4.3 Adaptations for Reproduction

VOCABULARY

asexual reproduction	egg	meiosis	species
binary fission	fertilization	mitosis	sperm
budding	genes	sex cells	
chromosomes	heredity	sexual reproduction	

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.

When organisms reproduce, parents pass on specific genetic instructions, called **genes**, to their offspring. The genes present in an organism determine which traits or characteristics the offspring will have. All organisms—whether they are animals, plants, or members of one of the other kingdoms—pass their genetic characteristics along in this manner. Because of this transfer of genetic information, offspring tend to resemble their parents.

Heredity and Genes

Heredity is the passing of genetic information from one generation to the next through reproduction. The hereditary information (DNA) is organized in the form of genes located in the chromosomes of each cell. **Chromosomes** are structures found in cell nuclei that contain DNA and therefore carry the genetic information. (See Figure 4-16.) The DNA molecules carry the genetic information of the cell.

Types of Reproduction

There are two methods of reproduction 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.

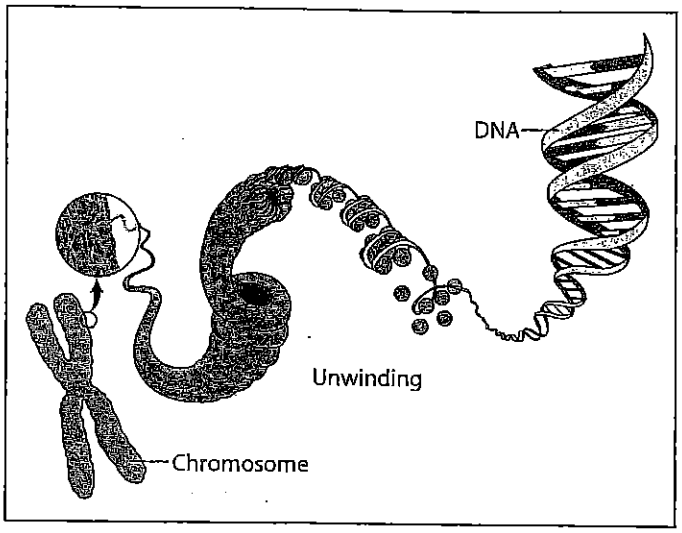


Figure 4-16. Chromosomes contain DNA: Notice that the chromosome contains one very long double strand of DNA.

ASEXUAL REPRODUCTION Organisms that reproduce asexually produce their offspring in a variety of ways. Unicellular organisms often divide into two cells of equal size, thus producing two new individuals. This process is called **binary fission**. The parent in this case *becomes* the offspring! Other organisms, such as molds and mushrooms, produce spores—special cells that have a complete set of genetic information. These individual spores can each develop into a new member of the species. Still others reproduce by **budding**, producing outgrowths of the body called buds, which later detach to become separate individuals. Many plants can develop from parts that are either broken off intentionally by humans or separated

