CHAPTER 6 OPENER, pp. 168–169

USING THE PHOTO AND TEXT

It may appear that the white birch trees in the opening photograph look the same, but they are genetically different, which means that their DNA is different. Have students consider the differences among members of their own family. Each sibling's unique genetic information causes unique physical traits. Point out that each birch tree has a unique DNA fingerprint, as does each human, and any organism that reproduces sexually.

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

In Chapter 5, students learned that asexual reproduction produces clones. Ask students why genetic diversity is important. Ask students to predict how genetic diversity is created.

USING THE FOLDABLES™ FEATURE

See the Foldables section of this resource.

6.1 MEIOSIS

BACKGROUND INFORMATION

The process of meiosis introduces variation into a species. Variation is necessary for survival. Although this is not a part of the curriculum, you may be interested to note that two events in meiosis I create variation: In metaphase I of meiosis I, the event of crossing over occurs, in which arms of chromosomes are exchanged and genetic information is recombined. In anaphase I of meiosis I, homologous chromosomes independently move to opposite poles. The process of meiosis shuffles genetic information and results in variation in the gametes.

COMMON MISCONCEPTIONS

- Students can easily confuse the process of mitosis with meiosis. Use as many activities as possible for students to distinguish between the two processes. Students need to understand that meiosis replaces mitosis in the cell cycle for gametes. In other words, an egg or sperm have a period of growth and development before the nuclear division process of meiosis occurs. There will be checkpoints in the cell cycle of a gamete similar to those of body cells.
- Students may think that the number of chromosomes gets doubled in meiosis, which is incorrect. The number of chromosomes is reduced by half in meiosis.
- Students may think that there are two nuclear divisions in meiosis. While there are two cytoplasmic cell divisions, the nuclear material or chromosomes replicate only once.

ADVANCE PREPARATION

- Gather the materials for Activity 6-1A, on page 171, at least one day before instruction. Useful research materials for advance preparation can be found at www.discoveringscience.ca.

INTRODUCING THE SECTION, pp. 170–171

Using the Text

Using the white birch trees as an example, have students create a list of ways in which one birch tree may differ from another, showing genetic diversity. Students will list the obvious traits, such as differences in height or tree girth, but there are less visible traits, as well. Genetics is involved in determining whether birch trees are resistant to insect pests, such as the bronze birch borer, and even whether they are resistant to pollution.

Many genetic differences that are not visible are differences in chemical pathways that create different chemical products in the body. For example, hand clasping is a behavioural phenotype that is not readily apparent in an individual. Have all students clasp their hands together. Tell them to take note of whether they place their right thumb or left thumb on top. Count the number of students who clasp their hands each way, by a show of hands. The frequency in the population is left thumb on top—55 percent; right thumb on top—44 percent; and no preference—1 percent.

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 all the terms in the unit, can be used to assist students.

Using the Activity

Find Out Activity 6-1A

Eating Like a Bird, p. 171

Purpose

- Students determine which type of beak variation provides a survival advantage given a particular food source.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Gather the materials. Once assembled, many of the items can be reused from year to year.	For each group: – 1 spoon – chopsticks (1 set) – forceps or tweezers (1 pair) – handful of marbles – small pile of toothpicks – small pile of cereal – handful of pennies – 1 timer

Time Required

- 30 min

Safety Precautions

- Remind students to never eat anything in the science room.

Science Background

An adaptation is a characteristic that helps a plant or an animal survive in its environment. Bird beaks have adapted for eating, defending, feeding young, gathering nesting materials, building nests, preening, scratching, courting, and attacking. Beaks act like tools for birds to perform their daily tasks. For example, parrots have heavy thick bills that act like a nutcracker to crack seeds. Hummingbirds have thin straw-like bills to sip nectar. Flamingos have bills like slotted spoons to filter their food out of the water. The design of a species' beak originated from mutations, which created beneficial characteristics for the bird.

Activity Notes

- Students should make predictions before beginning the activity.
- You may provide several food stations: two marble food stations, two toothpick food stations, two cereal food stations, and two penny food stations. Having separate stations will make clean-up easier as less food will get mixed up. Students can move to each food station with their tools and attempt to pick up the food.
- Remind students that they can use only the tools. They may not use their fingers.

Supporting Diverse Student Needs

- Pair English language learners with fluent English speakers.
- Body-kinesthetic learners, naturalistic learners, and intrapersonal learners will all enjoy this activity. Ensure that they remember to collect and organize data, as well as trying out the materials.
- For enrichment, students can research Darwin's finches and report on their findings.

What Did You Find Out? Answers

1. Answers will vary, but students should elaborate on how their predicted ability to pick up the objects with the different beaks was different from their results.
2. Answers will vary. Students will likely note that many results were common to several groups, but may notice that a few implements worked better in one group than in another. For example, one group may include students who have experience using chopsticks, and another may not.
3. Students should say that spoons would provide a survival advantage because students were able to pick up more marbles with spoons.
4. Tweezers would give a survival advantage where toothpicks were the only food source since more toothpicks can be picked up with tweezers.

TEACHING THE SECTION, pp. 172–175

Using Reading

Pre-reading—Predict-Read-Verify

Ask students how many chromosomes there are in each body cell (46). Ask students how many chromosomes they think are in a sperm cell or an egg cell. Ask, "How are sperm cells and egg cells created?" Have students jot down their predictions. Then have students read the section to verify their predictions.

During Reading—GIST

Students read to verify their predictions about the creation of sperm and egg cells. Have students reduce each chunk of text—The Role of Gametes, and Meiosis: Reducing Chromosome Number—to just 20 words. Encourage them to use some Key Terms in their summaries.

After Reading—Semantic Mapping

Have students create a concept map relating the Key Terms "gametes," "meiosis," "fertilization," "zygote," and "embryo." Students could complete BLM 2-20, How Variation Occurs in Meiosis, to demonstrate

their understanding of the section. Students could also complete any or all of BLM 2-21, Gametes; BLM 2-22, Mitosis and Meiosis; and BLM 2-23, Cell Reproduction.

Supporting Diverse Student Needs

- Students can use Think-Pair-Share to create a concept map after reading the section.
- Students who require additional support to extract the important information from the textbook about gametes can work with a partner to complete BLM 2-24, Gamete Summary. Pairs of students can search pages 172 to 175 of the textbook to help them fill in blanks that they are not able to fill in on their own.

Reading Check Answers, p. 175

1. Genetic diversity is the inherited differences in a population. For example, not everyone in the classroom is the same height.
2. The function of meiosis is to reduce the chromosome number so that when the egg and sperm unite, the original number of chromosomes will not be doubled.
3. Another name for a fertilized egg is a zygote.
4. When sex cells in a male undergo meiosis, four sperm cells are produced from each parent cell.

USING THE ACTIVITIES

- Activity 6-1A, on page 171 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.
- Activity 6-1B, on pages 176 and 177 of the student textbook, is best used after students read pages 173 to 175. Detailed notes on doing the activity follow.

Core Lab Conduct an Investigation 6-1B

Comparing Mitosis and Meiosis, pp. 176–177

Purpose

- By studying text diagrams, students compare the processes of mitosis and meiosis.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	Photocopy BLM 2-25, Conduct an Investigation 6-1B, Comparing Meiosis and Mitosis.	none

Time Required

- 40 min

Science Background

Mitosis is a process that cells must undergo to reproduce asexually. One-celled organisms and lower invertebrates reproduce by this method. Multicellular organisms require mitosis for cell division in growth and cell replacement. The cells that result from mitosis are genetic clones. Meiosis is a process necessary for sexual reproduction to ensure that the diploid number of chromosomes is maintained and which provides variation in the eggs and sperm that are produced in the process. This variation is necessary for survival of the species.

Activity Notes

- In this activity, students should learn that meiosis includes a division that reduces the number of chromosomes. The specifics of each stage of each process are not important for students to remember.
- Students could work with a partner and have one textbook open to page 174. BLM 2-26, Mitosis also shows the process of mitosis and could be used instead of a second textbook.
- Students could use BLM 2-25, Conduct an Investigation 6-1B, Comparing Meiosis and Mitosis, to make their drawings.
- To conclude the activity, show an animation comparing the processes from www.discoveringscience.ca.

Supporting Diverse Student Needs

- For enrichment, students could visit the interactive meiosis activities at www.discoveringscience.ca.

Analyze Answers

1. Meiosis II is more similar to mitosis because in meiosis II, the two strands of each chromosome separate and move to opposite poles.
2. Answers may vary but should include that in both processes, the nuclear material is duplicated before the cell divides; new daughter cells are produced; and single-stranded chromosomes move to the poles in mitosis and in anaphase II of meiosis.
3. Answers will vary but should include that in mitosis, there is only one cell division resulting in two daughter cells, while in meiosis, there are two cell divisions resulting in four daughter cells. The number of chromosomes remains the same after cell division in mitosis, while the number of chromosomes is halved in meiosis. In mitosis, the genetic information

in the daughter cells is the same as in the parent cell, and in meiosis, the genetic information in the daughter cells is different from the parent cell.

