Reproduction and Development

TOPIC 4

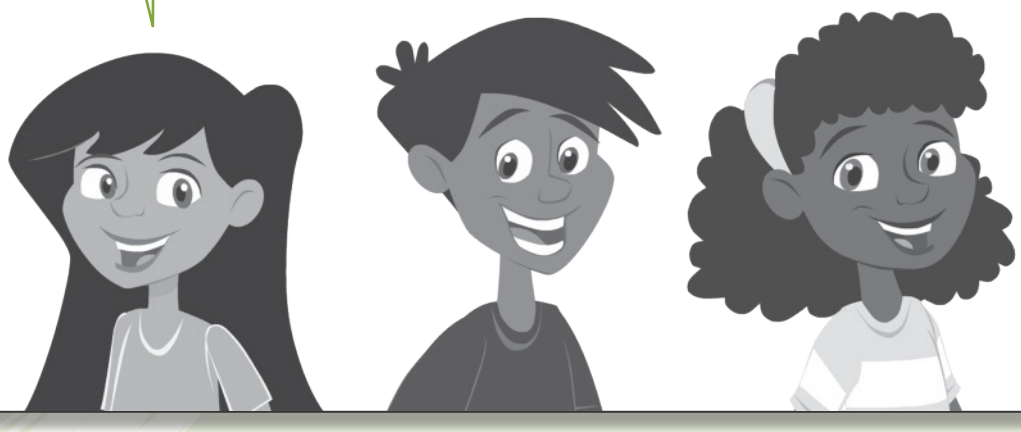
What do You Think?

Genes and Reproduction

Boys get most of their genes from their dad and girls get most of their genes from their mom.

One parent gives you the genes for some traits while the genes for your other traits come from the other parent.

Both parents contribute genes for each of the traits you have.



TOPIC 4

Reproduction and Development

Vocabulary

asexual reproduction
cloning
development
differentiation
egg
embryo
estrogen
expressed
fertilization
fetus
gamete
gene expression
meiosis
mitosis
ovaries
placenta
progesterone
recombination
sex cell
sexual reproduction
species
sperm
testes
testosterone
uterus
zygote

Topic Overview

A **species** is a group of closely related organisms that share certain characteristics and can produce new individuals through reproduction. For any species to survive past a single generation, reproduction is essential. All individuals eventually die, but the species continues because individuals reproduce. When individuals reproduce, their offspring begin a period of **development** that ends in adulthood. Once an individual reaches adulthood, it is usually able to reproduce and continue the species for another generation.

Types of Reproduction

Two methods of reproduction are associated with living organisms: asexual and sexual. **Asexual reproduction** involves just one parent and results in one or more offspring that are genetically identical to that parent. **Sexual reproduction** involves two parents and results in offspring that have some genetic material (DNA) from each parent. The result is an organism that may be similar to one or both parents, but is not identical to either.

Asexual Reproduction Organisms that reproduce asexually produce their offspring in a variety of ways. In some cases they merely divide in two, producing two new individuals. (The parent in this case *becomes* the offspring!) Other organisms produce special cells that have a complete set of genetic information, and these individual cells can develop into new members of the species. Still others produce an outgrowth of the body that later detaches to become a separate individual. Many plants can develop from parts that are either broken off intentionally by humans or separated naturally from the parent plant. In every case, organisms produced by asexual reproduction have only one parent, and they have the same genetic information (in the form of DNA) as the parent. Figure 4-1 shows some examples of asexual reproduction.

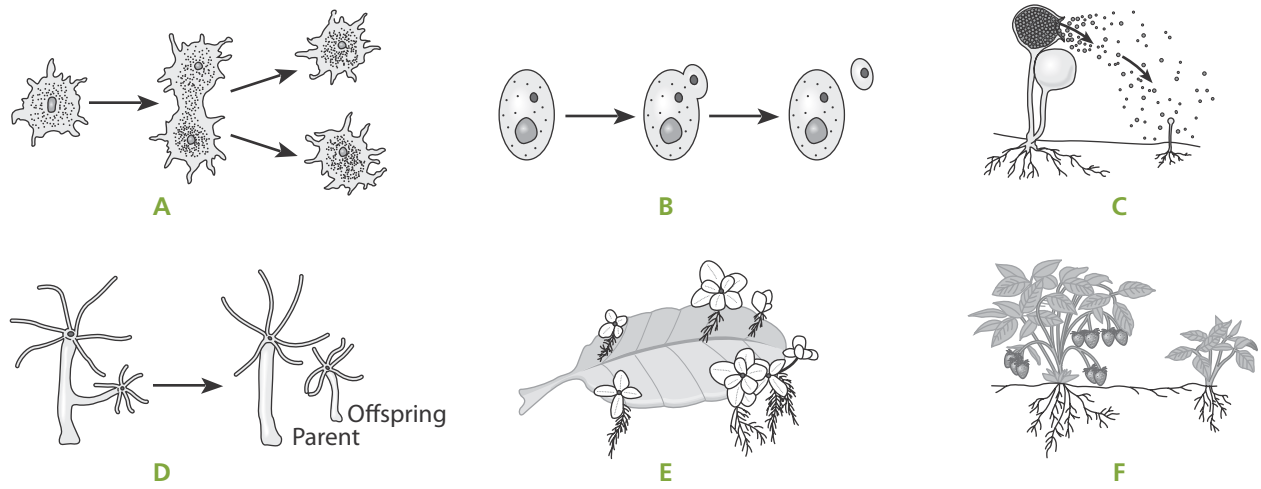


Figure 4-1. Examples of asexual reproduction: (A) An ameba divides to form two new amebas. (B) A yeast cell divides into two cells that are different sizes but genetically alike. (C) Mold spore cells reproduce the mold. (D, E, and F) Some offspring develop attached to the parent, but later separate to become independent individuals.

Sexual Reproduction In sexual reproduction, offspring receive half of their genes from one parent and half from the other. The genes are carried on chromosomes in **sex cells** (also known as **gametes** or egg or sperm cells), which join in **fertilization.** Each parent supplies half of the genetic information needed to form a complete individual. The **sperm,** which is the sex cell from the father, provides half of the information; the **egg,** which is the sex cell from the mother, provides the other half.

Offspring produced by sexual reproduction combine genes inherited from each parent's gametes. Since an offspring gets only half of its DNA from each parent, it will not be identical to either of its parents. Also, since each offspring gets a unique combination of genes from its parents, it will differ from its siblings (brothers and sisters).

Cloning **Cloning** is a technique that accomplishes the same end result as asexual reproduction. It is a way of making identical genetic copies. For example, if you cut a piece of stem from a plant and it grows roots and develops into a new plant, you have produced a genetically identical copy of the original plant. This could be called a clone of the plant.

Recently, however, it has also been possible to produce clones of animals that ordinarily only reproduce sexually. This is done by inserting a nucleus from a "parent" organism's cell (one that has a complete set of genetic information from that individual) into an egg cell from which the nucleus has been removed. The result is an egg that now contains not 50%, but 100% of the genetic information from a single parent. If this new egg cell with all of its genes can be made to develop normally, the resulting offspring is a clone of the individual that donated the original cell nucleus. (In mammals, the egg would be implanted and develop inside the body of the female.) Cloning has been accomplished with animals as complex as sheep and pigs.

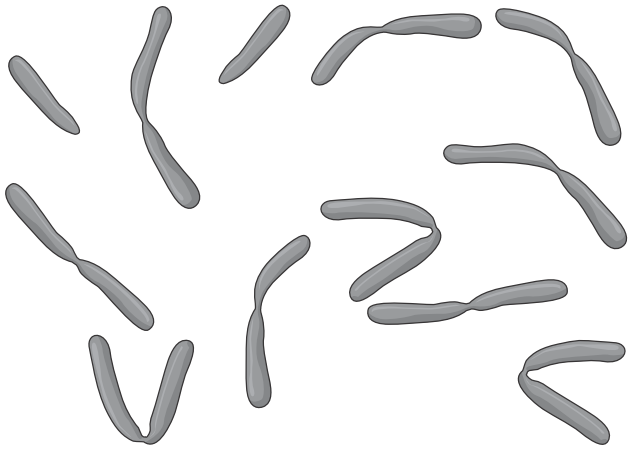
1. Which statement best describes the process of asexual reproduction?

(1) It involves two parents.
(2) It requires the combination of sperm and egg.
(3) It results in variation in the offspring.
(4) It involves the production of genetic copies.

2. Which statement concerning an organism produced by cloning is correct?

(1) The clone is genetically identical to its parent.
(2) The clone has the combined genes of both of its parents.
(3) The genetic makeup of the clone will be somewhat different from each of its parents.
(4) The appearance of the clone will be entirely different from that of its parents.

