Grade 9 Science April 29 - May 5, 2020

Below you will find this week's science nine assignments. This week there are 2 Parts to the assignment, please read instructions carefully for each part. The 'extending your learning' is offered for those who want to go beyond the minimal requirements.

If you need or want assistance on the assignment provided below, we are offering 'office hours' using the platform 'Zoom' twice per week with one of the four science teachers: Mr. Kyle Conne, Ms. Alanna Skene, Mr. Ricky Carr and Mr. James Cutt. Please see the end of this document for this week's office hours. However, if you wish to speak directly with your science nine teacher, please do not hesitate to email them or ask a question on your classes Office 365 Team page at any time and they will respond in a timely manner. Also, there will be a Zoom meeting to help any students with Office.com on Thursday April 30th at 11:00am:

Zoom MeetingTime: Apr 30, 2020 11:00 AM Pacific Time (US and Canada)

Join Zoom Meeting:

https://us02web.zoom.us/j/97209654319pwd=L1hvU2RsbWFEaFlhQ2JVdTFJWEd6Zz09

Meeting ID: 972 0965 4319

Password: office365

Submitting completed work: Please submit your completed work by May 5, 2020 via **your Office 365 Class Teams account, ideally by clicking the "Turned In" button or through email. Assignments and any relevant resources will be posted in your class' Teams Account.**

Learning Intentions:

1. Core Competencies of Communication, Thinking and Personal and Social Awareness and Curricular Competencies relating to making observations aimed at identifying students' own questions, including increasingly complex ones, about the world around them.
2. Big Idea: Electron arrangement of electrons determines the compounds formed (ionic or covalent)
3. Big idea: Cells are derived from cells
    - How do cells multiply and function

Assignment Instructions:

Outline: Please access your Office.com Science Class Teams account and ensure that you can access the instructions, online videos and student worksheets. Please complete the student worksheets and turn them into your teacher.

Required materials:

- Assignment # 4
- BC Science nine textbook of chapter 4.1 and 5.1
- You may also require chapter 3.2 from Assignment #2 to finish the Ionic and Covalent Review # 1 Student Worksheet
- Chemistry Databook (same as Assignment # 2)
- Ionic and Covalent Review # 1 Student Worksheet
- Introduction to Cell Biology Webquest Student Worksheet

Criteria / Rubric:

Assessment is based on a 4-point proficiency scale:

emerging	developing	proficient	extending
The student demonstrates an initial understanding of the concepts and competencies relevant to the expected learning.	The student demonstrates a partial understanding of the concepts and competencies relevant to the expected learning.	The student demonstrates a solid understanding of the concepts and competencies relevant to the expected learning.	The student demonstrates a sophisticated understanding of the concepts and competencies relevant to the expected learning.

Assignment Part 1 (Covalent and Ionic Naming/Formula Review):

Please complete the “Ionic and Covalent Review #1 Student Worksheet”. This worksheet has a mixture of Covalent, Type I Ionic, Type II Ionic and Polyatomic Ionic Compounds on it. Please follow the instructions on the top of the worksheet. You may need to refer to the Class Notes posted for Assignment # 2 and Assignment # 3 and you will need to refer to your Chemistry Databooklet (especially the last page). Once you have completed the worksheet, please “Turn-In” the worksheet in your Teams class account.

Assignment Part 2 (Introduction to Cell Biology)

Please complete the “Introduction to Cell Biology Webquest Student Worksheet”. You will need to watch the videos linked in the instructions of this assignment. You will probably wish to open the video in a new “tab” or “screen” so that you are able to pause and re-watch some of them and to also ensure that you are able to fill in the information in your student worksheet as you view the videos. Please ensure that your information is complete. Once you have finished, please “Turn-In” the worsheet to your Teams class account.

Extending Your Learning (Optional):

Please read the worksheet titled “Science 9 Enrichment Activity April 29 – May 12, 2020”. Student will need to read the article and watch the video posted in the worksheet, complete the worksheet and submit it to their teacher by turning it in to their Teams class account

Office Hours: April 30 – May 4 (via ZOOM: https://zoom.us/join):

Time - 1:00pm to 2:00pm

Thursday, April 30: Mr. James Cutt

- Meeting ID: 916 773 99798
- Password: science

Monday, May 4: Mrs. Alanna Skene

- Meeting ID: 990 8478 0100
- Password: science

Ionic and Covalent Review Student Worksheet #1

Please write the formula or name corresponding to the given name or formula for the following ionic compounds. You can use the "subscript"  *button in the "Home" bar to make small numbers.*

Hints:

1. *For every question ask yourself, "Is this covalent or ionic?".*
2. *If the question is covalent, use prefixes and DO NOT BALANCE charges. If you need help, use the flow chart for covalent compounds found on the back of the chemistry reference package.*
3. *If the question is ionic, you need to draw a t-chart to balance the charges. DO NOT use prefixes. If you need help, use the flow chart for ionic compounds found on the back of the chemistry reference package.*
4. *If an element ends in something other than 'ide' it might be polyatomic. Treat these as ionic compounds. We have created these in* ***bold*** *below.*
5. *We recommend you do this on paper, take a picture of your work, and submit it in TEAMS just below the word document where it says: "My Work + work."*

Sodium bromide	NaCl
Aluminum fluroride	Cs_3P
Tetraselinium monooxide	N_2Br_4
Silver nitride	CuI
Gold (III) iodide	$(NH_4)_2SO_3$
Telluride dinitride	C_5F

Aluminium chrom**ate**	$Mn(CN)_2$
Trisulfur nonaoxide	KCH_3C00
Ammonium nitr**ite**	Se_5Cl_2
Manganese (II) phosph**ite**	$Pb(OH)_4$
Calcium sulphide	CuI_2
Lead (IV) sulph**ate**	$Fe_3(PO_3)_2$

Introduction to Cell Biology Webquest Student Worksheet

HINT: You may want to watch the videos more than once or pause the video to answer questions.

Part A - What Are Cells?

At the following link, watch the "What Are Cells" video clip by Bill Nye the Science Guy.

As you watch fill in the blanks and answer the following questions.

https://www.youtube.com/watch?v=98hGuTScrjw

1) There are approximately _____cells are in the human body.
2) List 5 types of cells found in the human body:
   a) _____,
   b) _____,
   c) _____,
   d) _____,
   e) _____.
3) Cells are similar to bricks in a brick wall because _____ _____but different because_____.

Part B - How Are Prokaryotic and Eukaryotic Cells Different?

At the following link, watch the "Introduction to Cells - The Grand Tour" video by The Amoeba Sisters. As you watch fill in the blanks and answer the following questions.

https://www.youtube.com/watch?v=8IlzKri08kk

4) List the 3 parts of the Modern Cell Theory:
   a. _____,
   b. _____,
   c. _____.
5) What 2 major groups are cells divided into:
   a. _____ b) _____.
6) What 4 things do both eukaryotes and prokaryotes contain?
   a. _____,
   b. _____,
   c. _____,
   d. _____.

7) Prokaryotes have NO _____ or _____ which eukaryotes DO have (PRO=NO and EU=DO).
8) Ribosomes make _____ and can be found in the _____ of eukaryotes.
9) Endoplasmic reticulum attaches to the nuclear membrane, is involved in the _____ of molecules, and comes in smooth and rough form.
10) This organelle is the ultimate packing center? _____.
11) The power plants of the cell are _____ which make ATP energy through cellular respiration.
12) Eukaryotes can be _____ or animal cells.
13) Plant cells have _____ which make glucose using light energy through photosynthesis.
14) Plant cells have one large central vacuole, while animal cells have several smaller vacuoles but both often have this function _____.
15) What type of cell has a cell wall? _____

Part C - The Nucleus Controls the Function of Life

At the following link, watch the "Learn Biology Cells: The Nucleus" video by Mahalo and complete the following questions.

https://www.youtube.com/watch?v=55gFY7YfUHM

16) The _____ is where most of the _____ is stored.

The _____ is inside the nucleus, and is where _____ are made.

Long strands of _____ combine with special proteins to create a long fiber called

_____, this chromatin is then used to create _____.

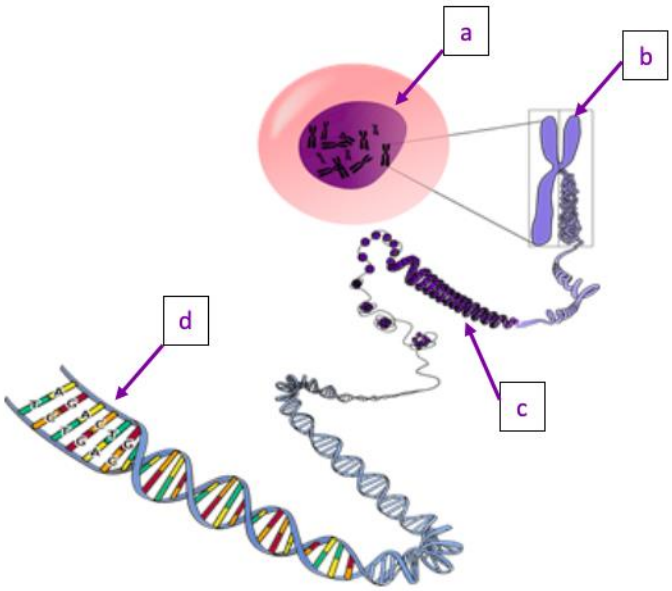
17) Label the following items on the diagram below:

a.

b.

c.

d.



18) Humans have _____ chromosomes in our body cells.

Part D - Chromosomes

At the following link, watch the video "Chromosomes" by Brightstorm and complete the following questions.

www.brightstorm.com/science/biology/cell-division-and-reproduction/chromosome

19) A _____ is a molecule of _____.

20) Chromatin is loosely organized _____.

21) Visible _____ are tightly packaged _____.

   a. Chromosomes only develop during _____ division.

   b. Chromatids are made of _____ strands of DNA molecules, these are attached to one another.

22) How many feet of DNA are packaged into the nucleus of all of our cells? _____Feet

23) When are chromosomes visible? During _____.

Using your **textbook** pages 127-129, answer the following questions (#24-26).

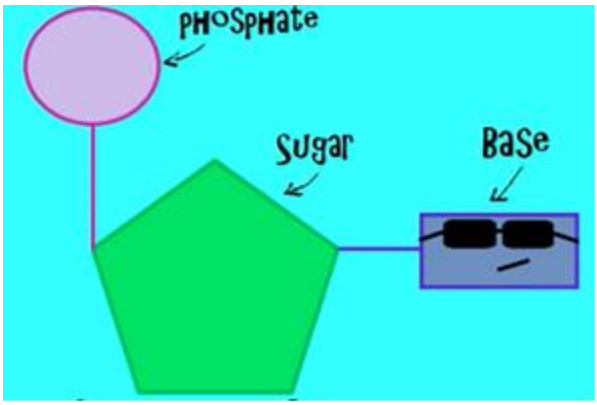
24) Chromosomes are generally found in pairs. What are the chromosome numbers found in the following organisms:
    a. Human _____.
    b. Cow _____.
    c. Chicken _____.
    d. Corn _____.
    e. Butterfly _____.
    f. Bat _____.
25) How many chromosomes are found in a single human sperm cell?_____.
26) How many chromosomes are found in a single human ovum cell?_____.

Part E - DNA and Genes

At the following link, watch the video called "DNA Structure and Function" by the Amoeba Sisters and complete the following questions.

https://www.youtube.com/watch?v=_POdWsii7AI

27) A clone is an _____ copy, because the material is the same.
28) List 4 traits that are controlled by our DNA:
    a.
    b.
    c.
    d.
29) What does every cell in our body have? _____.
30) Gene Regulation is: _____.
    Gene regulation depends on the function of the cell type (skin cells do not produce digestive enzymes).
31) DNA stands for _____.
32) The four base pairs are:
    a.
    b.
    c.
    d.



e. The Rhyme to help you remember is:
   i. _____ In the _____.
   ii. _____In the _____.

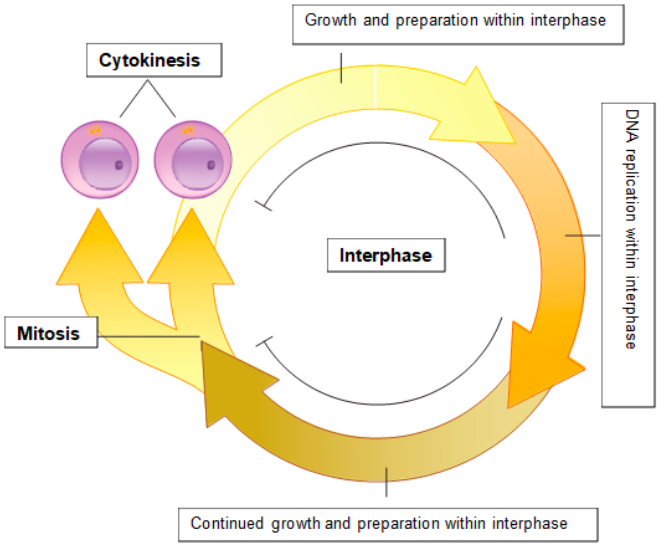
33) Using the above base pair knowledge, complete the sequence of base pairs that would exist on the other side of this DNA strand:

ACCTGCTAT

34) A mismatched base pair can result in a _____.

Part F: Cell Life Cycle

The life cycle of a cell is divided into three stages known as the cell cycle. See below for a diagram of the cell cycle.



The stages of the cell cycle are **interphase, mitosis,** and **cytokinesis.**

Explain below what occurs in each of the three stages of a cell's life cycle. See pages 153 to 158 of the textbook.

Interphase:	Mitosis:	Cytokinesis

Science 9 – Enrichment Assignment for April 29 – May 12, 2020

Has Corona Virus Helped the Environment?

Part A: We know that carbon emissions have sharply fallen during lockdown. But will these changes be good for the environment in the long run? Write YOUR OPINION, there are no wrong answers!

Your initial thoughts and your reasons for them:

Part B: Read the following and then watch the video posted below:

"There's clear water in the Venice canals, blue skies over Delhi and wild animals are roaming boldly in locked-down cities. The oil industry and airlines are floundering in this new world, and carbon emissions are falling fast.

But there are also mountains of food going to waste that our supply chains aren't set up to deal with. And, what's more, the radical changes to daily life that we're seeing now are not – thankfully – going to be permanent.

History tells us that when emissions have fallen sharply in the past, as they do after recessions, there's often a rocketing rebound that wipes out any short-term cut in emissions. *(Read more about Covid-19's lasting impact on the environment.)*

Is this pandemic any different?

Future Planet talks to BBC Minute about the close ties between lockdown and carbon emissions. In a nutshell: we could see long-lasting positive environmental change after the pandemic. But it's all down to how we move on after lockdown."

https://www.bbc.com/future/article/20200422-how-has-coronavirus-helped-the-environment

Part C: **After reading the above article and watching the above video, what are some of the reason's emissions are falling around the world (please state at least 2 different reasons, more are preferred)?**

Part D: **Once things go 'back to normal,' please state what are some of the positive aspects of being in a lockdown that we can continue to keep doing to help our environment as we look to the future?**

Part E: **A common theme we are seeing across Canada and around the world is that there is a strengthened sense of community. Write about an example of hope or positivity that you've seen in our community. Or, where do you think we could improve as a community in times like these?**

UNIT

2 Reproduction

Salmon in the wild lay big eggs stored with energy, and the offspring have a high survival rate after they hatch. Studies have shown that female chinook salmon raised in captive breeding programs lay many more eggs than wild chinook salmon. The eggs of captive females, however, are 25 percent smaller. Smaller eggs are less likely to survive in the wild and may eventually harm the survival of wild salmon populations into which captive females are reintroduced. Scientists are continuing to research the impact of human-controlled reproduction to ensure the survival of wild salmon populations.