Conclude and Apply Answers

1. (a) Differences between mitosis and meiosis should include the list above in the answer to Analyze question 3, as well as the fact that mitosis occurs in body cells and meiosis occurs only in sex cells.
   (b) Meiosis contributes to genetic variation because the daughter cell contains information from both parents of the person whose cells are undergoing meiosis.

USING THE FEATURE

National Geographic: Visualizing Polyploidy in Plants, p. 178

Polyploidy is very common in plants. It is estimated that between 30 percent and 70 percent of all flowering plants are polyploids. Ask students what "ploidy" means. "Ploidy" refers to the numbers of sets of chromosomes. Diploid means having two sets or $2n$ chromosomes, and triploid means having three sets of chromosomes. Ask students to predict how a $4n$ organism could be produced. Polyploids can result from the union of unreduced gametes—that is, eggs and sperm that have not undergone normal meiosis and still have $2n$ chromosomes. Another way that polyploidy could occur is through errors in mitosis. The large number of plants that show polyploidy suggests that there must be an evolutionary advantage to these chromosomal mutations. Ask students to think about what these advantages might be.

The feature describes octoploids as having very large leaves, flowers, and fruits. Ask students why each of these characteristics could be an advantage for the plant. Large leaves provide more efficient photosynthesis, large flowers provide more efficient pollination, and large fruits would suggest that more animals would eat the fruit, resulting in better seed dispersal. A less visible advantage of a polyploid plant is that if an organism has four copies of a gene and there are mutations in one of those genes, the other copies of the genes will make the correct protein and so the plant will be healthy.

Polyploidy is rare but does exist in animals. There are polyploid goldfish, flatworms, salamanders, lizards and insects. The animals may be able to reproduce asexually by parthenogenesis in which an unfertilized egg develops into a new individual.

SECTION 6.1 ASSESSMENT, p. 179

Check Your Understanding Answers

Checking Concepts

1. The number of chromosomes in a human skin cell is 46 (the diploid number) and in a human egg cell is 23 (the haploid number).
2. To identify a pair of chromosomes, you would look for two chromosomes that have the same size and shape.
3. The benefits of genetic diversity are that organisms may have new characteristics that allow them to be better equipped to cope with changes in the environment. The organism may gain an advantage over another organism.
4. (a) Meiosis II
   (b) Meiosis I
   (c) Meiosis I
5.

QUESTION	MITOSIS	MEIOSIS
Where does it take place?	Unicellular organisms and body cells of multicellular organisms	Sex cells of multicellular organisms
How many cells are produced?	Two	Four
What happens to the number of chromosomes?	Number remains the same as in parent cell	Half the number of chromosomes as in parent cell
How do parent and daughter cells compare genetically?	Identical	Not identical
How do daughter cells compare to each other genetically?	Identical	Not identical

6. In meiosis I, the homologous chromosomes are paired at the equator. In mitosis, the homologous chromosomes are unpaired and line up individually at the equator.
7. Meiosis occurs only in sexual reproduction.
8. The four daughter cells form during meiosis II.
9. A gamete is a specialized cell necessary for reproduction. In animals, male gametes are called sperm cells and female gametes are called egg cells.
10. During the process of fertilization, an egg cell is penetrated by a sperm cell, and the haploid genetic information of both male and female

gametes combines. The result of this process is a diploid cell called a zygote. A zygote receives half its chromosomes from its female parent and half from its male parent. The zygote then undergoes mitosis and cell division and develops into an embryo.

Understanding Key Ideas

11. Muscle cells do not undergo meiosis because they need a full set of chromosomes to function properly. Only cells that will become sperm and egg cells go through meiosis.
12. Meiosis is important for the survival of the organism because the process introduces variation, and variation is necessary for the survival of the species if conditions change.
13. You can tell whether a sperm cell is in meiosis I or meiosis II because in meiosis I, double-stranded chromosomes are moving to the poles. In meiosis II, single-stranded are separating and moving to the poles.
14. Drawings should resemble Figure 6.3 on page 172.
15. (a) The dog would have 38 homologous pairs of chromosomes.
    (b) Each sperm cell would have 38 chromosomes.
16. Cells produced by mitosis cannot be used for sexual reproduction because they contain a complete set of chromosomes. Cells used for sexual reproduction must contain half the number of chromosomes so that when two cells combine, the resulting cell has a complete set of chromosomes.

Pause and Reflect Answer

Answers will vary but may include the following: The twins will be exposed to different environments; for example, they may not work at the same place or have the same occupation. They will eat different foods, travel to different places, and be exposed to different amounts of sunlight. They will be exposed to many different factors that could influence the expression of their genes.

Other Assessment Opportunities

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

6.2 SEXUAL REPRODUCTION

BACKGROUND INFORMATION

Sexual reproduction is necessary for survival of the species as the process introduces genetic variation into the population. There are three stages in sexual reproduction: mating, fertilization, and development. As a result of meiosis and the union of sperm and egg cells, no two individuals will have the same DNA. Following fertilization, the zygote and embryo start to divide by mitosis, and cells will differentiate. The processes of mating, fertilization, and development differ among species. Fertilization can be internal or external, some parents continue to protect their young after birth, many plants produce seeds that can lie dormant for several years before developing, and insects undergo life cycles (incomplete metamorphosis and complete metamorphosis) that are different from those of mammals.

COMMON MISCONCEPTIONS

- Students may think that sexual reproduction and sexual intercourse are the same thing. In fact, sexual reproduction describes a much broader group of behaviours, all of which have the purpose of creating offspring. Mating is one part of sexual reproduction, as are fertilization and development. In humans, the method of fertilization used is sexual intercourse. Other organisms use other methods to bring male and female gametes together. Students will learn about many of these in this section.
- Students may believe that internal fertilization is superior to external fertilization. Point out that both types of fertilization provide advantages to the organisms that use them. Internal fertilization provides an embryo with a protected place to develop. External fertilization enables organisms to produce large numbers of offspring, while expending little energy.

ADVANCE PREPARATION

- You may want to book an LCD projector, if possible, for Using a Demonstration, below.
- If possible, gather a variety of seeds, cones, and flowers for students to examine.

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

INTRODUCING THE SECTION, pp. 180–181

Using the Text

Through the process of meiosis, the egg and sperm are formed. Fertilization of the egg by sperm produces a zygote. Have students imagine a tank full of seawater the size of the classroom. There could be billions of eggs and sperm in the seawater for hundreds of different species of marine plants and animals. Have students predict how a purple sea urchin egg will be

recognized by a purple sea urchin sperm and not be fertilized by a red sea urchin sperm or an orange sea cucumber sperm. Students can write their predictions and then read pages 180 and 181.

Then have students write a paragraph about what they now know about sperm and fertilization of the egg. You may want to share further interesting research information about the sea urchin found in the Did You Know? section on page 181.

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 all the terms in the unit, can be used to assist students.

Using the Did You Know, p. 181

The sea urchin has become a very important and exciting model for studying genes, evolution, and development. Scientists previously believed that a sea urchin's life span was about 15 years so were very surprised that these creatures can live as long as 200 years. Other exciting discoveries about the sea urchin are that they have genes for proteins that humans have, and these genes are involved in vision and hearing; however, sea urchins do not have eyes or ears. In addition, the sea urchin has 10 to 20 times more genes than humans have for the innate immune system. These proteins allow the sea urchin to detect unique molecules of bacteria and will signal to alert the body of intruders. Scientists have also found that the sea urchin has many genes that are associated with human diseases such as hardening of the arteries, muscular dystrophy, and brain disorders. The sea urchin does not have arteries, muscles, or a brain.

Using a Demonstration

If an LCD projector and Internet access are available, you may want to show students an animation of sea urchin fertilization found at www.discoveringscience.ca.

TEACHING THE SECTION, pp. 182–191

Using Reading

Pre-reading—Predict-Read-Verify

Have students skim the section headings and subheadings and use a whole page to construct a graphic organizer relating the headings in this section.

During Reading—Note Taking

Students can add main ideas to their graphic organizer as they read through the section.

After Reading—Reflect and Evaluate

After students have read the text and completed taking notes, have them reflect on the new information they learned in this section. Ask students to put an asterisk in their notes beside each new item that they learned.

Supporting Diverse Student Needs

- Have students complete a graphic organizer as they read the section. Then, in small groups, they can pass around their graphic organizers so that every group member has an opportunity to add to, and make constructive comments on, every organizer. Once organizers have been returned to their creators, allow time for students to ask one another to clarify the additions and comments they made. At the end of the process, each student in the group will have a graphic organizer of their own design that summarizes the section.
- Visual and body-kinesthetic learners would benefit from examining seeds, cones, and flowers. If possible, bring some samples to class for students to look at.