3. A student using a compound light microscope to observe a cell saw a number of threadlike nuclear structures resembling those shown below.



These threadlike structures are composed primarily of

(1) fat
(2) glucose
(3) DNA
(4) ATP

4. Plants with desirable qualities can be rapidly produced from the cells of a single plant by

(1) cloning
(2) gamete fusion
(3) meiosis
(4) immune response

5. Asexual reproduction differs from sexual reproduction in that, in asexual reproduction

(1) new organisms are usually genetically identical to the parent
(2) the reproductive cycle involves the production of gametes
(3) nuclei of sex cells fuse to form a zygote
(4) offspring show much genetic variation

6. Orchid plants reproduce slowly and take many years to produce flowers when grown from seeds. One technique that can be used in genetic research to reproduce rare orchid plants more rapidly is

(1) sexual reproduction
(2) fertilization
(3) selective breeding
(4) cloning

7. Some bacteria produce an enzyme known as penicillinase, which prevents their destruction by penicillin. Since these same organisms reproduce asexually, they normally produce offspring that

(1) can be killed by penicillin
(2) have an abnormally high rate of mutation
(3) have variable numbers of chromosomes
(4) are resistant to penicillin

8. In plants, one way sexual reproduction differs from asexual reproduction is that in sexual reproduction

(1) more offspring are produced
(2) more genetic variation is seen in the offspring
(3) the offspring and the parents are identical
(4) more offspring survive to maturity

9. A man cuts some stems from several plants that are growing in his garden. He places the stems in wet sand until they grow roots, and then he transplants them to new pots. This method of reproducing plants is most like

(1) sexual reproduction
(2) cloning
(3) natural selection
(4) fertilization

10. Compared to the offspring of sexual reproduction in animals, the offspring of asexual reproduction will

(1) show greater variety
(2) be more resistant to disease
(3) be genetically identical to the parent
(4) grow larger

Cell Division

Cell division is the orderly separation of one cell into two. Before a cell divides, the genetic information in the DNA of the cells is duplicated exactly.

The process, by which a cell's genetic material divides, creating two complete sets of the cell's genetic material, is known as **mitosis.** Mitosis produces two cells that each have a full set of identical genes and chromosomes (unless a mutation occurs somewhere along the way).

During mitosis, one copy of the genetic information is distributed to each new cell. As a result, each new cell has all the information it needs to function properly. One-celled organisms make use of mitosis for asexual reproduction. Multicellular organisms mainly use mitosis for growth and for cell replacement and repair.

A second type of cell division is **meiosis.** This process divides the genetic material in a way that results in the production of the sex cells required by organisms that reproduce sexually. Each sex cell has only half the genetic material needed for a cell to function properly.

Mitotic Division/Mitosis

During the process of mitotic cell division, the double-stranded chromosomes that are visible during mitosis split into two identical single strands and move apart to opposite ends of the cell. This process is shown in Figure 4-3.

The process concludes when the cytoplasm divides, resulting in two smaller, but genetically identical, cells. Mitotic cell division in plants is illustrated in Figure 4-4.

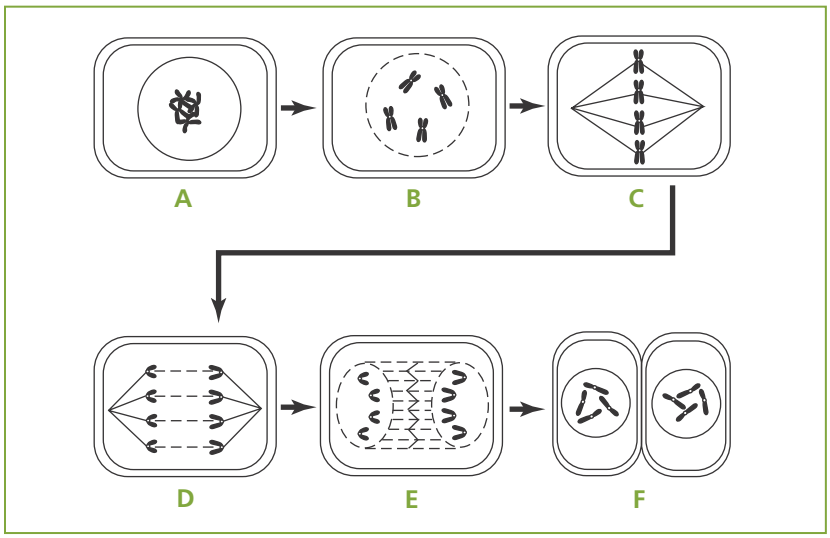


Figure 4-4. Mitotic cell division: The chromosomes in cell A have replicated, forming the double-stranded chromosomes that are finally visible in the cell at stage B. The four chromosomes line up single-file (C). Then the strands separate and move apart (D and E). The final result is two cells (F), each with four single-stranded chromosomes containing identical genetic information in their nuclei.

MemoryJogger

Recall that DNA replication makes an identical copy of all the genetic information in the molecule. The replicated strand carries the instructions for the same proteins as in the original strand. When the DNA replicates, it is actually turning a single-stranded chromosome into a double-stranded one. The double-stranded chromosome then has a duplicate set of instructions to pass on to each of two cells, as shown in Figure 4-2.

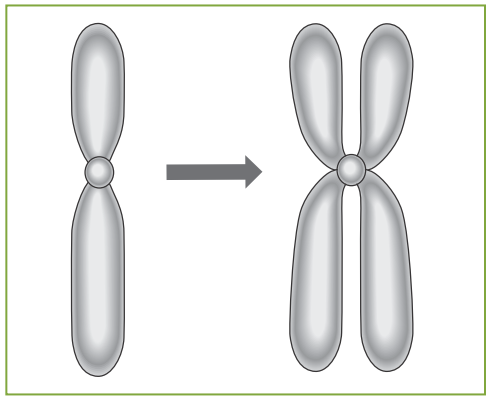


Figure 4-2. Chromosome duplication resulting from DNA replication: As a result of DNA replication, chromosomes become double-stranded.

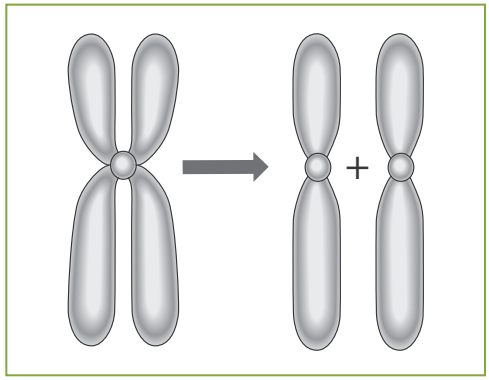


Figure 4-3. Chromosome during mitosis: When cells divide, each double-stranded chromosome separates into two identical single strands.

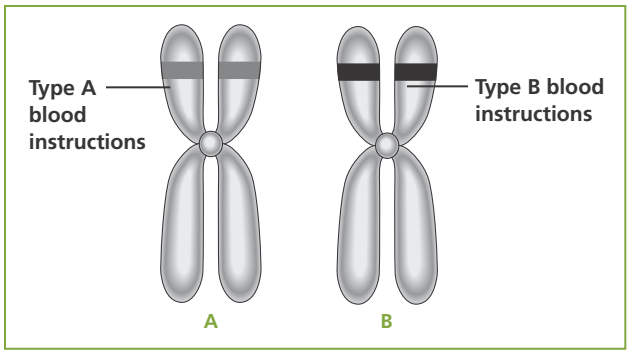


Figure 4-5. Two chromosomes with different information: The two chromosomes of each pair differ in the specific information they carry. For example, chromosome A may have coded gene instructions for type A blood, while the coded gene information on chromosome B may be for type B blood. Information for many other traits coded in the genes of these two chromosomes will be different, too, while some will be the same.

Meiotic Division/Meiosis

The gametes (sperm and eggs) formed during meiotic cell division each have only one half of the organism's genetic information—only one chromosome of each pair that is present in the body cells of that organism. However, a full set of genetic information is needed to produce a complete individual. When sperm and egg combine during **fertilization,** all of the newly paired chromosomes and all of the required genetic information are present in the fertilized egg.

Meiotic division begins with a body cell that has the full number of chromosomes typical of the species. Depending on the species, the cell contains one or more pairs of chromosomes that determine the traits of the organism. Figure 4-5 shows an example.

During the first phase of meiotic division, the double-stranded chromosomes line up in pairs in the center of the cell. The two chromosomes of each pair (still double-stranded) then separate, moving to opposite ends of the cell. Following this separation, the cell divides physically to form two cells.

