage of life during which reproductive hormones are formed and reproductive development begins, until the first viable sperm are formed. From the end of puberty, the male reproductive system is usually capable of producing sperm 24 hours a day, seven days a

week until death. Figure 15.2 shows the major parts of the male reproductive system.

The testes and the penis are outside the body cavity. The testes produce the sperm and reproductive hormones, and the penis transfers the sperm into the female reproductive system during sexual intercourse. The testes hang outside the body cavity within the scrotum so that they have the cooler temperatures (by two or three degrees) required for the formation of healthy sperm. The testes actually develop inside the body but descend into the scrotum during the last two months of fetal development. If the testes fail to descend, the result is usually sterility. This occurs in about three percent of all male births, but it can be corrected surgically.

The testes are composed of long, coiled tubes called the **seminiferous tubules**, which are surrounded by the **interstitial cells**. As shown in Figure 15.3 on the following page, spermatogenesis occurs within the seminiferous tubules, which can be up to 250 m long. The lining of each of these tubules is composed of cells undergoing meiosis, with sperm being continuously produced and released from the inner lining. **Sertoli cells**, which support, regulate, and nourish the developing sperm, are also found within the tubules. As sperm are formed, they move to the **epididymis** for maturation, where they become motile.

During sexual arousal, blood flows into the penis and is prevented from leaving; this forms an erection. The sperm move out of the epididymis, through the sperm duct (vas deferens), and are mixed with fluid from a series of glands. The **seminal vesicles** produce a mucus-like fluid containing the sugar fructose, which provides energy for the sperm. The **prostate gland** and the **Cowper's gland** secrete an alkaline fluid to neutralize the acids in the female reproductive tract. This combination of sperm and fluid enters the urethra from the urinary bladder and exits the body. The movement of the **semen**, which includes the sperm and the fluid from the glands, is the result of a series of interactions between the sympathetic, parasympathetic, and somatic nervous systems. Sensory stimulation, arousal, and co-ordinated muscular contractions combine to trigger the ejaculation of sperm.

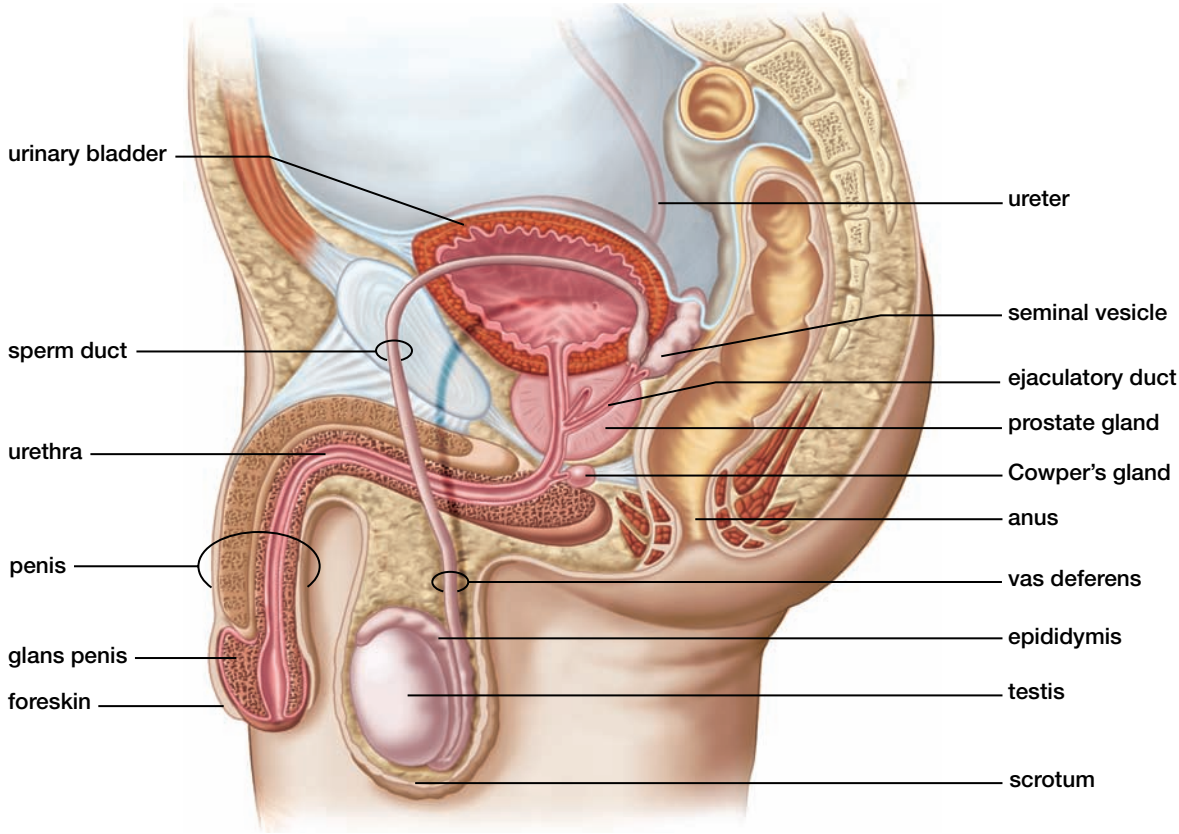


Figure 15.2 The testes produce sperm. The seminal vesicles, the prostate gland, and the bulbourethral gland provide a fluid medium. Circumcision is the removal of the foreskin. Notice that the penis in this drawing is not circumcised because the foreskin is present.

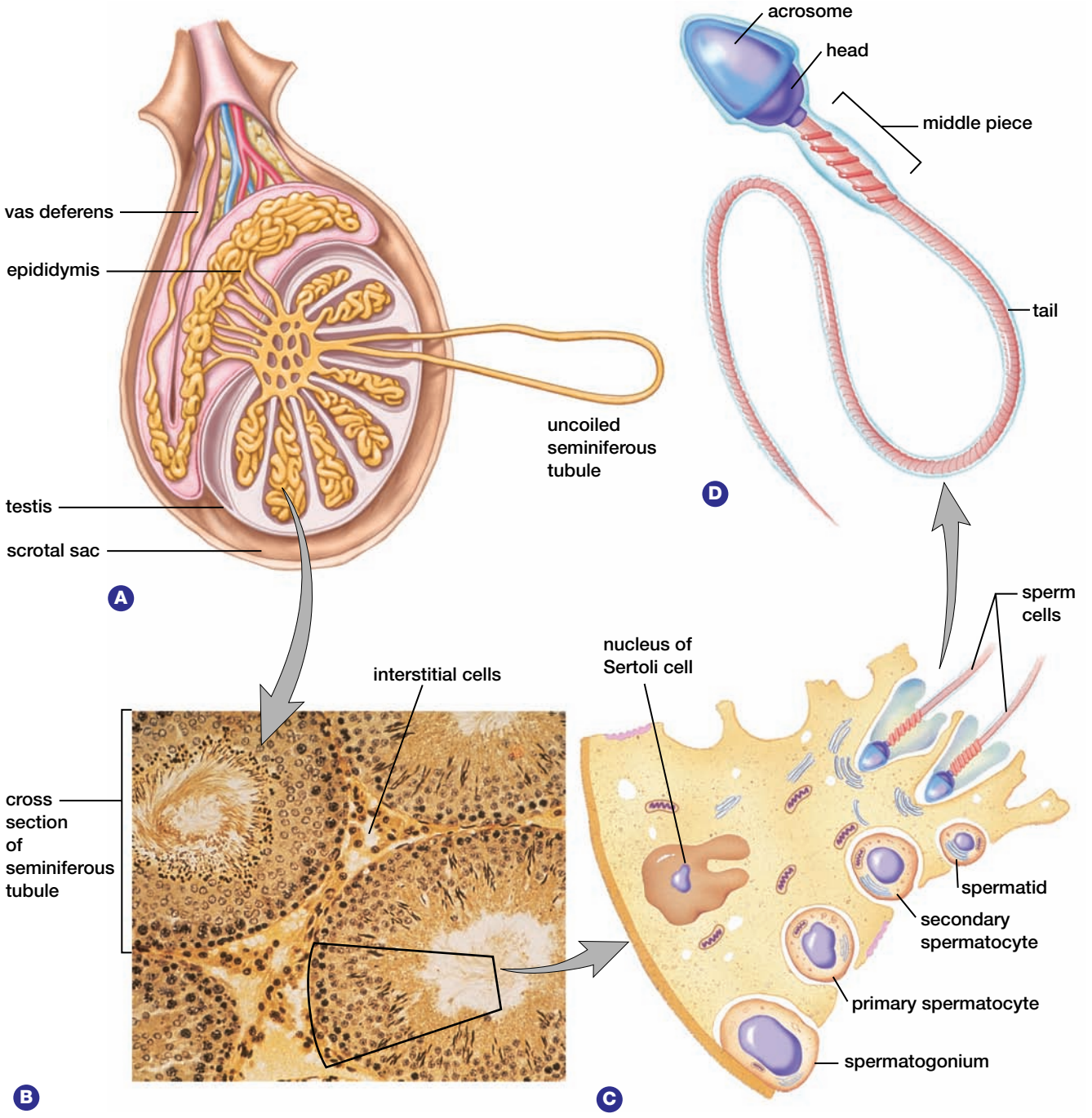


Figure 15.3 (A) The lobules of a testis contain seminiferous tubules. (B) Light micrograph of a cross section of seminiferous tubules, where spermatogenesis occurs. (C) Diagram of spermatogenesis, which occurs in the wall of the tubules. (D) A sperm has a head, a middle piece, and a tail. The nucleus is in the head, capped by the enzyme-containing acrosome.

Male Reproductive Hormones

The process of spermatogenesis is stimulated by FSH (follicle stimulating hormone) from the anterior pituitary gland. The seminiferous tubules, in addition to producing sperm, release the hormone **inhibin**, which forms a negative feedback loop with FSH (shown in Figure 15.4). Inhibin acts on the hypothalamus to slow the production of the releasing factors that control the release of FSH. The interaction of FSH and inhibin controls the rate of formation of sperm.

Another hormone from the anterior pituitary, LH (luteinizing hormone), stimulates the interstitial cells of the testes that surround the seminiferous tubules. These cells produce the male sex hormones.

The steroid hormone **testosterone** is the major androgen and is responsible for the development of the male secondary sexual characteristics. The secondary sexual characteristics include the enlargement of the primary sexual characteristics (the penis and testes) and the enlargement of the larynx (the Adam's apple). Testosterone also inhibits fat while promoting the development of muscle tissue, and stimulates the formation of hair on the face, chest, under the arms, and around the genitals. These characteristics begin to appear during puberty, with an increase in testosterone levels around ages 10 to 12. As Figure 15.4 shows, the level of testosterone in the blood inhibits the production of LH, forming the second negative feedback loop.

The following Thinking Lab looks at how testosterone levels vary in dominant and subordinate baboons.

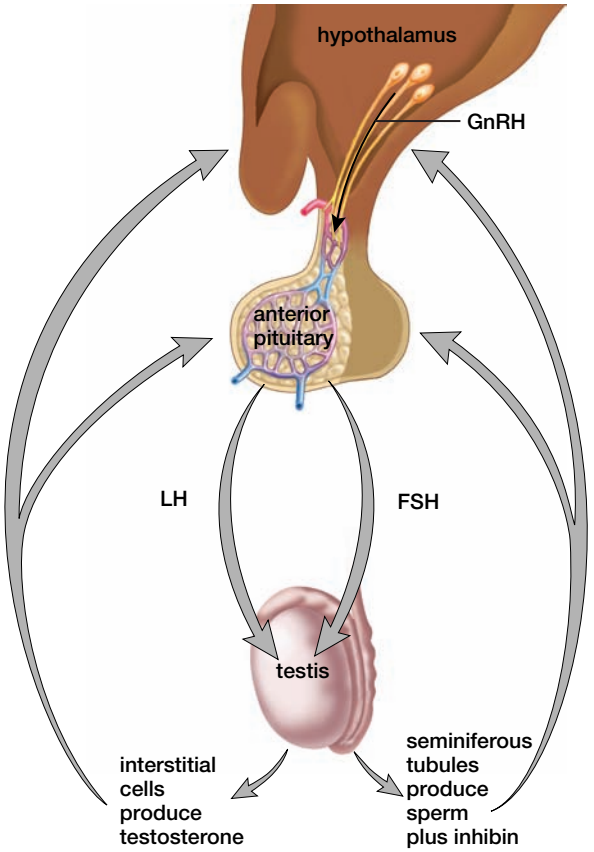


Figure 15.4 GnRH (gonadotropin-releasing hormone) stimulates the anterior pituitary to secrete the gonadotropic hormones FSH and LH. FSH stimulates the testes to produce sperm, and LH stimulates the testes to produce testosterone. Testosterone and inhibin exert negative feedback control over the hypothalamus and the anterior pituitary; this regulates the level of testosterone in the blood.

THINKING LAB

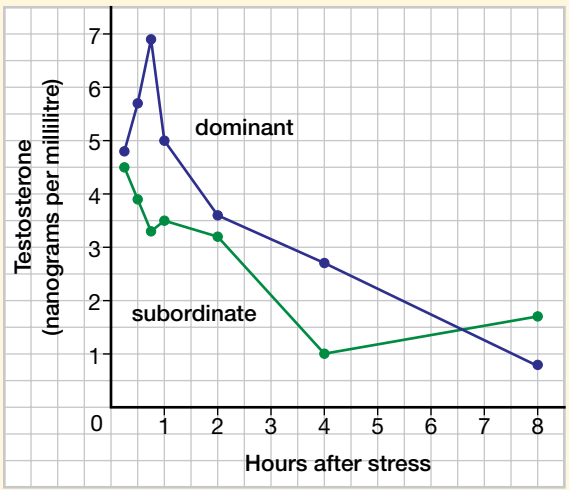
Testosterone and Baboon Behaviour

Background

In baboon tribes, a social structure of dominant and subordinate males exists. The dominant males have better access to food, the best resting spots, and the female baboons. In contrast, the subordinate male baboons must laboriously search for food, often only to have it stolen by a dominant male.

In males, the hormone testosterone regulates sexual behaviour and aggression and increases the rate at which glucose reaches the muscles. This graph shows testosterone levels of dominant and subordinate male baboons. When the male baboons are at rest, the testosterone levels are essentially equal. After being exposed to the same stress, however, the reactions of the dominant and subordinate males differ sharply for the first few hours.

Average testosterone levels in baboons



You Try It

Explain the adaptive advantage of higher levels of testosterone in the dominant male during times of stress.

The Female Reproductive System

The female reproductive system (illustrated in Figure 15.5) performs many functions — it produces the female reproductive cell (the ovum), maintains a fertilized egg through its development as an embryo and fetus, and allows for the birth of the baby.

The vagina acts as an entrance for the erect penis to deposit sperm during sexual intercourse and an exit for the fetus during childbirth. The cervix forms the opening/exit to the uterus, a thick-walled muscular organ about the size and shape of an inverted pear. Although the uterus is usually the size of a fist, it must be capable of expanding to six times its usual size to accommodate a fetus. The lining of the uterus, called the **endometrium**, is richly supplied with blood vessels to provide nutrients to a developing fetus. The endometrium is affected by the changing hormone levels of the menstrual cycle.

The two **ovaries** produce the ova and are suspended in the abdominal cavity. They are each held in place by two ligaments; one extends from the ovary to the abdominal wall while the other reaches from the ovary to the outside of the uterus.

The two **oviducts** transfer an ovum from the ovary to the uterus. The lining of each tube is ciliated to create a current that moves the ovum toward the uterus. The sperm fertilizes the ovum as it travels down an oviduct. Ova are released from different parts of the ovaries, so the openings of the oviducts consist of finger-like projections called **fimbriae**, which sweep over the ovaries. The fimbriae are also ciliated to sweep an ovum into an oviduct for its trip to the uterus.

Female Reproductive Hormones

Typically, puberty begins at age nine or 10 in North American girls but significantly later in many countries. A 1997 study showed some girls begin puberty as early as three years old. Although this is unusual, there is a trend toward earlier onset of puberty than has historically been the case. To a certain extent, this lowered age can be attributed to better diet, but many scientists are concerned. They are looking for other social or environmental factors that may be influencing this trend.

