CHAPTER 5 OPENER, pp. 134–135

USING THE PHOTO AND TEXT

Chapter 5 focusses on the events that occur to prepare cells for reproduction and the requirements necessary for a cell to reproduce. The photograph of a red tide illustrates the power of reproduction as microscopic organisms multiply very quickly in vast numbers.

Invite students to share any experiences or any background knowledge that they may have concerning red tide. Red tide is caused by a plankton bloom of a microscopic one-celled organism called a dinoflagellate. When conditions are favourable, these organisms become so numerous that the ocean appears red. There may be as many as 50 million organisms within 1 L of water. Dinoflagellates produce an extremely potent toxin that affects the nervous system of mammals but that does not affect the nervous system of shellfish, such as clams and oysters, which feed on the plankton. Shellfish that contain the toxin do not look any different than shellfish that do not contain it. Consuming the tainted shellfish can be fatal to humans. The nerve poison is thousands of times more powerful than cyanide, and there is no antidote. Mild poisoning can cause numbness; tingling of the mouth, fingers, and toes; or, in severe cases, respiratory paralysis and death because the diaphragm is unable to contract. If victims can be given artificial respiration or oxygen immediately, they can be saved.

Many organisms reproduce in large numbers when conditions are favourable. Have students predict what might be favourable conditions for a red tide. Usually these blooms occur in the summer in warm temperatures, when there are abundant nutrients and lots of sunlight, as these organisms are photosynthetic. Pollution and climate change attributed to the greenhouse effect are thought to be responsible for increasing the intensity and frequency of red tides. In Chapter 4, students learned how the nucleus controls the activities of a cell. Ask students to predict what must happen to the contents of a cell if the cell is to make an identical copy of itself. They should relate the fact that it is important that the contents of the nucleus be copied exactly. Ask students under what circumstances a cell might make an exact copy of itself.

USING THE WHAT YOU WILL LEARN/WHY IT IS IMPORTANT/SKILLS YOU WILL USE

To help students understand the importance of mitosis, have them brainstorm a list of things that grow in the world around them. Write down their suggestions where everyone can see them, then ask students to identify the examples on their list that involve mitosis. They will probably find that most of them do. Once they have this list, students can discuss ways the skills identified on page 135 might be useful in studying these types of growth.

USING THE FOLDABLES™ FEATURE

See the Foldables section of this resource.

5.1 THE CELL CYCLE AND MITOSIS

BACKGROUND INFORMATION

Living things must be able to reproduce. For unicellular organisms, cell reproduction is necessary to maintain the continuity of the species. For multicellular organisms, cell reproduction is necessary for growth of the individual and replacement of worn-out cells. Before a cell reproduces, the cell must replicate all the organelles within it, including the nucleus. The DNA within the nucleus must be duplicated so that daughter cells will contain identical information as the parent cell. Mitosis is a process that divides the duplicated DNA into two equal parts. Cytokinesis is a process that separates the cell contents into two daughter cells. There are specific conditions that must be met as the cell proceeds through the cell cycle and prepares to divide.

COMMON MISCONCEPTIONS

- Students might think that interphase is the period of inactivity in the cell cycle and that mitosis is the period of most activity in the cell cycle. However, in interphase, the cell is carrying out its own functions. For example, if the cell is in the digestive system, in interphase, hundreds of chemical reactions are occurring in that cell producing enzymes for secretion into the stomach.
- Students may not realize that the organelles in the cell are in constant motion. Some organelles are floating in the cytoplasm and moving around like toys in a bathtub of water. Some are attached to protein strands called microtubules that serve as highways for organelles to move along from one side of the cell to another.

ADVANCE PREPARATION

- You will need prepared slides of an onion root tip for Conduct an Investigation 5-1C, on pages 148 and 149. If you decide to have students do the suggested enrichment investigation, you will also need prepared whitefish blastula slides.

Useful research materials for advance preparation can be found at www.discoveringscience.ca.

INTRODUCING THE SECTION, pp. 136–138

Using the Text

After students read the passage, ask them to predict whether they think that all body cells reproduce as often as skin cells. Have students predict which cells in our body reproduce more frequently and which reproduce less frequently. Figure 5.3, on page 138, will help them later verify their predictions. Ask students to suggest how cell division is controlled or how a cell "knows" when to divide. (The DNA of the nucleus controls the timing of cell division.)

Using the Key Terms and Section Summary

At the beginning of each section in the student textbook are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the Key Terms by scanning the text and using the Glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are important for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 2-2, Unit 2 Key Terms, which lists the important terms in the unit, can be used to assist students.

Using the Did You Know, p. 137

To appreciate the number of cells in the human body, have students visualize one trillion. Ask students to estimate how long one million, one billion, and one trillion seconds would be. There are over one million seconds in 11 days. There are over one billion seconds in 32 years. One trillion seconds would be a period of 31 546 years. We have 50 million trillion cells in our body. An individual has between 20 trillion and 30 trillion red blood cells in his or her body at any time.

Using the Activity

Find Out Activity 5-1A

From One Cell to Many Cells, p. 138

Purpose

- Students will calculate how many cells result from one cell that continually divides for 30 days. This activity provides students with opportunities to determine and graph the theoretical population growth rate of cells, and to interpolate the cell population from the graph.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	Optional: Photocopy BLM 2–5, Find Out Activity 5-1A, From One Cell to Many Cells, and BLM 2-6, Showing Cell Growth with Pennies.	For each group: – Optional: calculator

Time Required

- 20 min

Science Background

In this activity, students investigate typical exponential growth in a population where nutrients are limitless and conditions are optimum.

Activity Notes

- Students could use a calculator to complete this activity.
- Students may or may not be familiar with exponential notation. If they are not, you may choose to introduce it here, as an efficient way to record very large or small numbers. Instead of 2 130 000 000, we can write 2.13×10^9.

