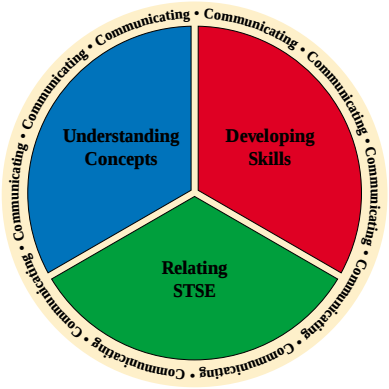
## How does *Nelson Biology 11* match the curriculum?

# Balanced Instruction and Assessment

- *Nelson Biology 11* reflects the overall aim of the secondary science program, which is to "ensure scientific literacy for every secondary school graduate." (*The Ontario Curriculum, Grades 11 and 12*: Science, p. 6), as well as the primary objective of the *Biology*, *Grade 11, University Preparation* science curriculum, which is to "equip students with the knowledge and skills they need to meet the entrance requirements for university programs."

  **The Ontario Curriculum, Grades 9–12 Program Planning and Assessment, p. 3**




- *Nelson Biology 11* addresses 100% of the Biology, Grade 11, University Preparation Science (SBI3U) course curriculum expectations

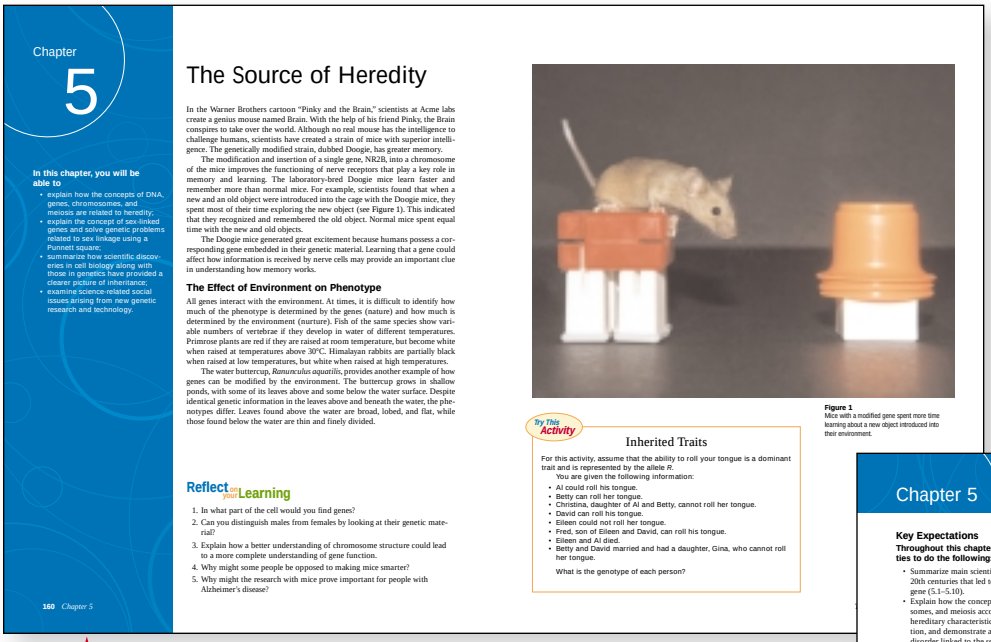
- *Nelson Biology 11* provides a balance of instruction and assessment, reflecting the three goals of secondary science curriculum, which are:

  **A** Understand the basic concepts of science

  **B** Develop the skills, strategies, and habits of mind required for scientific inquiry

  **C** Relate science to technology, society, and the environment

  **The Ontario Curriculum, Grades 11 and 12: Science, p. 6**



Chapter 5

The Source of Heredity

**In this chapter, you will be able to**

- explain how the concepts of DNA, genes, chromosomes, and meiosis are related to heredity;
- explain the concept of sex-linked genes and solve genetic problems related to sex linkage using a Punnett square;
- summarize how scientific discoveries in cell biology along with those in genetics have provided a clearer picture of inheritance;
- examine science-related social issues arising from new genetic research and technology.

