

Fetal hand—20 weeks

Fetal hand—6 weeks

Fetal hand—5 weeks

THEME FOCUS Stability and Change
The human body changes throughout life.

Idea Human reproduction involves the joining together of sperm and egg.

Section 1 • Reproductive Systems

Section 2 • Human Development
Before Birth

Section 3 • Birth, Growth, and Aging

Section 1

Reading Preview

Essential Questions

- What are the structures of the male and female reproductive systems and what are the functions of each?
- How do hormones regulate the male and female reproductive systems?
- What are the events that take place during a menstrual cycle?

Review Vocabulary

hypothalamus: portion of the brain that connects the endocrine and nervous systems, and controls the pituitary gland

New Vocabulary

seminiferous tubule
epididymis
vas deferens
urethra
semen
puberty
oocyte
oviduct
menstrual cycle
polar body



Reproductive Systems

Key Idea Hormones regulate human reproductive systems, including the production of gametes.

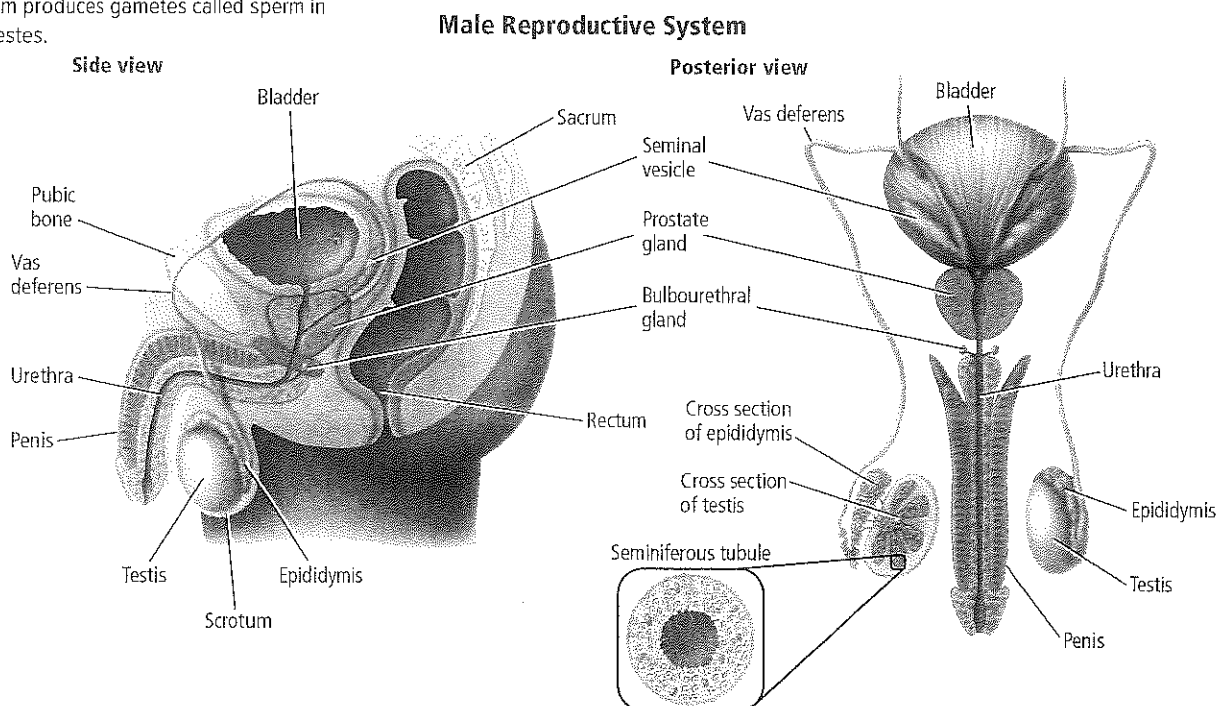
Real-World Reading Link You might have noticed how the temperature of a room affects the thermostat that controls furnace activity. If the room is warm, the thermostat will not allow the furnace to run. Similarly, male and female hormones in the human body have effects on body structures and influence human reproduction.

Human Male Reproductive System

Reproduction is necessary to ensure continuation of a species. The result of the human reproductive process is the union of an egg cell and a sperm cell, development of the fetus, and the birth of an infant. The organs, glands, and hormones of the male and female reproductive systems are instrumental in meeting this goal.

Figure 1 illustrates the male reproductive structures. The male reproductive glands are called the testes (tes TEEZ) (singular, testis) and are located outside of the body cavity in a pouch called the scrotum (SKROH tum). A temperature lower than 37°C—the average body temperature—is required for the development of sperm. Because the scrotum is located outside of the body cavity, it is several degrees cooler. This makes the environment suitable for the normal development of sperm.

Figure 1 The male reproductive system produces gametes called sperm in the testes.



Sperm cells The male reproductive cells, called sperm cells, are produced in the testes. Follow the path that sperm travel in **Figure 1** as you read about the structures in **Figure 2**, develop in the testes in the **seminiferous tubules** (se muh NIHF rus • TEW byulz). These tubules produce 100–200 million sperm each day. Next, sperm travel to the **epididymis** (eh puh DIH duh mus), a structure located on top of each testis where sperm mature and are stored. When the sperm are released from the body, they travel through the **vas deferens** (VAS • DEF uh runz), a duct leading away from the testis. There are two vas deferens, one leading away from each testis. The two vas deferens join together and enter the **urethra** (yoo REE thruh), the tube that carries both semen and urine outside of the body through the penis.

Sperm require a nourishing fluid to survive long enough to fertilize an egg. **Semen** (SEE mun) refers to the fluid that contains sperm, the nourishment, and other fluids from the male reproductive glands. The seminal vesicles contribute over half of the semen and secrete sugar into the fluid, which provides energy, other nutrients, proteins, and enzymes for the sperm. The prostate gland and bulbourethral glands contribute an alkaline solution to the fluid to neutralize acidic conditions that sperm might encounter in the urethra and the female reproductive tract.

Male hormones Testosterone (tes TAHS tuh rohn), which is made in the testes, is a steroid hormone that is necessary for the production of sperm. It also influences the development of male secondary sex characteristics that begin to appear at **puberty**, the period of growth when sexual maturity is reached. These characteristics include hair on the face and chest, broader shoulders, increased muscle development, and a deeper voice. Recall that the larynx contains the vocal cords. Because the vocal cords are longer in males than in females, the male voice is deeper. Later in life, testosterone might lead to a receding hairline or baldness.

Three hormones influence testosterone production. **Figure 3** indicates that the hypothalamus produces gonadotropin-releasing hormone (GnRH), which acts on the anterior pituitary gland. GnRH increases the production of follicle-stimulating hormone (FSH) and luteinizing (LEW tee uh ni zing) hormone (LH). Both FSH and LH travel from the anterior pituitary gland through the bloodstream and to the testes. In the testes, FSH promotes the production of sperm and LH stimulates the production and secretion of testosterone.

Levels of the male hormones are regulated by a negative feedback system that starts with the hypothalamus. Increased levels of testosterone in the blood are detected by cells in the hypothalamus and anterior pituitary, and the production of LH and FSH is decreased. When testosterone levels in the blood drop, the body responds by making more LH and FSH, as shown in **Figure 3**.

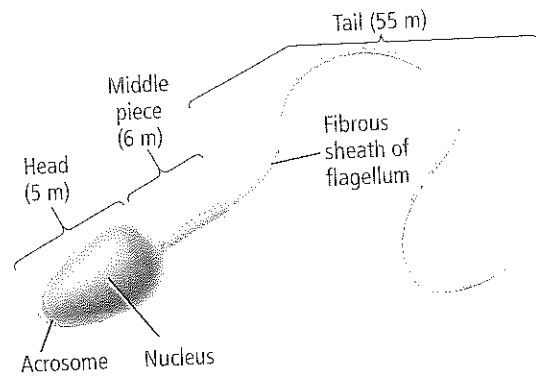
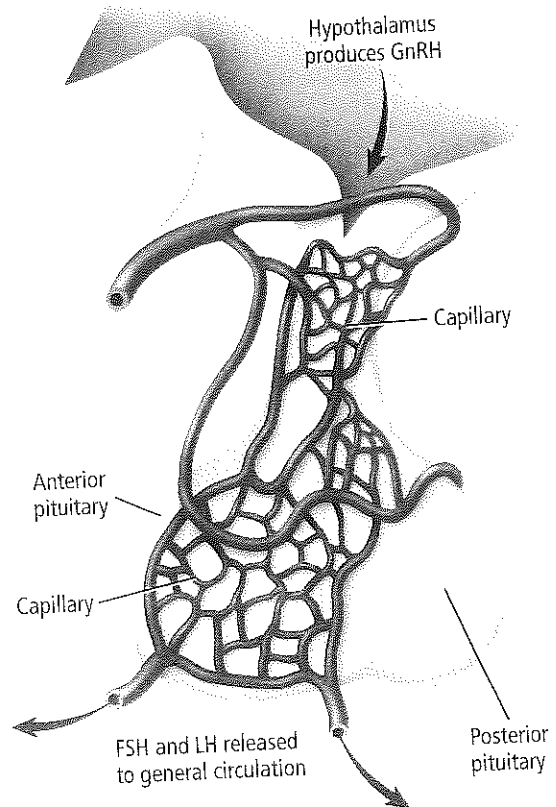
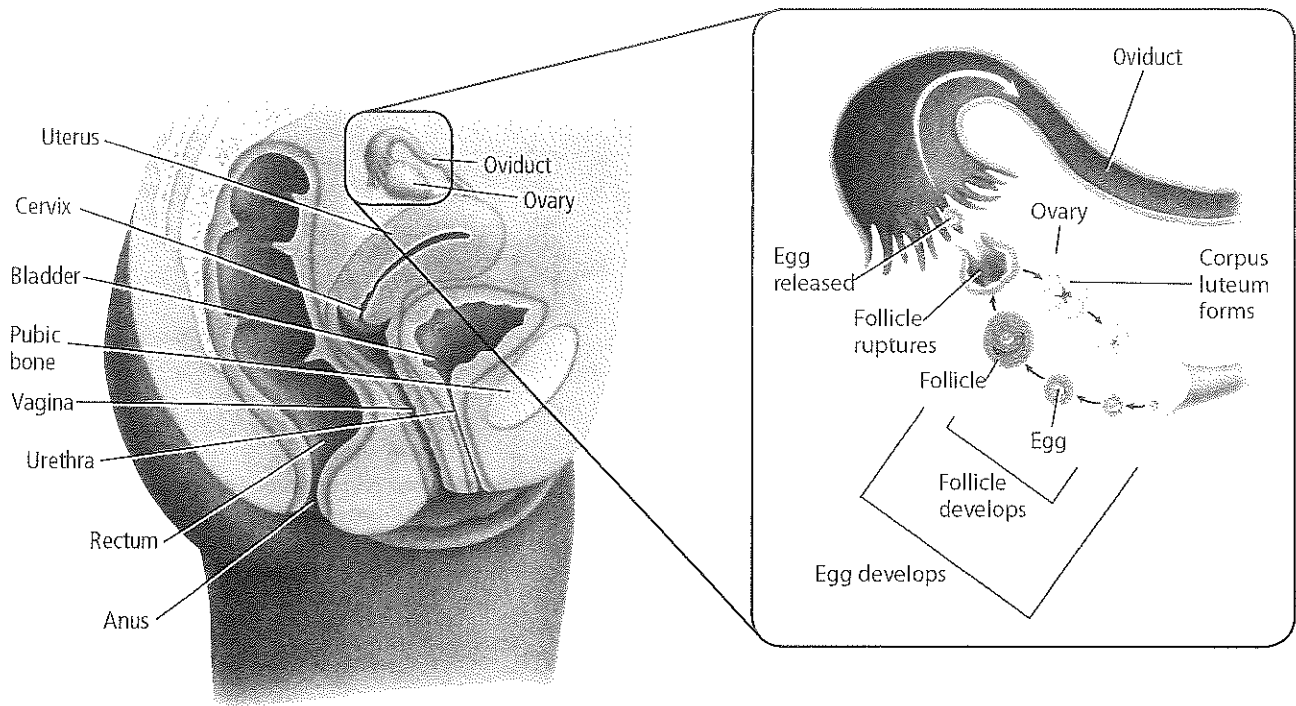


Figure 2 A sperm is a flagellated cell composed of a head, midpiece, and tail. Identify, in correct sequence, the structures that a sperm cell passes through or encounters as it makes its way out of the body.

