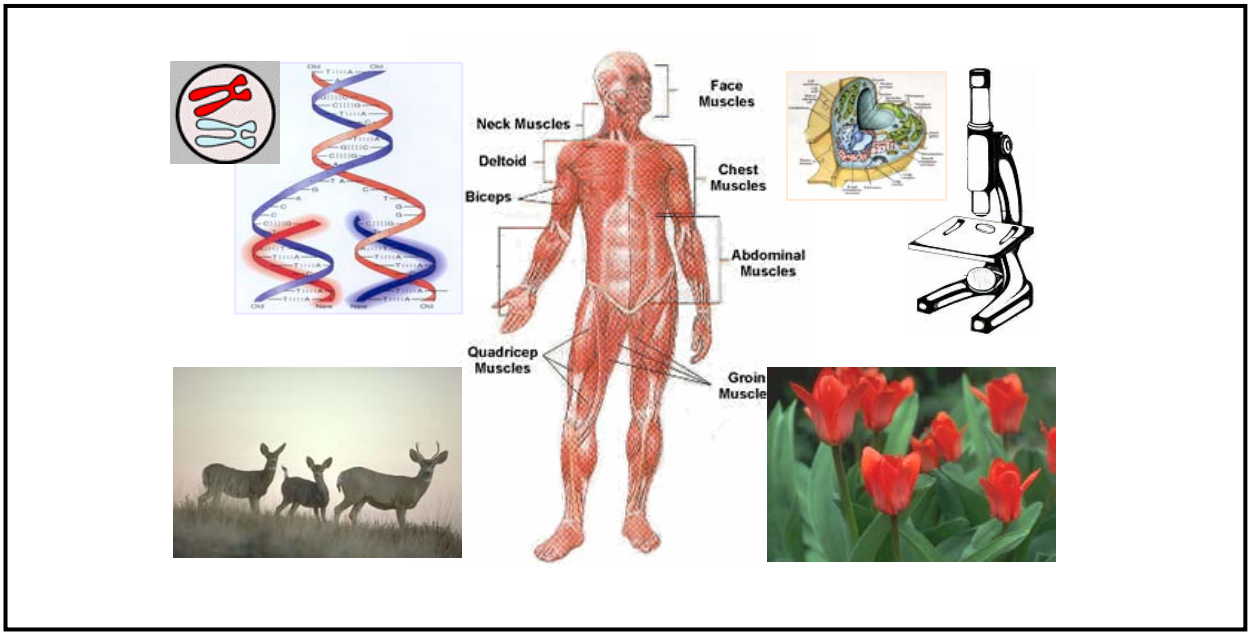
Project EASE

(Effective Alternative Secondary Education)

BIOLOGY



MODULE 12

Making New Cells

BUREAU OF SECONDARY EDUCATION
Department of Education
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Module 12
Making New Cells

What this module is about

In this module you will learn how cell division is essential to growth, repair and reproduction in eukaryotic organisms. The process of dividing the genetic material among the daughter cells is integral to both types of cell division. In mitosis, the daughter cells receive the same number of chromosomes as the parent cell. In meiosis, a reductive cell division, the daughter cells are haploid with respect to the parent cell.

This module has the following lessons:

- **Lesson 1 – Mitosis**
- **Lesson 2 – Meiosis**
- **Lesson 3 – Asexual and Sexual Reproduction**

What you are expected to learn

After going through this module, you are expected to:

1. describe the cell cycle;
2. differentiate mitosis from meiosis;
3. enumerate the different patterns of reproduction among organisms
4. differentiate sexual and asexual reproduction of organisms; and
5. appreciate the importance of cell division and reproduction.

How to learn from this module

I know you are excited to start the adventure just as I am but remember to do the following tips to successfully achieve the objectives of this self-learning kit.

1. Read the instructions carefully.
2. Follow the instructions carefully.

3. Answer the pretest before you start the lesson.
4. Take note and record points for clarifications.
5. Try to achieve at least a 75% level of proficiency in the tests.
6. Work diligently.
7. Answer the posttest honestly.

What to do before (Pretest)

Answer the pre-test to measure how much you know about the topic. You can start now.

- There are 20 questions. Each question has ONLY ONE CORRECT ANSWER. Choose the one you believe to be correct.
- Each question is worth 2 points.
- Read each question carefully. Take your time and think.
- GOOD LUCK!

1. Which of the following is involved in asexual reproduction?
   a. mitosis
   b. meiosis
   c. oogenesis
   d. binary fission
   e. both a & d are correct

2. Which of the following is not a form of asexual reproduction?
   a. budding
   b. regeneration
   c. fragmentation
   d. formation of rhizome
   e. union of egg cell and sperm cell

3. Variability in the offspring is an important benefit of what form of reproduction?
   a. Sexual
   b. Mitosis
   c. asexual
   d. binary fission

4. The following events are occurring in both mitosis and meiosis EXCEPT
   a. cytokinesis
   b. karyokinesis
   c. DNA replication
   d. pairing of homologous chromosomes

5. Which statement about mitosis is **NOT** correct?
   a. It makes diploid nuclei.
   b. It forms four daughter cells.
   c. The prophase is the first active phase.
   d. It does not affect the nuclear envelope.

6. Which statement about binary fission is **NOT** correct?
   a. It occurs in prokaryotic cells.
   b. It exhibits five active phases.
   c. It produces two daughter cells.
   d. DNA is replicated before division.

7. Polar bodies are formed during
   a. mitosis
   b. meiosis
   c. oogenesis
   d. spermatogenesis

In questions 8-14, label each statement with one of the following choices:
   a. meiosis I
   b. meiosis II

___ 8. It is the synapsis of homologous chromosomes.
___ 9. It involves the separation of homologous chromosomes.
___10. It results in one oocyte and one polar body in human females.
___11. It results in four sperm cells in human males.
___12. The daughter cells have double-stranded chromosomes.
___13. The daughter nuclei produced have single-stranded chromosomes.
___14. The crossing-over of chromosome occurs.

In questions 15-19, match the cell phase to its description. Write the letters only.
   a. DNA replication
   b. chromosomes first become visible
   c. chromatids separate at centromere
   d. chromosomes are aligned at the metaphase plate
   e. last phase of nuclear division

___15. anaphase
___16. metaphase
___17. prophase
___18. telophase
___19. interphase

20. The diploid chromosome number in an organism is 42. The number of chromosomes in its sex cells is normally
   a. 21
   b. 42
   c. 63
   d. 84

Got a perfect score? Check it out!

Key to answers on page 24.