Puberty is triggered by the hypothalamus, which secretes releasing factors to begin the production

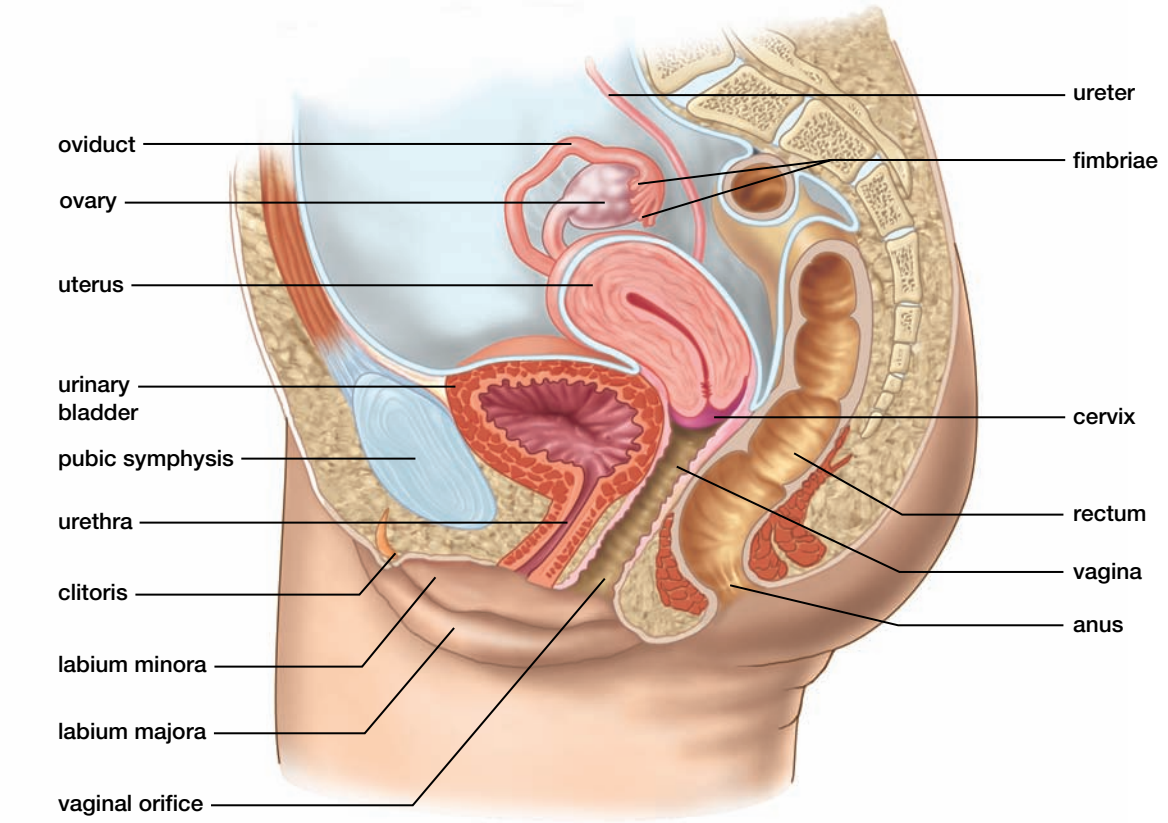


Figure 15.5 The ovaries release one egg a month; fertilization occurs in the oviduct, and development occurs in the uterus. The vagina is the birth canal and the organ of sexual intercourse.

of the reproductive hormones. Hormone levels typically rise gradually from ages eight to 12, and then rise sharply in the early teens. These hormones stimulate the development of the female secondary sexual characteristics, which include the development of breasts, the growth of hair around the genitals and under the arms, the widening of the hips, and an increase in body fat.

While the female reproductive system is not affected by season or location, the reproductive hormones follow a cyclical pattern. The release of an ovum is timed to coincide with the changes in the uterus that make it receptive to the fertilized ovum. This **menstrual cycle** is usually about 28 days long, although it commonly varies from 20 to 45 days and can differ from month to month.

BIO FACT

The first menstruation does not occur until a girl has at least 17 percent body fat. This accounts for the fact that some young athletes and dancers have delayed menstruation. In older women, menstruation stops if body fat is less than 22 percent. This prevents pregnancy if a woman's body is unable to carry a baby.

The menstrual cycle is controlled by the hypothalamus, which excretes releasing factors for the FSH and LH that are released from the anterior pituitary gland. The ovary is composed of many groups of cells called **follicles**, each of which contains a single ovum. Figure 15.6 shows the stages of maturation of a follicle and describes the hormones involved. Although a woman is born with over two million follicles, only approximately 400 will mature to release its ovum during her reproductive life.

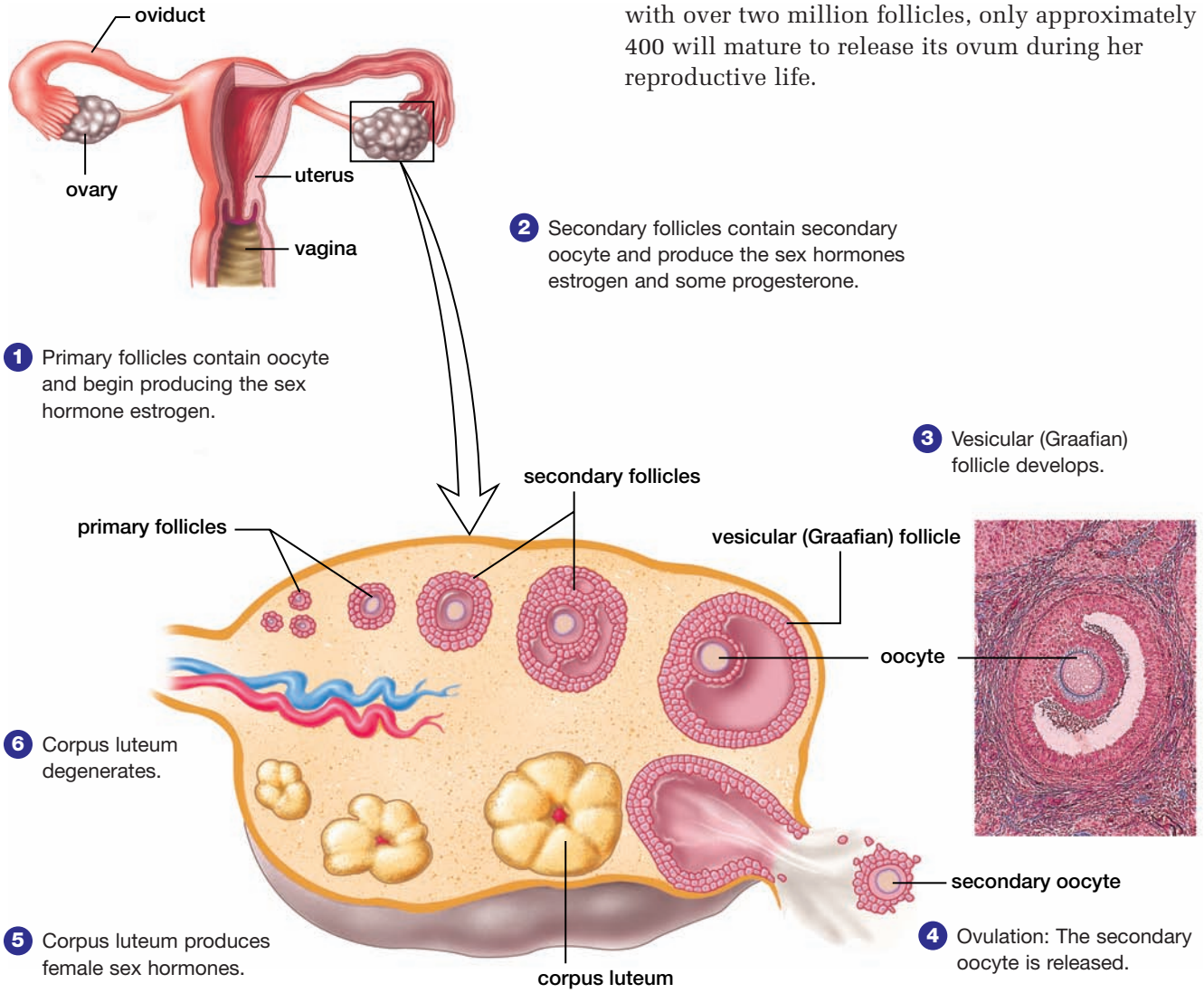


Figure 15.6 A follicle matures by growing layers of follicular cells and fluid. After ovulation, the follicle ruptures and the secondary oocyte is released to the oviduct. The follicle develops into a corpus luteum. After about ten days, the corpus luteum begins to degenerate if pregnancy does not occur. Note that a follicle does not migrate around the ovary, as shown here, but goes through all the stages in one place.

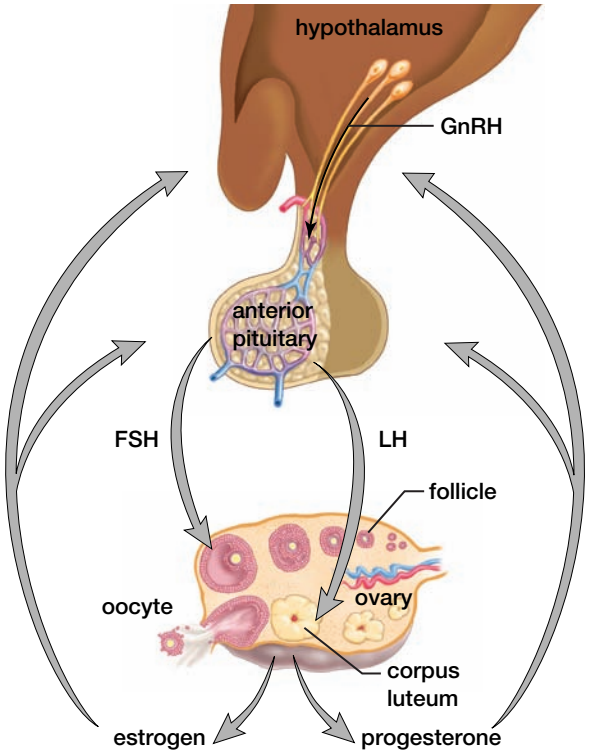


Figure 15.7 The hypothalamus produces GnRH, which stimulates the anterior pituitary to produce FSH and LH. FSH stimulates the follicle to produce estrogen. LH stimulates the corpus luteum to produce progesterone. One of the functions of estrogen and progesterone is to regulate the endometrium.

During the initial **follicular stage** of the menstrual cycle, increased levels of FSH stimulate the follicles to release increased quantities of estrogen into the bloodstream. Estrogen stimulates the endometrium of the uterus to thicken and increase the blood supply in preparation for a possible pregnancy. Estrogen also inhibits the levels of FSH, forming a negative feedback loop. At the same time, estrogen stimulates the hypothalamus to release large amounts of LH, which trigger the release of an ovum from one of the developing follicles.

Ovulation usually occurs at the midpoint (day 14) of a 28-day menstrual cycle. The release of the ovum triggers a rapid biochemical change in the follicle that released the ovum. The follicle changes to become the **corpus luteum**, a group of cells that produces the hormone **progesterone**.

Ovulation signals the beginning of the **luteal stage** of the menstrual cycle. LH stimulates the corpus luteum to produce progesterone, which inhibits the development of other follicles. Thus, only one ovum is released during each cycle. In addition, progesterone inhibits the production of LH. As the level of LH decreases, the corpus luteum begins to degenerate and progesterone levels decrease, ending the luteal stage. This decrease in progesterone decreases the blood supply to the endometrium, which leads to menstruation. During **menstruation**, the endometrium disintegrates, its blood vessels rupture, and the tissues and blood flow out the vagina. The beginning of menstruation signals the first day of the follicular stage of the cycle.

During the menstrual cycle, the hypothalamus, the anterior pituitary, the follicle, and the corpus luteum produce female hormones. Examine Figure 15.7 to see how the structures and hormones interact. In Investigation 15-A, you will organize what you have just learned about the roles of various female hormones by creating a chart to represent the changes that take place during the menstrual cycle.

Female Hormone Treatments

With age, there is a reduction in the number of functioning follicles, causing a decrease in the amount of estrogen and progesterone in the blood. The decrease in these hormones signals the onset of **menopause**, which is characterized by cessation of menstruation. During and after menopause, cholesterol levels rise and bone mass declines. Also during menopause, blood vessels alternately constrict and dilate, resulting in uncomfortable sensations known as "hot flashes." As well, some women experience mood changes. While some doctors prescribe low levels of estrogen and/or progesterone (**hormone replacement therapy**) to alleviate the symptoms, this practice is the subject of considerable debate. The potential benefits of hormone replacement therapy include

- relief of menopausal symptoms such as hot flashes, night sweats, and sleep disturbance
- prevention of bone loss (osteoporosis)
- improved memory
- decreased chance of urinary tract infections
- decreased rate of macular degeneration (a leading cause of blindness)

The risks associated with hormone replacement therapy vary with the hormone(s) prescribed. The potential side effects of estrogen replacement include

- irregular vaginal bleeding
- stomach upset
- severe headaches
- formation of blood clots
- increased risk of breast cancer

- increased risk of uterine cancer

The potential side effects of progesterone replacement include

- stomach upset
- irregular vaginal bleeding
- edema (water retention)

The potential side effects of combined estrogen and progesterone replacement include

- formation of blood clots
- increased risk of heart attack during first year of treatment
- headaches
- fluctuations of blood sugar level
- edema
- premenstrual-like syndrome

Contraception is another application of synthetic female hormones. Birth control pills contain either a combination of progesterone and estrogen or progesterone alone. Therefore, many of the risks associated with birth control pills are similar to the risks associated with hormone replacement therapy.

One common type of birth control pill contains synthetic forms of estrogen and progesterone. This type of pill is taken every day for the first 21 days of each menstrual cycle. The combination of estrogen and progesterone suppresses secretions of FSH and LH. As a result, ovulation is inhibited. In addition, the hormones cause the endometrium to develop abnormally so that if ovulation does occur and the egg is fertilized, implantation cannot occur. (You will learn more about birth control pills and other contraceptives in section 15.2.)

In the Thinking Lab below, you will compare different types of hormone replacement therapy.

THINKING LAB

Hormone Replacement Therapy

Women who experience unpleasant or harmful post-menopausal symptoms have several options if they want to try hormone replacement therapy.

Background

For many years, estrogen has been the preferred form of medication for hormone replacement therapy. However, estrogen is a potent medication that has been associated with increased risk of adverse reactions and various forms of cancer and other health problems.

You Try It

Compare the effectiveness of two types of drugs used in hormone replacement therapy, a treatment program designed to alleviate post-menopausal symptoms in women.

In the search for a safer alternative to estrogen, pharmaceutical companies recently developed a new class of prescription medications referred to as "Selective Estrogen Receptor Modulators," or SERMs. Two examples of these medications are "tamoxifen" and "raloxifene."

Find out more about how estrogen and SERMs are used in hormone replacement therapy by researching sources on the Internet. Then answer the following questions about these two medications.

1. Describe the physiological action of SERMs on cells and tissues.
2. Why are SERMs referred to as "estrogen antagonists"?
3. Make a table in your notebook similar to the one below and compare the health benefits and risks associated with estrogen and SERMs.

Comparing effectiveness and side effects of estrogen and SERM medications

Effectiveness Side effects	Post-Menopausal Medication	
	Estrogen	SERMs
Symptoms of Menopause		
Bone Density		
Uterine Cancer Risk		
Breast Cancer Risk		
Heart Disease Risk		
Other Side Effects		

4. Based upon your analysis, is it possible to claim that one of these medications is safer than the other?
5. If you were a doctor who was developing a hormone replacement program for a post-menopausal patient, would you prescribe estrogen, a SERM, or, perhaps, some combination of both medications? What criteria would you use to decide which drugs to use for an individual patient?