Figure 3 The hypothalamus produces gonadotropin-releasing hormone, the releasing hormone, which travels to the pituitary gland. GnRH influences the rate of LH and FSH production. The levels of LH and FSH are regulated by a negative feedback pathway.





• **Figure 4**

Left: The main structures of the female reproductive system are the vagina, uterus, and ovaries.

Right: During every menstrual cycle, one follicle fully matures and releases an egg. The follicle is then called the corpus luteum.

Predict what the result might be if more than one follicle fully develops during a cycle.



Animation



Personal Tutor

Human Female Reproductive System

A female's reproductive system is specialized to produce egg cells, receive sperm, and provide an environment that is right for fertilization of an egg and the development of an embryo. Refer to **Figure 4** as you read about the structures of the female reproductive system.

Egg cells The female reproductive cells, called egg cells, are produced in the ovaries, also illustrated in **Figure 4**. Each ovary is about the size of an almond. Inside each ovary are **oocytes** (OH uh sites), which are immature eggs. Approximately once every 28 days, oocyte development is stimulated and an egg, called an ovum, is formed. The ovum is surrounded by follicle cells that provide protection and nourishment.

After the egg is released from the ovary, it travels through an **oviduct** (OH vuh duct), a tube that connects to the uterus. The uterus, or womb, is about the size of an average human fist and is where a baby develops before birth. The cervix, at the lower end of the uterus, has a narrow opening into the vagina, which leads to the outside of the female's body.

Female hormones Estrogen and progesterone (proh JES tuh rohn) are steroid hormones made by cells in the ovaries. A female's anterior pituitary gland also produces LH and FSH, which influence estrogen and progesterone levels in a negative feedback loop. Effects of LH and FSH are different in males and females. During puberty, an increase in estrogen levels causes a female's breasts to develop, her hips to widen, and her amount of fat tissue to increase. During puberty, a female also will experience her first **menstrual** (MEN stroo ul) **cycle**, the events that take place each month in the human female to help prepare the female body for pregnancy.

Sex Cell Production

Through meiosis one cell in the male or female gonads—called testes and ovaries in humans—gives rise to four sex cells called gametes. In the human male, sperm are produced daily from primary spermatocytes, beginning at puberty and continuing throughout a male's lifetime.

The production of eggs in the human female differs, as illustrated in **Figure 5**. A female is born with all of her eggs already beginning to develop. The genetic material has replicated in primary oocytes before birth, and the process of meiosis stops before the first meiotic division is completed. Then, once each menstrual cycle during the reproductive years, meiosis continues for a single developing oocyte. The resulting structures at the end of the first meiotic division of the oocyte are of unequal size. The smaller of the two structures is called a **polar body**. The chromosomes have segregated, but there is an unequal division of the cytoplasm. Most of the cytoplasm from the original cell goes to the cell that eventually will become the egg, and the polar body disintegrates.

During the second meiotic division, a similar process takes place. During metaphase of the second meiotic division, an egg ruptures through the ovary wall in a process called ovulation. The second meiotic division is completed only if fertilization takes place. Then, the zygote and the second polar body are formed, as shown in **Figure 5**. The second polar body also disintegrates.

Thus, the two meiotic divisions have yielded only one egg instead of four. If four eggs were formed and released midway through a female's menstrual cycle, more multiple births would be expected.

The Menstrual Cycle

The length of the menstrual cycle can vary from 23 to 35 days, but it typically lasts around 28 days. The entire menstrual cycle can be divided into three phases: the flow phase, the follicular phase, and the luteal phase.

Flow phase Day one of the menstrual cycle is when menstrual flow begins. Menstrual flow is the shedding of blood, tissue fluid, mucus, and epithelial cells from the endometrium—the tissue that lines the uterus. The endometrium is where the embryo will implant if fertilization of the egg occurs. Because an embryo will need oxygen and nutrients, the endometrium has a good supply of blood. During menstruation, bleeding occurs because the outer layers of the endometrium tear away, and blood vessels that supply the endometrium are ruptured. Around day five, repair of the endometrial lining begins, and it becomes thicker as the cycle continues.

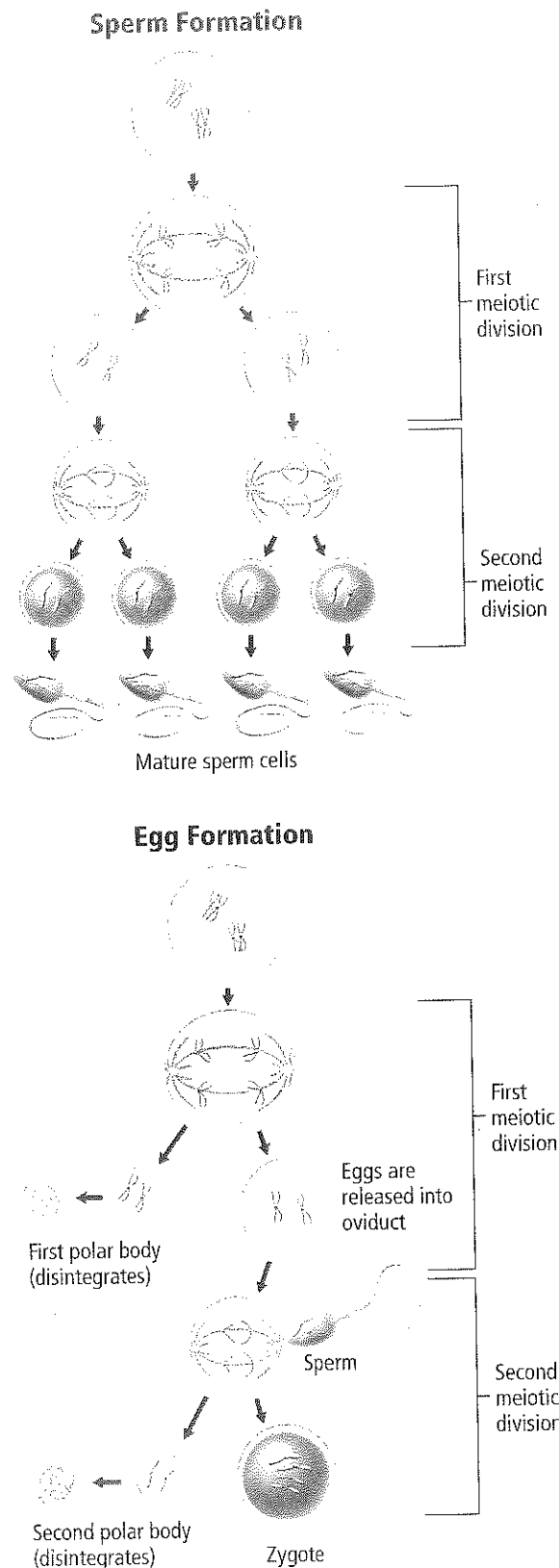


Figure 5
Top: The human male sex cell production follows the general pattern of meiosis and results in many sperm.
Bottom: Meiosis in the human female results in one egg. The second division in meiosis will not be completed in a human female unless the egg is fertilized.



LM Magnification: 10×

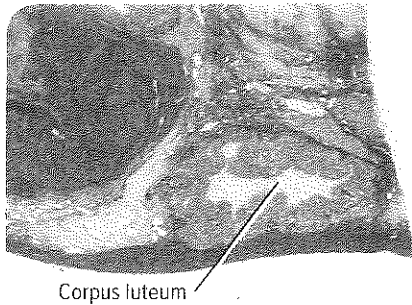


Figure 6 The corpus luteum produces progesterone and some estrogen.

Follicular phase During the menstrual cycle, changes also occur in the ovaries as a result of changing hormone levels, as illustrated in **Table 1**. At the beginning of a menstrual cycle, when estrogen levels are low, the anterior pituitary begins to increase production of LH and FSH. This stimulates a few follicles to begin to mature in the ovary. Cells in the follicles then begin to produce estrogen and a small amount of progesterone. Inside each follicle is an immature egg, the oocyte. After about a week, usually only one of the growing follicles remains. This remaining follicle continues to grow and secrete estrogen, which keeps levels of LH and FSH low, an example of negative feedback.

On about day 12, the high level of estrogen causes the anterior pituitary gland to release a surge of LH. This rapid release of a large quantity of LH causes the follicle to rupture, and ovulation occurs.

Luteal phase After ovulation, the cells of the follicle change, and the follicle is transformed into a structure called the corpus luteum (KOR pus • LEW tee um), as illustrated in **Figure 6**. The corpus luteum slowly degenerates as the menstrual cycle continues. The corpus luteum produces high amounts of progesterone and some estrogen, which keep levels of LH and FSH low through negative feedback. Recall that FSH and LH stimulate new follicles to develop, but when these hormones are kept at low levels, new follicles are temporarily prevented from maturing. Toward the end of the cycle, the corpus luteum breaks down, and it no longer produces progesterone and estrogen. This results in a rapid decrease in progesterone and estrogen levels. A rapid decrease in hormones triggers detachment of the endometrium, and the flow phase of a new menstrual cycle will begin.

VOCABULARY

WORD SMITH

Corpus luteum

corpus from Latin, meaning *body*
luteum from Latin, meaning *yellow*

Mini Lab 1

Model Sex Cell Production



MiniLab

Why does meiosis produce four sperm but only one egg? The difference in the division of cytoplasm is the major reason why meiosis is different in human males and females. Use clay to model how the sex cells are produced during meiosis.

Procedure

1. Read and complete the lab safety form.
2. Choose **two lumps of clay**, each of a different color. Choose one to represent a primary spermatocyte and the other a primary oocyte.
3. Use the primary spermatocyte to simulate the meiotic divisions as they occur in males.
4. Simulate maturation of the sperm by removing about half of the clay from each sperm and using a small part of it to add a flagellum to each cell.
5. Next, simulate the first meiotic division in females.
6. Use one of the sperm and mold it to one side of the large cell. Now simulate the second meiotic division.

