

# UNIT 6

# Reproduction and Development

## General Outcomes

### In this unit, you will

- explain how survival of the human species is ensured through reproduction
- explain how human reproduction is regulated by chemical control systems
- explain how cell differentiation and development in the human organism are regulated by a combination of genetic, endocrine, and environmental factors

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## Focussing Questions

- 1 In what ways does a human change from conception to childhood to adulthood, and then through the senior years?
- 2 What are the roles of chemical control systems in regulating human reproduction?
- 3 How do reproductive technologies challenge the options, assumptions, and beliefs of individuals and society?

**T**his man and his baby are biologically separate individuals. Each has completely distinct respiratory, circulatory, and other body systems. Like all human body systems, the reproductive system involves complex interactions among a variety of organs and chemical pathways. The reproductive system is unique, however, in that its organs and chemical pathways are not all contained within the body of one individual. The interactions between male and female parents, and between mother and fetus, are the basis for the continuance of human life.

The reproductive system is the only body system that functions mainly to support the continuation of the species, rather than the well-being of an individual. Knowledge and technologies that affect human reproduction have the potential to transform human societies. In this unit, you will study the structures and processes that contribute to human sexual reproduction and to the development of a new human. As well, you will consider some of the social and ethical questions associated with the science and technology of human reproduction and development.





## Prerequisite Concepts

This unit draws and builds upon your understanding of various hormones of the endocrine system in relation to the maturing and function of the human reproductive systems.

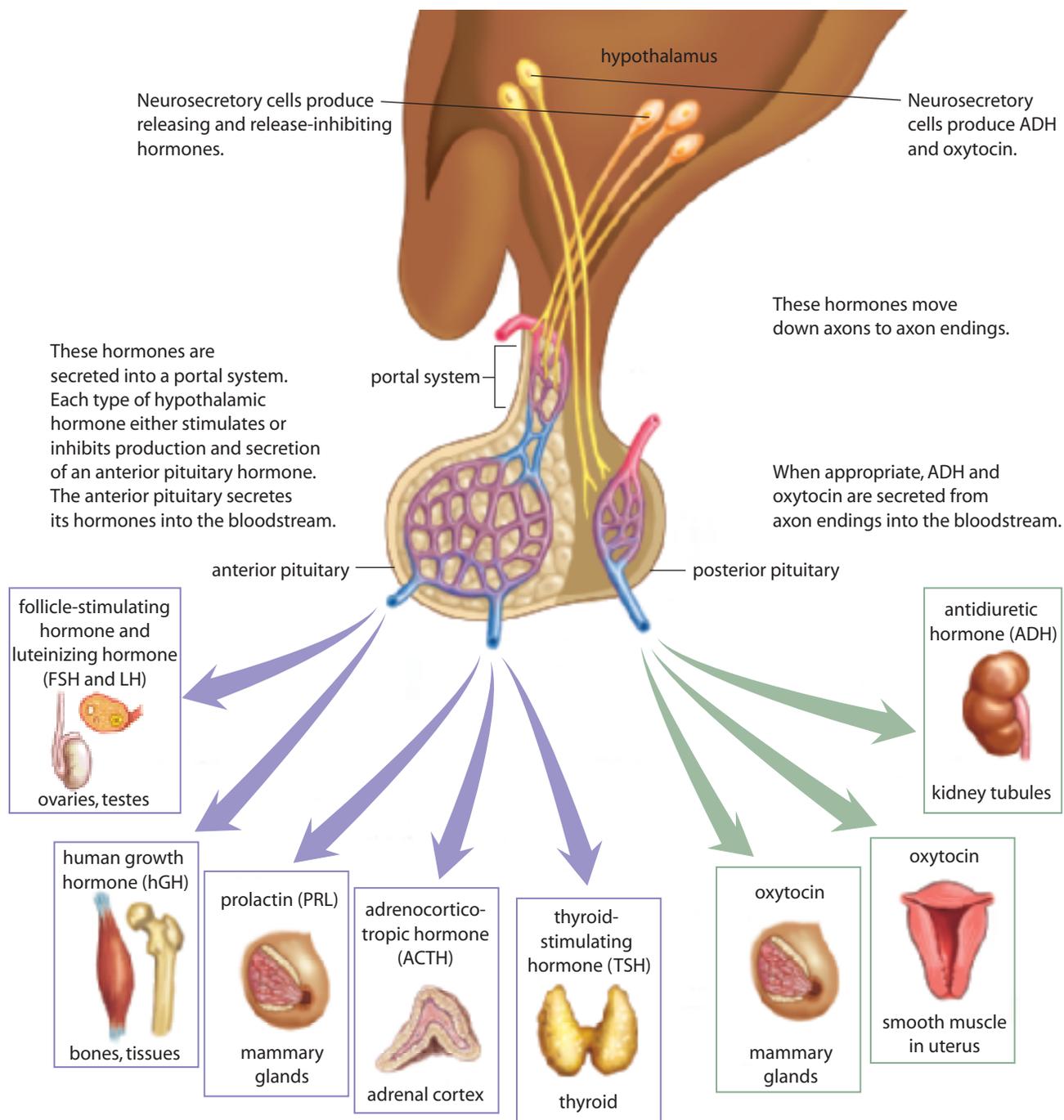
## The Endocrine System

The endocrine system consists of glands and tissues that secrete hormones—chemical signals that affect the activity of other glands or tissues of the body. The endocrine system interacts with the nervous system to regulate activities of other body systems and, as a result, to maintain homeostasis.

Table P6.1 reviews principle endocrine glands and some of their hormones. Figure P6.1 reviews hormones of the pituitary gland. Several of these—oxytocin, prolactin, hGH, FSH, and LH among them—play prominent roles in the development of reproductive organs as well the development of new human life.

**Table P6.1** Principal Glands of the Endocrine System and Some of their Hormones

Endocrine Gland	Hormone Secreted	Effects of Hormone on Target Tissues/Organs
hypothalamus	hypothalamic releasing- and inhibiting-hormones	regulates anterior pituitary hormones
anterior pituitary	human growth hormone (hGH)	stimulates cell division, bone and muscle growth, and metabolic functions
	thyroid-stimulating hormone (TSH)	stimulates the thyroid gland
	adrenocorticotrophic hormone (ACTH)	stimulates the adrenal cortex to secrete glucocorticoids
	follicle-stimulating hormone (FSH)	stimulates production of ova and sperm from the ovaries and testes
	luteinizing hormone (LH)	stimulates sex hormone production from the ovaries and testes
	prolactin (PRL)	stimulates milk production from the mammary glands
posterior pituitary	antidiuretic hormone (ADH)	promotes the retention of water by the kidneys
	oxytocin (OCT)	stimulates uterine muscle contractions and release of milk by the mammary glands
thyroid	thyroxine (T <sub>4</sub> )	affects all tissues increases metabolic rate and regulates growth and development
	calcitonin	targets bones and kidneys to lower blood calcium by inhibiting release of calcium from bone and reabsorption of calcium by kidneys
parathyroid	parathyroid hormone (PTH)	raises blood calcium levels by stimulating the bone cells to release calcium, the intestine to absorb calcium from food, and the kidneys to reabsorb calcium
adrenal cortex	glucocorticoids (e.g., cortisol)	stimulate tissues to raise blood glucose and break down protein
	mineralocorticoids (e.g., aldosterone)	promote reabsorption of sodium and water by the kidneys
	gonadocorticoids	promote secondary sexual characteristics
adrenal medulla	epinephrine and norepinephrine	fight-or-flight hormones raise blood glucose levels
pancreas	insulin	lowers blood glucose levels and promotes the formation of glycogen in the liver
	glucagon	raises blood glucose levels by converting glycogen to glucose
ovaries	estrogen	stimulates uterine lining growth and promotes development of the female secondary sexual characteristics
	progesterone	promotes growth of the uterine lining and prevents uterine muscle contractions
testes	testosterone	promotes sperm formation and development of the male secondary sexual characteristics



**Figure P6.1** The hypothalamus produces two hormones, ADH and oxytocin, which are stored and secreted by the posterior pituitary gland. The hypothalamus also controls the secretions of the anterior pituitary, which itself controls secretions of other endocrine glands such as the gonads.

# CHAPTER 14

# The Continuance of Human Life

## Chapter Concepts

### 14.1 The Male and Female Reproductive Systems

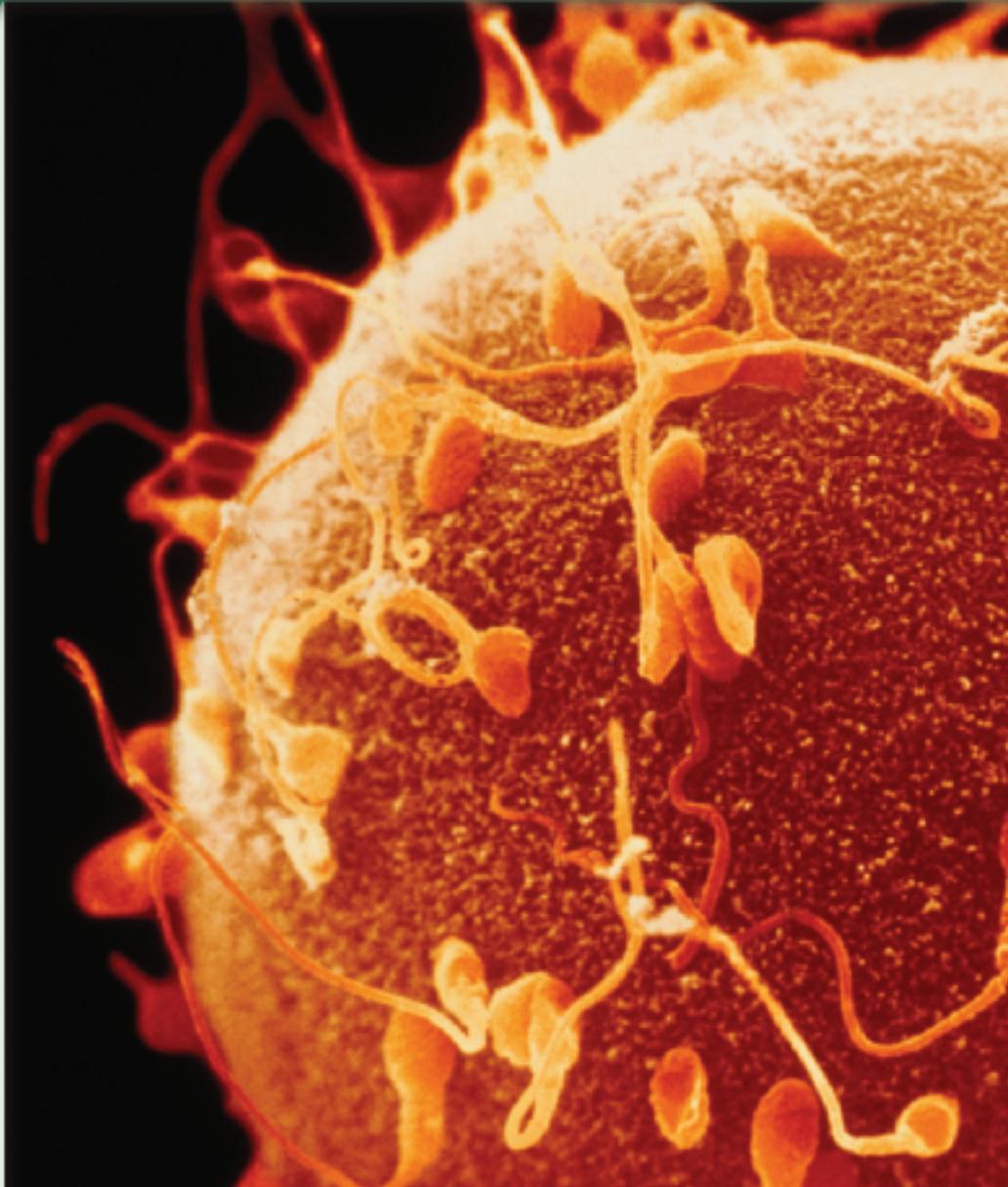
- The male and female reproductive systems have features in common as well as features that distinguish one from the other.
- The reproductive cells (gametes) in males are sperm and in females are eggs (ova).

### 14.2 The Effect of Sexually Transmitted Infections on the Reproductive Systems

- Sexually transmitted infections may be caused by a variety of organisms, including bacteria and viruses.
- Sexually transmitted infections can harm the health of individuals as well as interfere with the proper functioning of egg and sperm cells.

### 14.3 Hormonal Regulation of the Reproductive Systems

- Hormonal as well as genetic (chromosomal) factors affect the formation of the gonads and reproductive organs during prenatal (pre-birth) development.
- Sex hormones help in the maintenance and function of male and female reproductive systems.



**C**ontact between sperm and egg is the central event of human reproduction. At that moment, reproductive processes in two different individuals join together to create the single cell that will develop over a period of nine months into a new human being.

While most mammals can produce more young than humans can, humans are among the few species able to mate and produce young at any time of year. This ability helps to make human populations very mobile and adaptable to new surroundings. In association with our intelligence and technological capabilities, the ability to conceive at any time is one of the factors that has enabled our species to establish our populations almost everywhere on Earth and even to seek and create environments for ourselves beyond the confines of our planet.

## Launch Lab

### Inside Story

Different species of animals have evolved a wide range of reproductive strategies. For example, in the late fall, a female salmon lays 500 to 2500 eggs in the gravel bed of a stream. At the same time, the male releases a cloud of millions of sperm over the eggs. The fertilized eggs develop through the winter, and the hatchlings emerge in the spring. Based on what you already know about human reproduction, how do the strategies of salmon and humans compare?

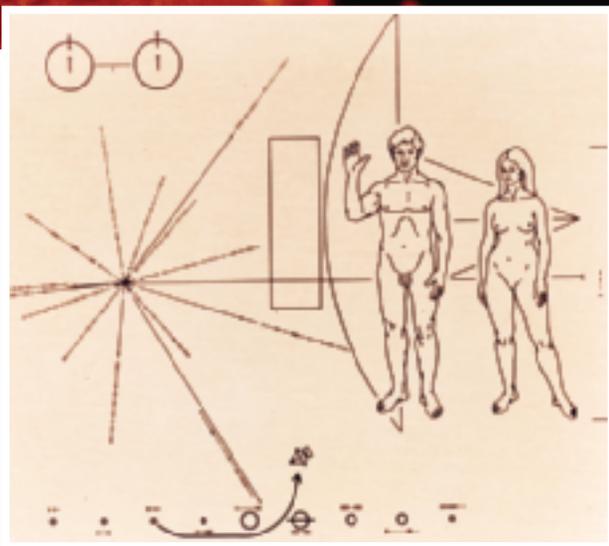
### Procedure

1. Working in small groups, make a list of some of the main features of salmon reproductive strategies. Compare human reproduction to each of these features. Create a table or a graphic organizer to help you organize your ideas.
2. Based on this comparison, what differences would you expect to see between the reproductive organs of the two species? Record your ideas in a table or chart.