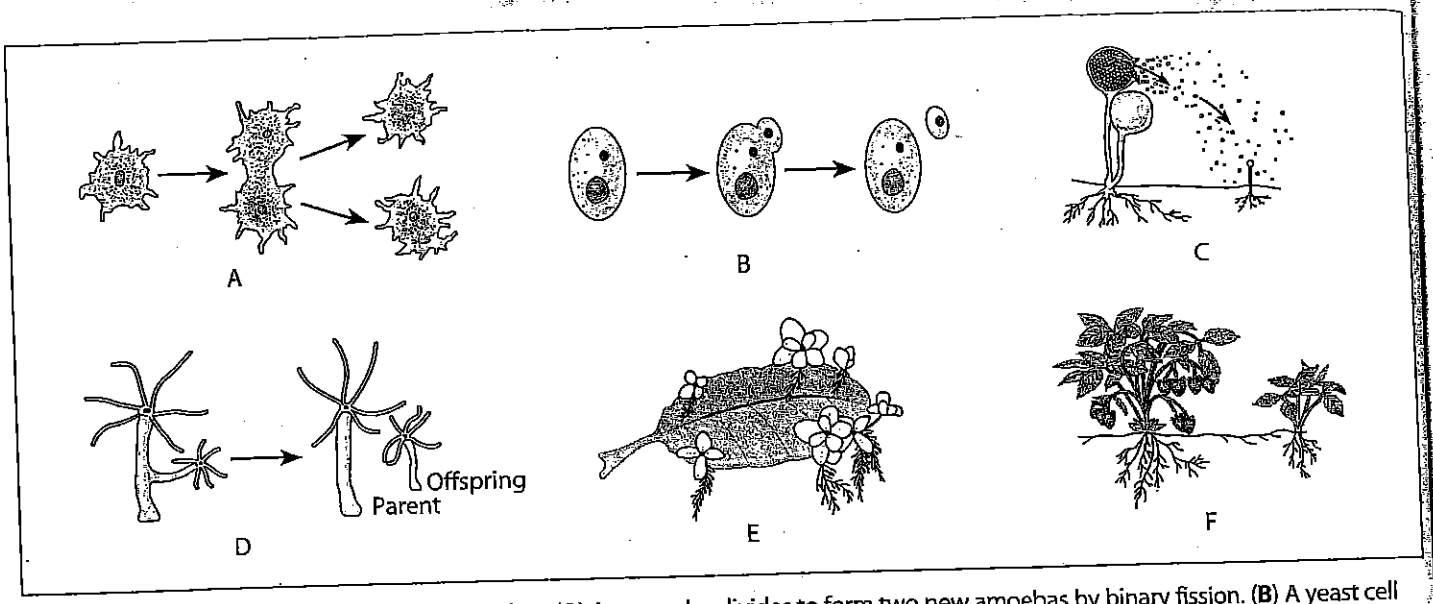


Figure 4-17. Examples of asexual reproduction: (**A**) An amoeba divides to form two new amoebas by binary fission. (**B**) A yeast cell forms a bud and eventually divides into two cells that are different sizes but genetically alike. (**C**) Mold spore cells reproduce the mold. (**D**) This animal forms a bud that later separates from the parent. (**E** and **F**) Some plant offspring develop attached to the parent, but later separate to become independent individuals.

naturally from the parent plant. In every case, organisms produced by asexual reproduction have only one parent, and they have the same genetic information as the parent. Figure 4-17 shows some examples of asexual reproduction.

SEXUAL REPRODUCTION In **sexual reproduction**, offspring receive half of their genes from one parent and half from the other. The genes from each parent are carried on chromosomes in **sex cells**, which are also known as gametes, or egg or sperm cells. These sex cells combine in the process called **fertilization**. In this way, 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, therefore, possess genes inherited from each parent's gametes. Since the offspring get only half of their DNA from each parent, they will not be identical to either of the parents. Also, since each one gets a unique combination of genes from its parents, it will differ from its siblings (brothers and sisters).

Animals rely on a moist environment, either outside in water or internally, for the sperm to swim to the egg for fertilization. Following fertilization, an embryo forms and develops either internally, as in mammals, or externally, as in birds, insects, and many other animals.

Angiosperms and other complex plants also reproduce sexually. Pollen is produced in flowers and released. Pollen is light enough to be carried by the wind, insects, or other animals. Pollination occurs when pollen from the male part of a flower eventually reaches the female part of the same or another flower of the same species. The pollen then produces a pollen tube that provides a way for the male sex cell, the sperm nucleus, to get to the egg nucleus, where fertilization occurs.

Next, the fertilized egg nuclei and other parts of the flower progress through of a series of stages that results in the formation of seeds. Each fertilized egg nucleus normally develops into an embryo plant, enclosed in a seed. In angiosperms the seeds are enclosed in a fruit.

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. During cell division, one copy of this 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 use cell division for asexual reproduction. Multicellular organisms mainly use cell division for growth and for tissue repair where cells must be replaced. This process, by

which a cell's genetic material divides, creating two complete sets of the cell's genetic material, is known as **mitosis**. Mitotic cell division produces two cells that each have a full set of identical genes and chromosomes—unless an error occurs somewhere along the way.

MEMORY JOGGER

Recall that DNA replication makes an identical copy of all the genetic information in the molecule. The replica 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 4-18.

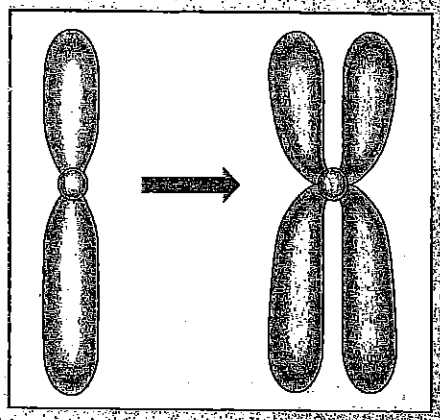


Figure 4-18. Chromosome duplication resulting from DNA replication: As a result of DNA replication, chromosomes become double-stranded.

A second type of cell division is meiosis. **Meiosis** 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 produced by meiotic division has only half the genetic material needed for a cell to function properly. Meiosis is covered in detail in Topic 5.

Mitotic Division

During the process of mitotic cell division, the double-stranded chromosomes that are visible split into two identical single strands (see Figure 4-19) and move apart to opposite ends of the cell.