The second phase involves the division of each of these two new cells. This time, however, the chromosomes line up in single file in the center of each cell. Each chromosome still consists of two strands. The strands separate and move to opposite ends of each of the dividing cells. When the process is complete, four cells have been formed, each having half the number of chromosomes of the organism's body cells. Each contains only one member of each original chromosome pair. Meiotic cell division is illustrated in Figures 4-6 and 4-7.

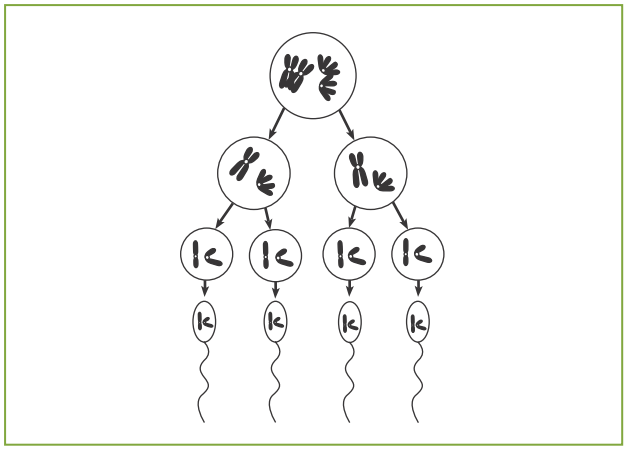


Figure 4-6. Meiotic cell division in the testes of males: Note the *four double-stranded chromosomes* (two pairs) present in the original cell. The pairs separate from each other during the first division—resulting in *two double-stranded chromosomes* in each of two cells. In the next division, the double-stranded chromosomes separate, leaving each final cell with *two single-stranded chromosomes*. These four cells can develop further into sperm cells in the testes of male individuals.

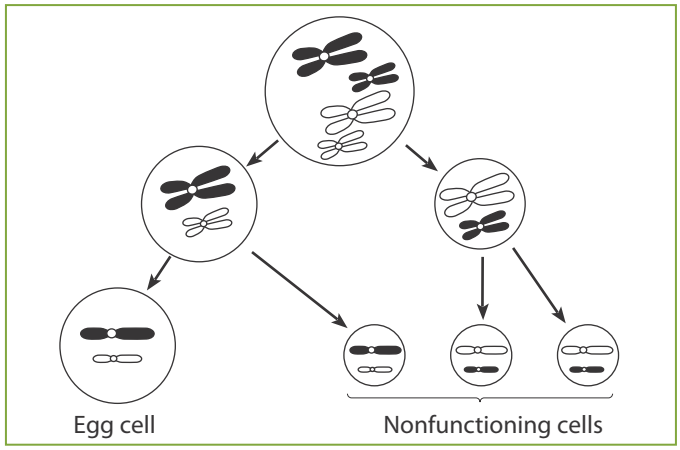


Figure 4-7. Meiotic cell division in the ovaries of females: This process is different from sperm cell formation because the cytoplasm divides unequally in each division, resulting in one large egg cell and three smaller cells that do not function. The egg cell is the one with the most cytoplasm.

Notice that the formation of cells during meiotic division, in which each cell has half the usual number of chromosomes, is very different from the duplication and distribution of a full set of chromosomes that occurs in mitotic division.

Meiotic division in females involves the same number of divisions and chromosome changes as in males. The division of the cytoplasm is where the two differ. The cytoplasm in a cell destined to become an egg cell divides unequally, resulting in one large egg cell and three small nonfunctioning cells. Meiotic division in females is shown in Figure 4-7.

Meiosis as a Source of Variation The events that occur during meiosis do more than simply divide chromosomes into smaller sets and form smaller cells. Meiosis is responsible for much of the genetic variation among the sex cells of each individual. For example, the two members of each pair of chromosomes carry different ways of expressing many of the organism's traits, so the way the different pairs randomly line up *in relation to other pairs* leads to many possible combinations in the sex cells that result. Two combinations are shown in Figure 4-8.

Another way variation can arise is by the exchange of parts of chromosomes, which occurs as they pair up during the first division. The process is sometimes called crossing-over. The result is shown in Figure 4-9. After separation, each set is unique. This means that there are no two sperm or egg cells, even from the same parent, that are alike. Each time a sperm and egg combine, a unique combination of genetic information results.

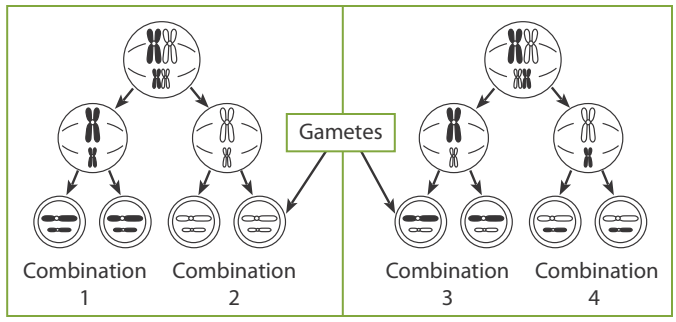


Figure 4-8. Two equally likely combinations of chromosomes lined up for meiotic division: A pair of chromosomes can be arranged in two ways when they pair up at the start of meiosis. This helps increase genetic variation. How many combinations do you see in the gametes? How would more pairs of chromosomes affect the number of possible arrangements?

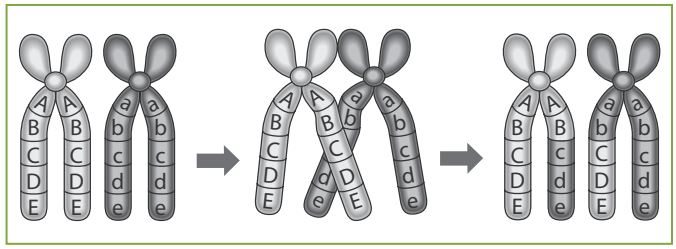


Figure 4-9. Result of exchanging parts between chromosomes: When chromosomes line up in pairs during meiosis (Step 1), their strands may connect or cross over (Step 2) and then separate in a way that parts are exchanged. All four strands now carry different combinations of information (Step 3).

Table 4-1. Summary of Mitotic and Meiotic Cell Division

Points of Comparison	Mitotic Division	Meiotic Division
Number of cell divisions	One	Two
Exchange of genetic material between chromosomes	No	Yes
Number of functioning cells produced from original	Two	Four sperm (in males) or one egg (in females)
Genetic makeup of final cells produced	Same as original	Highly variable gametes produced, each containing half of the genetic information of the original
Function of cells produced in multicellular organisms	Growth or replacement of body cells	Combine to form the zygote for reproduction

11. When complex plants are produced by cloning, which process is most directly involved?

(1) mitotic cell division
(2) meiotic cell division
(3) gamete production
(4) sperm cell fertilization

12. If a lobster loses a claw, it is capable of growing a new one. What process makes this possible?

(1) meiosis
(2) fertilization
(3) sexual reproduction
(4) mitosis

13. Organisms that reproduce asexually usually do so by a form of cell division called

(1) meiosis
(2) mitosis
(3) gamete formation
(4) sperm formation

14. A normal body cell of a fruit fly contains eight chromosomes. Each normal gamete of this organism contains

(1) four chromosomes as a result of meiosis
(2) four chromosomes as a result of mitosis
(3) eight chromosomes as a result of meiosis
(4) eight chromosomes as a result of mitosis

15. The process of mitotic cell division normally results in the production of

(1) four cells with half the number of chromosomes as the parent
(2) two cells with the same number of chromosomes as the parent
(3) two cells with only one chromosome from each parent
(4) one cell with a replicated set of matched chromosomes

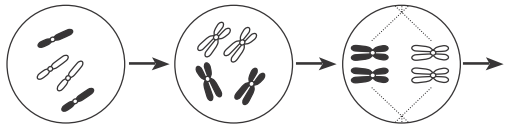
16. Each of the two daughter (or offspring) cells that result from the normal mitotic division of the original parent cell contains

(1) the same number of chromosomes but different genes than the parent cell
(2) the same number of chromosomes and genes identical to those of the parent cell
(3) one half of the number of chromosomes but different genes than those of the parent cell
(4) one half of the number of chromosomes and genes identical to those of the parent cell

17. All types of asexual reproduction involve the process known as

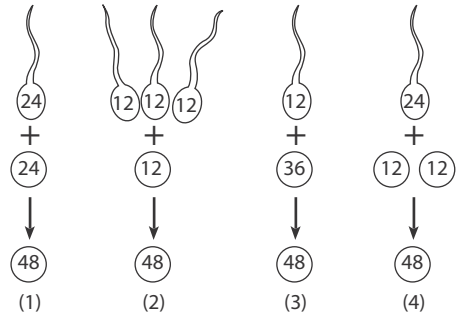
(1) mitosis
(2) fertilization
(3) meiotic division
(4) aging

18. The diagrams below represent the sequence of events in a cell undergoing normal meiotic cell division.

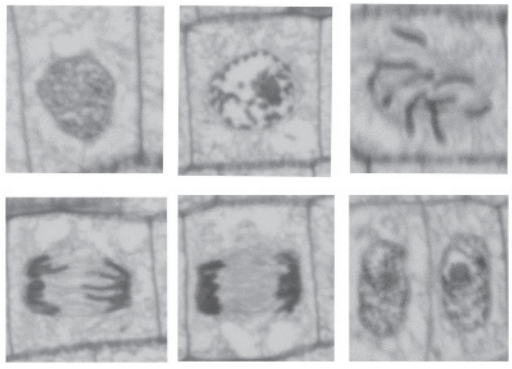


- How many cells will finally be produced? [1]
- How many chromosomes will be in each cell? [1]
- Sketch one of the final cells, showing its chromosomes. [1]

19. The species chromosome number of orangutans is 48. Which diagram represents normal fertilization in orangutans?



20. Which process is represented in the following photographs?



(1) mitotic cell division
(2) zygote formation
(3) fertilization
(4) recombination

21. If the sperm cells of a fish have 12 chromosomes, how many chromosomes would be found in the cells forming the scales of the fish?