Key Ideas

4 **The nucleus controls the functions of life.**

4.1 The Function of the Nucleus within the Cell

4.2 Mutation

5 **Mitosis is the basis of asexual reproduction.**

5.1 The Cell Cycle and Mitosis

5.2 Asexual Reproduction

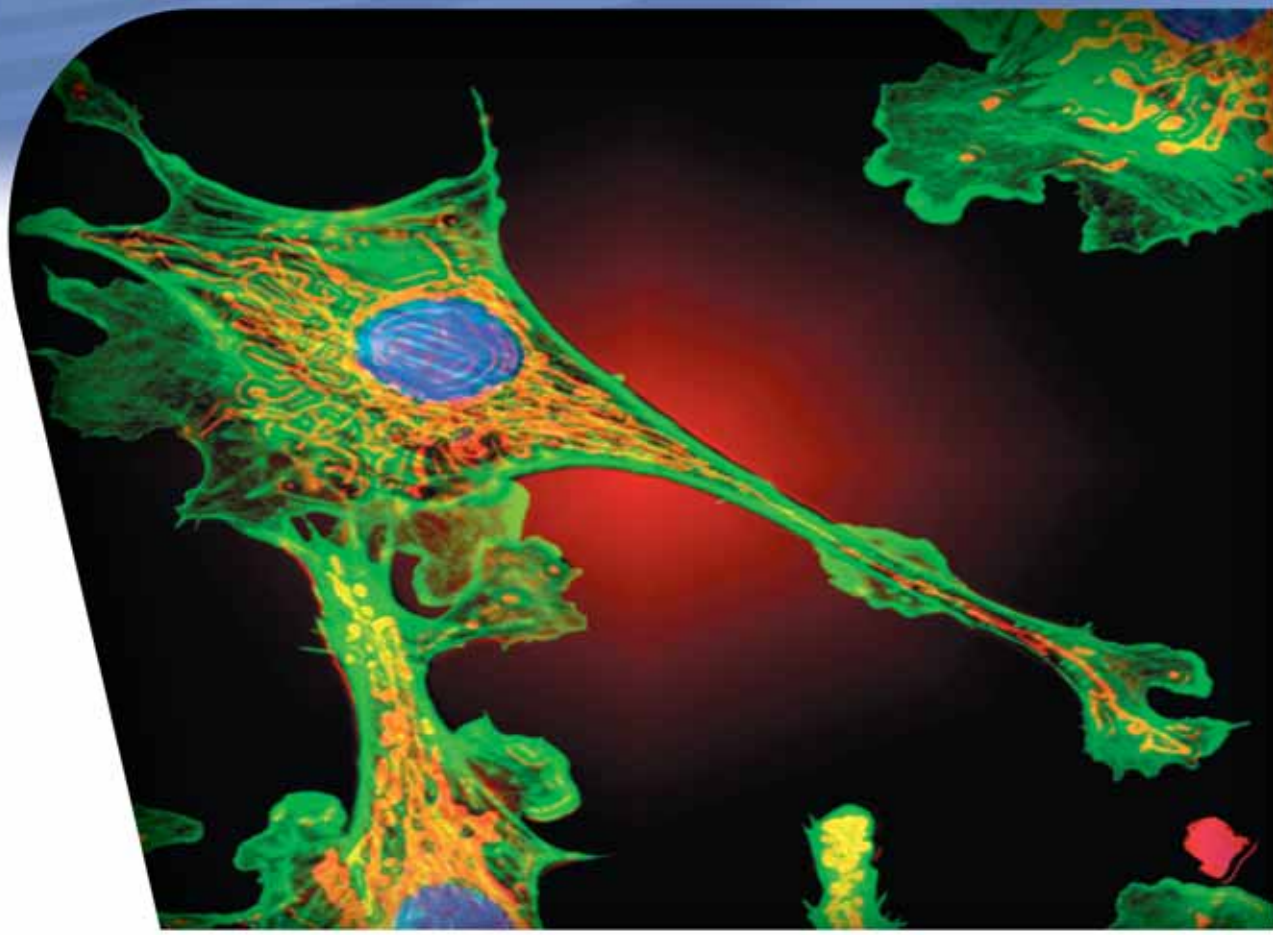
6 **Meiosis is the basis of sexual reproduction.**

6.1 Meiosis

6.2 Sexual Reproduction

6.3 Assisted Reproductive Technologies

Getting Started



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Nanotechnology is unlocking many mysteries of science. Find out how nanotechnology is playing a larger part in our everyday lives and in the world. Begin your search at **www.bcscience9.ca**.

Dr. Gill has just awoken from a restless night's sleep. This is the day she has dreamed about for months. In a few hours, she will take a new look inside the **nucleus**, the control centre of a living cell. As a cell biologist, she has used all types of microscopy to obtain images and information about what happens inside a cell's nucleus. Today is different, because Dr. Gill will be using nanotechnology to make her observations, and she will be able to see these processes in three dimensions.

Nanotechnology is the development and use of extra-small tools to study materials and living things on an extra-small, or nano, scale. Nanoscale objects are a billionth of a metre in size, or smaller. This is like comparing the size of a marble to the size of Earth.

Using nanoprobes, Dr. Gill will observe living cells carrying out their day-to-day activities during a one-week period. The nanoprobes are like nano-sized flashlights made of cadmium, selenium, and zinc. Getting them inside the nucleus is a challenge. The nucleus has a strong, protective barrier called the **nuclear membrane**. The nuclear membrane separates the nucleus from the rest of the cell. To get through this barrier, Dr. Gill and her team have disguised the nanoprobes so that they can pass through pores in the nuclear membrane.

Once inside the nucleus, the nanoprobes will allow Dr. Gill to observe the kind of detail that no one has seen before. The nanoprobes produce a much brighter light than other microscopy techniques, and the light does not fade away quickly. There is a good chance Dr. Gill will witness a rare event happening in the nucleus.

This story may sound like science fiction, but scientists today are already taking advantage of technology such as nanoprobes. Research using nanotechnology will confirm or change our current understanding of the cell and the activities of the nucleus. Nanotechnology will also help researchers find new ways to treat and cure diseases.

The Nucleus as a Black Box

Find Out ACTIVITY

In the early 1830s, a Scottish naturalist named Robert Brown first discovered the nucleus. He described it as a dark spot within the plant cell he was studying. Since then, scientists have learned much about the nucleus, especially during the last 20 years. However, many of the activities occurring within a cell's nucleus remain a mystery. Nanotechnology will allow scientists to gain more knowledge by posing new questions and making new predictions based on their observations.

Scientists use the term "black box" to describe something in which the inner workings cannot be seen. A cell's nucleus is a black box, because the activities within the nucleus are not always visible or understood.

In this activity, you will consider the limitations and challenges that a scientist must face when exploring the unknown. Using two different tools, you will investigate the inside of a sealed box. Then, from the information you gain, you will make inferences about the contents of the box.

Materials

- 1 black box
- 1 cotton ball
- 1 drinking straw
- clear adhesive tape
- 1 wooden skewer

What to Do

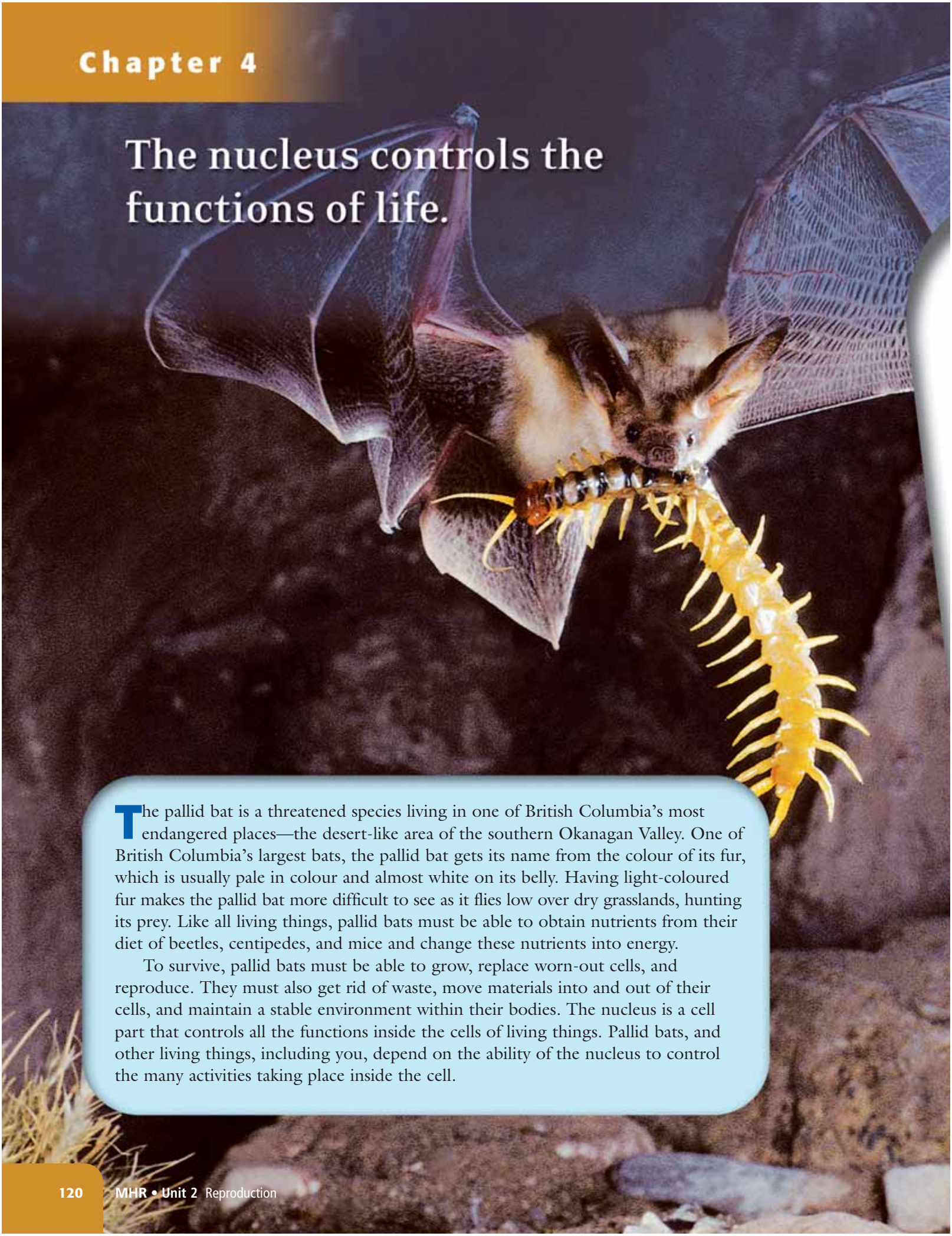
1. Your teacher will give you a closed box with a hole in the top. Do not open the box or look through the hole.
2. Attach the cotton ball to the drinking straw with adhesive tape.
3. Put the straw probe through the hole in the box. By feeling around with the straw, determine what is in the box. Draw a sketch of your observations in your notebook.
4. Repeat step 3 with the wooden skewer, using the sharp end. (Do not attach a cotton ball.) Draw a new sketch and add any new information.

What Did You Find Out?

1. List as many inferences as you can about the contents of the box.
2. What difficulties did you encounter when you probed the inside of the black box?
3. Explain how you were able to overcome these difficulties.
4. Compare the information you gained using the straw probe with the information you gained using the wooden skewer.
5. How confident are you that your drawing accurately represents the contents of the box? Explain.
6. Without opening the box, how could you gain further information?

Chapter 4

The nucleus controls the functions of life.



The pallid bat is a threatened species living in one of British Columbia's most endangered places—the desert-like area of the southern Okanagan Valley. One of British Columbia's largest bats, the pallid bat gets its name from the colour of its fur, which is usually pale in colour and almost white on its belly. Having light-coloured fur makes the pallid bat more difficult to see as it flies low over dry grasslands, hunting its prey. Like all living things, pallid bats must be able to obtain nutrients from their diet of beetles, centipedes, and mice and change these nutrients into energy.

To survive, pallid bats must be able to grow, replace worn-out cells, and reproduce. They must also get rid of waste, move materials into and out of their cells, and maintain a stable environment within their bodies. The nucleus is a cell part that controls all the functions inside the cells of living things. Pallid bats, and other living things, including you, depend on the ability of the nucleus to control the many activities taking place inside the cell.

What You Will Learn

In this chapter, you will

- **describe** the nucleus and the relationship of the nucleus with other cell parts
- **describe** the role of genes in the production of proteins
- **explain** how proteins function in a cell
- **describe** factors that may lead to changes in a cell's genetic information
- **demonstrate** an understanding of how mutations occur

Why It Is Important

Understanding the structure of DNA and how the nucleus controls cell activities provides us with knowledge about how cells function and how mutations occur. As scientists learn more about the nucleus, they will continue to develop technologies such as gene therapy to correct mutations and treat people with genetic disorders.

Skills You Will Use

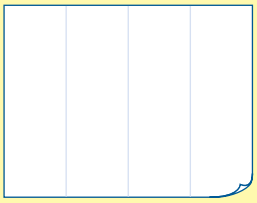
In this chapter, you will

- **observe** DNA from living things
- **construct** a model of DNA
- **work** co-operatively
- **communicate** your understanding of how the nucleus controls a cell's activities

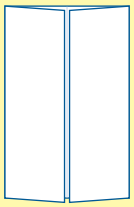
FOLDABLES™ Reading & Study Skills

Make the following Foldable and use it to take notes on what you learn in Chapter 4.

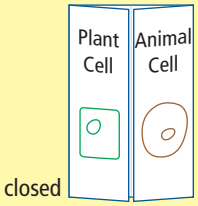
STEP 1 **Fold** a sheet of paper into fourths.



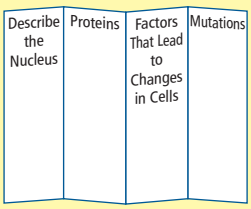
STEP 2 **Refold** to form a shutterfold as pictured.



STEP 3 **Draw** a plant cell on one side of the shutterfold and an animal cell on the other side.



STEP 4 Inside the shutterfold, **label** the four columns with the following titles: Describe the Nucleus, Proteins, Factors That Lead to Changes in Cells, Mutations.



Compare and Contrast Diagram, label, and explain the parts of a plant cell and an animal cell on the front of the Foldable, then compare and contrast the two. What part does the nucleus play in both types of cells?

4.1 The Function of the Nucleus within the Cell

The nucleus controls the functions of a living cell. Chromosomes within the nucleus are composed of deoxyribonucleic acid, or DNA. DNA carries the master set of instructions for cell function. Genes are small segments of DNA. Genes contain the information to produce proteins that control a cell's activities.

Words to Know

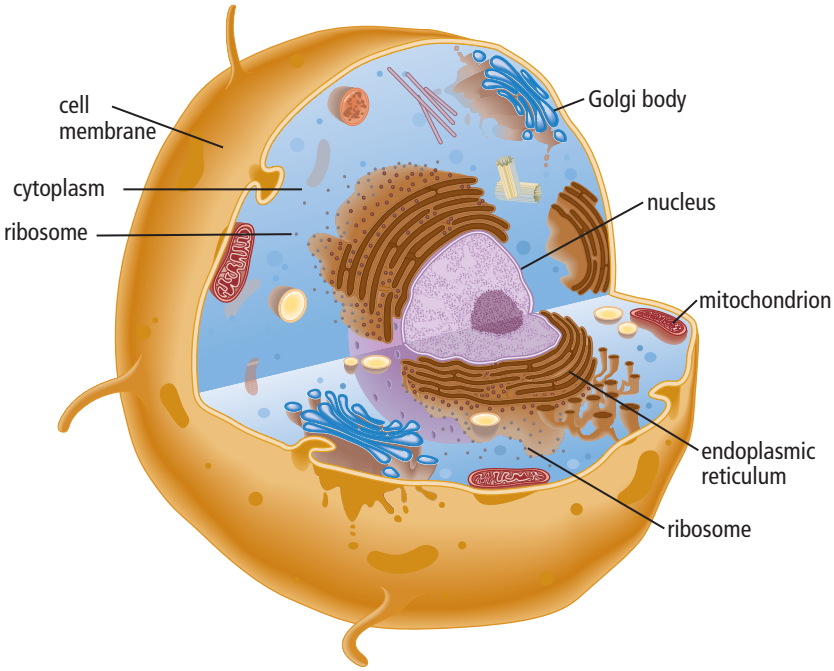
chromosome
DNA
gene
nucleolus
nucleus
protein

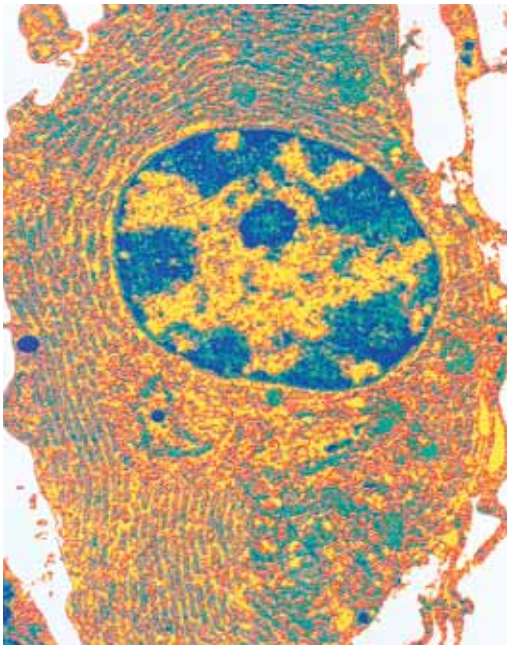
Life processes within cells occur very quickly. Using technologies such as nanoprobes, scientists are seeing these processes more clearly and learning more about how cell parts function and transmit messages to the nucleus. So far, the journey into animal and plant cells has helped scientists determine the structure and function of the cell parts shown in Figure 4.1A and Figure 4.1B on the next page.

