

Cellular Reproduction: Cellular Processes

- 1 The Cell - A Review
- 2 The Cell Nucleus
- 3 DNA, Chromosomes, Genes, and Proteins
- 4 Cell Division
- 5 Asexual and Sexual Reproduction
- 6 Genetic Engineering, Environment vs Genetics



Reproduction: Cellular Processes

Learning Outcomes

Students will be able to:

- recognize that the nucleus of a cell contains genetic information and determines cellular processes (305-1)
- explain the importance of using the terms gene and chromosome properly (109-14)
- identify major shifts in scientific understanding of genetics (110-3)
- illustrate and describe the basic processes of mitosis and meiosis (304-11)
- determine and graph the theoretical growth rate of a cell, and interpolate and extrapolate the cell population from the graph (210-2, 210-4, 210-9)
- distinguish between sexual and asexual reproduction in representative organisms (305-2)
- compare sexual and asexual reproduction in terms of their advantages and disadvantages (305-3)
- identify questions to investigate about sexual reproduction in plants (208-2)
- use tools and apparatus safely to investigate the structure of flowers (209-6)
- communicate the results of an investigation into the structure of flowers (211-2)
- provide examples of genetic conditions that cannot be cured using scientific and technological knowledge at the present time (113-10)
- compare factors that may lead to changes in a cell's genetic information: mutations caused by nature and mutations caused by human activities (305-5)
- evaluate information and evidence gathered on the topic of genetics and genetic engineering (209-5, 210-8)
- provide examples of how the knowledge of cellular functions has resulted in the development of technologies (111-1)
- provide examples of Canadian contributions to science and technology related to heredity and genetic engineering (112-12)

Lesson 1 The Cell – A Review

Before you begin this unit, review cell theory and the parts of animal and plant cells. The parts of a cell were studied in grade 8 science. You can review the parts of a typical animal and plant cell by referring to the figures on page 12 of the SciencePower 9. Cell theory is found on page 11 of the text. To appreciate how

a theory of the cell was developed, read text pages 5-9 and answer questions 1-9 on page 10 of the text. Instead of examining the parts of a cell again, you will focus on an extremely important part of the cell, the nucleus.

Lesson 1 Exercises

Text Reading: Introduction to Unit 1, p. 4-9, 11-13, 16

The text questions students are responsible to know the answers to are listed at the end of each lesson. Students should attempt to answer these questions, then compare their answers to the answers provided in the back of this guide.

Text Questions: p. 10 (1-9)
p. 16 (1-5)

In each lesson you will be expected to write a journal entry. In each lesson exercise you will read “Journal Entry” with a book icon placed beside the words. This reminds you to write your journal entry. A brief overview of a Journal Entry is provided on page 6 of this guide.

Journal Entry 

Lesson 2 The Cell Nucleus

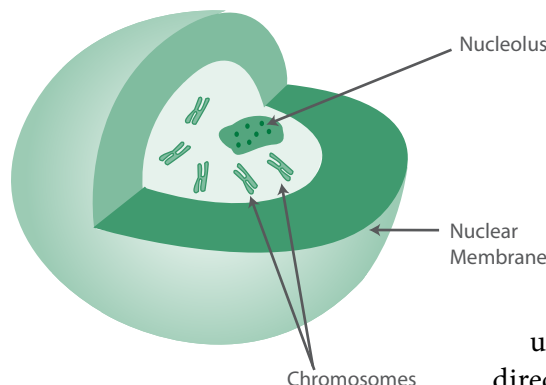
Our bodies are made up of about 100 trillion cells. Each cell has a job. The nucleus of a cell is one of the largest organelles found in cells, making up about 10% of the total volume of a cell. In a type of cell called eukaryotic cells, it is usually found near the centre. The nucleus is made up of three main parts, the **nucleolus**, the **nuclear envelope** (membrane), and the **chromatin**. Inside the nucleus are ribosomes, RNA, DNA, and proteins. The nucleus is enclosed and protected by a thin double layered porous membrane, which is similar to the cell membrane that encloses the entire cell. The nucleus membrane allows only certain chemicals (molecules) to get in or out. This nuclear envelope is important because it allows the nucleus to control the rest of the cell by sending out chemicals like ATP, DNA, and proteins, through the nuclear membrane, while keeping isolated from the cytoplasm that surrounds the nucleus. The chromatin contains DNA and proteins that form the chromosomes.