Reading Check Answers, p. 191

1. Mating is the process that enables male and female gametes to meet in the same place at the same time.
2. Mosses are both male and female during the part of their life cycle where they reproduce sexually. The male and female sex organs develop on the end of the stems or branches of the plants.
3. Mosses grow in wet environments and fertilization in mosses cannot happen without water. Sperm cells produced by the moss either swim to egg cells across the damp ground or are splashed by raindrops into

female parts of the plant. Fertilization results in a new plant that will mature and then reproduce asexually.
4. Pollination is the method of internal fertilization for land-dwelling plants, where sperm is transferred to the female reproductive part of the plant.
5. In flowering plants, the developing embryo is protected by the tough outer coating of the seed it grows inside.

USING THE ACTIVITIES

- Activity 6-2A, on page 191 of the student textbook, is best used after students have read pages 188 to 190.
- Activity 6-2B, on page 194 of the student textbook, is best used after students have studied section 6.2.

Detailed notes on doing the activities follow.

Find Out Activity 6-2A

Predict a Pollinator, p. 191

Purpose

- As an extension to learning about sexual reproduction in plants, you may choose to have some students complete this activity to predict what type of pollinator is needed to pollinate different types of flowers.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	No advance preparation necessary.	none

Time Required

- 15 min

Science Background

Flowering plants and their pollinators are a good example of co-evolution. Co-evolution can be defined as the interactions between two different species that affect the development of each other's characteristics during the course of evolution. Plants have evolved elaborate methods to attract animal pollinators, and to attract animals that have specialized body parts and behaviours that aid pollination.

Activity Notes

- Students can work independently and then compare their predictions with a partner.
- Encourage students to be creative when they design a flower and pollinator.

Supporting Diverse Student Needs

- To aid English language learners, you may have the class brainstorm a list of methods of pollination before students begin the activity.
- For enrichment, have students go beyond the life forms on this planet and imagine that they are designing plant pollinators for a new planet.

What to Do Answer

1. Sample predictions: (A) The orchid is probably pollinated by an insect or bird that is attracted by its colour, stripes and fragrance. (B) Bats probably pollinate this white flower. The flowers do not have to be colourful at night. (C) The wheat does not have attractive flowers or an attractive scent so it is probably pollinated by wind.

What Did You Find Out? Answers

1. Colours, designs such as stripes, and odours attract pollinators.
2. Answers will vary. Students should be able to justify their flower design for the particular pollinator.

Think About It Activity 6-2B

Comparing Sexual and Asexual Reproduction, p. 194

Purpose

- Students compare the processes of asexual and sexual reproduction and the advantages and disadvantages of each.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	No advance preparation necessary.	none

Time Required

- 30 min

Science Background

There are advantages and disadvantages to both sexual and asexual reproduction. The main advantage to asexual reproduction is that it is less complicated, requires less energy, and produces large numbers of offspring. The main advantage to sexual reproduction is that the offspring are genetically different from their parents, which could provide a survival advantage.

Activity Notes

- You could provide small self-adhesive removable notes for students to write on.
- Have students work in pairs, and then compare their graphic organizers with another pair of students.

Supporting Diverse Student Needs

- You may want to pair students with reading difficulties with strong readers to help them extract the relevant information from the tables.
- Consider posting the resulting graphic organizers in the classroom for all students to refer to.

What Did You Find Out? Answers

1. Students should state that the most important advantage of sexual reproduction is variation. The most important advantage of asexual reproduction is large numbers of offspring.

SECTION 6.2 ASSESSMENT, p. 195

Check Your Understanding Answers

Checking Concepts

1. For successful sexual reproduction to occur, two parents of the same species are required, and two gametes must come together for fertilization.
2. The three stages of sexual reproduction are mating, where gametes are brought together; fertilization, which is the union of the egg and sperm; and development, which is a series of mitotic and cell divisions of the zygote that form the embryo and fetus.
3. Answers may vary. Mammals that mate in water include whales, sea lions, sea otters, dolphins, and seals.
4. It is important that only one sperm fertilizes an egg so that there is only one full set of chromosomes in the fertilized egg. If several sperm fertilized an egg, there would be too many chromosomes and the embryo would not develop.
5. Water or water-containing fluid is necessary for animals that reproduce sexually to prevent the embryo from drying out.
6. In flowering plants, the seed is enclosed in a fruit. In cone-bearing plants, the seed is protected within the female cone.
7. Mosses are both male and female during the part of their life cycle where they reproduce sexually. The male and female sex organs develop on the end of the stems or branches of the plants. Sperm cells produced by the moss either swim to egg cells across the damp ground or are splashed by raindrops into female parts of the plant. Water is important because fertilization in mosses cannot happen without water.
8. Metamorphosis is the process where an insect dramatically changes its form, such as a caterpillar becoming a butterfly.
9. The three stages of incomplete metamorphosis are egg, nymph, and adult.
10. (a), (d), (c), (b)

Understanding Key Ideas

11. Graphic organizers may vary.

Question	Sexual Reproduction in Flowering Plants	Sexual Reproduction in Insects
What is the fertilization method?	external	internal
Where is the zygote formed?	in seed	in egg
How many fertilized eggs are there per organism?	many	many

12. Eggs and seeds are similar because they both nourish and protect the developing embryo.
13. Bees collect pollen and nectar to feed themselves and their young and, in doing so, transfer pollen between flowers of the same species.
14. Animals transport seeds to different locations in several ways. Insects and bats carry pollen from flower to flower as they gather pollen and nectar. Animals eat fruits and leave the seeds behind in their waste. Seeds such as thistles stick to an animal's fur and are later scraped or bitten off by the animal.
15. Most insects have an exoskeleton, which is an external skeleton that supports and protects the body. It does not allow them to grow very much. As insects outgrow their exoskeleton, they moult, and grow a new one. At a certain stage a moulting insect larva develops adult features, such as wings.
16. A grasshopper undergoes incomplete metamorphosis. The difference between complete metamorphosis and incomplete metamorphosis is the number of stages in the life cycle: three stages for incomplete metamorphosis and four stages for complete metamorphosis.

17. (Rows 1, 2, and 4 are extension.)

	Complete Metamorphosis	Incomplete Metamorphosis
Number of parents	Two	Two
Type of reproduction	Internal sexual reproduction	Internal sexual reproduction
Number of stages in life cycle	Four: egg, larva, pupa, adult Larva does not resemble adult.	Three: egg, nymph, adult Female nymph is wingless.
Habitat	Changes habitats at different stages of the life cycle. Might live in water as an egg and larva, then on land as a pupa and an adult.	Usually lives in the same habitat in each stage of the life cycle.

Pause and Reflect Answer

Sexual reproduction provides more of an opportunity for genetic diversity because the offspring are the result of the union of an egg and sperm. The egg and sperm are produced through the process of meiosis, which creates variation. Variation occurs in meiosis I through independent assortment and crossing over and by the chance union of a particular egg with a particular sperm. Offspring produced in asexual reproduction are genetic clones produced through mitosis.

Other Assessment Opportunities

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

6.3 HUMAN REPRODUCTIVE SYSTEMS

BACKGROUND INFORMATION

Humans, like all mammals, reproduce sexually by internal fertilization: the male's sperm fertilizes the female's egg internally to produce offspring. The male reproductive system produces, protects, and delivers the male gametes (sperm). The female reproductive system produces the female gametes (eggs), receives the sperm for fertilization, and protects and nourishes the zygote until birth.

The nine-month period of differentiation or pregnancy is divided into three equal trimesters. In general, the organs form in the first trimester, the organs differentiate and the fetus grows in the second trimester, and the fetus—especially the brain—continues to grow, and subcutaneous fat develops to keep the baby warm after birth in the third trimester.

COMMON MISCONCEPTIONS

- Students may have misconceptions about when pregnancy can occur. There is some evidence that sperm can survive in the female reproductive system for up to five days. It can survive outside of the body for several hours depending on the conditions.
- Students may assume that all animal pregnancies last nine months. Some animals, such as mice, carry their young for just a few weeks, while whales, giraffes, and elephants are pregnant for more than a year.
- Some students believe that it is not possible to get pregnant the first time they have sex. Pregnancy is possible at any point in a woman's life from her first period until about a year after her period stops. The only exception is during a pregnancy because hormones are released to stop the menstrual cycle and therefore prevent the ovaries from releasing more eggs.
- Students may not be aware of the risks involved in a child being born prematurely. It can be unsafe for a child to be born prematurely because they have not developed a layer of fat under the skin to help keep them warm, as noted in the section on the third trimester. As well, babies born prematurely may have organ systems that are not completely developed and able to function independently.