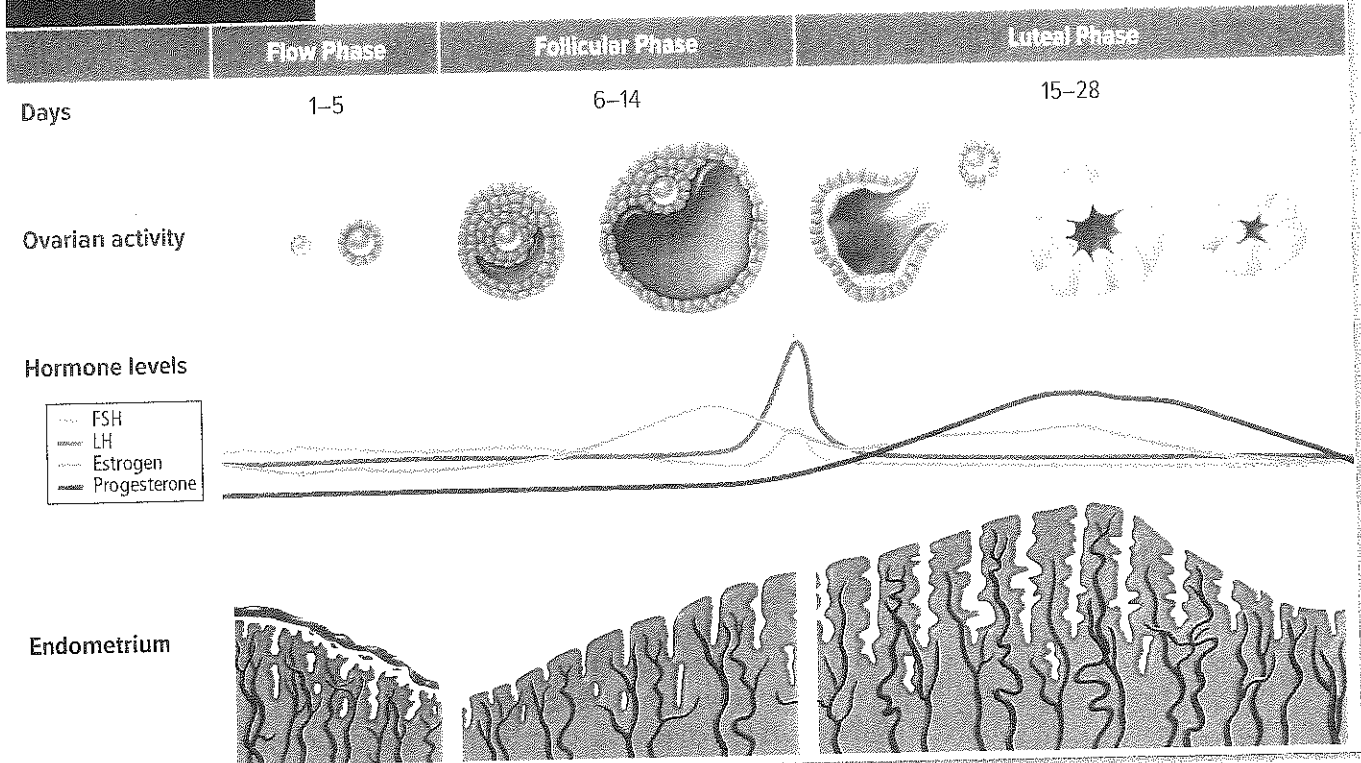
Analysis

1. **Model** Make drawings of each step above. Label the following: primary spermatocyte and oocyte, egg, sperm, first polar body, second polar body, fertilized egg, and zygote.
2. **Explain** the benefit of meiosis concentrating most of the cytoplasm into one egg.



Table 1**Menstrual Cycle Phases**

Interactive Table



If the egg is fertilized, a different chain of events occurs, and a new menstrual cycle does not begin. The progesterone levels remain high and increase the blood supply to the endometrium. The corpus luteum does not degenerate and hormone levels do not drop. The endometrium accumulates lipids and begins secreting a fluid rich in nutrients for the developing embryo.

Section 1 Assessment

Section Summary

- Levels of male and female hormones are regulated by negative feedback systems.
- The human male produces millions of sperm cells every day.
- The number of sex cells resulting from meiosis differs in males and females.
- The human female has a reproductive cycle called the menstrual cycle.
- The menstrual cycle has three phases: the flow phase, the follicular phase, and the luteal phase.

Understand Main Ideas

1. **Describe** how hormones regulate sperm and egg cells.
2. **Summarize** the structures of the reproductive systems and their functions.
3. **Describe** the origin and importance of substances found in semen.
4. **Explain** the major events that take place in the endometrium and in the ovary during the menstrual cycle.

Think Critically

5. **Infer** On about day 12, estrogen levels cause a sharp increase in the amount of LH that is released. According to a negative feedback model, what would you expect to happen?

MATH in Biology

6. Suppose a female began menstruating at age 12 and stopped menstruating at age 55. If she never became pregnant and her menstrual cycles averaged 28 days, how many eggs did she ovulate during her reproductive years?



Online Quiz



Section 2

Reading Preview

Essential Questions

- What are the events that take place during the first week following fertilization?
- What are the major changes that occur during each trimester of development?
- How are female hormone levels altered during pregnancy?

Review Vocabulary

lysosome: organelle that contains digestive enzymes

New Vocabulary

morula
blastocyst
amniotic fluid



Multilingual eGlossary



BrainPOP

Human Development Before Birth

WATKINS Idea A human develops from a single fertilized cell into trillions of cells with specialized functions.

Real-World Reading Link Just as a single seed can grow into a plant with a beautiful flower, your complex body began as a single cell at the union of an egg and a sperm at fertilization.

Fertilization

Figure 7 shows the process of a sperm joining with an egg, which is called fertilization. Fertilization usually occurs in the upper portion of an oviduct near the ovary. In humans, sperm and eggs each are haploid, and each normally has 23 chromosomes. Fertilization brings these chromosomes together, restoring the diploid number of 46 chromosomes.

Sperm enter the vagina of the female's reproductive system when strong muscular contractions ejaculate semen from the male's penis during intercourse. Some sperm can exit through the penis before ejaculation without the male's knowledge. As a result, sexual activity that does not result in ejaculation can lead to the release of sperm, fertilization, and pregnancy.

Sperm can survive for 48 hours in the female reproductive tract, but an unfertilized egg can survive for only 24 hours. Fertilization can happen if intercourse occurs anytime from a few days before ovulation to a day after ovulation. Overall, there is a relatively short time when fertilization can occur successfully. However, it is important to remember that the length of the menstrual cycle can vary and ovulation can occur at any time.

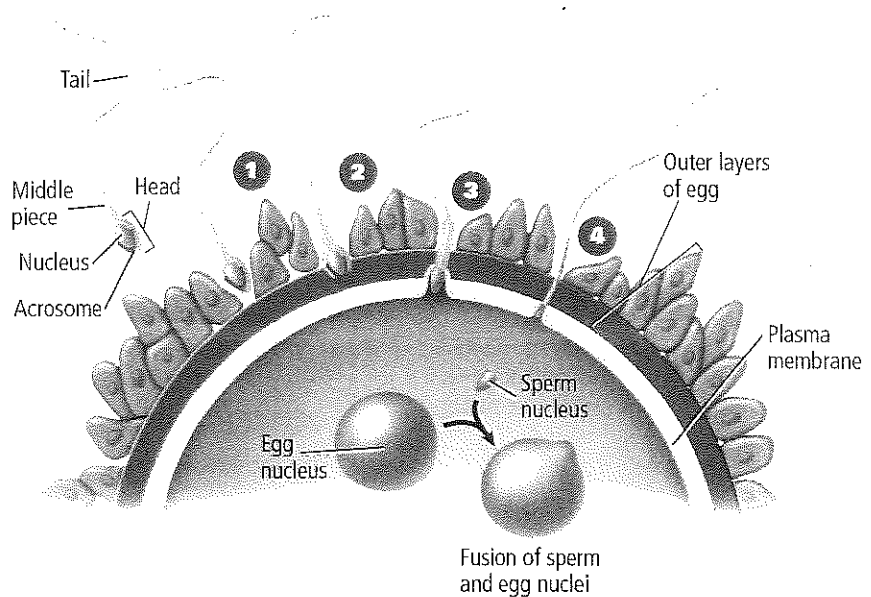
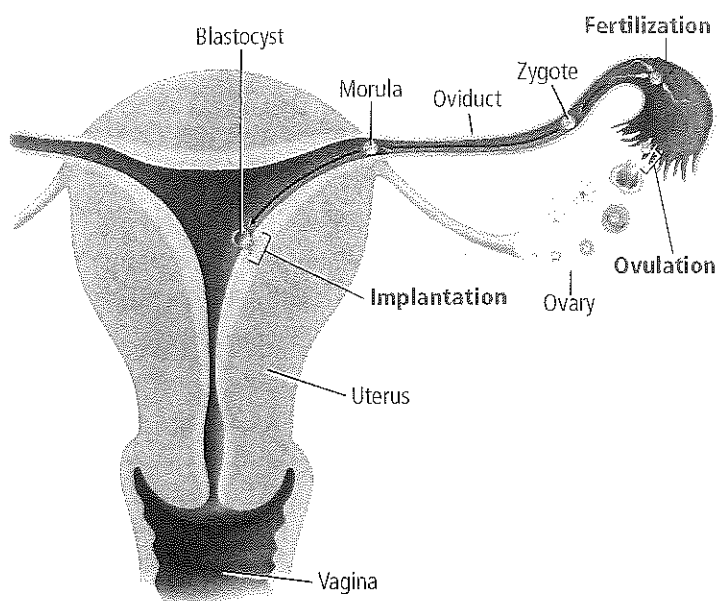


Figure 7 Although many sperm are needed to weaken the barrier that surrounds the egg, only one sperm fertilizes an egg (steps 1-4). Fertilization is complete when the sperm nucleus fuses with the egg nucleus.



About 300 million sperm are released into the vagina during intercourse. Only several hundred of them will successfully complete the journey to the egg. Many never make it out of the vagina, some are attacked by white blood cells, and many simply die along the way. Only one sperm can fertilize an egg, but it takes several hundred to participate in the process.

Connection to Chemistry A single sperm cannot penetrate the plasma membrane that surrounds the human egg. Recall that lysosomes are organelles that contain digestive enzymes. Notice in **Figure 7** that the tip of each sperm is a specialized lysosome called an acrosome. As each of several hundred sperm bombard the egg, the enzymes inside of the acrosome weaken the plasma membrane surrounding the egg. Eventually the plasma membrane becomes weak enough that one sperm can penetrate the egg. Immediately following this penetration, the egg forms a barrier to prevent other sperm from entering the now-fertilized egg.

Reading Check Explain why hundreds of sperm are necessary for fertilization to take place.

Early Development

Figure 8 illustrates the first week of human development. The fertilized egg, which is called a zygote (ZI goht), moves through the oviduct propelled by involuntary smooth muscle contractions and by the cilia lining the oviduct. Around 30 hours after fertilization, the zygote undergoes its first mitosis and cell division. Cell division continues, and by the third day, the embryo leaves the oviduct and enters the uterus. At this point, the embryo is described as a **morula**, a solid ball of cells.

By the fifth day, the morula has developed into a **blastocyst**, which can be described as a hollow ball of cells. The blastocyst attaches to the endometrium around the sixth day and is fully implanted by day 10. **Figure 8** shows that the blastocyst is not completely hollow. Inside the blastocyst is a group of cells called the inner cell mass. The inner cell mass eventually will become the embryo. Sometimes, the inner cell mass splits, and identical twins might form.

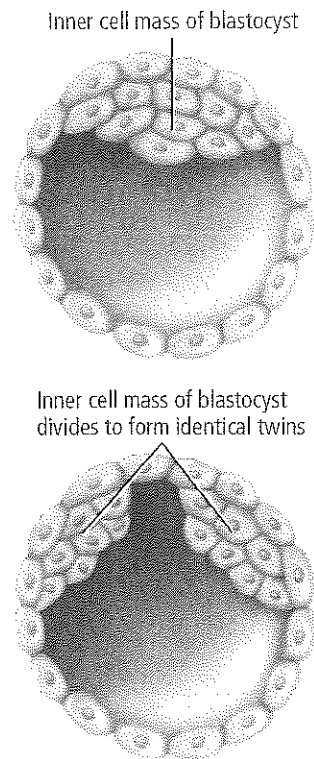


Figure 8

Left: During the first week of development, many changes occur as the zygote travels through the oviduct.