A Survey of Animal and Plant Cells

All cells are surrounded by a thin covering called the **cell membrane** that separates the inside of a cell from its external environment. The cell membrane controls the flow of materials into and out of the cell. In addition to a cell membrane, plant cells also have a **cell wall**. The cell wall is a tough, rigid structure that surrounds the cell membrane. The cell wall provides support for the plant cell and prevents the cell from bursting when a plant is in a very moist environment.

Figure 4.1A An animal cell





The **cytoplasm** is a jelly-like substance that contains the organelles and other life-supporting materials, such as water and sugar. An **organelle** is a specialized cell part that carries out specific functions to ensure a cell's survival. Remember from previous science courses that in eukaryotic cells, such as animal cells, most organelles are surrounded by a membrane. Prokaryotes, such as bacterial cells, do not have membrane-bound organelles.

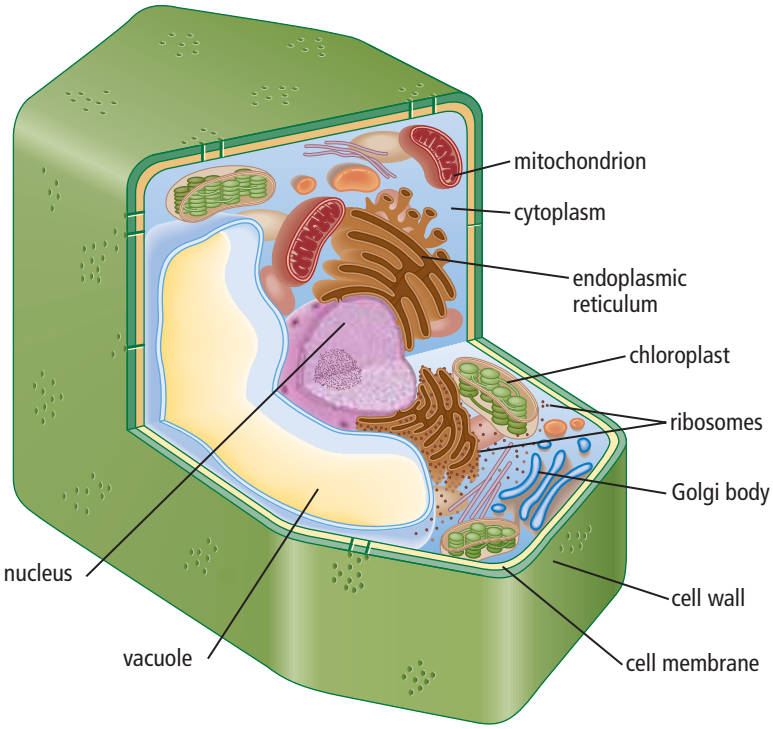
The **mitochondria** (singular: mitochondrion) are organelles that are specialized to provide energy for cells by changing sugar called glucose into usable energy. The chemical reactions that occur on the many folds of the inner membrane of a mitochondrion provide energy for the cell.

Plant cells have specialized organelles called **chloroplasts** that trap the energy from the Sun and make glucose. The production of glucose takes place on the stacks of membranes within a chloroplast.

Ribosomes are small organelles that do not have a membrane. Some ribosomes float in the cytoplasm. Other ribosomes are attached to the endoplasmic reticulum. Each ribosome is like a manufacturing plant that makes proteins. **Proteins** are essential materials required for the cell to carry out the activities necessary for its survival.

The **endoplasmic reticulum** is a network of membrane-covered channels within a cell. This organelle acts as a transport system for materials made in the cell. Proteins made on ribosomes that are attached to the endoplasmic reticulum travel through these channels and are often processed further in the Golgi body.

Figure 4.1B A plant cell



Vesicles are membrane-covered sacs that form off the ends of the endoplasmic reticulum. Vesicles transport new proteins to the Golgi body for further processing and export out of the cell.

The **Golgi body** is a specialized organelle that sorts and packages proteins for transport. If a protein is to be transported out of the cell, a vesicle will form off the end of the Golgi body. The vesicle is then carried to the cell membrane.

Vacuoles are membrane-covered storage containers within cells. Plant cells often contain small vacuoles to store starch and a large vacuole to store water. Some animal cells have small vacuoles.

The **nucleus** (plural: nuclei) is the organelle that controls all the activities of the cell parts described above. The nucleus is surrounded by the **nuclear membrane**, which is similar in structure to the cell membrane. The nuclear membrane protects the contents of the nucleus (Figure 4.2).

The **nucleolus** is a membrane-free organelle that floats in the interior of the nucleus. The function of the nucleolus is to make ribosomes. **Nuclear pores** are openings in the nuclear membrane that allow only certain materials into and out of the nucleus. Ribosomes made in the nucleolus will leave through the pores and go to the cytoplasm or the endoplasmic reticulum.

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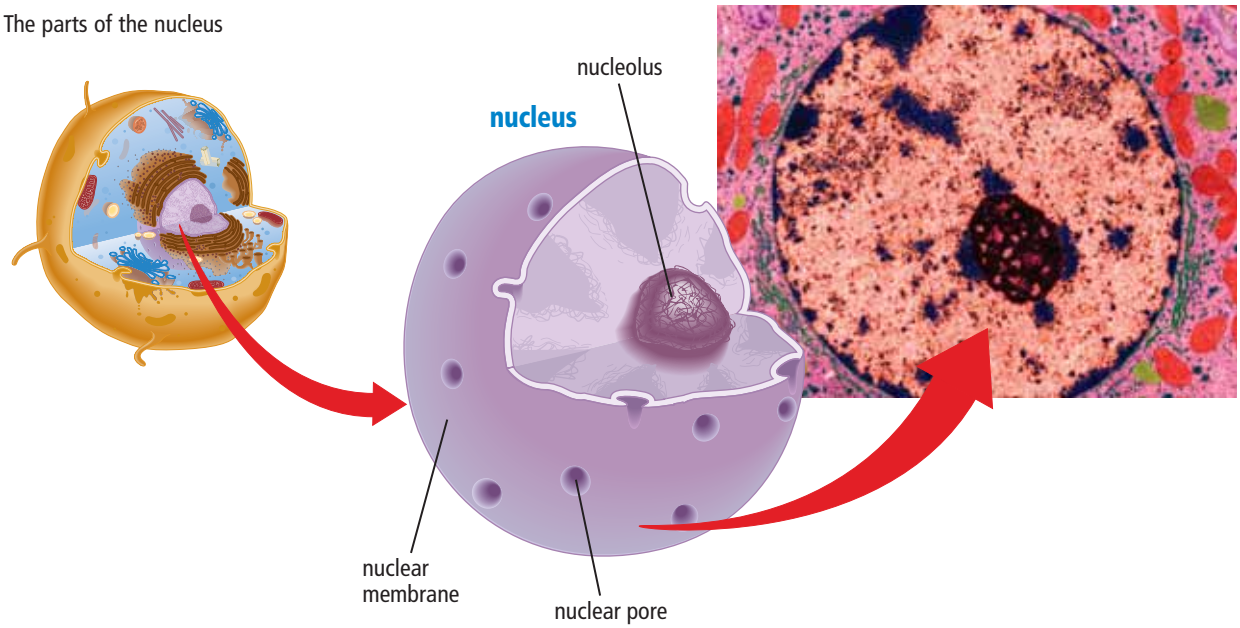
To find out more about cell parts and organelles, go to **www.bcscience9.ca**.

Figure 4.2 The parts of the nucleus



Reading Check

1. What is the function of a cell membrane?
2. Describe the structure of a cell wall.
3. What is an organelle?
4. What is the function of mitochondria?
5. What is the function of a ribosome?
6. Where do proteins go after they are made on the endoplasmic reticulum?
7. What is the function of the nucleolus?

4-1A Help Wanted: Apply Within

Find Out ACTIVITY

A cell is often compared to a factory or a business office. Companies write help-wanted advertisements to find employees with particular qualifications for a specific job. In this activity, your group will form a hiring committee for a company called Know Your Cells, Inc. Your group will create a help-wanted advertisement for the job of a specific cell part. Then you will ask your classmates to guess which cell part is described in your advertisement.

Materials

- sample newspaper help-wanted advertisements

What to Do

1. Study a few help-wanted advertisements to determine what information they have in common. You may want to share your findings with another group.
2. Choose a cell part and write a help-wanted advertisement for the cell part you have chosen. Be sure to include all the information required in a help-wanted advertisement. Do not name the cell part in your advertisement.
3. Share your advertisement with the rest of the class to see if they are able to guess your cell part.

What Did You Find Out?

1. How many cell parts were you able to recognize from the help-wanted advertisements written by your classmates?
2. How could you improve your help-wanted advertisement?
3. Which help-wanted advertisement did you enjoy the most, and why?

The Nucleus: Control Centre of the Cell

Studying the picture on this page and looking up at your teacher require the activity of different cells in the retinas of your eyes. Every cell in your body has a specific function, yet you have seen that every body cell contains the same cell parts and organelles. So how do retina cells become retina cells and not toenail cells? The answer lies in the nucleus. The nucleus contains the master set of instructions that determines what each cell will become, how it will function, when it will grow and divide, and when it will die (Figure 4.3).

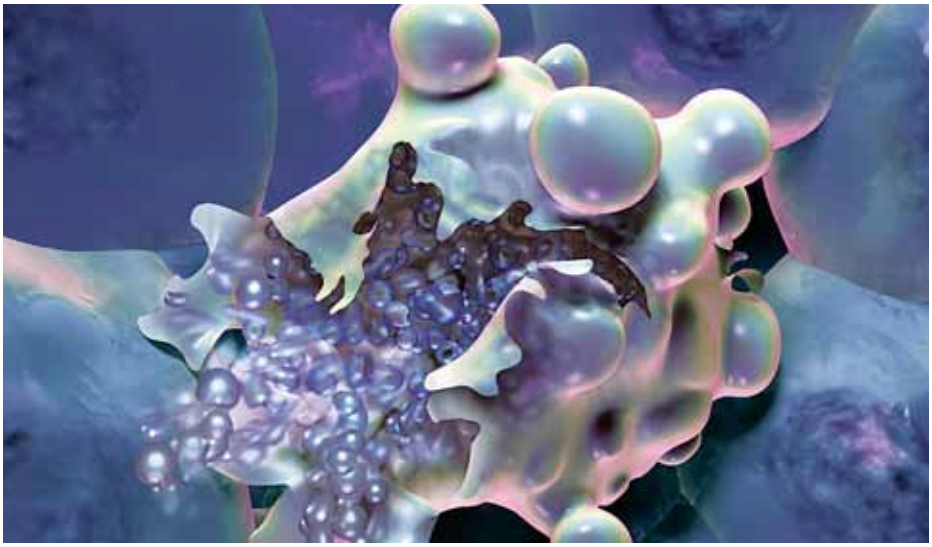


Figure 4.3 A cell in the process of dying. Cell death is important to an organism's growth and life cycle. For example, during your development as an embryo, your fingers started to form when the nuclei in the cells between your fingers instructed these cells to die.

Figure 4.4 A model of the DNA molecule

DNA carries the master set of instructions for cell function

The instructions in the nucleus are carried in long, two-stranded molecules called **deoxyribonucleic acid**, or **DNA**. The DNA molecule looks like a twisted ladder (Figure 4.4). The two strands, or sides, of the DNA ladder wrap around each other in a spiral shape that scientists call a double helix. The word "helix" comes from a Greek word meaning to wrap.

The sides of the DNA ladder are made of sugar and phosphate. The steps of the ladder are made of four nitrogen bases, which are represented by the letters A (adenine), G (guanine), C (cytosine), and T (thymine). Figure 4.5 shows the structure of the DNA molecule.

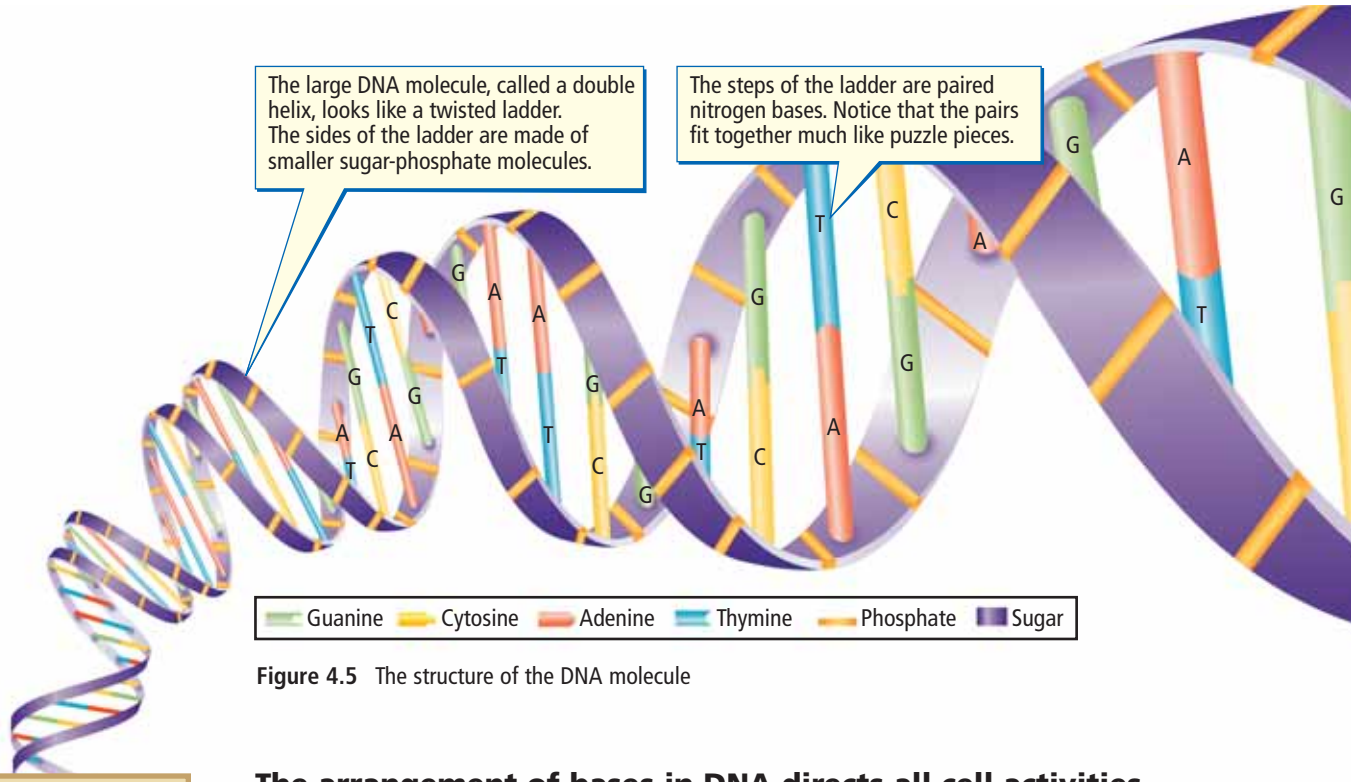


Figure 4.5 The structure of the DNA molecule

Connection

Section 3.1 has more information about phosphate.

The arrangement of bases in DNA directs all cell activities

Everything that occurs within a cell is the result of how the bases on the DNA molecule are arranged. This arrangement is known as the DNA message. As you can see in Figure 4.5, bases in a DNA molecule always join in a specific way:

- A always joins with T
- G always joins with C

However, the order and number of these bases can vary greatly within the DNA molecule. In humans, a single DNA molecule can be several million base pairs in length.

4-1B Creating DNA Messages

Find Out ACTIVITY

The number and order of the A, G, C, and T bases determine the message carried by a DNA molecule. In this activity, you will work in groups to come up with as many combinations of A, G, C, and T as possible to create as many DNA messages as you can. Each DNA message must be 12 bases long, and you will be given 3 min to complete this activity.

Materials

- paper and pencil

What to Do

1. Use the letters of the four bases, A, G, C, and T, to create a list of different DNA messages. Remember that each message must be 12 letters in length.
2. After 3 min, count how many different DNA messages your group created. Write this number at the top of your paper.
3. Compare your DNA messages with those of two other groups. Put a red checkmark beside any of your messages that are identical to the messages of another group.
4. Post your list on the classroom wall.
5. After all the lists are posted, visit each list and count the number of red checkmarks. Total the number from all groups.

What Did You Find Out?

1. How many identical DNA messages did you find when you compared your list with another group's list?
2. If you had compared your list with all groups in the class, do you think you would have found more identical messages? Explain.
3. A single DNA molecule can be several million base pairs in length. Knowing that, what can you say about the number of messages in a DNA molecule?

DNA is stored in chromatin

Most of the time, DNA exists in the nucleus in the form of **chromatin** (Figure 4.6). Chromatin is a substance that contains DNA and proteins. Within each strand of chromatin is one molecule of DNA. When a cell is growing, the DNA is uncoiled and aids in the manufacture of proteins the cell requires.