Supporting Diverse Student Needs

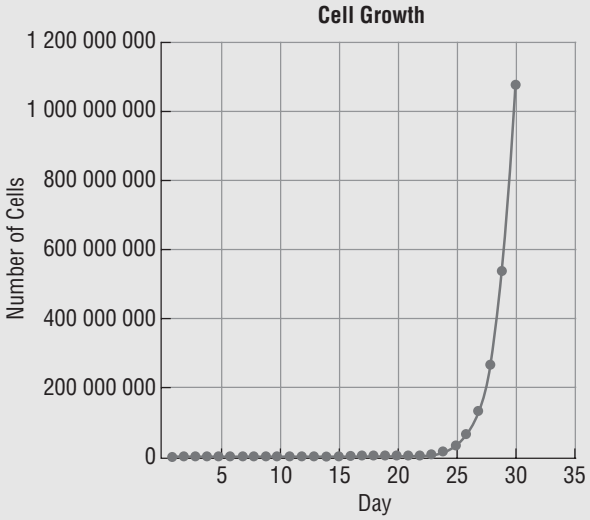
- If you anticipate that some students will have trouble with the math, have them work with a classmate who has strong mathematical skills.
- You may wish to distribute BLM 2-5, Find Out Activity 5-1A, From One Cell to Many Cells, for students to use when recording their data.
- For enrichment, ask students to explain why Earth is not covered with several kilometres of houseflies. Ask, "How does exponential growth get checked?"
- Students can complete BLM 2-6, Showing Cell Growth with Pennies, as an alternative or additional activity.

What to Do Answers

2.

Day	Number of Cells	Day	Number of Cells	Day	Number of Cells
1	2	**11**	2 048	**21**	2 097 152
2	4	**12**	4 096	**22**	4 194 304
3	8	**13**	8 192	**23**	8 388 608
4	16	**14**	16 384	**24**	16 777 216
5	32	**15**	32 768	**25**	33 554 432
6	64	**16**	65 536	**26**	67 108 864
7	128	**17**	131 072	**27**	134 217 728
8	256	**18**	262 144	**28**	268 435 456
9	512	**19**	524 288	**29**	536 870 912
10	1 024	**20**	1 048 576	**30**	1 073 741 824

3. Between day 18 and day 19, the mass of cells would reach about 1 mm in width.
4. Graphs will vary. Graphs should show an exponential curve that increases rapidly after day 25.



5. If students graph to day 30, as shown above, they will not be able to estimate effectively. From their chart, or from a graph with a larger scale on the *y*-axis:
   (a) approximately 48 cells
   (b) approximately 190 000 cells

What Did You Find Out? Answers

1. The tumour would be able to be detected at $10 \times 250\,000$ cells = 2 500 000 cells, which would be a little after day 21.
2. The cells would form a tumour and could cause pain if the tumour presses against a nerve or blocks blood flow to an organ, which may cause part of the organ to die.
3. To calculate the number of cells on a particular day, you could multiply 2 times the power of the number of days; for example, at 50 days the number of cells would be $2^{50} = 1.125\,899\,91 \times 10^{15}$.
4. (a) You cannot use the graph to predict the approximate number of cells after 40 days of growth. The numbers are increasing too rapidly to accurately extrapolate from the graph.
   (b) The skin cells will not continue to multiply at the same rate indefinitely. The older cells will die and the new cells will not have as much room to grow in, reducing the rate of growth.

Using a Demonstration

The following activity will help students understand the difference between plant- and animal-cell cytokinesis. Blow up and tie a balloon so that it is round but not completely full, to represent an animal cell. Wrap some string around the equator of the balloon to serve as the microfilaments of the contractile ring. Tighten the string and observe the formation of the fission furrow. Of course, on the actual cell, the contractile ring is on the inside, but this demonstration will show the furrow formation very well. Then produce a small cardboard box to represent a plant cell with a cell wall. Wrap the string around the box. The cell wall prevents the sort of division that an animal cell undergoes. This result is why plant cells use a cell plate instead of the fission furrow used by animals.

TEACHING THE SECTION, pp. 138–147

Using Reading

Divide the reading into two parts: The Cell Cycle and Mitosis (pp. 138 to 144), and Checkpoints in the Cell Cycle and The Cell Cycle and Cancer (pp. 145 to 147). The Cell Cycle and Mitosis is a core component of the course. Checkpoints in the Cell Cycle and The Cell Cycle and Cancer can be completed as enrichment if time permits.

The Cell Cycle and Mitosis, pp. 138–144

Pre-reading—Predict-Read-Verify

Have students look at a diagram of a cell (such as BLM 2-7, Parts of the Cell) projected on the screen. Ask students to work in pairs to brainstorm what activities have to happen in the cell to make an

identical copy of it. Remind students that the chromosomes are kept inside the nucleus. Have students devise a model of how each daughter cell will end up with the same number of chromosomes as the original parent cell. They can record their model on paper before they read the section.

During Reading—Note Taking

Students can use BLM 2-8, Stages of the Cell Cycle, to record the main points in each stage of the cell cycle as they read.

After Reading—Reflect and Evaluate

Students can compare their original predictions with the actual cell cycle activities recorded in their notes, and notice similarities and differences. You may wish to have students complete any or all of BLM 2-9, The Cell Cycle; BLM 2-10, Steps of Mitosis; and/or BLM 2-11, Cell Growth and Division.

Checkpoints in the Cell Cycle and The Cell Cycle and Cancer, pp. 145–147

These sections are provided as enrichment for capable students who are interested in addressing these issues.

Pre-reading—Predict-Read-Verify

Before reading, discuss what a checkpoint is and why it is important. Use the mountain bike race described in the textbook as an example to begin your discussion. Then have students predict answers to the questions below:

- Why is it important that there are checkpoints in the cell cycle?
- What causes a cell to become cancerous?
- How might the cell cycle be related to cancer, which is uncontrolled growth of cells?

During Reading—Think, Pair, Share

Ask students to read this section of text independently, record their thoughts, and then pair up with another student to discuss and share their thoughts on the text. Students can refer back to the pre-reading questions. Partners can collaborate to come up with one shared response.

After Reading—Reflect and Evaluate

Students can compare their original predictions with the actual information in the text.