In the Warner Brothers cartoon "Pinky and the Brain," scientists at Acme labs create a genius mouse named Brain. With the help of his friend Pinky, the Brain conspires to take over the world. Although no real mouse has the intelligence to challenge humans, scientists have created a strain of mice with superior intelligence. The genetically modified strain, dubbed Doogie, has greater memory.

The modification and insertion of a single gene, NR2B, into a chromosome of the mice improves the functioning of nerve receptors that play a key role in memory and learning. The laboratory-bred Doogie mice learn faster and remember more than normal mice. For example, scientists found that when a new and an old object were introduced into the cage with the Doogie mice, they spent most of their time exploring the new object (see Figure 1). This indicated that they recognized and remembered the old object. Normal mice spent equal time with the new and old objects.

The Doogie mice generated great excitement because humans possess a corresponding gene embedded in their genetic material. Learning that a gene could affect how information is received by nerve cells may provide an important clue in understanding how memory works.

**The Effect of Environment on Phenotype**

All genes interact with the environment. At times, it is difficult to identify how much of the phenotype is determined by the genes (nature) and how much is determined by the environment (nurture). Fish of the same species show variable numbers of vertebrae if they develop in water of different temperatures. Primrose plants are red if they are raised at room temperature, but become white when raised at temperatures above 30°C. Himalayan rabbits are partially black when raised at low temperatures, but white when raised at high temperatures.

The water buttercup, *Ranunculus aquatilis*, provides another example of how genes can be modified by the environment. The buttercup grows in shallow ponds, with some of its leaves above and some below the water surface. Despite identical genetic information in the leaves above and beneath the water, the phenotypes differ. Leaves found above the water are broad, lobed, and flat, while those found below the water are thin and finely divided.

Reflect on your Learning

1. In what part of the cell would you find genes?
2. Can you distinguish males from females by looking at their genetic material?
3. Explain how a better understanding of chromosome structure could lead to a more complete understanding of gene function.
4. Why might some people be opposed to making mice smarter?
5. Why might the research with mice prove important for people with Alzheimer's disease?

160 Chapter 5

Figure 1
Mice with a modified gene spent more time learning about a new object introduced into their environment.

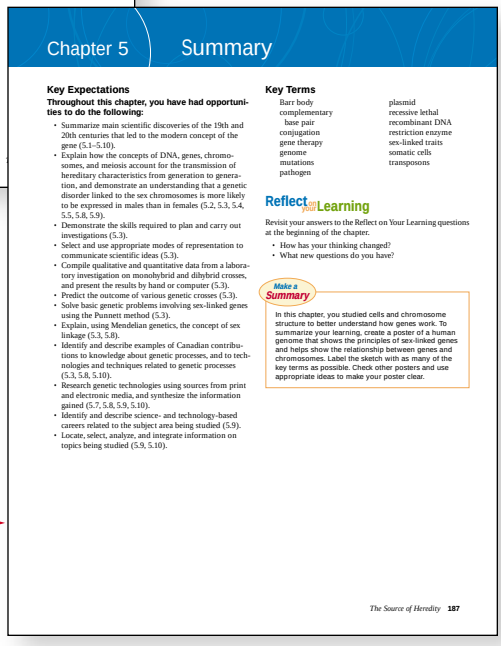
Try This Activity

Inherited Traits

For this activity, assume that the ability to roll your tongue is a dominant trait and is represented by the allele *R*.
You are given the following information:

- Al could roll his tongue.
- Betty can roll her tongue.
- Christina, daughter of Al and Betty, cannot roll her tongue.
- David can roll his tongue.
- Eileen could not roll her tongue.
- Fred, son of Eileen and David, can roll his tongue.
- Eileen and Al died.
- Betty and David married and had a daughter, Gina, who cannot roll her tongue.

What is the genotype of each person?