Right: The inner cell mass of the blastocyst will develop into a fetus (top). If the inner cell mass divides, identical twins might form (bottom).

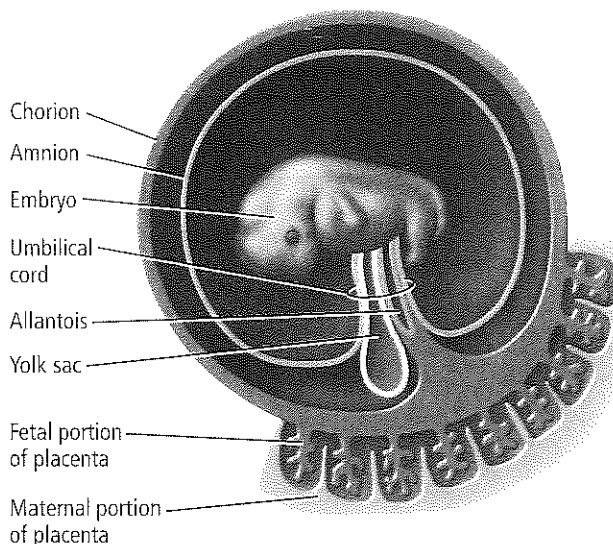
CAREERS IN BIOLOGY

Reproductive Endocrinologist

Physicians who have advanced training in the treatment of infertility and disorders involving the reproductive hormones are called reproductive endocrinologists. A reproductive endocrinologist also might conduct research or train medical students.



• **Figure 9** Four extraembryonic membranes—the amnion, chorion, yolk sac, and allantois—are important in development. Identify the role of the yolk sac in humans.



Extraembryonic membranes The membranes that extend beyond an embryo are called the extraembryonic membranes. You also might have learned about the development of the amniotic egg, and how this enabled animals to reproduce on land. Developing humans have these membranes, as shown in **Figure 9**. But because humans and most other mammals develop inside the mother's body, these membranes have somewhat different functions.

Early in human development, four extraembryonic membranes form. These membranes are the amnion, the chorion (KOR ee ahn), the yolk sac, and the allantois (uh LAN tuh wus), as illustrated in **Figure 9**. The amnion is a thin layer that forms a sac around the embryo. Inside this sac is the **amniotic fluid** (am nee AH tihk • FLU id), which protects, cushions, and insulates the embryo. Outside of the amnion is the chorion, which, together with the allantois, contributes to the formation of the placenta. The yolk sac in humans does not contain any yolk but serves as the first site of red blood cell formation for the embryo.

The placenta About two weeks after fertilization, tiny fingerlike projections of the chorion, called chorionic villi (VIH li), begin to grow into the wall of the uterus. The placenta (pluh SEN tuh), the organ that provides food and oxygen and also removes waste, begins to form and is fully formed by the tenth week. The placenta has two surfaces—a fetal side that forms from the chorion and faces the fetus and a maternal side that forms from uterine tissue. When completely formed, the placenta is 15–20 cm in diameter, 2.5 cm thick, and has a mass of about 0.45 kg. The umbilical cord, a tube containing blood vessels, serves as the connection between the fetus and the mother. **Figure 10** illustrates the connection between the mother and fetus.

The placenta regulates what passes from the mother to the fetus and from the fetus to the mother. Oxygen and nutrients can travel from the mother to the fetus. Alcohol, drugs, various other substances, and the human immunodeficiency virus (HIV) also can pass through the placenta to the developing fetus.

Metabolic waste products and carbon dioxide travel from the fetus to the mother. Because the mother and the fetus have their own separate circulatory systems, blood cells do not pass through the placenta. However, the mother's antibodies pass to the fetus and help protect the newborn until its immune system is functioning.

VOCABULARY

ACADEMIC VOCABULARY

Enable

to make able or feasible

Amniotic eggs enable reproduction on land.

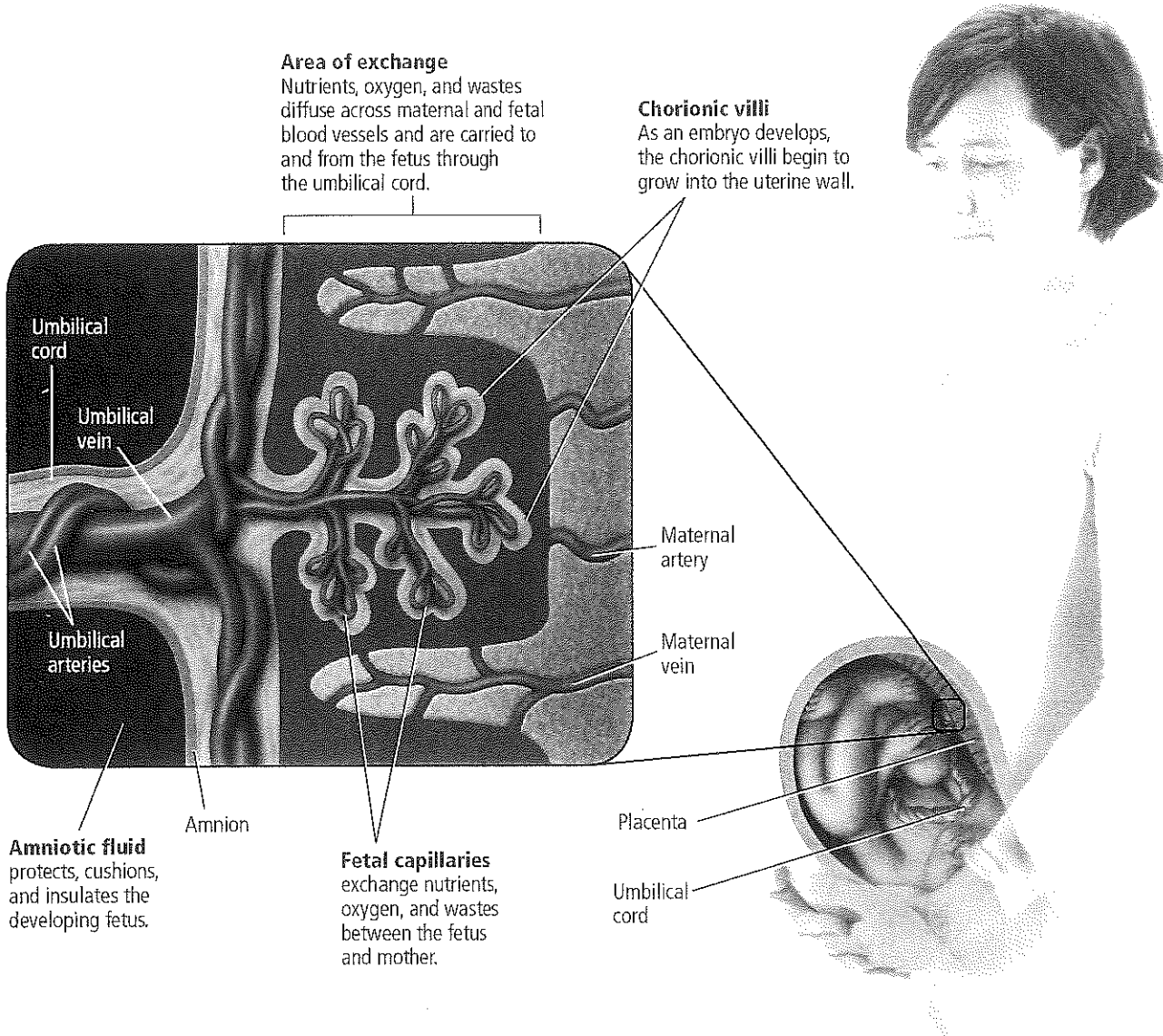
Study Tip

Time Line Create a time line showing the development of a human being from fertilization to adulthood. Use average ages for various stages of development. Include major characteristics of each stage of development.

Visualizing a Placenta

Figure 10

A growing fetus exchanges nutrients, oxygen, and wastes with the mother through the placenta. The placenta contains tissue from both mother and fetus.



1001 0151



Animation

Hormonal regulation during pregnancy During the first week of development, the embryo begins to secrete a hormone, called human chorionic gonadotropin (hCG) (kor ee AH nihk • go na duh TROH pen), which keeps the corpus luteum from degenerating. If the corpus luteum remains active, progesterone levels, and to a lesser extent estrogen levels, remain high. Remember from the previous section that the decline of progesterone triggers a new menstrual cycle. If levels of these hormones remain high, a new menstrual cycle will not begin. Two to three months into development, the placenta secretes enough progesterone and estrogen to maintain the proper conditions for pregnancy.


 **Reading Check** Compare two functions of the placenta.

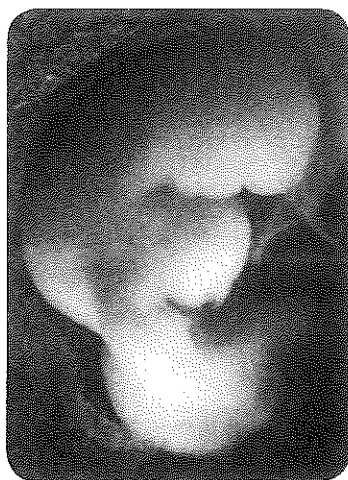
Three Trimesters of Development

On average, human development takes around 266 days from fertilization to birth. This time span is divided into three trimesters, each around three months long. During this time, many events take place. The zygote grows from a single cell into a baby that has trillions of cells. These cells develop into tissues and organs with specialized functions. Follow **Figure 11**, which shows different stages of human development during the first trimester.

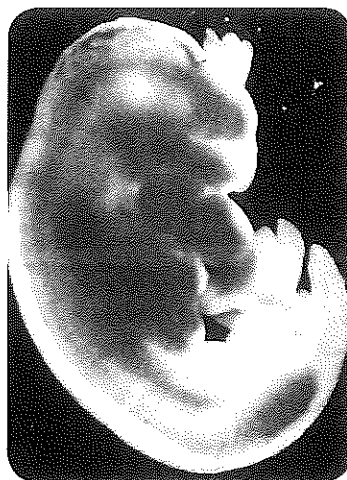
The first trimester In the first trimester, all tissues, organs, and organ systems begin to develop. During this time of development, the embryo is especially vulnerable to the effects of alcohol, tobacco, drugs, and other environmental influences, such as environmental pollutants. During the first two weeks of development, the mother might not realize that she is pregnant because she has not yet missed a menstrual period. A lack of certain essential nutrients during this time might cause irreversible damage to the developing embryo. A few of the major causes of preventable birth defects are listed in **Table 2**.

At the end of eight weeks, the embryo is called a fetus. All of the organ systems have begun to form. By the end of the first trimester, the fetus can move its arms, fingers, and toes and make facial expressions. Fingerprints also are present.

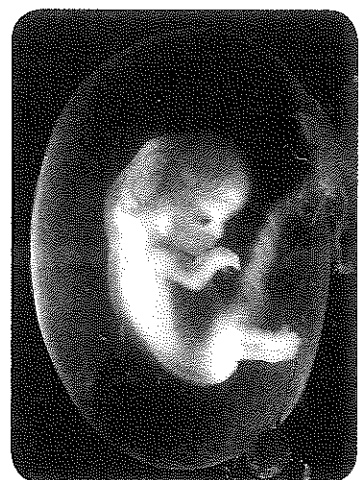
 **Figure 11** The embryo develops into a fetus during the first trimester of pregnancy. By the end of the third month, the fetus can make small movements.