Supporting Diverse Student Needs

- Body-kinesthetic learners may benefit from acting out the stages in the cell cycle with small props such as pieces of string to act as chromosomes, the nuclear membrane, and so on. They can also include the checkpoints and their effects as described in the textbook.
- Students can create cards showing the name of each stage with a sketch, and showing the name of each checkpoint. They can shuffle the cards, and then arrange them in the proper sequence to remember the stages of mitosis.

Reading Check Answers, p. 141

1. Skin cells of an adult must divide because the skin cells need to be replaced as they get worn out.
2. The three stages of the cell cycle are interphase, mitosis, and cytokinesis.
3. During interphase, there is a period of growth and preparation, a period when the DNA replicates, and another growth-and-preparation phase just before cell division.
4. DNA replication is important because replicating the DNA ensures that the newly formed cells will have an identical copy of the genetic information that was contained in the original DNA molecule.
5. At the end of interphase, the DNA is in its loosely coiled form so that proteins can be made.
6. In addition to copying the DNA, the cell prepares for cell division by duplicating organelles such as mitochondria and chloroplasts.

Reading Check Answers, p. 146

Note: Questions 4 and 5 relate to enrichment material.

1. The four phases of mitosis are prophase, metaphase, anaphase, and telophase.
2. During prophase, the nuclear membrane begins to break down. The double-stranded chromosomes become visible.
3. During cytokinesis in animal cells, the cell membrane pinches together and the cytoplasm divides (Figure 5.9, on page 144). During cytokinesis in plant cells, a cell plate forms across the middle and contains material to form a new cell wall and cell membrane (Figure 5.10, on page 144).
4. The importance of checkpoints in the cell cycle is that at these checkpoints, the cell can be stopped from growing or dividing if conditions are unsuitable. This precise control is important to the survival of the organism.
5. If a checkpoint protein no longer functions, which could occur when a mutation occurs in a gene producing the instructions for a checkpoint protein, cell cycle control will be lost, which could lead to cancer.

USING THE ACTIVITIES

- Activity 5-1A, on page 138 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.
- Activity 5-1B, on page 144 of the student textbook, is best used after students have a good working knowledge of mitosis.
- Activity 5-1C, on pages 148 and 149 of the student textbook, is best used after students have a good working knowledge of mitosis.

Detailed notes on doing the activities follow.

Find Out Activity 5-1B

The Cell Cycle: A Play in Six Scenes, p. 144

Purpose

- Students will increase their understanding of the cell cycle by participating in a play about the cell cycle.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	No advance preparation necessary	For each group: – Students obtain or design their own props.

Time Required

- 60 min

Science Background

In interphase, the cell is carrying on its life functions.

- The interphase scene should indicate a lot of activity within the cell. Proteins are being made, the cell is growing, and many of the organelles replicate. The scene should also show how DNA replicates.
- The prophase scene should show pairs of double-stranded chromosomes, and the nuclear membrane should disappear.
- The metaphase scene should show the double-stranded chromosomes organized in a single line across the middle of the cell, attached to fibres.
- The anaphase scene should show the fibres shortening and pulling the two strands of each chromosome apart, and the two strands of each chromosome moving to opposite poles.
- The telophase scene should show two sets of single-stranded chromosomes at opposite poles and a nuclear membrane forming around each set of chromosomes.
- The cytokinesis scene should show the cell's contents dividing in two and the membrane pinching together, if the group is representing animal cell division. If the group is representing plant cell division, the scene should include a cell plate forming and no physical separation of the cells.

Activity Notes

- Divide the class into six equal groups. If there are extra students, put them into the interphase group, as extra bodies could be used in DNA replication.
- Tell students that they need to write a "scene" representing their stage of the cell cycle. Have them refer to the text to determine the essential "characters" as well as what the characters should be doing in each scene. In addition, have students choose a narrator (or more than one) to explain the processes as they are happening in the skit.
- Some ideas for props could include the following: A circle of students could hold plastic wrap to represent the cell membrane. A skipping rope could represent the nuclear membrane. Students could hold up construction paper X's to represent double-stranded chromosomes that line up at the equator in metaphase and separate out along spindle fibres in anaphase, or wear headbands with the chromosomes marked on them.
- Give students some time in class to plan their activity, and have them present their skits a few classes later so that they have time to practise.
- Encourage students to select music for their presentation.
- If space in the classroom is too limited, book the library or go to the cafeteria and have students present there.

Supporting Diverse Student Needs

- Ensure English language learners are grouped with fluent English speakers.
- This activity will allow body-kinesthetic, musical-rhythmic, and interpersonal learners to demonstrate their learning.
- For enrichment, have students re-enact the skit when the checkpoints are removed and the cell has become a cancer cell.

What Did You Find Out? Answers

1. Answers will vary, but students should say that interphase is very active. This statement clears up a common misconception that during interphase the cell is only resting. Interphase is the time of greatest cell activity.
2. If actors did not know their roles, there would be chaos in the play and the play would fall apart. Actors would not know their places on stage. If chromosomes did not know their roles, there would be chaos during mitosis, and some chromosomes would end up in the wrong location. This result would lead to mutations in the daughter cells, since there would be an incorrect number of chromosomes in each cell.

3. Answers will vary but may include working together, brainstorming, and practising their parts.
4. Answers will vary but may include better props, more practice, and better teamwork.

Conduct an Investigation 5-1C

Observing the Cell Cycle in Plant Cells, pp. 148–149

Purpose

- Students observe the four phases of mitosis in onion root tips.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Gather materials and apparatus. Photocopy BLM 2-12, Conduct an Investigation 5-1C, Observing the Cell Cycle in Plant Cells.	For each group: – ruler – pencil – microscope – prepared slide of an onion root tip – optional: calculators

Time Required

- 45 min

Safety Precautions

- Microscopes and slides can break, especially when using the high-power objective lens. Remind students to handle microscopes carefully.