Chapter 5 Summary

**Key Expectations**

**Throughout this chapter, you have had opportunities to do the following:**

- Summarize main scientific discoveries of the 19th and 20th centuries that led to the modern concept of the gene (5.1–5.10).
- Explain how the concepts of DNA, genes, chromosomes, and meiosis account for the transmission of hereditary characteristics from generation to generation, and demonstrate an understanding that a genetic disorder linked to the sex chromosomes is more likely to be expressed in males than in females (5.2, 5.3, 5.4, 5.5, 5.8, 5.9).
- Demonstrate the skills required to plan and carry out investigations (5.3).
- Select and use appropriate modes of representation to communicate scientific ideas (5.3).
- Compile qualitative and quantitative data from a laboratory investigation on monohybrid and dihybrid crosses, and present the results by hand or computer (5.3).
- Predict the outcome of various genetic crosses (5.3).
- Solve basic genetic problems involving sex-linked genes using the Punnett method (5.3).
- Explain, using Mendelian genetics, the concept of sex linkage (5.3, 5.8).
- Identify and describe examples of Canadian contributions to knowledge about genetic processes, and to technologies and techniques related to genetic processes (5.3, 5.8, 5.10).
- Research genetic technologies using sources from print and electronic media, and synthesize the information gained (5.7, 5.8, 5.9, 5.10).
- Identify and describe science- and technology-based careers related to the subject area being studied (5.9).
- Locate, select, analyze, and integrate information on topics being studied (5.9, 5.10).

**Key Terms**

Barr body
complementary base pair
conjugation
gene therapy
genome
mutations
pathogen
plasmid
recessive lethal
recombinant DNA
restriction enzyme
sex-linked traits
somatic cells
transposons

Reflect on your Learning

Revisit your answers to the Reflect on Your Learning questions at the beginning of the chapter.

- How has your thinking changed?
- What new questions do you have?

Make a Summary

In this chapter, you studied cells and chromosome structure to better understand how genes work. To summarize your learning, create a poster of a human genome that shows the principles of sex-linked genes and helps show the relationship between genes and chromosomes. Label the sketch with as many of the key terms as possible. Check other posters and use appropriate ideas to make your poster clear.

The Source of Heredity 187

The Chapter Opener describes the key student expectations for the unit. Curricular expectations are synthesized into an easy-to-understand "student language" format.

The chapter-ending Summary feature lists the specific Key Expectations addressed, and points to where the expectations have been addressed in the chapter. The expectations are expressed in the same language used in the curriculum document.

# A Understand the Basic Concepts of Science

*Nelson Biology 11* provides complete and accurate coverage of all content in Ontario's *Biology*, *Grade 11, University Preparation* science curriculum (SBI3U). The goal of the program is to adequately prepare students for success in *Biology, Grade 12, University Preparation* (SBI4U), and future post-secondary studies. Concepts fundamental to each strand in the curriculum are developed with text and images. Students learn to apply a number of strategies, such as using headings, reading labels, and interpreting diagrams to assist their understanding of concepts.

## Overall Expectation Addressed

• describe and explain the major processes, mechanisms, and systems, including the respiratory, circulatory, and digestive systems, by which plants and animals maintain their internal environment.

Ontario Curriculum, Grades 11 and 12 Science, p. 17

DID YOU KNOW ?

Rennin is another enzyme found in the stomach. Rennin slows the movement of milk through the gastrointestinal tract, thereby permitting more time for the breakdown and absorption of nutrients. Rennin has little impact in the stomachs of adults; however, it causes milk to curdle in the stomachs of infants, allowing more nutrients to be absorbed. Curds and whey, mentioned in the nursery rhyme "Little Miss Muffet," are made by adding a type of rennin to milk. The proteins are the milk curds; the watery portion is the whey. Rennin is used to make cheese.