4 weeks



5–6 weeks



7–8 weeks

(l)Pettit Format/Photo Researchers; (c)Claude Edelmann/Photo Researchers; (r)Dr. G. Moscoso/Photo Researchers



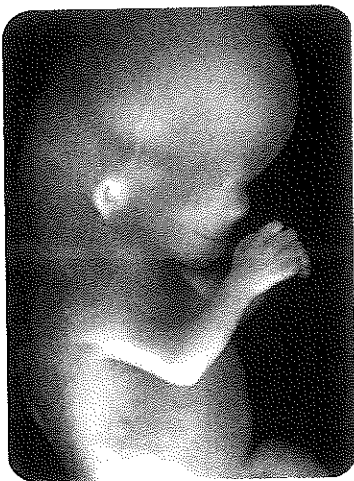
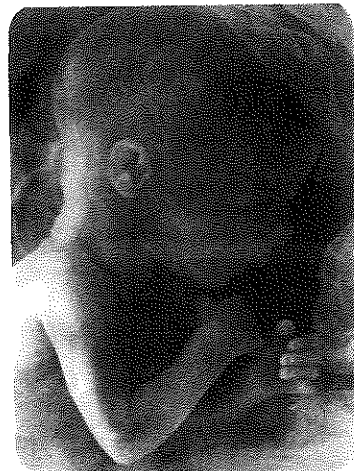
Table 2**Preventable Causes of Birth Defects**

Interactive Table

Cause	Defect
Alcohol consumption	• Mental retardation
Cigarette smoking	• Health problems related to premature births and underweight babies
Lack of folic acid in diet	• Anencephaly (head and brain do not completely form) • Spina bifida (nerve cells from the spinal cord are exposed, leading to paralysis)
Cocaine	• Low birth weight • Premature birth • Possible permanent brain damage and behavioral disorders
Methamphetamine	• Premature birth • Extreme irritability

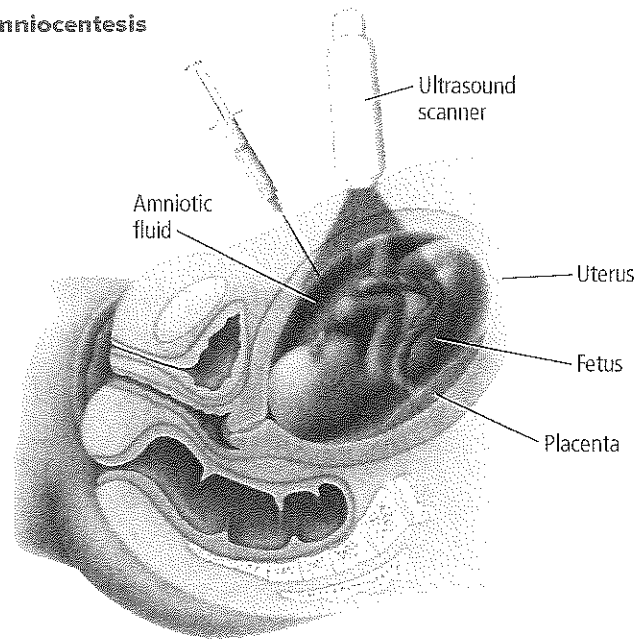
The second trimester The second trimester primarily is a period of growth. Around 18 to 20 weeks, the fetal heartbeat might be heard using a stethoscope. The developing fetus is capable of sucking its thumb and can develop the hiccups. The mother might feel a fluttering sensation or might even feel light kicks. Hair usually forms, and the fetal eyes will open during this period. At the end of this trimester, the fetus might be able to survive outside the mother's uterus with the aid of medical intervention, but the chances for survival are not very high. If born this early, the baby cannot maintain a constant body temperature. The baby's lungs have not developed fully, so respiratory failure is a great risk. Also, the baby is very likely to become seriously ill because its immune system is not fully functional.

The third trimester During the third trimester, the fetus continues to grow at a rapid rate. Fat accumulates under the skin to provide insulation for the fetus once it is born. Adequate protein intake by the mother is important during this time. Protein is essential for the rapid amount of brain growth that occurs. New nerve cells in the brain are forming at a rate of 250,000 cells per minute. The fetus now might respond to sounds in the environment, such as music or the sound of its mother's voice.

**9–10 weeks****12 weeks**

* **Figure 12** In amniocentesis, fluid and cells lost from the fetus are removed from the amniotic fluid and analyzed.

Amniocentesis



CAREERS IN BIOLOGY

Ultrasound Technician

Technical skills are needed in biology. An ultrasound technician obtains ultrasound images that are interpreted by a physician.

Diagnosis in the Fetus

Many conditions can be diagnosed before a baby is born. Identifying certain conditions as early as possible increases the chance for proper medical treatment to help a newborn baby have the highest quality of life possible.

Ultrasound One way to identify conditions in the fetus is by using ultrasound, a procedure in which sound waves are bounced off the fetus. These sound waves are converted into light images that can be seen on a video monitor. Ultrasound can be used to determine if the fetus is growing properly, the position of the fetus in the uterus, and the gender of the fetus.

Mini Lab 2

Sequence Early Human Development



What developmental changes occur during the first eight weeks of life? Fertilization begins when a sperm penetrates the egg. The zygote undergoes predictable developmental changes. Cell division produces increasing numbers of cells. Cells move and arrange themselves to form specific organs, making it possible for cells to perform specific functions.

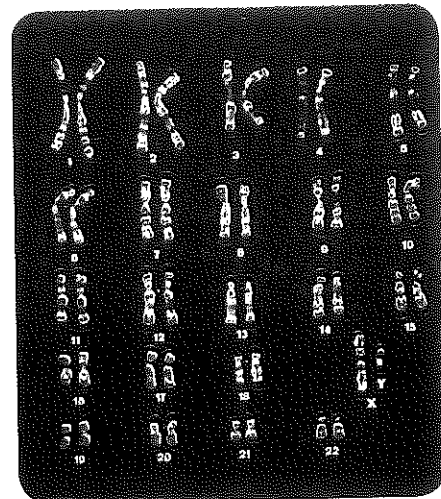
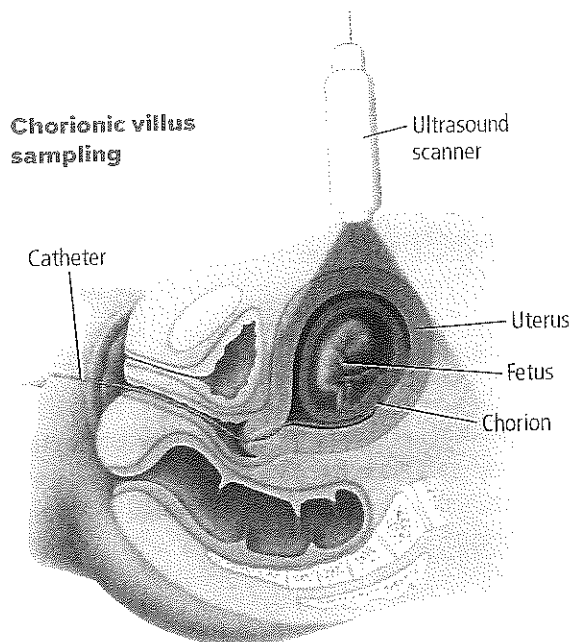
Procedure

1. Refer to **Figure 11** to see **images of embryos**.
2. Study the images for the first trimester of pregnancy. Choose one factor to track through this developmental period. Factors might include embryonic size, overall structural changes, specific organ or organ system development, or others.
3. Chart the development of this factor along a time line through the first trimester of pregnancy.

Analysis

1. **Analyze** the time line you created. Identify developmental milestones related to this factor during the ten-week period.
2. **Summarize** the level of development of the factor you examined by the end of the first twelve weeks.





Karyotype

Figure 13

Left: Chorionic villus sampling involves removing cells from the chorion and analyzing them. This procedure carries a small risk of a miscarriage. **Right:** Karyotypes can be analyzed to help with diagnosis.

Amniocentesis and chorionic villus sampling Amniocentesis (am nee oh sen TEE sus) and chorionic villus sampling are prenatal tests. During amniocentesis—usually performed in the second trimester—a needle is inserted through the abdomen of the pregnant female, illustrated in **Figure 12**. Fluid from the amniotic sac is removed and analyzed. Tests that measure enzyme levels associated with certain conditions can be performed. Fetal cells can be examined by a karyotype or even by DNA analysis. Remember a karyotype is a chart of chromosome pairs, shown in **Figure 13**, that is valuable in identifying unusual chromosome numbers or the sex of the fetus.

In chorionic villus sampling—usually performed during the first trimester—a small tube, called a catheter, is inserted through the vagina and cervix of the mother, as illustrated in **Figure 13**. Cells from the chorion are removed and analyzed by karyotyping. The chromosomes in the cells of the chorion are identical to those of the cells in the fetus.

Section 2 Assessment

Section Summary

- Fertilization is the joining of egg and sperm.
- Four extraembryonic membranes are associated with a human embryo.
- The placenta regulates what substances can be exchanged between a fetus and its mother.
- Hormone regulation during pregnancy is different from hormone regulation during the menstrual cycle.
- Pregnancies are divided into three trimesters.
- Some medical conditions of a baby can be detected before it is born.

Understand Main Ideas

1. **WRITE** Describe the changes that the zygote undergoes during the first week following fertilization.
2. **Describe** how defective acrosomes would affect the process of fertilization.
3. **Summarize** the development that occurs during each trimester in a concept map.
4. **Compare and contrast** hormonal regulation during pregnancy with hormonal regulation during the menstrual cycle.

Think Critically

WRITING in Biology

5. Write a paragraph explaining the functions of the extraembryonic membrane in humans, and contrast those functions with the functions in other animals.

MATH in Biology

6. Determine the due date (predicted birth date) of a baby if the egg was fertilized on January 1.



Section 3

Reading Preview

Essential Questions


- What are the events that occur during the three stages of birth?
- What are the stages of human development from infancy to adulthood?
- What are the hormones necessary for growth?

Review Vocabulary


growth: increase in the amount of living material and formation of new structures in an organism

New Vocabulary

labor
dilation
expulsion stage
placental stage
adolescence
infancy
adulthood

 Multilingual eGlossary

Birth, Growth, and Aging

 **Read** Developmental changes continue throughout the stages of life.

Real-World Reading Link You know from looking at your family photo album that you have grown and changed since you were born. Your bones, teeth, eyes, and muscles have changed. You can look forward to continued changes in your face and body structure throughout your life.

Birth

Birth occurs in three stages: dilation, expulsion, and the placental stage, as shown in **Figure 14**. Just before giving birth, the posterior pituitary gland releases the hormone oxytocin (ahk sih TOH sun), which stimulates involuntary muscles in the wall of the uterus to contract. This is the beginning of the birthing process called **labor**.

Another sign that the baby is going to be born is the **dilation** (di LAY shun), or opening, of the cervix. The cervix must open to allow the baby to leave the uterus. Contractions of the uterus become stronger and more frequent, and at some point the amniotic sac tears. The amniotic fluid flows out of the vagina, which is sometimes described as the “water breaking.”