### Analysis

1. What are the adaptive advantages of a reproductive strategy in which fertilization and fetal development take place within the body of the female? What are the disadvantages of this strategy?
2. Would you expect a male salmon to have a penis? Why or why not?
3. Would you expect a female salmon to have a uterus? Why or why not?
4. Human sperm are much smaller than a human egg. What other differences can you see between them? What might be the adaptive advantages of these differences?

Two space probes, Pioneers 10 and 11, are carrying this plaque into deep space, awaiting possible discovery by intelligent beings from another planet. Many people on Earth expressed concern that human sexual characteristics were displayed so prominently. Why are human sexuality and reproduction such sensitive topics?



## SECTION 14.1

# The Male and Female Reproductive Systems

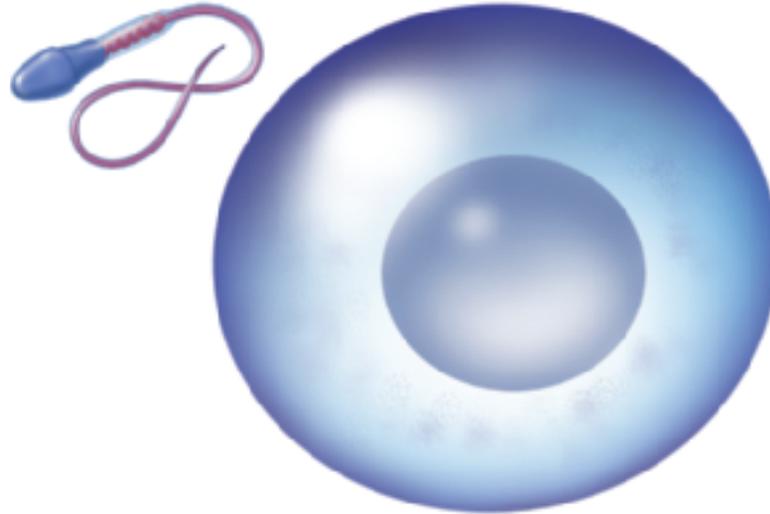
### Section Outcomes

In this section, you will

- **examine** the principal features of the human reproductive system
- **identify** male and female reproductive structures and **describe** their functions
- **observe** prepared slides of ovaries and testes, and **distinguish** gametes from their supporting structures in each of these organs

### Key Terms

gonads  
sex hormones  
primary sex characteristics  
secondary sex characteristics  
sperm cells  
testes  
scrotum  
seminiferous tubules  
Sertoli cells  
epididymis  
ductus deferens  
ejaculatory duct  
penis  
seminal vesicles  
prostate gland  
Cowper's gland  
semen  
urethra  
ejaculation  
ovaries  
ova  
follicle  
ovulation  
fimbriae  
oviduct  
uterus  
endometrium  
cervix  
vagina  
menstruation  
vulva



**Figure 14.1** All human life begins when an egg cell that is about the size of the period at the end of this sentence is fertilized by an even smaller sperm cell. The length of an average human sperm is about one-half to one-third the diameter of an average human egg.

The human reproductive system is adapted to unite a single reproductive cell from a female parent with a single reproductive cell from a male parent (see Figure 14.1). To achieve this outcome, the male and female reproductive systems have very different structures and functions. The two systems also have many features in common.

Both the male and female reproductive systems include a pair of gonads. The **gonads** (testes and ovaries) are the organs that produce reproductive cells: sperm in males and eggs in females. The male and female reproductive cells are also called *gametes*. (You will learn more about the production of gametes in Chapter 16.)

The gonads also produce sex hormones. **Sex hormones** are the chemical compounds that control the development and function of the reproductive system.

In addition to the gonads, the human reproductive system includes internal and external sex organs, as well as ducts and glands that play a role in forming and transporting gametes. The structures (organs, ducts, and glands)

that play a direct role in reproduction are called the **primary sex characteristics**. Males and females also have a distinct set of features that are not directly related to reproductive function. These are known as **secondary sex characteristics**. Table 14.1 outlines the organs, structures, and features that comprise the primary and secondary sex characteristics of males and females.

In human societies, sexual relationships serve a range of social and emotional functions. In this chapter, however, you will examine how the male and female reproductive systems are adapted to the biological functions of creating and supporting a human embryo.

**1** Distinguish between primary sex characteristics and secondary sex characteristics.

### Structures and Functions of the Male Reproductive System

The male reproductive system includes organs that produce and store large numbers of **sperm cells** (the male

**Table 14.1** Primary and Secondary Sex Characteristics

Sex	Primary sex characteristics	Selected secondary sex characteristics (with wide variations among individuals and ethnic groups)
male	<ul style="list-style-type: none"> <li>gonads (testes)</li> <li>penis</li> <li>scrotum</li> <li>seminal vesicles</li> <li>epididymis</li> <li>prostate gland</li> <li>ductus deferens</li> <li>Cowper's gland</li> </ul>	<ul style="list-style-type: none"> <li>facial hair</li> <li>body hair</li> <li>deeper voice, broader shoulders, narrower hips, and more obvious muscle development compared with female</li> </ul>
female	<ul style="list-style-type: none"> <li>gonads (ovaries)</li> <li>cervix</li> <li>oviducts</li> <li>vagina</li> <li>uterus</li> <li>vulva</li> </ul>	<ul style="list-style-type: none"> <li>minimal facial hair</li> <li>minimal body hair</li> <li>prominent breasts (compared with male)</li> <li>higher voice, more rounded shoulders, wider hips, and less obvious muscle development compared with male</li> </ul>

## BiologyFile

### FYI

The term *gonad* comes from a Greek word that means "procreation." The term *gamete* comes from a Greek word that means "marriage," referring to the union of a sperm and an egg.

gametes) and organs that help to deposit these sperm cells within the female reproductive tract. Some of the male reproductive structures are located outside the body, and others are located inside the body. Figure 14.2 shows the male reproductive system. Refer to this figure as you read through the following paragraphs. Table 14.2, on page 481, summarizes the functions of the male reproductive organs.

### The Testes

The two male gonads are called the **testes**. The testes are held outside the body in a pouch of skin called the **scrotum**. The scrotum regulates the temperature of

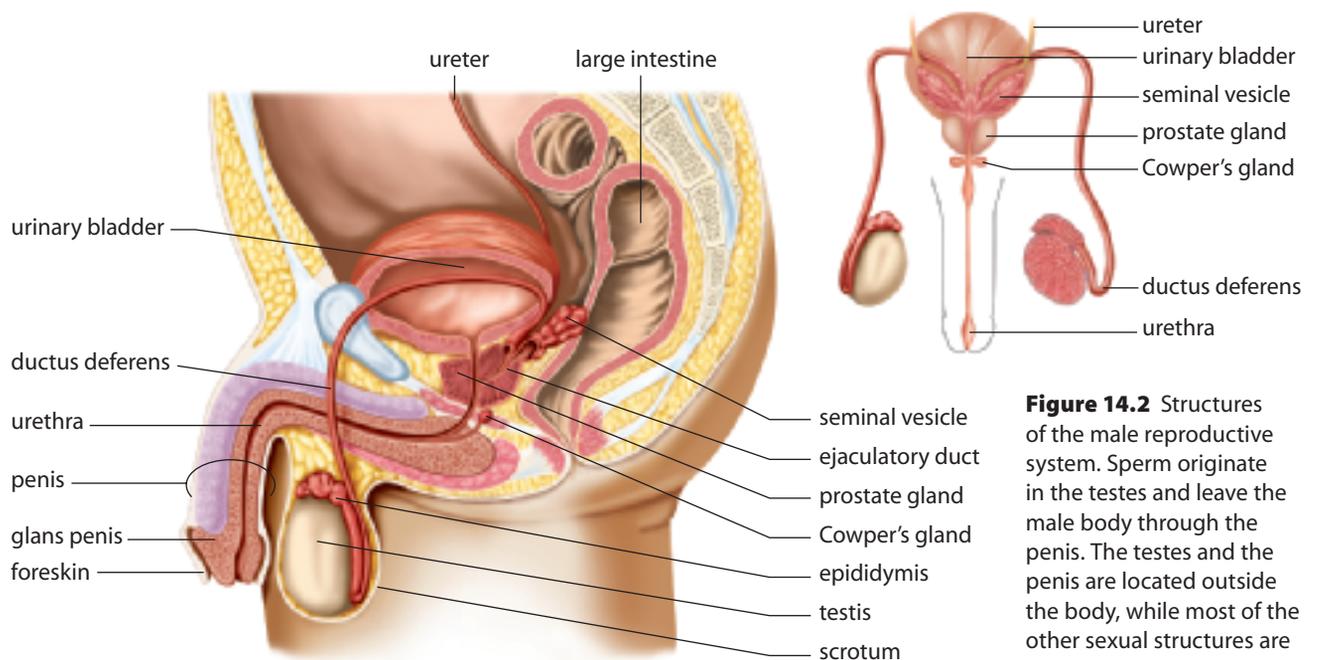
the testes. Sperm production is most successful at temperatures around 35 °C—that is, a few degrees cooler than normal body temperature. In cold conditions, the scrotum draws close to the body, so the testicles stay warm. In hot conditions, the scrotum holds the testicles more loosely, allowing them to remain cooler than the body.

As shown in Figure 14.3, the testes are composed of long, coiled tubes, called **seminiferous tubules**, as well as hormone-secreting cells, called interstitial cells, that lie between the seminiferous tubules. The interstitial cells secrete the male hormone testosterone. The seminiferous tubules are where sperm

## BiologyFile

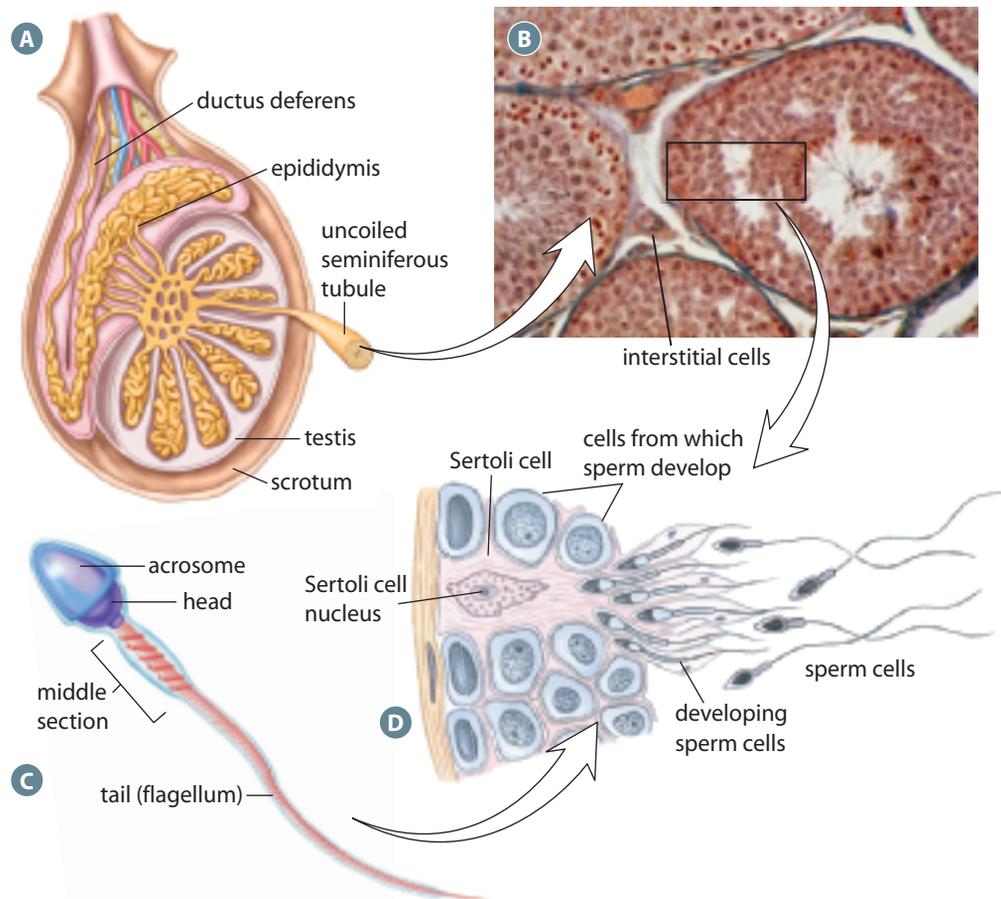
### FYI

About 3 percent of all baby boys are born with testes that have not descended properly. This condition can be corrected surgically.



**Figure 14.2** Structures of the male reproductive system. Sperm originate in the testes and leave the male body through the penis. The testes and the penis are located outside the body, while most of the other sexual structures are located inside the body.

**Figure 14.3** Human testis and sperm. **(A)** Each testis contains several compartments, packed with seminiferous tubules. **(B)** This light micrograph shows a cross-section of a seminiferous tubule. Some of the cells are engaged in sperm formation (spermatogenesis). **(C)** A mature sperm has a head, a middle section, and a tail. **(D)** Sertoli cells line the inner walls of the seminiferous tubules. Sertoli cells secrete chemicals required for the nourishment and development of sperm cells.



are produced. (The production of sperm is called *spermatogenesis*. You will learn more about the cellular processes of spermatogenesis in Chapter 16.) Each testis contains more than 250 m of seminiferous tubules and can produce more than 100 million sperm each day.

A mature sperm is a tadpole-shaped structure, about 0.06 mm long. Each sperm cell has three parts: an oval head, a cylindrical middle piece, and an extended tail. The head contains a nucleus with 23 chromosomes. It is covered by a cap-like structure called the acrosome. The acrosome stores enzymes that are needed to penetrate the protective layer surrounding a female egg. The middle piece contains mitochondria, which provide energy for the movement of the tail. The tail propels the sperm with a lashing motion. The sperm can move at a rate of about 3 mm per hour.

Developing sperm are supported and nourished by **Sertoli cells**, which are also located in the seminiferous tubules.