(1) 6
(2) 12
(3) 24
(4) 48

Zygote Formation During fertilization, the gametes unite to form a **zygote**—a cell that contains all of the genetic information needed by the offspring. This process is known as **recombination,** since the genes from both parents recombine when fertilization occurs. Since a sex cell contains a unique combination of genetic material, the result of the random combination of any sperm and egg explains the variation found in offspring produced by sexual reproduction. This variation plays a key role in evolutionary change and species survival.

The zygote contains all the information necessary for growth, development, and eventual reproduction of the organism. The zygote divides by mitosis to form a multicellular organism. Fertilization, zygote formation, and some early mitotic divisions that occur in development are shown in Figure 4-10.

Early Development During the early stages of development, the cells that are formed by mitotic division begin to undergo **differentiation,** which simply means that they become different from one another. This leads to the formation of specialized cells, which form the tissues, and then the organs, of multicellular organisms.

In an **embryo,** an organism in an early stage of development, all the genetic information in each cell starts out the same. However, different genes are activated or deactivated in certain cells, causing them to make only some of the many proteins they are capable of synthesizing. As a result, these cells become different from others, and may develop into skin cells, muscle cells, or any of the other specialized cells of the organism. The activation or inactivation of genes can be due to environmental influences from within the cell, from surrounding cells, or from outside the organism.

When a gene is actively producing its protein, scientists say that the gene is **expressed.** There is much evidence that **gene expression,** which is the result of activated genes, can be modified through interaction with the environment. For example, fruit flies that have genes to develop curly wings will develop straight wings instead, if they are raised in a cooler than normal environment. Another example of an environmentally produced gene modification is a plant grown without light. Such a plant is white instead of green, because sunlight is needed to stimulate the gene that produces chlorophyll.

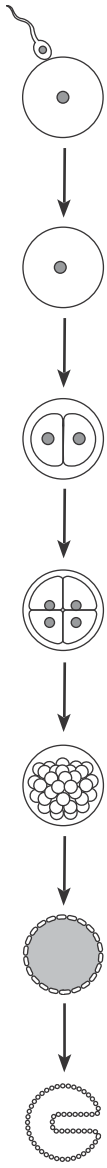


Figure 4-10. Fertilization, zygote formation, and early development: Note that all cell divisions here are by MITOTIC division.

Review Questions Set 4.3

22. An exact duplication of the complete set of chromosomes of a cell, followed by the separation of these duplicate sets into two new cells, is known as

(1) mitotic cell division (3) meiotic cell division
(2) zygote formation (4) fertilization

23. New cells are produced within the uterus as a direct result of

(1) gamete formation
(2) meiotic cell division
(3) mitotic cell division
(4) ecological succession

24. The data table below summarizes the results of an experiment using primrose plants grown under different temperature conditions.

Data Table: Primrose Color Under Two Growing Conditions				
Flower Color	**Temperature of 20°C**		**Temperature of 31°C**	
Color coded in DNA	Red	White	Red	White
Actual color expressed	Red	White	White	White

Which conclusion can be drawn from this data table?

(1) Color in primroses is determined only by gene action.
(2) Many traits are not inherited.
(3) Gene exchanges only occur when the plants are grown at lower temperatures.
(4) There is an interaction between environment and heredity.

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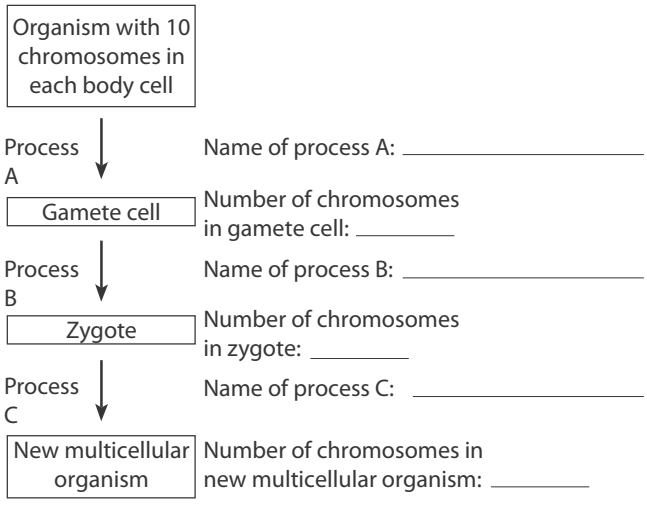
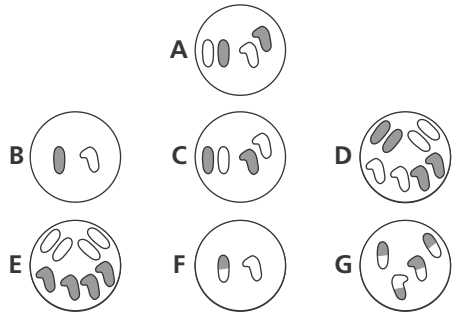
25. When organisms reproduce sexually, the species number of chromosomes is maintained. This can be demonstrated with a diagram like the one below. Complete the diagram by filling in the blanks with the appropriate information.



Base your answers to questions 26 through 29 on the diagrams below and on your knowledge of biology.

Diagram A represents the chromosomes in the nucleus of the body cell of a worm. Diagrams B through G represent chromosomal arrangements that may occur in other cells produced by this worm.



26. If meiosis failed to occur in both male and female worms, the zygote nucleus would resemble diagram

(1) E (2) G (3) C (4) D

27. If genes were exchanged between a single pair of chromosomes during gamete formation, the gamete nucleus would most closely resemble diagram

(1) F (2) B (3) C (4) G

28. The nucleus of a normal zygote formed when fertilization occurs in this species would most likely resemble diagram

(1) E (2) F (3) C (4) D

29. The nucleus of a mature gamete from a female worm would most likely resemble diagram

(1) E (2) B (3) C (4) D

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30. In human females, gametes are produced in the

(1) uterus (3) ovaries
(2) testes (4) estrogen

31. Complex organisms produce sex cells that unite during fertilization forming a single cell known as

(1) an embryo (3) a clone
(2) a gamete (4) a zygote

Human Reproduction and Development

Human reproduction and development are carried out by specialized organs. The function of these organs is regulated by hormones from the endocrine system. In humans, as in nearly all mammals, fertilization and development occur internally—within the mother's body. Reproductive organs in other mammals are similar in appearance and function.

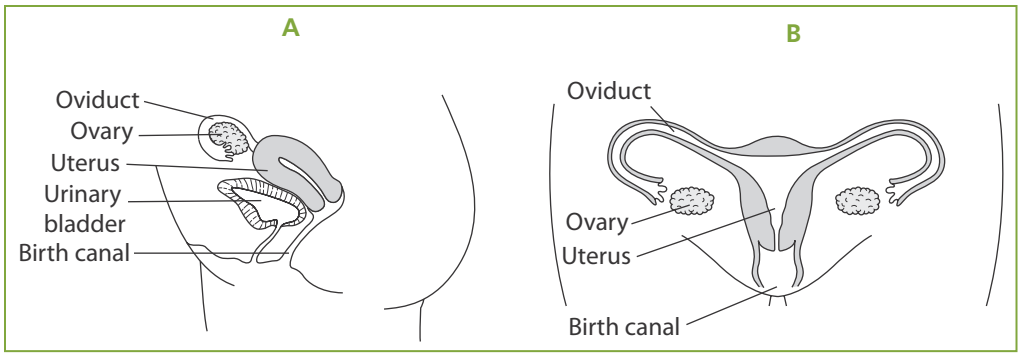


Figure 4-11. Two views of essential parts of the human female reproductive system and other structures: View A is from the side; View B is from the front.