The **nucleus** is the most important part of the cell because it is the structure that determines

cell reproduction. It contains all of the plans or blueprints which determine the shape, size, and job or function for each cell. In addition, these blueprints determine the number of new cells and repairs for each cell. It basically determines what the cells look like and what they do. The nucleus is the site of DNA and RNA synthesis, and is therefore the storage site for our genetic material.

In summing up the role of the nucleus, we can say that the nucleus is the control centre for cell activities. The information required to synthesize cellular proteins is coded into the DNA found in the chromatin. Within the DNA, the gene contains the information in a protein. This information in a protein-encoding gene is copied into a messenger RNA (mRNA) which is capable of moving through the nuclear membrane into the cytoplasm. While in the cytoplasm, the mRNA molecules are used by ribosomes as directions for the assembly of proteins. The nucleus is also involved in the duplication of DNA in the chromatin as part of cell reproduction, a process known as **replication**.

Fig. 1-2-1 The Nucleus of a Cell



Lesson 2 Exercises

1. What is the size of the nucleus of a cell compared to the total volume of a cell?
2. What are the three main parts of a nucleus and what is the function or job of each?
3. Why is the nucleus the most important part of a cell?
4. How is the nucleus able to control the rest of the cell?
5. How is the nucleus protected from other matter in the cell?
6. What is meant by replication?

Journal Entry 

Lesson 3 DNA, Chromosomes, Genes, and Proteins

The nucleus contains the chemical substance **DNA**, deoxyribonucleic acid. The DNA exists as long threads called chromatin. If the DNA from a single human cell was stretched out, it would be three metres long. The structure of DNA can be seen on page 114 of the text, Figure 4.7. The DNA is in the form of a twisted ladder shape that is known as a “double helix”. The ladder’s rungs are made up of the four letter DNA alphabet: A, C, T, and G. The messages found in the DNA are given in a code made of three consecutive bases which are along one strand of DNA. These three consecutive bases are known as a **codon**. Codons have the instructions for one kind of protein, see text, page 117, Figure 4.8. The DNA undergoes compact folding and coiling to form structures called chromosomes, see text page 114, Figure 4.6. The DNA is wrapped tightly around some proteins. Chromosomes can be viewed under a light microscope when the cell is in the process of dividing. A **chromosome** is made up of two DNA chains running in opposite directions. If the DNA was stretched it would look like a string with beads. Each of these beads of DNA is called a **gene**.

A **gene** supplies a piece of genetic information. It is a heredity unit that specifies an organism’s traits. One or more genes determine the traits that a person exhibits. A **trait** is a distinguishing feature or quality in a person. Each chromosome is made up of thousands of genes. Each gene has its own specific location on the chromosome. Every human cell contains 46 chromosomes or 23 pairs of chromosomes. Both the chromosomes and genes come in pairs. The chromosomes are the recipe for an organism’s body. Each gene does one specific job and is a different packet of information necessary for a body to work and grow. They will determine such traits as height, colour of eyes, shape of the nose, etc. You have about

25,000 genes. To summarize: the DNA strand is made up of letters, which in turn make words, which in turn make sentences. The genes are these sentences that tell the cell to make proteins. This is illustrated below:

Letters

ATGCTCGAATAAATGTCAATTTGA

Words

ATG CTC GAA TAA ATG TCA ATT TGA

Sentences

[ATG CTC GAA TAA] [ATG TCA ATT TGA]

Proteins

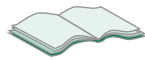
Each cell contains thousands of different proteins. **Proteins** are chemicals, polymers of amino acids, which are made up of hundreds or thousands of amino acids. There are estimated to be about 100 000 different proteins in the human body. Each protein is made up of a combination of different combinations of just 20 amino acids. Proteins work together like machines to operate the cell. One of the two main roles of proteins is to form most of the solid material in the human body (structural proteins), such as skin, muscles, tendons, and hair. The other role is to carry out functions and activities in our bodies (functional proteins), such as the haemoglobin protein that helps to transport oxygen in the body, and the insulin protein that helps regulate the storage of the sugar glucose in our bodies. Another important class of functional proteins are enzymes which speed up and allow certain chemical reactions to occur in our bodies.