After a period of time that could be as short as a few hours or as long as a couple of days, the cervix fully dilates to around 10 cm. The uterine contractions are now very strong. The mother consciously will contract her abdominal muscles to help push the baby, usually head first, through the vagina in the **expulsion stage**. When the baby is out of the mother’s body, the umbilical cord is clamped and cut. A small piece of the cord still attached to the baby soon will dry up and fall off, forming the navel, or belly button.

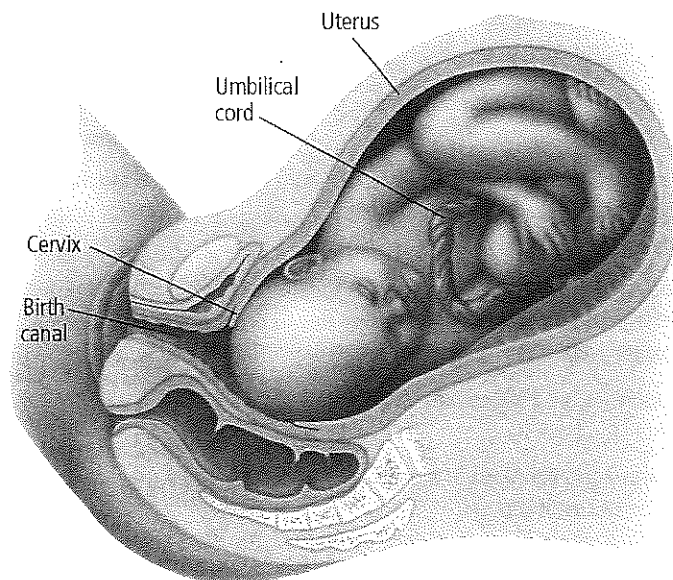


Figure 14 Note the three stages of birth. Dilation stage: Contractions open the cervix. Expulsion stage: The baby rotates as it moves through the birth canal, making expulsion easier. Placental stage: The placenta and umbilical cord are expelled.

Hypothesize *what might happen if the placenta was not expelled quickly.*


Dilation



Shortly after the baby is delivered, the placenta detaches from the uterus and leaves the mother's body along with extraembryonic membranes. This is the **placental stage** of the birthing process.

Sometimes, complications prevent the baby from being born through the vagina. In these cases, an incision is made through the mother's abdomen and uterus, and the baby is removed from the mother's body. This process is called a cesarean section.


During the first four weeks of life, the baby is called a newborn. Human newborns vary in size. However, on average, a newborn human baby has a mass of 3300 g and is 51 cm long.

 **Reading Check** Describe major events that occur during each stage of labor.

Growth and Aging

Humans go through many stages of growth during their lives. After you were born, you were in your infancy, but soon you will enter adulthood. You now are in a major development phase called **adolescence** (a dul ES unts), which began with puberty and ends at adulthood.

Hormones, such as human growth hormone, thyroxine, and steroids, influence growth. Human growth hormone stimulates most areas of the body to grow as cells replicate by the process of mitosis. This hormone works by increasing the rates of protein synthesis and the breakdown of fats. Thyroxine from the thyroid increases the overall metabolic rate and is essential for growth to occur. Steroid hormones, such as estrogen and testosterone, are also important for growth. Recall that testosterone and estrogen pass through the plasma membrane and into the nucleus of a target cell. The hormones activate certain genes that promote the formation of proteins. In this way, testosterone, and to a lesser extent, estrogen, cause an increase in the size of cells.

 **Reading Check** Summarize the roles of human growth hormone and thyroxine.

VOCABULARY

SCIENCE USAGE / COMMON

USAGE

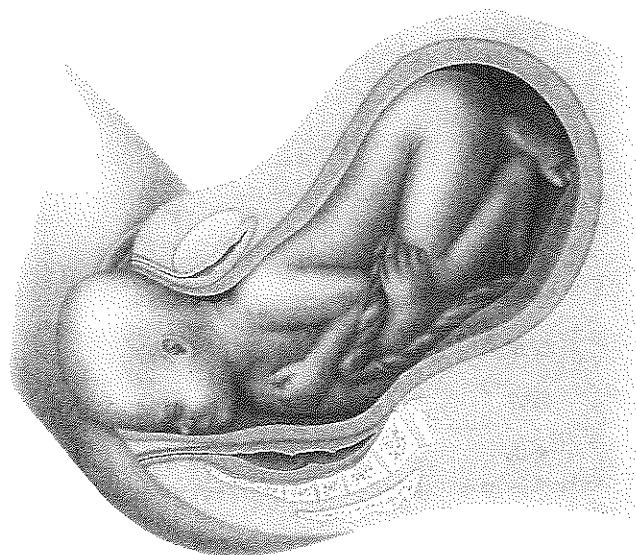
Labor

Science usage: the process of giving birth

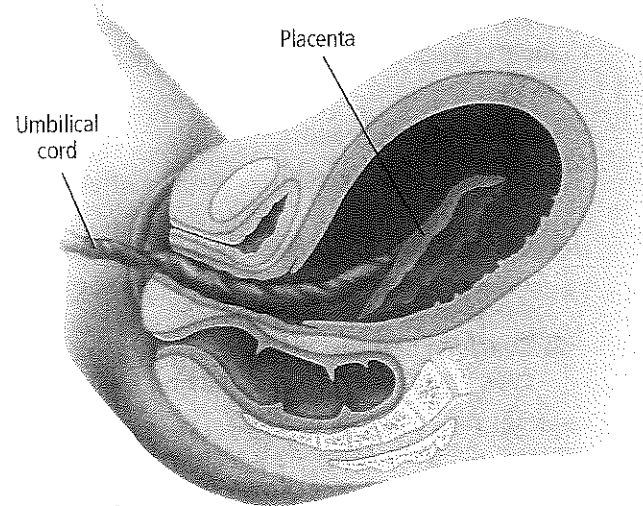
There are three stages of labor: dilation, expulsion, and the placental stage.

Common usage: the use of physical or mental effort

Lifting the heavy bags of soil requires labor.



Expulsion stage



Placental stage



Infancy The first two years of life are known as **infancy**. Many changes take place during these years. An infant learns how to roll and crawl, grasp objects, and perform simple tasks. By the end of the first year, the infant likely is walking and might be uttering a few words. An enormous amount of mental development also occurs during these first two years.

In the first year, a baby typically grows about 25 cm in length and weighs three times more than when the baby was born. The child's growth slows during the second year; children grow at a rate of around 6 cm per year until the beginning of puberty.

Childhood and adolescence Childhood is the period of growth and development that extends from infancy to adolescence. The child's ability to reason and solve problems develops progressively during childhood. Puberty marks the beginning of adolescence, the period of growth between childhood and adulthood. Puberty usually begins between ages 8 to 13 in girls and ages 10 to 15 in boys.

In addition to the hormonal and sexual development that occur during this time, other physical changes also take place. An adolescent experiences a growth spurt—girls grow approximately 6–11 cm and boys grow approximately 7–13 cm—in one year. In girls, the hips become wider and the waist might become narrower. In boys, the shoulders usually become broader. At the end of adolescence, physical growth is complete, marking the beginning of **adulthood**. The transition between adolescence and adulthood can be hard to define because of physical, emotional, and behavioral changes.

DATA ANALYSIS LAB 1

Based on Real Data*

Form a Conclusion

Is SIDS linked to smoking? Researchers studied the annual SIDS rate per 1000 infants for mothers who smoked and mothers who did not smoke during pregnancy. In 1994, doctors began to recommend that infants sleep on their backs to reduce the risk of Sudden Infant Death Syndrome (SIDS). Use the table to determine how smoking and the Back to Sleep recommendation impacted SIDS.

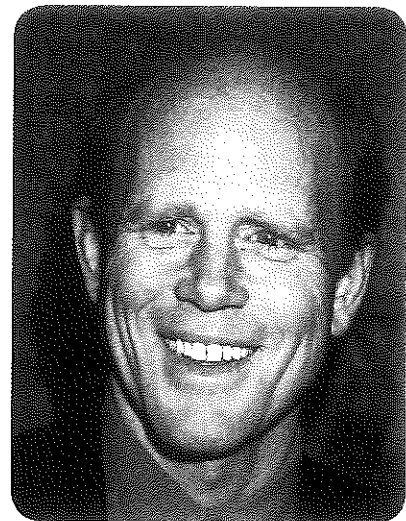
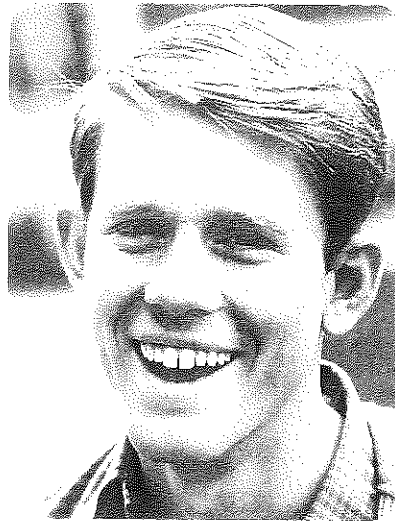
Think Critically

- Analyze** whether sleeping position affects SIDS. Explain.
- Calculate** the percentage of SIDS for babies born to smoking mothers and to those of non-smoking mothers each year.
- Conclude** how this data shows that some SIDS cases might be linked to smoking.

SIDS Deaths		
Year	Smoke Exposed	Unexposed
1989	3.21	1.33
1990	2.96	1.34
1991	3.32	1.72
1992	2.93	1.41
1993	3.28	1.17
1994	1.65	0.79
1995	2.19	0.65
1996	1.61	0.82
1997	3.21	0.64
1998	1.80	0.37

*Data obtained from: Anderson, M.E., et al. 2005. Sudden Infant Death Syndrome and prenatal maternal smoking: rising attributed risk in the Back to Sleep era. *BMC Medicine* 3: 4.





« **Figure 15** These photos show actor and director Ron Howard in various stages of life. **Summarize changes that occur in adulthood.**

Adulthood There are a number of theories on why people age. However, scientists do agree that the body goes through many changes as it ages, as shown in **Figure 15**. Physical changes perhaps are the most noticeable signs of aging, such as hair turning gray or white as pigment production declines. An individual might lose as much as two centimeters of height during the aging process because the discs between the vertebrae in the spine become flattened. Other changes include a decrease in muscle mass, a slowing of overall metabolism, and a decreased pumping ability of the heart. The skin loses its elasticity, and sensory perceptions might diminish somewhat. In women, the ability to have children ends with menopause (MEN uh pawz). Sperm production decreases in men.

Despite all of the potential challenges of aging, many people continue to be physically and mentally active as they grow older. Some older adults even begin new careers. Anna Mary Robertson Moses, known as Grandma Moses, became a famous artist when she was in her late 70s.

Section 3 Assessment

Section Summary

- Humans go through many changes throughout the stages of life.
- There are three stages of the birthing process.
- Levels of several hormones influence human growth.
- The first year of life is a time of learning motor skills and of rapid growth.
- Puberty causes many changes in the body, and changes continue to occur as an adult grows older.

Understand Main Ideas

1. **Write an Idea** **Construct** a chart that illustrates major changes that occur during the stages of human growth and aging.
2. **Identify** two signs that tell a pregnant woman she is almost ready to give birth.
3. **Name** the events that occur during the three stages of birth.
4. **Describe** how the human growth hormone causes a person to grow.