Female Reproductive System The human female reproductive system is organized to produce gametes, to support internal fertilization and development, to exchange materials through the placenta, and to provide milk to the offspring.

In human females, the **ovaries** produce egg cells (female gametes) and the hormones **estrogen** and **progesterone.** These hormones are associated with sexual development and the reproductive process. The ovaries are located near the open ends of tubes called oviducts (egg ducts). The egg cell can be fertilized in the oviduct if sperm are present. The oviducts lead to the **uterus,** where the embryo develops into a fetus. The main parts of the female reproductive system are illustrated in Figure 4-11.

After the fertilized egg sinks into the thickened wall of the uterus, a placenta begins to form. The **placenta** is the organ responsible for the passage (by diffusion) of nutrients and oxygen from the mother's blood to the fetus. Wastes from the fetus also diffuse to the mother's blood through the placenta. During birth, the muscular uterus undergoes a series of contractions that eventually push the baby out of the mother's body. The early events of pregnancy are shown in Figure 4-12.

Male Reproductive System The **testes** of the male reproductive system are the organs that produce sperm cells. The testes also produce the hormone **testosterone,** which is associated with male sexual development and reproduction. Other structures associated with the male reproductive system produce the fluids and nutrients that are needed for the proper function and delivery of the male gametes to the female reproductive system. The essential parts of the human male reproductive system are shown in Figure 4-13.

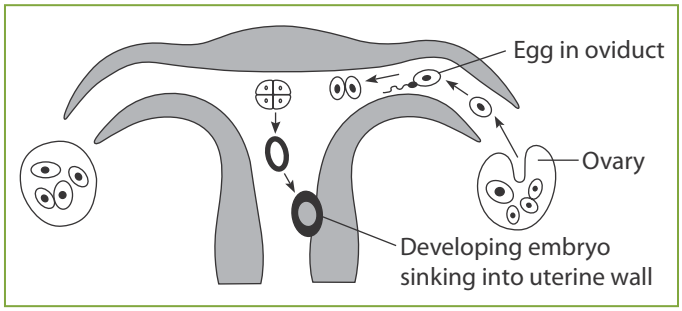


Figure 4-12. Early events of pregnancy: The egg released by the ovary travels down the oviduct where fertilization occurs. Mitotic divisions of the zygote begin as it continues to the uterus, where the developing embryo sinks into the uterine wall, and the placenta forms. The placenta will supply essential materials and remove wastes throughout the rest of the pregnancy.

Table 4-2. The Functions of the Parts of the Human Female Reproductive System

Structure	Function
Ovary	Produces egg cells; releases the hormones estrogen and progesterone
Oviduct	Site of fertilization; carries egg to uterus
Uterus	Site where embryo and fetus develop in association with placenta
Birth canal (vagina)	Site where sperm enter and swim to egg in oviduct; passageway for the birth of baby

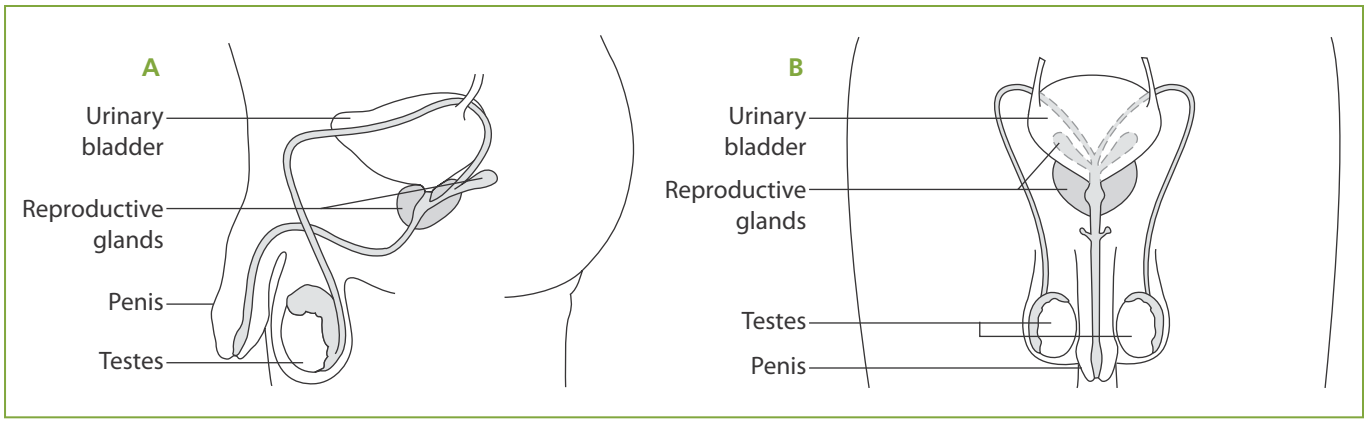


Figure 4-13. Two views of the essential parts of the human male reproductive system and other structures: View A is from the side; View B is from the front.

Hormonal Regulation The male reproductive system and other male characteristics, such as facial hair and a deep voice, that develop as sexual maturity is reached are influenced by several hormones, including testosterone from the testes. The development of the female reproductive system and female features, such as breast development and widening of the hips, also involves several important hormones, such as estrogen and progesterone.

Once sexual maturity is reached, females begin a regular cycle of about 28 days, during which an egg is released on about day 14. The timing of the events of this cycle is regulated by two hormones from the ovaries, along with several others from an endocrine gland in the brain. Figure 4-14 illustrates the changes in the level of several hormones associated with regulating this monthly cycle. The cycle varies slightly from individual to individual.

Although the interactions of the hormones are quite complex, estrogen and progesterone play important roles in the female reproductive cycle. Estrogen from the ovaries influences the sexual development of females. Together, estrogen and progesterone influence the preparation of the lining of the uterus so that a fertilized egg that embeds itself there can develop normally. Progesterone also maintains the uterine lining throughout pregnancy. For this reason, progesterone is often called the hormone of pregnancy. At the end of the cycle, if an egg is not fertilized, the levels of estrogen and progesterone decrease, and the lining of the uterus breaks down. Then the cycle begins again.

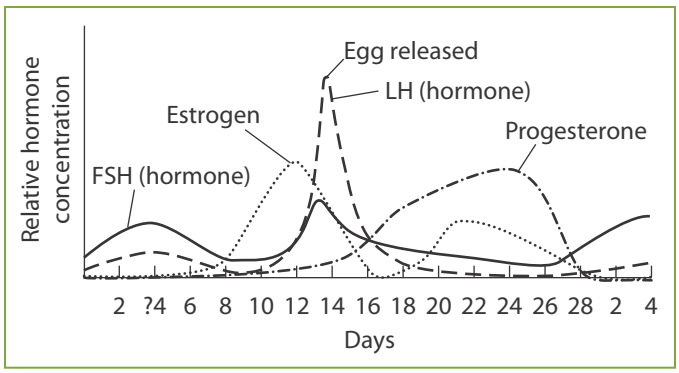


Figure 4-14. Hormones and events associated with the monthly reproductive cycle in human females: Notice the rise and fall in hormone levels at various times. These changes influence such events as the release of the egg from the ovary, the preparation of the uterus for a possible pregnancy, and the breakdown of the uterine lining if no pregnancy occurs. Remember that the timing of this cycle is NOT the same for everyone.

Human Development As with most other mammals, embryonic development continues in the uterus. Figure 4-15 shows some of the features of the uterus during pregnancy.

During the first part of pregnancy, cells continue to divide by mitotic division and begin to differentiate, forming tissues and organs. The placenta and a fluid-filled sac that cushions and

protects the developing embryo both form at this time, too. After about two months, when all the major organs have begun to form, the embryo is called a **fetus.**

During the first few months, when essential organs are forming in the embryo, things can go wrong. Problems associated with either the embryo's inherited genes or the mother's exposure to various harmful environmental factors can affect the embryo. Harmful environmental factors that a woman should avoid at any time during pregnancy include alcohol, drugs, and tobacco. Use of these can lead to the birth of a baby with brain damage, drug addiction, and/or low birth weight and the problems associated with it. An embryo or fetus may also be harmed if the mother has a poor diet, is exposed to certain toxic substances, or gets certain infections, such as German measles or AIDS.