SKILL FOCUS

Analyzing and interpreting

Communicating results

The Menstrual Cycle

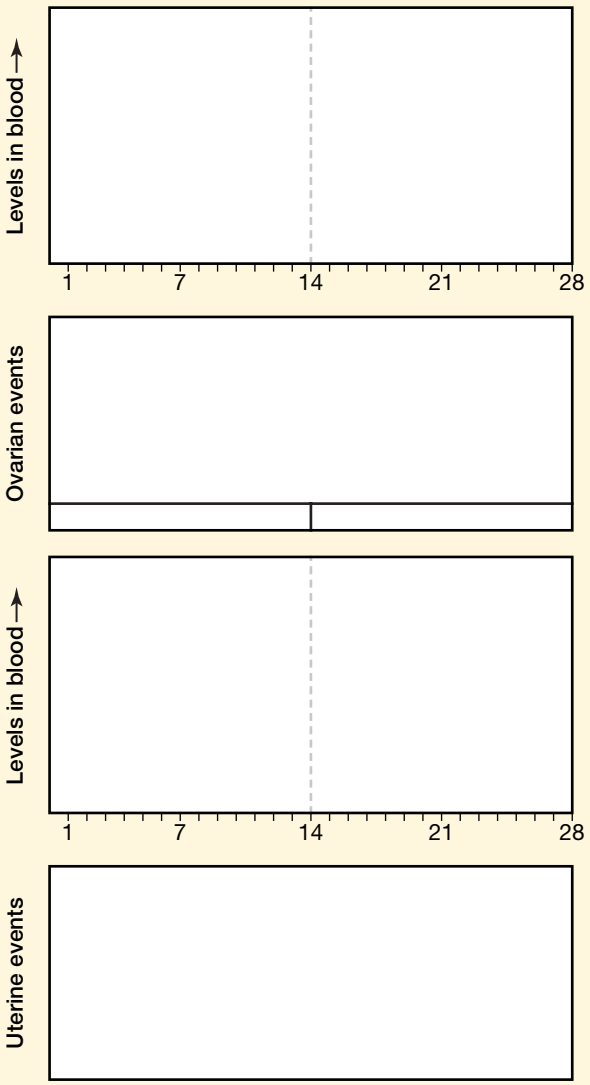
LH and FSH can be categorized as *pituitary hormones* because they are produced by the pituitary gland. Similarly, progesterone and estrogen are known as *ovarian hormones* because they are produced in the ovaries. In this investigation, you will create a diagram to show how levels of pituitary and ovarian hormones affect, and are affected by, ovarian and uterine events during the menstrual cycle.

Pre-lab Questions

- How do reproductive hormones change as a follicle develops?
- What happens to the levels of reproductive hormones during ovulation?
- How do reproductive hormones change as the endometrium thickens and then sloughs off during menstruation?

Problem

How do the levels of FSH, LH, estrogen, and progesterone interact with one another and affect the events of the menstrual cycle?



Prediction

Predict the key role of each reproductive hormone.

Materials

graph paper
sketching supplies, including coloured pencils or markers
craft supplies, such as scissors, glue, unlined paper, and tape (optional)

Procedure

Part A: Pituitary Hormones and the Ovarian Cycle

1. Examine the template on the left. Draw a similar template on a sheet of graph paper. You may wish to tape together two sheets of graph paper, to make your template larger.
2. Use the data in the first table on the next page to create a graph that shows the relative levels of FSH and LH in the blood. Draw your graph in the top box of your template.
3. Carefully examine the information on pages 490 to 492 of this textbook. Decide how the various stages of the ovarian cycle (including development of the follicles, ovulation, formation of the corpus luteum, and luteal regression) correspond to the hormone levels on your graph.
4. In the second box of your template, create seven sketches to show the development of the follicle, ovulation, the corpus luteum, and luteal regression. Put each sketch below the appropriate day, or range of days, in the cycle. You may wish to draw your sketches on white paper, and then attach them to your template.
5. Which stage of the cycle corresponds to the follicular phase? Which stage corresponds to luteal phase? Indicate the two phases just below your sketches.

Part B: Ovarian Hormones and the Uterine Cycle

1. Use the data in the second table to create a graph that shows the relative levels of estrogen and progesterone in the blood. Draw your graph in the third box of your template.

2. Again, carefully examine the information on pages 490 to 492 of this textbook. Decide how the varying levels of estrogen and progesterone correspond to the build-up of the endometrium and the subsequent sloughing-off during menstruation.

3. In the bottom box of your template, show the changes in the endometrium. First indicate the point where the endometrium is thickest (high on the *y*-axis). Then indicate the point where the endometrium is thinnest (low on the *y*-axis). Sketch a curve to suggest the way that the endometrium changes each day. (Instead, you may choose to draw three or four sketches of the uterus, showing the thickness of the endometrium at each stage.)

4. During which days does menstruation occur? Indicate this period on your curve (or on the appropriate drawing).

Post-lab Questions

1. **(a)** During which days of the cycle does the level of FSH increase?

   (b) During this period, what is happening to the follicle?

2. **(a)** On which day is the level of LH in the bloodstream at its highest?

   (b) What event occurs just after the level of LH peaks in the bloodstream?

   (c) What occurs as the level of LH decreases after peaking?

3. **(a)** During which days of the cycle does the level of estrogen increase significantly?

   (b) What is happening to the endometrium during this period?

4. **(a)** During which days of the cycle does the level of progesterone increase significantly?

   (b) What is happening to the endometrium during this period?

5. **(a)** During which days of the cycle are the levels of estrogen and progesterone at their lowest?

   (b) What is happening to the endometrium during this period?

   (c) What is this period called?

Conclude and Apply

6. Which hormones are at their highest levels in the blood when the uterine lining is the thickest?

7. How do increased levels of estrogen and progesterone appear to affect the level of FSH?

8. Does the name of FSH correspond to its function? Explain your answer.

9. Does the name of LH correspond to its function? Explain your answer.

10. Summarize the effects of progesterone and estrogen on the endometrium. Do progesterone and estrogen have a similar function? Explain your answer.

11. What would you expect the relative levels of the hormones to be on day 29? Explain your answer.

Relative Levels of LH and FSH

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LH	7	7	6	4	2	2	3	5	8	16	26	45	62	29
FSH	1	3	5	8	10	11	10	7	5	4	6	10	20	14
Day	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
LH	16	9	8	9	8	7	5	4	2	2	3	4	6	8
FSH	7	3	1	1	1	3	4	4	5	6	6	5	4	2

Relative Levels of Estrogen and Progesterone

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
estrogen	7	7	7	8	10	13	16	19	23	27	35	38	29	16
progesterone	1	1	2	2	2	2	2	2	2	3	5	6	7	8
Day	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
estrogen	15	18	21	21	21	20	20	20	20	19	18	16	14	9
progesterone	10	12	15	18	21	25	26	27	27	26	25	23	20	8

Sexually Transmitted Infections

A disease that is transmitted mainly through sexual contact is called a **sexually transmitted infection (STI)**. You may have also heard the older term, "sexually transmitted disease (STD)," used to describe this type of infection. The most common STIs are caused by viruses or bacteria. In the past, bacterial infections, such as gonorrhea and syphilis, were deadly. Today, however, they can usually be cured using antibiotics. Viral infections, such as AIDS and genital herpes, cannot yet be cured, but they can be treated. Different STIs have different effects, ranging from mild discomfort to infertility or sterility, major organ failure, or death.

AIDS

The acronym AIDS stands for "acquired immunodeficiency syndrome." This syndrome is caused by the virus HIV, which attacks the immune system of the infected person — specifically, the helper T cells. As the level of helper T cells in the blood decreases, the infected person becomes susceptible to a variety of different infections. These infections eventually lead to sickness and death in AIDS patients.

HIV is transmitted through sexual contact with an infected person. Sexual contact includes vaginal or rectal intercourse, as well as oral/genital contact. HIV is also transmitted by sharing needles among intravenous drug users. In the past, people became infected with HIV through blood transfusions. Today, however, all donated blood is screened for infection. Children of mothers who are infected with HIV may be infected before or during birth, or through breast-feeding.

AIDS proceeds through three stages of infection: Stages A, B, and C. Stage A lasts about a year. During this stage, the infected person has no symptoms but can infect others. As long as the body continues to produce enough T cells to replenish the diminished supply, the infected person remains well.

Eventually, the body is not able to replace T cells fast enough and Stage B begins. During Stage B, which lasts about 6 to 8 years, the lymph nodes swell and the person experiences weight loss, night sweats, fatigue, fever, and diarrhea. Infections, such as thrush and herpes, recur.

Stage C is full-blown AIDS. The person begins to suffer from nervous disorders and opportunistic diseases, such as pneumonias and skin cancer. (Opportunistic diseases are diseases that occur in people who have little or no ability to fight an infection.) If the person does not receive treatment, she or he will die in seven to nine years.

Although there is no cure or vaccine, people with AIDS live longer today than in the past due to the success of new treatments for the associated infections.

Chlamydia

Chlamydia is a common and potentially dangerous infection that is caused by the bacterium *Chlamydia trachomatis*. In Canada in 2001, approximately 49 000 cases of chlamydia were reported, compared with 6500 cases of gonorrhea and 280 cases of syphilis. As shown in Figure 15.8, young people between the ages of 15 and 24 tend to account for the majority of new chlamydia cases.

After infection with chlamydia, some people experience symptoms immediately. Men may feel a burning sensation when urinating and notice a discharge from the penis. After 8 to 12 days, women may have vaginal discharge and symptoms of urinary tract infection, including pain on urination and fever.

One of the greatest dangers of chlamydia, however, is that up to 75% of cases may be asymptomatic. In other words, sufferers experience no symptoms until irreversible damage has been

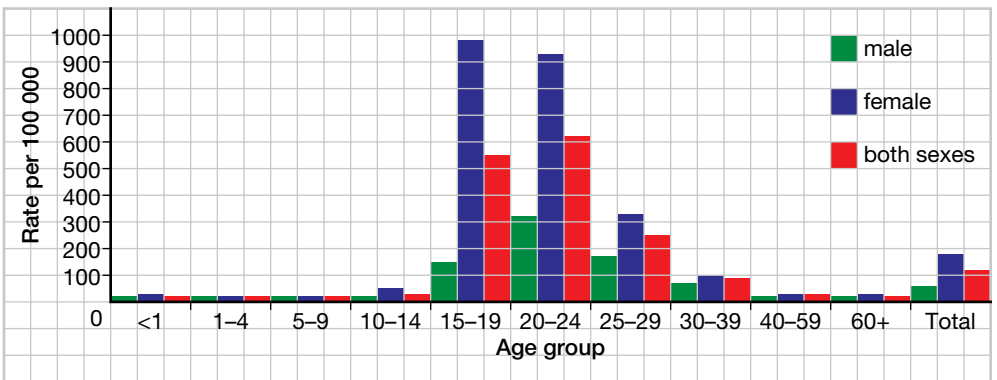


Figure 15.8 Rates of new chlamydia cases are highest among young men and women. In 1997, the highest rate for women was among the 15 to 19 age group. The highest rate for men was among the 20 to 24 age group. Overall, young people between the ages of 15 and 24 accounted for 69% of infections.

done. If the infection progresses undetected in a woman, ulcers (sores) on the cervix may appear, increasing the risk of acquiring AIDS. If the infection spreads to the cervix and oviducts, the infected female may contract pelvic inflammatory disease (PID). PID is painful and can result in blocked oviducts and infertility.

Fortunately, there are effective tests for chlamydia, which can help physicians diagnose it early. If the infection is caught early enough, it can be treated and cured using antibiotics and the infected person suffers no permanent effects.

A baby who comes in contact with chlamydia during birth can develop inflammation of the eyes or pneumonia.

Hepatitis

Hepatitis includes three types of viral infections: Hepatitis A, B, and C. Hepatitis A is usually contracted by drinking water that is contaminated with sewage. It can also be transmitted through oral or anal contact. Hepatitis B is spread in the same way as HIV — through sexual contact, blood, or body fluids. For this reason, Hepatitis B is considered to be a sexually transmitted disease. Hepatitis C is transmitted via infected needles or syringes.

Symptoms of initial infection are flu-like, including fever, headache, nausea, loss of appetite, and abdominal pain. As well, the skin of an infected person may turn yellowish (jaundice). A Hepatitis infection can progress to cause infection of the liver, leading to liver failure, liver cancer, and even death. Some people recover completely, while others become asymptomatic carriers and infect others.

Effective and safe vaccines for Hepatitis A and B are available. Physicians usually recommend vaccination for people at a high risk for hepatitis, including people who engage in high-risk sexual activities.

Hepatitus viruses can cross the placenta to infect an unborn child.

Genital Herpes

Genital herpes is a viral infection that is caused by one of two herpes viruses: herpes simplex 1 (HSV 1) or herpex simplex 2 (HSV 2). HSV 1 more commonly causes cold sores and fever blisters on the mouth. HSV 2 is more likely to be acquired through sexual contact, causing genital herpes.

Once infected, symptoms usually appear within a month. The infected person may feel a tingling or itching, followed by the appearance of blisters, which rupture. The blisters may occur on the genitals, buttocks, or thighs, or on internal tissues. The resulting, painful sores take anywhere from five days to three weeks to heal. The outbreak may be accompanied with flu-like symptoms. After the initial episode, the blisters may recur with varying frequency, or not at all. Fever, stress, sunlight, vaginal intercourse, or certain foods may trigger an outbreak. Researchers believe, however, that many people who are infected never experience any symptoms.

Although the risk of passing on genital herpes is greatest when the carrier has an active sore, the disease can be transmitted even when there are no visible or active sores. No blood test is currently available to test for genital herpes. The disease cannot be diagnosed unless there is an active sore.

Genital herpes is an extremely common STI. In the United States, doctors report that 50 million people are living with the herpes virus, with an estimated 1 million new cases being reported each year. (In Canada, physicians are not required to report incidences of genital herpes infections. Therefore, no dependable data are available for Canada.)

There is no cure for herpes, although antiviral medication can decrease the severity of the first outbreak and help to control and diminish the severity of future outbreaks. Once a person is infected with genital herpes, he or she is infected for life.

As well as the discomfort that is associated with herpes outbreaks, herpes sores mean an increased risk of AIDS infection. If a newborn baby encounters a sore during birth, the resulting infection can cause blindness, neurological disorders, and even death. Physicians usually recommend that mothers with genital herpes give birth by Caesarean section to avoid infecting the newborn.

Syphilis

Syphilis is an infection that is caused by the bacterium *Treponema pallidum*. Syphilis proceeds in three stages, with each stage separated by a period of latency. During the first stage, ulcerated sores with hard edges, called chancres ("shan-kers"), appear at the infection site.

The second stage is characterized by a rash, which may appear anywhere on the skin but generally appears on the palms of the hands and the soles of the feet. During this stage, any contact with the infected person may spread the infection.

During the tertiary stage, the infection begins to affect the cardiovascular and nervous system.

Sufferers may develop mental illness, become blind, walk with a shuffle, and develop heart disease. Large, destructive ulcers, called Gummas, may develop on the skin or internal organs.

Historically, syphilis was the cause of a devastating epidemic ("the pox") throughout Europe and other parts of the world. Syphilis can now be treated effectively with antibiotics, including penicillin. It can be diagnosed using a blood test, symptom recognition, or microscopic identification of the bacteria. The disease must be diagnosed and treated early, before the bacteria cause permanent damage.

Syphilitic bacteria can infect a developing embryo, causing birth defects or, in many cases, a stillbirth.

Gonorrhoea

Gonorrhoea is caused by the bacterium *Neisseria gonorrhoeae*. Gonorrhea can cause infection of the urethra, cervix, rectum, and throat. The infection is often characterized by pain on urination and a

Biology At Work

Sexual Health Coordinator

Jeanne Breau

Jeanne Breau is a regional sexual health coordinator in Miramichi, New Brunswick. She works to keep her community healthy through education and nursing care. She says one of the toughest parts of her job is convincing the community to talk about sexual issues in an open way. "The World Health Organization says that we need to use education to have healthy communities," Jeanne says, and it's a motto she lives by.

Jeanne joined the work force after just a year's training as a registered nurse's assistant. Over the next thirteen years, she continued her education to become a registered nurse (RN), and then got her bachelor's degree in nursing (BN) and a masters degree in education (MEd). Jeanne was one of the first people in Canada to earn a degree at home through teleconferencing and videoconferencing with the University of New Brunswick in Fredericton.