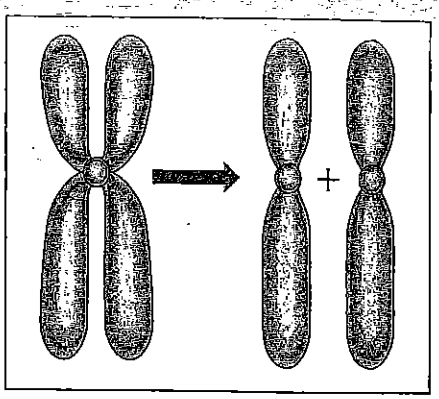


Figure 4-19. Chromosome during mitosis: When cells divide, each double-stranded chromosome separates into two identical single strands.

The process concludes when the cytoplasm divides, resulting in two smaller but genetically identical cells. Mitotic cell division in plants is illustrated in Figure 4-20.

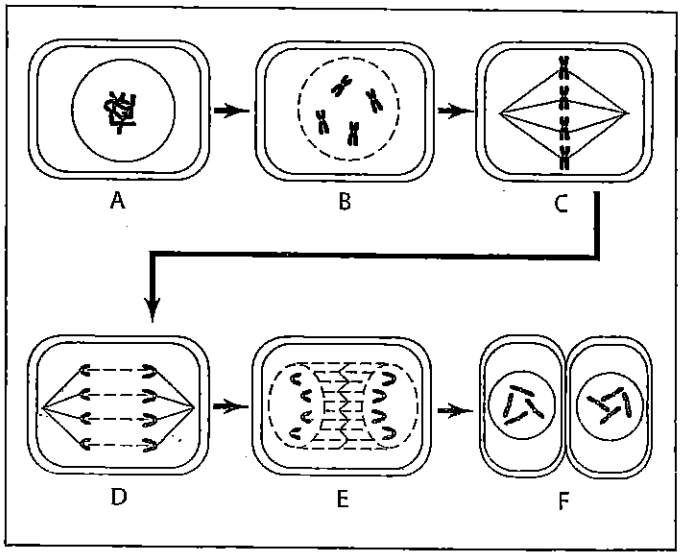


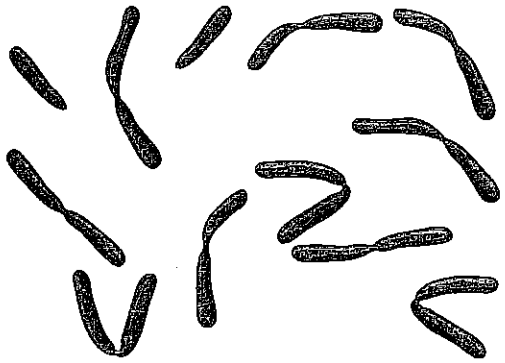
Figure 4-20. Mitotic cell division: The chromosomes in cell A have replicated, forming the double-stranded chromosomes that are finally visible in the cell at stage B. The four chromosomes line up single-file in stage C. Then the strands separate and move apart at stages D and E. The final result is two cells, shown at stage F, each with four single strands of chromosomes containing identical genetic information in their nuclei.

4.3 Review

1. Which statement best describes the process of asexual reproduction? (A) It involves two parents. (B) It requires the combination of sperm and egg. (C) It results in variation in the offspring. (D) It involves the production of genetic copies.

3

2. 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 (A) fat (B) glucose (C) DNA (D) ATP

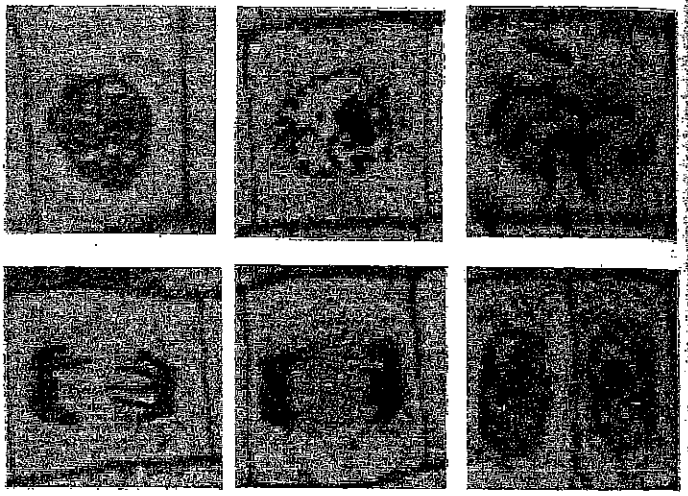
3. Some bacteria produce an enzyme known as penicillinase, which prevents their destruction by penicillin. Since these same organisms reproduce asexually, they normally produce offspring that (A) can be killed by penicillin (B) have an abnormally high rate of mutation (C) have variable numbers of chromosomes (D) are resistant to penicillin

4. In plants, one way sexual reproduction differs from asexual reproduction is that in sexual reproduction (A) more offspring are produced (B) more genetic variation is seen in the offspring (C) the offspring and the parents are identical (D) fewer offspring survive to maturity