ADVANCE PREPARATION

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

INTRODUCING THE SECTION, pp. 196–197

Using the Text

Read the introductory text on page 196 aloud to students. Then discuss the advantages that internal fertilization and development provide for young mammals. (For example, they are protected while they undergo the first weeks or months of development, and they are close to their mother when they are born so she can attend to their needs.) Have students list some of the developmental milestones that occur before and shortly after birth in mammals that they are familiar with.

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 all the terms in the unit, can be used to assist students.

TEACHING THE SECTION, pp. 196–200

Using Reading

Pre-reading—Preview Key Terms

In small groups or as a class, have students categorize the Key Terms as parts of the male reproductive system or the female reproductive system.

During Reading—Connect to the Diagrams

As students read the Male Reproductive System and Female Reproductive System sections, have them locate each structure on the appropriate diagram (Figure 6.27, on page 196, and Figure 6.28, on page 197) as they read about its function.

Students can read the Fetal Development and Noticeable Signs of Pregnancy sections on their own or in pairs, taking notes to summarize the key aspects of development that occur in each trimester.

After Reading—Summarize

- Students can complete BLM 2-27, The Male Reproductive System, and BLM 2-28, The Female Reproductive System to summarize what they have learned.
- Have students work in pairs or small groups to create time lines showing the milestones in fetal development, as described on pages 198 and 199.

Supporting Diverse Student Needs

- Visual-spatial learners and others may benefit from visiting www.discoveringscience.ca to follow the week-by-week development of a fetus, as described in the Internet Connect feature on page 199, to help them internalize the stages of development.
- Some students may be interested in learning more about medical techniques that can help babies who are born prematurely to survive. Students can then report back to the class.

Reading Check Answers, p. 197

1. The testes produce gametes in the male reproductive system. In the female reproductive system, the ovaries produce gametes.
2. The internal structures of the male reproductive system are the testes and the vas deferens.
3. Fertilization takes place in the oviducts or fallopian tubes.
4. Meiosis occurs in the testes in males and in the ovaries in females.

Reading Check Answers, p. 200

1. The zygote develops into an embryo when the fertilized egg goes through mitosis and cell division.
2. The three major phases of fetal development are developing organ systems in the first trimester, growth in the second trimester, and continued rapid growth in the third trimester.
3. Mitosis begins when the egg is fertilized by the sperm. The zygote begins dividing, first into two cells, then four, then eight, and so on, as it travels down the oviduct to the uterus.
4. Answers will vary. Early signs of pregnancy include missed period(s), positive pregnancy test, nausea, food cravings, and aversion to foods.

USING THE FEATURE

Science Watch: Embryo Screening, p. 201

Reproductive technologies have an impact on society. If you have not already done so, use this opportunity to summarize the issues arising from these technologies. In this feature on embryo screening, more ethical concerns are raised. After students read the article, discuss the ethical concerns and poll students for their opinions.

Science Watch Answers

1. Embryo screening is used to identify genetic conditions, for sex selection, and to tissue type embryos.
2. Ethical concerns arise with embryo screening since the screening can be used for selection of only healthy embryos, for selection of embryos of a particular sex, and for selection of embryos that are a tissue match. The remaining embryos will likely be destroyed.
3. Amniocentesis is usually done in the second trimester. By this stage, the fetus is well developed and can survive with specialized care outside of the mother. Genetic screening is done on an embryo at the eight-cell stage, when the embryo is only three days old.

USING THE ACTIVITY

- Activity 6-3A, on page 202 of the student textbook, is best used after reading Embryo Screening on page 201. Detailed notes on doing the activity follow.

Find Out Activity 6-3A

Comparing Differentiation in Embryos, p. 202

Purpose

- As an extension to learning about the process of human fetal development, you may choose to have some students complete this activity to compare embryonic development in six vertebrate embryos.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	No advance preparation necessary.	none

Time Required

- 20 min

Science Background

All vertebrate embryos follow a common developmental plan because they have a set of genes that gives the same instructions for development. As each organism grows, it diverges according to its species' way of life.

Activity Notes

- For increased student engagement and to enhance students' understanding of embryo development, you may want to show embryo development video clips listed at www.discoveringscience.ca.

Supporting Diverse Student Needs

- Make certain that all students know what a salamander and a tortoise are.
- This is an excellent activity for visual-spatial learners. If students work in pairs or small groups, ensure that all groups include students with strong visual-spatial skills.
- For enrichment, have students investigate fetal alcohol syndrome and relate the condition to human embryo developmental stages.

What to Do Answers

1. The embryos from left to right are a fish, a salamander, a tortoise, a chicken, a rabbit, and a human.
2. Answers may vary. Three similarities between the embryos are that they all have a head, body and tail; a head region with an eye; and similar throat regions. Three differences are that some have limb buds and some do not, some have tails in their later embryonic stages and some do not, and some develop a larger head relative to the body.

What Did You Find Out? Answers

1. Students are not able to tell the difference between the embryos in stage 1 (see answer to question 3).
2. Differentiation becomes most apparent in stage 3.
3. Organisms appear to be similar in stage 1 because the same kinds of genes are read to make the same proteins, so the embryos look the same. In later stages, these genes are no longer read. For example, the rabbit and human no longer have a long tail.

SECTION 6.3 ASSESSMENT, p. 203

Check Your Understanding Answers

Checking Concepts

1. The human structures that produce gametes are the testes in males and the ovaries in females.
2. (a) The picture shows the process of fertilization.
   (b) The structures involved are a sperm cell and an egg cell.
   (c) In humans, this process occurs in the oviducts or fallopian tubes inside the female's body.
3. Male reproductive systems: (b), (c), (d), (h), (j); Female reproductive systems: (a), (e), (f), (g), (i)
4. The human female reproductive organs in order from the location of gamete formation to the exit of the fetus are the ovaries, the oviduct or fallopian tubes, the uterus, the cervix, and the vagina.
5. The zygote develops into an embryo when the fertilized egg goes through mitosis and cell division.
6. The human fetus develops inside the uterus.
7. In human fetal development, the major organs of the body develop during the first trimester.

Understanding Key Ideas

8. In the human male reproductive system, gametes (sperm) are produced in the testes and travel through the vas deferens and penis, and out through the urethra. In the female reproductive system, gametes (eggs) are produced in the ovaries and travel through the oviducts or fallopian tubes into the uterus.

9. (a) Answers may vary. Signs of pregnancy include missed period(s), nausea, food cravings, aversion to foods, sore breasts, widened hips, enlarged breasts, bulging belly, more frequent urination, fatigue, dizziness, stronger sense of smell, heartburn, weight gain, constipation, mood swings, higher body temperature, and cramping.
   (b) She could know for certain if she is pregnant by taking a urine test to check for the presence of the hormone that is released when the zygote implants in the uterus.
10. The four phases of human reproduction are mating, fertilization, gestation, and birth.
11. (a) Answers may vary. Some of the first structures to develop in a human fetus include the brain, spinal cord, digits, and organs.
    (b) The last structures to develop in a human fetus are fat deposits under the skin to help keep the baby warm after birth.
12. (a) The main function of the testes is to produce sperm,.
    (b) The main purpose of the vas deferens is to mix the sperm with fluids to produce semen.
    (c) The main purpose of the urethra is as an opening for the sperm to leave the male body.

Pause and Reflect Answer

If the embryo develops in the oviduct or outside of the reproductive system, it will not be attached to the umbilical cord and will not get the necessary nutrition to develop properly. It will be growing in a place where it is not designed to grow, which will affect the mother's internal organs and cause her extreme medical complications. Delivering the fetus would also be very complicated and would require surgery.

Other Assessment Opportunities

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

6.4 STUDYING GENETIC CHANGES

BACKGROUND INFORMATION

All of a human's genetic information is contained in a series of incredibly long molecules of DNA. Long sequences of DNA contain genes (hereditary units), which make up chromosomes. Humans have a genome of 46 chromosomes arranged in 23 pairs. These chromosomes are in the nucleus of almost every cell in the body (red blood cells do not contain DNA).

Scientists collaborating on the human genome project have worked for approximately 20 years to identify every gene on human chromosomes. They have now completed the identification process, but data is still being analyzed. Because different methods of counting are being used, estimates of the number of genes in a human cell vary. Generally it is agreed that the number is between 24 000 and 30 000.

Genetic disorders can arise from having the wrong number of chromosomes (as in Down syndrome) or a fundamental problem with one of the chromosomes (as in Allderdice syndrome).

Cloning occurs naturally in plants and animals that reproduce asexually. Cloning complex animals is a difficult process with poor results thus far. Dolly the sheep (1996–2003) was the first cloned mammal, though she started as one of 29 candidate embryos.