Science Background

Growth occurs in the tips of the roots and stems. In regions other than the apical meristem (tips) tissue, cells are not actively dividing. Cells at different stages of mitosis can be observed. Most cells in the tip, the region of active division, will be in interphase, but a few cells will be observed in each of the other stages. The cells in interphase are not dormant. They are elongating, differentiating, and performing their functions for the organism. Students should not concern themselves with observing the details of each stage. The key point for them to observe is that cells divide in stages to make two identical copies.

Activity Notes

- Distribute BLM 2-12, Conduct an Investigation 5-1C, Observing the Cell Cycle in Plant Cells, for students to use when recording their observations.
- Make sure students look at the tip of the onion root, as regions higher up are not actively dividing.
- Counting the number of cells is not an onerous task if students estimate the number of cells. They can count the number of cells across the field of view and count the number of rows down. The largest number of cells will be in interphase. Students do not have to count these cells because the number of cells in interphase can be obtained indirectly. Students should add together the number of cells seen in prophase, metaphase, anaphase, and telophase, and then subtract this total from the number of cells estimated in the field of view.
- Remind students how to calculate percentage. Percentage = number of cells seen at a particular stage ÷ total number of cells in the field of view.
- Answers will vary somewhat. Students should conclude percentages similar to the following: The cell spends about 90 percent of its time in interphase, 5 percent of its time in prophase, about 3 percent of its time in metaphase, 2 percent of its time in anaphase, and 1 percent of its time in telophase.
- Rather than constructing a bar graph, students could construct a pie chart.

Supporting Diverse Student Needs

- While all students should have opportunities to observe the cells in each stage, tasks can be assigned in each group to take advantage of each student's strengths.
- If students have forgotten how to use a microscope safely, refer them to Science Skill 6, on page 490 of the student textbook.
- For enrichment, students could observe animal cell division from prepared whitefish blastula slides.

Analyze Answers

1. Since most of the cells appear to have been in interphase when this onion root tip slide was prepared, the event that occurs most frequently is interphase.
2. You can tell that the cell cycle is a continuous process because cells at each stage are found.
3. (a) The event that takes the longest period of time is interphase.
   (b) Since most of the cells are found in interphase, this phase must be the longest.
4. Answers will vary but may include the fact that one onion root tip is younger than another, the counting of cells may have been inaccurate, and each onion is an individual, so there could be differences in cell division rates.

Conclude and Apply Answers

1. Answers will vary, but sample answers could be as follows: If students find that 90 percent of the time the cell is in interphase, 0.9×16 h = 14.4 h;

5 percent of the time in prophase,
0.05×16 h = 0.8 h;
3 percent in metaphase: 0.03×16 h = 0.48 h;
2 percent in anaphase: 0.02×16 h = 0.32 h;
1 percent of the time in telophase:
0.01×16 h = 0.16 h

2. Students can investigate or predict the role of a lab technician. Lab technicians may count different numbers of different types of white blood cells in a blood sample, distinguish cancerous cells from normal cells, and maintain cell cultures in research labs.

USING THE FEATURE

Science Watch: Stopping the Cell Cycle Clock, p. 150

As an extension for interested students, this article is an excellent introduction to new research about why cells age and die. Students have learned about the cell cycle. Ask students to predict why a cell dies and how a cell "knows" when to die. Have students read the feature and answer the questions. More information about telomeres and their role in cancer can be found at www.discoveringscience.ca.

Science Watch Answers

1. Cells stop dividing when the telomeres, the ends of the chromosomes, become too frayed and the chromosomes are unable to divide correctly. An enzyme, telomerase, maintains the telomere caps, but this enzyme stops being made in most cells before you are born.
2. Telomerase is important to a rapidly dividing cell, such as an embryonic cell, since it is important that the chromosomes do not become frayed or else successful cell division will not occur.
3. Cells in our body eventually die because the chromosome ends become worn with repeated cell divisions and the cells no longer make telomerase. In cancer cells, the telomerase gene remains active so these cells continue to divide.

SECTION 5.1 ASSESSMENT, p. 151

Check Your Understanding Answers

Checking Concepts

1. (a) During growth and preparation, the cell increases in size and makes the proteins and molecules necessary for it to function. Some organelles begin to duplicate.
   (b) During replication, the DNA copies itself.
   (c) In the continued-growth-and-preparation phase, the cell makes materials such as proteins, and duplicates organelles such as mitochondria and chloroplasts.
2. It is important for the DNA to replicate so that each daughter cell has an identical copy of the genetic information contained in the original DNA molecule.
3. The function of mitosis is to divide the contents of the cell's nucleus so that each daughter cell will have the same number and kinds of chromosomes as the original cell.
4. Mitosis is occurring only in cells that are preparing to divide. Some cells stay in the growth-and-preparation phase for a long period of time. For example, brain cells get replaced every 30 to 50 years. Cells that become worn out easily, such as stomach lining, intestinal lining, and skin cells, undergo mitosis more frequently. Figure 5.3, on page 138, gives examples of different cell replacement times.
5. There are 2 daughter cells formed during mitosis.
6. (a) A; (b) A; (c) D; (d) C, B A, D
   (e) You could tell whether a cell is just entering mitosis by observing if the chromosomes were double stranded. The cell would be just completing mitosis if the chromosomes were single stranded.

Understanding Key Ideas

7. If you wanted to study mitosis in humans, it would be best to choose skin cells. Skin cells replicate in children and adults.
8. Plant cell division is different from animal cell division because, in plant cell division, the daughter cells do not physically move apart. A cell plate forms in the middle of the cell, and from the cell plate, a cell membrane and cell wall develop. In animal cells, the daughter cells pinch apart. No cell plate forms in animal cells.
9. It is important that the chromosomes be tightly packed or the DNA from different chromosomes would become all tangled together and the chromosomes could break. Imagine each chromosome as a spool of thread, and imagine 46 of these spools in your cells. Now imagine these 46 spools with the thread all unwound from the spools. The thread would become all tangled and knotted, and chromosomes would be unable to separate.