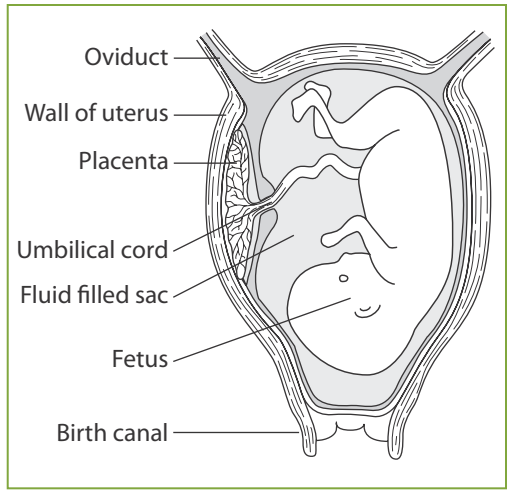


Figure 4-15. The uterus during pregnancy

After birth, cell differentiation and body growth continue until adulthood. During adulthood, the structures of the body slowly begin to age. Eventually, the organism weakens and dies. This process of birth, growth, development, aging, and death is a predictable pattern that applies not just to humans, but to all organisms.

Applications of Reproductive Technology

Recent discoveries by scientists have greatly changed the way we can deal with many problems involving the reproduction of humans as well as plants and other organisms. The knowledge we have gained has a variety of agricultural, ecological, and medical applications.

In the field of agriculture, scientists have produced plants that are resistant to insects, weed killers, and even frost. Such altered plants can then be cloned to produce thousands of genetically identical offspring. Using artificial insemination, scientists can generate hundreds of offspring from one farm animal. They can also freeze the sperm or fertilized eggs of an animal and transport them to animals thousands of miles away, at far less cost than transporting the animals themselves.

In the field of ecology, reproductive technology is being used to help build up populations of endangered species. Embryos from the endangered species have been transplanted into related species, who later give birth to offspring that are no different than they would be if they developed in the bodies of the endangered animals themselves. Also, hormones of insects that regulate their reproduction and development have been studied in an attempt to find ways to control insects without using poisonous chemicals.

In the field of medicine, recent scientific discoveries have led to new ways of dealing with reproductive problems in humans, other animals, and plants. Some women cannot become pregnant because of problems with their hormones, ovaries, or other parts of their reproductive systems. Reproductive technologies have enabled doctors to help infertile women become pregnant by using hormone therapy to adjust their hormones to normal levels. Sometimes doctors can extract several eggs from a woman's ovaries and fertilize them with sperm in a laboratory dish. When these

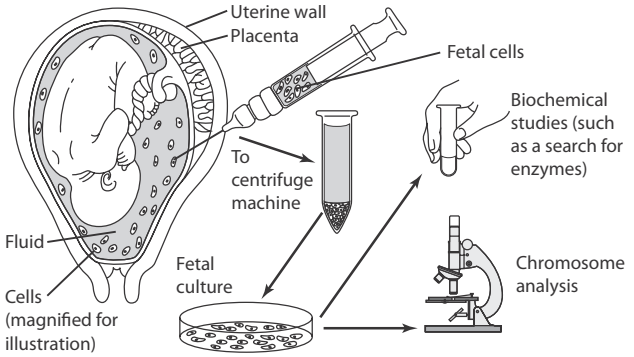


Figure 4-16. Obtaining fetal cells and fluids during pregnancy: Biochemical studies and chromosome analysis of the fetus can be done with cells and fluids removed during pregnancy.

fertilized eggs are implanted in the woman's uterus, a successful pregnancy may result.

Ultrasound and miniature video cameras allow doctors to view ovaries, oviducts, and other reproductive structures, or even a developing fetus, to determine if or where problems exist. Methods have also been developed to retrieve fetal cells that are present in the fluids around the developing fetus. (See Figure 4-16.) Doctors can then analyze the cells for chromosome abnormalities and the fluids for biochemical deficiencies that may threaten the health or development of the fetus.

Review Questions — Set 4.4

32. What substances are involved in controlling the production of sperm and eggs in humans?

(1) vitamins (3) starches
(2) hormones (4) minerals

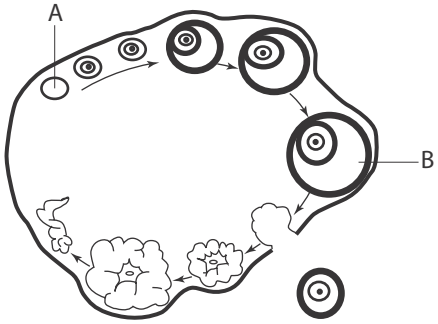
33. Which practice is essential to good prenatal care?

(1) increased egg production
(2) frequent dieting
(3) avoidance of drugs
(4) intake of antibiotics

34. Which part of the human male reproductive system produces hormones that influence the development of male sex characteristics?

(1) penis (3) gametes
(2) testes (4) ovaries

35. The diagram below represents a sequence of events in a human ovary.



The process that occurs between stage A and stage B is known as

(1) egg formation (3) mitotic cell division
(2) sperm formation (4) cell recombination

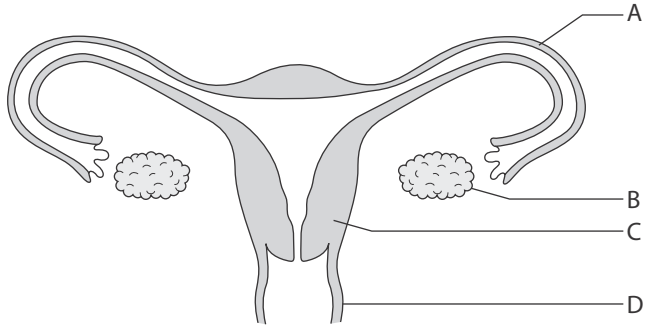
36. The diagram below represents a series of events that takes place in the life cycle of humans.

Egg and Sperm Formation → **X** → Many Rapid Cell Divisions → New Organism

Which term best describes the event taking place in the box labeled X?

(1) fertilization (3) meiosis
(2) immune response (4) protein synthesis

Base your answers to questions 37 through 39 on the diagram below and on your knowledge of biology. The diagram represents the human female reproductive system.



37. Fertilization usually occurs within structure

(1) A (2) B (3) C (4) D

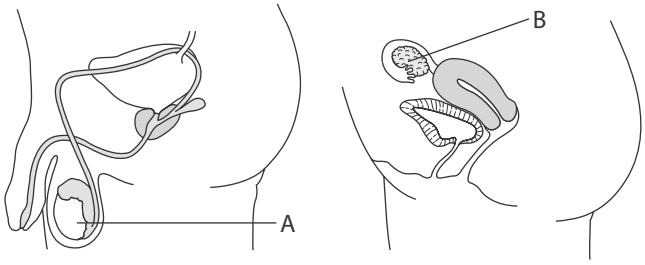
38. A placenta normally develops in structure

(1) A (2) B (3) C (4) D

39. The structure that produces estrogen and progesterone is

(1) A (2) B (3) C (4) D

Base your answers to questions 40 through 42 on the diagram below and on your knowledge of biology. The diagram represents the human male and female reproductive systems.



40. Gametes are produced in

(1) A, only
(2) B, only
(3) both A and B
(4) neither A nor B

41. Estrogen and progesterone are produced in

(1) A, only
(2) B, only
(3) both A and B
(4) neither A nor B

42. A substance is produced that influences both the reproductive cycle and the development of sex characteristics in

(1) A, only
(2) B, only
(3) both A and B
(4) neither A nor B

---

43. In humans and other mammals, nutrients are transferred from the mother's bloodstream to the embryo's bloodstream across the

(1) placenta
(2) uterus
(3) ovary
(4) intestine

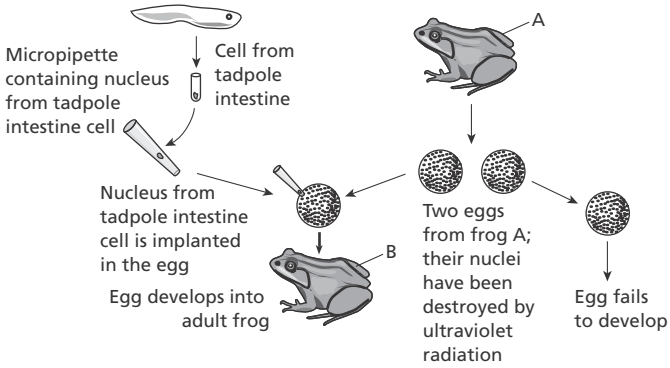
44. Which substance is a waste that would normally diffuse across the placenta from the embryo to the mother?

(1) glucose
(2) oxygen
(3) amino acid
(4) carbon dioxide

45. The egg of a mammal is smaller than that of a bird because the embryo of the mammal obtains its nutrients from the

(1) placenta through the process of diffusion
(2) mammary glands of the mother
(3) blood of the mother when it mixes with the blood of the embryo
(4) yolk stored in the uterus of the mother

Base your answers to questions 46 and 47 on the diagram below, which represents an experiment, and on your knowledge of biology.