Lesson 3 Exercises

Text Reading: p. 114, 117

1. DNA is an abbreviation. It is a chemical substance. What is the name of the acid in the abbreviation DNA?
2. What is the job or function of the DNA?
3. What is a chromosome? What is the job of the chromosome?
4. Where are genes located?
5. What is the function or job of genes?
6. What is the job of proteins?

Journal Entry



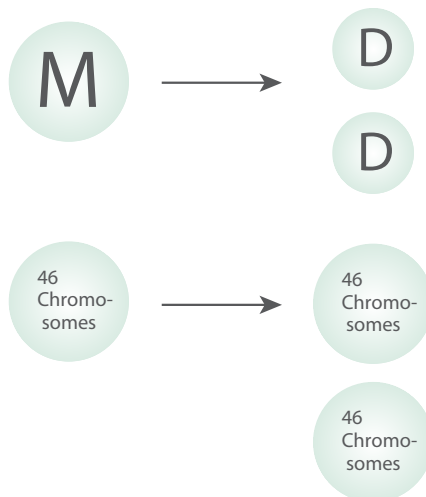
Lesson 4 Cell Division

There are about 100 trillion cells in our bodies, yet life began as a single cell. Where do all the cells come from? How do we grow and develop into mature adults? How is life perpetuated and how is our species allowed to continue? The answers to the questions are examined in this lesson. The answer has to do with cell division.

Mitosis

Mitosis is a process where the nucleus of a cell divides to produce two new nuclei. Each contains an exact copy of the DNA of the original nucleus. The division of the rest of the cell is called **cytokinesis**. In multicellular organisms, like humans, this cell division enables the organism to grow larger and to repair damaged tissue or replace dead cells. In humans, three billion cells die every minute. One cell divides to make two cells, which divide to make four cells and so on. In mitosis, the original cell called the mother cell divides to produce two daughter cells that are identical to the parent cell.

Fig. 1-4-1 Mitosis Cell Division



During cell division there is the division of the nuclear materials and the sharing of the cytoplasm, including the organelles. There

are four phases of mitosis in an animal cell. In grade 9 a summary of events between cell division are examined. The events include:

- The cell takes in nutrients and produces building material, such as proteins.
- The cell uses these materials to repair damaged cells, and for growth and energy.
- The cells grow rapidly.
- The chromosomes in the nucleus are duplicated in order to prepare for cell division. This is called replication. These chromosomes contain the genetic material for the operation of cells including cell division.
- There is another period of growth and preparation for cell division.

Before mitosis is complete, the cytoplasm and its contents separate into equal portions which go to each daughter cell. This is the process of cytokinesis. The daughter cells grow and eventually reach the size of the parent cell. Because duplicated chromosomes are divided into two daughter cells, cells will have the same set of chromosomes before and after mitosis. Therefore, they will have the same set of genes.

Meiosis

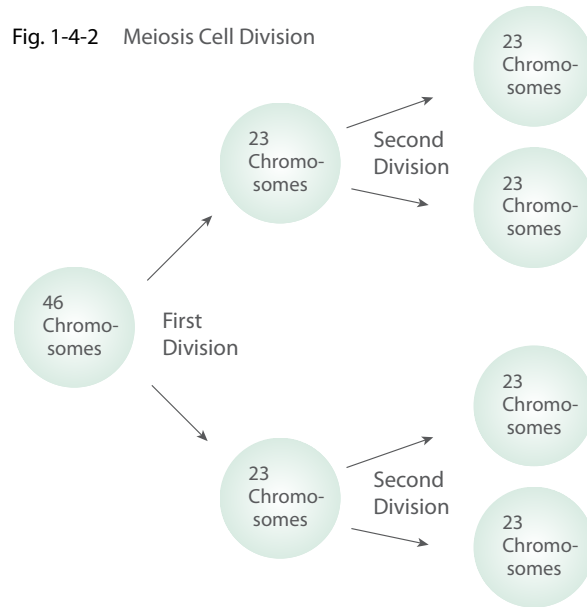
In the process of mitosis the mother cell divides to produce two daughter cells. Each daughter cell is identical to the mother cell and has the same number of chromosomes. This type of cell is called a **somatic cell**. Examples include muscle and skin cells.