Lesson 1. Mitosis

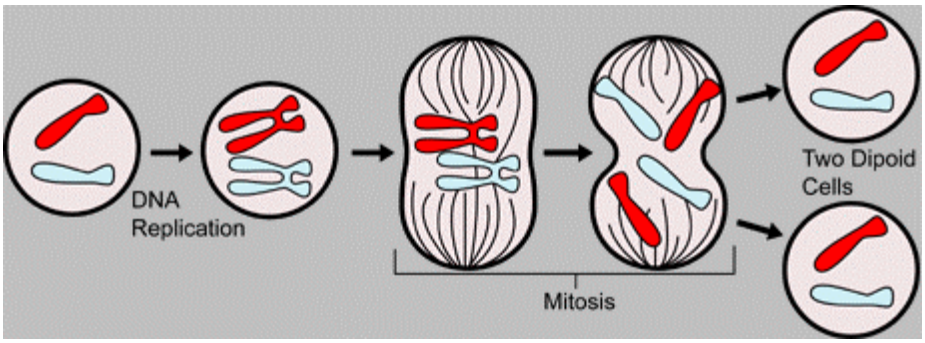


Figure 1.1 Overview of the major events in mitosis
Source: http://web.jjay.cuny.edu/~/acarpi/NSC/13-cell.htm

How much did you weigh when you were born? How long were you? Your body needed millions of new cells to become as large as you are now!

It's very likely that each time you go to the doctor, a nurse measures your height and mass. This activity gives the medical profession an idea of how people grow. Much of the growth happens because **the number of cells in your body increases as you develop**.

Most of the kinds of cells in your body are constantly replacing themselves. Bone cells make new bone cells. Muscle cells make new muscle cells. The fact is that you are constantly changing. You aren't the same now as you were a year ago or even a few hours ago.

At this very moment, as you read this page, groups of cells throughout your body are growing, dividing, and dying. Worn out cells on the palms of your hands are being replaced. Cuts and bruises are healing. Other organisms undergo similar processes.

How does this happen?

There are two ways by which cells increase in number:

- **Mitosis** – is the process in which a cell nucleus divides into two new nuclei, each of which contains the same number of chromosomes as the parent cell.

  * The parent cell is the cell that undergoes division.

- **Meiosis** – is the process in which there are two divisions of the nucleus: meiosis I and meiosis II.

Cell division is controlled by the chromosomes found in each cell.

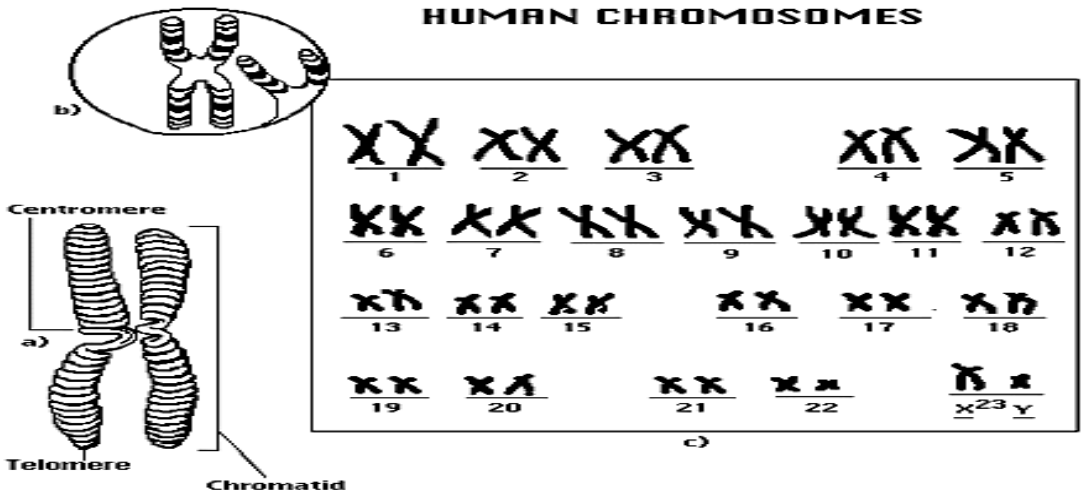


Figure 1.2 A complete set of chromosomes in human.
(A telomere contains bits of DNA on the ends of our chromosomes.)
Source: http://www.accessexcellence.org/RC/VL/GG/human.html

Study the figure below and take a closer look at what really happens during cell division (Mitosis).

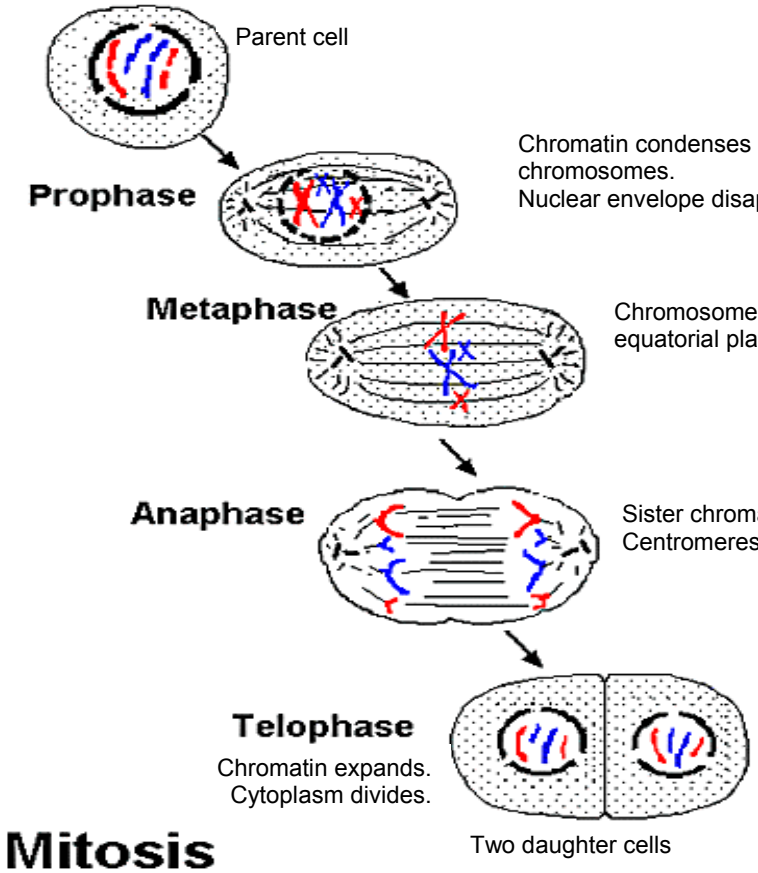


Figure 1.3
Illustration of the process by which somatic cells multiply and divide.
Source:
http://www.accessexcelence.org

Mitosis is a process of cell division that results in the production of two daughter cells from a single parent cell. The daughter cells are identical to one another and to the original parent cell.