(The Sertoli cells are named after the Italian physiologist Enrico Sertoli, who first described them in 1865.) From each testis, sperm are transported to a nearby duct called the **epididymis** (plural: epididymides). Within each epididymis, the sperm mature and become motile. The epididymis is connected to a storage duct called the **ductus deferens** (plural: ductus deferentia), which leads to the penis via the **ejaculatory duct**. (The ductus deferens is also known by an older term, *vas deferens*. In Latin, the term *deferens* means “to carry,” referring to the role of the ductus deferens in carrying sperm to the penis.)

### The Penis

The **penis** is the male organ for sexual intercourse. Its primary reproductive function is to transfer sperm from the male to the female reproductive tract. The penis has a variable-length shaft with an enlarged tip called the glans penis. A sheath of skin, called the foreskin, surrounds

### BiologyFile

#### FYI

The fruitfly *Drosophila bifurca* is about 3 mm long, yet its sperm cells are nearly 60 mm long—about 200 times larger than its body. On a similar scale, a human sperm would be as long as a blue whale—about 30 m!

2 Using sentences, a graphic organizer, or a diagram, outline the relationship among the following structures: ductus deferens, epididymis, scrotum, seminiferous tubules, testes.

3 Distinguish between interstitial cells and Sertoli cells.

and protects the glans penis. The foreskin does not have any reproductive function. *Circumcision*, the surgical removal of the foreskin, is a common practice in some cultures and families.

During sexual arousal, the flow of blood increases to specialized erectile tissues in the penis. This causes the erectile tissues to expand. At the same time, the veins that carry blood away from the penis become compressed. As a result, the penis engorges with blood and becomes erect. Sperm cells move out of each epididymis through the ductus deferens.

### Seminal Fluid

As the sperm cells pass through the ductus deferentia, they are mixed with fluids from a series of glands. The **seminal vesicles** produce a mucus-like fluid that contains the sugar fructose, which provides energy for the sperm. The **prostate gland** and **Cowper's gland** also secrete mucus-like fluids, as well as an alkaline fluid to neutralize the acids from urine in the urethra. The combination of sperm cells and fluids is called **semen**. (The term semen comes from a Latin word that means "seed.")

If sexual arousal continues, semen enters the urethra from the ductus deferentia. The **urethra** is a duct that carries fluid through the penis. The urethra is shared by the urinary and reproductive systems. (During sexual intercourse, a sphincter tightens to prevent urine from mixing with the semen.) The movement of semen is the result of a series of interactions between the sympathetic, parasympathetic, and

**Table 14.2** Functions of the Male Reproductive Organs

Organ	Function
testes	produce sperm and sex hormones
epididymides	mature and store developing sperm
ductus deferentia	conduct and store sperm
seminal vesicles	contribute fructose and fluid to semen
prostate gland	contributes alkaline and mucoid fluids to semen
Cowper's gland	contributes alkaline and mucoid fluids to semen
urethra	conducts semen through the penis
penis	carries semen into the female reproductive tract

somatic nervous systems. Sensory stimulation, arousal, and co-ordinated muscular contractions combine to trigger the release, or **ejaculation**, of semen from the penis. The semen is deposited inside the vagina.

4 Arrange the following structures into the order in which sperm passes through them: ductus deferens; urethra; epididymis; seminiferous tubules; ejaculatory duct.

5 What is the significance of the acrosome of the sperm?

6 Name the glands that contribute fluids to semen, and list what each contributes.

### BiologyFile

#### FYI

In some men, the erectile tissue does not expand enough to cause an erection. This creates a condition known as *erectile dysfunction* or *impotence*. The drug sildenafil (Viagra™) acts on the enzymes that control blood flow in the penis. Because the same enzymes are found in the retina, the potential side effects of this drug include vision problems.

## Structures and Functions of the Female Reproductive System

In contrast to the male reproductive system, the female reproductive system does not mass-produce large numbers of gametes. The two female gonads, or **ovaries**, produce only a limited number of gametes. The female gametes are called **eggs**, or **ova** (singular: ovum). The other female sexual organs are adapted to provide a safe environment for fertilization, for supporting and nourishing a developing fetus, and for allowing the birth of a baby.

Most of the structures of the female reproductive system are located inside

### BiologyFile

#### FYI

Several hundred million sperm cells may be released in a single ejaculation. Sperm cells make up about 1 percent of the total volume of semen released in an ejaculation.

## BiologyFile

### FYI

The two oviducts are commonly called Fallopian tubes in honour of the Italian anatomist Gabriele Falloppio (1523–1562), who described their structure. Falloppio compared their shape with the shape of a trumpet.

the body. Figure 14.4 shows the main structures of the female reproductive system. Refer to this figure as you read the following paragraphs. Table 14.3 on page 484 summarizes the functions of the female reproductive organs.

### The Ovaries

The two ovaries are suspended by ligaments within the abdominal cavity. The ovaries are the site of *oogenesis*—the production of an ovum. (Oogenesis comes from two Greek words that mean “egg-creation.” Ova are also called oocytes. You will learn more about oocytes and the cellular processes of oogenesis in Chapter 16.) In contrast to the male reproductive system, in which both testes function at the same time, the ovaries usually alternate so that only one produces an egg each month.

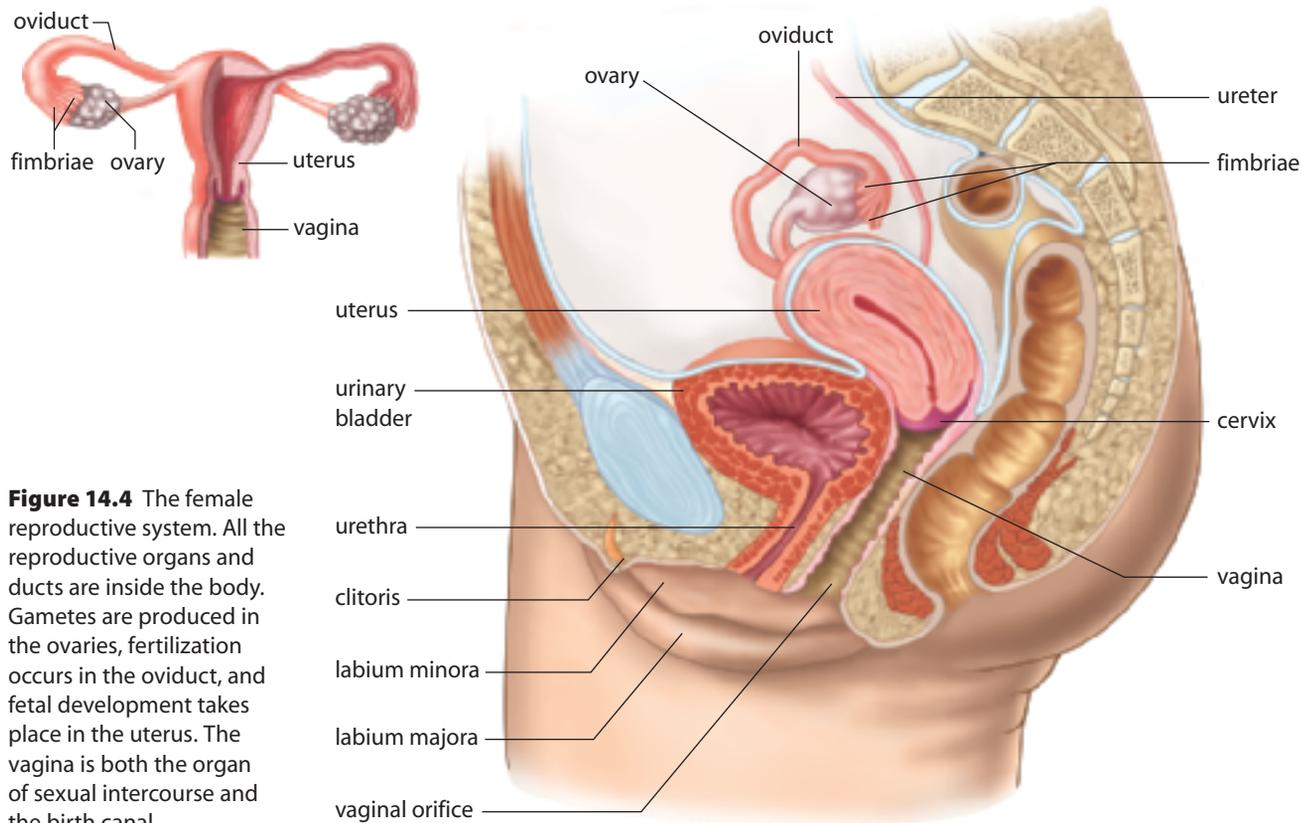
The ovary contains specialized cell structures called **follicles**. A single ovum develops within each follicle. Each month, a single follicle matures and then ruptures, releasing the ovum into the oviduct. This event is called **ovulation**.

Thread-like projections called **fimbriae** continually sweep over the ovary. (The term *fimbriae* comes from a Latin word that means “threads” or “fringes.”) When an ovum is released, it is swept by the fimbriae into a cilia-lined tube about 10 cm long called an **oviduct**. The oviduct carries the ovum from the ovary to the uterus. Within the oviduct, the beating cilia create a current that moves the ovum toward the uterus.

A mature ovum is a non-motile, sphere-shaped cell approximately 0.1 mm in diameter (that is, over 20 times larger than the head of a sperm cell). The ovum contains a large quantity of cytoplasm, which contains nutrients for the first days of development after fertilization. The ovum is encased in a thick membrane which must be penetrated by a sperm cell before fertilization can take place.

### The Uterus and Vagina

The **uterus** is a muscular organ that holds and nourishes a developing fetus. The uterus is normally about the size and shape of a pear, but it expands to many



**Figure 14.4** The female reproductive system. All the reproductive organs and ducts are inside the body. Gametes are produced in the ovaries, fertilization occurs in the oviduct, and fetal development takes place in the uterus. The vagina is both the organ of sexual intercourse and the birth canal.

times its size as the fetus develops. The lining of the uterus, called the **endometrium**, is richly supplied with blood vessels to provide nutrients for the fetus. (The term endometrium comes from two Greek words that mean “inner

uterus.”) At its upper end, the uterus connects to the oviducts. At its base, the uterus forms a narrow opening called the **cervix**. The cervix, in turn, connects to the **vagina**. The vagina serves as an entrance for the erect penis to deposit

## INVESTIGATION 14.A

### Target Skills

Using a microscope to **observe** prepared slides of ovarian and testicular tissues

**Distinguishing and identifying** ovarian and testicular structures

## Examining Gonads and Gametes

Testicles and ovaries serve the same two basic purposes: the production of gametes and the release of sex hormones. These two organs are quite different, however. In this investigation, you will use a microscope to examine and compare testicular and ovarian tissues.

### Question

How do the structures of testicular and ovarian tissues relate to their biological functions?



### Safety Precautions

Handle microscopes and microscope slides with care.

### Materials

- blank paper
- pencil
- prepared slides of testicular tissue
- prepared slides of ovarian tissue
- microscope

### Procedure

#### Part 1: Testicular Tissue

1. Mount the prepared slide of testicular tissue on the microscope stage.
2. Under low power, examine the specimen. Look for several circular structures. These are the seminiferous tubules.
3. Draw and label a diagram of the specimen as it appears under low power.
4. Switch to medium and then high power to examine one seminiferous tubule. Try to identify developing sperm cells, mature sperm cells, and interstitial cells. You may want to refer to the descriptions on pages 479–480 of this textbook to help you identify these structures.

5. Draw and label a diagram of the specimen as it appears under high power.

#### Part 2: Ovarian Tissue

1. Mount the prepared slide of ovarian tissue on the microscope stage.
2. Under low power, examine the specimen. Look for developing follicles near the outer edge of the ovary. Try to identify immature ova within the developing follicles.
3. A mature follicle will appear as a large, fluid-filled structure that contains an ovum. How many mature follicles can you find in the specimen?
4. Create and label a diagram of the specimen as it appears under low power. You may want to refer to the descriptions on pages 481 and 482 of this textbook to help you identify the structures you see.
5. Switch to medium and then high power to examine a mature follicle with an ovum.
6. Draw and label a diagram of the specimen as it appears under high power.

### Analysis

1. How does the number of sperm cells that are visible in the testicular tissue specimen compare with the number of ova that are visible in the ovarian tissue specimen?
2. How does the size of the sperm cells in the testicular tissue specimen compare with the size of the ova in the ovarian tissue specimen?

### Conclusion

3. Explain how the differences in the size and quantity of the gametes in the male and female gonads contribute to their reproductive functions.

**Table 14.3** Functions of the Female Reproductive Organs

Organ	Function
ovaries	produce eggs and sex hormones
fimbriae	sweep an egg into an oviduct
oviducts (Fallopian tubes)	conduct an egg from the ovary to the uterus; place where fertilization occurs
uterus (womb)	houses the developing fetus
cervix	is the opening to the uterus
vagina	receives the penis during sexual intercourse; serves as the birth canal and as the exit for menstrual flow

sperm during sexual intercourse. The vagina also serves as an exit for the fetus during childbirth.

The ovum survives in the oviduct for up to 24 hours after ovulation. If a living egg encounters sperm in the oviduct, fertilization may take place. The fertilized egg, now called a zygote, continues to move through the oviduct for several days before reaching the uterus. During this time, the endometrium thickens as it prepares to receive the zygote. The zygote implants itself in the endometrium, and development of the embryo begins. If the egg is not fertilized, it does not implant in the endometrium. The endometrium disintegrates, and its tissues and blood flow out the vagina in a process known as **menstruation**.

The vagina opens into the female external genital organs, known together as the **vulva**. The vulva includes the *labia majora* and *labia minora*, which are two pairs of skin folds that protect the vaginal opening. The vulva also includes the glans clitoridis. Like the penis, the glans clitoridis becomes erect during sexual arousal.

7 In which part of the female reproductive system does fertilization take place?

8 How does the path of an unfertilized ovum differ from the path of a fertilized ovum?

9 What is the endometrium?

10 What is menstruation?

## Differences between Sperm Cells and Egg Cells

In Investigation 14.A, you studied some of the visible differences between sperm cells and egg cells. These gametes differ in many other significant ways, some of which are outlined in Table 14.4. All of these differences relate to the biological function of uniting one gamete from each parent to create the single cell that will develop to become a new person.

### Section 14.1 Summary

- Fertilization takes place when a sperm cell, the male gamete, fuses with an ovum, the female gamete. This event follows from reproductive processes that take place within the bodies of the male and female parent.
- The male reproductive system is adapted to produce and release large quantities of motile sperm cells.
- Sperm production begins in the seminiferous tubules of the testes. Developing sperm are transported into the epididymis for maturation and storage.
- During sexual arousal, sperm move into the ductus deferens.
- Sperm are mixed with fluids from a series of glands to create semen. Semen is carried through the penis and released into the female reproductive tract.
- The female reproductive system is adapted to produce and release small numbers of ova.
- Ova are produced in follicles within the ovary.
- Each month a single ovum is released and is carried through the oviduct. If the egg encounters sperm in the oviduct, it may be fertilized.
- The fertilized egg continues through the oviduct to the uterus, which has been prepared to receive it. If the fertilized egg implants in the endometrium of the uterus, pregnancy begins.
- If the egg is not fertilized, it does not implant. Instead, the egg and endometrial tissues flow out through the vagina (menstruation).