Another set of cells divide through a process called meiosis. These are the so called reproductive cells that produce sex cells. The

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specialized cell for reproduction is called a **gamete** and examples are egg cells (female) and sperm cells (male). During meiosis daughter cells are produced that have only half the number of chromosomes as the parent cell. A sperm cell and an egg cell from the two parents must combine during fertilization to form new offspring. If mitosis was involved to produce sperm or egg by a creature with 6 chromosomes, the offspring would have 12 chromosomes, a new species! Meiosis is necessary to ensure that the joining together of the two gametes doubles the number of chromosomes to equal the number of chromosomes characteristic of that particular species. Meiosis ensures that each of the gamete cells contains one-half of the set of chromosomes (23). Meiosis involves two cell divisions that produce 4 daughter cells.

Fig. 1-4-2 Meiosis Cell Division



The difference in forming sperm and egg cells is shown in Figure 2.5, page 50 of the text.

Lesson 4 Exercises

Text Reading: p. 17-19; 22-25; 46-50

1. Approximately, how many cells are there in the human body?
2. What are the names of the two types of cell division in our bodies?
3. Describe the process of mitosis and draw a diagram to represent it.
4. Briefly describe what happens in between cell divisions during mitosis.
5. What is cytokinesis?
6. What is the purpose of mitosis?
7. What type of cell is involved in mitosis?
8. Describe the process of cell division called meiosis and draw a diagram to represent it.
9. What type of cell is involved in meiosis?
10. What is the purpose of meiosis?

Journal Entry 

Lesson 5 Asexual and Sexual Reproduction

Organisms of all species need to reproduce. The two ways this may happen are asexual reproduction and sexual reproduction.

Asexual Reproduction

In asexual reproduction, a single organism produces offspring with identical genetic information. Most single – cell organisms, like bacteria and some multicellular organisms, produce offspring by asexual reproduction.

Binary Fission

The one – celled bacteria reproduce asexually, see pages 29-30 in the text. The process by which they reproduce asexually is called binary fission. The bacteria cell does not contain a nucleus. It contains a single chromosome which is duplicated to contain the complete set of DNA from the original parent chromosome. In Figure 1.22, page 30 of the text, the two identical chromosomes move to opposite sides of the cell. The cell membrane is pinched inward near the middle to create two cells. Unicellular organisms such as the amoeba, a Protist, use asexual reproduction to produce offspring. The difference, when compared to bacteria, is that the amoeba contains a true nucleus with the DNA inside. Mitosis takes place in the cell to produce two identical offspring, as shown in Figure 1.24, page 32, in the text.

Budding

Yeast, a fungi, reproduces asexually by a process called budding, Figure 1.27, page 33 of the text. In yeast process a copy of the nucleus is made. This nucleus ends up in a small outgrowth from the parent, a bud on the cell wall. It grows and eventually breaks off, forming a new independent cell. Budding not only occurs in single – cell organisms like yeast, but in some multicellular organisms like the hydra.

Spore Asexual Reproduction

Moulds reproduce asexually through spore reproduction. The parent cell produces many smaller, identical cells called spores through mitotic cell division. These spores usually remain within the parent cell and have a tough coating that allows them to survive after the parent cell dies. Each spore is capable of developing into a mature organism.

Sexual Reproduction

The human body produces specialized sex cells or gametes which are responsible for sexual reproduction. If this process occurred through mitosis, the daughter cells would be identical to the parent cell and all offspring would look exactly like the parent. However, if we examine the members of a human family, we will notice some similarities, but we will also notice some differences, a variation in characteristics of family members. Therefore, reproduction cannot be through only mitosis. In sexual reproduction the gametes (reproductive cells) from two parents, sperm and egg cell gametes, combine during a process called **fertilization**, to form a new cell called a **zygote**. This new cell is therefore the first body cell to form in the new organism. The chromosomes in our body cells are arranged into 23 pairs of chromosomes that are similar in size and shape. They are known as homologous pairs. For each pair of chromosomes, one comes from the father, and one comes from the mother. Chromosomes in the human body cells come in pairs. They are referred to as “**diploid**”, “di” meaning two, $2 \times 23 = 46$ chromosomes. The diploid number for human cells is 46. Human gamete cells contain only half of the diploid number, 23 chromosomes and are referred to as “**haploid**”. The differences in characteristics of the same family members, is explained by what happens during meiosis, which is responsible for sexual reproduction. During **meiosis**, a