10. If DNA replication was not highly controlled, many errors in the bases creating mutations would occur and many diseases like cancer would result. If mitosis were not highly controlled, some cells may receive more chromosomes in the daughter cells while other cells would receive less. Cells would die or be unable to divide again.
11. There are several things that might go wrong in the cell cycle to cause a mutation. The DNA could be copied incorrectly. This situation might not have an effect or it might cause the wrong type of protein to be made. The two strands of the double stranded chromosome might not pull apart or might not go to opposite ends of the dividing cell, resulting in one daughter cell having less DNA and the other having too much DNA.
12. Mitosis continues to occur after you stop growing to repair and replace damaged or dead cells.

Pause and Reflect Answer

The resting stage is not an appropriate description for interphase because the cells are very active during this time. They are performing all the life functions of the cell. For example, intestinal lining cells are busy producing enzymes to help digestion, red blood cells are carrying oxygen to the cells, and nerve cells in the brain are sending messages to each other at the speed of tiny fractions of seconds. These cells will double most of their cell contents, including DNA and organelles, during interphase as well.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable assessment Blackline Masters.

5.2 ASEXUAL REPRODUCTION

BACKGROUND INFORMATION

All living things must be able to reproduce. One-celled organisms continue the species through asexual reproduction. Multicellular organisms grow and replace worn-out cells through asexual reproduction. Asexual reproduction has its advantages, as large numbers of one-celled organisms can be reproduced very quickly. The main disadvantage is that all the cells produced from this method are genetic clones except for differences caused by mutations.

COMMON MISCONCEPTIONS

- Students may be under the impression that only single-celled organisms reproduce asexually. As they will see in this section, that is not the case. Sponges, sea stars, and plants all reproduce asexually, as do other organisms. You might ask students if they have ever seen someone root a cutting of a houseplant to grow a new plant. This is asexual reproduction.

ADVANCE PREPARATION

- You will need Knop's solution and eight duckweed plants per group for Find Out Activity 5-2A, on page 153.
- Useful research materials for advance preparation can be found at www.discoveringscience.ca.

INTRODUCING THE SECTION, pp. 152–153

Using the Text

Have students read page 152, and then have students discuss with a partner what a clone is and what asexual reproduction means. Have each pair work with another pair to list examples of each, then share those with the class. Although the Tazmanian tiger project described on page 152 produced some exciting results, it has been cancelled. While the researchers had some success cloning individual genes, it was decided that the small chance of any success in cloning an entire tiger was not worth the vast amounts of money the project required. It was felt that the money would be much more effectively spent in protecting current endangered species instead.

Using the Key Terms and Section Summary

At the beginning of each section in the student textbook are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the Key Terms by scanning the text and using the Glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are important for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can

use the Key Terms and section summary for review. BLM 2-2, Unit 2 Key Terms, which lists the important terms in the unit, can be used to assist students.

Using the Did You Know, p. 153

The Frozen Ark in Britain is collecting DNA samples from all kinds of species and freezing them at –80° C. Scientists are giving priority to species that are most in danger of extinction. The first seriously threatened animals to enter the Frozen Ark were the yellow seahorse, scimitar horned oryx, Socorro dove, Polynesian tree snails, and the flame-knee tarantula. A similar DNA storage bank for plants has also opened in Australia.

Other DNA banks exist. Ask students for other reasons why people would want to store DNA.

The Canadian National DNA Data Bank located in Ottawa and operated by the RCMP stores DNA for law enforcement purposes only. The National DNA Data Bank assists officers in solving crimes by linking crime scenes together and helping to identify and eliminate suspects. There are more than 100 000 entries, and the bank has helped solve thousands of crimes since opening.

There are many personal reasons why people want to save their DNA. Some people are interested in tracing their roots. Some want to help contribute to science and the search for cures for diseases. Some want to keep records of their children in case of abduction. Others fear disease in the future and believe that new organs can be cloned from their DNA. Others might have aspirations about living forever through human cloning in the future. There are also those who bank their pets' DNA.

Using the Activity

Find Out Activity 5-2A

Asexual Reproduction in Duckweed, p. 153

Purpose

- By growing duckweed, students will observe asexual reproduction in an organism, resulting in almost exponential growth when environmental conditions permit. They will also observe the decreasing growth rate that occurs due to limiting factors in the environment.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 weeks before the activity 1 day before the activity Day of the activity	Order duckweed. Prepare Knop's solution (see below). Assemble the other materials.	For each group: – 100 mL Knop's solution (prepared from 1 g potassium nitrate, 1 g magnesium sulphate, 1 g potassium phosphate dibasic, and 3 g calcium nitrate in distilled water) – 100 mL distilled water – 2 small jars or culture dishes – distilled water – wax pencils – 8 duckweed plants

Time Required

- 20 min to set up the experiment
- 5 min per day for two weeks to observe
- 20 min after two weeks to graph and answer questions

Safety Precautions

- Ensure students wear protective clothing, including lab coats and gloves, as well as safety goggles.

Science Background

Populations of duckweed grow quickly by asexual reproduction. By graphing the number of duckweed leaves in each container each day for two weeks, students will see a rapid growth curve. They will also notice that the number of leaves of duckweed in distilled water increases slightly for a few days, due to asexual reproduction, to a total of four or five, then decreases, due to the limits of the environment. There are no nutrients in distilled water for plants to use.

Knop's solution contains minerals necessary for growth. The number of leaves of duckweed in the Knop's solution should increase throughout the two-week duration of the experiment, resulting in up to about 40 leaves. Students may see the growth rate decrease toward the end of the two-week period, again due to the limits of the environment. Knop's solution contains no organic material, which is necessary for sustained growth. Also, space and access to light become limited when the population becomes too large.

Activity Notes

- Prepare Knop's solution by dissolving 1g potassium nitrate, 1 g magnesium sulphate, 1 g potassium phosphate dibasic, and 3 g calcium nitrate in 1 L of distilled water, and then add 5 L of distilled water to this solution.

- Have groups label each of their containers with their name or group number, as well as the letter A or B.
- If some groups have atypical results, you may wish to have groups combine their results and graph and analyze the combined results.

Supporting Diverse Student Needs

- This activity makes use of several skills. If possible, ensure that each group includes visual-spatial, body-kinesthetic, and logical-mathematical learners.
- Students who have difficulty drawing graphs can record on BLM 2-13, Find Out Activity 5-2A, Asexual Reproduction in Duckweed.