5. The process of mitotic cell division normally results in the production of (A) four cells with half the number of chromosomes as the parent (B) two cells with the same number of chromosomes as the parent (C) two cells with only one chromosome from each parent (D) one cell with a replicated set of matched chromosomes

6. 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 (A) sexual reproduction (B) asexual reproduction (C) natural selection (D) fertilization

7. Which process is represented in the following photographs?



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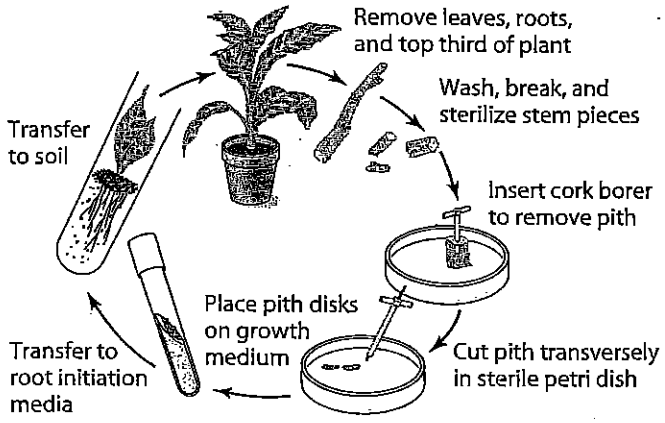
(A) mitotic cell division (B) zygote formation (C) fertilization (D) recombination

8. The following diagram shows some steps involved in preparing tissue cultures in plants.



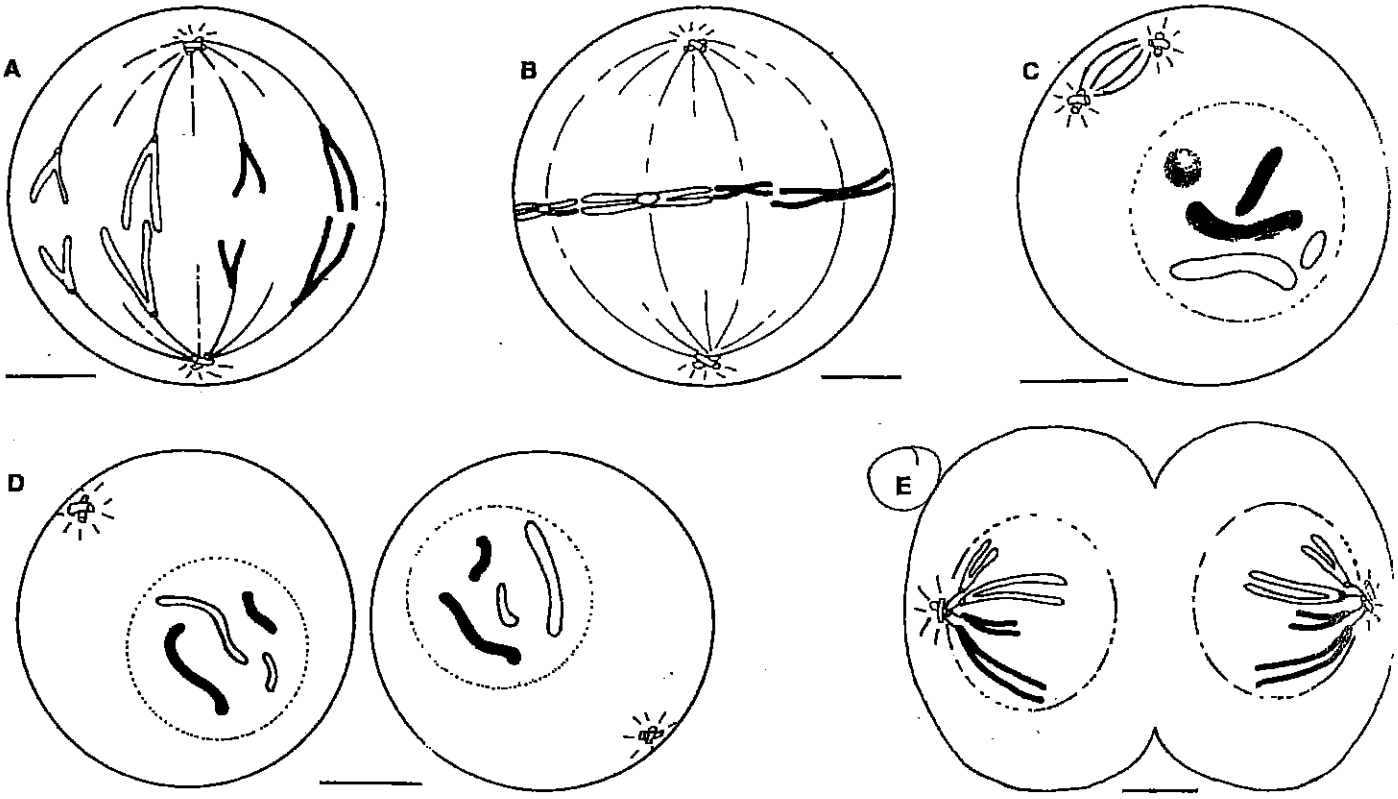
Compare the genetic makeup of the offspring plants that are transferred to the soil to that of the parent plant that provided the stem pieces.