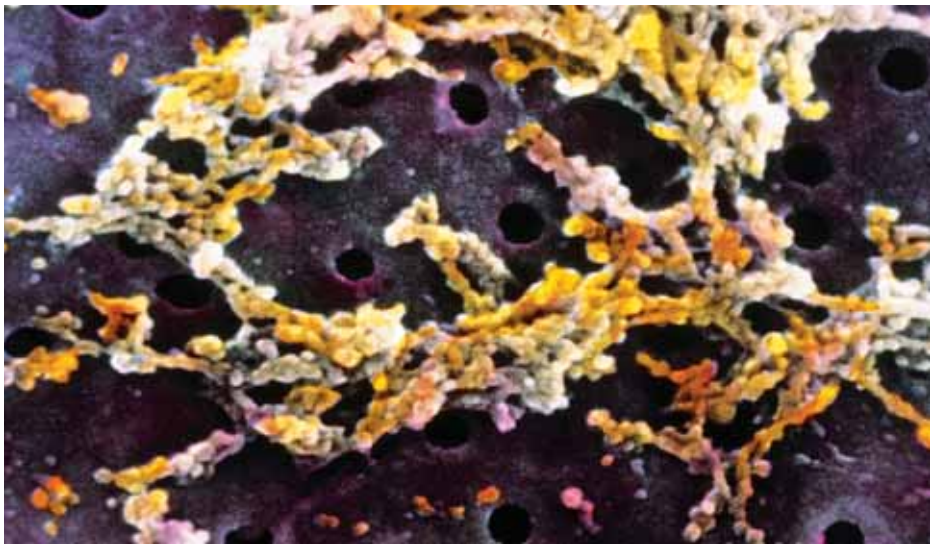


Figure 4.6 Chromatin (yellowish colour) inside the nucleus. The nuclear pores are also visible.

Word Connect

The word "chromatin" comes from the Greek word *chroma*, meaning colour. Chromatin was given its name because of the way it becomes coloured and is visible when a cell is stained.

When a eukaryotic cell is ready to divide, each strand of chromatin coils up into a very compact, X-shaped structure called a **chromosome**. Figure 4.7 shows the relationship between DNA, chromatin, and chromosomes.

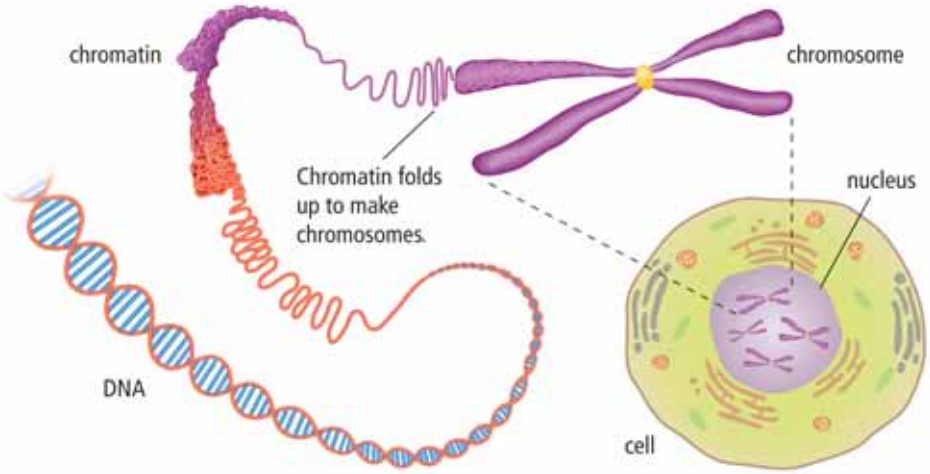
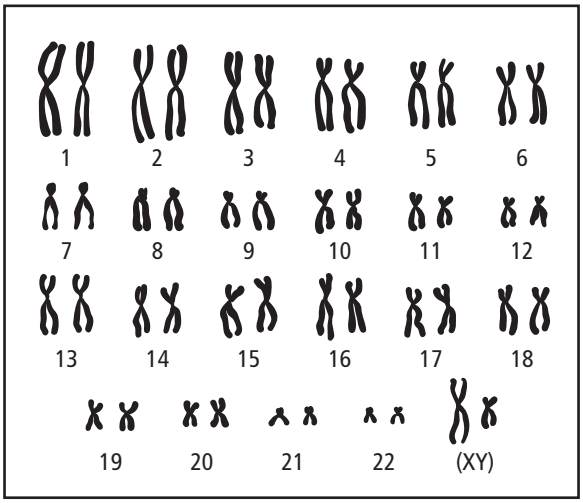


Figure 4.7 DNA, chromatin, and chromosome relationship

Every organism has a characteristic number of chromosomes

Chromosomes within the nucleus are found in pairs. Most human cells have 46 chromosomes arranged in 23 pairs, including one pair of chromosomes that help determine sex (Figure 4.8). In males, the 23rd pair of chromosomes is the XY pair. In females, it is the XX pair. Every living thing has a characteristic number of chromosomes, as shown in Table 4.1 on the next page.



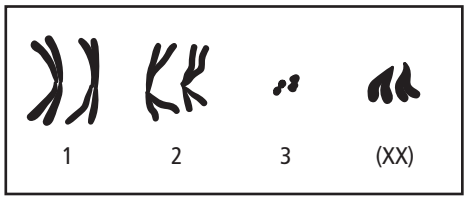


Figure 4.8 The chromosomes of a human cell compared with the chromosomes of a fruit fly cell.

Table 4.1 Comparison of Chromosome Number in Various Organisms

Organism	Chromosome Number	Organism	Chromosome Number
	46		20
	60		80
	78		44

Did You Know?

A genome is all the genetic information stored within the chromosomes of a living cell. The Human Genome Project, completed in 2003, found that human cells contain about 3 billion base pairs that carry the information to produce between 25 000 and 35 000 genes. (This number is currently thought to be 25 000 genes.) The British Columbia Cancer Research Centre participated in this project and since 2003 has supported many projects studying genome mapping to improve cancer research, diagnosis, and treatment.

Genes are found on chromosomes

Genes are small segments of DNA located at specific places on a chromosome (Figure 4.9). Genes store the information needed to produce 90 000 to 100 000 different proteins used in the cells of your body.

The arrangement of bases in a gene will usually be used to produce a specific protein. Genes can vary in length from hundreds to thousands of bases. Every chromosome carries thousands of genes and therefore contains the information to make thousands of different proteins.

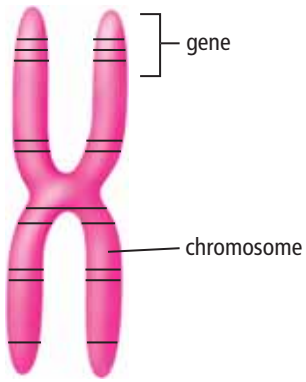


Figure 4.9 Genes are located on chromosomes and contain the information to produce a protein.

Proteins determine what body cells will become and how they will function

Each of your body cells has the same amount of genetic information stored within its 46 chromosomes. However, only specific genes are "read" in each cell to produce specific proteins. By making specific proteins, a cell becomes specialized to carry out a particular function. That is why the cells in your retina are different from the cells in your toenails. Specialized cells come together to form tissues (such as your retinas), and tissues come together to form organs (such as your eyes).

Therefore, proteins needed to make your muscles work are made only in your muscle cells. Proteins needed to help you read this page are made only in the cells of your eyes (Figure 4.10).

Thousands of different, specialized proteins called **enzymes** speed up the hundreds of chemical reactions that occur within each cell. For example, digestive enzymes work in chemical reactions to break food down into nutrient molecules that provide energy for the cell.

Some proteins act as chemical messengers called **hormones**. For example, growth hormone functions to prepare a cell for cell division by ensuring the cell has enough nutrients to divide.

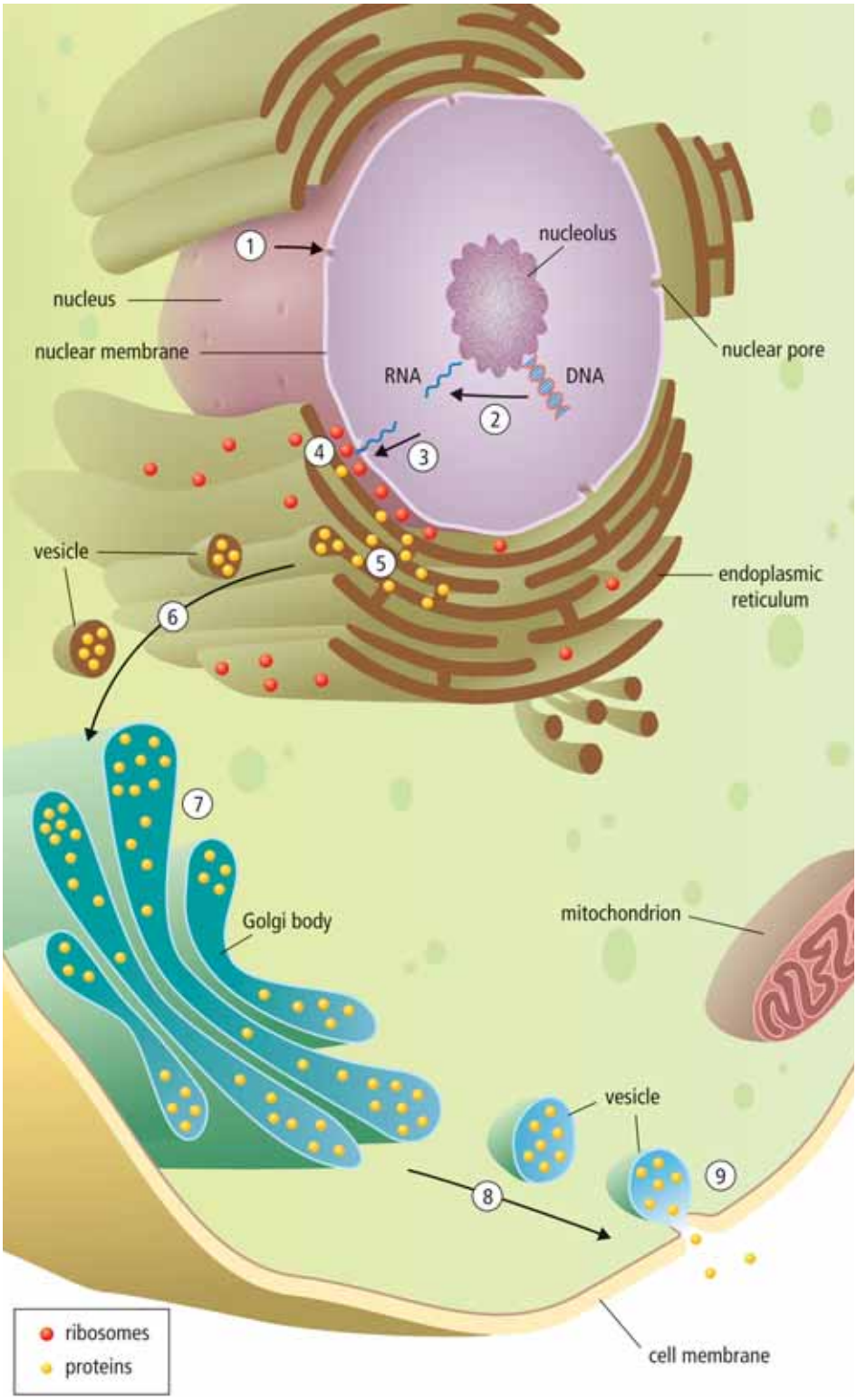
Figure 4.10 Although every cell in your body contains the same genes, only certain genes will be read to produce specific proteins, as shown in the three examples on the right.

Reading Check

1. What are the parts of the DNA molecule?
2. Describe how bases pair up in the DNA molecule.
3. What is chromatin?
4. How many chromosomes does a human body cell contain?
5. (a) What are genes?
   (b) Where are they located?
6. Your retina cells and muscle cells contain identical DNA. How are these cells able to function differently?

How Proteins Are Produced

So far in this chapter, you have read about the important function proteins perform in directing the activities of your cells. Figure 4.11 shows how a protein is produced in an animal cell and transported through a cell's membrane.



Key to Protein Production

1. The nucleus receives a chemical signal to make a specific protein.
2. The DNA message for a specific protein is copied into a small molecule called ribonucleic acid or RNA.
3. RNA leaves through a nuclear pore.
4. The RNA message is delivered to the ribosome, and the ribosome makes the protein.
5. The manufactured protein enters the endoplasmic reticulum.
6. A vesicle forms off the end of the endoplasmic reticulum and carries the protein to the Golgi body.
7. The Golgi body repackages the protein for transport out of the cell.
8. A vesicle forms off the end of the Golgi body to carry the protein to the cell membrane.
9. The vesicle attaches to the cell membrane, and its protein contents are released out of the cell.

Figure 4.11 The production of a protein in an animal cell

Explore More

Muscular dystrophy weakens the muscles in the body. In the late 1990s, to help find a cure, American scientist Dr. Lee Sweeney injected a gene into the leg muscles of rats and mice, which instructed the animals' muscles to grow more muscle tissue. Find out why athletes became interested in these experiments. Begin your research at **www.bcscience9.ca.**

A New Task for Scientists

Before the human genome was decoded, scientists hypothesized that one gene produced one protein. However, scientists know that there are at least 90 000 different proteins but only 25 000 genes in the human body. The new finding raises the question: How can one gene code for more than one protein? Scientists are currently researching the answer to this question.

Reading Check

1. What must occur before a new protein is made in the cell?
2. What is RNA?
3. How is the message carried from the nucleus to the ribosomes?
4. What happens to a protein once it is made?
5. What is the function of the Golgi body?

4-1C Modelling DNA

Find Out ACTIVITY

In 1953, American scientist James Watson and British scientist Francis Crick determined the structure of DNA without performing a single experiment. Piecing together information gained from other scientists' experiments, they constructed a model using cutouts of the shapes of the four bases. From conclusions reached by other researchers, Watson and Crick knew the following:

- The amount of base A equalled the amount of base T.
- The amount of base C equalled the amount of base G.
- Phosphates and sugars were on the outside of the molecule, and the bases were on the inside.
- DNA was a double helix made of two strands.
- There were 10 base pairs in each turn of the helix.

In this activity, you will use the same knowledge available to Watson and Crick when they constructed their model to help you build your own model of DNA.

Materials

- coloured paper templates of the parts of a DNA molecule
- scissors
- clear adhesive tape
- paper clips

What to Do

1. Your teacher will give you paper templates for the parts of a DNA model. You will model one turn of the DNA helix, so calculate how many of each template you will need. Cut out the correct number of parts.
2. Assemble your DNA model using clear adhesive tape.
3. Twist your model into a double helix and use the paper clips to hold it together. Then tape the ends.
4. Compare your completed DNA model with another group's completed model.
5. Attach the two completed models together.

What Did You Find Out?

1. How did your DNA model compare with another group's model? What was similar, and what was different?
2. If all the models in the class were attached together, would this simulate the entire DNA molecule in a chromosome or only part of the information on one chromosome? How do you know?
3. Explain how models are helpful to scientists.

4-1D Extracting DNA from Strawberries

Find Out ACTIVITY

DNA is often obtained from mouth swabs or from samples of blood, hair, or plants. Before technicians from a crime or genetics laboratory can conduct their analysis, they must first isolate the DNA and remove it from the sample. In this activity, you will perform this first step in DNA analysis.

Safety

- Do not eat or drink anything during this activity. Do not put your hands near your face.
- Handle rubbing alcohol or ethanol with care. Both are poisonous.
- Wash your hands thoroughly after this investigation.

Materials

- 1 frozen strawberry
- a small, resealable plastic bag
- measuring spoons
- 5 mL dish soap
- 2.5 mL table salt
- 25 mL tap water, approximately
- test tube and test tube rack
- flask containing rubbing alcohol or ethanol (ice cold)
- graduated cylinder
- wooden stick or paper clip hook
- paper towel

What to Do

1. Place the frozen strawberry into the plastic bag. Add 5 mL of dish soap, 2.5 mL of table salt, and about 25 mL of tap water. Seal the bag.
2. Gently crush the contents of the plastic bag with your hand so that the strawberry and other substances combine. Be careful not to damage the plastic bag.
3. Keep the bag at room temperature and wait for 5 min.
4. Cut a small hole in one corner of the plastic bag, and carefully drain about half of the strawberry solution into a test tube, filling it halfway.
5. Pour the ice cold rubbing alcohol or ethanol from the flask into the graduated cylinder. Then slowly pour a layer of rubbing alcohol or ethanol on top of the strawberry solution so that the test tube is about $\frac{3}{4}$ full.
6. Observe the DNA forming between the layers of alcohol and strawberry solution.
7. Using a wooden stick or paper clip hook, pull the DNA out and onto a paper towel. Record your observations.
8. Clean up and put away the equipment you have used. Dispose of the alcohol and strawberry solution as your teacher instructs.
9. Wash your hands thoroughly.