What Did You Find Out? Answers

1. The daughter plants are smaller.
2. The genetic material in the offspring is the same as the genetic material in the parent plant.
3. One container was set up with distilled water to act as a control.
4. Container A showed the greater number of new plants. Knop's solution contains nutrients that the duckweed needs to grow so more plants grew in this container than in container B, which only had distilled water.

TEACHING THE SECTION, pp. 154–161

Using Reading

Pre-reading—Predict-Read-Verify

Ask students to predict which types of organisms can clone themselves through asexual reproduction. Have them brainstorm a list of possible organisms. As students read the section, ask them to think about why some organisms can reproduce asexually while others cannot.

During Reading—GIST

GIST helps students distil text material into its most important ideas or concepts. Have students write down the subheadings, then read the text for each subheading and write down a summary of ideas presented. They must reduce the passage to just 20 words that capture the gist of the text. Guide students to focus on the types of organisms that display each method and how the cloned organism is produced.

Supporting Diverse Student Needs

- If some students have difficulty understanding written text or summarizing it, have groups of students create their summaries as a write-around. One person in each group begins a summary of each of the types of asexual reproduction discussed (binary fission, budding, fragmentation, vegetative reproduction, and spore formation). They then pass each summary around the group until every person has had a chance to add to it or comment on it. The group then has a complete set of summaries.
- Visual-spatial learners may benefit from using graphic organizers such as concept webs to create their summaries.

After Reading—Reflect and Evaluate

Ask students to think about why not all animals reproduce asexually. The higher invertebrates and all vertebrates are too complex with their many layers and types of tissues to reproduce asexually. Of interest is that some higher plants, including trees, have the ability to clone themselves. You may wish to use any or all of the following Blackline Masters as overhead projections: BLM 2-14, New Plants from Cuttings; BLM 2-15, New Plants from Roots; BLM 2-16, New Plants from Stems; and BLM 2-17, New Plants from Grafting.

USING THE ACTIVITIES

- Activity 5-2A, on page 153 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.
- Conduct an Investigation 5-2B, on pages 162 to 164 of the student textbook, should be completed after students read Types of Asexual Reproduction, on pages 154 to 161. Detailed notes on doing the activity follow.

Conduct an Investigation 5-2B

Determining the Best Conditions for Yeast Reproduction, pp. 162–164

Purpose

- Students observe the asexual reproduction of yeast and determine the optimum conditions for this reproduction to occur.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Purchase yeast and balloons. Assemble materials for lab. Photocopy BLM 2-18, Conduct an Investigation 5-2B, Determining the Best Conditions for Yeast Reproduction.	For each group: – see table below

APPARATUS/MATERIALS		
Part 1 – petri dish – 0.5 g yeast – 1 g sucrose (table sugar) – 5 mL warm tap water (24° C – 27° C) – thermometer – medicine dropper or toothpick – microscope slide – cover slip – microscope	**Part 2** – 4 Erlenmeyer flasks or small glass soft-drink bottles – wax pencil or marker – 320 mL hot tap water (40° C) – thermometer – 85 g sucrose (table sugar) – stirring rods – 16 g yeast – four 7.8 cm balloons – masking tape – string or thread	**Part 3** – 4 Erlenmeyer flasks or small glass soft-drink bottles – wax pencil or marker – 320 mL hot tap water (40° C) – thermometer – 20 g sucrose (table sugar) – stirring rods – medicine dropper – 10 mL vinegar – 10 mL ammonia – pH paper – 16 g yeast – four 7.8 cm balloons – masking tape – thread or string

Time Required

- 60 min

Safety Precautions

- Remind students to be careful when handling acids (vinegar) and bases (ammonia).
- Ensure students wash their hands thoroughly after doing this investigation.

Science Background

Yeast are small, single-celled fungi from the same kingdom that includes moulds and mushrooms. Yeast, such as *Saccharomyces cervisiae* used here, require carbohydrates such as table sugar to grow. Through the fermentation of sugar, the yeast produce carbon dioxide gas and alcohol and cause the rising of bread and the fermentation of wines and beer. Unlike bacteria, which multiply by binary fission, yeast reproduce asexually by budding, where a small bud forms on the parent cell and separates to become a new yeast cell. Using the compound microscope, students will observe a tiny bulge forming on the replicating cell as shown in the photograph on page 162 of the student textbook.

As more yeast are produced, more fermentation will occur. The amount of fermentation that occurs can be compared by collecting the carbon dioxide gas produced. The amount of carbon dioxide produced under the varied conditions and amounts of nutrients or varied pH can be compared by measuring the circumferences of the balloons inflated with the collected carbon dioxide gas.

Activity Notes

- Students can be put into small groups to reduce the amount of materials needed and reduce the time needed to conduct these activities
- If you prepare the solutions ahead of time, lab time will be reduced.
- The activity can be conducted in several ways—with all students in groups repeating all tests, or divide the class in half and then have everyone complete Part 1 of the experiment, half the class complete Part 2, and the other half complete Part 3. Data can then be shared.
- Warm water must be made available at a temperature of 24° C – 27° C and at 40° C. Beakers of water could be heated in the microwave, or use a kettle and adjust with cold water if a water bath is not available.
- Students should attach the balloons securely with masking tape and remove them very carefully, as the foam will rise into the balloons. You may wish to leave the balloons attached to the flasks until the next class to allow the carbon dioxide to escape overnight.
- In Part 2, students must make sure the sugar is dissolved before adding the yeast. Remind students to swirl the contents around every 2 min. The results of this activity should be that flask A (the control) shows no growth. If the balloon on flask A does inflate, it would be a result of air being heated inside the flask. Flask C with 30 g of sugar should show the most growth. Flask D should show little growth.
- In Part 3, students should add vinegar or ammonia drop-by-drop and gently swirl the flasks. Use pH paper to test the solution. The most growth should occur in flask G as the ideal pH for yeast growth is around 7. Little or no growth should occur in the other flasks.
- In Conclude and Apply, students are asked to design an experiment to determine the optimum temperature. You may wish to allow students to conduct this experiment. They can hypothesize an optimum temperature before they begin.