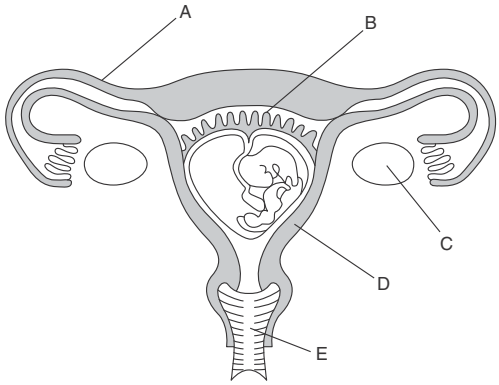
46. An inference that can be made from this experiment is that

(1) adult frog B will have the same genetic traits as the tadpole
(2) adult frog A can develop only from an egg and a sperm
(3) fertilization must occur in order for frog eggs to develop into adult frogs
(4) the nucleus of a body cell fails to function when transferred to other cell types

47. Other scientists substituted a nucleus from a frog sperm cell and no adult frog developed. Explain why a sperm cell nucleus would not work in this procedure. [1]

Base your answers to questions 48 through 51 on the diagram below and on your knowledge of biology. The diagram represents the human female reproductive system.

Fill in the boxes numbered 48 through 51 in the chart below using the information from the diagram.



Name of Structure	Letter on Diagram	Function of Structure
48. _____ [1]	**49.** _____ [1]	produces gametes
uterus	D	**50.** _____ [1]
51. _____ [1]	B	transports oxygen directly to the embryo

Directions

Review the Test-Taking Strategies section of this book. Then answer the following questions. Read each question carefully and answer with a correct choice or response.

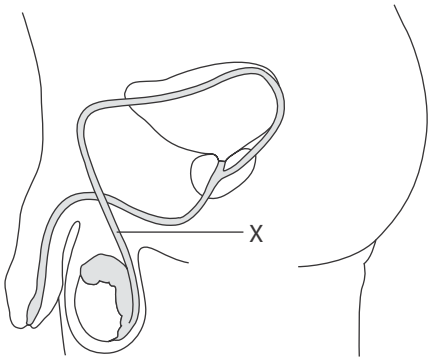
Part A

1 Compared to the number of chromosomes in a normal human body cell, the number of chromosomes in a normal sperm cell is
(1) the same
(2) twice as great
(3) half as great
(4) four times as great

2 Children born to the same parents are usually very different from each other. These differences result primarily from the process of
(1) mitotic division
(2) meiosis
(3) asexual reproduction
(4) cloning

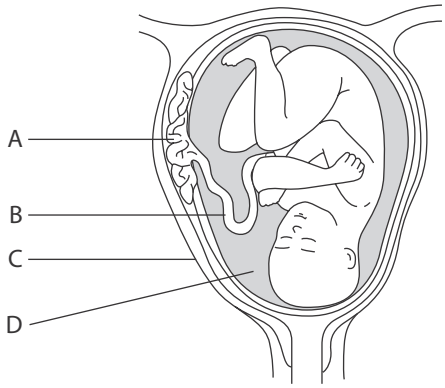
3 Human growth and sexual development are controlled by
(1) nerves
(2) hormones
(3) the digestive system
(4) the excretory system

4 The diagram below represents the human male reproductive system.



If structure X were cut and tied off at the line, which change would occur immediately?
(1) Hormones would no longer be produced.
(2) Sperm would no longer be produced.
(3) Sperm would be produced but no longer released from the body.
(4) Urine would be produced but no longer released from the bladder

Base your answers to question 5 through 7 on the diagram below, which represents a stage in human development.



5 The exchange of oxygen, food, and wastes between mother and fetus occurs at
(1) A
(2) B
(3) C
(4) D

6 What is the function of the fluid labeled D?
(1) nourishment
(2) protection
(3) excretion
(4) respiration

7 The structure labeled C, within which development occurs, is known as the
(1) birth canal
(2) uterus
(3) ovary
(4) placenta

---

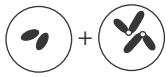
8 Which is arranged in the correct sequence?
(1) fertilization → embryo development → meiosis → birth
(2) embryo development → meiosis → fertilization → birth
(3) meiosis → fertilization → embryo development → birth
(4) fertilization → meiosis → embryo development → birth

9 The diagram at the right represents a cell that will undergo mitosis.

Which of the diagrams best illustrates the daughter cells that result from a normal mitotic cell division of the parent cell shown?

(1) 

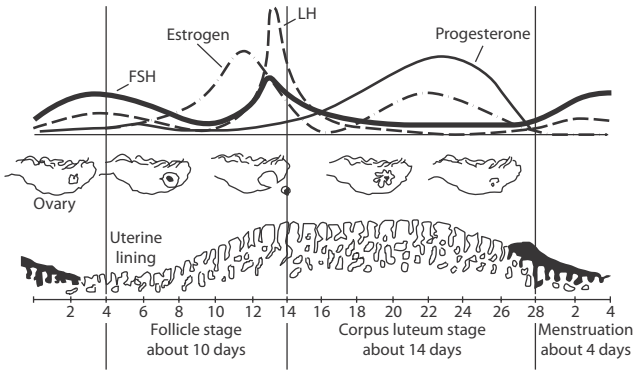
(2) 

(3) 

(4) 

Part B

Base your answers to questions 10 through 14 on the diagram below, which shows some events in the human female reproductive cycle, and on your knowledge of biology.



10 During which part of this cycle does the breakdown of the thickened uterine lining occur?
(1) ovulation
(2) corpus luteum stage
(3) menstruation
(4) follicle stage

11 On or about which day is the egg released from the ovary?
(1) day 8
(2) day 14
(3) day 20
(4) day 28

12 What is the average length of this reproductive cycle?
(1) 32 days (3) 14 days
(2) 28 days (4) 4 days

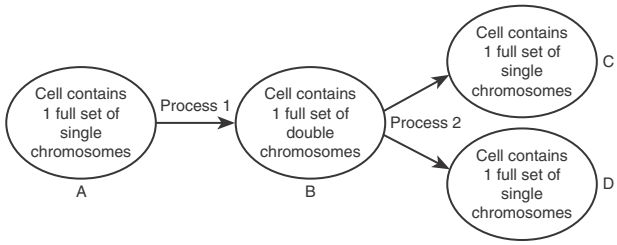
13 The hormone FSH stimulates the development of a follicle in the ovary of a human female. As the follicle develops, it secretes estrogen. A high level of estrogen decreases the secretion of FSH. This mechanism is an example of
(1) gamete development
(2) cell differentiation
(3) positive feedback
(4) negative feedback

14 Identify another human reproductive hormone that is *not* shown on this diagram. [1]

---

15 Compare the number of chromosomes present in the offspring with the number of chromosomes present in the parent organism in the process of cloning. [1]

Base your answers to questions 16 through 19 on the diagram below and on your knowledge of biology. The diagram represents a single-celled organism, such as an ameba, undergoing the changes shown.



16 As a result of these processes, the single-celled organism accomplishes
(1) gamete production (3) sexual reproduction
(2) energy production (4) asexual reproduction

17 Process 1 is known as
(1) replication (3) differentiation
(2) meiosis (4) digestion

18 Process 1 and process 2 are directly involved in
(1) meiotic cell division (3) fertilization
(2) mitotic cell division (4) recombination

19 The genetic content of *C* is usually identical to the genetic content of
(1) *B* but not *D* (3) *D* but not *A*
(2) both *B* and *D* (4) both *A* and *D*

Base your answers to questions 20 and 21 on the information below and on your knowledge of biology.

The reproductive cycle in a human female is not functioning properly. An imbalance of hormones is diagnosed as the cause.

20 Identify one hormone directly involved in the human female reproductive system that could cause this problem. [1]

21 Explain why some cells in a female's body respond to reproductive hormones while other cells do not. [1]

22 The data in the table below indicate the presence of specific reproductive hormones in blood samples taken from three individuals. An *X* in the hormone column indicates a positive lab test for the appropriate levels necessary for normal reproductive functioning in that individual.

Data Table

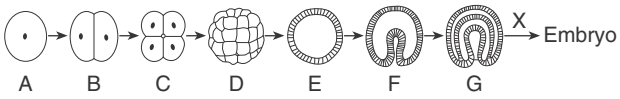
Individuals	Hormones Present		
	Testosterone	Progesterone	Estrogen
1		X	X
2			X
3	X		

Which processes could occur in individual 3?

(1) production of sperm, only
(2) production of sperm and production of eggs
(3) production of eggs and embryonic development
(4) production of eggs, only

Base your answers to questions 23 through 25 on the diagram below, which represents some stages in the development of an embryo, and on your knowledge of biology.