To educate her community about sexual health issues, Jeanne gives talks to community groups and schools and works to set up and maintain clinics for sexual health. She also works as a nurse in her clinic, where she discusses her patients' concerns, carries out physical examinations, and tests patients for STIs and other diseases that affect sexual organs, such as cervical cancer.

Testing is important. Jeanne says that cervical cancer in Canada could be completely wiped out if all women would get a Pap smear done every year. A Pap smear involves the removal and examination of cells from the cervix and vagina to determine the presence of cancerous and pre-cancerous cells. If the cancer is caught early enough, treatment can prevent it from spreading and causing permanent damage.

Similarly, damage from many STIs can be prevented with early testing and treatment. For example, chlamydia, a common STI, rarely shows symptoms, but if it is not treated, it can cause sterility. With early diagnosis, however, the condition can be cured with antibiotics and the patient will suffer no permanent damage. There are 70 strains of genital warts, another STI Jeanne often sees in her clinic. Two of those seventy strains cause cancer if they are allowed to spread, yet Jeanne says that people may not realize that they have the warts on their skin.

Jeanne believes that communication is a vital part of developing healthy attitudes about sexuality. She feels her hard work is rewarded by the trusting relationships that she has built with her clients. She is proud that her clinic provides a safe, friendly, non-judgmental place where people can come to ask questions, discuss their concerns, or get tested for sexually transmitted infections.

Career Tips

A bachelor's degree in nursing is now the standard for anyone who wants to become a nurse. You will need good marks in high school biology to gain entrance to the nursing program. The degree program will include further courses in biology and microbiology.

To work as a sexual health coordinator, Jeanne says you will need to develop a tough skin to be comfortable talking about sexuality in front of a hundred people or more. She says you must strive to be supportive and helpful, and be ready to "listen, not lecture."

thick greenish-yellow discharge from the urethra. Some people who are infected, however, experience no initial symptoms. If the infection progresses in a woman, PID can develop and affect her oviducts. The tubes may become blocked by scar tissue, leading to infertility. An untreated infection can also spread through the bloodstream to joints, heart valves, or the brain.

Gonorrhoea can be successfully treated with antibiotics. Although many strains of the bacterium are becoming resistant to traditional antibiotics, such as penicillin, alternative antibiotics remain effective.

A baby who passes through the birth canal of a mother who is infected with gonorrhea can develop an eye infection, which may lead to blindness. Physicians give eye drops to newborns, to prevent this from occurring.

In this section, you learned about the male and female human reproductive organs and hormones. You also read about some diseases that are transmitted via sexual contact. You learned that some of these diseases may lead to infertility or sterility. In the next section, you will examine technologies that have been developed to counteract infertility or sterility for people who wish to have children. You will also examine the various technologies that have been developed to control reproduction at its various stages.

WEB LINK

www.mcgrawhill.ca/links/atlbiology

The term *vaginitis* includes two common infections of the vagina. To learn about these infections, their symptoms, and their treatments, go to the web site above and click on **Web Links**. Find out how these infections are transmitted, and whether they are both transmitted the same way. How can a woman prevent these infections? Why do you think these two infections are grouped together under a common name?

SECTION REVIEW

1. Explain the effects of puberty in males and females.

2. Define the term "sex hormone."

3. Identify the organs that produce sex hormones in males and females. List the hormone(s) produced by each structure.

4. Explain the roles of FSH, inhibin, LH, and testosterone in mature males.

5. Describe how female sex hormones prepare the reproductive system for a possible pregnancy during a normal menstrual cycle.

6. When a woman becomes pregnant, menstruation stops for the duration of the pregnancy. Explain how menstruation is prevented if pregnancy occurs.

7. Some types of birth control pills contain small amounts of both estrogen and progesterone. Explain why these pills must be taken at roughly the same time each day to be effective.

8. Osteoporosis is a bone disease that can afflict both males and females. Generally, however, it is associated with post-menopausal women. Research how hormones are sometimes used to help prevent the onset of osteoporosis. Identify the criteria that are used to develop treatment protocols for patients who are diagnosed with this disease. Are there other, non-pharmaceutical ways to prevent osteoporosis? If possible, research the occurrence of osteoporosis in your family.

9. Because chlamydia is caused by bacteria and not a virus, it is a curable STI.

(a) Since chlamydia is curable, why are there so many new cases each year? Give several reasons.

(b) Chlamydia is potentially a very damaging STI, even though it is curable. Explain why.

10. STIs, such as AIDS and chlamydia, are uncomfortable, painful, harmful, and sometimes deadly for the individuals who contract them. What are the effects of STIs on society?

(a) Choose an STI. Create a concept map to show the ways in which a person with this STI may interact with other individuals and with society as a whole.

(b) For the STI you have chosen, what steps can be taken to improve, avoid, or eliminate the negative effects you identified? For example, someone who is infected with HIV has the potential to infect others through sexual contact. Health organizations can lobby for better education about protection during sexual activity, and individuals can abstain from sexual activity or practice safer sex.

11. List some effective ways to reduce the transmission of STIs.

15.2 Reproductive Control

OUTCOMES

- **Explain how different technologies can be used to influence conception.**
- **Assess the effects of conception control technologies on the population demographics of more industrialized countries and less industrialized countries.**
- **Debate the merits of funding solutions to human fertility problems versus the merits of funding human population control. Which should be a priority?**

On July 25, 1978, Leslie Brown made history by giving birth to a healthy baby girl. Little Louise Joy Brown, born in Great Britain, was the first successful "test-tube" baby. Her life began in a laboratory, when scientists removed an egg from her mother and mixed it with sperm from her father. After two and a half days, scientists placed the fertilized egg in her mother's uterus. Almost nine months later, Louise Joy Brown, shown in Figure 15.9, was delivered by Caesarean section.

The success of the first "test-tube" baby gave many infertile couples hope that they, too, could have a child. However, the new technology also caused a great deal of controversy: Was the technology ethical? Were researchers "playing God"? Would people find ways to abuse the technology? Reproduction is a highly charged issue, and controversy surrounds almost any technology that affects it.

Figure 15.9 Louise Joy Brown, the first "test-tube" baby, symbolized hope for many people. Her birth touched off a major controversy, however. She is shown here at the age of one appearing on the Donahue Show.

Despite the controversy, researchers continue to develop and refine reproductive technologies. These technologies can be divided into two categories:

1. technologies that enhance reproductive potential
2. technologies that reduce reproductive potential

In other words, researchers have developed (and continue to develop) technologies that solve problems on both sides of the reproductive issue. They enable people who are infertile to have children, and they enable people who are fertile to avoid or delay conception.

Infertility

The term **sterile** is used to describe couples who are unable to have any children. The term **infertile** is used to describe couples who have fewer children than they wish. Couples are considered to be infertile when they have been trying unsuccessfully to become pregnant for a year or more. Researchers have identified numerous causes of infertility and sterility in women and men. It is not always possible, however, to identify the exact cause of a couple's infertility.

A woman may be infertile or sterile for any of the following reasons:

- *blocked oviducts*, often caused by PID (pelvic inflammatory disease), which is often caused by STIs
- *failure to ovulate*, caused by hormonal imbalances that occur for a variety of reasons, including being underweight or overweight
- *endometriosis*, a painful condition in which the endometrium grows outside the uterus
- *damaged eggs*, which may be caused by environmental factors, such as exposure to chemicals

A man may be infertile or sterile for any of these reasons:

- *obstruction in the vas deferens or epididymus*, which may be caused by complications arising from STIs or from varicose veins in the testicles
- *low sperm count*, caused by numerous factors, including overheated testicles, smoking, and alcohol intake
- *high proportion of abnormal sperm*, caused by factors including overheated testicles, exposure to toxins, and infections, such as STIs

Technological Solutions to Infertility

The technology that allowed Louise Joy Brown to be conceived is today called *in vitro fertilization* (*IVF*). Since 1978, researchers have built on this technology, developing other ways to help infertile couples have a child. Artificial insemination, however, is a technology that predates in vitro fertilization. It was widely used among humans in the 1950s, although breeders had been using it with animals for many years before. Table 15.1 lists several reproductive technologies that are used today.

Controlling Reproduction

You have just examined some technologies that were designed to help couples who have difficulty reproducing. If a woman does *not* wish to conceive, she can use technologies to reduce the likelihood that she will become pregnant. **Contraception** is the intentional prevention of conception.

Table 15.2 on the next page describes some methods of contraception, or birth control, and their effectiveness. The effectiveness of each method relates to the number of sexually active women, per year, who will avoid pregnancy while using this method.

Researchers continue to develop new methods of contraception. For example, a relatively new method is the female condom, shown in Figure 15.10. The female condom has just recently become available in Canada.

Figure 15.10 Women who are allergic to latex may prefer the female condom to the male condom. The female condom is made of polyurethane instead of latex.

Table 15.1
Reproductive Technologies

Technology	How it works	Who uses it
artificial insemination (AI)	Sperm is placed in the vagina by a physician.	an infertile couple, if the man has a low sperm count (sperm can be collected and concentrated), or a woman who does not have a male partner and wants a child
in vitro fertilization (IVF)	Fertilization takes place outside the body, in a laboratory procedure. The fertilized oocytes are implanted in the uterus.	a woman who has damaged or blocked oviducts
in vitro maturation (IVM)	Primary follicles are removed from the uterus and induced to mature into secondary oocytes. IVM is used to produce numerous oocytes for in vitro fertilization.	a woman who will undergo in-vitro fertilization
superovulation	Superovulation is used to produce multiple eggs for in vitro fertilization, to increase the chance of pregnancy. FSH injections stimulate the development of multiple follicles. HCG (human chorionic gonadotropin) stimulates ovulation.	a woman who is undergoing in-vitro fertilization, or a women who does not ovulate regularly, frequently, or at all, to increase her chances of pregnancy
surrogate motherhood	A fertilized oocyte from an infertile couple (obtained by IVF) is placed in the uterus of a surrogate mother. Alternatively, a surrogate mother undergoes AI, using sperm from the male of the infertile couple.	a woman who cannot bring a child to term, or a couple who is infertile due to unknown causes or due to factors that cannot be overcome by other technologies
cryopreservation	Oocytes, semen, and even embryos are preserved by freezing.	a male or female cancer patient, who may become infertile or sterile due to radiation therapy, or a sperm bank that supplies semen for AI

Table 15.2
Some Common Methods of Birth Control

Method	Effectiveness	Description	How it works	Risks
abstinence	100%	Woman must refrain from sexual intercourse.	Sperm does not contact the vagina.	none
vasectomy	close to 100%	The sperm ducts are cut and tied.	There is no sperm in the ejaculate.	permanent, irreversible sterility
birth control pill	close to 100% (if used correctly)	The pill is a daily hormone medication, which is taken orally.	FSH and LH are not released.	blood clots, especially in smokers, and hormonal side effects
tubal ligation	close to 100%	The oviducts are cut and tied.	The eggs do not reach the oviduct or uterus.	permanent, irreversible sterility
needle (Depo-Provera)	99%	A woman is given one hormone injection every three months.	FSH and LH are not released.	hormonal side effects
Contraceptive implant (Norplant)	over 90%	Hormones are implanted under the skin.	FSH and LH are not released.	hormonal side effects
IUD	over 90%	An IUD is a plastic coil or armature that is inserted into the uterus. It lasts about five years.	Implantation is prevented.	PID
diaphragm	about 90%	A diaphragm is a large latex cup that fits over the cervix and prevents sperm from entering. (It is usually used with spermicidal jelly or foam.)	Sperm is blocked at the cervix.	reaction to latex
cervical cap (must be used with jelly)	almost 85%	A latex cap is attached to the cervix by suction.	Sperm is blocked, and killed by spermicide, at the cervix.	reaction to latex
male condom	about 85%	A male condom is a latex sheath that fits over the erect penis.	The male condom traps sperm.	reaction to latex
female condom	about 85%	A female condom is a polyurethane pouch that is inserted into the vagina.	The female condom prevents sperm from contacting the vagina and cervix.	none known
spermicidal jelly and foam	about 75%	These products are inserted into the vagina before intercourse. They are often used with a condom or a diaphragm.	A large percent of sperm are killed	reaction to spermicide
rhythm method	about 70%	The date of ovulation is determined by record keeping and temperature measurements.	Intercourse is avoided at the most fertile times.	none

BIO FACT

Not all new contraceptive technologies are available in Canada. For example, Mifepristone, also called RU-486, is a pill that was developed in France in 1980. It blocks progesterone receptors in endometrial cells. The blockage results in the endometrium sloughing off, along with the implanted embryo. This pill has not been approved for use in Canada, partly because of the controversy surrounding its use and the perceived potential for misuse.

Emergency Contraception

The term *emergency contraceptive* refers to medication that is taken after unprotected sexual intercourse (if a condom breaks, for example) to prevent pregnancy. The most familiar type of emergency contraceptive is commonly called the "morning-after pill," although it can be taken up to three days after unprotected sexual intercourse. The sooner it is taken, however, the higher its success rate is.

The most commonly used type of morning-after pill contains relatively high doses of synthetic estrogen and progesterone. Two of these pills are taken as soon as possible after unprotected sexual intercourse, and two more are taken 12 hours later. The hormones disrupt the uterine cycle. This disruption prevents or delays the release of an oocyte from the ovary. If fertilization has taken place, this disruption can prevent an embryo from

implanting in the endometrium. The most common side effects of the morning-after pill are nausea and vomiting.

Population Demographics and Conception Control

In what way has the development of safe and effective contraception affected the population demographics of various countries? In Chapter 8, you learned about countries in Stages 2 and 3 of demographic transition. Recall that Stage 2 is a period of rapid population growth. In Stage 3, birth rates begin to decline, and the country moves toward a state of zero population growth. More industrialized countries, such as Canada and Japan, are generally in Stage 3 of demographic transition. Many less industrialized countries, including those in Africa and some parts of Asia, remain in Stage 2.

The first demographic transitions took place in northern, more industrialized countries, such as Britain, through the eighteenth and nineteenth centuries. During this time, there was no widespread use of contraceptives, and most of today's contraceptive technologies had not yet been developed. Condoms were available, but withdrawal of the penis before ejaculation seems to have been the primary method of birth control. Similarly, the United States and Canada achieved their demographic transitions over the nineteenth and early twentieth centuries, mainly before current methods of contraception were available.

More recently, in less industrialized nations, moving from Stage 2 to Stage 3 seems to depend largely on improved contraceptive technologies. Many of these technologies were rapidly developed and refined in the 1960s and 1970s. The availability of effective contraception has enabled countries to move more and more quickly through Stage 2 to Stage 3 of their demographic transition. For example, it took 58 years for fertility in the United States to drop from 6.5 to 3.5 births per woman. The same drop in birth rate was achieved in 27 years in Indonesia, 15 years in Colombia, and 7 years in China.

THINKING LAB

Debating Funding Decisions: Fertility or Contraception?

Background

Many industrialized countries are moving toward zero population growth. Other, less industrialized countries, including many in Africa, remain in Stage 2. Because people in countries that are experiencing rapid population growth often suffer from lack of water and poor sanitation, organizations such as the World Health Organization run programs that provide contraception and education to people in those countries. The aim of these programs is to reduce the birth rate and ultimately improve the quality of life for the people. Wealthy countries, including Canada, help to fund these programs.

Meanwhile, fertility problems seem to be increasing in more industrialized countries. Researchers have blamed the problems on numerous factors, from increased levels of toxins in the environment to women waiting longer to have children. Research into technological solutions to infertility is funded by private companies and also by governments.

Debate the merits of funding solutions to human fertility problems versus the merits of funding human population control programs. Which should be a priority?

You Try It

1. As a class, choose two teams, made up of two students each, to debate the issue. One team will argue that funding solutions to human population control is more important. The other team will argue that funding solutions to human fertility problems is more important.
2. Assign two additional students to work with each team. These students will find information and statistics to back up their team's arguments.
3. The remainder of the class will judge the debate. The judges should research both sides of the issue, so they are prepared to assess the arguments made by each team.
4. Count the votes, and announce which team won the debate.
5. If you were a judge, use your notes to answer the following questions.
   - **(a)** Explain what made the winning team's argument more convincing — its research or its presentation.
   - **(b)** Did this debate cause you to change your opinion? If so, explain why. If not, did the opposing team raise any points you had not considered? Explain your answer.
6. If you were a debater or a researcher for one of the teams, answer these questions.
   - **(a)** Assess your team's ability to work together.
   - **(b)** Which of your opponents' points were most difficult to counter?