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gamete is produced that has a combination of chromosomes different from each parent. Since the nuclei are not identical, it is possible to produce offspring that are different from their parents, yet have the same number of chromosomes. The production of non-identical

nuclei occurs early in the meiosis process during “crossing over”. In this event, the double-stranded chromosomes come in contact and exchange some segments of DNA, see text, page 47, Figure 2.4.

Advantages and Disadvantages of Sexual Reproduction	
Advantages	Disadvantages
Increase in the genetic variability of offspring. This is very useful in unstable or unpredictable environments in order to survive. This mixing of the gene pool produces diversity and aids in the fight against parasites and predators who cannot adapt instantly to altered offspring. This allows for the development of a population that is specifically adapted to its surroundings, increasing its chance to survive.	Too much variation prevents close adaptation to any environment.
Seeds/ fruits which are formed allow for effective long distance dispersal.	Seed germination and seedling stages are unreliable due to high mortality rates in stressful environments.
Care of young	Expenditure of time and energy to find a mate.
	The need to find a mate, which may be difficult in low population densities.
	Genes are diluted when an animal mates, since only half of its genes go into an offspring.
	Some adaptive combinations of genes are lost.
	Lowered rate of population growth since only half a population (female) can produce offspring.

Advantages and Disadvantages of Asexual Reproduction	
Advantages	Disadvantages
Faster and easier than sexual reproduction because another partner is not needed and doesn't have to be found.	Produce clones and since there is no variation in offspring, cannot cope with changing environment.
The animal or pollen grains don't have to travel in order to reproduce.	
Requires very little expenditure of energy.	
Does not allow genetic variation which means mutations or "bad" qualities will not be passed on. Well – adapted organisms can be preserved and multiplied, thus keeping its desired combination of traits.	
More reliable than sexual reproduction because of less steps involved and therefore less chance for something to go wrong.	
Good for harsh environments and not as easily affected by environmental conditions.	
Vigorous regrowth after disturbances.	
Large numbers can be produced.	
Spores can be widely dispersed, increasing chance of survival.	

In summary, asexual reproduction seems to be favoured when rapid population growth is needed, and sexual reproduction is favoured when there are changing environmental conditions.

Sexual Reproduction in Plants

The stages by which plants reproduce sexually is similar to how animals reproduce sexually. The product of sexual reproduction in most plants is seeds. A seed contains all the material necessary for reproduction: an embryo, a food supply, and a seed coat which protects it. More than half of plant species are **angiosperms**. In these, the flowers contain the plants' reproductive organs. Figure 2.25 on page 62 of the text shows the female reproductive organ called the **pistil**, and the male reproductive organ, called the **stamen**. Part of the process

of **fertilization** involves either self-pollination or cross-pollination, see page 67 text, Figures 2.26B and 2.27. **Gymnosperms** are plants that do not produce flowers. They produce seeds inside cones. Some plants produce sexually but without producing seeds, examples ferns and mosses. Such plants reproduce through spores, see text, page 70, Figure 2.35.

Asexual Reproduction in Plants

Asexual reproduction in plants enables each new plant to have the same DNA as its parents. The tips of the roots and stems of plants contain growing areas called **meristem**. This area contains cells that can undergo mitosis over and over again to produce new cells. There are different ways that plants reproduce asexually.

These include:

New plants from roots
New plants from stems
New plants from tissue culture

Pages 38-40 of the text, discusses each of these methods.