**Table 14.4** Comparing Sperm Cells and Egg Cells

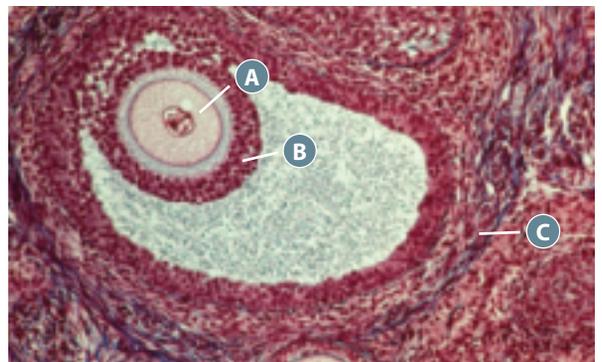
Criterion for comparison	Sperm cell	Egg cell
		
size	The head is about 5 $\mu\text{m}$ long. The middle piece is about 5 $\mu\text{m}$ long. The flagellum is about 40 $\mu\text{m}$ long.	An egg cell is about 100 $\mu\text{m}$ in diameter.
energy reserves	Before ejaculation, the mitochondria process fat to provide energy. After ejaculation, the mitochondria process fructose (a sugar) in seminal fluid to provide energy. Inside a woman's body, sperm can live for three to five days.	An egg can only live for about one day if it is not fertilized. If it is fertilized, it will implant in the endometrium, which serves as an energy source.
mitochondria	The middle piece of a sperm cell contains about 50 to 100 mitochondria, which supply ATP to provide energy for movement.	The cytoplasm of an egg cell contains about 140 000 mitochondria.
numbers produced	Sperm are continuously produced. About 300 to 500 million sperm are produced each day in a male's lifetime.	At puberty, each ovary contains 300 000 to 400 000 egg-forming structures (follicles). Usually, one egg is released from one of the ovaries each month.
motility	Sperm are motile. A sperm cell has an undulating tail (flagellum) that enables it to swim in fluid media.	Eggs are not motile. They have no structures to propel themselves.
outer structures	The sperm head has a cap called an acrosome, which contains enzymes that help the sperm enter an egg.	An egg is covered by a specialized outer coating which, in most cases, can only be penetrated by sperm of the same species.

**Section 14.1** Review

1. What are the two main purposes of the gonads in both males and females?
2. For each of the following structures, write a short description to indicate whether it is found in the male or female reproductive system and to summarize its function:
 

a) fimbriae	c) endometrium
b) ductus deferens	d) epididymis
3. List the organs and glands that contribute to the components of semen.
4. Which structures contribute to the movement of the ovum from the ovary to the uterus?
5. Draw a labelled diagram to describe the pathway of a sperm cell through the male reproductive system, beginning from the testes. **ICT**

6. Identify the labelled structures in the following image.



7. Briefly describe the structures of a sperm cell and an ovum. How does the structure of each cell relate to its function?
8. A man who is having difficulty conceiving children with his wife is advised by his doctor to wear looser pants. How could a change in clothing make a difference to this man's reproductive system?

# SECTION 14.2

## The Effect of Sexually Transmitted Infections on the Reproductive Systems

### Section Outcomes

- In this section, you will
- **identify** the risks that sexually transmitted infections present to individuals and to human reproduction
  - **explain** how sexually transmitted infections can interfere with the passage of eggs and sperm
  - **research** the effects of sexually transmitted infections
  - **design** and **collaborate** on a plan to communicate information about these infections, including their prevention and control, to young adults

### Key Terms

sexually transmitted infection (STI)  
 AIDS  
 HIV  
 hepatitis  
 genital herpes  
 human papilloma virus (HPV)  
 chlamydia  
 pelvic inflammatory disease (PID)  
 gonorrhea  
 syphilis

Sexual intercourse involves close physical contact and the exchange of body fluids. For this reason, sexual intercourse can transmit infections from one person to another. An infection that is transmitted only or mainly by sexual contact is generally known as a **sexually transmitted infection**, or **STI**.

STIs may be caused by viruses, bacteria, and parasites. STIs of greatest concern are those caused by viruses and bacteria. The most common viral STIs are HIV/AIDS, hepatitis, genital herpes, and human papilloma virus (HPV). The most common bacterial STIs are chlamydia, gonorrhea, and syphilis.

### HIV/AIDS

The acronym **AIDS** stands for *acquired immunodeficiency syndrome*. AIDS is caused by a group of related viruses that are collectively called *human immunodeficiency virus*, or **HIV**. HIV attacks a particular form of white blood cell known as helper T cells, which form part of the immune system. As the level of helper T cells in the blood decreases, the infected person becomes more vulnerable to infections that may lead to sickness and death in people who are diagnosed with acute AIDS.

HIV is transmitted through sexual contact with an infected person. HIV can also be transmitted among intravenous drug users who share needles. Children of mothers who are infected with HIV may themselves be infected before or during birth or through breast-feeding.

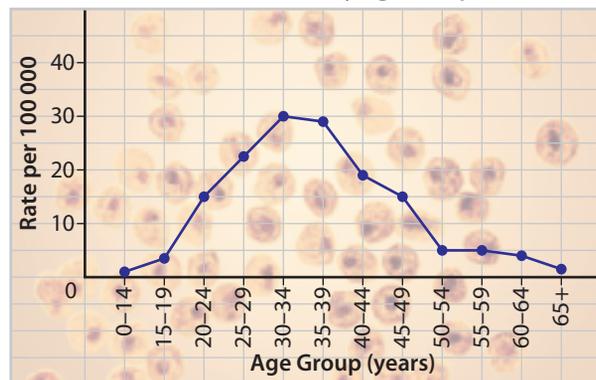
According to the Centre for Infectious Disease Prevention and Control, between 1985 and 2004, approximately 57 000 people in Canada tested positive for HIV infection. (See Figure 14.5.) About 20 000 of these people have developed full-blown AIDS, and more than 13 000 have died.

There is no cure for HIV. Treatments can alleviate the symptoms of specific diseases and can extend the life expectancy of someone with AIDS. Many of these treatments have harmful side effects. While the search continues for effective treatments and for a vaccine that can help to protect against AIDS, the most effective solution is to prevent transmission.

### Hepatitis

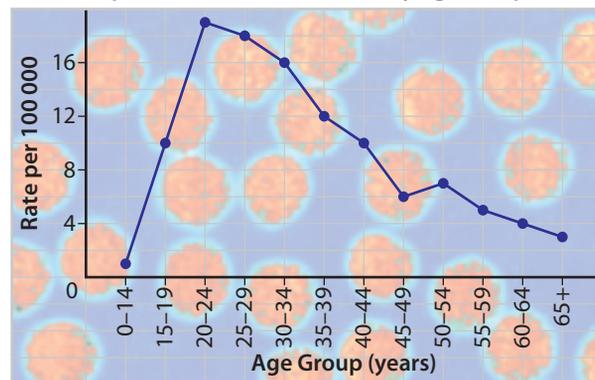
The group of diseases known as **hepatitis** includes three types of viral infections: hepatitis A, B, and C. Hepatitis A is usually contracted by drinking water that is contaminated with fecal material. As well, it can be transmitted through oral or anal contact. Hepatitis B is spread in

Rate of HIV infection in Alberta by Age Group, 1998–2001



**Figure 14.5** A graph of the rate of HIV infection in Alberta by age group, superimposed on a photomicrograph of the HIV virus.

Rate of Hepatitis B infection in Alberta by Age Group, 1986–2001



**Figure 14.6** A graph of the rate of hepatitis B infection in Alberta by age group, superimposed on a photomicrograph of the hepatitis B virus.

the same way as HIV—through sexual contact or through other contact with infected body fluids or blood. For this reason, hepatitis B is considered to be an STI. (See Figure 14.6.) Hepatitis C is transmitted through blood to blood contact with infected needles or syringes.

Each year, about 3000 Canadians are diagnosed with hepatitis B. Symptoms of the initial infection are flu-like, including fever, headache, nausea, loss of appetite, and abdominal pain. The skin of an infected person may become yellowish, a condition known as jaundice. A hepatitis B infection can progress to cause infection of the liver, leading to liver failure, liver cancer, and even death. Hepatitis viruses can cross the placenta to infect an unborn child. Some people recover completely. Others become *asymptomatic*—that is, they do not show any symptoms. Asymptomatic carriers can still, however, infect other people with the virus.

Effective and safe vaccines for hepatitis A and B are available. The hepatitis B vaccine is administered routinely to babies in Canada. As well, physicians recommend vaccination for people who work in the health system and for people whose lifestyles put them at risk of infection.

- 11 Describe how HIV leads to sickness and death in people who have AIDS.
- 12 How is HIV transmitted?
- 13 Compare the transmission of hepatitis A, B, and C.

## Genital Herpes

**Genital herpes** is an extremely common viral STI. The Canadian health system does not maintain statistics on rates of herpes infection. Based on international data, however, researchers estimate that almost one in three sexually active people in Canada has genital herpes and this number is rising. (See Figure 14.7.)

Genital herpes is a viral STI that is caused by one of two herpes viruses: herpes simplex 1 (HSV 1) or herpes simplex 2 (HSV 2). HSV 2 is more likely to be acquired through genital contact, causing genital herpes. HSV 1 commonly causes infections of the mouth (such as cold sores), but also causes genital infections.

Once someone is infected with herpes, the symptoms usually appear within a month. The symptoms vary widely among individuals. The most common set of symptoms includes a tingling or itching in a particular area of the body, followed by the appearances of blisters. The most common areas of infection are the genitals, buttocks, and thighs, but the blisters can form anywhere on the body, even on internal tissues such as the urethra. The blisters rupture, causing painful sores that can take 5 to 20 days to heal. The outbreak may be accompanied by flu-like symptoms, such as swollen glands, aching joints, and fatigue. After the initial outbreak, the blisters may recur with varying frequency, or not at all. Fever, stress, sunlight, intercourse, or certain foods may trigger future outbreaks.

Along with the discomfort associated with herpes outbreaks, the herpes sores mean an increased risk of HIV infection. There is also a risk of transmission from an infected mother to her baby during birth. The resulting infection in the baby may cause blindness, neurological disorders, and even death. Physicians usually recommend that a mother with genital herpes give birth by Caesarean

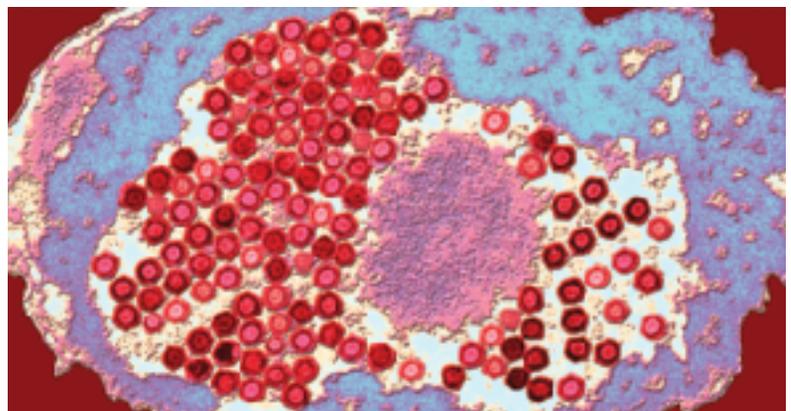
## BiologyFile

### FYI

The herpes simplex viruses are closely related to the viruses that cause chicken pox and mononucleosis.

### Figure 14.7

A photomicrograph of the herpes virus infecting a cell. Genital herpes infects one in five Americans and one in two people in some less industrialized countries. Despite over 20 years of research and promising, but inconclusive, clinical trials, a successful vaccine remains elusive.



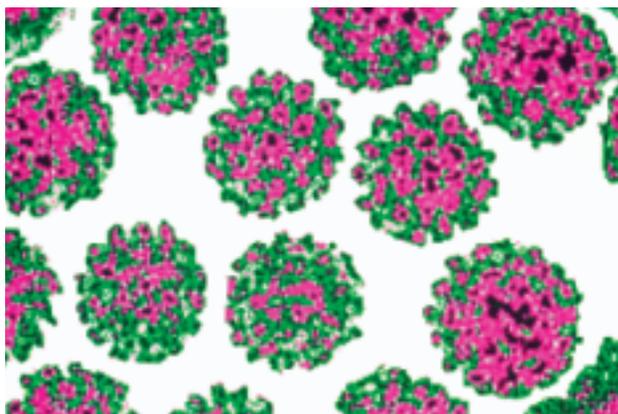
section to reduce the risk to her baby. (A Caesarean section is a surgical procedure in which a physician delivers the baby through an incision made in the abdomen and uterus.)

There is no cure for herpes. Once infected, an individual carries the virus for life and may infect others at any time. Although the risk of passing on genital herpes is greatest when the carrier has an active sore, the disease can be transmitted even when no sores are visible. Antiviral medication can help to control and diminish the severity of outbreaks. Researchers are also working to develop a herpes vaccine.

### Human Papilloma Virus (HPV)

The group of viruses known as **human papilloma virus** (HPV) is responsible for a condition known as *genital warts*. Like herpes, HPV infection is very common in North America. It is transmitted by skin-to-skin contact. (See Figure 14.8.)

Many people who are infected with HPV develop flat or raised warts around the genital area. Many others, however, show no symptoms. Because the direct symptoms of an HPV infection are not always obvious, many people carry the virus without knowing it. This is a health concern because HPV can lead to more serious disorders. Some forms of HPV are linked to cervical cancer in women. As well, HPV increases the risk of tumours of the vulva, vagina, anus, and penis.