COMMON MISCONCEPTIONS

- Students may expect human DNA to be significantly different from the DNA of other animals. One of the results of the Human Genome Project was to identify how other mammals (pigs and mice) have many of the same genes as humans.
- Students may think that every part of the DNA sequence is important, when only about 2 percent of all human DNA serves a known purpose. Some studies have determined that removing sections of the nonfunctional DNA has no noticeable effect on an animal.
- Students may think that the larger or more complex the species is, the more chromosomes or DNA it must have. Dogs, horses, goldfish, and potatoes have more chromosomes than humans.
  It is the information in the DNA that determines the size and complexity of a plant or an animal.
- Students may be unsure about the process of DNA testing. In forensics, collecting DNA from a crime scene does not mean that the suspect can be identified conclusively from his or her DNA. Some basic information such as gender can be determined, but DNA evidence is used mostly to verify if a suspect is a highly likely match to the criminal by comparing several parts of their DNA structure.

ADVANCE PREPARATION

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

INTRODUCING THE SECTION, p. 204

Using the Text

The introductory text on page 204 points out that until recently, the mechanism of genetics was not well understood. Like other scientific concepts, people could observe and manipulate the effects of heredity,

but they did not have the technology to determine the specific causes of those effects. Remind students of what they learned about light in Grade 8. For centuries, people were able to design technologies based on the properties of light, although they did not understand the precise nature of light itself. Genetics is similar in this way. For hundreds of years, farmers have been selecting seeds from plants with desirable characteristics to ensure that new plants will share those characteristics, but the discovery of genes and the role they play in inheritance was made quite recently.

Review what students have already learned about genes in Chapter 4 by having them construct their own concept map. Have students write the word "genes" in the centre, and see what connections students can supply. Create the first two or three connections together as a class. Encourage students to explain each connection they suggest, and to ask questions about any connections that they do not agree with or do not understand.

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 all the terms in the unit, can be used to assist students.

TEACHING THE SECTION, pp. 204–209

Using Reading

Pre-reading—Predict-Read-Verify

Have students preview the text features; including the headings, Key Terms, and figures; and use them to predict what they will learn in this section, and how new information will fit into the concept map that they have created. When they have read the section, they can add new ideas to their concept map.

During Reading—GIST

Have students write brief notes about each chunk of text, summarizing each chunk in no more than 20 words. They can use diagrams if they would like.

Point out to students that the count of 25 000 human genes that they will read is an estimate. Other estimates range from about 24 000 to closer to 30 000.

As students have read the Reproductive Cloning and Therapeutic Cloning sections, have them think about the differences between reproductive and therapeutic cloning.

Supporting Diverse Student Needs

- Students can create their summaries in small groups as write-arounds. Each student in the group begins summarizing one chunk. Then group members pass around the summaries until everyone in the group has had an opportunity to add to, or make suggestions about, each summary. At the end, the group will have complete summaries of each chunk in the section.

After Reading—Create Questions

Have students work in groups to create questions about the key concepts of this section. Each student in the group can write two questions about one of the following chunks:

- The Changing Understanding of Genes
- Current Understanding of Genes
- Diagnosing Genetic Disorders, and Allderdice Syndrome
- Human-assisted Cloning

Every student in the group should answer all of the questions, and then all students in the group can discuss the answers and revise their own answers as necessary.

USING THE ACTIVITY

- Activity 6-4A, on page 207 of the student textbook, is best used after students learn about karyotypes. Detailed notes on doing the activity follow.

Find Out Activity 6-4A

Analyzing a Karyotype, p. 207

Purpose

- If time permits, you may choose to have students complete this extension activity to analyze a karyotype of Edwards syndrome.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	No advance preparation necessary.	none

Time Required

- 15 min

Science Background

A karyotype is the magnified image of the chromosomes from a cell. The chromosomes are arranged in pairs. The chromosomes are identified and paired by size, location, and banding patterns. Karyotypes are used to study chromosome mutations, such as duplication or translocation of chromosomes. They may be used to determine the sex of the individual.

Activity Notes

- Students can work independently and then pair-share to compare their answers.
- To extend this concept further, students could visit the karyotype interactive websites at www.discoveringscience.ca.

Supporting Diverse Student Needs

- Using the figure on page 207, ask students how the chromosomes are sorted, before they begin the activity.
- Pair visual-spatial learners with students who have difficulty with spatial tasks.
- For enrichment, students could investigate other syndromes such as Turner's syndrome, cri-du-chat syndrome, or supermale syndrome.

What to Do Answers

2. The total number of chromosomes is 47, and there are 22 pairs of chromosomes and one triplet.
3. The individual is male because the last pair is XY.

What Did You Find Out? Answers

1. There are three chromosome number 18s.
2. (a) Karyotyping would not identify a gene mutation.
   b) Gene mutations occur in the sequences of the bases, which cannot be seen with this type of testing.

USING THE FEATURE

Career Connect, p. 210

In this section, students learn about important genetic research that was carried out at Memorial University. Ask students to think about what educational background would be helpful to someone conducting research similar to the research that Dr. Young conducted. What personality traits and habits would be useful to a researcher like this?

Career Connect Answers

1. Arrhythmogenic right ventricular cardiomyopathy or ARVC is a genetic condition that causes sudden death in young men due to heart failure.
2. The gene responsible for ARVC was identified by studying the DNA of everyone in the communities where ARVC occurred. By comparing the genomes of people with ARVC to people who did not have the condition, Dr. Terry-Lynn Young and her team were able to pinpoint the affected chromosome and the mutated gene that caused ARVC.
3. A genetic researcher is similar to a crime investigator because they both need to be very patient, gather a lot of evidence, keep an open mind, think critically, and test their theories.

SECTION 6.4 ASSESSMENT, p. 211

Check Your Understanding Answers

Checking Concepts

1. Two possible causes of genetic disorders are added or missing chromosomes or mutations in one or more genes.
2. Answers will vary. Examples of genetic disorders include Allderdice syndrome, Down syndrome, Edwards syndrome, and ARVC.
3. A genome consists of the full set of genetic material that makes up an organism.
4. Genes store the information necessary to make proteins.
5. Allderdice syndrome is a genetic disorder caused by a mutation of a single chromosome. It is passed on by the mother. Each offspring of a mother with this syndrome has a 31 percent chance of inheriting the syndrome.
6. Genes are found on chromosomes and contain the instructions necessary to make proteins. Chromosomes contain thousands of genes.
7. A genome is the name for the full set of genetic material that makes up an organism, and a karyotype is an organized image of all the chromosomes taken from a body cell during mitosis.
8. This section of karyotype shows pairs of chromosomes.

Understanding Key Ideas

9. (c), (b), (d), (a)
10. Mitotis is best stage of the cell cycle to use for karyotyping because the pairs of chromosomes are lined up, making them easy to identify.
11. Karyotyping can help people with genetic disorders identify the cause of their disorder. This information could be used in genetic screening to ensure the disorder is not passed on to their offspring.
12. If a population is geographically isolated, there are a limited number of mates to choose from and a limited number of genetic combinations in offspring. This limitation means that any genetic mutations that occur in the population are more likely to be passed on to the offspring. Over time, there will be more offspring who inherit the same mutation from both parents, leading to an increase in that genetic disorder.
13. There is a huge variation between individual humans because there are so many genes on each human chromosome and therefore so many possible combinations of offspring.
14. Cloning is more like asexual reproduction because there is only one parent and the offspring is genetically identical to the parent.
15. Mendel's detailed experiments with pea plants showed that traits are inherited from parent plants. He was even able to isolate the parts in the seeds that passed on specific traits such as colour and shape but lacked the technology to examine the seeds at a more microscopic level. Watson and Crick showed that DNA is an organization of genes into a double helix shape. The genome project has identified every gene in the human DNA. This "map" can be used to search for and identify particular genes. This information could be used to check whether the gene for a particular disease is present. Eventually, scientists may be able to alter or remove certain genes.
16. Both Down syndrome and Allderdice syndrome are cause by genetic mutations. In Down syndrome, there is an extra 21st chromosome, and in Allderdice syndrome, there is a mutation on one chromosome.
17. The karyotype shows the DNA of a woman with Down syndrome. There is an extra 21st chromosome, which is the cause of 95 percent of the cases of Down syndrome.

Pause and Reflect Answer

Selective mating of the most successful plants or animals could be considered genetic modification because the farmer is influencing how the offspring are determined. The traits that the farmer is selecting are not necessarily traits that would be selected in nature. Inserting beneficial genes into a plant or an animal is clearly genetic modification because the genetic material is being changed at a cellular level.