Mutations

Before a cell reproduces, the DNA must be copied to provide the same information to the new cell. However, a perfect copy is not always made. When mistakes are made during the copying process, the mistakes are called

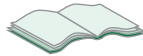
mutations. This changes the genetic code. Mutations can be either neutral, beneficial to the cell, or damaging to the cell. Some damaging mutations can cause cancer. Mutations are also inherited. A mutation in a body cell is less damaging than a mutation in reproductive cell. Mutations can be caused by a number of sources. These include extreme temperatures, exposure to the radiation from the sun or radioactive sources, exposure to certain chemicals. This could cause the cell not to function at all, or to lose control of the cell division process. Page 118 of the text, Figure 4.10 shows types of chromosome mutations.

Lesson 5 Exercises

Text Reading: p. 29-30; 32-35; 44-47; 50-52; 60-63; 66-71; 72-74; 118

Text Questions: p. 35 (1-6)
p. 50 (1-7)
p. 71 (1-5)
p. 74 (1, 2, 6)
p. 121 (4)

Journal Entry



Lesson 6 Genetic Engineering, Environment vs Genetics

Genetic engineering involves a process that artificially combines genes in a cell. Scientists can take DNA from the cell of one organism and place it in the cell of another organism to produce a new combination. Many diseases result from genetic disorder. Some genetic diseases are considered incurable today. Others can be helped through **gene therapy**. In this process, defective genes are replaced with healthy genes. Gene therapy promises to be a very useful technique for testing genetic disorders. In 1990, the Human Genome Project was started in the United States. A genome is all the DNA in an organism including its genes. The object of the project was to locate all of the approximately 20,000 – 25,000 genes located on human DNA. The project was completed in 2003. It involved a number of countries. Analysis of the data continues. It will permit the diagnoses, treatment, and perhaps one day the prevention of thousands of disorders. With

this genetic information, comes ethical, legal, and social challenges.

Environment vs Genetics

Physical characteristics such as height, hair colour, eye colour, are hereditary, and are therefore determined by genetics. Is behaviour, such as a talent for singing and a thrill seeking personality genetic? Is this learned through your environment with your parents or is this predetermined by your genes? This argument has continued over the years and is often referred to as “nature vs nurture”. Some scientists think we behave as if we had a genetic predisposition to act in a certain way (nature). Other scientists believe that we behave in certain ways because of what we have been taught or learned in our environment, the environmental factors of our upbringing (nurture). The debate continues!

Lesson 6 Exercises

Text Reading: p. 119-122, 124-133, 135-138, 140

Text Questions: p. 126 (2-4), p. 131 (1-2, 4-6), p. 140 (1-2, 4)

Journal Entry 

Unit 1 - Do and Send

Reproduction: Cellular Processes – Assignment Questions

Textbook pages 148-151	Short Answer 24-27, 30-33
True/False 1-3, 6	Problem Solving 35, 39-40
Completion 7-9, 11-12	Critical Thinking 45
Multiple Choice 14-16, 19, 21-23	Applications 46-48

Reproduction: Cellular Processes Research – Assignment

Use the text, the internet, EBSCO, and any other resources to research the following topics. Write a 3 paragraph description on each topic. List all references.

- Genetically modified food
- Diseases of a genetic nature that are currently incurable through science and technology
- Ways in which genetic information can be altered within an individual and between generations

Home Activities/Experiments

- Page 25, Graphing Human Body Growth
- The Rate of Cells Dying and Being Replaced Through Cell Division**
This activity illustrates the rate in general at which cells die and are being replaced through cell division. Picture a chess board with 64 squares. You are going to place numbers on each of these squares. The rule is to double the number on the preceding square each time until the first 20 squares have numbers on them. We will start with the number 1 on the first square. The next square will have the number 2. The next square will have the number 4. The next square will have the number 8, etc. After you have calculated the numbers on the first 20 squares, plot a graph of the value of the number you have calculated for each square (y axis) versus the number of the square, i.e., square 1, 2, 3, 4,20 (x axis). Comment on the shape of the graph. If the graph is supposed to be similar to the rate at which cells die and are replaced through cell division, comment on the rate at which cells die and are replaced through cell division.
- Page 34, Making a Mould
Propose an experiment, but do not do the actual experiment. Answer questions 1 and 2 of “What To Do Section”.
- Page 120, The Cloning Controversy
- Page 124, Genetic Disorders