Name _____ Date _____ Class _____

MITOSIS

In your textbook, read about the steps of mitosis in Section 22:1.

1. The following steps of mitosis are out of order. Place the numbers *1-5* in the blanks to show the correct order.



2. In the blanks below, write the letter of the diagram above that is being described.

1) A Two new identical cells are formed. _____

2) C Cytoplasm begins to separate. _____

3) D Sister chromatids are first pulled apart. _____

4) E Chromosomes are completely separated and at opposite ends of the cell. _____

5) B Sister chromatids can be seen for the first time. _____

6) A This is what cells look like before going through mitosis. _____

7) C Nuclear membrane begins to break down. _____

8) B Sister chromatids move to the cell's center and line up on fibers. _____

9) A A nuclear membrane begins to form around chromosomes. _____

5

Name _____ Date _____ Class _____

Use with Section 22:1.

MITOSIS IN A ROOT TIP

Use your textbook and the numbered cells in the diagram of the root tip below to answer the questions. You may find it helpful to examine the diagram with a hand lens.

1. Write the numbers of the cells in the diagram below that show the following steps of mitosis.

   _____ Step 1 _____ Step 3

   _____ Step 2 _____ Step 4

2. In which step does a new cell membrane form? _____

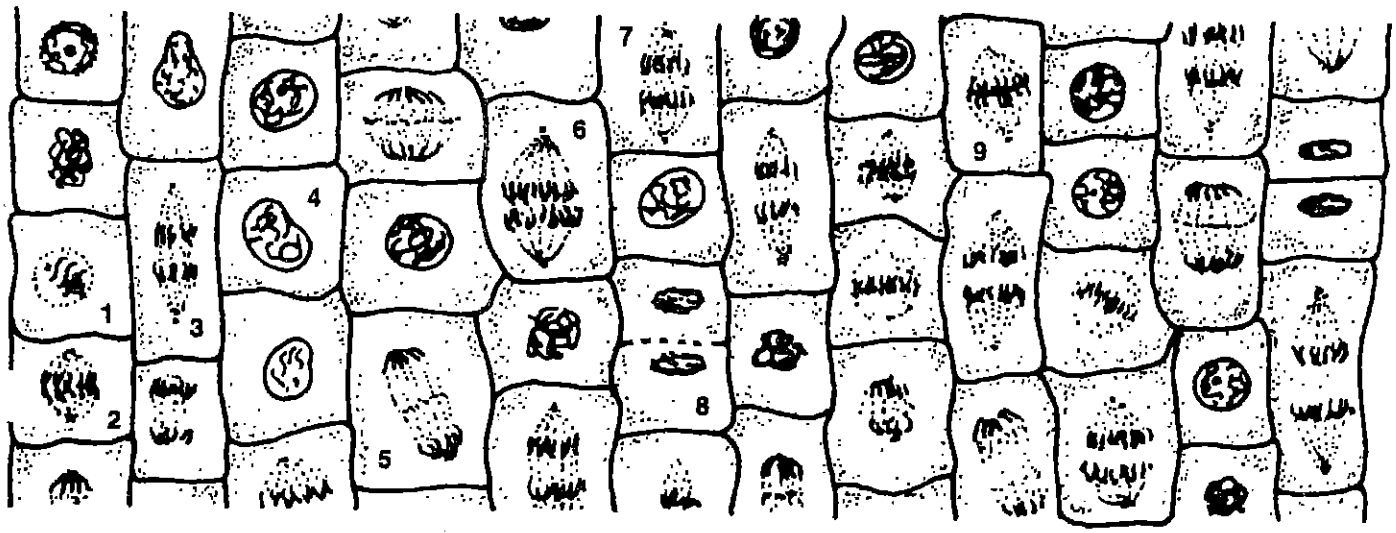
3. At what step(s) do you see fibers clearly? _____

4. What do the fibers do? _____

5. What is the difference between chromosomes in a new cell and at the end of Step 3? _____

6. What happened to chromosomes in Step 3? _____

7. Which step of mitosis is seen most often in this root tip? _____



The five types of asexual reproduction are:

Fission

Single celled organisms, such as paramecium and bacteria, which reproduce by splitting in two. This is often the only mode of reproduction for these organisms.