What Did You Find Out?

1. (a) Describe the appearance of the DNA.
   (b) Did the DNA look as you expected? Explain.
2. Do you think the DNA from another organism would have a different appearance? Explain why or why not.
3. Why do you think it was necessary to crush the strawberry in this activity?
4. What step was necessary to make the DNA visible?
5. If you wanted to maximize the amount of DNA that came out of the strawberry, which ingredient might you increase?

Wild, Weird, Wonderful

www Science

Glowing Genes

The process that makes fireflies glow brightly in the summer night to attract mates has also shone light on the field of biotechnology. Fireflies produce a protein enzyme, called luciferase [lu-SIF-uh-raze], which aids in a light-producing chemical reaction. When living things produce light, the process is called bioluminescence.

Bioengineers have identified the small piece of DNA, called a gene, in the firefly that contains the information to make luciferase. They are able to remove the gene from the firefly, make copies of the gene in the laboratory, and put the gene into another organism. The process where genes are taken from one organism and inserted into the DNA of another organism is called recombinant DNA.

Taking genes from one plant or animal and transferring them into another plant or animal creates a transgenic organism. A transgenic plant or animal has DNA in its nucleus from another plant or animal. Bioengineers have created transgenic organisms that glow in the dark. Glow-in-the-dark pigs, mice, and monkeys help scientists trace activities going on within a cell. The brighter the light shining from a cell tagged with luciferase, the more activity within the cell.

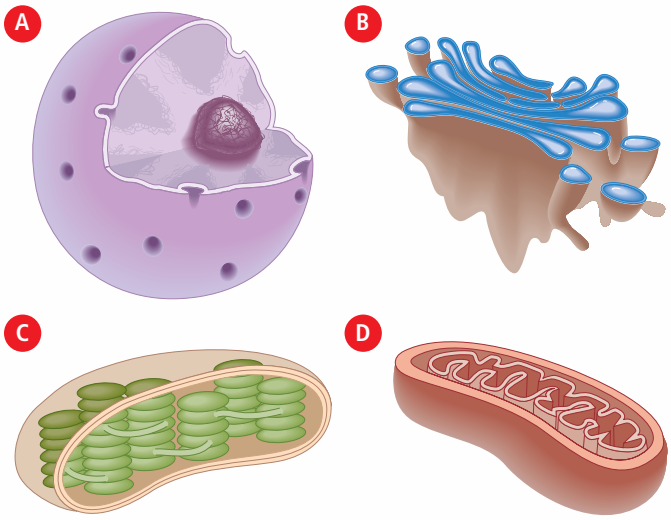
In the future, scientists may use the process of transferring genes from one organism to another to speed up the testing of new drug and gene treatments. For example, if light shines from the cell that receives the glow-in-the-dark gene, scientists will know that the correctly functioning gene has entered the cell successfully. Gene transfer procedures may be used to treat diseases such as diabetes, AIDS, and cancer. Glowing genes may help identify and treat cells injured by heart attacks or nerve-damaging diseases such as Alzheimer's and Parkinson's. Tumour cells that light up will tell surgeons exactly where to cut to remove a tumour.

The glowing genes of the firefly hold much more potential for medical discoveries in the future, since they are inexpensive and allow scientists to quickly trace cell activity. Unlike other chemicals used to monitor activity in cells, luciferase is non-radioactive, so it will not harm the organism it is transferred into.

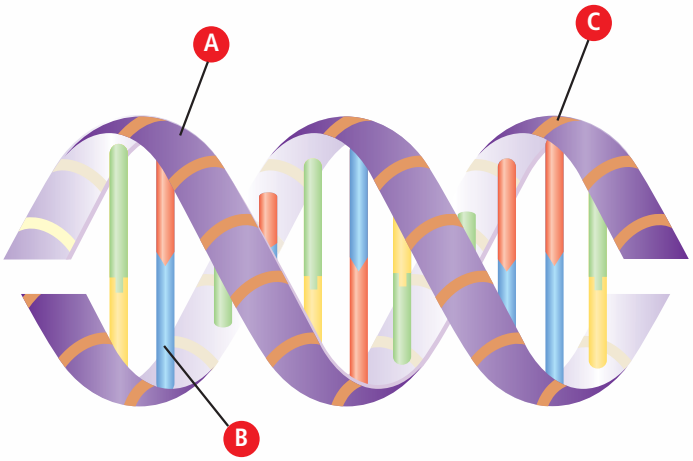
Check Your Understanding

Checking Concepts

1. (a) Which of the structures shown in the diagram below contains the information to make proteins?
   (b) Which of the structures shown in the diagram below is used to prepare proteins for transport out of the cell?
   (c) Identify the remaining two structures and describe their function.



2. Draw a simple diagram of a chromosome and indicate the location of a gene.
3. Explain the function of genes in a cell.
4. How is the information contained in DNA transported out of the nucleus?
5. Where are the ribosomes that manufacture proteins for transport out of the cell located?
6. What is the function of the Golgi body?
7. In the diagram below, identify which part is the phosphate, the sugar, and the base.



Understanding Key Ideas

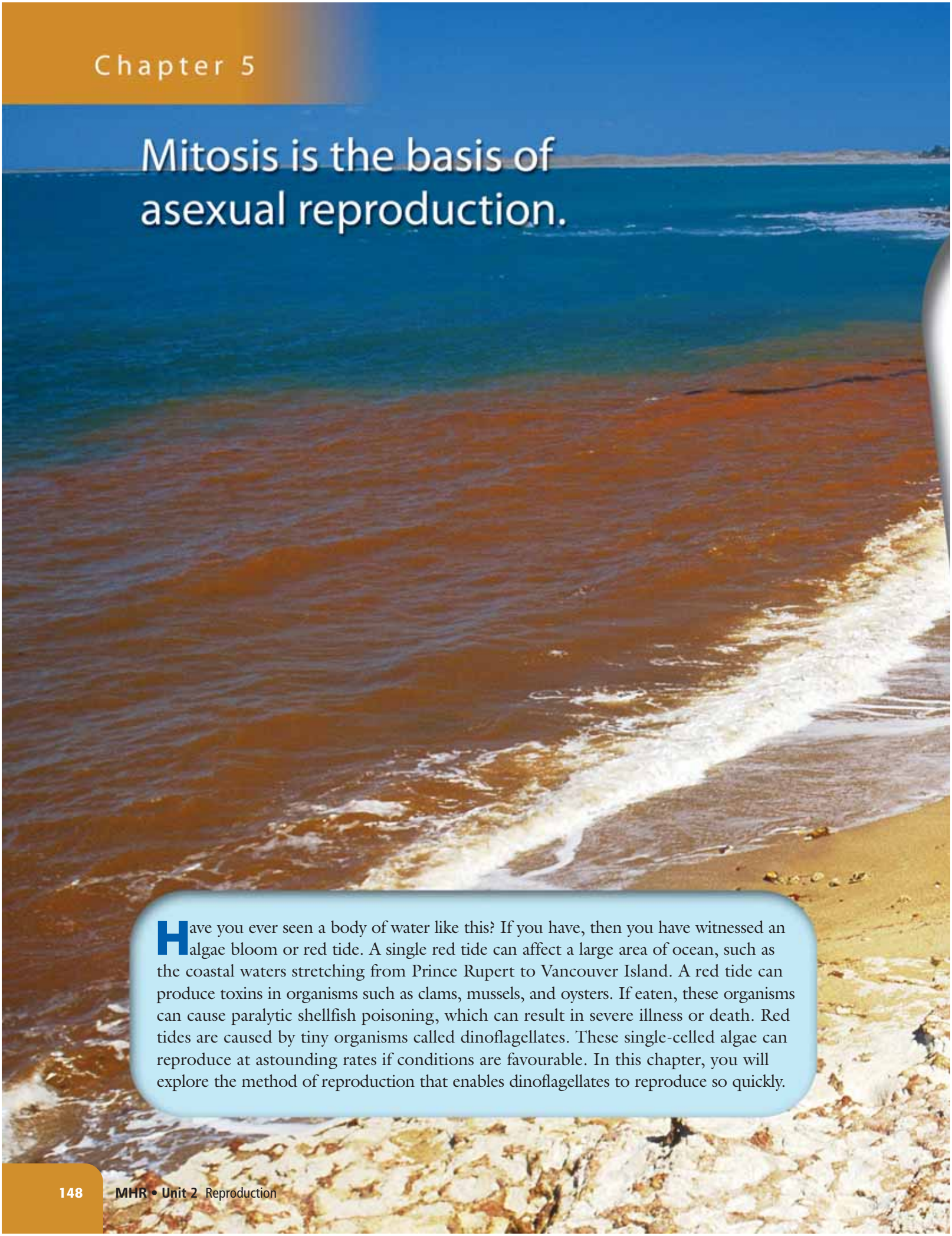
8. Draw a nucleus and label the nuclear membrane, nuclear pores, and chromatin.
9. Explain how the nucleus controls the functions of life.
10. What makes a skin cell different from a nerve cell?
11. The protein hemoglobin, which carries oxygen in red blood cells, is not made in a skin cell. Explain why.
12. Predict what might happen to a cell if a required protein was not made in that cell.
13. One side of a DNA molecule contains the following sequence of bases.
    ACCTGCTAT
    Write the sequence of the bases on the other side of the molecule.
14. A DNA molecule is made when one strand of bases joins with a corresponding strand of bases. What do you think would happen if one strand lacked T (thymine)?
15. In which part of the DNA molecule would a change be more damaging to the cell: in the sugar-phosphate sides of the molecule or in the A, G, C, T bases? Explain.
16. Explain why DNA cannot leave the nucleus.

Pause and Reflect

DNA is sometimes referred to as the code of life. Explain why you think scientists have used these words to describe DNA.

Chapter 5

Mitosis is the basis of asexual reproduction.



Have you ever seen a body of water like this? If you have, then you have witnessed an algae bloom or red tide. A single red tide can affect a large area of ocean, such as the coastal waters stretching from Prince Rupert to Vancouver Island. A red tide can produce toxins in organisms such as clams, mussels, and oysters. If eaten, these organisms can cause paralytic shellfish poisoning, which can result in severe illness or death. Red tides are caused by tiny organisms called dinoflagellates. These single-celled algae can reproduce at astounding rates if conditions are favourable. In this chapter, you will explore the method of reproduction that enables dinoflagellates to reproduce so quickly.

What You Will Learn

In this chapter, you will

- **demonstrate** an understanding of the cell cycle
- **explain** what happens to the chromosomes, nucleus, and cell membrane during mitosis
- **relate** errors that occur in the cell cycle to the development of cancer
- **compare** the advantages and disadvantages of asexual reproduction

Why It Is Important

Understanding mitosis and asexual reproduction is important for understanding how our body cells maintain themselves and how certain organisms in our environment reproduce. Such knowledge has been used for centuries to develop food crops and most recently to clone animals.

Skills You Will Use

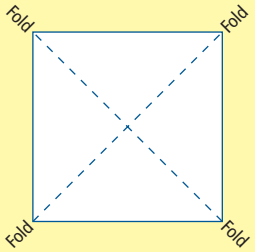
In this chapter, you will

- **model** the cell cycle
- **observe** asexual reproduction
- **graph** results

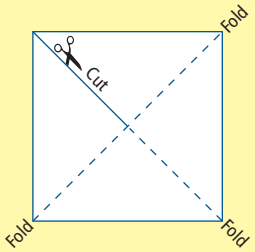
FOLDABLES™ Reading & Study Skills

Make the following Foldable and use it to take notes on what you learn in Chapter 5.

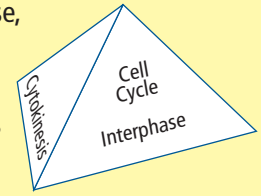
STEP 1 **Fold** a large square of paper diagonally to form an X as illustrated.



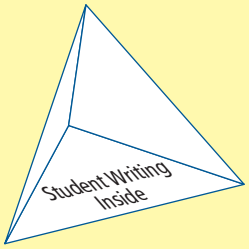
STEP 2 **Cut** along one of the fold lines, stopping at the centre intersection point. This cut will form two "legs" or sections.



STEP 3 **Fold** and glue one of these legs under the other to form a three-sided pyramid. Use a computer to generate four labels—Cell Cycle, Interphase, Mitosis, Cytokinesis—and glue them onto the outer sides of the pyramid.



STEP 4 **Lay** the pyramid on its side to write notes inside on the triangular sections.



Show a Cycle This pyramid is perfect for illustrating cycles that occur in threes or other information that is always in threes. For example, this pyramid could be used for the water cycle (evaporation, condensation, precipitation); the states of matter (solid, liquid, gas); or the three types of galaxies (irregular, spiral, elliptical).

5.1 The Cell Cycle and Mitosis

There are three stages in the cell cycle. Interphase is the stage in which cells carry out the functions necessary for survival and cells that divide prepare for cell division. Mitosis divides the duplicated contents of the cell's nucleus into two equal parts. Cytokinesis separates the two nuclei and cell contents into two daughter cells. Proteins monitor the activities of the cell at checkpoints in the cell cycle. Cancer may result when errors occur in the cell cycle.

Words to Know

cancer
cell cycle
cytokinesis
interphase
mitosis
replication
spindle fibres

If you look around your home carefully, you will find some skin cells left behind by your family or friends. That grey dust ball in the corner is mostly human skin. The tiny flakes of skin that we lose on a daily basis create more than 70 percent of the dust in your home and in your classroom. Each day, you shed millions of skin cells per hour (Figure 5.1). Each month, you completely replace the outer layer, or epidermis, of your skin.

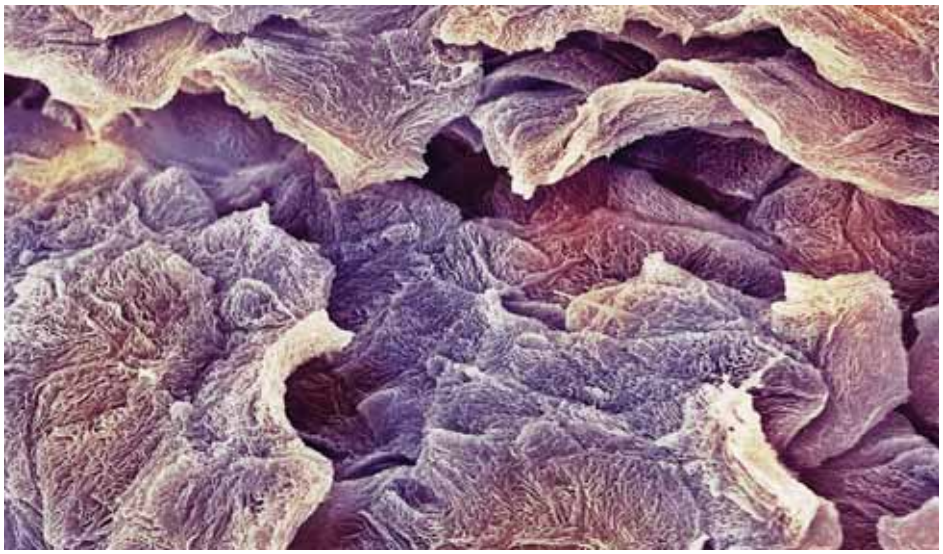


Figure 5.1 Dead skin cells. You are constantly shedding your outer layer of skin cells. Replacement skin cells form underneath this layer.

Word Connect

The word "amphibian" refers to an organism that can live both in water and on land. Amphibian comes from the Greek words *amphi*, which means on both sides, and *bios*, which means life.

When humans shed millions of skin cells each day, it is really not noticeable. Other animals such as snakes and lizards shed their whole skin at once. You may find a shed snake skin in your backyard or when hiking in a park. Replacing worn-out skin cells is an ongoing process for humans. For snakes, shedding occurs several times a year, and each shed takes several days. Newly hatched snakes may shed their skins twice a month, whereas adult snakes shed three to four times a year.

In 2006, scientists reported that a legless, underground-dwelling amphibian, called *Boulengerula taitanus*, develops a new layer of skin for a different reason. *B. taitanus* is found in Kenya, Africa, and hatchlings are

born with specialized teeth for peeling and eating skin. Their mother's skin is thick and rich in fat, and the young strip off and feed on her skin for up to four weeks.

Biologists report that the young press their heads against their mother, move over her body, and repeatedly chew on her skin with their specialized teeth (Figure 5.2A). Some teeth are spoon-shaped for scraping, and some have spiked points for piercing the skin. Other teeth look like grappling hooks with a claw-like structure on one end designed for staying tightly attached to the mother (Figure 5.2B). A mother loses 14 percent of her body weight during this feeding period and does not appear to be harmed.

The process of producing new skin for replacement, for growth, or, in the case of *B. taitanus*, for lunch, requires that cells divide. Cell division is strictly controlled by specialized proteins in the nucleus.