Cell division is a cycle of events. The process of cell division has been divided into five phases. These are:

- **Interphase**: the state of a eukaryotic cell when not undergoing division. Every time a cell divides, it must first replicate all of its DNA. Because chromosomes are simply DNA wrapped around protein, the cell replicates its chromosomes also. These two chromosomes, positioned side by side, are called **sister chromatids** and are identical copies of one another. Before this cell can divide, it must separate these sister chromatids from one another.

- **Prophase**: The chromatin (The total collection of DNA and proteins in a chromosome.), diffuses in interphase, condenses into chromosomes. Each chromosome has duplicated and now consists of two sister chromatids. The centrioles form asters (ray-like structures) and move toward the opposite sides of the cell. At the end of prophase, the nuclear envelope breaks down into vesicles.

- **Metaphase**: The chromosomes align at the equatorial plate (center of the cell) and are held in place by microtubules attached to the mitotic spindle and to part of the centromere.

- **Anaphase**: The centromeres divide. Sister chromatids separate and move toward the corresponding poles.

- **Telophase**: Daughter chromosomes arrive at the poles and the microtubules disappear. The condensed chromatin expands and the nuclear envelope reappears. The cytoplasm divides, the cell membrane pinches inward ultimately producing two daughter cells (phase: Cytokinesis).

What happens after telophase?

Two new nuclear membranes form and two new nuclei are seen. **Two daughter cells** are produced from one dividing parent cell. Mitosis has come to an end.

> In animal cells, two canals (cleavage furrow) form one on each side of the cell. These canals pinch in until two new daughter cells are formed. Plant cells do not pinch in. Instead, a new cell wall (cell plate) forms between the two new nuclei.

What you will do

Activity 1.1

Science and Math Problem

If a single cell undergoes mitosis every five minutes, how many cells will result from this single cell after 30 minutes?

Activity 1.2

1. Describe the cell cycle.

Key to answers on page 24.

What you will do

Self-Test 1.1

Indicate whether each statement is true (T) or false (F) and change all false statements to true statements.

___1. Binary fission and mitosis ensure that each daughter cell is genetically identical to the parent cell.
Rewrite: _____
_____

___2. Cell division in unicellular organisms is a form of asexual reproduction.
Rewrite: _____
_____

___3. Both binary fission and mitosis are necessary to the growth and repair of multicellular organisms.
Rewrite: _____
_____

___4. Spindle formation occurs both during binary fission and mitosis.
Rewrite: _____
_____

___5. Spindle formation occurs during plant and animal cell division.
Rewrite: _____
_____

Key to answers on page 24.

Remember:

- Each cells in your skin, like most of the cells in your body, has **46 chromosomes.**
- Each new skin cell produced by mitosis will also have **46 chromosomes.**

Cell Cycle Control and Cancer
As cells cycle through interphase and mitosis, a surveillance system monitors the cell for DNA damage and failure to perform critical processes. If this system senses a problem, a network of signaling molecules instructs the cell to stop dividing. These so-called "checkpoints" let the cell know whether to repair the damage or initiate programmed cell death, a process called **apoptosis**. Programmed cell death ensures that the damaged cell is not further propagated. Scientists know that a certain protein, called p53, acts to accept signals provoked by DNA damage. It responds by stimulating the production of inhibitory proteins that then halt the DNA replication process. Without proper p53 function, DNA damage can accumulate unchecked. A direct consequence is that the damaged gene progresses into a cancerous state. Today, defects in p53 are associated with a variety of cancers, including some breast and colon cancers.

Lesson 2. Meiosis

How are sex cells (sperm and egg cells) formed? The process meiosis (cell division) produces sex cells. In meiosis, there are two divisions of the nucleus: meiosis I and meiosis II. The cell divides twice in this process.

All human cells have forty-six chromosomes. When human cells reproduce (increase in number), mitosis ensures that each new cell will have forty-six chromosomes. There is one exception to this in the human body. Each of the **sperm and egg** has **twenty-three** single chromosomes.

Why must meiosis take place for each sperm and egg?

When a sperm unites with an egg, each of them contributes twenty-three chromosomes to the new zygote (combination of sperm and egg/the future baby). Thus, a new life begins with the normal number of forty-six chromosomes. Then the process of mitosis begins, producing cells with forty-six chromosomes each. This is the reason why you are growing.

If the sperm and egg did not have only twenty-three chromosomes each, the new baby would have ninety-two chromosomes rather than the normal number of forty-six chromosomes. The number of chromosomes would double every generation if meiosis did not occur.