Supporting Diverse Student Needs

- Ensure students have read the investigation before beginning the activity.
- Students who have difficulty organizing observations in writing could use BLM 2-18, Conduct an Investigation 5-2B, Determining the Best Conditions for Yeast Reproduction, to record their data.
- For enrichment, have students conduct the test for temperature. Alternatively, students could design and conduct experiments using fructose, glucose, lactose, and table sugar (sucrose).

Procedure Answers

Part 2 Observing the Effect of Nutrients

Flask	Conditions	Fermentation Observed	Carbon Dioxide Produced
A	0 g sucrose	None	Little or none
B	5 g sucrose	Some initially	Some
C	30 g sucrose	The most	The most
D	50 g sucrose	None	A little

Part 3 Observing the Effect of pH

Flask	Conditions	Fermentation Observed	Carbon Dioxide Produced
E	40° C + pH 3	None	Little or none
F	40° C + pH 5	Some	Initially some
G	40° C + pH 7	The most	The most
H	40° C + pH 10	A little	A little

Analyze Answers

1. Students should describe buds forming from parent yeast cells.
2. The greatest yeast production in Part 2 should be seen in flask C with 30 g of sugar. The most growth seen in Part 3 should occur in flask G as the ideal pH for yeast growth is around 7. If a temperature experiment was conducted, the flask at 40° C should show the most growth.
3. At the beginning of Part 2 all 4 flasks were empty. At the end of Part 2, flasks A, B, and D contained liquid. Flask C contained liquid and bubbles. The balloon on flask C was inflated because it contained gas.
4. At the beginning of Part 3, all four flasks were empty. At the end of Part 3, flasks E, F, and H contained liquid. Flask G contained liquid and bubbles. The balloon on flask G was inflated because it contained gas.
5. The least favourable conditions for reproduction were when no sugar was present and the pH was 3 (acidic conditions).
6. The following controls were used in the experiment: the same amount of water was added to each flask; the same amount of yeast was added to each flask; the same size of flasks were used; the same size of balloons were used; and the same type of yeast was used.

Conclude and Apply Answers

1. To design a similar experiment to test the effect of temperature, students could take four flasks and add the same amount of tap water (80 mL) to each and place the flasks in the following conditions:
   Flask 1 in an ice bath
   Flask 2 at room temperature
   Flask 3 in a 40° C water bath
   Flask 4 in an 80° C water bath
   Dissolve 5 g of sugar in each flask. Add 4 g of yeast to each flask and stir. Then place a balloon on each flask and seal it securely with masking tape.
   Results: Flask 3 should show the best production of carbon dioxide, as 40° C is the ideal temperature for yeast production. There should be little or no production of gas in the other three flasks. In flask 4, the balloon may expand, but this result would be due to the air inside the balloon being heated.
2. Bar graphs should have pH and amount of sugar along the bottom and the circumference in centimetres for bar height.
3. If a baker wanted to maximize the rising of bread, the temperature of water should be 40° C, the concentration of sugar should be 30 g/80 mL of water, and the pH of the water should be neutral or 7.

SECTION 5.2 ASSESSMENT, p. 165

Check Your Understanding Answers

Checking Concepts

1. (a) D; (b) A; (c) B; (d) C; (e) E
2. Budding: occurs in multicellular organisms, may or may not separate from parents
   Binary fission: occurs in unicellular organisms only, separates from parent
   Both: methods of asexual reproduction, new offspring produced are identical to the parent
3. Yeast are an example of a unicellular organism that reproduces by budding.
4. fragmentation; vegetative reproduction, such as runners and potato eyes; grafting, cuttings, and spore formation
5. Organisms that reproduce asexually often produce large numbers of offspring to outcompete other organisms for nutrients and water. In addition, large colonies may survive when environmental conditions are altered or the number of predators changes.

6. (extension) Some spores have a tough outer covering that allows them to survive in harsh conditions, such as drought or extreme temperature, until conditions become favourable.

Understanding Key Ideas

7. The number of times a bacterium will be able to divide depends on the amount of nutrients, the availability of moisture, and the temperature (since enzymes that catalyze chemical reactions work at an optimum temperature).
8. Most multicellular organisms are unable to reproduce by budding because there are too many specialized cell types within the organism. Sponges and hydras have only a few different types of cells.
9. (extension) In the process of mitosis, the nucleus disappears and the chromosomes assemble themselves at the equator of the cell and move to opposite poles. Bacteria do not undergo mitosis because they do not have a nucleus and they have only one chromosome ring, not the X-shaped chromosomes of eukaryotes.
10. Bacteria do not undergo mitosis because they do not have a nucleus.
11. The sea stars multiplied asexually by fragmentation and the population increased even more.
12. If you graft four scions that each produce a different variety of apples to a rooted stock, then you will have an apple tree that bears four different varieties of apples.
13. Plants, such as tulips, have special cells, usually in plant stems and plant roots, which can divide repeatedly to form structures that will eventually develop into a plant identical to the parent. This is how the number of plants in a flowerbed can increase without additional bulbs being planted.
14. Advantages of asexual reproduction: (a) large numbers of offspring are produced in a short period of time from only one parent when conditions are favourable; (b) large numbers of offspring can outcompete other organisms for nutrients and water; (c) large numbers of offspring mean that species can survive when the conditions or number of predators change; and (d) very little energy is required. Disadvantages of asexual reproduction: (a) offspring are genetic clones and a negative mutation may make the organism susceptible to disease and can destroy large numbers of offspring; (b) some types of asexual reproduction produce offspring that are close together and compete for food and space; (c) unfavourable conditions can wipe out an entire colony.

Pause and Reflect Answer

Corals, and other similar organisms, can regenerate parts they have lost through injury by budding. Scientists would study mitosis and budding to learn more about how coral can regenerate parts.