Did You Know?

You have 50 million trillion to 100 million trillion cells in your body. Every minute your body produces about 300 million new cells.

A

B

Figure 5.2 Young *B. taitanus* feeding on mother's skin (A). Close-up of one of the types of teeth used to strip off the mother's skin (B).

5-1A From One Cell to Many Cells

Find Out ACTIVITY

B. taitanus mothers must produce new skin cells to nourish their offspring for up to four weeks. In this activity, you will calculate how many skin cells will result from just 1 cell that continually divides during a 30 d period.

What to Do

1. Copy the cell division chart below into your notebook.

Day	Number of Cells	Day	Number of Cells	Day	Number of Cells
1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

2. Assume that the cells divide once a day. Calculate how many cells will result in 30 d, if the cells do not stop dividing at any time during the 30 d period.
3. A mass of cells would become just visible to the eye at about 1 mm in width, which is about 250 000 cells. Calculate approximately on which day the cells would be visible.

What Did You Find Out?

1. On which day would the cell mass be visible? Explain.
2. If scientists can detect a tumour when it is about 1 cm in width, how many days would the cells have to divide for the tumour to reach this size?
3. What do you think would happen if all cells in the human body continually divided without stopping?
4. Look at the pattern in the numbers you entered in the chart. How could you quickly calculate the number of cells that would be present after a particular number of days had passed?

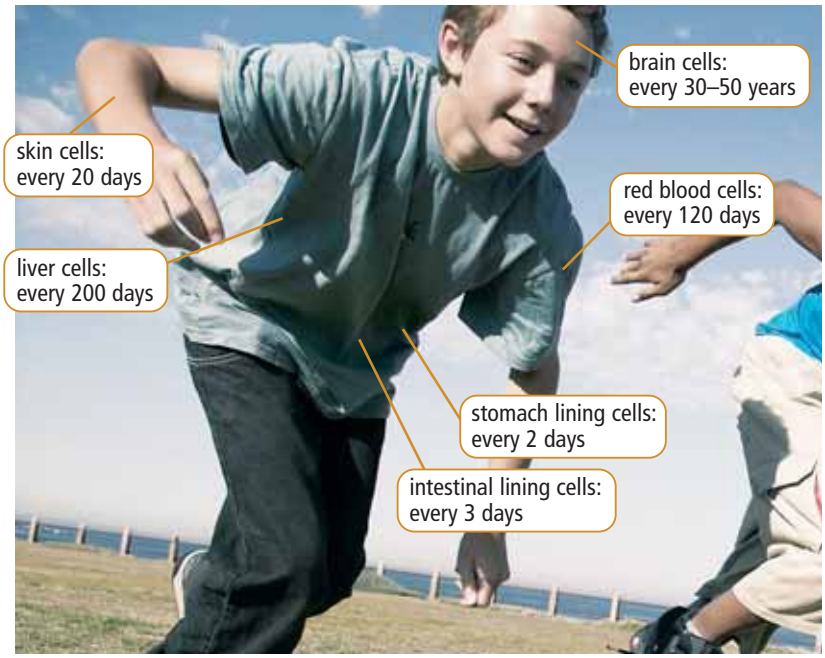


Figure 5.3 Cells in the human body divide at different rates.

Cell Replacement and Development

From the time your life began as a fertilized egg, your cells have continued to divide as you continued to grow. After puberty, your body growth slows. But your body will continue to replace cells that take a lot of wear and tear such as skin cells, stomach cells, and intestinal cells. Cells such as muscle and nerve cells usually do not continue to divide in an adult, but they do continue to carry out functions necessary for survival. Figure 5.3 shows the different life spans of a variety of human body cells.

The Cell Cycle

The life of a cell is divided into three stages known as the **cell cycle** (Figure 5.4). The stages of the cell cycle are interphase, mitosis, and cytokinesis.

- Interphase is the stage in which cells carry out the functions necessary for survival and cells that divide prepare for reproduction.
- Mitosis divides the duplicated contents of the cell's nucleus into two equal parts.
- Cytokinesis separates the two nuclei and cell contents into two daughter cells.

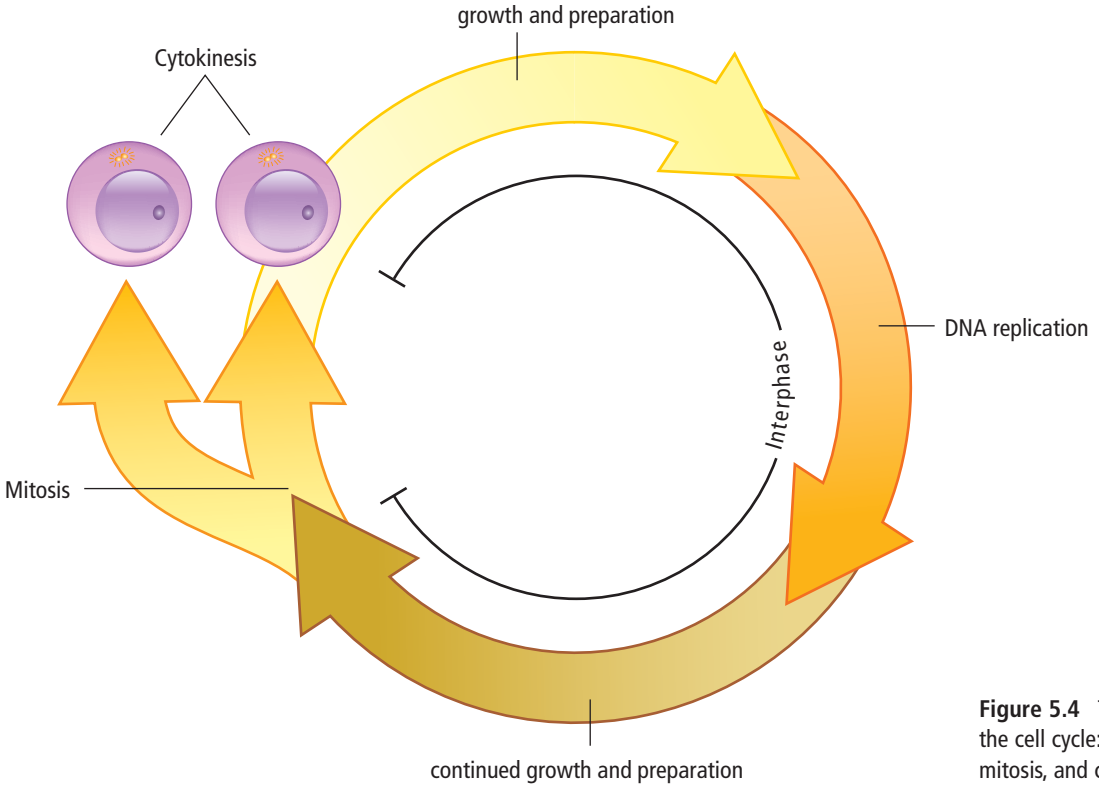


Figure 5.4 The stages of the cell cycle: interphase, mitosis, and cytokinesis

Interphase

Figure 5.4 shows that **interphase** is the longest stage in the cell cycle. This is a time when a cell carries out its various functions within the organism. For example, a cell in your stomach lining might be making and releasing enzyme molecules that aid in digesting the food you eat. During interphase, the cell roughly doubles everything in its cytoplasm.

Growth and preparation

During the first phase of interphase, a cell increases in size and makes the proteins and molecules necessary for the cell to function. Some organelles begin to duplicate.

Replication

In the next phase, DNA copies or makes a "replica" of itself in a process called **replication**. During replication, the cell copies the 3 billion base pairs of DNA information in the nucleus of the cell. Then the cell temporarily has two complete sets of DNA. Enzymes control this process.

To replicate itself, the DNA molecule unwinds and the steps of the DNA ladder break apart as shown in Figure 5.5. Each side then becomes a pattern or a template on which a new side forms. In section 4.1, you saw that base A will pair with base T, and base G will pair with base C. The process of replication results in two new DNA molecules that have the same sequence of bases as the original DNA molecule.

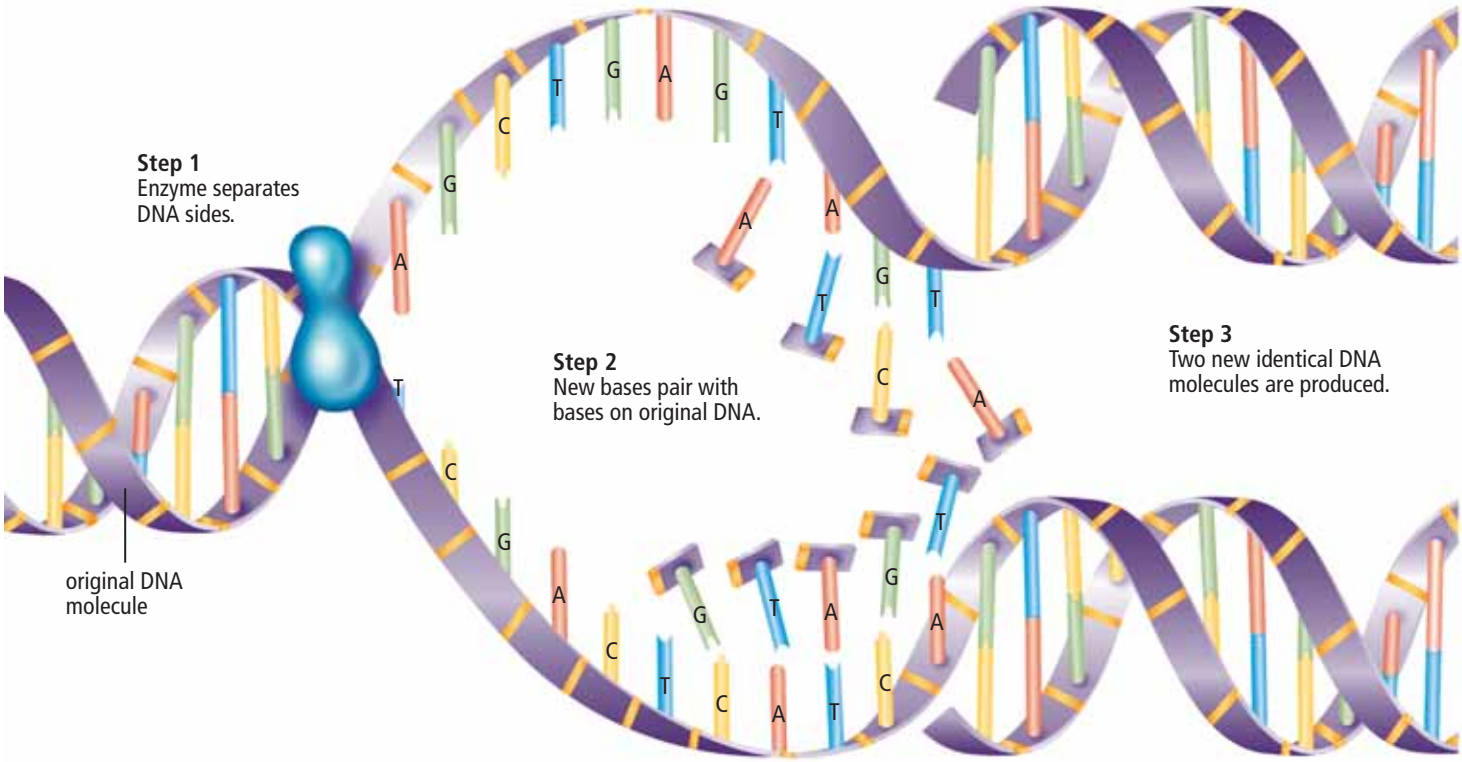


Figure 5.5 During replication, the steps of the DNA ladder break apart with the help of an enzyme.

Replicating DNA ensures that newly formed cells will have an identical copy of the genetic information contained in the original DNA molecule.

Continued growth and preparation

After the DNA replicates, the cell continues to grow and is active making materials such as proteins for the new cells that will be formed after cytokinesis. Early biologists referred to these cells as "daughter cells," and scientists continue to use this term today. The chromatin, which contains the replicated DNA, is in its loosely coiled form (Figure 5.6A and Figure 5.6B). In its loosely coiled form, the DNA can be copied into RNA so that proteins can be made in preparation for cell division. In addition, during this final phase before cell division, organelles such as mitochondria and chloroplasts will be duplicated.

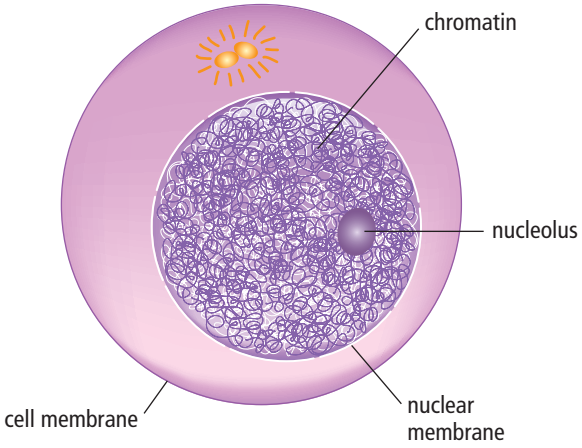


Figure 5.6A Chromatin, which contains the DNA, is located in the nucleus.

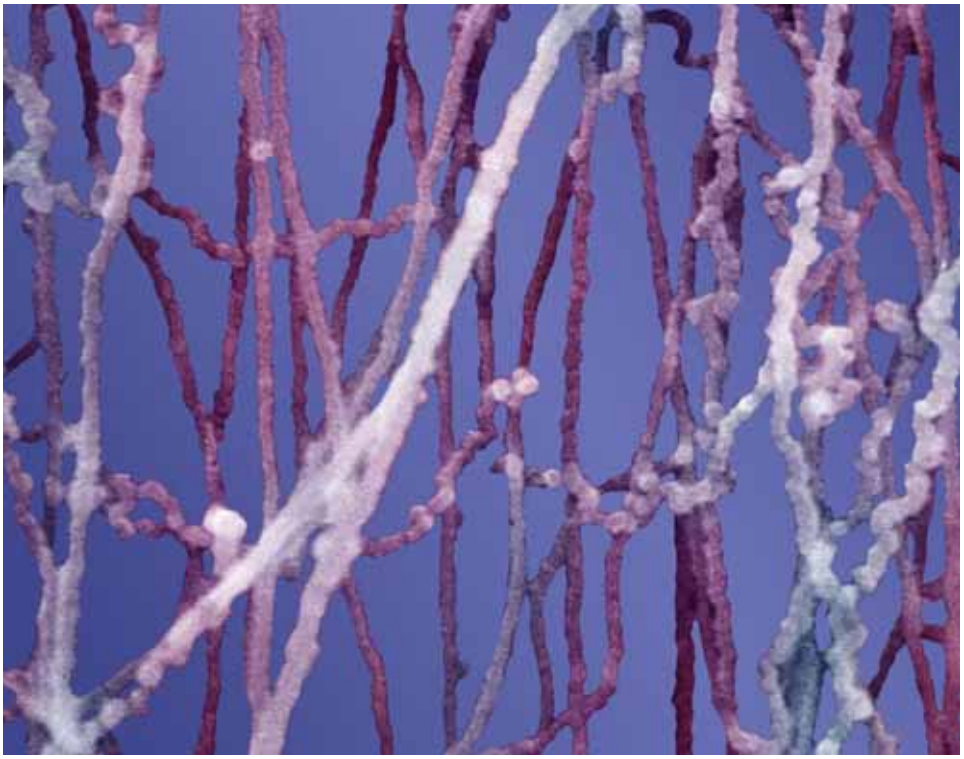


Figure 5.6B DNA is uncoiled during interphase so that proteins required for cell division can be made.

Reading Check

1. Explain why the skin cells of an adult must divide.
2. List the three stages of the cell cycle.
3. What are the events that take place during interphase?
4. Why is DNA replication so important?
5. What does DNA look like at the end of interphase?
6. How does the cell prepare for cell division?

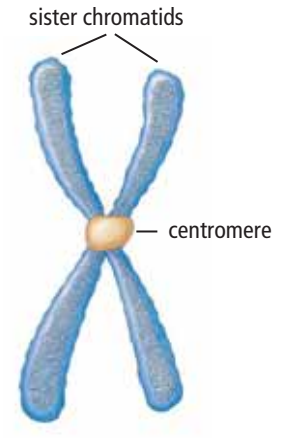


Figure 5.7 The sister chromatids of a replicated chromosome are joined by a centromere.