If a rapid drop in birth rate is possible with new contraceptive technologies, why do some countries remain in Stage 2? It is not enough for effective contraception to exist. People must know that it exists, and they must know how to use it. It also must be accessible to the people who want to use it. Contraception is not always available to people in less industrialized nations, especially poor people. In addition, people have to *want* to have fewer children. Time is needed for people to adjust

Biology Magazine TECHNOLOGY • SOCIETY • ENVIRONMENT

Population Control Policy in Andhra Pradesh

In rural areas of Andhra Pradesh, couples traditionally tried to have many children to help with farm work.

In an effort to reduce birth rates, the state of Andhra Pradesh (India's fifth largest state) developed a policy that set quotas on sterilization operations and offered incentives to couples who agreed to undergo the operations.

This policy caused sterilization operations (mostly tubal ligations) to increase from over 500 000 performed in 1996 to over 800 000 performed in 2001. As a result, over half the married women in Andhra Pradesh have undergone tubal ligation as of 2001 — the highest rate in India, and one of the highest rates in the world at the time.

The state offered numerous anti-poverty incentives to couples that agreed to sterilization, including houses, land, wells, and loans. In one district, officials realized that they might not make sterilization targets and organized a drive for donations of gifts, such as clocks and pots. These gifts were used as incentives for people who agreed to sterilization, and the district met its target. In addition to district-specific incentives, the state of Andhra Pradesh held a statewide lottery that was only open to sterilized couples. The winners received money and a free trip to the state capital.

It seems clear that the policy worked to reduce population growth in Andhra Pradesh. In 2001, the state had the sharpest drop in the rate of population growth of India's large states, while other states saw increases. Early estimates pointed to a birth rate of 2.1 children per woman for 2001, close to the rate necessary for zero population growth.

Do the ends justify the means, however? Some people see the policy in Andhra Pradesh as a model for other developing countries. They say that the policy uses no force and provides rewards to those who act in a socially responsible manner. Other people consider the policy to be coercive and intrusive, capitalizing on the desperate needs of the poor in order to influence their reproductive decisions.
[Source: Celia W. Dugger, "Relying on Hard and Soft Sells India Pushes Sterilization," *New York Times*, June 22, 2001.]

Follow-up

1. Do you think that the government of Andhra Pradesh was justified in using the methods described above to lower the birth rate quickly? Explain your answer in detail. If possible, do some research on the Internet to find out if the policy in Andhra Pradesh has changed since the year 2001.
2. In 1979, China adopted a policy that is known today as the one-child policy. Using Internet and print resources, research the policy. Why was it adopted? Did it achieve its aims? Is the policy still in effect? How was it enforced? What contraceptive method was used most? Why was this method chosen? Once you have found some facts, do one of the following:
   - Write a brief essay, explaining why you agree or disagree with China's one-child policy.
   - Write a brief essay, comparing China's one-child policy to Andhra Pradesh's sterilization policy.
3. Should governments play a role in influencing the reproductive choices of their people? If so, how much control should governments have? If not, why not?

to lowered mortality rates and for cultural attitudes about how many children are appropriate to change. A power and education imbalance between women and men in a society can affect how widely contraception is used, as well.

Some governments play an active role in attempting to lower the fertility rate in their countries. For example, they may enforce limits on the number of children a family can have or use incentives to promote conception control. Both of these controversial methods depend on the availability of effective contraception technologies. The Biology Magazine on the facing page describes how one government program promoting sterilization had a noticeable effect on the birth rate.

In this section, you examined two sides of the fertility technology issue: enhancing reproductive potential and reducing reproductive potential. You considered various reproductive technologies and some ways in which these technologies have affected individuals and society. In the final section, you will learn what happens when pregnancy does occur by tracing the development of a new human.

SECTION REVIEW

1. Explain the difference between the terms "infertility" and "sterility."

2. The average sperm count in males has been declining for several decades. Researchers do not agree on the reasons for the decline. If you were researching the decline, what kind of information would you want to have before forming a hypothesis?

3. For each of the following cases, suggest a reproductive technology that might be appropriate. Briefly explain your suggestion.

(a) The male has a low sperm count. The female is reproductively healthy.

(b) The male has a normal sperm count. The female rarely ovulates but is otherwise reproductively healthy.

(c) The male has a normal sperm count. The female has blocked oviducts.

(d) A male is about to undergo radiation therapy. He currently has no female partner, but he wants to have children in the future.

(e) A female has no male partner but wants to conceive.

4. Choose three contraceptive technologies from Table 15.2 or from your own research.

(a) Evaluate the design of each technology, using at least five criteria (such as effectiveness, ease of use, and side effects). If possible, use Internet and print resources to do some research. Set up your evaluation in a table, and summarize it in a paragraph. Use visuals to enhance your evaluation.

(b) Compare and contrast each of the three technologies. Ask and answer questions such as the following: Does the technology require surgery? Is it permanent? Does it protect against STIs? Does it have serious side effects? How much does it cost?

(c) Suggest a good application for each technology, based on your analysis. For example, you might decide that tubal ligation is the best option for a woman who is at low risk for STIs and has decided that she does not want any (or any more) children. Explain your choice.

5. Researchers have long searched for a safe and effective male birth control pill.

(a) Using your knowledge of the way that male hormones work, suggest the kinds of hormones a male pill might contain, and how these hormones would work as a contraceptive.

(b) What would be the advantages of a male pill? What might be some disadvantages?

(c) Use the Internet or print resources to find out what research has been done to develop a male pill. What types of hormones have been tested? Were they effective? Did they have any drawbacks? Write a one-page press release, outlining the progress of research to develop a male pill, to date.

6. Describe the relationship between conception control technologies and countries that are currently in Stage 2 of demographic transition.

7. Many population control programs focus on improving education and health for women and children. How might this focus help to lower birth rates in Stage 2 countries?

15.3 Development and Differentiation

OUTCOMES

- Trace the journey of sperm and an egg from their origins until fertilization.
- Explain how fraternal and identical offspring are produced.
- Describe the basic stages of embryonic development.
- Examine the effects of teratogens on the development of the embryo.
- Describe the functions of primary membranes during the embryonic development of animals.
- Describe the roles of the placenta and umbilical cord during pregnancy and the process of childbirth.
- Identify chemical control hormones that are associated with implantation, embryo development, birth, and lactation in humans.

When seventeenth-century scientists saw a sperm cell for the first time through a microscope, they thought that the head contained a tiny, fully formed person. Once this tiny person was implanted in the uterus, they thought, it would simply grow into a full-sized baby, ready to be born after nine months. As we know today, the truth is much different, although perhaps no less astonishing. A sperm and an egg become a zygote. The zygote splits and multiplies, the cells changing until they eventually form the complex organ systems and tissues that make up a human. First, however, the sperm must reach the egg. You know from section 15.1 that during ejaculation stimulated by sexual intercourse, sperm travel from the epididymis, through the vas deferens, exiting the body through the urethra. Once the sperm enter the female's vagina, they must make their way through it to the cervix, through the uterus, and finally to the oviduct. If sperm encounter an egg, fertilization can take place.

Several hundred million sperm exit the urethra during each ejaculation. This ensures that many of them will survive the acidity of the female's reproductive tract, that many of them will enter the oviduct that has an egg, and that many of them will succeed in reaching the egg, swimming against the current in the oviduct. The egg, if there is one, has been released from an ovary during ovulation and has been swept into and down the oviduct by the fimbriae.

Fertilization and Implantation

Fertilization is the first stage of development. It occurs when a sperm and an egg interact successfully, forming a zygote. Figure 15.11 shows human sperm on an egg. Only one sperm can fertilize an egg. When the head of a sperm successfully connects with an egg, its acrosome releases enzymes that digest the jelly coating around the egg and stimulates the egg to develop an impenetrable coat. These changes prevent any other sperm from fertilizing the egg. (Go back to Figure 15.3 to see a diagram of a sperm cell.)

When the sperm nucleus fuses with the egg nucleus, fertilization is complete. The resulting cell is called a zygote.

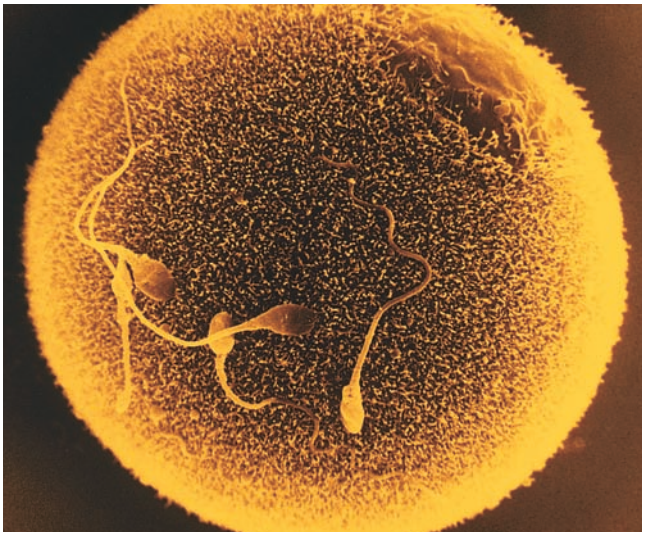


Figure 15.11 Only one of these sperm will fertilize the egg. Why is the egg so much larger than the sperm?

After fertilization, the zygote continues down the oviduct toward the uterus, as shown in Figure 15.12. The zygote, meanwhile, undergoes cell division. Its overall size, however, does not change. The process of cell division without cell growth is

called **cleavage**. Because the overall size does not change, the cells become smaller with each division. As soon as the zygote begins to undergo cleavage, until bone cells begin to form weeks later, it is called an **embryo**. While the embryo is undergoing cleavage, the mass of identical cells is known as a **morula**.

By the time the embryo reaches the uterus, it has formed a nearly hollow ball of cells, called a **blastocyst**. The blastocyst contains a group of cells called the inner cell mass. The inner cell mass will eventually develop into a baby. The outer layer of cells, called the **trophoblast**, will eventually give rise to the membranes that nourish and protect the developing embryo.

Implantation occurs at the end of the first week, when the embryo attaches itself to the endometrium. The trophoblast secretes human chorionic gonadotropin (HCG), which prevents the corpus luteum from disintegrating. For three weeks, the corpus luteum continues to produce progesterone. The progesterone maintains the endometrium and prevents menstruation.

BIO FACT

A woman begins to excrete traces of human chorionic gonadotrophin (HCG) in her urine once the trophoblast begins to secrete it. Pregnancy test kits have strips with chemicals that change colour when exposed to even very small amounts of HCG.

Twins

In most cases, a woman becomes pregnant when one egg is released during ovulation and is fertilized by a single sperm. How, then, do you explain twins? Twins are born about once for every 86 births. *Fraternal twins* form when more than one egg is released from the ovary or ovaries at the same time, and more than one of the eggs is successfully fertilized. Aside from being born at the same time, fraternal twins are as different as normal siblings. About 70 percent of all twins are fraternal.

Identical twins, on the other hand, form when one sperm fertilizes one egg as usual. In the early stages of development, however, the zygote or blastocyst splits into two separate bodies. This

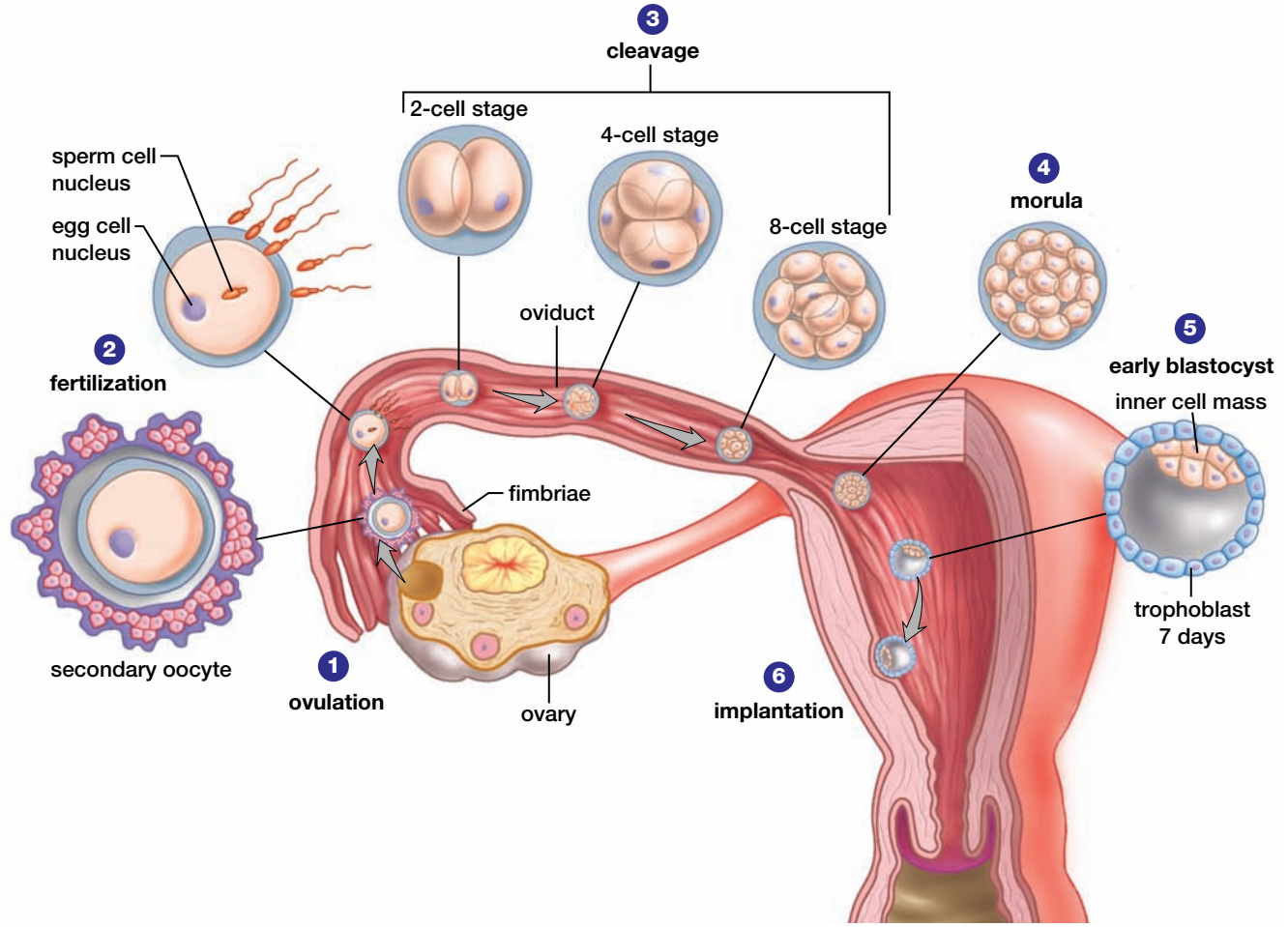


Figure 15.12 Early human development, from ovulation through implantation

split usually occurs within the first five days of development. Researchers do not yet know what causes a zygote or blastocyst to split. As shown in Figure 15.13, identical twins look the same and are always the same sex because they have the same genetic material. Identical twins account for about 30 percent of all twins.

Embryonic Development

In the blastocyst stage, the cells of the inner cell mass are similar to each other. During the second week, the cells begin to specialize. This process is called gastrulation, and the embryo is now called a **gastrula**. During gastrulation, the embryo's cells become arranged into distinct layers, called **germ layers**. Cells form germ layers by continuing mitotic division and migration. By the end of gastrulation, the embryo has three layers: the endoderm, the mesoderm, and the ectoderm. Figure 15.14 shows how the cells of each layer eventually develop into different parts of the body.

Primary Membranes

Most animals go through the embryonic stages of zygote, morula, blastocyst, and gastrula much like humans do. Interesting and significant differences, however, are found among the tissues that surround the embryo in different animals.

Primary membranes are membranes that are not part of the embryo but that support, nourish, and protect it. In reptiles, primary membranes made development on land first possible. Consider what happens if an embryo develops in an ocean. A system for the delivery of oxygen and removal of waste products is unnecessary — the water carries out both functions. The water also provides a cushion and prevents the embryo from drying out. On land, however, the primary membranes perform these functions.