Fragmentation

Some animals can grow from a separate piece of parent animal. This happens in only the simplest animals, such as some flatworms. These animals may also reproduce sexually.

Vegetative propagation

New plants can be produced from sections of parent plants that are cut off. Cambium cells from stems, roots and leaves of a parent plant can take root and sprout. New plants reproduced in this way are genetically identical to the parent plant. We see this in spider plants and willow trees, for example. Note that these plants also reproduce sexually, usually sperm and egg which produce seeds.

Budding

Cell division produces a bud. As the bud grows, it forms an identical copy of its parent, then separates from the parent and becomes independent. An example is a hydra. These organisms may also reproduce sexually. The "choice" between sexual and asexual reproduction is often mediated by environmental conditions.

Parthenogenesis

Some animals may produce eggs that develop directly into offspring without fertilization. Common examples occur in insects, reptiles and fishes. Often, these organisms may also reproduce sexually. The "choice" between sexual and asexual reproduction is typically mediated by environmental conditions.

Asexual Reproduction

Match the following types of asexual reproduction and their examples.

A. fission

B. fragmentation

C. budding

D. parthenogenesis

E. vegetative propagation

_____2. Cell division that forms a bud and as it grows, forming an identical copy of its parent, then separating from the parent to become independent.

_____3. Paramecium or protists

_____4. Single-celled organisms that reproduce by splitting in two.

_____5. Spider plant and geraniums

_____6. Growing a new plant without a seed.

_____7. Hydra

_____8. An animal produces offspring from eggs that were not fertilized.

_____9. An animal that grows from a separated piece of a parent animal.

10. On the reverse side of this paper, describe the five types of asexual reproduction; fission, fragmentation, budding, parthenogenesis, vegetative propagation. Include examples of organisms that use each kind of asexual reproduction.

10

LESSON 19 | What is meiosis?

In asexual reproduction there is only one parent and one set of chromosomes. The chromosomes are duplicated. The offspring are just like the parent.

Sexual reproduction is different. In sexual reproduction, there are two parents—two sets of chromosomes. A new organism is formed with one set of chromosomes from each parent. The offspring inherits traits from both parents.

Think of yourself, for example. In some ways you are like your mother. In other ways you are like your father. You have inherited traits from both your parents.

How are chromosomes exchanged during sexual reproduction? The chromosomes of body cells are paired. The chromosomes of sex cells are not paired. Chromosomes of sex cells are single chromosomes. Therefore, a sperm or an egg cell has only half as many chromosomes as a body cell.

When fertilization takes place, the sperm chromosomes join the egg chromosomes. Together, they add up to the full number of chromosomes found in body cells.

The fertilized egg, or zygote, now has chromosomes from both parents. It also has traits from both parents.

Reproductive cells also are called **gametes** [GAM-eets]. Gametes develop from special cells in the body. The process by which gametes form is called **meiosis** [my-OH-sis]. You can see the process of meiosis on the next page.

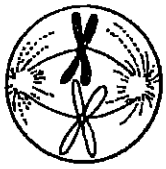
1. Original cell with two pair of chromosomes.

2. Each pair of chromosomes doubles.

3. Spindle fibers form in the cell. The pairs of chromosomes attach to the spindle fibers.

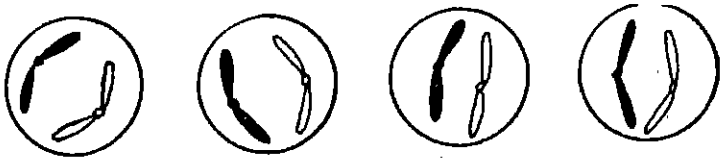
4. The chromosomes separate.

5. The cell splits in two, with each cell containing one double chromosome from each pair.



6. Spindle fibers form in each new cell. Double chromosomes attach to the spindle fibers.

7. The double chromosomes split. One chromosome goes to each side of the cell. Then, each cell splits.



8. Four cells are produced. Each cell has one chromosome from each pair.

Figure A

Body cells are produced by mitosis. But sperm and egg cells do not form this way. Reproductive cells are formed by meiosis. Each gamete has only half the usual number of chromosomes. But when the sperm and egg join, the zygote has the full number of chromosomes.

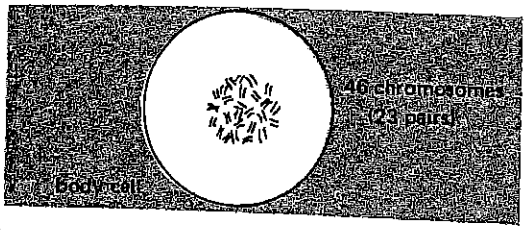


Figure B

A human body cell has *46* chromosomes. The chromosomes are paired. So there are *23* pairs.