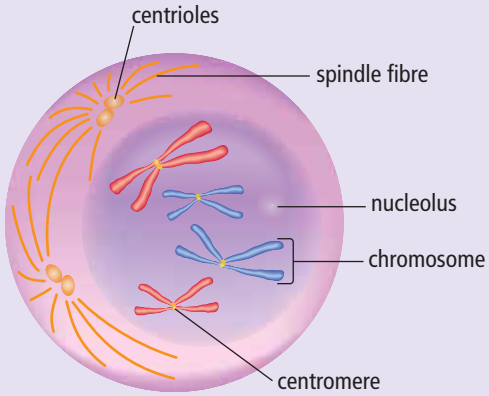
Mitosis

Mitosis is the next stage of the cell cycle and is usually the shortest. Mitosis is the process in which the contents of a cell's nucleus divides. This division results in two daughter nuclei, each with the same number and kinds of chromosomes as the original cell. Occasionally, mistakes are made during replication, but the daughter cells are usually identical to the parent. Therefore, as you learned in section 4.2, most mutations result in little change.

As the nucleus prepares to divide, the DNA molecules that replicated during interphase join together to form the **sister chromatids** of a chromosome. The **centromere** joins the sister chromatids as shown in Figure 5.7.

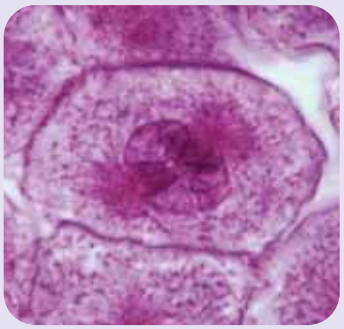
Figure 5.8 shows the phases of mitosis.

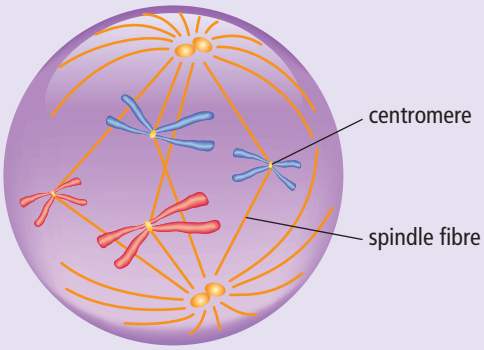
Figure 5.8 Mitosis in a typical animal cell. Notice that, at the end of mitosis, each nucleus has the same number and kind of chromosomes.



Early prophase

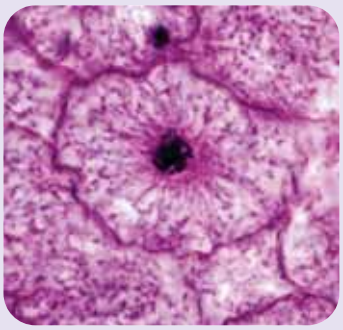
The replicated chromosomes coil up into X-shaped chromosomes and become visible under a light microscope. The nucleolus will disappear, and the nuclear membrane will begin to break down. In animal and plant cells, **spindle fibres**, which are tiny tube-like structures made of protein, begin to form. Spindle fibres stretch across the cell from centrioles that have moved to opposite ends (poles) of the cell. Centrioles are organelles that "organize" spindle fibres during mitosis. In animal cells, the centrioles begin to move apart. (You can observe a similar process in the cells of plants, fungi, and some protists. They also form spindle fibres but not centrioles.)

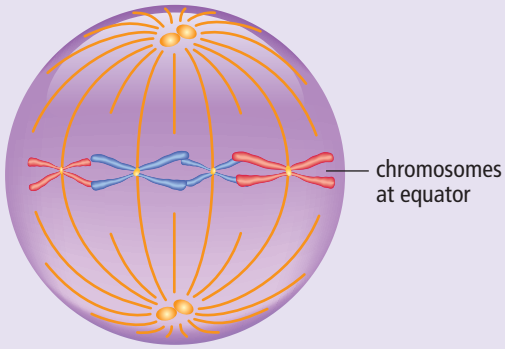




Late prophase

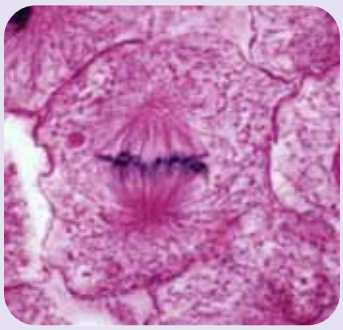
The spindle fibres complete forming. The chromosomes attach to the spindle fibres at their centromeres, and the nuclear membrane disappears.

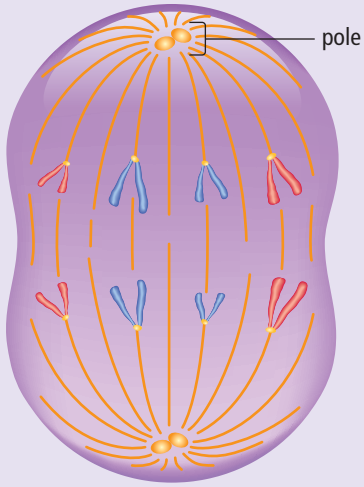




Metaphase

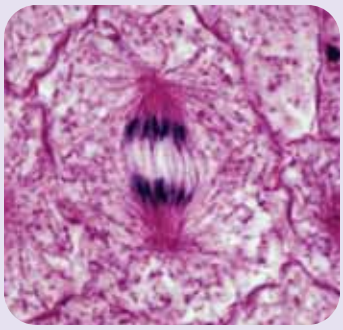
The tugging action of the spindle fibres pulls the X-shaped chromosomes into a single line across the middle (or equator) of the cell.

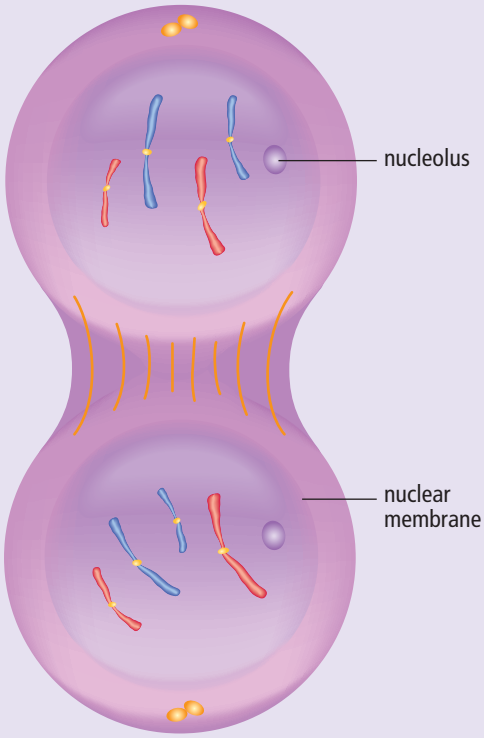




Anaphase

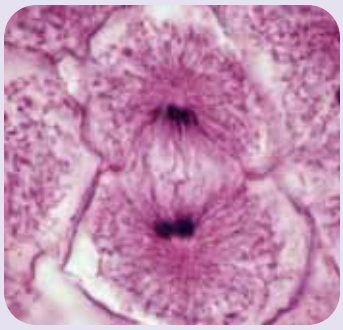
The spindle fibres begin to contract and shorten. This action pulls the centromere apart, allowing the sister chromatids to move to opposite poles of the cell. Once they separate, each sister chromatid is considered to be a chromosome.





Telophase

In the final stage of mitosis, one complete set of chromosomes is now at each pole of the cell. The spindle fibres begin to disappear, and a nuclear membrane forms around each set of chromosomes. A nucleolus appears within each nucleus. Now there are two nuclei in one cell, and the cell is ready to divide.



Word Connect

The word "cytokinesis" has two Greek roots: *cyto*, which means cell, and *kinesis*, which means movement.

Cytokinesis

The final stage of the cell cycle is called **cytokinesis**. Cytokinesis separates the two nuclei into two daughter cells. These new cells are identical to the original parent cell. In animal cells, the cell membrane pinches together to divide the cell's cytoplasm and organelles, as shown in Figure 5.9. In plant cells, a cell plate forms along the centre of the cell to divide the cell into two daughter cells (Figure 5.10).

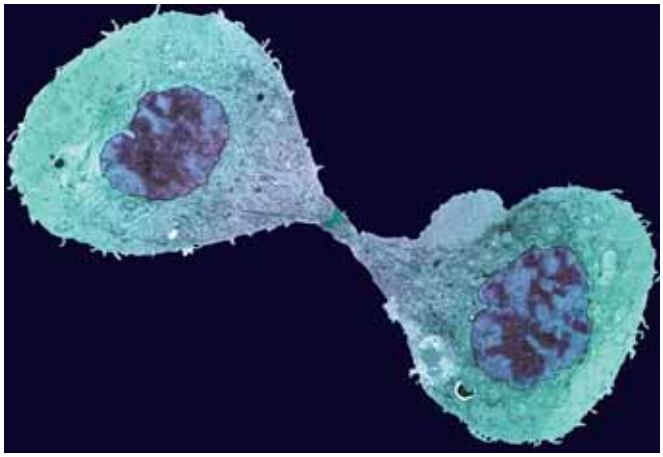


Figure 5.9 Cytokinesis in skin cells. Once mitosis is complete in animal cells, the cell membrane pinches together and the cytoplasm divides.

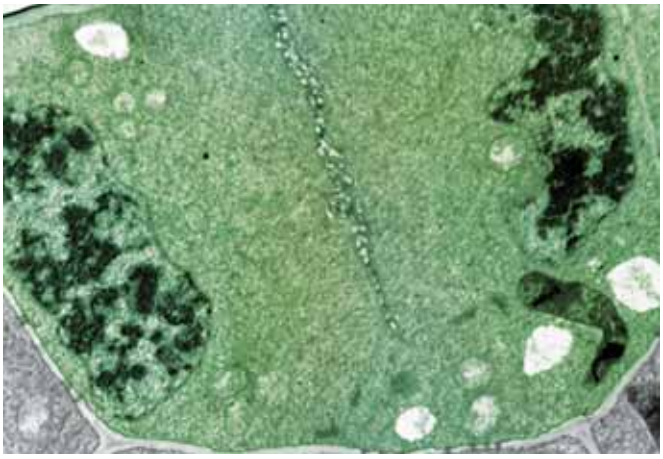


Figure 5.10 Cytokinesis in a coleus plant cell. A cell plate is forming (crossing the middle of the picture) and contains materials to form a new cell wall and membrane.

5-1B The Cell Cycle: A Play in Six Scenes

Find Out ACTIVITY

There are many changes occurring within the cell and cell nucleus during the cell cycle. In this activity, you will increase your understanding of the cell cycle by participating in a play about the cell cycle as an audience member and as an actor.

What to Do

1. Your teacher may assign you to an acting troupe, or you may choose your own group members.
2. Choose **one** of the following events of the cell cycle, which includes the phases of mitosis, for your scene of the play: interphase including DNA replication, prophase, metaphase, anaphase, telophase, or cytokinesis.
3. In your group, review and discuss what the cell would be doing during the event of the cell cycle you have chosen.
4. Prepare a brief script for your cell cycle event. Include a list of props that you will use in your scene.
5. Practise and then perform your scene for the rest of the class.

What Did You Find Out?

1. Is any cell cycle event more active than another event? Explain.
2. To perform a play well, actors must know their lines and where they should stand. How is the process of mitosis similar to what actors must do in a play? What would happen to a cell if chromosomes did not "know" their roles or where they must move during mitosis?
3. What part of developing your group's scene did you enjoy most? Why?
4. After viewing other groups' presentations, reflect on how the scene you performed could be improved.

Checkpoints in the Cell Cycle

Activities within the cell during the cell cycle are monitored and controlled at specific stages, or checkpoints. Checkpoints in the life of a cell are like checkpoints during a mountain bike race. Officials monitor racers to ensure that competitors have enough water and food and that no one is hurt. If an official thinks a racer cannot complete the race because of injury, the racer will be removed from the race.

Checkpoints during the cell cycle have a similar function. Special proteins at these checkpoints monitor cell activities and send this information to the nucleus. The nucleus then instructs the cell whether or not to divide. Cells will not divide if:

- There are not enough nutrients to support cell growth.
- DNA within the nucleus has not been replicated.
- DNA is damaged.

Figure 5.11 shows the specific checkpoints in the cell cycle.

internet connect

To find out more about the cell cycle, go to **www.bcscience9.ca**.

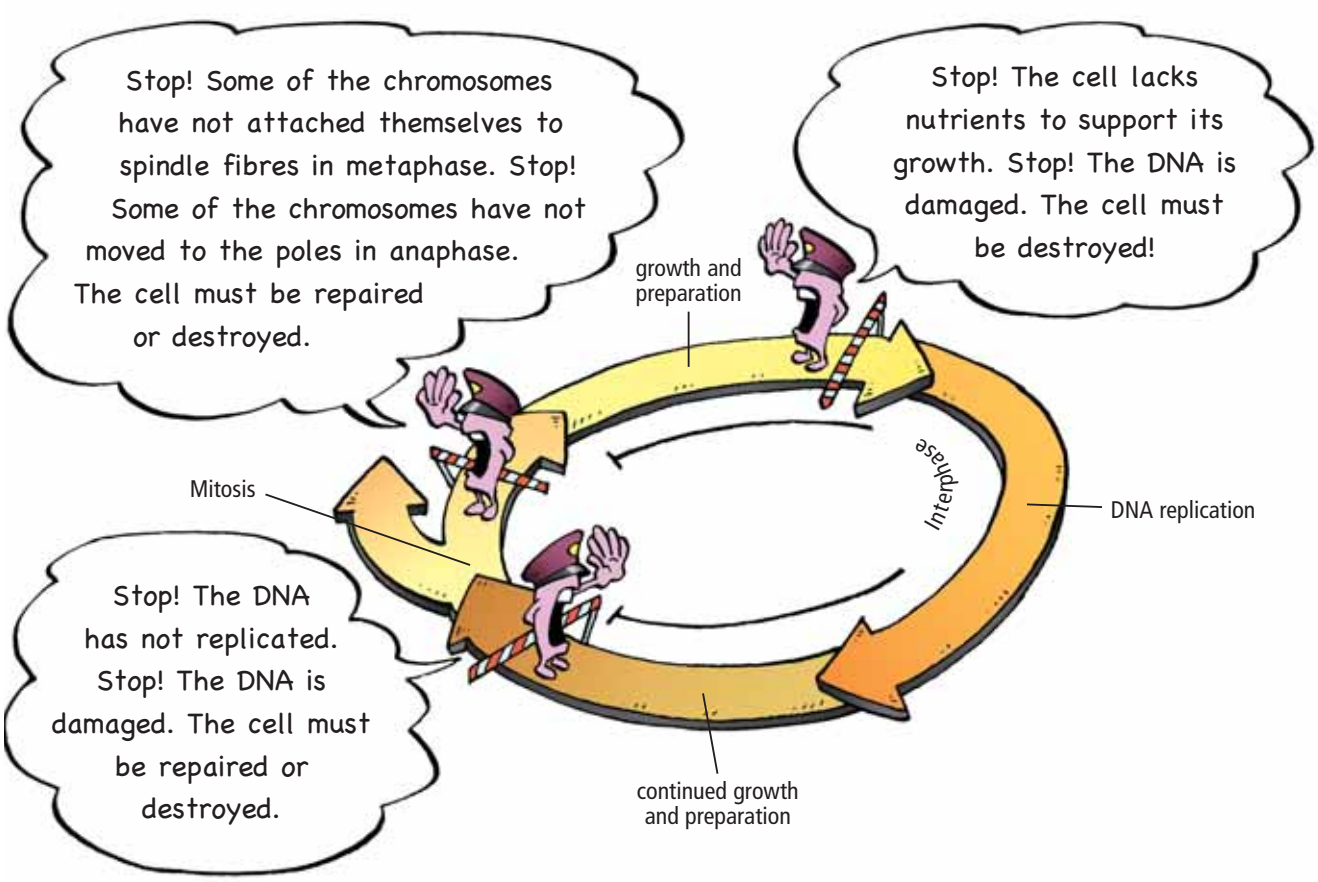


Figure 5.11 Checkpoints in the cell cycle

The Cell Cycle and Cancer

You have seen that checkpoints in the cell cycle can stop the cell from growing or dividing. Such precise control of the cell cycle is important to the survival of an organism. In section 4.2, you learned that mutagens can cause mutations in a cell and may harm the organism. These mutagens can include viruses, X rays, ultraviolet light, and chemicals such as acetone in cigarettes. Figure 5.12 shows the effect of radiation on a cell during mitosis. Skin cancer may eventually result from a single lengthy exposure to the Sun (Figure 5.13).