**Figure 14.8** A photomicrograph of HPV. The infection can be treated but not cured.

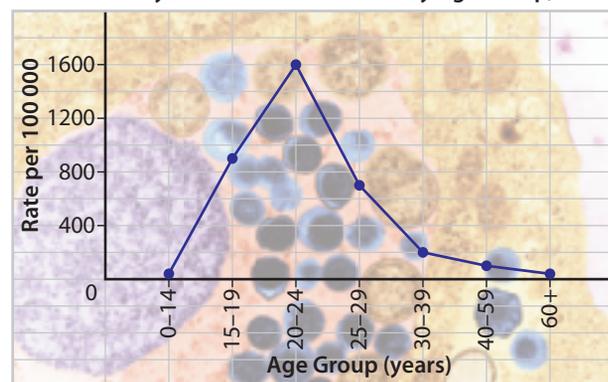
- 14 List the most common symptoms of genital herpes infections.
- 15 Why do physicians usually recommend that mothers who have genital herpes give birth by Caesarean section?
- 16 People who have infections caused by human papilloma virus do not always show symptoms of the infection. Explain why this is potentially dangerous.

### Chlamydia

**Chlamydia** is a potentially dangerous infection caused by the bacterium *Chlamydia trachomatis*. It is the most common bacterial STI in Canada, with more than 55 000 new cases reported each year. As shown in Figure 14.9, people between the ages of 15 and 24 account for the majority of new cases. The rate of infection in young women is more than twice the rate in young men.

After infection with chlamydia, some people experience symptoms immediately. The symptoms may include a discharge from the penis or vagina, a burning pain while urinating, or a fever. One of the greatest dangers of chlamydia is that up to 75 percent of infected people have no obvious symptoms. These people may unknowingly pass the

**Rate of Chlamydia infection in Alberta by Age Group, 2004**



**Figure 14.9** A graph of the rate of Chlamydia infection in Alberta by age group, 2004, superimposed on a photomicrograph of a cell infected with chlamydia.

infection on to others, and they may be unaware of the damage that is occurring within their own bodies.

In women, if the infection is not detected, it can spread to the cervix and the oviducts. This, in turn, can lead to **pelvic inflammatory disease** (PID). PID is painful and can result in a build-up of scar tissue in the oviducts. The oviducts may become fully blocked, causing infertility. Infection of the cervix can result in open sores that increase the risk of acquiring HIV. A baby who comes in contact with chlamydia during birth can develop infections of the eyes and respiratory tract. Fortunately, there are effective tests for chlamydia. If an infection is diagnosed early enough, treatment with antibiotics can lead to a complete cure with no permanent effects.

## Gonorrhea

**Gonorrhea** is the second most widespread bacterial STI in Canada. Some of the effects of gonorrhea are similar to the effects of other bacterial infections, such as chlamydia. In fact, the two infections are often found together. In contrast to chlamydia, however, the reported rate of infection is almost twice as high in men as in women. As shown in Figure 14.10, young people have the highest risk of contracting gonorrhea.

Gonorrhea is caused by the bacterium *Neisseria gonorrhoeae*. It can cause infection of the urethra, cervix, rectum,

and throat. The infection often causes pain when urinating and a thick greenish-yellow discharge from the urethra. As with chlamydia, some people experience no initial symptoms. Left untreated, the disease can lead to PID and may spread through the bloodstream to the joints, heart, or brain. A baby who comes in contact with gonorrhea in the birth canal can develop a serious eye infection. Physicians routinely give eye drops to newborns to prevent this.

Like chlamydia, gonorrhea 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.

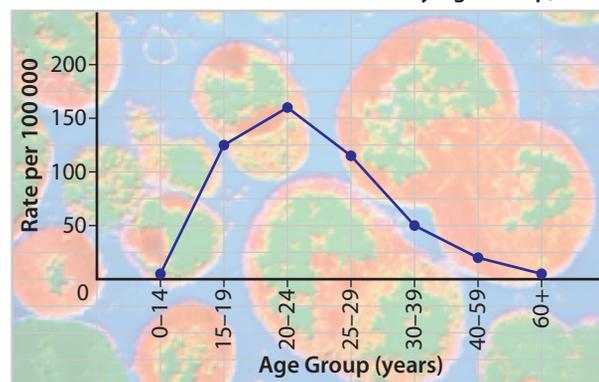
## Syphilis

**Syphilis** is the least common of the three bacterial STIs. Until very recently, health practitioners thought that eliminating syphilis completely in Canada would be possible. Unfortunately, the rate of syphilis infection has increased sharply in Canada since 1997 (see Figure 14.11).

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

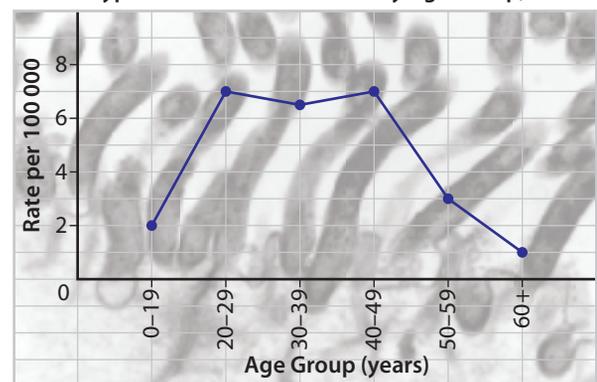
The second stage is characterized by a rash. The rash may appear anywhere on

Rate of Gonorrhea infection in Alberta by Age Group, 2004



**Figure 14.10** A graph of the rate of gonorrhea infection in Alberta by age group, 2004, superimposed on a photomicrograph of *Neisseria gonorrhoeae*.

Rate of Syphilis infection in Alberta by Age Group, 2004



**Figure 14.11** The rate of syphilis infection in Alberta by age group, 2004, superimposed on a photomicrograph of *Treponema* on the surface of the human duodenum.

the skin, but it generally appears on the palms of the hands and the soles of the feet. Any contact with the infected person may spread the infection.

During the third stage, the infection begins to affect the cardiovascular and nervous systems. An infected person may become mentally ill, blind, or lame, and may develop heart disease. Large, destructive ulcers called gummas may develop on the skin or internal organs.

During any stage, syphilitic bacteria can infect a developing embryo, causing birth defects or stillbirth.

If the disease is not treated early, the bacteria can cause permanent damage. Fortunately, syphilis is readily diagnosed and can be treated effectively with antibiotics, including penicillin. Health professionals are concerned, however, that both risky sexual behaviour and lack of awareness are contributing to new regional outbreaks of syphilis.

**17** Use a table to compare the causes and treatments for chlamydia, gonorrhoea, and syphilis.

**Table 14.5** Preventing Transmission of STIs

Way to prevent transmission	Description
abstinence	Not engaging in any sexual activity is the only sure protection against all STIs.
long-term monogamous relationships	Relationships with the same partner are generally safe, if neither partner has an STI. Some STIs, such as HPV, can be dormant for many years before symptoms appear, however. Many people who have STIs are not aware of their infection.
condoms	Using male or female condoms can reduce, but does not eliminate, the risk of STI transmission.
personal responsibility	Personal responsibility is crucial. Safe sexual practices include not using alcohol or drugs, which can impair self-control or personal judgment. Sexual practices that are known to increase the risk of STI transmission include having multiple partners or partners who use intravenous drugs. Any practices that involve contact between the genitals and the mouth or rectum also increase the risk of STI transmission.

## Controlling the Spread of STIs in Canada

Many cases of STIs go undiagnosed simply because people are not aware of the significance of their symptoms. When people know the symptoms of STIs, they are more likely to be tested and treated before they infect others. For this reason, health practitioners stress education and awareness programs as an essential part of controlling the spread of STIs. Since many people carry STIs without knowing it, health practitioners also stress the importance of personal responsibility for safe sex practices. Table 14.5 provides some examples of ways that people can protect themselves from STI transmission. STIs can lead to very serious diseases, but they are preventable.

### Section 14.2 Summary

- Sexual intercourse can be a way of transmitting infections from one person to another.
- Sexually transmitted infections (STIs) may have a variety of effects, from temporary discomfort to permanent damage of the reproductive system and other body systems. Some STIs can be fatal.
- STIs may be caused by viral and bacterial infection.
- Common viral STIs include HIV/AIDS, hepatitis B, genital herpes, and human papilloma virus (genital warts).
- Common bacterial STIs include chlamydia, gonorrhoea and syphilis. For many of these STIs, young people show the highest rates of infection.
- One of the greatest challenges in controlling the spread of STIs is that many people who are infected show no symptoms. These people may unknowingly pass the infection on to other individuals.
- Education, awareness, and responsible practices are important elements of public health strategies for prevention and treatment of STIs.

**Planning** a strategy to communicate effectively information about sexually transmitted infections to a teenage audience

**Working cooperatively** to research and communicate findings about damage to the reproductive systems caused by STIs

In Canada, the rate of infection for several STIs is highest among teenagers and young adults. In the coming years, many of these people will want to start families. What do young people need to know about how STIs can affect their bodies? What strategy would you design to reach this audience?

### Procedure

1. In your group, choose one STI that will be the focus of your education program.
2. Use print and Internet resources to learn about the STI you chose. In particular, find out what effects the STI can have on the male and female reproductive systems. **ICT**
3. Organize your findings in a written report. Your report should include the following information:
  - the cause of the STI
  - the effects of the STI on the human body and, in particular, the male and female reproductive systems
  - why young adults are the age group at greatest risk for acquiring an STI
  - the issues and challenges involved in preventing and controlling the transmission of the STI
4. Using the information in your report, develop an education program aimed at young people. Decide on the two or three most important messages. Then decide how you will deliver these messages. For example, you could create print advertisements for a magazine, produce a music video, or write and perform a play. Deliver your presentation to your class. **ICT**

### Analysis

1. Which STIs are most likely to disrupt the function of the human reproductive system?
2. Which STIs are most likely to cause permanent damage to the human reproductive system?
3. Which education program do you think was the most effective? What made it effective?
4. What do you think are the most serious challenges for health practitioners who want to reach young people in Canada? What could be done to meet these challenges?

### Extension

5. Some strategies to control the spread of STIs raise social and ethical issues. For example, some people argue that people should be able to test themselves for STIs in the privacy of their own homes. Other people believe that tests should always be conducted in a health clinic so that the results can be recorded. Working with a partner, choose an ethical issue associated with STIs. Prepare a short debate to argue both sides of the issue. What did you conclude?

## Section 14.2 Review

1. Give two examples of viral STIs and two examples of bacterial STIs.
2. What is pelvic inflammatory disease, and why is it a concern?
3. In what ways can a woman who is infected with an STI present a health risk to her baby? Give three examples.
4. Some people who become infected with an STI may show no symptoms.
  - a) How does this present a risk to the health of the infected individual?
  - b) How does this present a public health risk?
5. A friend says to you, “viral STIs are always more serious than bacterial STIs, because they are not curable.” How would you respond? Include specific examples to support your argument.
6. Programs that are designed to teach young people about STIs are often controversial. Many people believe that young people should be taught to abstain entirely from sexual contact. Other people believe that young people should be taught about safe sex practices.
  - a) List two arguments that could be made on each side of this issue.
  - b) Is it possible for health practitioners to design education campaigns that respect both views? Explain your ideas in an editorial. **ICT**

## SECTION 14.3

# Hormonal Regulation of the Reproductive System

### Section Outcomes

In this section, you will

- **identify** the main reproductive hormones and **describe** how they interact
- **explain** the role of sex hormones in the development and regulation of primary and secondary sex characteristics
- **analyze** blood hormone data and associated physiological events
- **research** and **assess** the medical use of reproductive hormones in humans



**Figure 14.12** The cells of this four-week-old human are already programmed with a genetic sex. The primary sex characteristics of this embryo, however, will not be evident for several more weeks.

### Key Terms

chromosomal sex  
puberty  
gonadotropin releasing hormone (GnRH)  
follicle-stimulating hormone (FSH)  
luteinizing hormone (LH)  
testosterone  
inhibin  
andropause  
estrogen  
progesterone  
menstrual cycle  
corpus luteum  
follicular stage  
luteal stage  
menopause  
hormone replacement therapy (HRT)

The **chromosomal sex**, or genetic sex, of an individual is determined at fertilization (Figure 14.12). In humans and other mammals, an embryo that carries the sex chromosome combination XY is genetically male. An embryo that carries the sex chromosome combination XX is genetically female. (You will learn more about the structure and function of chromosomes in Unit 7.)

The chromosomal sex remains constant throughout the life of an individual. The structure and function of the male and female reproductive systems, however, are more than simply a matter of genetics. Until about the seventh week of development, male and female embryos are anatomically identical. After this time, the presence or absence of specific hormones determines which sex organs develop, when the sex organs mature, and how they function.

Many of the same reproductive hormones are at work in both males and females. The interaction of genetic and hormonal factors produces different reproductive systems in each sex. The main sex hormones and their effects are summarized in Table 14.6. You may want

to refer to Table 14.6 as you read through this section.

- 18 What chromosome combination results in an offspring that is
- (a) genetically male and
  - (b) genetically female?

### Sex Hormones and the Male Reproductive System

The development of the male sex organs begins before birth. In embryos that are genetically male, the Y chromosome carries a gene called the *testis-determining factor* (TDF) gene. The action of this gene triggers the production of the male sex hormones. (The male sex hormones are also known as *androgens*. The prefix *andro-* comes from a Greek word that means “man” or “male.”) The presence of androgens initiates the development of male sex organs and ducts in the fetus.

As the reproductive structures develop, they migrate within the body to their final locations. For example, the testes first develop in the abdominal cavity. During the third month of fetal

**Table 14.6** Summary of Key Reproductive Hormones and Their Functions

Hormone	Production site	Target organ(s)	Function in male reproductive system	Function in female reproductive system
gonadotropin releasing hormone (GnRH)	hypothalamus	anterior pituitary gland	stimulates the release of FSH and LH from the anterior pituitary	stimulates the release of FSH and LH from the anterior pituitary
follicle stimulating hormone (FSH)	anterior pituitary	ovaries and testes	stimulates the development of the sex organs and gamete production	stimulates the development of the sex organs and gamete production
luteinizing hormone (LH)	anterior pituitary	ovaries and testes	stimulates the production of testosterone	triggers ovulation, and (with FSH) stimulates estrogen production
estrogen	ovary (follicle)	entire body	minor	stimulates the development of the female reproductive tract and secondary sex characteristics
progesterone	ovary (corpus luteum)	uterus	minor	causes uterine thickening
testosterone	testes (interstitial cells)	entire body	stimulates the development of the male reproductive tract and secondary sex characteristics	minor
inhibin	testes (Sertoli cells)	anterior pituitary and hypothalamus	inhibit FSH production	inhibit FSH production

development, the testes begin to descend toward the scrotum. This process is not complete until shortly before birth.

## Maturation of the Male Reproductive System

A boy's genitalia are visible at birth, but his reproductive system will not be mature until puberty. **Puberty** is the period in which the reproductive system completes its development and becomes fully functional.

Most boys enter puberty between 10 and 13 years of age, although the age of onset varies greatly. At puberty, a series of hormonal events lead to gradual physical changes in the body. These changes include the final development of the sex organs, as well as the development of the secondary sex characteristics.