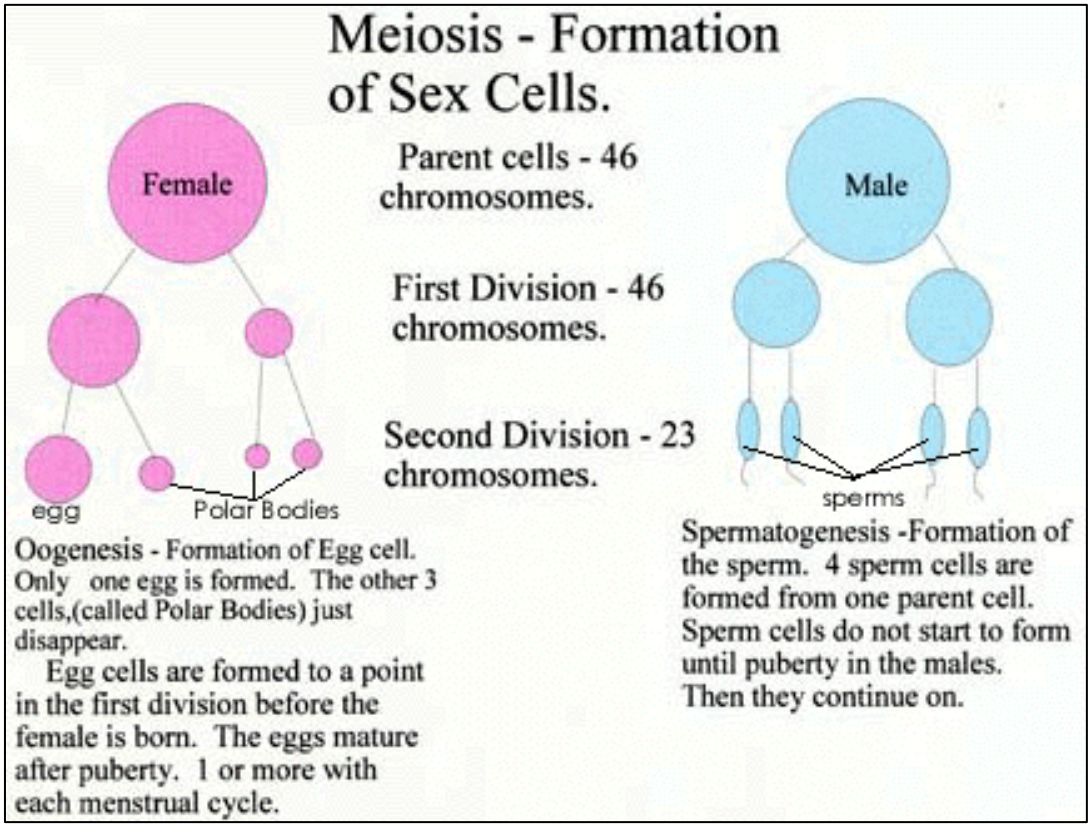


Figure 2.1 Formation of sex cells.
Source: http://www.usoe.k12.ut.us/curr/science/sciber00/7th/genetics/sciber/compare.htm

Meiosis-Sex Cell Formation

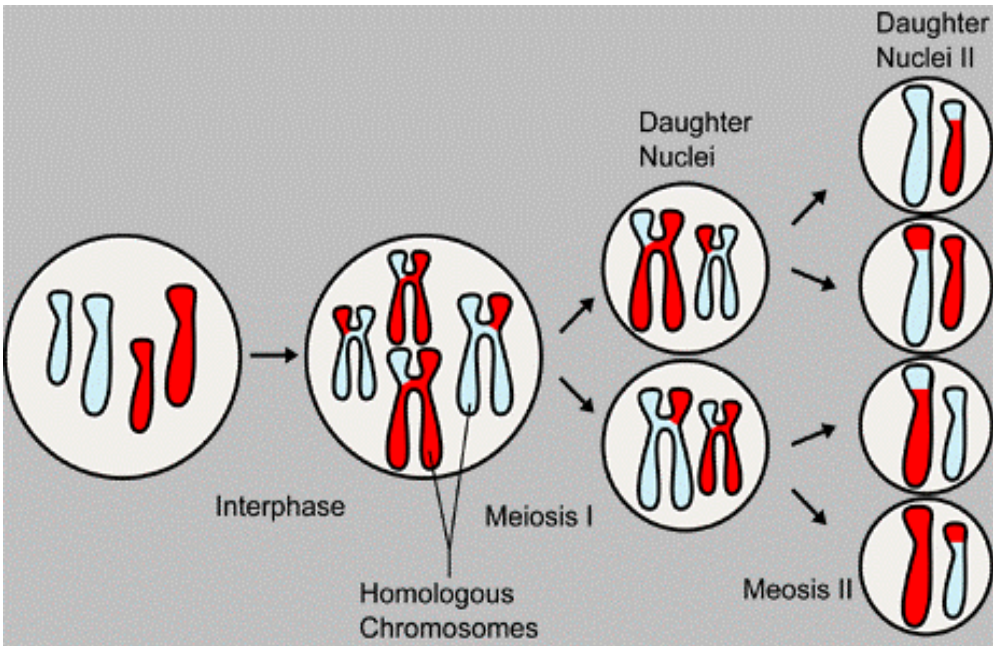


Figure 2.2 Overview of the major events in meiosis (Homologous chromosomes means two chromosomes that are similar in structure.)
Source: http://web.jjay.cuny.edu/~acarpi/ NSC/13-cell.htm

Carefully follow the steps of meiosis shown here and look at the illustration on the next page when studying this.

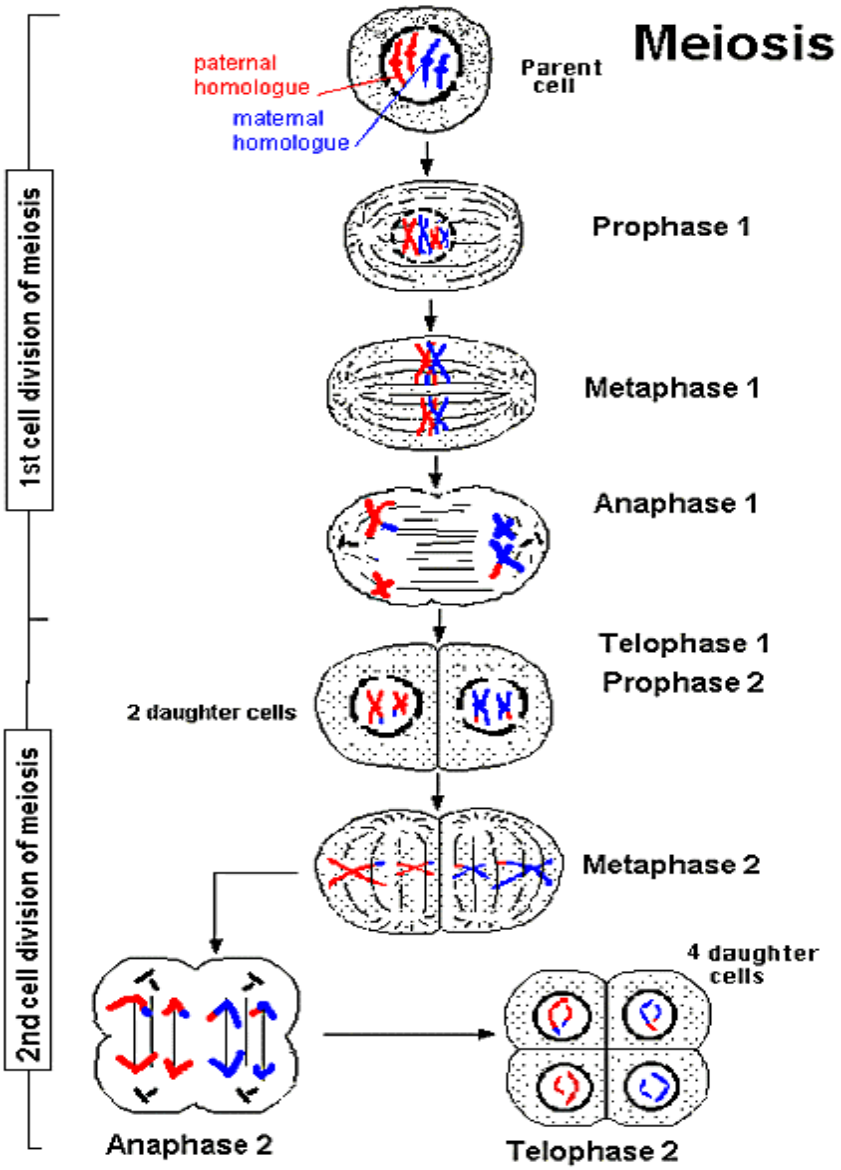


Figure 2.3 Meiosis
Source: http://www.accessexcelence.org

*Illustration of the process by which a **single parent diploid cell** (Both homologous chromosomes) divides to produce **four daughter haploid cells** (One homologous chromosome of the pair).*

Meiosis is the type of cell division by which germ cells (eggs and sperm) are produced. Meiosis involves a reduction in the amount of genetic material.