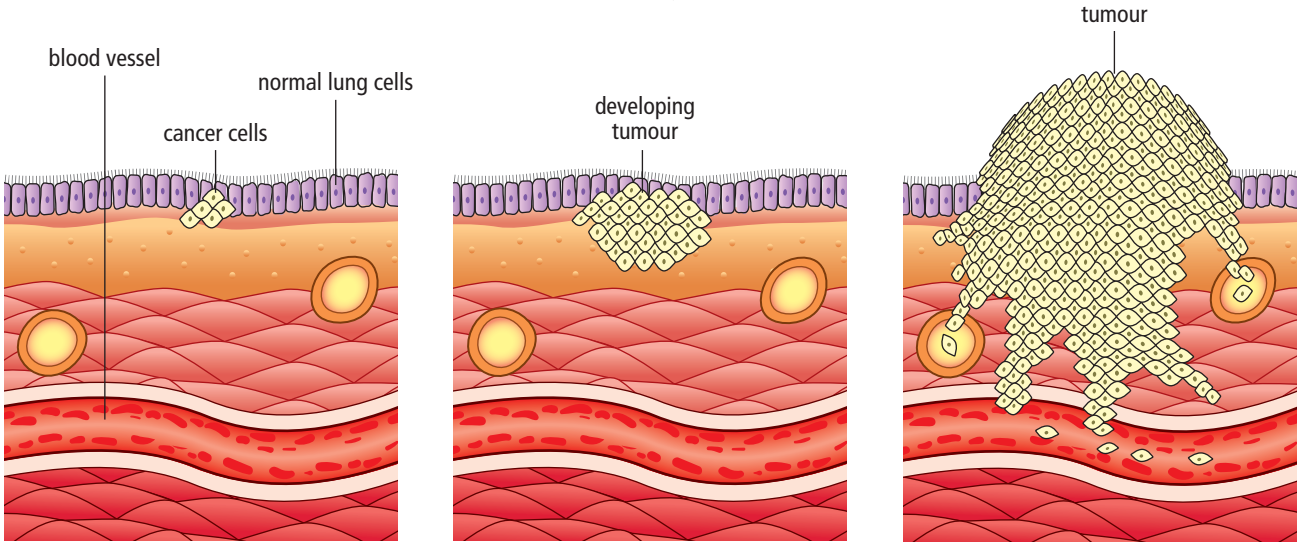
Figure 5.12 The effect of radiation on cells in mitosis. Here some chromosomes fail to move to opposite poles of a cell during anaphase.

Figure 5.13 A severe sunburn is a risk factor for developing skin cancer.

If a mutation occurs in a gene producing the instructions for a checkpoint protein, cell cycle control will be lost. As a result, a damaged cell like the one in Figure 5.12 may divide uncontrollably. **Cancer** is the name given to certain diseases that result from uncontrolled cell division. Researchers have linked certain types of inherited colon cancer and breast cancer with gene mutations in checkpoint proteins.

Healthy, normal cells grow in a single layer and stop dividing when they receive messages from neighbouring cells. Cancer cells, however, do not respond to messages from nearby cells, so they begin to grow in multiple layers. These multiple layers form a tumour as shown in Figure 5.14 on the next page.

When viewed with a microscope, cancer cells also show large, abnormal nuclei. These large nuclei result because cell division checkpoints no longer function and the chromosomes do not divide correctly.



A few abnormal-looking (cancer) cells are growing.

Cancer cells multiply to form a tumour.

Some cancer cells break away, move into the bloodstream, and spread to a new location.

Figure 5.14 A cancer cell divides uncontrollably and becomes a tumour. Nearby blood vessels provide nutrients to the tumour and carry cancer cells to new locations.

Cancer cells are not specialized, so they do not function as part of your body. A cancer cell formed in your lungs does not function as a lung cell because the cancer cell does not make the proteins for a lung cell. However, cancer cells can release chemicals to attract small nearby blood vessels. The blood vessels branch into the tumour and deliver nutrients to it. Nutrients feed the growing tumour, and tumour cells divide even more rapidly. Cancer can spread to other areas of the body if some tumour cells break away and are carried by the blood vessels to a new location where they may begin to divide and form a new tumour.

Cancer researchers strive to understand how cancer can disrupt the cell cycle, especially by looking for mutated genes that produce non-functioning checkpoint proteins. Cancer researchers also work to identify potential treatments, such as drugs that work by blocking cell division in a cancer cell and preventing the formation of a tumour.

Explore More

Scientists have found that for a cell to become cancerous it must have several mutations in its checkpoint proteins. This explains why the risk of cancer increases as you grow older. Find out more about the relationship between age and cancer. Begin your search at **www.bcscience9.ca**.

Reading Check

1. What are the phases of mitosis?
2. What do the nucleus and chromosomes look like during prophase?
3. How does cytokinesis differ in plant and animal cells?
4. What is the importance of checkpoints in the cell cycle?
5. What may happen when checkpoint proteins no longer function?

5-1C Observing the Cell Cycle in Plant Cells

SkillCheck

- Observing
- Modelling
- Working co-operatively
- Graphing

The cells in the tips of onion roots constantly divide as the tip grows. In this activity, you will work in groups to observe the cells of onion root tips to determine the frequency of the events of the cell cycle.

Question

What is the frequency of the events of the cell cycle in an onion root tip?

Procedure

1. In your notebook, draw six boxes that are 30 mm high by 20 mm wide. Use a ruler to draw the boxes.
2. Label the boxes: prophase, metaphase, anaphase, telophase, cytokinesis, and interphase.
3. Place the onion root tip slide on the stage of the microscope, and focus on the tip of the root at low power.
4. Change the objective lens to medium power, refocus, and then move to high power. Review the diagrams and micrographs on pages 156 to 158. Find a cell in prophase and draw it in the prophase box. Let the lines of the box represent the walls of the cell. Label the chromosomes and the spindle fibres.
5. Find a cell in metaphase, anaphase, telophase, and cytokinesis and draw your observations in the appropriate boxes.
6. After you have observed and drawn each of the above events, copy the chart below into your notebook. In your group, you will determine the number of cells in each event of the cell cycle. This is called the frequency. Follow steps 7 to 11 to complete the chart.

Cell Cycle Event	Group Data		Class Data	
	Frequency (number of cells)	Percentage	Frequency (number of cells)	Percentage
Prophase				
Metaphase				
Anaphase				
Telophase				
Cytokinesis				
Interphase				
Totals				

Science Skills

Go to Science Skill 9 for information about using a microscope and Science Skill 6 for information on making scale drawings.

Safety

- Microscopes, slides, and cover slips can break, especially when using the high-power objective lens. Handle with care.

Materials

- ruler
- pencil
- microscope
- prepared slide of an onion root tip

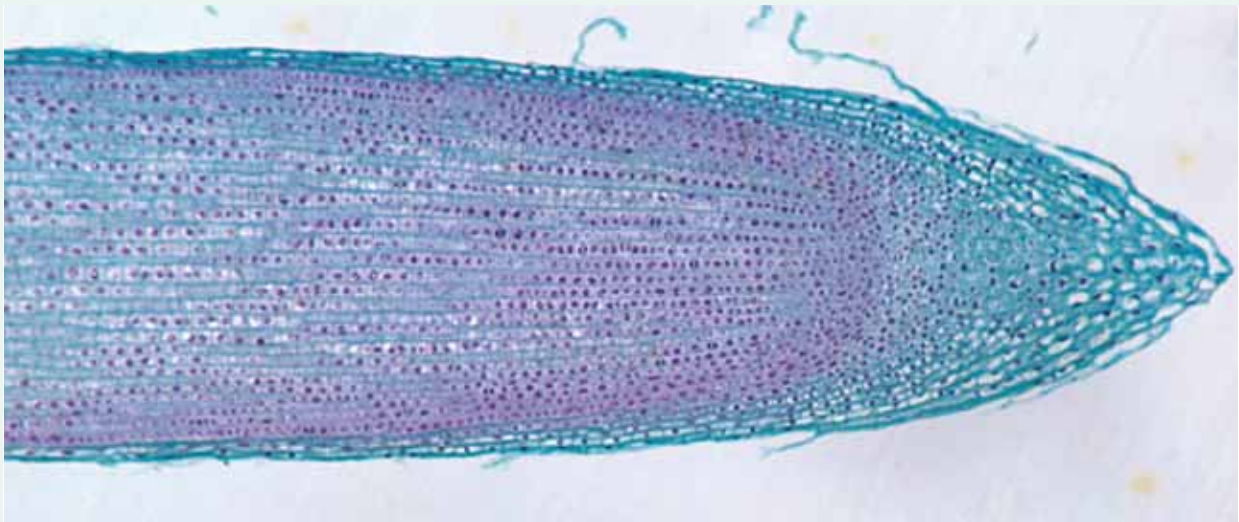
7. Count the number of cells across your field of view. Then count the number of rows of cells in the field. Multiply these two numbers together. This will give you an estimate of the total number of cells in your field of view. Record this estimate in the last box of the first column of the chart.
8. Have the person viewing the cells under high power call out the number of cells he or she can see in prophase. Have another person record this number in the prophase box in the table.
9. Repeat step 8 for each of the other events except interphase. Try not to count the same cell showing the same event twice. (You will determine the number of cells in interphase in step 10.)
10. Add together the number of cells seen in each event. Subtract this total from the number you estimated in step 7. This will give you the number of cells in interphase. Record this number in the chart.
11. Calculate the percentage for each event.
12. Share your results with the rest of the class and calculate total class frequencies.
13. Calculate class percentages for each event.
14. Plot a bar graph using the class data percentages.
15. Clean up and put away the equipment you have used.

Analyze

1. Which event of the cell cycle occurs most frequently?
2. How can you tell that the cell cycle is a continuous process?
3. (a) Which event of the cell cycle takes the longest period of time?
   (b) Explain how you made your decision.
4. Are your individual results in this investigation different from the rest of the class? If so, how could you explain this?

Conclude and Apply

1. Suppose that you were told that the cell cycle lasts 16 h. Use your class data percentages to estimate the length of each of the six events in this 16 h cycle.
2. Many scientific and medical careers involve examining cells in great detail. Find out about and summarize what a technician in a medical laboratory does. Begin your research at **www.bcscience9.ca.**



The growing tip of an onion root

Science Watch

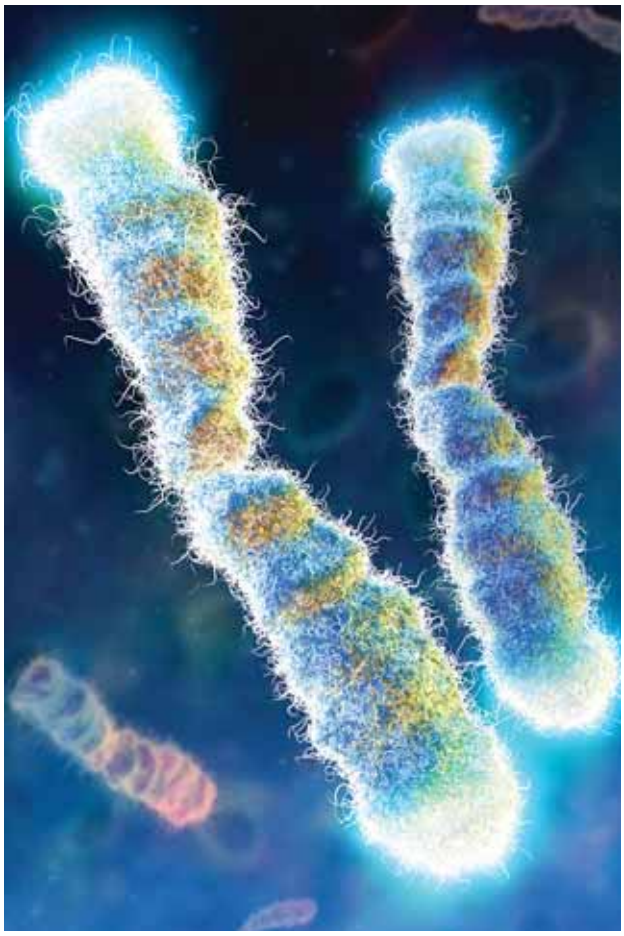
Stopping the Cell Cycle Clock

A cell cannot live forever, and eventually its cell cycle stops. On average, a human cell can divide only about 50 times. Embryonic stem cells are different. They are the early stage cells of a developing embryo. (An embryo is the early stage of development of a multicellular organism.) Scientists have discovered that embryonic stem cells have the potential to live indefinitely. However, once a cell becomes specialized, this fountain of youth is lost. One of the secret elixirs of stem cells is the enzyme telomerase [teh-loh-MEH-raze], which is found in egg, sperm, and embryonic cells.

Think of your chromosomes as pairs of shoelaces. As shoelaces become worn, the plastic end caps break and the shoelaces begin to fray. At the tips of your chromosomes are telomeres. These telomeres act like plastic shoelace caps to stop chromosomes from fraying and becoming tangled with other chromosomes. Each time your cells divide, your chromosomes shorten by about 50 base pairs. Eventually, the telomere cap disappears and the chromosomes are unable to divide correctly. When this happens, the cell dies.

Telomerase maintains the telomere caps so that the chromosomes do not become frayed. Since almost all cells in your body no longer make telomerase, each of your cells will age and eventually die.

Have researchers found the fountain of youth? Probably not, since there are other factors involved in cell aging. However, scientists have recently found that 90 percent of human cancer cells do not turn off the telomerase gene. Therefore, the telomere caps of these chromosomes do not shorten when the cells divide. As a result, these cells divide for longer than regular cells. Researchers believe that, if they can block the action of telomerase in cancer cells, they will be able to treat the disease and stop the clock of the cancer cell cycle.



Telomeres glow at the end of these chromosomes.

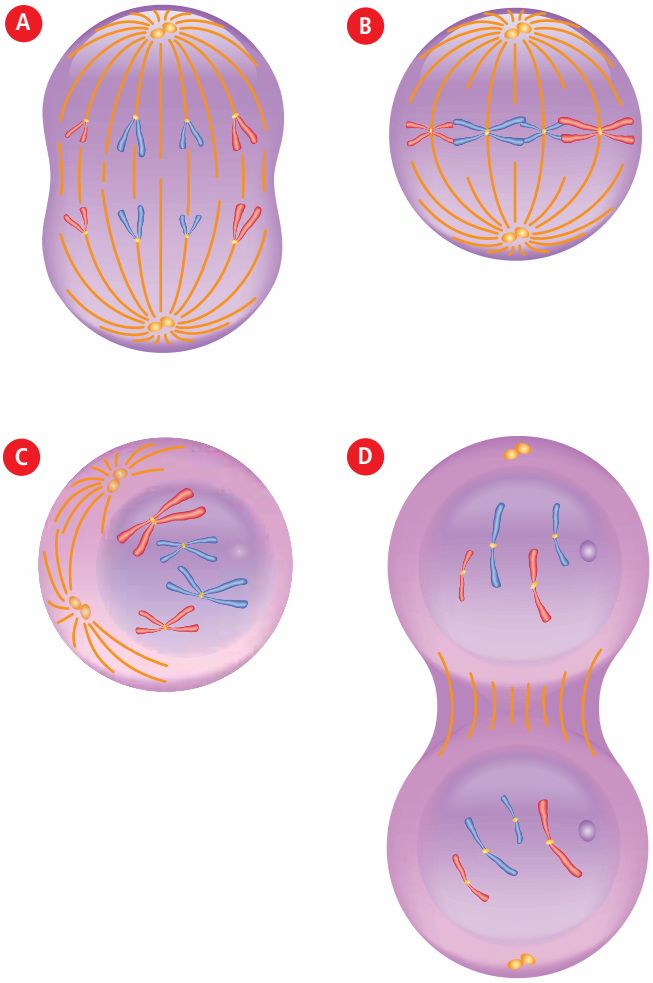
Questions

1. What causes cells to stop dividing?
2. Why is telomerase important to a rapidly dividing cell such as an embryonic cell?
3. How do cancer cells escape programmed cell death?

Check Your Understanding

Checking Concepts

1. Outline the activities in the cell at each of the following phases of interphase:
   (a) growth and preparation
   (b) replication
   (c) continued growth and preparation
2. List the steps in DNA replication.
3. What is the function of mitosis?
4. Is mitosis constantly occurring in your cells? Explain.
5. What is the function of the spindle fibres?
6. Use the diagrams on the right to answer questions (a) to (e).
   (a) Which diagram shows a cell at the beginning of anaphase?
   (b) Which diagram shows a cell with sister chromatids moving to opposite poles?
   (c) Which diagram illustrates a cell where a new nuclear membrane is forming?
   (d) Write down the correct sequence of letters to show the phases of mitosis from beginning to end.
   (e) Using the diagrams, explain how you could tell whether a cell has just completed mitosis or is entering mitosis.



Understanding Key Ideas

7. How is plant cell division different from animal cell division?
8. Why must the nuclear membrane break down for mitosis to occur?
9. In interphase, the DNA is loosely coiled. Why do you think it is important that the DNA be compact and tightly coiled during mitosis? (**Hint:** Think of an unravelled spool of thread.)
10. What might happen if DNA replication and mitosis were not highly controlled?
11. What are some environmental factors that can contribute to the development of cancer?
12. How is a cancer cell different from a normal cell?

Pause and Reflect

Interphase was previously called the resting stage of the cell cycle. Explain why "resting stage" is not an appropriate description.