Puberty begins when the hypothalamus increases its production of **gonadotropin releasing hormone (GnRH)**. GnRH acts on the anterior pituitary gland, causing it to release two different sex hormones: **follicle-stimulating hormone (FSH)** and **luteinizing hormone (LH)**. In males, these hormones cause the testes to begin producing sperm and to release

testosterone. **Testosterone** acts on various tissues to complete the development of the sex organs and sexual characteristics.

## Hormonal Regulation of the Male Reproductive System

From the end of puberty, the male reproductive system is usually capable of producing millions of sperm every hour of the day, seven days a week until death. The same hormones that trigger the events of puberty also regulate the mature male reproductive system over a person's lifetime. Hormone feedback mechanisms control the process of spermatogenesis, and they maintain the secondary sexual characteristics. Refer to Figure 14.13 as you read the following paragraphs.

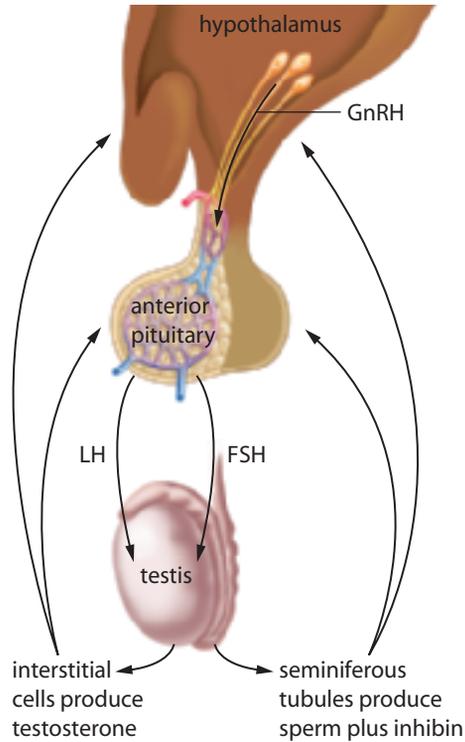
As you can see, the release of GnRH from the hypothalamus triggers the release of FSH and LH from the anterior pituitary. FSH causes the interstitial cells in the testes to produce sperm. At the same time, FSH causes cells in the seminiferous tubules (where sperm are produced) to release a hormone called **inhibin**. Inhibin acts on the anterior pituitary to inhibit the production of FSH. The result is a negative feedback loop. As the level of FSH drops, the testes

### BiologyFile

#### FYI

LH and FSH are produced by both males and females, but they are named for their actions in the female. In the male, LH is sometimes called interstitial cell stimulating hormone (ICSH) because it controls the production of testosterone by interstitial cells. Chemically, however, LH (ICSH) in males is identical to LH in females.

**Figure 14.13** Hormonal control of the male reproductive system. GnRH from the hypothalamus stimulates the anterior pituitary to release LH and FSH. LH and FSH act on the testes to trigger sperm production and the release of testosterone and inhibin. Testosterone and inhibin exert regulatory control over the anterior pituitary and hypothalamus.



release less inhibin. A decrease in the level of inhibin causes the anterior pituitary to release more FSH. This feedback loop keeps the level of sperm production relatively constant over time.

A similar feedback loop maintains the secondary sex characteristics. LH causes the testes to release testosterone, which promotes changes such as muscle development and the formation of facial hair. As well, testosterone acts on the anterior pituitary to inhibit the release of LH. This feedback loop keeps the testosterone level relatively constant in the body.

Reproductive function and secondary sex characteristics both depend on the continued presence of male sex hormones. Substances that interfere with the hormonal feedback system can cause changes in the reproductive system. For example, anabolic steroids mimic the action of testosterone in promoting muscle development. For this reason, some athletes illegally use steroids to increase their speed or strength. Steroids, however, also disrupt the reproductive hormone feedback systems. The side effects of steroid use in men may include shrinking testicles, low sperm count, loss of body hair, and the development of breasts.

## Thought Lab 14.2 Testosterone and Male Development

### Target Skills

**Analyzing** blood hormone data and physiological events for a human male

**Inferring** the roles of male sex hormones

**Selecting and using** an appropriate mode of representation to communicate ideas and information about sex hormone levels

Blood tests of testosterone levels are sometimes used to help diagnose disorders of the male reproductive system, as well as other conditions that affect hormone balance in the body. In this activity, you will plot and analyze blood testosterone data for male children and young adult males.

### Procedure

1. Examine the data in the table below. Graph these data using the type of graph you think is most appropriate.
2. Based on the data, at what age does puberty begin? Mark this on your graph.

Normal Blood Testosterone Levels in Males

Age (years)	Blood testosterone level (ng/dL)
1 to 7.9	40
8 to 10.9	42
11 to 11.9	260
12 to 13.9	420
14 to 17.9	1000
18 to 29	1100

3. Use print or Internet resources to research the physiological changes that take place during male puberty. Write a brief description of the changes that are associated with changing levels of testosterone. Identify which of these changes are directly related to reproductive function. **ICT**

### Analysis

1. Is it possible to use blood hormone data to identify the end of puberty? Explain your answer.
2. In young men, the growth of facial hair begins at the same time as blood testosterone levels start to increase.
  - a) From this evidence, can you conclude that testosterone causes facial hair growth? Justify your answer.
  - b) Design an experiment to test the hypothesis that testosterone causes facial hair growth in men.

19 List five male sex hormones and briefly describe their significance.

## Aging and the Male Reproductive System

A man in good health can remain fertile for his entire life. Even so, most men experience a gradual decline in their testosterone level beginning around age 40. This condition is called **andropause**. In some men, the hormonal change may be linked to symptoms such as fatigue, depression, loss of muscle and bone mass, and a drop in sperm production. However, some studies suggest that low doses of testosterone can help to counter the symptoms of andropause. Because not all men experience symptoms of andropause, and because the symptoms can vary widely, this condition is difficult to diagnose accurately.

Other hormonal changes associated with aging can also affect the male reproductive system. For example, the prostate gland often begins to grow gradually in men over age 40. This can lead to discomfort and urinary difficulties, because the prostate squeezes on the urethra as it grows. Older men have an increased risk of cancer of the prostate gland, as well. Surgery may be used to provide relief and to reduce the cancer risk. Younger men, however, are more prone to developing infections of the prostate. The resulting inflammation of the prostate (a condition called prostatitis) may cause a burning sensation when urinating or a need to urinate more frequently. Antibiotics are usually prescribed to fight the infection and reduce the inflammation.

## Sex Hormones and the Female Reproductive System

Our understanding of the specific factors that trigger the development of female sex organs in a genetically female embryo is incomplete. Until recently, scientists

assumed that the development of female sex organs was a “default” pattern—that is, if there is no Y chromosome, then female organs will develop. Researchers now suspect that the processes of female sex development are more complex and that specific hormonal triggers cause female sex organs to develop.

Like a baby boy, a baby girl has a complete but immature set of reproductive organs at birth. North American girls usually begin puberty between 9 and 13 years of age. The basic hormones and hormonal processes of female puberty are similar to those of male puberty. A girl begins puberty when the hypothalamus increases its production of GnRH. This hormone acts on the anterior pituitary to trigger the release of LH and FSH.

In girls, FSH and LH act on the ovaries to produce the female sex hormones **estrogen** and **progesterone**. These hormones stimulate the development of the female secondary sex characteristics and launch a reproductive cycle that will continue until about middle age.

20 What is the role of GnRH, FSH, and LH in the development of the female reproductive system?

## Hormonal Regulation of the Female Reproductive System

In humans, female reproductive function follows a cyclical pattern known as the **menstrual cycle**. The menstrual cycle ensures that an ovum is released at the same time as the uterus is most receptive to a fertilized egg.

The menstrual cycle is usually about 28 days long, although it may vary considerably from one woman to the next, and even from one cycle to the next in the same woman. By convention, the cycle is said to begin with menstruation and end with the start of the next menstrual period. The menstrual cycle is actually two separate but interconnected

## BiologyFile

### Try This

Copy an outline of Figure 14.13 into your notebook, including the labels. Add plus signs (+) and negative signs (–) beside the arrows to show which hormones have a stimulating action and which have an inhibitory action.

## BiologyFile

### Web Link

Testosterone may be prescribed by a licensed physician for specific medical conditions and treatments. It may also be used illegally, in synthetic form as an anabolic steroid, by people looking for a fast, easy way to build muscle mass, reduce fat, and improve endurance. How do the legal and illegal uses of testosterone differ? What are the risks of using this hormone?

[www.albertabiology.ca](http://www.albertabiology.ca)  
WWW

## BiologyFile

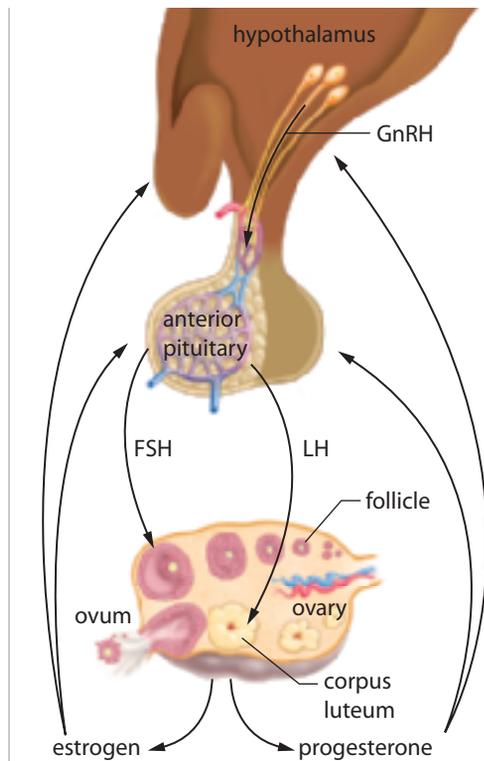
### Try This

Copy an outline of Figure 14.15 into your notebook, including the labels. Add plus signs (+) and negative signs (-) beside the arrows to show which hormones have a stimulating action and which have an inhibitory action.

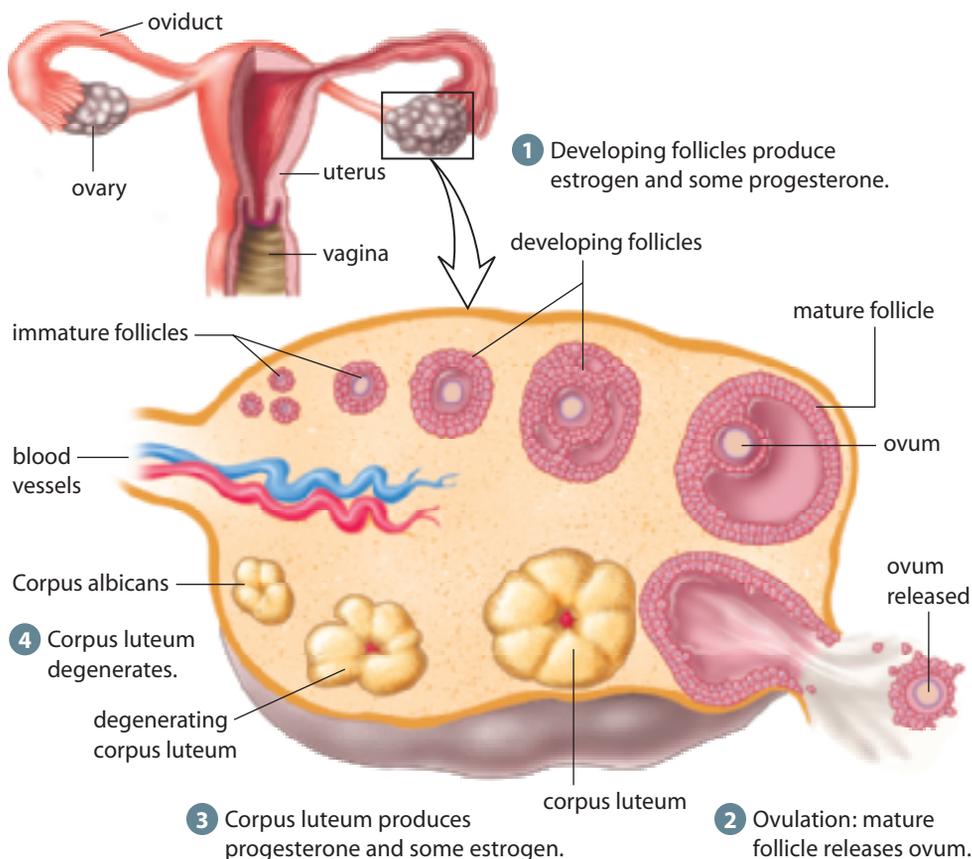
cycles of events. One cycle takes place in the ovaries and is known as the *ovarian cycle*. The other cycle takes place in the uterus and is known as the *uterine cycle*. Both cycles are controlled by the female sex hormones estrogen and progesterone, which are produced by the ovaries.

### The Ovarian Cycle

As you saw in Section 14.1, the ovary contains cellular structures called follicles. Each follicle contains a single immature ovum. At birth, a baby girl has over 2 000 000 follicles. Many degenerate, leaving up to about 400 000 by puberty. During her lifetime, only approximately 400 of these follicles will mature to release an ovum. In a single ovarian cycle, one follicle matures, releases an ovum, and then develops into a yellowish, gland-like structure known as a **corpus luteum**. The corpus luteum then degenerates. (The term *corpus luteum* comes from two Latin words that mean “yellow body.” The term *follicle* comes from a Latin word that means “small



**Figure 14.15** 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.



**Figure 14.14** A follicle matures by growing layers of follicular cells and a central fluid-filled vesicle. The vesicle contains the maturing ovum. At ovulation, the follicle ruptures and the ovum is released into the oviduct. The follicle develops into a corpus luteum. If pregnancy does not occur, the corpus luteum starts to degenerate after about 10 days. Note that the follicle does not migrate around the ovary, as shown here for clarity, but goes through all the stages in one place.

bag.”) Figure 14.14 illustrates the ovarian cycle, and Figure 14.15 illustrates the hormone systems that control this cycle.

The ovarian cycle can be roughly divided into two stages. The first stage is known as the **follicular stage**. It begins with an increase in the level of FSH released by the anterior pituitary gland. FSH stimulates one follicle to mature. As the follicle matures, it releases estrogen and some progesterone. The rising level of estrogen in the blood acts on the anterior pituitary to inhibit the release of FSH. At the same time, the estrogen triggers a sudden release of GnRH from the hypothalamus. This leads to a sharp increase in LH production by the anterior pituitary triggering ovulation—the follicle bursts, releasing its ovum.