Meiosis comprises two successive nuclear divisions with only one round of DNA replication.

Four stages can be described for each nuclear division.

- First division of meiosis
  - **Prophase 1**: Each chromosome duplicates and remains closely associated. These are called sister chromatids. Crossing-over can occur during the latter part of this stage.
  - **Metaphase 1**: Homologous chromosomes align at the equatorial plate.
  - **Anaphase 1**: Homologous pairs separate with sister chromatids remaining together.
  - **Telophase 1**: Two daughter cells are formed with each daughter containing only one chromosome of the homologous pair.

- Second division of meiosis: Gamete formation
  - **Prophase 2**: DNA does not replicate.
  - **Metaphase 2**: Chromosomes align at the equatorial plate.
  - **Anaphase 2**: Centromeres divide and sister chromatids migrate separately to each pole.
  - **Telophase 2**: Cell division is complete. Four haploid daughter cells are obtained.

One parent cell produces four daughter cells. Daughter cells have half the number of chromosomes found in the original parent cell and with crossing over, are genetically different.

Meiosis differs from mitosis primarily because there are two cell divisions in meiosis, resulting in cells with a haploid number of chromosomes.

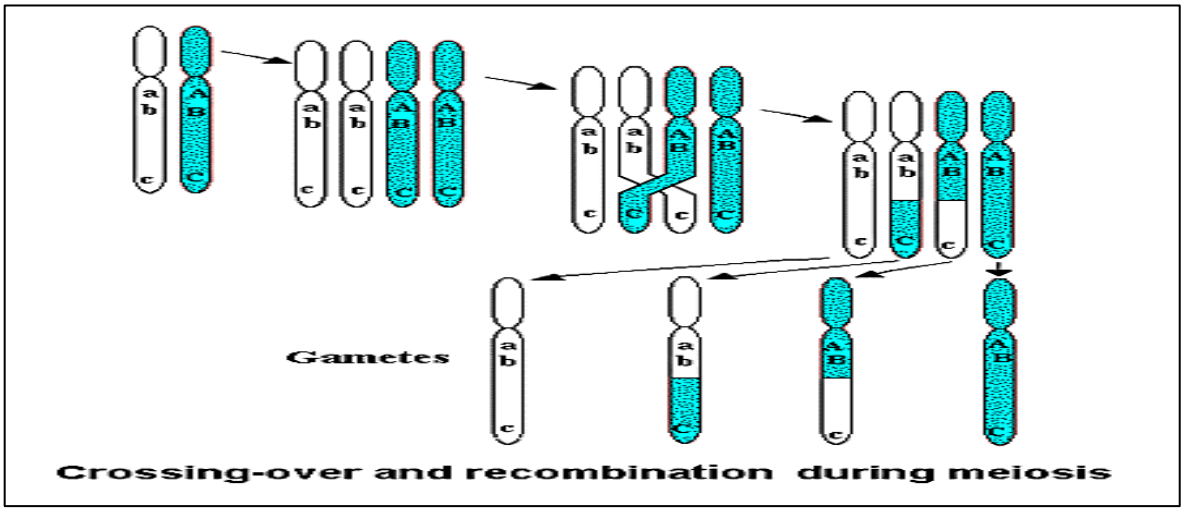


Figure 2.4 Crossing over

Source: Morgan T.H., Sturtevant A.H., Muller H.J., and Bridges C.B. (1915). The Mechanism of Mendelian Heredity.

Illustration of crossing-over and recombination during the formation of gametes (germ cells) or *meiosis*. **Crossing-over** is part of a complicated process which can occur during cell division.

In meiosis, the primordial (primary) cells of the sperm or ova must multiply and at the same time reduce the number of chromosomes to one full set. During the early stages of cell division in meiosis, two chromosomes of a homologous pair may exchange segments in the manner shown above, producing genetic variations in germ cells.

What you will do

Activity 2.1

Can you do this? Write the correct answers under each column. If you find difficulty, review the lesson on mitosis and meiosis.

Basis of Comparison	Mitosis	Meiosis
1. Type of cell where the process occurs		
2. Number of cell division		
3. Number of chromosomes (2 sets/1 set)		
4. Number of daughter cells produced per parent cell		

Key to answers on page 24.

To further familiarize you with the process of cell division, here's another activity.

What you will do

Self-Test 2.1

Answer these:

1. Meiosis is sometimes called reduction division. Why is this so?
2. How many cells are there at the end of meiosis II? (Refer to the discussion of meiosis II if you find difficulty in answering this question)

3. If body cells of a horse have 64 chromosomes, how many chromosomes are there in a horse sperm cell?

Key to answers on page 25.

Was it quite difficult? If you did not understand it well, I would suggest that you read the lesson on cell division again.

Congratulations! Why? You're on the final lap of the module! To be in the last lesson means you are really very, very good. You will not reach this part if you didn't show interest and determination to learn. So, what are you waiting for? Go!

Lesson 3. Asexual versus Sexual Reproduction

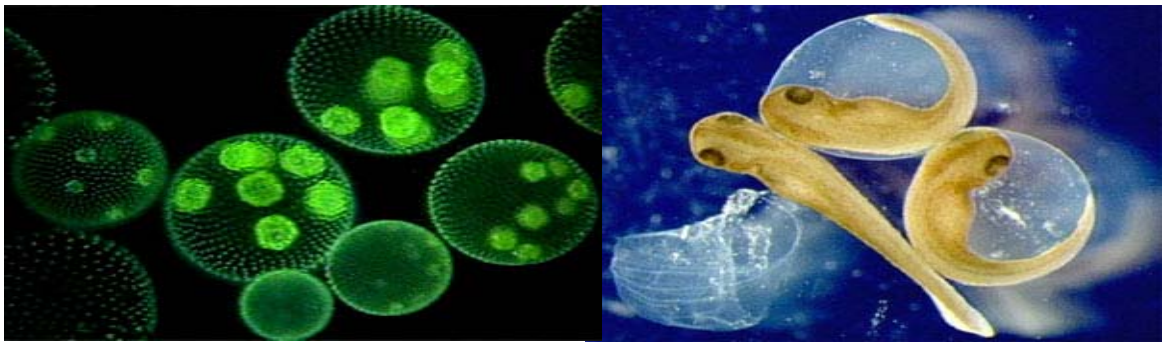


Figure 2.5
Asexual reproduction (volvox) vs sexual reproduction (tadpoles)
Source: Pictures copyright biodidac.bio.uottawa.ca

Reproduction in Animals

Reproduction is a marvelous activity of individual existence. Individual organisms come and go, but, to a certain extent, organisms surpass time by reproducing offspring. We'll take a look at reproduction in animals.