Figure 15.15 compares the primary membranes in a human embryo and a chick embryo. Primary membranes develop from the germ layers. In a chick, the **chorion** is located next to the shell. It is involved in gas exchange. The **amnion** contains the amniotic fluid, which provides a liquid environment for the developing embryo. The **allantois** collects waste, and the yolk sac surrounds the yolk.

The **yolk** is a dense material that nourishes the embryo. The amount of yolk in various animals is related to the environment in which the animal develops. For example, a frog has less yolk than a chick, because a frog embryo develops quickly to the stage where it can swim and find its own food. A developing chick, on the other hand, needs to stay in its shell until it is capable of surviving on land. It therefore needs enough nourishment to last until it hatches.

Humans and other mammals have the same primary membranes as a chick. The chorion develops into the placenta, and the blood vessels of the allantois become the blood vessels of the umbilical cord. (You will learn more about the placenta and umbilical cord shortly.) The amnion, like the amnion in a chick, contains fluid to cushion and protect the embryo. Humans have very

Figure 15.13 These identical twins were formed when a zygote or blastocyst split in two. Each new group of cells developed into a genetically identical human being.

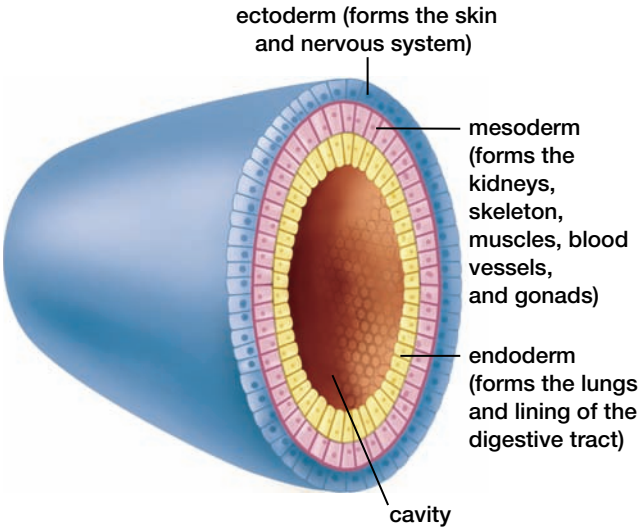


Figure 15.14 This simplified diagram of a gastrula shows the tissues that each germ layer will eventually form.

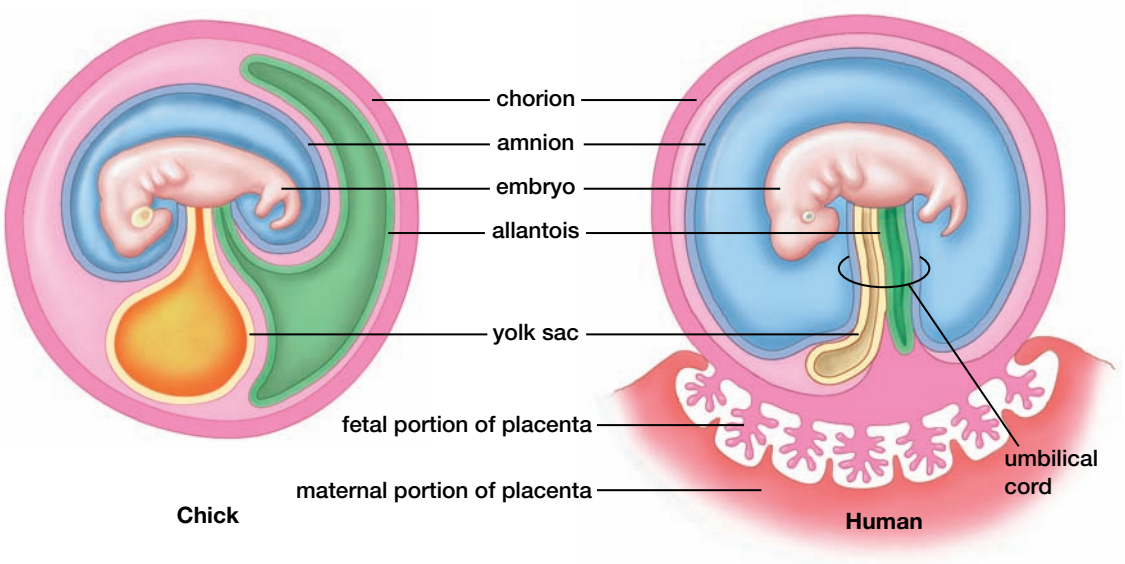


Figure 15.15 Chicks and humans have many of the same primary membranes.

little yolk, but they do have a yolk sac. In humans, the yolk sac is the first site of blood cell formation.

Neural Development

The development of the nervous system proceeds in a similar way for all vertebrates. In the gastrula, the mesoderm cells that lie along what will be the back of the vertebrate come together to form a rod called the *notochord*. The nervous system develops from ectoderm that is located just above the notochord. First, cells along the surface above the notochord begin to thicken. Folds develop on each side of a groove along this surface. The folds become a tube when they fuse. Once the folds have fused, the embryo is called a **neurula**. In humans, this occurs at the third week. The anterior, or "head" end, of the neural tube becomes a brain. Figure 15.16 shows the neurula stage.

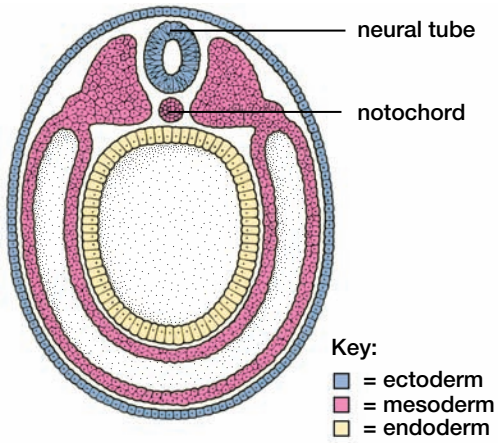


Figure 15.16 The neurula stage of development is similar for any animal with a spinal cord (chordate).

Overview of Human Development

The development of the nervous system from the ectoderm is an example of differentiation. **Differentiation** is the process in which each of the three layers of the gastrula develop into different parts of the body, as you saw in Figure 15.14. In other words, cells become specialized to perform different tasks in the body. This is why we can have red blood cells, heart muscle cells, nerve cells, and skin cells, to name just a few.

Over 38 weeks, differentiation allows a tiny clump of identical cells to develop into a tiny human with fully formed tissues and organs. Based on the period of time during which the tissues and organs form, these 38 weeks are often divided into the first, second, and third trimester. Each trimester lasts approximately three months.

The First Trimester (Weeks 1 to 12)

You have already looked, in detail, at the embryonic stages of development, which take place during the first three weeks of development. At four weeks, differentiation has begun in earnest, and the limbs, eyes, and spine begin to form. At eight to nine weeks, the first bone cells form. Once the first bone cells form, the embryo is called a **fetus**. Figure 15.17 on the following page shows a photograph of a fetus at eight weeks. After 12 weeks, all the major organ systems have started to form, including the liver, stomach, brain, and heart. The fetus has a noticeable head and limbs. By the end of the first trimester, the fetus is about 100 mm long.

Figure 15.17 At the end of eight weeks, the fetus is about 30 mm long. Eyes, limbs, and a head are noticeable.

Figure 15.18 This 20-week-old fetus has well formed facial features, fingers, and toes.

BIO FACT

As early as the end of the first trimester, the sex of the fetus can sometimes be determined by *ultrasound*. This technology works by sending high-frequency sound waves through the mother's abdomen. The sound waves bounce off different tissues at different rates because the tissues have different densities. The returning waves are recorded and are used to create an image of the fetus.

Second Trimester (Weeks 13 to 24)

By the fourth month, the fetus's heartbeat is loud enough for a physician to hear it, with a stethoscope placed on the mother's abdomen. The skeleton begins to form. The brain grows rapidly, and the nervous system begins to function. As the fetal legs grow and develop, the mother begins to feel movement. By 24 weeks, the fetus is 300 mm long. Most of its organs have formed, but they are still developing. If a fetus is born at this stage, it is unlikely to survive. Figure 15.18 shows a fetus at week 20 of development.

Third Trimester (Weeks 25 to 38)

During the third trimester, the fetus's overall size increases very rapidly. The mother can feel the fetus as it moves around, stretching and kicking. The immune system develops during this trimester. The brain continues to develop and grow. By the eighth month, the fetus's eyes are open. Proper nutrition is important during all phases of pregnancy. For both the mother and the fetus, however, nutrition is particularly important during the third trimester, as the fetus needs more and more calories. If the mother does not take in sufficient nutrients, nutrients from her body will be used to supply the fetus. In extreme cases, a woman who has an improper diet late in the third trimester may suffer permanent health problems. By the end of nine months, the fetus is about 525 mm long and weighs about 3380 g.

Lifeline: The Placenta and Umbilical Cord

During all three trimesters, the fetus needs to be nourished. As well, it needs oxygen, and it must get rid of waste. The placenta and umbilical cord perform these functions. The **placenta** is a blood-vessel-rich organ that is present only during pregnancy. It begins to form from the chorion once the embryo is fully implanted. The chorion develops many tree-like projections that extend into the uterine wall, serving as an anchor. The projections contain blood vessels, which, together with the chorion, form the placenta.

The placenta is fully formed by the tenth week of development. During and after its development, it produces progesterone and estrogen. These hormones prevent any new follicles from maturing, and they also maintain the uterine lining. Thus, a woman does not ovulate or menstruate during pregnancy, due to the relatively high levels of progesterone and estrogen in her blood. Recall that the corpus luteum produces progesterone during the first three weeks of pregnancy.

The developing embryo or fetus depends on the placenta for survival. It gets all its nutrients and

oxygen from the placenta, and all its wastes are removed through the placenta. The **umbilical cord** — truly a lifeline — connects the developing embryo and fetus to the placenta.

Figure 15.19 shows the placenta and umbilical cord in a fetus at six to seven months. As you can see in the figure, the mother's blood and the fetus's blood never mix. The transfer of nutrients and oxygen from the mother to the fetus, and the transfer of carbon dioxide and other waste substances from the fetus to the mother, take place across plasma membranes.

The Effects of Teratogens on Development

Unfortunately, a mother can transfer harmful substances to her baby in addition to beneficial substances. Whatever the mother ingests or inhales can end up in her blood. Her blood circulates through her body, and some substances can pass through the plasma membranes to the fetus's blood. This is especially significant during the first nine weeks, when developing organs are highly sensitive to environmental factors, as shown in Figure 15.20.

Numerous substances and factors can affect the normal development of the fetus. The term **teratogen** refers to any agent that causes a structural abnormality due to fetal exposure during pregnancy. Cigarette smoke, for example, may constrict the fetus's blood vessels, preventing it from getting enough oxygen. Mothers who smoke, or are exposed to significant amounts of second-hand smoke, during pregnancy tend to have babies that are underweight. The babies may also suffer convulsions. Alcohol is another teratogen.

Alcohol can affect the fetus's brain, central nervous system, and physical development. Babies that are born to women who drink frequently or heavily during pregnancy are likely to have fetal alcohol syndrome (FAS). FAS babies have decreased weight, height, and head size. As well, the head and face may be malformed. FAS children show varying degrees of mental retardation and may exhibit unusual aggression or personality disorders.

Many prescription and over-the-counter drugs have teratogenic properties. For example, thalidomide is a drug that was first prescribed to women in the 1950s to reduce morning sickness. At the time, thalidomide had no known side effects. Unfortunately, many mothers who used thalidomide during pregnancy gave birth to babies with missing or deformed limbs. Thalidomide is no longer prescribed to pregnant women. While doctors at the time did not know thalidomide was teratogenic, doctors today know the teratogenic properties of many medications. A pregnant woman should always check that any new medication will be safe for her baby. Other teratogenic factors include radiation, such as X-rays, and certain pollutants, including PCBs and organic mercury compounds. These factors may lead to cancers or genetic defects.

By getting proper nutrition and avoiding known teratogenic factors, a woman can significantly decrease her chance of having a child with a birth defect. Some birth defects, however, are due to

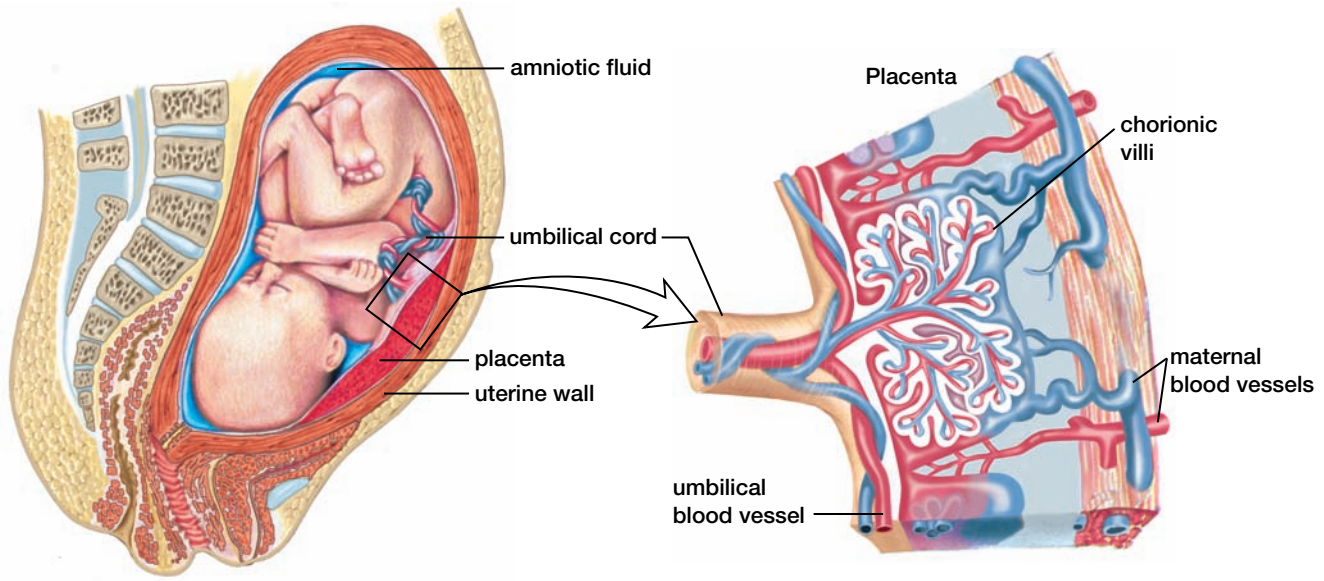


Figure 15.19 The placenta is composed of fetal and maternal tissues. The mother and fetus exchange substances across the walls of the chorionic villi.