Ovulation marks the end of the follicular stage and the beginning of the second stage. The second stage is called the **luteal stage**. Once the ovum has been

released, LH causes the follicle to develop into a corpus luteum. The corpus luteum secretes progesterone and some estrogen. As the levels of these hormones rise in the blood, they act on the anterior pituitary to inhibit FSH and LH production. The corpus luteum degenerates, leading to a decrease in the levels of estrogen and progesterone. The low levels of these sex hormones in the blood cause the anterior pituitary to increase its secretion of FSH, and the cycle begins again.

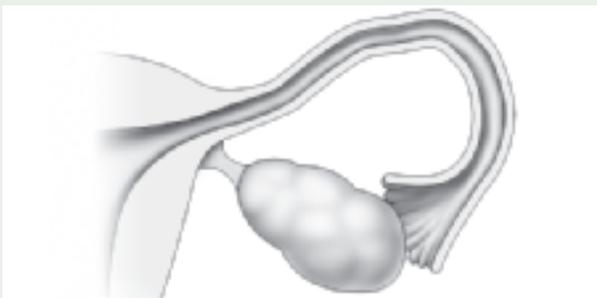
If the ovum is fertilized and implants in the endometrium, blood hormone levels of progesterone and estrogen remain high under stimulus of hCG released by embryo-supporting membranes. The continued presence of progesterone maintains the endometrium to support the developing fetus. The continued presence of estrogen stops the ovarian cycle so no additional follicles mature.

## Thought Lab 14.3 Development of the Corpus Luteum

### Target Skills

Identifying structures within the ovary from a diagram

Some structures in the ovary remain fairly constant throughout a female's lifetime. Other structures develop, change, and disappear through each menstrual cycle. In this activity, you will identify the structures that remain constant and the structures that change in the ovary.



### Procedure

1. Copy the outline of an ovary into your science notebook. (The fimbriae, oviduct, and a portion of the uterus have been included to help you visualize the orientation of the ovary. Do not include these structures in your copy.)
2. Using the descriptions in this textbook as a reference, sketch and label the following structures in your diagram:
  - immature follicle
  - developing follicle
  - mature follicle
  - ovum
  - mature corpus luteum
  - disintegrating corpus luteum

3. All of these structures are not visible in an ovary at any one time. Which structures would you expect to see if this diagram showed the ovary of a woman who was just beginning her menstrual period? Highlight the labels for these structures.

### Analysis

1. If you were using a microscope to find the corpus luteum in a tissue sample, would you first look near the outer edge of the ovary or near the centre of the ovary? Explain your answer in terms of the events of the ovarian cycle.
2. Unlike most human organs, the corpus luteum is not a permanent structure in the body. What might be one adaptive advantage of having reproductive function regulated by a gland that develops and then disappears within a few weeks?

### Extension

3. Use appropriate presentation software or develop and write your own code to demonstrate—for example, through animation—the development and disintegration of the corpus luteum within the ovary. **ICT**

## BiologyFile

### FYI

The menstrual cycles of individual women differ widely in their length and timing. When women live together, however, their menstrual cycles tend to synchronize.

- 21 What is the significance of the menstrual cycle?
- 22 Name the two stages of the ovarian cycle and briefly describe them.
- 23 What is the function of the corpus luteum?

### The Uterine Cycle

The uterine cycle is closely linked to the ovarian cycle. As you have seen, ovulation takes place about halfway through the ovarian cycle, around day 14. The ovum survives for up to 24 h after ovulation.

If fertilization occurs, the fertilized egg completes the passage through the oviduct and arrives at the uterus a few days later. The timing of the uterine cycle ensures that the uterus is prepared to receive and nurture a new life. The events of the uterine cycle cause a build-up of blood vessels and tissues in the endometrium. If fertilization does not occur, the endometrium disintegrates and menstruation begins.

The uterine cycle begins on the first day of menstruation (which is also the first day of the ovarian cycle). On this day, the corpus luteum has degenerated and the levels of the sex hormones in the blood are low. As a new follicle begins to mature and release estrogen, the level of estrogen in the blood gradually increases. Beginning around the sixth day of the uterine cycle, the estrogen level is high enough to cause the endometrium to begin thickening. After ovulation, the release of progesterone by the corpus luteum causes a more rapid thickening of the endometrium. Between days 15 and 23 of the cycle, the thickness of the endometrium may double or even triple. If fertilization does not occur, the corpus luteum degenerates. The levels of the sex hormones drop, the endometrium breaks down, and menstruation begins again.

You have seen that the menstrual cycle involves a number of different

hormones, each of which triggers different events in the body. In Investigation 14.B on page 500, you will synthesize what you have learned about this reproductive cycle.

- 24 Explain how the uterine cycle differs from the ovarian cycle.

### Aging and the Menstrual Cycle

After puberty, the male reproductive system can continue to produce viable sperm for a lifetime. In contrast, the number of functioning follicles in the female reproductive system decreases with age. This, in turn, leads to a gradual overall decline in the amount of estrogen and progesterone in the blood. As hormone levels drop, a woman's menstrual cycle becomes irregular. Within a few years, it stops altogether. The end of the menstrual cycle is known as **menopause**. Among North American women, the average age of menopause is approximately 50, but menopause can begin earlier or later.

A woman who has completed menopause no longer produces ova, so she is no longer fertile. As well, the decrease in the sex hormones disrupts the homeostasis of a number of hormone systems. This has a range of effects on the body. During menopause, blood vessels alternately constrict and dilate, resulting in uncomfortable sensations for some women known as "hot flashes." Some women also experience variable changes in mood. Over the longer term, menopause is associated with rising cholesterol levels, diminishing bone mass, and increased risk of uterine cancer, breast cancer, and heart disease. For these reasons, many women consider **hormone replacement therapy** (HRT) during or following menopause. Hormone replacement therapy is a prescription of low levels of estrogen with or without progesterone. However, while this therapy can ease some

symptoms of menopause, the treatment also carries a number of health risks. In recent studies, hormone replacement therapy has been linked to

- an increased risk of coronary heart disease, strokes, and blood clots
- an increased risk of breast cancer and colorectal cancer
- an increased risk of dementia

For this reason, Health Canada advises that a woman should not begin hormone replacement therapy without a thorough medical evaluation and a careful assessment of her own particular needs, health, and medical history. In some cases, the benefits of the therapy may outweigh the risks. In other cases, the reverse is true. Scientists continue to search for other ways to alleviate the symptoms and long-term health effects of menopause.

### Section 14.3 Summary

- Sex hormones work to stimulate the development of male and female reproductive systems and regulate the function of the mature reproductive system.

- Human babies are born with complete but immature reproductive systems. At puberty, an increase in production of GnRH by the hypothalamus stimulates the release of FSH and LH in the anterior pituitary. These hormones, in turn, trigger the development of gametes and the release of sex hormones.
- In males, the main sex hormone is testosterone. In females, the main sex hormones are estrogen and progesterone.
- In addition to their effect on the reproductive system, the sex hormones act throughout the body to cause the development of secondary sex characteristics.
- In the male reproductive system, a negative feedback hormone system maintains a relatively constant level of sperm production and testosterone.
- In females, hormone systems interact to regulate a monthly menstrual cycle.
- The menstrual cycle combines events in the ovary and in the uterus to maximize the chance of a zygote successfully implanting in the uterus for development into a fetus.

## Thought Lab 14.4 Therapy Options for Menopause

### Target Skills

**Identifying** physiological and ethical concerns about the medical use of reproductive hormones

**Researching and assessing** the medical use of reproductive hormones and their effects

For many years, doctors in North America routinely prescribed estrogen, or a combination of estrogen and progesterone, to help alleviate the symptoms of menopause. In 2000, the U.S.-based National Institutes of Health began a detailed investigation of the effects of hormone replacement therapy (HRT). Researchers stopped the study several years early, however, when they found that HRT was associated with a significant increase in the risk of strokes, heart disease, and breast cancer among their test subjects. The findings led scientists to look for a safer alternative to HRT.

### Procedure

1. Using print or Internet resources, research two or three different kinds of therapies available to women who want to alleviate the symptoms of menopause. **ICT**
2. For each of the therapies you are studying, gather information about
  - how the treatment affects cells and tissues in the body
  - how the treatment affects hormone feedback systems
  - any known health risks and benefits

3. Organize the information you have gathered. Create a short report or presentation to summarize and communicate your findings. **ICT**

### Analysis

1. Based on your research, is it possible to claim that one of these therapies is better than the others?
2. Many people argue that women should never have been prescribed hormone replacement therapy in the years before the NIH study was completed. Do you agree? What, if anything, should health practitioners and pharmaceutical companies have done differently?

# INVESTIGATION 14.B

## Target Skills

**Graphing** changes in blood hormone levels through a single menstrual cycle

**Analyzing** blood hormone data and physiological events for a single menstrual cycle

**Inferring** the roles of female sex hormones

**Selecting and using** an appropriate mode of representation to communicate ideas and information about sex hormone levels

## The Menstrual Cycle

LH and FSH are *pituitary hormones* because they are produced by the pituitary gland. Similarly, progesterone and estrogen are *ovarian hormones* because they are produced in the ovaries. In this investigation, you will see how pituitary and ovarian hormones affect, and are affected by, ovarian and uterine events during the menstrual cycle.

### Question

How do pituitary and ovarian hormones interact with ovarian and uterine events during the menstrual cycle?

### Procedure

1. Study the graphs, and observe how the levels of hormones affect each other as well as the follicle and endometrium.
2. Use the Analysis questions to analyze and interpret the graphs.

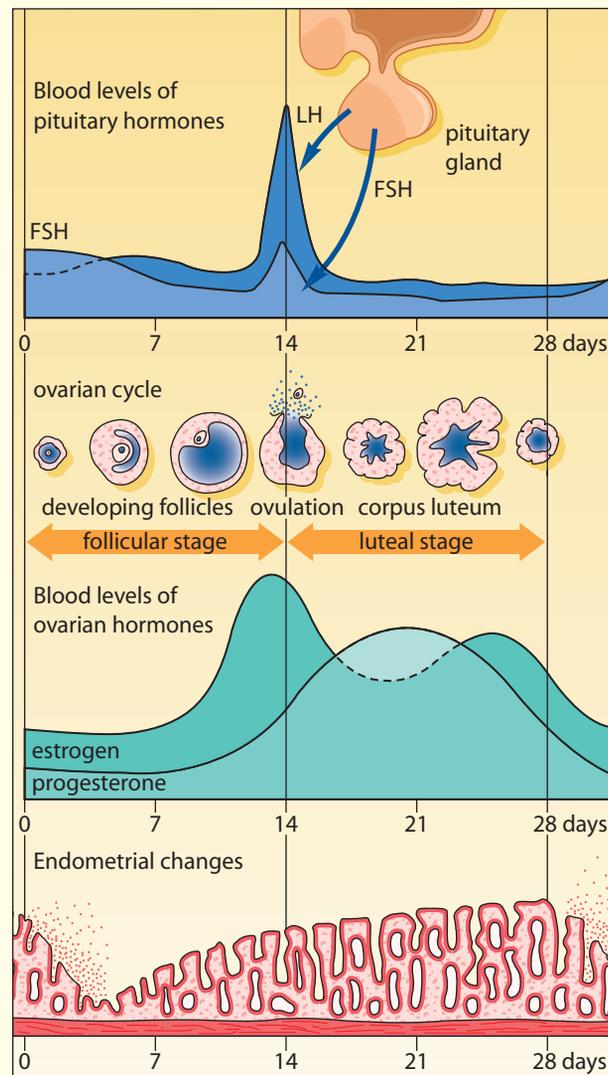
### Analysis

1. During which days of the menstrual cycle does the level of FSH increase? What happens to the follicle during this time?
2. On which day is the level of LH in the bloodstream at its highest? What event occurs immediately after this peak?
3. What event is associated with the decline of LH in the blood?
4. During which days of the cycle does the level of estrogen in the blood increase most rapidly? What happens in the uterus during this time?
5. During which days of the cycle does the level of progesterone in the blood increase most rapidly? What happens in the uterus during this time?
6. During which days of the cycle are the levels of estrogen and progesterone at their lowest? What happens in the uterus during this time?

### Conclusions

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

8. Do the names of the hormones FSH and LH correspond to their functions? Explain your answer.
9. Select and use an appropriate mode of representation to compare and contrast the functions of estrogen and progesterone in the menstrual cycle. **ICT**
10. At which time in the menstrual cycle is a woman most fertile? Explain your answer.



## Endocrine Disruptors in the Environment

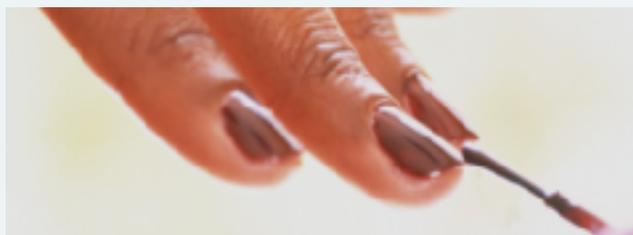
Hormones influence nearly all aspects of the body processes in animals, notably cellular development, growth, and reproduction. Thus, when people noticed that animals in areas that are contaminated by pollutants began to exhibit certain types of abnormalities, scientists began to wonder if there might be a link between certain pollutants and endocrine effects on body systems.

### Examining the Evidence

Substances that interfere with the normal functions of hormones are called *endocrine disruptors*. These chemicals upset the growth, development, and reproduction of organisms by mimicking natural hormones or by blocking their effects. For example, when fish populations are exposed to reproductive endocrine disruptors, the sexual organs of young males fail to fully develop. In extreme cases, the males produce eggs! Both effects are examples of feminization. Endocrine disruptors that mimic estrogen can cause feminization. Substances that block the action of male reproductive hormones can also have feminizing effects.

While the effects of known endocrine disruptors can be demonstrated in a laboratory, it is not always easy to assess their impact in the environment. One problem is that endocrine disruptors tend to be diluted in lakes and rivers. Even so, scientists have observed effects such as the feminization of fish near sewage discharge sites. Scientists have also observed impaired reproduction and development of fish near pulp and paper mills. As shown in the table, sewage and mill wastes both contain endocrine disruptors. Even treated sewage contains obvious endocrine disruptors such as synthetic estrogen from birth control pills.

Are estrogen disruptors to blame for the increase in abnormalities in frogs in some regions and the decrease in amphibians worldwide? Why do some female black bears and polar bears develop male sexual traits? It could be that increased exposure to UV light is harming



Many cosmetics—including some, but not all, brands of nail polish—contain endocrine-disrupting chemicals in amounts that are comparable to, and sometimes greater than, hormone levels in the human body. Should this be cause for concern?

amphibians, and that some bears simply inherit the trait of showing both male and female sexual characteristics.