Other Assessment Opportunities

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

SECTION 6 ASSESSMENT, pp. 212–213

PREPARE YOUR OWN SUMMARY

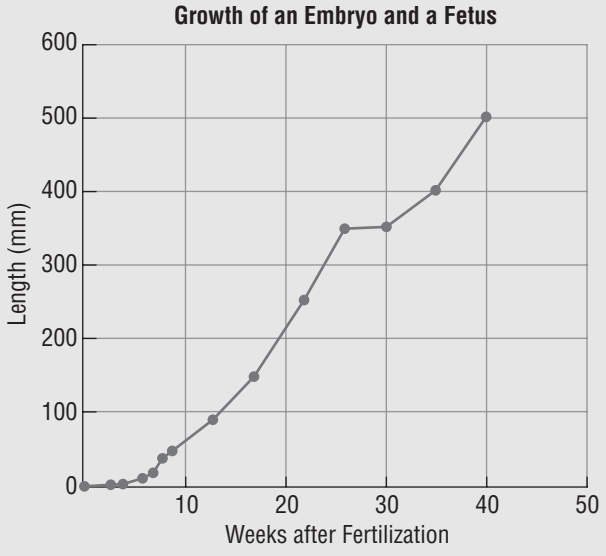
Students' summaries should incorporate the following main ideas:

1. Meiosis
   - Meiosis is necessary to produce gametes with the haploid number of chromosomes.
   - Meiosis creates genetic diversity, which can give one organism an advantage over another.
   - There are two cell divisions in meiosis including meiosis I and meiosis II, but the DNA only replicates once.
   - Chromosome mutation can occur in the process of meiosis and can create a syndrome in the offspring.
2. Genetic Variation
   - Genetic variation is also created by the chance fertilization of a certain egg cell with a certain sperm cell.
3. Sexual Reproduction in Mosses, Flowering Plants, and Insects
   - Sexual reproduction brings together non-identical gametes to form a new organism through mating, fertilization, and development.
   - One of the main advantages of sexual reproduction is that there will be genetic variety in the offspring.
   - One of the main advantages of asexual reproduction is that it requires only one parent. It can be an advantage that the offspring will be genetically identical to the parent (except for mutations).
   - Most insects reproduce sexually.
   - Insects often change drastically between hatching and adulthood, through incomplete or complete metamorphosis.

4. Changing Understanding of Genetics
   - Gregor Mendel discovered that traits in plants were inherited from their parent plants.
   - Francis Crick and James Watson described DNA as an organization of genes into a double helix shape.
   - The human genome project worked to locate and identify the function of each of the approximately 25 000 genes on the 46 chromosomes in human cells.
   - The results of the project determined that a human cell contains only about one sixth the estimated number of genes.
   - It was also determined that the genes of very different animals are alike; for example, mice, pigs, and humans have most of the same genes even though they are very different animals.
   - The human genome project made a "map" that can be used to search for and identify particular genes.
   - Our changing understanding of genetics has allowed us to diagnose and treat some genetic disorders.
5. Human Reproduction and Embryonic Development
   - The role of the human male's reproductive system is to produce male gametes (sperm) and deliver them to the egg's environment for fertilization and development. The human female's reproductive system performs roles in gamete formation, fertilization, and embryo development.
   - In the first trimester of human development, the organ systems are formed. In the second trimester, the fetus grows rapidly. In the third trimester, the fetus continues to grow in preparation for birth.
   - There are many noticeable signs that a woman is pregnant, including missed period(s), sore breasts, widened hips, nausea, more frequent urination, fatigue, dizziness, stronger sense of smell, and higher body temperature. Each of these signs may or may not be present.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. Meiosis is necessary for multicellular organisms so that the chromosome number can be retained and so that genetic variation can occur.
2. Meiosis II is very similar to mitosis since in both processes, the two strands of the chromosome separate.
3. At the beginning of meiosis, the parent cell is diploid. At the end of meiosis, there are four haploid cells.
4. The two events that produce genetic variation are crossing over, where genetic information is exchanged between chromosomes, and independent assortment, where there are two possibilities for how a chromosome will sort itself into daughter cells. This depth of understanding is not covered in the curriculum.
5. You are not identical to your parents or siblings because the egg contained chromosomes from your grandparents on your mother's side, and the sperm contained genetic information from your grandparents on your father's side. For each chromosome in the egg, there was a 50 percent chance that you inherited your grandmother's genetic information, and a 50 percent chance that the genetic information was from your grandfather on your mother's side. This is true for all 23 chromosomes, which results in 2^{23} possibilities from just the egg, and then there would be 2^{23} possibilities for the sperm.
6. A karyotype allows geneticists to determine whether there has been a chromosomal mutation. A whole chromosome could have been deleted or added, or a piece of a chromosome could have been added, deleted, or moved onto another chromosome.
7. The syndrome with three chromosome 21s is Trisomy 21, commonly known as Down syndrome.
8. Answers will vary as there are many ways that students could connect these ideas. Check for correct associations.
9. (a) insects
   (b) mosses
   (c) humans
   (d) flowering plants
10. 

(a) The period of rapid growth rate is from three to six months.
(b) The growth is the slowest between the sixth and seventh month.
(c) The fastest growth rate shows the steepest slope on the graph. The slowest growth rate is shown in the least steep slope.

Understanding Key Ideas

11. The purpose of fertilization is to join the egg and the sperm, to restore the diploid number for the offspring.
12. Mosses need to live in moist environments because they use water to bring the male and female gametes together.
13. A single fertilized egg grows into a multicellular embryo by dividing millions of times by mitosis. The cells differentiate and become specialized to perform a particular function. This means that certain genes will now be read and other genes will no longer be read.
14. Pollen is male sperm and therefore contains DNA. Each species would have unique DNA in the pollen that might help in a crime investigation. If an investigator found pollen on a suspects shoe, for example, DNA analysis might show that the shoe must have been near a certain group of plants that have similar DNA.
15. (a) The illustration is of the human male reproductive system.
    (b) The illustration should be labelled like Figure 6.27 on page 196.
    (c) Gametes are formed in the testes.
16. (a) Asexual reproduction uses little energy. Sexual reproduction uses more energy.
    (b) Asexual reproduction requires no parental care. Sexual reproduction requires no parental care (external fertilization) or days to years of parental care (internal fertilization).
    (c) Asexual reproduction produces no genetic variety in offspring. Sexual reproduction produces great genetic variety in offspring.
17. The picture is of a karyotype so a researcher could be analysing a patient's genetic make-up to determine if he has a genetic mutation.
18. Metamorphosis changes insect nymphs or pupas into adult insects that can reproduce.

Pause and Reflect Answer

A new species of sea urchin would not occur as easily in a large population because there are too many possibilities of genes mixing. Small populations have fewer genes in the pool, so there is less mixing of genes. If a mutation occurred that made an individual more successful, that gene would be passed on and possibly create a new species.

UNIT 2 ASSESSMENT

PROJECT

Making a Decision for Genetown, p. 216

Purpose

- Students research stem cell technology and consider the impact of a biotechnology company on a small community.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before instruction	Photocopy BLM 2-30, Making a Decision for Genetown Stakeholder List. Prepare cards numbered 1–30 that students can randomly pick from an envelope. Photocopy BLM 2-31, Presentation Organizer, for students.	For each group: – Students acquire their own props (optional).

Time Required

- 100 min

Science Background

Stem cell research has many possibilities for the future, but there are ethical issues involved. New breakthroughs and changes in stem cell use regulations are announced regularly in the media so you should check the Internet for updates. With this information, you may decide to add or change some of the stakeholders' roles.

Activity Notes

- Copy BLM 2-30, Making a Decision for Genetown Stakeholder List. You may choose to modify some roles. Prepare cards numbered 1 to 30 that students can randomly pick from an envelope. The numbers will correspond to the stakeholder list on the blackline master.
- Copy BLM 2-31, Presentation Organizer, for students to record their ideas.
- Read over the criteria in the textbook with students. Emphasize the importance of research to back up their arguments. Encourage students to cite their references when presenting for a more persuasive argument.
- Review Science Skill 2: Scientific Inquiry, Problem Solving, and Decision Making, on pages 481 to 483 of the student textbook with students.
- Encourage students to memorize their points or use cue cards for prompts, but do not let them read from the cards as this method is less persuasive.
- You may choose to give students the opportunity to swap roles before they sign up on the stakeholder list.
- The "mayor" and "town council members" should also research stem cell issues to be able to make informed decisions.
- The "mayor" and each "town council member" need to prepare a three-minute presentation to be performed after hearing the arguments. You may defer their presentations until the next class period to allow them time to prepare.

Supporting Diverse Student Needs

- Make sure the criteria for the presentations are clear for English language learners.
- This is an excellent activity for visual-spatial and existentialist learners.

Report Out Answer

Students will report out and present their arguments to the council. Have students hand in their completed presentation organizer as part of their assessment.