Think Critically

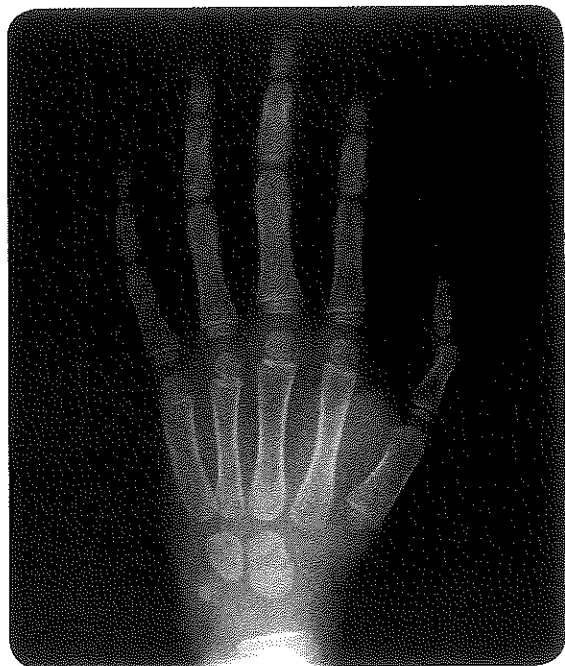
5. **Hypothesize** Robert Wadlow, the tallest human being on record, was 272 cm tall and weighed 220 kg when he died at age 22. He was an average-sized newborn but developed a tumor in his anterior pituitary gland. Develop a hypothesis to explain how this tumor led to his great height.
6. **Infer** How do you think scientists determine which specific substances cause birth defects?



Biology & Society

HGH: The Tall and Short of It

Terry is a 157.5-cm tall high school senior. He has not grown in the last two years. His dad is 190.5 cm, and his other three brothers are 177.8 cm or taller. He doesn't seem to mind his height—or lack of it. His mom, though, wonders if he might have a disadvantage in sports because he is short. She suggests that he take growth hormones to become taller. She thinks that they might help him be more successful in sports—and in life. What should he do?



The oval bones are the growth plates, where bone growth occurs. If the growth plate is no longer visible, no more growth can occur.

What is human growth hormone?

Human growth hormone (HGH) is a protein produced in the pituitary gland found in the brain. It is plentiful during the growth period of youth. Children with a lack of HGH are known as pituitary dwarfs and generally do not reach a height of over 135 cm.

What is HGH therapy? During adolescence, pituitary dwarfs can receive injections of synthetic HGH to increase their growth 10–12 cm during the first year. Less growth occurs during subsequent years. In 2003, the Food and Drug Administration approved HGH therapy for children who are otherwise healthy, but are predicted to reach adult heights of 160.0 cm or shorter for males and 149.9 cm or shorter for females. For these children, HGH therapy adds an average of 4–7 cm of height by adulthood. Using X-rays, a child's bone age—and therefore their growth potential—can be determined.

Therapy v. enhancement Sometimes HGH therapy can be used by physicians for individuals who are short and want to be taller or stronger athletes; however, this type of treatment is rare. There have been instances in which HGH drugs have been sold illegally and obtained by professional athletes to enhance their performance. These athletes were fined heavily or suspended because the drugs were in their systems.

HGH supplements sold in health food stores have less than one percent of HGH in them. Based on numerous scientific studies, they show no significant impact on human performance. Only HGH injections can improve growth and increase one's metabolism.

DEBATED Biology

Debate Should HGH therapy be permissible when a teen is dissatisfied with his or her height for primarily cosmetic or athletic reasons? Consider Terry's situation, where he is feeling pressured to use HGH to become taller simply because the option exists. Conduct additional research about HGH and HGH therapy.

BIO LAB

INTERNET: HOW ARE ULTRASOUND IMAGES USED TO TRACK FETAL DEVELOPMENT?

Background: Ultrasound is a medical imaging technique that uses high-frequency sound waves and their echoes to produce an image of something inside the body. While two-dimensional images are the current standard, technology capable of producing three-dimensional fetal images and four-dimensional, or moving images, is now available.

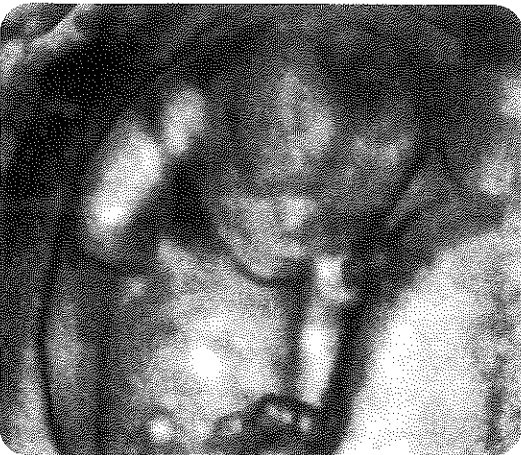
Question: *How are ultrasound images used to assess fetal characteristics and development?*

Materials

computer with Internet access
labeled ultrasound images showing embryos and fetuses at various developmental stages
ultrasound images showing embryos and fetuses at unknown stages of development

Procedure

1. Read and complete the lab safety form.
2. Visit the Internet to examine fetal development from the second trimester through week 40. Use this information to complete the development time line you started in **MiniLab 2**.



3. Study the ultrasound images of fetuses during identified stages of development provided by your teacher. Compare these to your time line, and identify as many features as possible. As you study the images, choose a body structure that you would like to examine further.
4. Study the ultrasound images provided by your teacher of fetuses at unknown stages of development. Use your time line and what you have learned to determine the approximate stage of fetal development. Look for clues based on the development of the system you choose.

Analyze and Conclude

1. **Interpret Data** During which time period does the developing embryo or fetus change the most? Justify your answer.
2. **Analyze** What physical characteristics were most helpful in identifying the level of fetal development? Explain.
3. **Compare** two- and three-dimensional ultrasound images. Which are easiest to interpret?
4. **Think Critically** What advantages are provided by four-dimensional imaging?
5. **Error Analysis** How accurate were your estimates of fetal development? Explain how your estimates could have been improved.

WRITING in Biology

Poster Session Create a flowchart that illustrates the reproductive process. Begin with the creation of sex cells and end with a fetus at full term.



Chapter 36 Study Guide

THEME FOCUS Stability and Change Once fertilization occurs, human growth and development involve constant changes in structures and processes.

Big Idea Human reproduction involves the joining together of sperm and egg.

Section 1 Reproductive Systems

seminiferous tubule (p. 1049)
epididymis (p. 1049)
vas deferens (p. 1049)
urethra (p. 1049)
semen (p. 1049)
puberty (p. 1049)
oocyte (p. 1050)
oviduct (p. 1050)
menstrual cycle (p. 1050)
polar body (p. 1051)

Big Idea Hormones regulate human reproductive systems, including the production of gametes.

- Levels of male and female hormones are regulated by negative feedback systems.
- The human male produces millions of sperm cells every day.
- The number of sex cells resulting from meiosis differs in males and females.
- The human female has a reproductive cycle called the menstrual cycle.
- The menstrual cycle has three phases: the flow phase, the follicular phase, and the luteal phase.

Section 2 Human Development Before Birth

morula (p. 1055)
blastocyst (p. 1055)
amniotic fluid (p. 1056)

Big Idea A human develops from a single fertilized cell into trillions of cells with specialized functions.

- Fertilization is the joining of egg and sperm.
- Four extraembryonic membranes are associated with a human embryo.
- The placenta regulates what substances can be exchanged between a fetus and its mother.
- Hormone regulation during pregnancy is different from hormone regulation during the menstrual cycle.
- Pregnancies are divided into three trimesters.
- Some medical conditions of a baby can be detected before it is born.

Section 3 Birth, Growth, and Aging

labor (p. 1062)
dilation (p. 1062)
expulsion stage (p. 1062)
placental stage (p. 1063)
adolescence (p. 1063)
infancy (p. 1064)
adulthood (p. 1064)

Big Idea Developmental changes continue throughout the stages of life.

- Humans go through many changes throughout the stages of life.
- There are three stages of the birthing process.
- Levels of several hormones influence human growth.
- The first year of life is a time of learning motor skills and of rapid growth.
- Puberty causes many changes in the body, and changes continue to occur as an adult grows older.

Section 1

Vocabulary Review

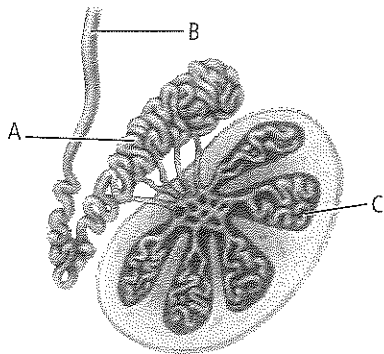
Explain the difference between the terms in each pair below, and then explain how the terms are related.

- urethra, semen
- oocyte, oviduct
- menstrual cycle, polar body

Understand Main Ideas

- What would happen if the testes were located inside the body cavity?
 - Sperm would not be produced because it is too warm.
 - Testosterone levels would increase because of the warm temperature.
 - The seminal vesicles would no longer be needed.
 - Hormones from the testes would have difficulty entering the bloodstream.

Use the diagram below to answer questions 5 and 6.



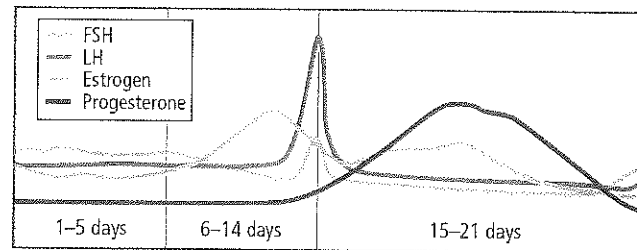
- What occurs in the structure labeled C in the illustration?
 - sperm cell storage and maturation
 - sperm cell production
 - secretion of sugar
 - production of FSH
- What is the function of the structure labeled A in the illustration?
 - sperm cell storage and maturation
 - sperm cell production
 - secretion of sugar
 - production of FSH

Constructed Response

- Short Answer** Why are the secretions of the male reproductive glands so important to sperm?
- Compare and Contrast** Compare the actions of FSH and LH in the ovaries and testes.
- Short Answer** What advantages are there for the formation of one egg and polar bodies as compared to four eggs?

Think Critically

Use the diagram below to answer question 10.



- Cause and Effect** Based on what you know about the hormonal control of a woman's reproductive cycle shown above, explain the hormonal basis of why a woman cannot get pregnant again while she is pregnant.
- Hypothesize** All of the reproductive hormones in a human male are present at birth. Develop a hypothesis to explain why the hormones have a greater influence on the body once puberty begins.

Section 2

Vocabulary Review

For questions 12-14, describe each of the following vocabulary terms.

- morula
- blastocyst
- amniotic fluid

Understand Main Ideas

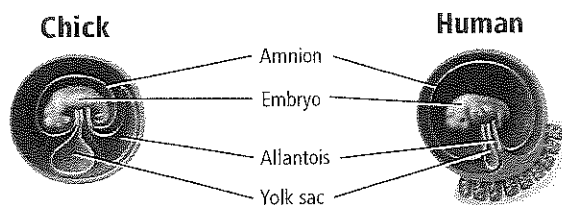
- Where in the human female reproductive tract does fertilization usually occur?
 - in the uterus
 - in the vagina
 - in the corpus luteum
 - in an oviduct



Chapter 36 Assessment

16. Which of the following describes the proper sequence of development?
- A. zygote, blastocyst, morula
 - B. morula, zygote, blastocyst
 - C. zygote, morula, blastocyst
 - D. morula, blastocyst, zygote
17. Which is produced by the placenta?
- A. human chorionic gonadotropin
 - B. estrogen and progesterone
 - C. oxytocin
 - D. endometrial birth hormone

Use the diagram below to answer question 18.