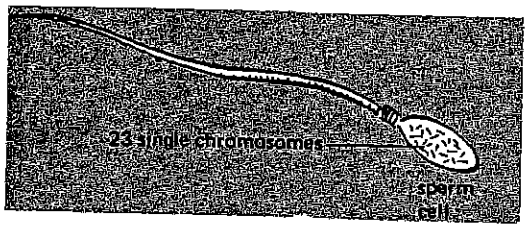


Figure C

Each human sperm cell has *23* single chromosomes.

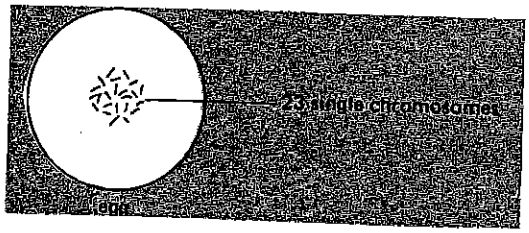


Figure D

Each human egg cell has 23 single chromosomes.

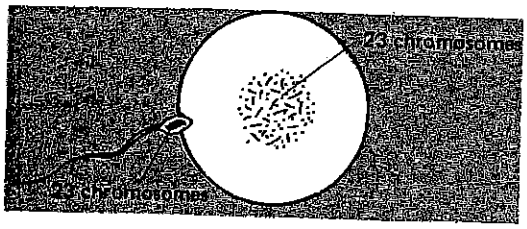


Figure E

Fertilization links the gamete chromosomes.

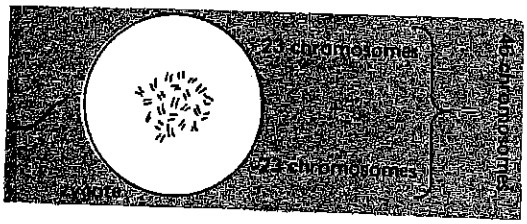


Figure F

The zygote, then has a total of 46 chromosomes. 23 are from the mother, 23 are from the father.

The zygote starts to divide after fertilization. It divides by mitosis. It divides over and over again as it develops.

Scientists often study fruit flies because they have large numbers of chromosomes that are easy to count.

- Every body cell of a fruit fly has 8 chromosomes.
- Every fruit fly gamete (sperm or egg) has 4 chromosomes.

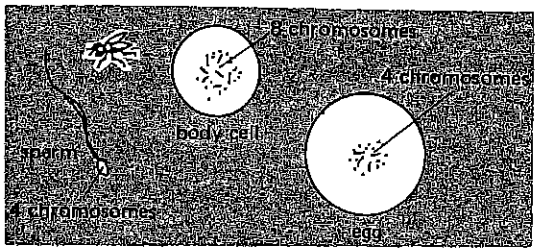


Figure G

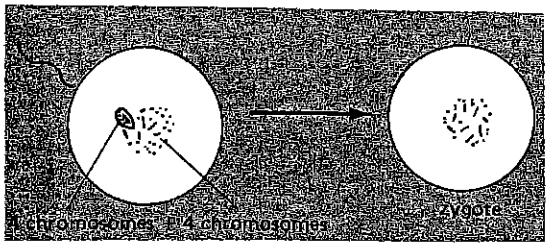


Figure H *A sperm fertilizes an egg.*

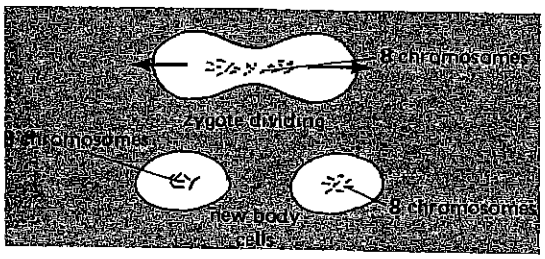


Figure I *The zygote divides. Then each new cell divides.*

1. Body cells reproduce by a process called _____ .
2. Gamete cells are formed by a process called _____ .
3. **a)** How many chromosomes does the egg cell of a fruit fly have? _____
   b) Sperm cells? _____
4. What do chromosomes control? _____
5. How many chromosomes does a fruit fly zygote have? _____
6. How many chromosomes will each body cell have? _____
7. The offspring will have traits of the mother and the father. Why? _____

Why must a gamete have only one half the number of chromosomes found in body cells?

Name_____ Review: Mitosis/ Meiosis

1. There are _____steps in mitosis. (4, 6,8)

2. A cell is undergoing mitosis and the parent cell has 6 chromosomes in the nucleus, so the 2 daughter cells will have _____ chromosomes in their nuclei. (3, 6)

3. _____ is easy to identify because the chromosomes line up in the center (middle) of the cell. (teleophase, metaphase)

4. During _____ the 2 identical daughter cells are still connected to each other because cytokinesis did not occur yet. (telophase, anaphase)

5. There are _____ cell divisions during mitosis. (1, 2)

6. There are _____ cell divisions during meiosis. (1, 2)

7. In mitosis, the daughter cells are _____ the parent cell. (different from, identical to)

8 _____is the process that separates the cytoplasm of the new daughter cells during the cell cycle. (Cytokinesis , Mitosis)

9. Diploid means it has _____ the chromosome number. (all , half)

10. _____means it has half the chromosome number (haploid , diploid).