Other Assessment Opportunities

- Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

CHAPTER 5 ASSESSMENT, pp. 184–185

PREPARE YOUR OWN SUMMARY

Students' summaries should incorporate the following main ideas:

1. Cell Cycle
   - Cells must be able to replicate and divide for growth and to replace worn-out cells.
   - The life of a cell has three stages: interphase, mitosis, and cytokinesis.
   - In interphase, the cell grows, replicates the DNA, and prepares to divide.
   - In mitosis, the nuclear material divides.
   - In cytokinesis, the cell contents including the two nuclei separate into two daughter cells.
2. Mitosis
   - Mitosis is a process that divides the contents of the cell's nucleus, the chromosomes.
   - There are four stages of mitosis including prophase, metaphase, anaphase, and telophase.
3. Types of Asexual Reproduction
   - Methods of asexual reproduction include binary fission, budding, fragmentation, vegetative reproduction, and spore formation.
   - One-celled organisms can reproduce by binary fission and budding.
   - Multicellular organisms reproduce by fragmentation, vegetative reproduction, and spores.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. Cell division is necessary in unicellular organisms so that these organisms can reproduce in great numbers.
2. Cell division is necessary in multicellular organisms for growth and repair and to replace worn-out cells.

3. The three stages of the cell cycle are interphase, mitosis, and cytokinesis.
4. Cells are performing the life functions of a cell during interphase. Digestive system cells will be making enzymes, and retina cells will be performing chemical reactions so that you are able to see. In addition, the cell is preparing for cell division by duplicating organelles.
5. (extension) If the cell is unable to make the proteins to form spindle fibres, mitosis could not occur successfully since the chromosomes would not be able to attach. The result would be that the chromosomes would not be equally distributed between cells.
6. Bacteria use binary fission to reproduce very rapidly, sometimes every 20 min if conditions are favourable, which means that a few bacteria entering your body can multiply into millions of bacteria within a few days, making you sick.
7. The chart should include the following:
   Interphase: Cell carries out the functions necessary for survival, and if the cell is going to divide, it will prepare for cell division by copying the DNA and duplicating organelles.
   Mitosis: The duplicated chromosomes are divided into two equal parts.
   Cytokinesis: The two nuclei and the contents of the cell separate into two daughter cells.
8. The chart should include the following:
   Prophase: The double-stranded chromosomes become visible.
   Metaphase: The double-stranded chromosomes are pulled into a single line at the equator.
   Anaphase: The two strands of the double stranded chromosome are pulled to opposite poles of the cell.
   Telophase: The nuclear membrane forms around each set of chromosomes.
9. Students' diagrams may be the same, except for the shape of the cell. Some students may show that in plant cells there are no centrioles, although they should not be expected to know this.
10. The major disadvantage of asexual reproduction is that there is very little variation so all the offspring are identical. If conditions change, all of the individuals could die.
11. There are several commercial uses of vegetative reproduction. For example, plants will reproduce and spread through a field without farmers needing to plant additional seeds, which saves time and money. Farmers can grow exact copies of individual plants that have desirable traits, such as abundant yield. Plant growers can quickly reproduce houseplants by taking cuttings.
12. Spores are very light and can be blown or washed away from the parent plant, giving spore production a unique advantage over other asexual methods of reproduction where the offspring grow close to the parent and compete for food and space.
13. When a yeast cell reproduces through budding, part of the yeast cell pushes outward to form an outgrowth or bud. This bud then pinches off from the parent cell to become a yeast cell, identical to the parent cell. When an amoeba reproduces through binary fission, the amoeba replicates its genetic material and divides into two equal parts. Amoebas go through mitosis; yeast cells do not.

Understanding Key Ideas

14. Two characteristics of asexual reproduction are that only one parent is required and all of the offspring are genetic clones of the parent.
15. The nuclear membrane must disintegrate during prophase so that the chromosomes are free to move to opposite ends of the cell later.
16. (a) These cells are plant cells.
    (b) There appears to be a cell wall and the cells remain side-by-side after cell division.
    (c) The correct sequence is C, A, D, B.
    (d) Diagram C shows prophase where the chromosomes become visible. Diagram A show metaphase where the double-stranded chromosomes are lined up in single file at the equator. Diagram D shows anaphase where the two strands of the double stranded chromosome move to opposite poles. Diagram B shows telophase where the nuclear membrane forms around the sets of chromosomes.
17. If the chromosomes do not separate out correctly during anaphase, the cell will probably not go through the rest of the cell cycle. The cell will die, or one daughter cell may end up with more chromosomes than the other daughter cell.
18. Vegetative reproduction is helpful to farmers in several ways. Plants will reproduce and spread through a field without farmers needing to plant additional seeds, which saves time and money. Farmers can grow exact copies of individual plants that have desirable traits, such as abundant yield. This process cannot be done with grain crops, which reproduce

sexually. Because these plants can reproduce from a stem, a leaf, or a root, growers can graft fruit trees to produce smaller trees that mature faster and are easier to harvest.

19. Organisms that produce spores have several advantages over organisms that reproduce by budding or binary fission. Because spores are very light, organisms that produce spores are able to use the wind or water to spread their offspring far away. In contrast, the offspring produced by budding or binary fusion grow beside the parent and compete for space and food. Spores are also usually covered in a tough outer coating that makes them very durable. They can survive harsh conditions and start growing when conditions are more favourable. The offspring produced by budding or binary fission do not have this protection and will die in harsh conditions.
20. Only less complex forms of life can reproduce asexually without human assistance because lower forms have only a few types of cells. Higher forms have many types of specialized cells to form complex tissues.
21. Because asparagus dies back to the ground in the winter and regrows new shoots from its roots in the spring, farmers do not need to prune the plants or reseed the asparagus each year.

Pause and Reflect Answer

Offspring that are produced through asexual reproduction are not always identical to their parents. Mistakes can occur when the genetic material is being copied, making the offspring different from the parent. This result is common in bacteria, which have a simple DNA structure. Bacteria can also reproduce rapidly in ideal conditions, producing millions of generations in a short period of time. The final offspring bacteria can be very different from the original parent bacteria.