- **What is reproduction?**

Reproduction is the creation of a new individual or individuals from previously existing individuals. In animals, this can occur in two primary ways: through asexual reproduction and through sexual reproduction. Let's look at asexual reproduction.

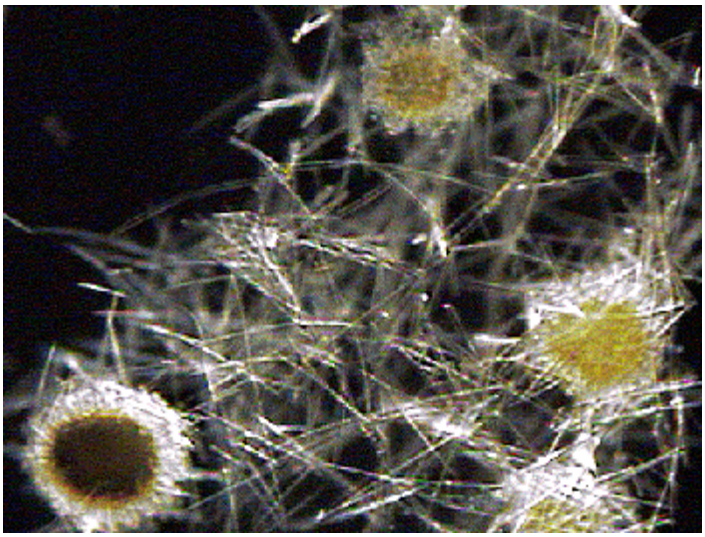


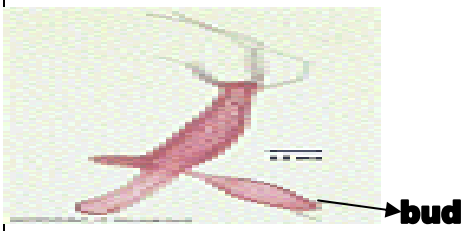
Figure 2.6
Gemmules of the freshwater sponge spongilla.
Source: Image courtesy of J. Houseman; BIODIAC

- **Asexual Reproduction**

In asexual reproduction, one individual produces offspring that is genetically identical to itself. This offspring is produced by mitosis. There are many invertebrates, including sea stars and sea anemones for example, that produce by asexual reproduction. Common forms of asexual reproduction are the following:

Budding

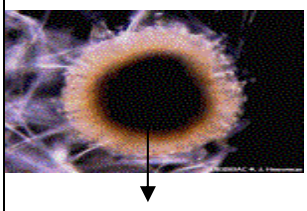
- In this form, an offspring (in the form of bud) grows out of the body of the parent.
- Hydras exhibit this type of reproduction.



Hydra Budding
Image courtesy of BIODIAC

Gemmules (Internal Buds)

- In this form, a parent releases a specialized mass of cells that can develop into an offspring.
- Sponges exhibit this type of reproduction.

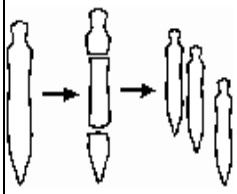


Internal buds (gemmules)

Sponge Gemmmules
Image courtesy of BIODIAC

Fragmentation

- In this form, the body of the parent breaks into distinct pieces, each of which can produce an offspring.
- Planarians exhibit this type of reproduction.

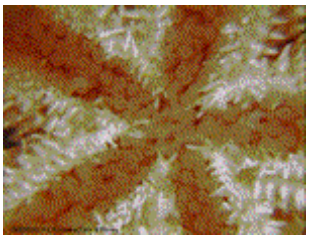


Planarian

http://www.mrothery.co.uk/module2/mod2trimmednotes.htm

Regeneration

- In this form, if a piece of a parent is detached, it can grow and develop into a completely new individual.
- Echinoderms exhibit this type of reproduction.



Oral surface of a star fish.
Image courtesy of BIODIAC

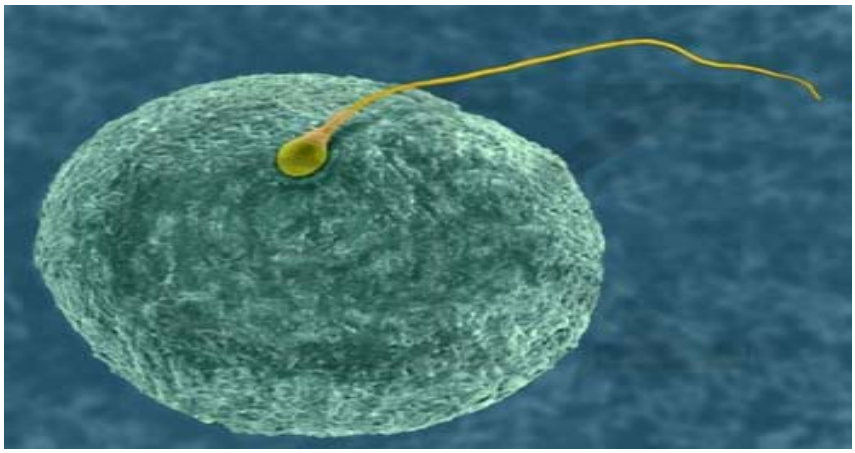
Reproduction in Animals: Sexual Reproduction

- **Sexual Reproduction**

In sexual reproduction, two individuals produce offspring that have genetic characteristics from both parents. Sexual reproduction introduces new gene combinations in a population.

Image credit: U.S. Fish and Wildlife Service

- **Gametes : Sex Cells**



In animals, sexual reproduction encompasses the fusion of two distinct gametes to form a zygote. Gametes are produced by a type of cell division called **meiosis**. The gametes are haploid (containing only one set of chromosomes) while the zygote is diploid (containing two sets of chromosomes). In most cases, the male gamete, called the spermatozoon, is relatively moving and usually has **flagella**. On the other hand, the female gamete, called the ovum, is not moving and relatively large in comparison to the male gamete.

Human Ovum(Egg) and Sperm
Image credit: Copyright Dennis Kunkel

- **Types of Fertilization**

There are two types by which fertilization can take place. The first is external (the eggs are fertilized outside of the body); the second is internal (the eggs are fertilized within the female reproductive tract).