Other Assessment Opportunities

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

INTEGRATED RESEARCH INVESTIGATION

Just Because We Can, Does It Mean We Should? p. 217

Purpose

- Students use print and electronic sources to research a reproductive technology issue.

Activity Notes

- Students can present in a multimedia presentation, a debate, or a combination of both.
- Provide examples of how you expect references to be cited.
- Encourage students to rehearse their argument to make it more convincing.
- Provide students with BLM 2-32, Debate Procedures, if you choose to present the material as a debate.

Supporting Diverse Student Needs

- Ensure that English language learners understand the debate procedure that you are using for this method of presentation.
- This is an excellent activity for verbal-linguistic, visual-spatial, and existentialist learners.
- For enrichment, use the debate method of presentation as it stimulates enthusiasm and develops persuasive argumentative abilities. This method also exposes all students to many points of view on these ethical issues.

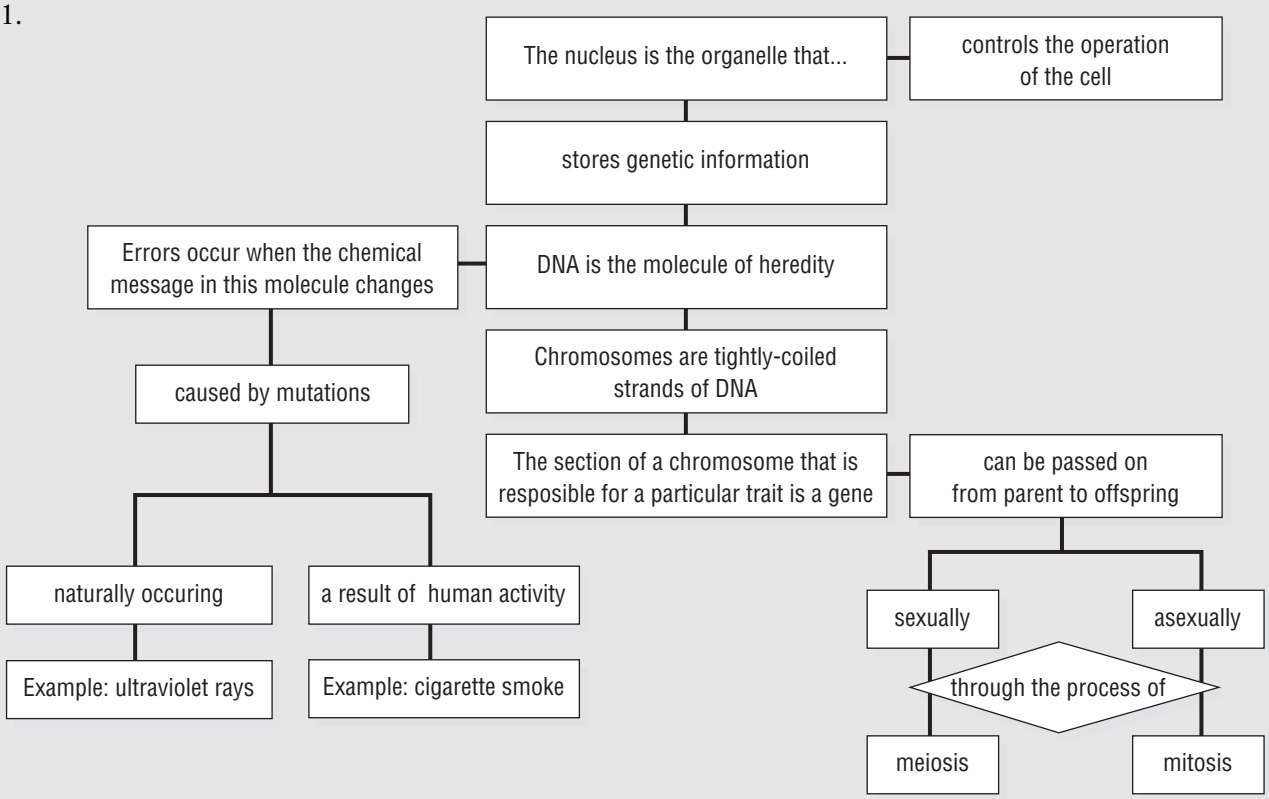
Other Assessment Opportunities

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

UNIT 2 REVIEW ANSWERS, pp. 218–219

Visualizing Key Ideas

1.



Using Key Terms

2. Answers will vary. Check for the correct relationships in students' sentences. Accept all reasonable answers. Some sample connections are given below.
   (a) Chromosomes are made up of many genes that contain coded information for specific traits.
   (b) Two examples of mitosis, the process of asexual reproduction, are binary fission in amoebas and budding in yeast cells.
   (c) Interphase, the first stage in the cell cycle, involves the replication of DNA.
   (d) The first step in embryonic development is the joining of the two gametes, the sperm and the egg, in the process of fertilization.
   (e) Research on stem cells taken from embryos and the production of embryos used for therapeutic cloning are two examples of reproductive technology.

Checking Concepts

Chapter 4

3. The nucleus is sometimes called the control centre of the cell because it 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.
4. Information in the nucleus is stored in long two-stranded molecules called DNA.
5. A chromosome is a very compact structure that is made up of one molecule of DNA.
6. A human cell, such as a skin or muscle cell, contains 92 chromosomes when it is ready to divide (each resulting cell will have 46 chromosomes). A human cell that will become a gamete will contain 46 chromosomes when it is ready to divide (each resulting cell will have 23 chromosomes).

7. Genes are important to the functioning of a cell because they contain the information to code for proteins that carry out the activities of the cell necessary for the cell's survival.
8. Answers will vary. Accept answers that reflect the following main ideas:
   (a), (e) The nucleus is the organelle that is responsible for heredity. The information in the nucleus determines the traits you will inherit from your parents.
   (b) The nucleus is also responsible for controlling the functions of the cell. The genes contained in the nucleus instruct your cells to produce the proteins they need to survive.
   (c), (d) The instructions in the nucleus are carried in DNA molecules. Most of the time, DNA exists in the nucleus in a loosely coiled form but can fold tightly into chromosomes when the cell is ready to divide.
   (f) A genome is all the genetic information stored within the chromosomes in the nucleus of a living cell.
9. Three factors that could change the cell's genetic information are radiation (X rays, ultraviolet rays), chemicals, and viruses.
10. Students' answers may include crops resistant to pests, cystic fibrosis, spirit bears, or other examples.

Chapter 5

11. Body cells must be able to reproduce for growth and to replace worn-out cells.
12. (a) Interphase is important for cell reproduction because it prepares the cell for division by duplicating all the organelles as well as the DNA.
    (b) Mitosis is important for cell reproduction because the nuclear material gets equally divided between the two forming cells.
    (c) Cytokinesis is important for cell reproduction to separate the two nuclei and cell contents into two separate cells.
13. (extension) Cell reproduction is controlled by checkpoint proteins that ensure that the cell is ready to move forward into the next stage of the cell cycle.
14. Replication occurs in the interphase stage of the cell cycle. All the organelles and the cell's DNA are replicated.
15. During anaphase, the two strands of each chromosome split and move to opposite poles of the cell.
16. (a) There are no centrioles for the spindle fibres to attach to in plants.
    (b) In plant cells, a cell plate forms along the centre of the cell to divide the cell into two daughter cells. In animal cells, there is no cell plate and the cell membrane pinches together to divide the cell's cytoplasm and organelles.
17. Students should supply descriptions of three of the following five methods: In binary fission, a single parent cell replicates its genetic material and divides into two equal parts. In budding, part of the parent cell pushes outward to form an outgrowth or bud, which pinches off from the parent cell to become an offspring cell, identical to the parent cell. In fragmentation, if an organism breaks apart as a result of injury, each fragment then develops into a clone of its parent. In vegetative reproduction, special cells—usually in plant stems and plant roots—divide repeatedly to form structures that will eventually develop into a plant identical to the parent. In spore formation, single-celled spores grow into new individuals by mitosis.
18. Humans assist plant reproduction through cutting and grafting.
19. The benefits of plant grafting are that growers can reproduce plants that cannot grow roots from cuttings; the stem can be attached to a plant with a strong root system so that it can grow flowers or fruit much quicker than from seeds; and you can also control the size of the plant by grafting stems onto dwarf trees, which makes it easier to obtain the fruit.

Chapter 6

20. The purpose of meiosis is to create variation among the individuals of a species and to halve the number of chromosomes so that when fertilization occurs, the diploid number for the species will be maintained.
21. (a) While mitosis and meiosis are both methods of reproduction, mitosis is asexual reproduction and meiosis is sexual reproduction. Mitosis produces very little genetic variation, whereas meiosis does create variation. In the process of mitosis, there is one cell division and diploid cells are produced. In meiosis, there are two cell divisions and haploid cells are produced.
    (b) In meiosis I, pairs of double-stranded chromosomes move together to the equator and chromosomes separate. In meiosis II, single chromosomes line up at the equator and the strands of each one separate.