11. The human gametes are the _____ & _____. (ovaries / testes, sperm / eggs).

12. _____ is the process used to make sperm & egg. (mitosis, meiosis)

13. Cells spend the most time in interphase during the cell cycle. (anaphase, interphase)

14. During meiosis the daughter cells are _____ to the parent cell (identical , different).

15. Cancer is a disease characterized by _____cell division. (controlled , uncontrolled)

15

16. During meiosis, _____ daughter cells are produced. (2, 4)

17. During mitosis & meiosis, the parent cell is _____. (diploid , haploid)

18. What is the purpose of mitosis & meiosis? _____

Mitosis and Meiosis Review

Characteristic	Mitosis (Body Cells)	Meiosis (Gametes)
Number of Daughter Cells	2 (autosomes)	4 (sex cells)
Number of Cell Divisions	1	2
Daughter Cells are Diploid or Haploid?	diploid (full chromosome number)	Haploid (½ the chromosome number)
Daughter Cells and Parent Cells are Identical or Different?	identical	Different
Parent Cell is Diploid or Haploid?	Diploid	diploid

Word Bank (words can be used more than once):

Interphase *Prophase* *Metaphase* *Anaphase* *Telophase* *Cytokinesis*
Mitosis *Meiosis* *Cancer* *Centromere*

1. The process used to make sperm and egg is _____.
2. The phase in which chromosomes line up in the center of the cell is _____.
3. _____ is a type of cell division that requires two cell divisions.

5. A group of diseases characterized by uncontrollable cell division _____.

7. The last phase of mitosis is called _____.

9. This process results in 2 identical daughter cells _____.

10. The daughter cells of this process are haploid, which means they have ½ the original number of chromosomes _____.

Name _____ Date _____ Class _____

CELL REPRODUCTION

A. Understanding Ideas

On the line to the left, write TRUE if the statement is true or FALSE if the statement is false.

_____ **1.** Sex cells form during mitosis.

_____ **2.** During mitosis, fibers in the cell pull apart sister chromatids.

_____ **3.** Mitosis occurs in childhood only.

_____ **4.** Meiosis may form egg cells.

_____ **5.** Sex cells have twice as many chromosomes as other cells.

_____ **6.** A cell with six chromosomes undergoes mitosis. Each new cell will also have six chromosomes.

_____ **7.** Four new cells are formed from each original cell in meiosis.

_____ **8.** Fibers are formed by a chromatid.

_____ **9.** As a person ages, the rate of mitosis slows down.

_____ **10.** Cancer cells reproduce more rapidly than other cells.

_____ **11.** Growth in humans occurs mainly by mitosis.

_____ **12.** Sperm have twice as many chromosome as eggs have.

B. Vocabulary Check

Complete the following sentences by writing the correct term in the space provided on the left.

_____ **13.** In the process of ____, four sex cells are formed.

_____ **14.** The human female sex organs are the ____.

_____ **15.** ____ is the stage of life when a person begins to develop sex cells.

_____ **16.** ____ are the male sex organs.

_____ **17.** The two strands of a doubled chromosome are ____.

_____ **18.** New body cells form through the process of ____.

_____ **19.** Eggs are the ____ of the female.

Name _____ Date _____ Class _____

C. Using Ideas

Place check marks on the lines to show which kind of cell has the trait listed.

Trait	Sperm Cell	Egg Cell	Both Sperm and Egg
20. is a sex cell	_____	_____	_____
21. formed by female	_____	_____	_____
22. larger in size	_____	_____	_____
23. formed during meiosis	_____	_____	_____
24. has a tail	_____	_____	_____
25. formed in testes	_____	_____	_____
26. involved in fertilization	_____	_____	_____

D. Interpreting Ideas

Arrange the changes that take place before or during mitosis in order. Number them 1 through 5.

_____ **27.** A nuclear membrane begins to form around both sets of chromosomes.

_____ **28.** Each chromosome makes a copy of itself.

_____ **29.** The membrane around the nucleus begins to break down.

_____ **30.** The sister chromatids are pulled apart to form two sets of chromosomes.

_____ **31.** Sister chromatids line up along the center of the cell.

Arrange the steps in meiosis in order. Number them 1 through 8. Number 1 has been filled in for you.

_____ **32.** _____ **38.**

_____ **33.** _____ **39.**

_____ **34.**

_____ **35.**

_____ **36.**

_____ **37.**