- **Patterns and Cycles**

Reproduction is not a continuous activity and is subject to certain patterns and cycles. Oftentimes these patterns and cycles may be linked to environmental conditions which allow organisms to reproduce effectively. For example, many animals have estrous cycles that occur during certain parts of the year so that offspring can typically be born under favorable conditions. Likewise, these cycles and patterns can be controlled by hormonal cues as well as other seasonal cues like rainfall. All of these cycles and patterns allow organisms to manage the relative expenditure of energy for reproduction and maximize the chances of survival for the resulting offspring.

Asexual reproduction does not involve sex cells or gametes (produced through meiosis). Rather, it is reproduction by mitosis allowing a new, genetically identical individual to be produced. Both methods of reproduction have advantages and disadvantages. Sexual reproduction allows genetic variation and allows the development of a population that is specifically adapted to its surroundings (and is therefore more likely to survive). However, when a very desirable combination of traits is found, sexual reproduction risks losing them in the randomness of the process. Asexual reproduction does not allow genetic variation, but guarantees reproduction (no dependence on others). It rapidly increases numbers of an organism and keeps its

desired combination of traits. Many plants reproduce using a combination of sexual and asexual reproduction to get the benefits of both methods.

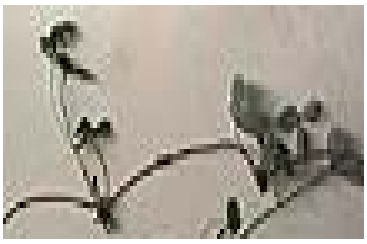
Types of Asexual Reproduction in Plants

Among the many ways that plants produce asexually are the following:

- **Formation of stolon:** Stolon is an above ground runner from which plants roots can grow to start off a new plant.

  Wild strawberry plants connected by stolons

  Epiphyllum has roots that are preformed at the nodes along the stem. As the heavy stems bend over or break off coming in contact with the soil, the preformed roots will penetrate the soil and form a new attachment for the plant.



- **Formation of rhizome:** Rhizome is an underground runner that gives rise to new plants.

  This grass species is a good example of a rhizome.

  Paul displays a sample of weed, a notorious invader of gardens due to its habit of sending long underground stems.

- **Formation of tubers:** Tubers are underground storage stems (e.g. potato) from which new plants can grow after a dormant season.

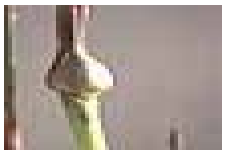
  Reka holds a clump of artichoke. The tubers are displayed up close.

- **Development of bulbs:** Bulbs are underground storage units that divide by mitosis allowing many new plants to form new bulbs. A hybrid amaryllis is a good example of a bulb that can reach up to 12 cm in diameter.

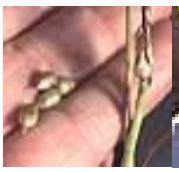
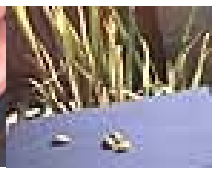
This species of garlic also produces flower-like heads with small bulbs developing in the head.


Nono checks out the garlic bulbs. Shown here are the bulbs that divided underground, after one season's growth.

- **Formation of "bulblets":** This is a form of asexual reproduction which is quite unique. Some types of garlic will form small bublets in the place of a flower head.

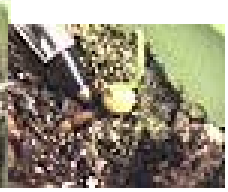


Schizostylus is a late flowering garden ornamental from the iris family. It produces small bulbs with a shoot preformed on its stem after flowering. These small bulblets drop off and produce new plants.

A week or so after the flowers have dried up, on the flower stem small bulbs begin to form

They send out a shoot while on the stem and then they easily break away from the stem. Falling on moist soil, they start to grow and resemble a plant like one that grows from a creeping rootstock, as shown here in the photo.

- **Formation of corms:** Corms are bulbous underground stems that lie dormant during the winter, just as rhizomes do. They also produce new plants the next growing season. The gladiolus in this photo is a typical representative. Gabi also develops corms.


- **Fragmentation:** Parts of a plant break off and grow into a new plant. It may also include *vegetative* reproduction in which a part of the plant, not specialized for reproduction, breaks off and grows into a new plant.

  Opuntia Cactus has very brittle stems and leaves that often break off when animals walking by brush into them. Any piece of leaf tissue touching the ground will form roots and grow into a new plant when conditions are right. These are some samples that have grown from the receptacles of flowers.

  Lucas works with another Xerophytic plant (a plant that can live in hot environment) *Crassula.* When dropped on moist soil, each leaflet will produce a tiny plant at the point of attachment.

- **Budding Plantlets**: several plants bud off tissue that develops into a miniature version of the parent plant. This tissue may even develop roots while still attached to the parent plant.

  Bits of the plants are specialized for breakaway and dispersal (look like tiny plants with very small leaves and roots already visible). Katakataka plant produces plantlets along leaves.

  Another species of katakataka produces completed plantlets at the ends of its leaves.

Artificial Asexual Reproduction

Economically speaking, it is very beneficial to reproduce plants asexually. It guarantees a "perfect" product every time because once the desired combination of genes is found, there is no need to risk losing it through sexual reproduction.

One of the most common methods of asexual reproduction is by **cuttings**. In this method, a piece of the plant (a cutting) is removed, usually dipped in rooting hormone, and then left in water or moist soil allowing new roots and therefore a new plant to form. Another method often used is **grafting** where a cutting or a scion is taken from one plant with desirable characteristics and grafted into a rootstock. The rootstock will keep its traits and allow the scion to grow, enabling disease resistant varieties of high quality crop plants to be produced. In the photo, the students are preparing cuttings of *Ribes Sanguineum*, a local native species of flowering plant that flowers or blooms very early in the spring, in February or early March. They will plant these on our campus. Their bright red blossoms are one of the first food sources for migrating hummingbirds.

(All photos/pictures are courtesy of www.pearson-college.uwc.ca/pearson/biology/asex/asex.htm)

What you will do

Activity 3.1

Share your opinions.

- What do you think? What are the advantages and the disadvantages of asexual reproduction and sexual reproduction? Share your thoughts, opinions and feelings.

_____
_____
_____
_____

Activity 3.2

1. Give five examples of asexual reproduction in organisms (animal or plant)

Key to answers on page 25.

What you will do

Self-Test 3.1

Label each of the following as describing asexual reproduction (A) or sexual reproduction (S).

___ 1. Budding is an example of this type of reproduction.
___ 2. Gametes are produced by the same or different individuals.