22. Pairs of chromosomes separate during meiosis I.
23. (a) The formation of an egg cell is different than the formation of a sperm cell because in a sperm cell, there is an equal division of cytoplasm distributed among the four cells. In an egg cell, there is an unequal division of cytoplasm.
    (b) All four sperm cells that result are the same size and available for fertilization. One egg will be larger than the other eggs, and only the large egg is available for fertilization.
24. (extension) A gene mutation describes a change to a gene. A chromosome mutation describes a mutation to an entire chromosome, such as having more than the standard number of chromosomes.
25. Down syndrome and Edwards syndrome are caused by chromosomal mutations.
26. (a) Animals aid plant reproduction through pollen transport by carrying the pollen to another plant of the same species so that the egg and sperm can unite for fertilization.
    (b) Animals aid plant reproduction through seed transport by carrying the seeds on their fur or by eating fruit and depositing undigested seeds in a new location.

Understanding Key Ideas

27. The nucleus is responsible for heredity and for controlling the functions of the cell. The information contained in the nucleus instructs your cells to produce or import all of the materials they need to survive. This information also determines what you will look like.
28. A brain cell does not contain more DNA than a liver cell. Both cells have 46 chromosomes.
29. Format of answer may vary. Sexual reproduction requires two parent cells, involves meiosis (which includes the formation of gametes) and mitosis, requires more energy, introduces genetic variation, and can involve care by the parent. Asexual reproduction requires only one parent cell, involves mitosis but not meiosis, requires less energy, results in offspring identical to the parent, except for mutations, and does not include care by the parent. Both result in offspring, and can involve mutations.
30. Examples will vary. The gene is like a sentence that describes one trait and the chromosome is like a book that contains many sentences and describes many traits.
31. A male cell will have one chromosome 23 or an X chromosome and a small piece of chromosome which is the Y chromosome. A female will have two copies of chromosome 23 or two X chromosomes.
32. Answers will vary. Check that students justify their point of view. Sample answer: It is an advantage that humans cannot reproduce asexually because the offspring from asexual reproduction are genetically identical to the parents. Having only one or two offspring at a time who are genetically identical to their parents would make a human population very vulnerable to disease and changes in our environment.
33. Genes contain information that determines what an organism will look like or what traits they have, such as hair or eye colour.
34. (a) It is important that the DNA uncoils during DNA replication so that the steps of the ladder can break apart and form a template for the newly forming strand.
    (b) It is important that DNA coils when it is not being replicated to that it does not get tangled or broken when the cell is reproducing.
35. Charts will vary, but should include the following information:
    Prophase: The chromosomes become visible.
    Metaphase: The chromosomes pull the X-shaped chromosomes into a single line at the equator.
    Anaphase: The single-stranded chromosomes are pulled to opposite poles of the cell.
    Telophase: The nuclear membrane forms around each set of chromosomes.
36. (extension) (a) It is important that the cell does not divide when there are not enough nutrients because energy is required for cell division and many materials are needed to form new cell membranes and organelles. A lack of nutrients would mean that both the parent and daughter cell will have insufficient nutrients to survive.
    (b) If the DNA has not been replicated and mitosis occurs, each cell would end up with only half of the chromosomal material and the new cells would not be able to function.
    (c) It is important that the cell does not divide if the DNA is damaged because if damaged cells divide, the result would be a mutation which could be carried to the next generation of cells.

37. (a) ii
    (b) iii
    (c) i
    (d) i
    (e) iii
    (f) i
    (g) ii
    (h) ii
38. Meiosis I produces genetic because meiosis I results in the creation of a gamete with half of the genetic information of the parent. The other half of the gamete's genetic information will come from the other parent, resulting in genetic diversity.
39. A mutation might be beneficial to the individual or may not produce an effect to harm the individual. An example of a beneficial mutation to humans is better night vision. An example of a neutral mutation for humans is a new hair colour.
40. A mutation can change the activities occurring in a cell by causing the cell to produce the wrong type of protein, which might have no effect or might leave the cell unable to function properly. A mutation might also affect the cell's natural checkpoints, making the cell cancerous.
41. Some natural causes of mutations are ultraviolet rays, gamma rays, and X rays. Some human causes of mutations are cigarette smoke, cleaning products, and industrial waste.
42. (extension) Two differences between reproductive cloning and therapeutic cloning are that reproductive cloning produces an entirely new individual with desirable characteristics whereas therapeutic cloning produces only new cells or tissue with the purpose of correcting health problems.
43. A daughter egg or sperm cell for a horse will have 32 chromosomes.
44. Organizers may vary. Check for correct associations.
45. (a) In the first trimester, the brain and spinal cord are forming and organs are developing.
    (b) The second trimester is the period of growth.
    (c) The third trimester is the period of growth and preparation for birth. Rapid weight gain occurs due to the growth and accumulation of fat.

46.

	Complete Metamorphosis	Incomplete Metamorphosis
Number of parents	Two	Two
Type of reproduction	Internal sexual reproduction	Internal sexual reproduction
Number of stages in life cycle	Four: egg, larva, pupa, adult	Three: egg, nymph, adult

Thinking Critically

47. If the joining of cells is common in muscle cells, there must be some benefit to having two nuclei or at least it cannot be very harmful to the cell. A cell with two nuclei might produce proteins more quickly or more efficiently because it has more DNA from which to read the instructions.
48. The most obvious factor that would determine the frequency of mitosis is the amount of wear on each cell type. The less obvious factor is the number of cells that perform the same function. Stomach, intestine, and skin cells can be replaced frequently because there are many cells of the same type in an organism. If a large percent of the cells are going through mitosis, there are still enough cells left to perform the organ's normal function. In contrast, small groups of specialized cells, such as liver or blood cells, replicate less frequently so that there are very few cells going through mitosis at any one time.
49. Mitosis does not produce genetic variation because the offspring will be genetically identical to the parent cell.
50. A karyotytpe shows an organized picture of all the pairs of chromosomes in a person's cell. By counting the chromosomes and checking their size, researchers can identify chromosome mutations such as repeated, missing, or damaged chromosomes.
51. You cannot identify a gene mutation in a karyotype because a gene mutation in the base sequence cannot be identified by examining chromosomes under the microscope.
52. A mutation in your skin would not be inherited by your children. Only a mutation in your sex cells, eggs, or sperm can be passed on to the next generation.

53. (a) If the protein that checks for DNA replication fails and the DNA does not replicate, the daughter cells will not receive the correct number of chromosomes. If the cell divided, neither daughter cell would have the full DNA message, as the DNA would have been divided between the cells.
    (b) The daughter cells would not be able to function properly, as the message found on both genes of the chromosome pair is necessary for a cell to function.
54. Answers will vary. The map of our genetic material might allow scientists to develop better screening techniques for genetic diseases and cancers, and to create medical treatments that can correct the flaws in a person's genetic make-up.
55. Answers will vary. Reasons why scientists should change plant genes include providing sufficient food to feed the world population. Someone might argue against changing the plant because new species are being created unnaturally, which might have an effect on the environment. For example, if an insect can no longer feed on the plant, it may die, and its predators may die.
56. Mutations introduce new genes that may benefit the organism if the conditions in the environment change. For example, if a virus appears in the population, some individuals might be resistant to the virus and survive to carry the resistance on to the next generation.
57. (extension) Gene therapy in theory should work if obstacles can be overcome, and some gene therapy has proven to be successful.
58. (a) Moisture keeps the embryo from drying out.
    (b) The embryo needs nutrients to grow and develop.
    (c) The egg must be warm enough to ensure that the embryo survives.
    (d) Predators can eat the eggs, or eat the parent fish that are protecting the eggs.

Developing Skills

59. The diagrams should show half of the double-stranded chromosomes moving to each pole in meiosis and one strand of each double-stranded chromosome moving to each pole in mitosis.
60. (a)

Time (h)	Number of Bacteria
0.0	1
0.5	2
1.0	4
1.5	8
2.0	16
2.5	32
3.0	64
3.5	128
4.0	256

    (b) Asexual reproduction allows bacteria to quickly produce offspring without spending time finding a mate, fertilizing an egg, or nurturing a growing embryo. By producing many generations of offspring quickly, bacteria can take over an environment, such as your body, within a matter of days. It would take much longer to produce even a few generations through sexual reproduction.
61. Accept all possible answers. The egg and sperm unite through fertilization to form a zygote. The zygote undergoes mitosis to form an embryo. Tissue layers begin to form, and a fetus develops.

Pause and Reflect Answer

The main point is that asexual reproduction does not produce much variation, so if conditions change, an organism that reproduces solely by this method may be quickly wiped out.