18. Why is the human yolk sac shown in the illustration smaller than that of the chick?
- A. The yolk in humans is converted into muscle.
 - B. The yolk sac in chicks keeps the embryo warm.
 - C. Developing humans get their nourishment from the placenta.
 - D. The yolk sac serves no purpose for a developing human.
19. When can a pregnant woman first feel the movements of her fetus?
- A. in the first trimester
 - B. in the second trimester
 - C. in the third trimester
 - D. in the last month only

Constructed Response

20. **Short Answer** Why is it important that the endometrium is refreshed each cycle?
21. **CAREERS IN BIOLOGY** Some couples consult with a reproductive endocrinologist because they are having difficulty conceiving a child. What are some possible biological reasons that could contribute to this difficulty?
22. **IDEA** What do you think are the reasons that the greatest amount of harm to an embryo or fetus caused by alcohol or drugs occurs in the first trimester?

Think Critically

23. **Compare and contrast** the division of the inner cell mass during normal development and during the development of identical twins.
24. **Formulate a Model** A woman is carrying an embryo, but not enough hCG is getting into her system. Propose a possible treatment that might allow the embryo to be saved.

Section 3

Vocabulary Review

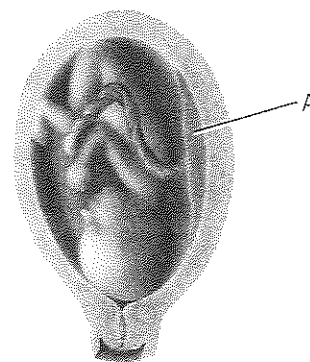
Explain the difference between the terms in each pair below. Then explain how the terms are related.

- 25. labor, placental stage
- 26. dilation, expulsion
- 27. adolescence, adulthood

Understand Main Ideas

28. At which measurement is the cervix fully dilated?
- A. 10 mm
 - B. 2 cm
 - C. 10 cm
 - D. 20 cm
29. When a pregnant woman tells her doctor that "her water broke," what does she mean?
- A. The amniotic sac has torn.
 - B. There is a lot of pressure on her bladder.
 - C. The yolk sac has torn.
 - D. The placenta is leaking.

Use the diagram below to answer questions 30 and 31.



30. What is the name of the structure labeled A in the illustration?
- A. uterus
 - B. placenta
 - C. fetus
 - D. cervix



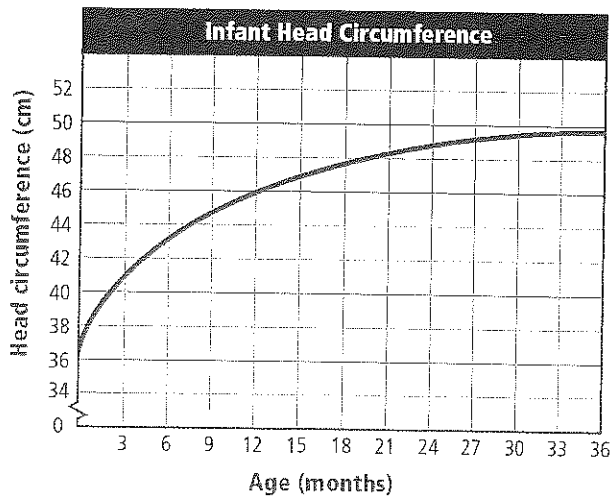
31. During which stage of birth does structure A leave the female's body?
- first
 - second
 - third
 - fourth
32. During which year of a person's life does the most rapid rate of growth occur?
- the first year of infancy
 - the first year of puberty
 - the second year of puberty
 - the first year of adulthood

Constructed Response

33. **Open Ended** What biological reasons can you think of to explain why women go through menopause and stop producing eggs, while men can produce sperm all their lives?
34. **THINK** Compare puberty in females with puberty in males.
35. **CAREERS IN BIOLOGY** During rare occasions, a pediatrician examines a newborn baby who does not produce enough thyroxin. What are some possible results of this? Suggest a treatment for this condition.

Think Critically

Use the graph below to answer question 36.



36. **Change** During which period shown on the graph is the rate of change in head circumference greatest?

Summative Assessment

37. **BIG Idea** Human reproduction involves the joining together of sperm and egg. What is the result of human reproduction? What is the ultimate goal of human reproduction? Construct your answer from a scientific point of view.
38. **WRITING** **Biology** Prepare a pamphlet for pregnant women on health and lifestyle issues during pregnancy. Include a chart about the major events of fetal development.

Document-Based Questions

To reduce the chances of brain and spine birth defects, the U.S. Public Health Service recommended in 1992 that women of childbearing age increase folic acid in their diets. The U.S. Food and Drug Administration required all cereal products be enriched with folic acid beginning in January 1998 (an optional period began in March 1996).

Below is a table showing the rate per 100,000 births of anencephaly—incomplete head and brain development—from 1991–2002.

Year	Rate	Year	Rate
1991	18.38	1997	12.51
1992	12.79	1998	9.92
1993	13.50	1999	10.81
1994	10.97	2000	10.33
1995	11.71	2001	9.42
1996	11.96	2002	9.55

Data obtained from: Mathews, T.J. Trends in Spina Bifida and Anencephalus in the United States, 1991–2002. National Center for Health Statistics/Centers for Disease Control and Prevention/Department of Health and Human Services.

39. Construct a graph to represent these data and describe the relationship between the variables that you observe.
40. Explain the overall trend in the number of cases of anencephaly during this time period.



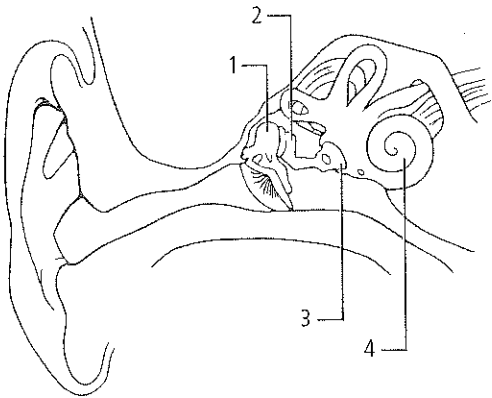
Standardized Test Practice

Cumulative

Multiple Choice

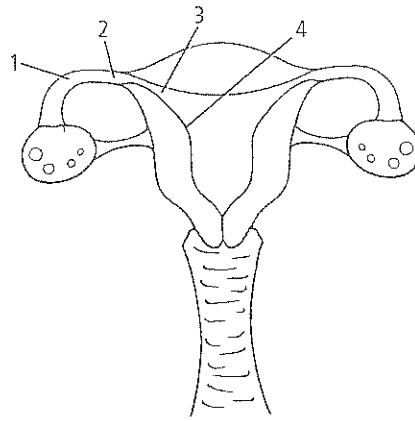
1. Which is the role of arteries in the circulatory system?
- A. to carry blood away from the heart
 - B. to carry blood back to the heart
 - C. to provide individual cells with nutrients
 - D. to prevent blood from flowing backward

Use the diagram below to answer question 2.



2. Which contains sensors for the auditory nerve?
- A. 1
 - B. 2
 - C. 3
 - D. 4
3. What is the role of hormones in the body?
- A. They act as reaction catalysts.
 - B. They control the breathing process.
 - C. They help synthesize proteins.
 - D. They regulate many body functions.
4. Which is the sequence of human development during the first week?
- A. egg → morula → blastocyst → zygote
 - B. egg → zygote → morula → blastocyst
 - C. morula → blastocyst → egg → zygote
 - D. morula → egg → zygote → blastocyst
5. What is the function of the kidneys?
- A. to deplete carbon dioxide from the blood
 - B. to eliminate undigested foods from the body
 - C. to remove excess water and wastes from the blood
 - D. to rid excess proteins from the blood

Use the diagram below to answer question 6.

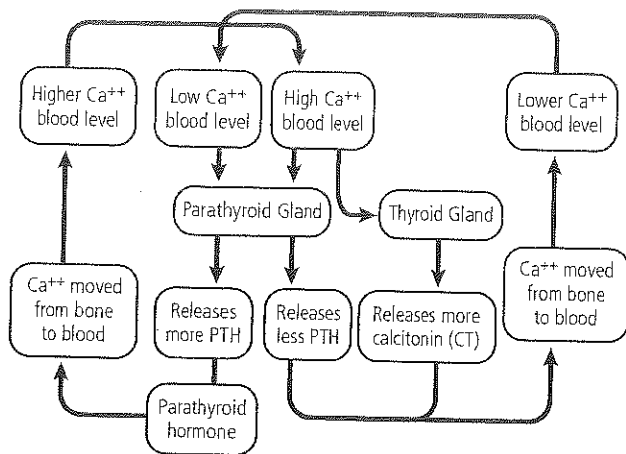


6. Where does fertilization take place?
- A. 1
 - B. 2
 - C. 3
 - D. 4
7. When blood glucose levels are very high, what does the pancreas secrete?
- A. glycogen
 - B. insulin
 - C. insulin and glycogen
 - D. neither insulin nor glycogen
8. Which describes the human circulatory system?
- A. four-chambered heart, one circulatory loop
 - B. four-chambered heart, two circulatory loops
 - C. two-chambered heart, one circulatory loop
 - D. two-chambered heart, two circulatory loops
9. Which statement describes what happens during internal respiration?
- A. Carbon dioxide is used to derive energy from glucose.
 - B. Gases are exchanged between the atmosphere and the blood.
 - C. Gases are exchanged between the blood and the body's cells.
 - D. Oxygen is used to derive energy from glucose.



Short Answer

Use the diagram below to answer questions 10 and 11.



- Assess how the parathyroid hormone affects bone tissue.
- Evaluate how a person's blood calcium levels would be affected if his or her thyroid gland stopped working.
- Analyze how Ivan Pavlov conditioned dogs to salivate when they heard a bell.
- Assess how emphysema would cause difficulty for a person when climbing stairs.
- Name and describe the two divisions of the human skeleton. Critique this division of the skeleton.
- Think about the structure of the middle and inner ear. Infer why people might experience a temporary hearing loss after attending a loud concert.
- Explain how the villi in the small intestine affect the rate of absorption.

Extended Response

- A student did an experiment in a sunny room using unripe bananas. He found that bananas ripened faster in a paper bag than on top of a plate. Based on these results, what conclusion could the student make about the ripening of the bananas? Give one example of a way to improve the experiment.
- Muscles in the legs tend to store large amounts of glycogen and fat. Muscles in the arms do not. When the muscles are used repeatedly, why do the muscles in the arm fatigue more quickly?
- Different kinds of mammals have different digestive systems. Explain how the digestive systems of ruminant herbivores differ from other herbivores.

Essay Question

As elevation increases, air pressure decreases. At sea level, air pressure is about 760 mmHg. The percentage of oxygen in the atmosphere is about 21 percent. At 3200 m in elevation, the air pressure is 30 percent less than that at sea level; however, the percentage of oxygen is the same. The difference in pressure occurs because the molecules of gas are spread farther apart. As altitude continues to increase, the pressure continues to decrease. Mountain climbers face the problems of decreased pressure when they climb a mountain. When climbers go to the summit of the highest mountains, they carry oxygen tanks with them to help them breathe.

Using the information in the paragraph above, answer the following question in essay format.

- Evaluate why breathing oxygen would enable a mountain climber to reach a higher altitude.

NEED EXTRA HELP?

If You Missed Question . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Review Section . . .	34.1	33.3	35.1	36.2	34.3	36.2	35.3	34.3	34.2	35.3	35.3	31.1	34.2	32.2	33.3	35.1	1.3	32.3	30.2	34.2