___ 3. Offspring has a different combination of genes than either parent.
___ 4. It produces an offspring that may be better adapted to a new environment.
___ 5. Regeneration is an example of this type of reproduction.
___ 6. Usually, a large number of offsprings are produced.
___ 7. Strawberry plants grown from the nodes of stolons
___ 8. Potato plants grown from the eyes of a potato
___ 9. Gametes of gumamela flower fuse
___10. Ornamental plants grown from stem cuttings

Key to answers on page 25.

Let's Summarize

1. The cell cycle is a process of cellular division consisting of five phases: interphase, prophase, metaphase, anaphase and telophase.
2. Each cell must have a set of chromosomes similar to the set in the mother cell. This ensures that the baby will look like the parent.
3. To produce duplicate sets of chromosomes, the processes of mitosis and meiosis take place.
4. In mitosis, each new cell formed has the same number of chromosomes as the parent cell.
5. In meiosis, each new cell formed has half the normal number of chromosomes.
6. A cell with **46 chromosomes** at the beginning of meiosis I divides to produce cells each having only **23 single-stranded chromosomes** at the end of meiosis II.
7. The two nuclear divisions result in **four** cells.
8. Each of these four cells is a **sex cell** (sperm and egg cells).
9. Each sex cell has **half the number** of chromosomes of the original cell.
10. Reproduction is the creation of a new individual or individuals from previously existing individuals. In animals, this can occur in two primary ways: through asexual reproduction and through sexual reproduction.
11. Animals reproduce sexually and asexually (budding, regeneration, fragmentation).
12. Plants reproduce sexually and asexually (formation of bulbs, formation of rhizome, formation of corm, formation of tubers).
13. Reproduction ensures the existence of organisms.

Whew! That was a tough job. At last! You have finished studying the module. But, before you completely exit from this module, let us find out how much you learned from this learning material.

Posttest

- There are 20 questions. Each question has ONLY ONE CORRECT ANSWER. Choose the one you believe to be correct.
- Each question is worth 2 points.
- Read each question and carefully. Take your time and think.
- GOOD LUCK!

1. Which of the following is involved in asexual reproduction?
   a. mitosis
   b. meiosis
   c. oogenesis
   d. binary fission
   e. both a & d are correct

2. Which of the following is not a form of asexual reproduction?
   a. budding
   b. regeneration
   c. fragmentation
   d. formation of rhizome
   e. union of egg cell and sperm cell

3. Variability in the offspring is an important benefit of what form of reproduction?
   a. Sexual
   b. Mitosis
   c. asexual
   d. binary fission

4. The following events are occurring in both mitosis and meiosis EXCEPT
   a. cytokinesis.
   b. karyokinesis.
   c. DNA replication.
   d. pairing of homologous chromosomes

5. Which statement about mitosis is **NOT** correct?
   a. It makes diploid nuclei.
   b. It forms four daughter cells.
   c. The prophase is the first active phase.
   d. It does not affect the nuclear envelope.

6. Which statement about binary fission is **NOT** correct?
   a. It occurs in prokaryotic cells.
   b. It exhibits five active phases.
   c. It produces two daughter cells.
   d. DNA is replicated before division.

7. Polar bodies are formed during
   a. mitosis
   c. oogenesis

b. meiosis
d. spermatogenesis

In questions 8-14, label each statement with one of the following choices:
a. meiosis I
b. meiosis II

___ 8. It is the synapsis of homologous chromosomes.
___ 9. It involves the separation of homologous chromosomes.
___10. It results in one oocyte and one polar body in human females.
___11. It results in four sperm cells in human males.
___12. The daughter cells have double-stranded chromosomes.
___13. The daughter nuclei produced have single-stranded chromosomes.
___14. The crossing-over of chromosome occurs.

In questions 15-19, match the cell phase to its description. Write the letters only.
a. DNA replication
b. chromosomes first become visible
d. chromatids separate at centromere
e. chromosomes are aligned at the metaphase plate
f. last phase of nuclear division

___15. anaphase
___16. metaphase
___17. prophase
___18. telophase
___19. interphase

20. The diploid chromosome number in an organism is 42. The number of chromosomes in its sex cells is normally
a. 21
b. 42
c. 63
d. 84

Got a perfect score? Check it out!

Key to answers on page 25.

Key to Answers

Pretest

1. b	6. b	11. b	16. d
2. e	7. e	12. a	17. b
3. a	8. a	13. b	18. e
4. d	9. a	14. a	19. a
5. b	10. a	15. c	20. a

Lesson 1

Activity 1.1

The number of cells that would result from the division of a single cell after 30 minutes is 64. In mitosis, one dividing cell produces two daughter cells.

Activity 1.2

The cell cycle is a process of cell division divided into five phases namely: interphase, prophase, metaphase, anaphase and telophase. Different events/activities take place in each phase.

Self-Test 1.1

1. T
2. T
3. F Mitosis is necessary (multicellular organisms do not undergo binary fission).
4. F Spindle formation occurs only during mitosis
5. T

Lesson 2

Activity 2.1

1. Body cells such as bone, skin and muscle cells divide by mitosis. Reproductive cells such as sperm and egg cells are formed by meiosis.
2. The dividing cell in mitosis divides once. In meiosis, the dividing cell divides twice.
3. The number of chromosomes in the parent and daughter cells is the same which are two sets in mitosis (46). In meiosis, the number of chromosomes in the daughter cells is one half the original number (23).
4. Since the dividing cell in mitosis divides once, the number of daughter cells produced is two. In meiosis, the dividing cell divides twice producing four daughter cells.

Self-Test 2.1

1. Meiosis is sometimes called reduction division because the number of chromosomes is reduced by half. The cell here also divides producing four daughter cells.
2. There are four cells at the end of meiosis II.
3. Since sperm cell is a sex cell, it will have half the number of chromosomes which is 32.

Lesson 3

Activity 3.1

Asexual reproduction versus sexual reproduction

Advantages of Asexual: no cost of meiosis; no cost of males; no cost of finding mates.

Advantages of Sexual: genetic recombination; offspring have a different combination of genes than either parent; offspring may be better adapted to a new environment; usually, a large number of offspring are produced

Activity 3.2

1. budding
2. regeneration
3. fragmentation
4. formation of rhizome
5. formation of bulb

Self-Test 3.1

1. A
2. S
3. S
4. S
5. A
6. A
7. A
8. A
9. S
10. A

Posttest

1. b
2. e
3. a
4. d
5. b
6. b
7. e
8. a
9. a
10. a
11. b
12. a
13. b
14. a
15. c
16. d
17. b
18. e
19. a
20. a

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