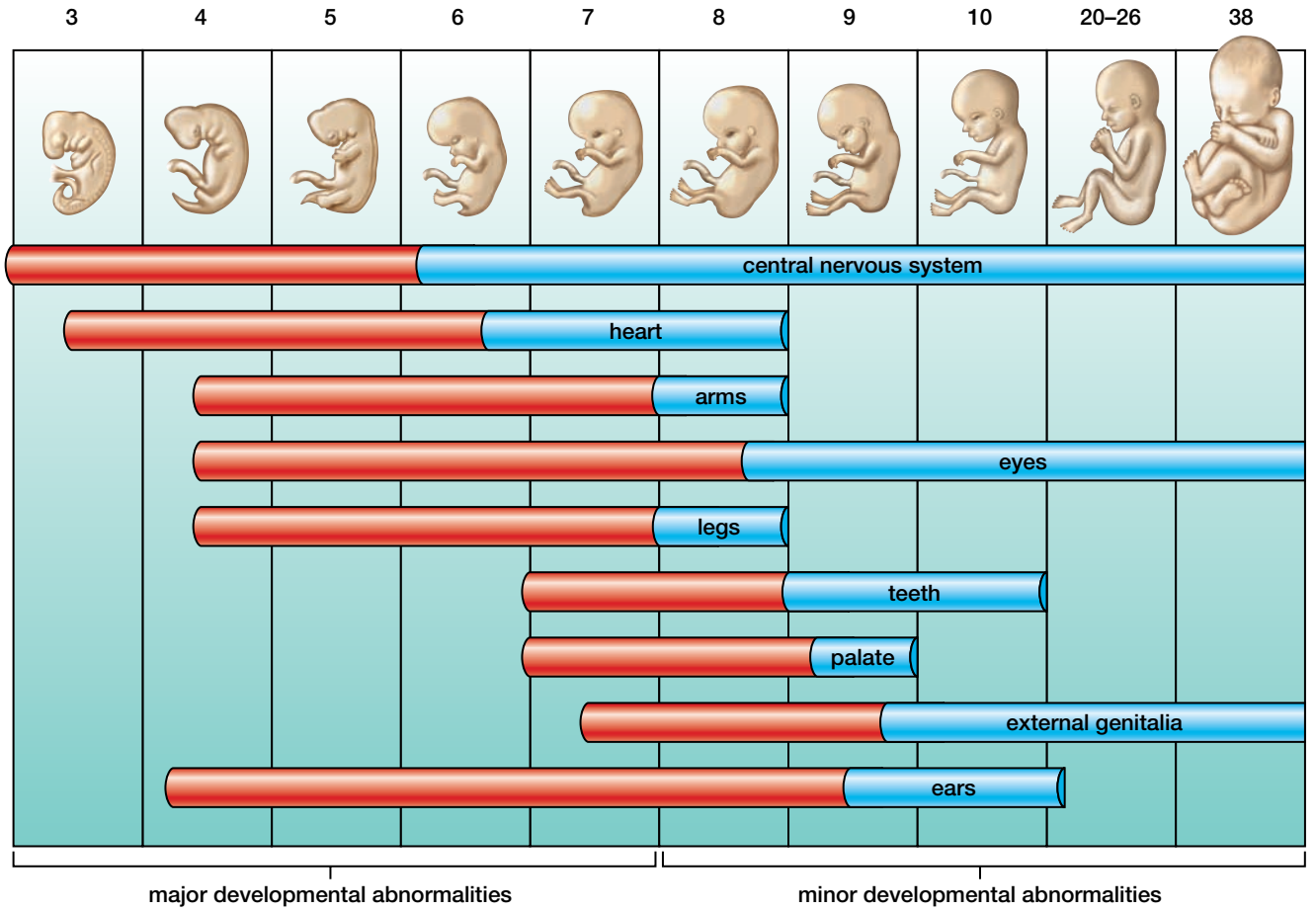


Figure 15.20 This graph shows the critical phases of development. The red parts correspond to periods when organs are most sensitive to environmental factors. The numbers show the age, in weeks.

heredity or other unavoidable or unknown factors. In Chapter 18, you will learn about various techniques that have been developed to test for genetic defects before birth.

Birth

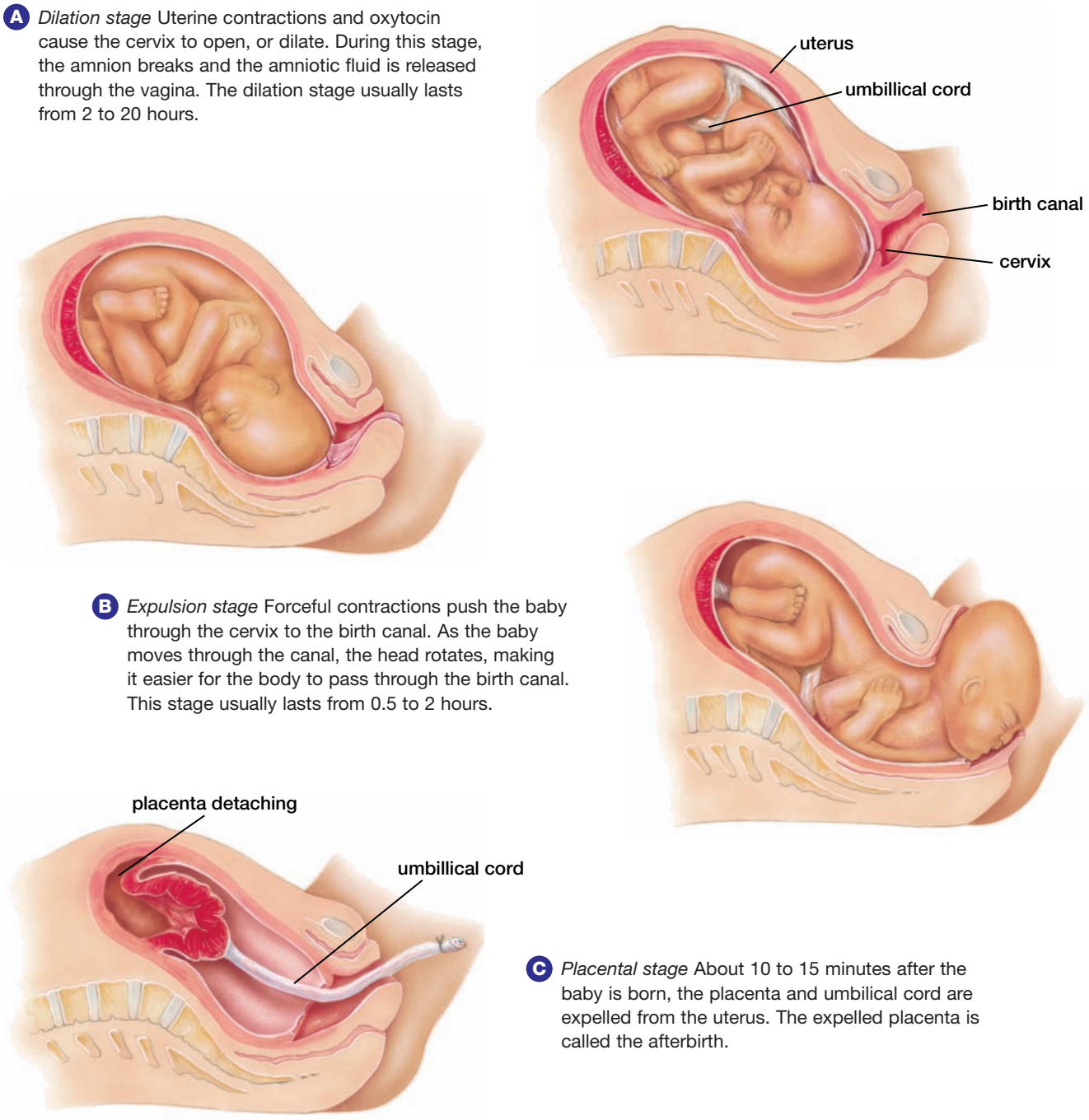
Birth is triggered by sudden, dramatic changes in hormonal levels. Scientists do not yet fully understand the precise nature of these changes. They do know, however, that estrogen and progesterone levels drop. Scientists now believe that hormones called **prostaglandins** are also involved. Prostaglandins may cause the release of oxytocin. Both prostaglandins and oxytocin cause the uterus to contract. Contractions signal the beginning of **labour**, the process that ends with the birth of an infant.

Figure 15.21 on the facing page illustrates the various stages of childbirth. Although the diagram shows the birthing mother in a horizontal position, mothers may choose to give birth from a squatting or partially upright position, so that gravity can help with the delivery.

For a number of reasons, it may not be safe or possible to deliver a baby in the usual way. For example, the baby may be in a rump-first position. It is difficult for the cervix to expand enough to accommodate this type of birth (called a breech birth), and the baby or mother may be harmed. Therefore, the baby is usually delivered by a Caesarean section.

In a Caesarean section, a physician makes an incision in the mother's abdomen and uterus and delivers the baby through the incision. A mother with an STI, such as herpes, or a mother with a small pelvis may also have her baby delivered by Caesarean section to protect herself and her baby from injury or infection.

Once the baby is breathing normally, the umbilical cord is clamped, cut, and tied. The baby is now cut off from the source of nutrients it has depended on for nine months. It must ingest food



A *Dilation stage* Uterine contractions and oxytocin cause the cervix to open, or dilate. During this stage, the amnion breaks and the amniotic fluid is released through the vagina. The dilation stage usually lasts from 2 to 20 hours.

B *Expulsion stage* Forceful contractions push the baby through the cervix to the birth canal. As the baby moves through the canal, the head rotates, making it easier for the body to pass through the birth canal. This stage usually lasts from 0.5 to 2 hours.

C *Placental stage* About 10 to 15 minutes after the baby is born, the placenta and umbilical cord are expelled from the uterus. The expelled placenta is called the afterbirth.

Figure 15.21 Delivery of baby and afterbirth

and eliminate wastes on its own. The cord eventually shrivels, and the place where the cord was attached to the fetus becomes the baby's navel.

Lactation and the Suckling Reflex

Hormones control the onset of **lactation**, or the secretion and formation of breast milk in the mother. *Prolactin*, the hormone that is needed for milk production, is not secreted during pregnancy. High levels of estrogen and progesterone suppress the anterior pituitary production of prolactin. Once the mother has given birth, however, the pituitary begins to secrete prolactin. Milk production begins within a few days. Before then, the breasts secrete *colostrum*, a thin, yellowish fluid that is similar to breast milk but contains more protein and less fat.

Figure 15.22 shows how a suckling baby stimulates milk letdown in the mother. When a baby suckles a breast, it stimulates nerve endings in the nipple and areola (circular area of different-coloured skin around the nipple). The nerve

impulses travel to the hypothalamus which, in turn, stimulates the pituitary to release oxytocin. Oxytoxin causes contractions within the mammary lobules. The mammary lobules contain alveoli, sacs with cells that produce milk. The mammary lobules end in mammary ducts at the nipple. Contractions within the mammary lobules cause milk to flow to the ducts, where the infant can draw it out by suckling. If suckling does not occur, or if it ceases, milk production ceases. Conversely, increased suckling stimulates increased milk production.

In Unit 5, you have followed the journey of the sperm and the egg from their formation in a male and a female to their union through fertilization as a zygote. You followed the zygote through its development into a new human. In Unit 6, you will learn more about the genetic material that makes this journey possible.

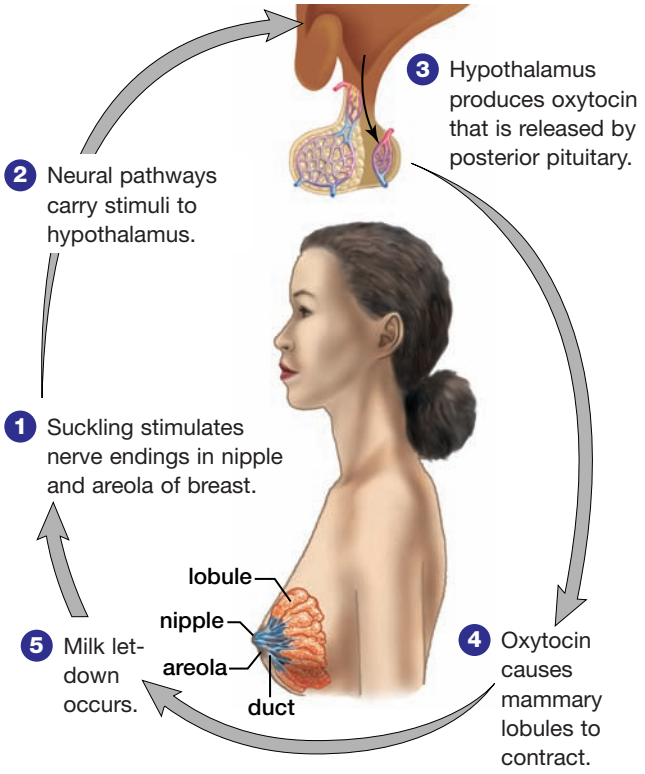


Figure 15.22 **A suckling baby initiates the events that lead to milk letdown.**

SECTION REVIEW

1. Describe, in detail, the series of events that lead from fertilization to implantation.
2. Distinguish between a fetus and an embryo.
3. List the primary membranes, and briefly outline their functions in humans.
4. **(a)** Developing human embryos do not have a significant amount of yolk as part of their supporting tissues, while chick embryos do. Explain why.
   (b) Do frog embryos have little yolk for the same reasons that human embryos have little yolk? Explain your answer.
5. Explain how the maintenance of high levels of estrogen and progesterone during pregnancy prevents ovulation. Be as specific as possible.
6. Create a concept organizer to summarize the roles of the various hormones that are involved in pregnancy and the sources of these hormones.
7. Create an illustrated and annotated flowchart to show the changes in the fetus that occur during each trimester of pregnancy.
8. Folic acid has been identified as a vitamin that is crucially important during the early stages of pregnancy. Use Internet and print resources to answer the following questions about folic acid.
   (a) What is the role of folic acid in a developing fetus? At what stage is it most important? What happens to the fetus if a woman does not get enough folic acid?
   (b) How did researchers determine the role of folic acid in the developing fetus?
   (c) What has been done to ensure that women who might become pregnant get enough folic acid?

Chapter Summary

Briefly explain each of the following points.

- Human males and females have specialized reproductive systems. (15.1)
- Reproductive hormones help in the maintenance and function of male and female reproductive systems. (15.1)
- Estrogen and progesterone treatments can be used to treat symptoms of menopause and to prevent conception. (15.1)
- STIs, with a broad range of symptoms and effects, are the possible outcome of unprotected sexual contact. (15.1)
- Scientists have identified numerous causes of human infertility and sterility. (15.2)
- Several technologies are available to enhance the chances of conception. (15.2)
- Contraceptive technologies have widely varying designs and levels of effectiveness. (15.2)
- Conception control technologies can affect population demographics. (15.2)
- Beginning with the zygote, the embryo goes through several different stages before implantation. (15.3)
- An implanted embryo goes through a number of different stages of development during the first few weeks of pregnancy. (15.3)
- Environmental factors can have an effect on embryonic development. (15.3)
- The primary membranes in chicks and humans have some important similarities and differences. (15.3)
- Hormones play an important role during pregnancy and birth. (15.3)

Language of Biology

Write a sentence using each of the following words or terms. Use the terms in concept maps to show your understanding of how they are related. Be prepared to explain your rationale.

- puberty
- seminiferous tubules
- interstitial cells
- Sertoli cells
- epididymis
- seminal vesicles
- prostate gland
- Cowper's gland
- semen
- inhibin
- testosterone
- endometrium
- ovaries
- oviducts
- fimbriae
- menstrual cycle
- follicles
- follicular stage
- ovulation
- corpus luteum
- progesterone
- luteal stage
- menstruation
- menopause
- hormone replacement therapy
- sexually transmitted infection (STI)
- sterile
- infertile
- contraception
- fertilization
- cleavage
- morula
- embryo
- blastocyst
- trophoblast
- implantation
- gastrula
- germ layers
- primary membranes
- chorion
- amnion
- allantois
- yolk
- neurula
- differentiation
- fetus
- placenta
- umbilical cord
- teratogen
- prostaglandins
- labour
- lactation

UNDERSTANDING CONCEPTS

1. Name the structures within a testis, and describe their functions.

2. Explain the role of testosterone in a mature male, and state where it is produced.

3. (a) What makes AIDS such a devastating disease?

(b) How is AIDS different from other STIs?

(c) Explain why having an STI, such as chlamydia or herpes, increases a person's susceptibility to HIV.

4. Outline the path of a sperm from where it forms to where it fertilizes an egg. What glands contribute fluids to semen?

5. Describe the development of a follicle within an ovary.

6. Describe the changes in the endometrium through the various stages of the menstrual cycle.

7. Compare the levels of sex hormone secretions in females before and after the onset of menopause. Discuss how these changes in hormone secretions affect the reproductive system.

8. Explain how in vitro fertilization might help a couple achieve pregnancy if the man has a low sperm count. What other options does the couple have?