23 This entire sequence (*A* through embryo) started directly after



(1) the periodic shedding of a thickened uterine lining
(2) mitotic cell division in a testis
(3) meiotic cell division in the placenta
(4) the process of fertilization

24 If cell A has 46 chromosomes, how many chromosomes will most likely be found in each cell of stage *G*?

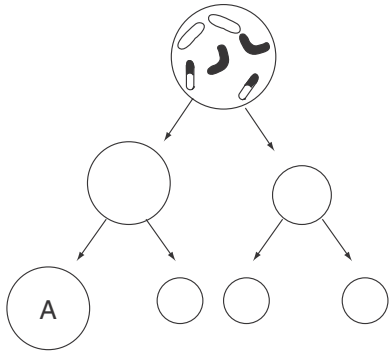
(1) 23 (3) 69
(2) 46 (4) 92

25 The arrow labeled *X* represents the process of

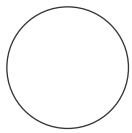
(1) meiosis (3) differentiation
(2) recombination (4) cloning

---

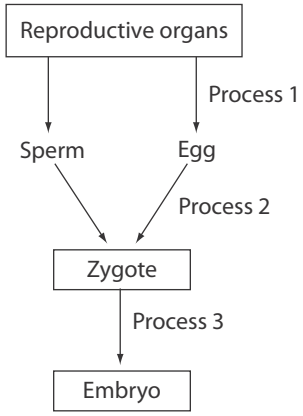
26 An incomplete diagram of meiosis in the ovary of an animal is shown below.



On the diagram below, draw in the chromosomes of cell *A*. Your drawing should show the usual result of the process of meiosis. [1]



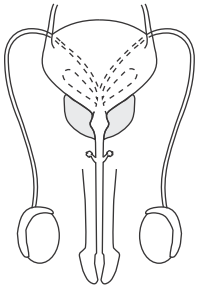
Base your answers to questions 27 and 28 on the diagram below and on your knowledge of biology.



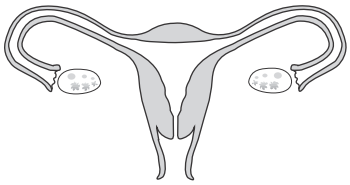
27 State why Process 2 is necessary in sexual reproduction. [1]

28 State *one* difference between the cells produced by Process 1 and the cells produced by Process 3. [1]

Directions (29–31): The diagrams below represent organs of two individuals. The diagrams are followed by a list of sentences. For each phrase in questions 29 through 31, select the sentence from the list below that best applies to that phrase and record its number.



Individual A



Individual B

Sentences

1. The phrase is correct for both Individual *A* and Individual *B*.
2. The phrase is not correct for either Individual *A* or Individual *B*.
3. The phrase is correct for Individual *A*, only.
4. The phrase is correct for Individual *B*, only.

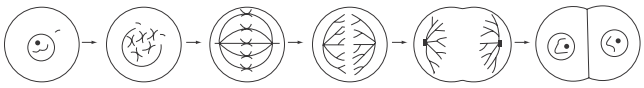
29 Contains organs that produce gametes [1]

30 Contains organs involved in internal fertilization [1]

31 Contains a structure in which a zygote divides by mitosis [1]

---

32 Which activity most directly involves the process represented in the diagram below?



(1) a gamete reproducing sexually
(2) a white blood cell engulfing bacteria
(3) a zygote being produced in an ovary
(4) an animal repairing damaged tissue

Part C

Base your answer to question 33–35 on the information below and on your knowledge of biology.

The Critical Role of the Placenta

The proper functioning of the placenta is critical to the growth and development of a healthy fetus. For example, the placenta appears to act as a nutrient sensor. It regulates the amounts and types of nutrients that are transported from the mother to the fetus.

Improper functioning of the placenta can alter the structure and function of specific cells and organ systems in the developing fetus, putting it at risk for health problems as an adult. For example, in some pregnancies, the placenta develops a resistance to blood flow.

This resistance appears to force the heart of the fetus to work harder. This could result in an increased chance of the individual developing heart disease as an adult. A group of hormones known as glucocorticoids affects the development of all the tissues and organ systems. One of the things this group of hormones does is to alter cell function by changing the structure of cell membrane receptors.

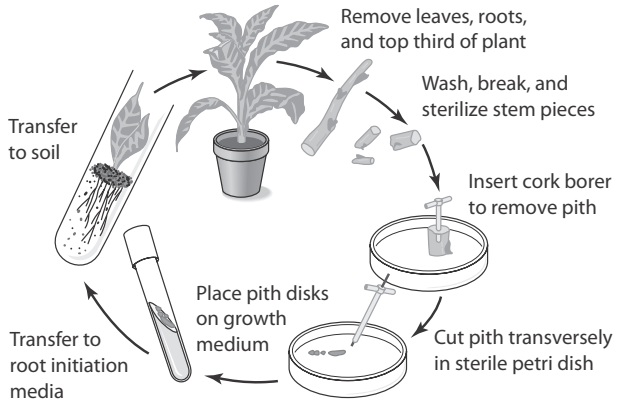
33–35 Discuss the importance of the placenta in the development of a healthy fetus. In your answer, be sure to:

- identify two factors that could influence the nutrients that can pass from the mother to the fetus [1]
- identify the group of hormones that alter cell membrane receptors and explain how this alteration can affect cell function [1]
- state the role of the uterus in the development of the fetus and the placenta [1]

---

36 The production of a normal baby involves protecting the developing embryo from harmful environmental factors. State three ways in which the pregnant woman could avoid exposing the developing embryo to environmental risks. [1]

37 The diagram below shows some steps involved in preparing tissue cultures in plants.



Compare the genetic makeup of the offspring plants that are transferred to the soil to that of the parent plant that provided the stem pieces. [1]

38 The process of meiosis followed by fertilization is necessary to maintain the species chromosome number of a sexually reproducing species. For instance, a species with 24 chromosomes in each body cell normally has offspring that also have 24 chromosomes in their body cells.

Explain the specific way that meiotic cell division and fertilization interact to help maintain the species chromosome number. [1]

Base your answers to questions 39 through 41 on the information below and on your knowledge of biology.

Egg Laying vs. Bearing Live Young

Three groups of animals in which most species lay eggs for reproduction are amphibians, reptiles, and birds.

Most female amphibians lay hundreds of eggs in water, which are then fertilized by sperm from the male. Many reptiles lay between 1 and 200 eggs at a time, often in nests on land. The eggs have a leathery shell.

Birds usually lay between one and four eggs at a time in nests on land. Wild bird eggs usually have shells similar to those of the domestic chicken.

Most mammals bear live young. Some of these mammals, humans, for example, usually give birth to one live offspring at a time.

39 State one reason that individuals of some species must lay hundreds of eggs in order for the species to survive. [1]

40 Explain why fertilization in reptiles and birds must be internal. [1]

41 State two reasons that the human species has been able to survive, even though usually only one offspring is born at a time. [1]

Base your answers to question 42–46 on the information below and on your knowledge of biology.

Scientists have successfully cloned sheep and cattle for several years. A farmer is considering having a flock of sheep cloned from a single individual.

42–46 Discuss the process of cloning a flock of sheep. In your answer be sure to:

- state how a cloned flock would differ from an flock of sheep that was not cloned [1]
- state one advantage of having a cloned flock [1]
- state one disadvantage of having a cloned flock [1]
- state one reason the farmer would be able to mate the sheep in his flock with others in the flock [1]
- explain why breeding a sheep from his flock with sheep not in his flock would produce offspring that are not all identical clones [1]

Base your answers to question 47–48 on the information below and on your knowledge of biology.

47–48 Sexual and asexual reproduction are similar in some ways and different in others. Compare the two types. In your answer be sure to:

- Identify which type of reproduction results in genetically identical offspring. Explain why this occurs [1]
- describe one other way the two methods differ from each other [1]

49–53 Base your answers to question 49-53 on the information below and on your knowledge of biology.

A human is a complex organism that develops from a zygote. Briefly explain some of the steps in this process. In your answer be sure to:

- explain how a zygote is formed [1]
- compare the genetic content of the zygote to that of a body cell of the parents [1]
- identify one developmental process involved in the change from a zygote into an embryo [1]
- identify the structure in which fetal development usually occurs [1]
- identify one factor that can affect fetal development and explain how that factor affects fetal development [1]

Base your answers to questions 54 and 55 on the information below and on your knowledge of biology. The reproductive cycle in a human female is not functioning properly. An imbalance of hormones is diagnosed as the cause.

54 Identify one hormone directly involved in the human female reproductive system that could cause this problem. [1]

55 Explain why some cells in a female's body respond to reproductive hormones while other cells do not. [1]