Selected Products Containing Endocrine Disruptors

Source/Product	Endocrine Disruptors
flame retardants	polybrominated diphenyl ethers (PBDEs)
paint (for ships' hulls)	tributyltin
pesticides	DDT, lindane, permethrin
soft plastics	phthalates
pulp and paper mill effluent	phytoestrogens
perfumes and soaps	polycyclic musks
shampoo and other cosmetics	phthalates

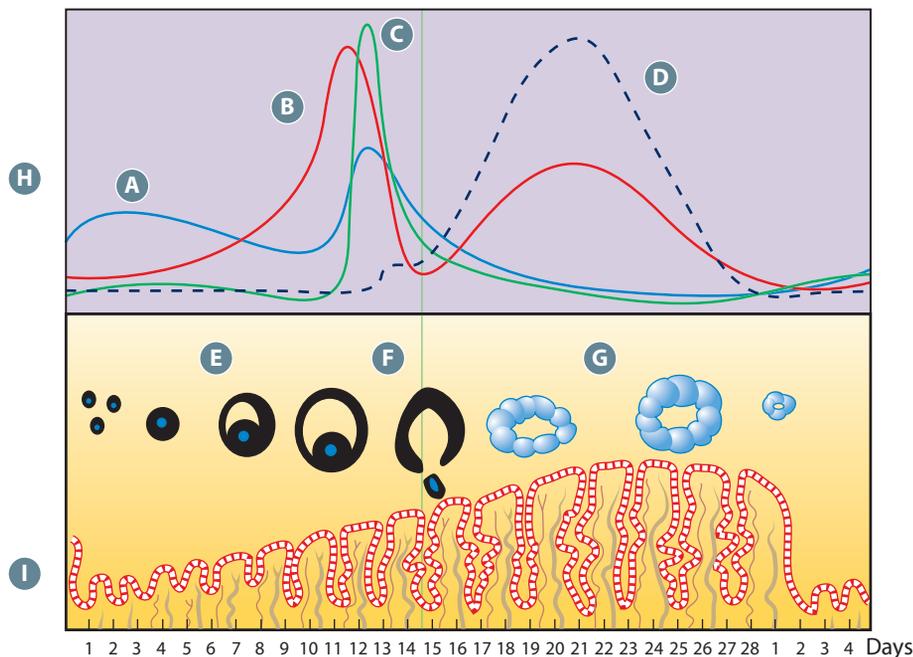
### Assessing the Risks

If endocrine disruptors in the environment are affecting wild animals, are they also affecting people? Scientists and representatives of industrial manufacturers continue to debate whether these chemicals pose a health risk to humans. There is evidence that endocrine disruptors are leading to lower sperm counts, reduced fertility in both men and women, and increased rates of certain types of cancers. Some studies have suggested a link between endocrine disruptors and learning and behaviour problems in children. To date, however, direct (causal) links between environmental exposure to endocrine disruptors and human health effects have not been established. Continued research that includes the cooperation of industry and financial support of governments is necessary to identify and mediate the risks that these chemicals pose to the environment and organisms.

• • •

1. Should a potential endocrine disruptor be considered “guilty until proven innocent” or “innocent until proven guilty” before being put on the market? Justify your response.
2. What would you need to know to link a particular substance to specific endocrine disrupting effects in a population, such as unusually high cancer rates?

1. Distinguish between the following terms: chromosomal sex and reproductive sex.
2. Use a diagram to summarize the hormone interactions that regulate the male reproductive system. **ICT**
3. Briefly describe the main hormonal and physiological events of
  - a) male puberty
  - b) female puberty
  - c) the ovarian cycle
  - d) the uterine cycle
4. Examine the graphs and answer the following questions:
  - a) Identify the hormones represented by the letters A, B, C, and D.
  - b) Describe the events that are occurring in the region of the diagram labelled E.
  - c) Identify what is happening at the region of the diagram labelled F.
  - d) Describe the events that are occurring in the region of the diagram labelled G.
- e) Write suitable labels for the regions of the diagram labelled H and I.
- f) Write a caption that briefly and accurately summarizes what is being depicted in this whole diagram.
5. Compare and contrast the effects of testosterone on the male body with the effects of estrogen on the female body. In what ways are these effects similar? In what ways do they differ? **ICT**
6. How does the menstrual cycle contribute to successful human reproduction?
7. Assuming that all other body systems remain unaffected, what physiological effects would you expect to find in an adolescent male whose anterior pituitary produced FSH but not LH? Use a flow chart or labelled diagram to explain your reasoning. **ICT**
8. Predict what would happen to testosterone production in the testes in response to an injection of a large amount of testosterone in an adult male.



In both males and females, the reproductive system includes a pair of gonads which produce sex cells (gametes) as well as sex hormones that regulate reproductive function. Male gonads are the testes, located outside the body. The testes are adapted to produce large quantities of male gametes called sperm. The scrotum regulates the temperature of the testes. Female gonads are the ovaries, located within the body and adapted to produce a single female gamete, called an ovum, each month.

In males, developing sperm are transported from the testes to the epididymis, where they mature and are stored. Sexual stimulation causes sperm cells to move through the ductus deferens and to become mixed with other fluids to produce semen. Semen is carried through the urethra and is released from the penis into the female reproductive tract.

In females, ova develop within follicles in the ovary. Each month a single ovum matures and is swept into the oviduct. The movement of cilia in the oviduct carries the ovum toward the uterus. If the ovum is fertilized by sperm in the oviduct, it may implant in the uterus. Otherwise the ovum, along with excess uterine tissues, flow out of the body.

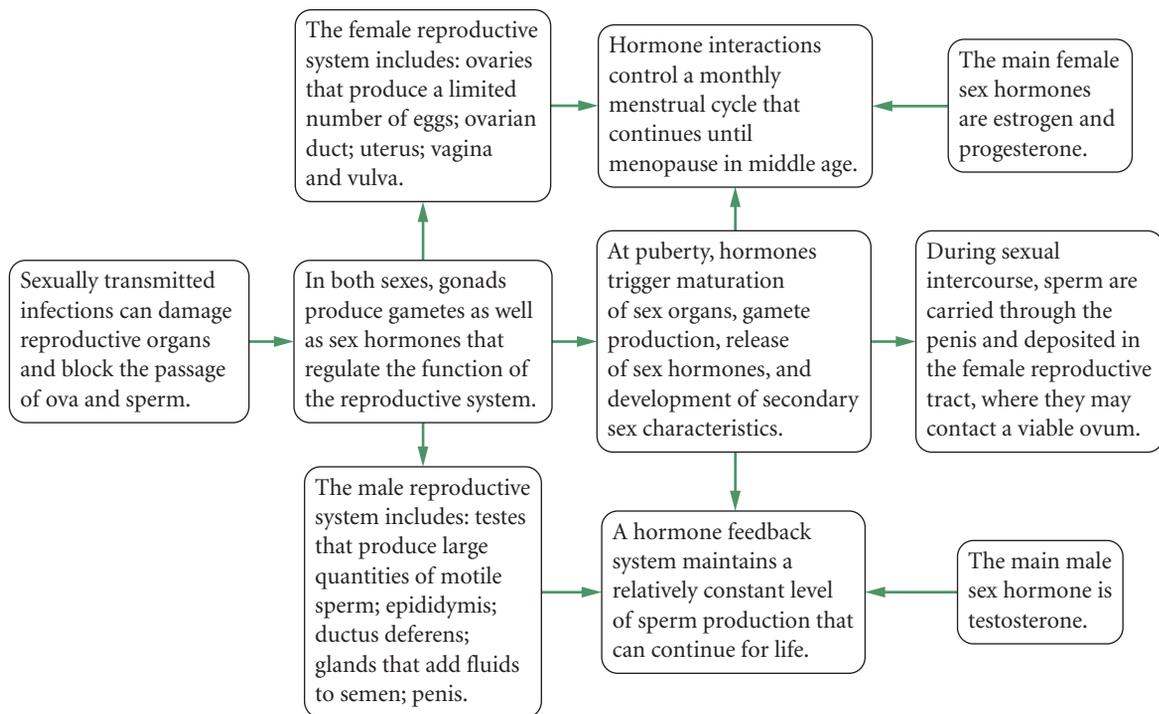
Sexually transmitted infections (STIs) may be primarily viral or bacterial in origin. These infections can have severe consequences and are a serious health concern. STIs include HIV/AIDS, hepatitis, genital herpes, human papilloma virus, chlamydia, gonorrhea, and syphilis.

In males, puberty begins when an increase in GnRH production in the hypothalamus triggers the release of FSH and LH from the anterior pituitary. These hormones in turn stimulate the production of sperm and a surge in testosterone. Hormone interactions maintain secondary sex characteristics along with the steady production of sperm.

In females, puberty begins when an increase in GnRH production in the hypothalamus triggers the release of FSH and LH from the anterior pituitary. These hormones in turn stimulate the production of ova and initiate the menstrual cycle.

The menstrual cycle controls the maturation of an ovum and the preparation of the uterine lining to receive a zygote. The menstrual cycle continues until middle age, at which time diminishing hormone levels lead to menopause.

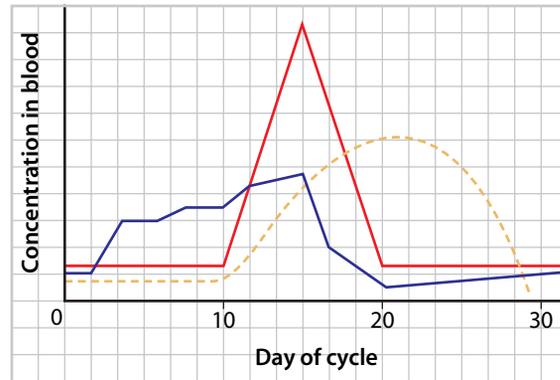
## Chapter 14 Graphic Organizer



### Understanding Concepts

- Name the structures within a testis, and describe their functions.
- In which part of the body are each of the following produced?
  - testosterone
  - progesterone
  - sperm
  - luteinizing hormone
  - follicle stimulating hormone
  - ovum
- Outline, in the form of a labelled sketch or flow chart, the path of a sperm cell from its formation to the moment it reaches an ovum. In your answer, identify all the male and female structures through which the sperm travels. **ICT**
- List three of the components of semen, and briefly explain what these fluids contribute to reproductive function.
- Construct a table or graphic organizer to compare and contrast the source, common modes of transmission, effects, and treatments for the following sexually transmitted infections. **ICT**
  - HIV/AIDS
  - hepatitis B
  - genital herpes
  - human papilloma virus
  - chlamydia
  - gonorrhea
  - syphilis
- How would a newborn child acquire an infection of chlamydia, gonorrhea, syphilis, and herpes?
  - What effects do these STIs have on infants?
- What are the health risks and treatment options associated with each of the infections in question 5?
- Describe the stages of development of a follicle within an ovary.
- Describe the changes in the endometrium through the stages of the menstrual cycle.
- Compare the levels of sex hormones in the blood of a female before and after the onset of puberty, and describe how these changes affect the reproductive system.

- 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:



- Which line represents luteinizing hormone?
- Which line represents progesterone?
- Which hormone increases during the last half of the menstrual cycle?

### Applying Concepts

- Penicillin is an antibiotic that effectively cures syphilis. Explain why penicillin would be ineffective against AIDS.
- Describe the effect you would expect to see in a human male whose sperm cells have no acrosome.
- Do the names “follicle stimulating hormone” and “luteinizing hormone” correspond to their function in the human reproductive system? Give examples to justify your answer.
- Young female athletes often experience delayed puberty. What would you expect to find if you compare the blood hormone levels of a fourteen-year-old gymnast with those of less athletic girls of the same age?
- Farmers who maintain stocks of large animals often castrate the males. Based on the hormonal control of the male reproductive system, explain the likely physiological and behavioral effects of castration. What advantages does castration offer to the farmer?
- A young woman tells her doctor that she is experiencing irregular menstrual periods.
  - Hypothesize some possible causes of the irregularity.
  - Design an investigation that could test for one of these causes.

- 18. a)** Two main events of the menstrual cycle are the release of an egg from an ovary and the build-up of the uterine lining. Use the data table to predict which of the hormones A, B, or C would be associated with each of these two events. Assume the cycle length is 28 days.

Day of menstrual cycle	Relative hormone concentration		
	A	B	C
1	12	5	10
5	14	5	14
9	14	5	13
13	70	10	20
17	12	60	9
21	12	150	8
25	8	100	8
1	12	5	10

- b)** A woman is having difficulty becoming pregnant. For the last month, her hormone levels have been measured on each of the eight days listed in the data table. Hormone A remained steady at 12. Hormone B remained steady at 5. Hormone C had the levels shown in the data table. How could these hormone levels explain her fertility difficulties?
- 19.** Imagine that you are a government official in a health department. In response to pressure from community groups, your department has created a new, \$10 million program to fight the spread of STIs. The program includes work in two different areas: education and awareness campaigns; and scientific research on treatment and vaccines. How would you divide the funding between these two program areas? Explain your reasoning.

## Making Connections

- 20.** An individual whose chromosomal (genetic) sex is XX has inherited a genetic defect so that cellular receptors for estrogen are lacking.
- Would you expect this person to have testes or ovaries? Explain why.
  - Can this person respond to estrogen? Why or why not, and what effects will this have on the body?
  - The adrenal cortex produces some testosterone. Is it possible that this person could have the secondary sex characteristics of a male? Explain.
  - Predict whether this individual is fertile and give reasons for your answer.
- 21.** The mortality rate of sperm is high compared to the mortality rate of eggs. Suggest reasons why this might be the case.
- 22.** Chlamydia can be readily cured with antibiotics. Why then are there so many new cases of chlamydia reported each year? Give three reasons.
- 23.** When a woman becomes pregnant, menstruation stops for the duration of the pregnancy.
- Explain how menstruation is prevented if pregnancy occurs.
  - Explain why menstruation begins again after the pregnancy.
- 24.** Some male athletes take anabolic steroids to enhance their performance. These substances mimic the action of testosterone, but are not identical to testosterone. The side effects of steroid use can include changes that might be associated with an increase in sex hormones in the body, such as increased muscular development and aggressiveness. However, side effect can also include changes that might be associated with a decrease in sex hormones, such as the shrinking of testicles and the loss of facial hair. Using hormone feedback systems, explain how a drug that mimics the effect of testosterone could have these apparently contradictory effects on the male body.