9. Distinguish between identical and fraternal twins. Explain how each type of twins is formed.

10. Explain why only one sperm can fertilize an egg. Why is this important?

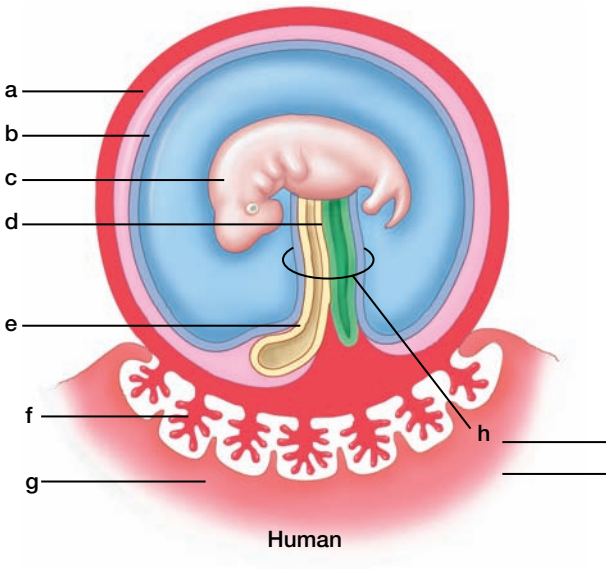
11. At which stage of embryonic development does differentiation begin?

12. Describe how the environment in which an embryo develops relates to the amount of yolk it has.

13. Describe the significance of each of the following stages of embryonic development: cleavage, blastocyte, gastrula, and neurula.

14. Label the diagram on the right, showing the placement of the primary membranes. Give a function for each structure in humans. (Do not write in this textbook.)

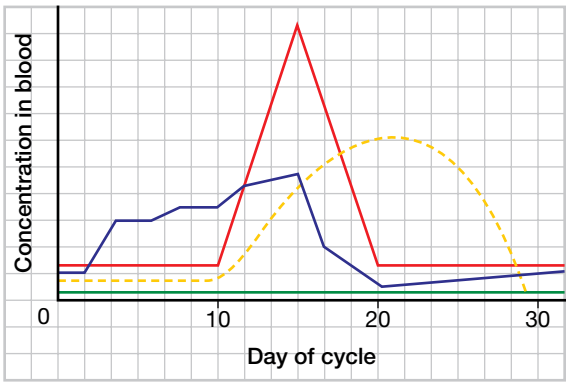
15. Describe the structures and functions of the umbilical cord and placenta.



16. Explain why a woman's milk "dries up" if her baby no longer suckles.

INQUIRY

17. The following graph represents the average blood concentration of four circulating hormones collected from 50 healthy adult women who were not pregnant. Use the graph to answer the following questions:



(a) Which line represents luteinizing hormone?
- **(i)** red line
- **(ii)** blue line
- **(iii)** yellow line

(b) Which line represents progesterone?
- **(i)** red line
- **(ii)** blue line
- **(iii)** yellow line

(c) Which hormone increases during the last half of the menstrual cycle?
- **(i)** estrogen
- **(ii)** progesterone
- **(iii)** LH
- **(iv)** FSH

(d) Suggest a hormone that the green line might represent.

18. Does the month of the year in which fertilization occurs (or, from another perspective, the month in which birth occurs) affect the development of the fetus in any way?

(a) Formulate a hypothesis and prediction. Suggest how you might conduct research to test your prediction.

(b) Use Internet or print resources to find out if any research on this topic has been conducted. If so, what were the results?

19. The mortality rate of sperm is high compared with the mortality rate of eggs. Suggest reasons why this is the case.

COMMUNICATING

20. Write a brief essay about the major biological factors that can lead to infertility in males and females.

21. Choose one type of contraceptive technology, and write a brief report about it. Include the following information:
- when it was first developed
- how it has been changed and refined, up to now
- its risk factors
- the benefits it has due to its design
- the downsides it has due to its design
- the types of people who are most likely to benefit from it

22. Create an informative pamphlet to summarize the effects that various environmental factors can have on the development of an embryo and fetus. Include suggestions for pregnant women, describing how they can avoid these factors.

23. Create a labelled flowchart to show the various stages of childbirth.

24. A baby experiences a number of shocks as it is born. Write a creative account of childbirth from the baby's perspective.

25. Choose one technology for enhancing fertility, and research the procedures that are involved. Write a fictional account of a person or couple who uses this technology to try to conceive.

26. Create a pamphlet to accompany a home pregnancy test kit. Write one or two paragraphs, describing the role of human chorionic gonadotropin in the pregnancy test.

MAKING CONNECTIONS

27. Fetal surgery, as the name suggests, is surgery performed on the fetus before it is born. Use Internet or print resources to find out what types of fetal problems have been solved through fetal surgery. How do physicians diagnose these problems?

28. How does reproduction in humans differ from reproduction in other animals that reproduce sexually? Choose an animal that reproduces sexually and use Internet or print resources to investigate how it reproduces. Then write a two-page report comparing reproduction in your animal to reproduction in humans. The following are some questions you might answer in your report:
- is the animal fertile at all times, or only during certain parts of the year?
- how is the egg fertilized by the sperm?
- does the embryo develop inside the female's body? If not, where does it develop?
- what is the gestation period?

29. The human body's immune system usually tries to get rid of any foreign matter it encounters. This is how the body fights bacterial infections, and why organ transplants may be rejected.

(a) Suggest what might prevent a mother's immune system from rejecting the developing fetus.

(b) Use Internet or print resources to find out whether your suggestions were correct. Write a paragraph explaining why a mother's immune system does not reject her fetus.

30. (a) Compare the availability of effective treatment programs for AIDS in Canada and in developing countries. How does the average life span of an AIDS patient in Canada compare with the average life span of an AIDS patient in a developing country? To what extent does the quality of medical care depend on where an AIDS patient lives?

(b) Should Canadians be concerned about the incidence of AIDS in developing countries? Why or why not?

31. Many types of birth control pills contain synthetic forms of both estrogen and progesterone. Another type of pill, called the mini-pill, contains a synthetic form of progesterone but no estrogen. Use Internet or print resources to find out about the mini-pill. Then create a chart comparing the mini-pill to birth control pills containing estrogen and progesterone. Include information on effectiveness, risks, and any benefits besides contraception.

UNIT 5 REVIEW

UNDERSTANDING CONCEPTS

True-False

In your notebook, indicate whether each statement is true or false. Correct each false statement.

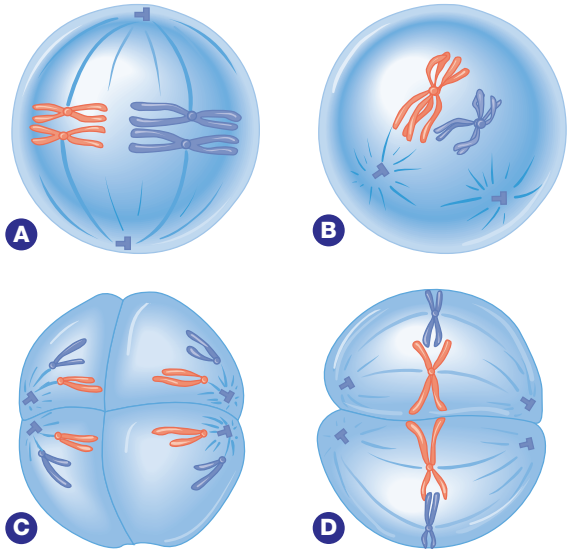
1. Each human somatic cell contains the haploid number of chromosomes.
2. The end product of meiosis is four viable gametes.
3. A sperm is an example of a haploid cell.
4. The term tetrad is used to describe a pair of homologous chromosomes.
5. During oogenesis, one oogonium forms one diploid egg.
6. Mitosis is the stage of the cell cycle that cells occupy for the longest proportion of time.
7. An animal with a somatic cell that has a haploid number of 38 has 19 chromosomes.
8. In male humans, FSH promotes the production of sperm.
9. In a human female, a surge of progesterone triggers ovulation.
10. The length of a sperm from tip to tail is about half the diameter of an egg.
11. Twins result when more than one sperm fertilize the same egg.
12. An embryo is called a fetus once its heart begins to develop.
13. The central nervous system of an embryo is most sensitive to environmental factors up to about the end of the tenth week.
14. The blood of a fetus and the blood of the mother mix across the placenta as they exchange nutrients and waste products.
15. An embryo has three germ layers called the ectoderm, the mesoderm, and the endoderm when it is in the blastocyst stage.

Multiple Choice

In your notebook, write the letter of the best answer for each of the following questions.

16. How many chromosomes are found in a human somatic cell?
    (a) 11
    (b) 23
    (c) 34
    (d) 46
    (e) 52

The structures in the diagram below represent animal cells in various stages of meiosis. Use the diagram to answer questions 17 to 19.



17. Which letter best represents anaphase II of meiosis?
    (a) A
    (b) B
    (c) C
    (d) D
    (e) none of the above
18. What phase of meiosis is represented by letter D?
    (a) prophase I
    (b) metaphase II
    (c) metaphase I
    (d) telophase II
    (e) anaphase I
19. Which letter represents the stage during which crossing over takes place?
    (a) A
    (b) B
    (c) C
    (d) D
    (e) none of the above
20. Which of the following functions do the seminiferous tubules have?
    (a) they release LH
    (b) they release inhibin
    (c) they produce sperm
    (d) both (a) and (c)
    (e) both (b) and (c)

21. What is the key function of the acrosome in a sperm?

(a) It contains enzymes that help penetrate the egg during fertilization.

(b) It contains mitochondria that provide energy for the movement of the tail.

(c) It protects the sperm from the acidic environment of the vagina.

(d) It allows the sperm to locate the egg.

(e) It secretes GnRH.

Refer to the following list of STIs to answer questions 22 and 23:

I AIDS
II genital herpes
III gonorrhea
IV chlamydia
V syphilis

22. Which of the STIs on the list are caused by bacterial infections?

(a) II and IV only

(b) III and IV only

(c) III, IV, and V only

(d) II, III, and V only

(e) none of the above

23. Of the STIs on the list, which have symptoms that can be triggered by stress or sunlight?

(a) I

(b) II

(c) II

(d) I and II

(e) II and IV

24. In a human female, where does fertilization usually take place?

(a) vagina

(b) urethra

(c) uterus

(d) oviduct

(e) ovary

25. At what stage is the embryo while it is undergoing cleavage?

(a) gastrula

(b) blastocyst

(c) zygote

(d) morula

(e) trophoblast

Short Answer

In your notebook, write a sentence or short paragraph to answer each of the following questions.

26. Describe the process of cytokinesis in plant cells and in animal cells.

27. At what time of year would mitosis in a plant occur least frequently? Explain your answer.

28. Briefly explain the importance of crossing over during meiosis.

29. Explain why the number of chromosomes in sex cells must be reduced.

30. In a human male, over 300 million sperm may be produced at one time. In contrast, a human female produces only one egg approximately every 28 days. Suggest an explanation for this difference.

31. Explain why progesterone and estrogen are known as ovarian hormones, while LH and FSH are known as pituitary hormones.

32. Describe the roles of FSH in females and in males.

33. What form of contraceptive technology provides the best protection against STIs?

34. Explain how tubal ligation prevents pregnancy.

35. List three possible causes of infertility in males and females.

36. What hormonal changes occur just before labour begins?

37. Describe the three stages of birth in your own words.

38. Explain why the suckling reflex is crucial to the production of breast milk.

39. What prevents a second pregnancy in a woman who is already pregnant?

40. Briefly describe the path of a sperm from where they are produced to where it fertilizes an egg.

41. Can women become pregnant after menopause? Explain your answer.

42. State how smoking during pregnancy can affect the fetus.

43. Briefly list the changes that take place during the first trimester.

44. What is a Cesarean birth? State two instances in which a Cesarean birth might be required.

INQUIRY

45. You wish to carry out an investigation to determine the percentage of time that garlic root cells spend during each phase of the cell cycle. Assuming that you have access to prepared slides of garlic root cells, outline a suitable procedure. Include a prediction, safety precautions, and a materials list. (Do not carry out the procedure without your teacher's permission.)

46. A researcher examines two different groups of plant cells from the same plant. The first group had an average cell cycle of 32 hours. The second set had an average cell cycle of 91 hours. The researcher knows that one group of cells came from the root tip of the plant.

(a) Based on your understanding of mitosis, which group came from the root tip of the plant? Explain your answer.

(b) Suggest a part of the plant from which the other group might have come. Explain your answer.

47. Radiation affects mitosis. For example, the photo shows a cell that has been exposed to radiation during anaphase.

(a) How can you tell from the photo that mitosis has been affected by the radiation?

(b) Which is more likely to sustain serious damage from the same exposure to radiation: an embryo in the first four weeks of development, or a five-month-old fetus? Explain your answer in detail.

48. A researcher is studying daily progesterone levels in a group of women by testing urine samples. Some of the women become pregnant during the study.

(a) Describe the expected rise and fall of progesterone levels of the women that do not become pregnant. Explain what happens as progesterone peaks during a typical menstrual cycle.

(b) Describe what would happen to progesterone levels in the pregnant women after fertilization has taken place. Explain why and how this occurs.

49. A technician makes ultrasound images of a fetus at 9 weeks and then again at 24 weeks. What differences do you expect the technician will observe?

50. Using the data from the table below, create a graph using graph paper or a spreadsheet. Title the graph and label the *x*-axis and *y*-axis. Then answer the questions that follow.

Fetal Age and Length

Fetal age (weeks)	Fetal length (mm)
9	50
16	140
24	230
32	300
38	360

(a) During which weeks does length increase the most?

(b) What events are occurring at this time?

(c) During which weeks does length increase the least?

(d) What events are occurring at this time?

51. A researcher wants to investigate what causes the ectoderm on the dorsal side of an embryo to develop into nervous tissue. The researcher hypothesizes that the mesoderm on the dorsal side somehow stimulates the ectoderm and initiates neural development.

(a) Using two animal embryos, how could the researcher test the hypothesis? (The researcher has the capability to transfer pieces of mesoderm between embryos.)

(b) Based on the hypothesis, make a prediction stating what will happen if the researcher carries out the investigation.

(c) If the hypothesis is incorrect, what might the researcher observe?

COMMUNICATING

52. Create a table to summarize the various stages of mitosis. Use diagrams within your table to illustrate each stage.

53. Could in vitro fertilization be used to create identical twins, triplets, and so on? Explain your answer in detail.

54. Oral contraceptives (birth control pills) usually contain a combination of estrogen and progesterone. Explain why taking these hormones prevents pregnancy.

55. How do pregnancy tests work? Would you expect a pregnancy test to give accurate results three days after fertilization? Write a brief explanation of your answers.

56. If several different alternative reproductive methods are used in conjunction, a baby could have as many as five "parents." Explain how this is possible.

57. Does human development end at birth? What evidence do you have that this is not the case? Using print resources or the Internet, research the stages of life after birth: infancy, childhood, adolescence, and adulthood. What major physical and hormonal changes take place during each stage? What happens, physically and hormonally, after a human reaches adulthood and begins the aging process? Use your research to create an annotated timeline, showing human development from birth to old age. Use visuals to enhance your timeline.

58. You want to explain to a younger relative how a fetus survives and grows inside a woman's body. Write a paragraph comparing the relationship between a fetus and the uterus and placenta to the relationship between astronauts and their space shuttle.

MAKING CONNECTIONS

59. Suggest some of the problems that could arise in a developing fetus if the mother is inadequately nourished. Name a specific substance that is needed for the development of a skeleton. What might happen if the supply of that substance were inadequate? How could the mother avoid this problem?

60. A 35-year-old female long-distance runner wants to have children with her male partner, but they have been unable to conceive for over a year. Tests on her partner's semen reveal that his sperm count is at a healthy level, and his sperm are in good condition.

- **(a)** Based on the information above, suggest several reasons that may explain why the couple has been unable to conceive.
- **(b)** Suggest a course of action the couple could try *before* they turn to reproductive technologies. Explain why your suggestions might help.
- **(c)** If the couple remains infertile, what reproductive technologies might help them to conceive?

61. Technologies can have repercussions on a large scale. For example, consider the use of contraceptive technologies and how they have affected the populations of different countries.

- **(a)** Explain how the development of contraceptive technologies has affected the demographics of more industrialized and less industrialized countries.
- **(b)** What challenges do governments of less industrialized countries face if they seek to reduce their birth rate through contraceptive technologies?
- **(c)** Describe at least two courses of action that a government could take to try to reduce the birth rate of a region or country. Should governments have the power to carry out these types of policy? Explain your answer.
- **(d)** Should more industrialized countries provide aid for contraceptive programs for less industrialized countries that are still in stage 2 of demographic transition? If so, what form should the aid take? If not, why not? Explain your position in the form of a letter to the editor of a newspaper.