**Sections 6.1–6.3 Questions**

**Understanding Concepts**

1. How are the digestive system and other organ systems interdependent?
2. What advantage is gained from digesting food along a digestive tract rather than in a single gastrovascular cavity?
3. How do toothless animals such as birds break down food particles? Suggest advantages of being able to swallow food without needing to chew.
4. Differentiate between physical and chemical digestion. Provide examples of each.
5. Is the movement of food through your digestive system voluntary or involuntary? What mechanisms are responsible for moving food along the alimentary tract?
6. The type of teeth that a mammal has is matched to diet. Keeping in mind the function of different types of teeth, name an animal that would have well-developed (a) canines, and (b) molars and premolars.

sphincters: constrictor muscles that surround a tubelike structure

mucus: a protein produced by a layer of epithelial cells known as a mucous membrane

pepsin: a protein-digesting enzyme produced by the stomach

ulcer: a lesion along the surface of an organ

esophagus, cardiac sphincter, pyloric sphincter, J-shaped stomach

## 6.4 The Stomach and Digestion

The stomach is the site of food storage and initial protein digestion. The movement of food to and from the stomach is regulated by circular muscles called **sphincters**. Sphincters act like the drawstrings on a bag. Contraction of the cardiac sphincter closes the opening to the stomach located nearer the heart, while its relaxation allows food to enter. A second sphincter, the pyloric sphincter, regulates the movement of foods and stomach acids to the small intestine (Figure 1).

The J-shaped stomach has numerous ridges that allow it to expand so that it can store about 1.5 L of food. Millions of cells line the inner wall of the stomach. These cells secrete the various stomach fluids, called gastric fluids or gastric juice, that aid digestion. Approximately 500 mL of these fluids are produced following a large meal. Gastric fluid includes mucus, hydrochloric acid (HCl), pepsinogens, and other substances. **Mucus** provides a protective coating. Hydrochloric acid kills many harmful substances that are ingested with food. It also converts pepsinogen into its active form, **pepsin**, which is a protein-digesting enzyme. Pepsin breaks the long amino acid chains in proteins into shorter chains, called polypeptides.

The pH inside the stomach normally ranges between 2.0 and 3.0, but may approach pH 1.0. Acids with a pH of 2.0 can dissolve fibres in a rug! It is the high acidity (low pH) of hydrochloric acid that makes it effective at killing pathogens and allows pepsin to do its work. How does the stomach safely store these strong chemicals, both of which dissolve the proteins that make up cells? A layer of alkaline mucus protects the stomach lining from being digested. Pepsinogen moves through the cell membrane and mucous lining, is activated by HCl, and becomes

As the acids irritate the cells of the stomach lining, there is an increase in blood flow and acid secretions. With this increased blood flow and acid secretion, more tissue is burned, the allergic reaction becomes even stronger, and the cycle continues. Eventually the blood vessels begin to break down.

Most ulcers have been linked to a bacterium called *Heliobacter pylori* (H. pylori) shown in Figure 2. Although diet, stress, and other factors may still play a part in the development of ulcers, this harmful microbe has changed how stomach ulcers are commonly treated. Dr. Barry Marshall, an Australian physician, is credited with changing the minds of many in the medical community. Prior to Dr. Marshall's research, scientists believed that microbes were unable to withstand the highly acidic conditions of the stomach. However, *H. pylori* can survive in this harsh environment and often only powerful antibiotics can kill it.

Dr. Marshall's research, now conducted in the United States, is attempting to prove a possible link between the microbe and some forms of stomach cancer. A simple breath test for the presence of *H. pylori* is now widely available.

Figure 2
*Heliobacter pylori*

### Frontiers of Technology: Ulcers and Lasers

By 1960, American physicist Theodore Maiman had built the first laser. Laser beams have many medical applications. They can be used to remove damaged tissues such as those created by stomach ulcers. The laser beam is thinner than most scalpels and provides the added advantage of sealing small blood vessels. In addition, the laser may reduce the need for surgery.

A device called an **endoscope** can be fitted with a light-emitting glass fibre and then positioned inside a patient's body (Figure 3). The endoscope can be used to view such things as stomach ulcers. Tiny forceps, fitted in the endoscope, can even extract small pieces of tissue for a biopsy.

endoscope: an instrument to view the interior of the body

Figure 3
The endoscope can be used to provide a view of the stomach.

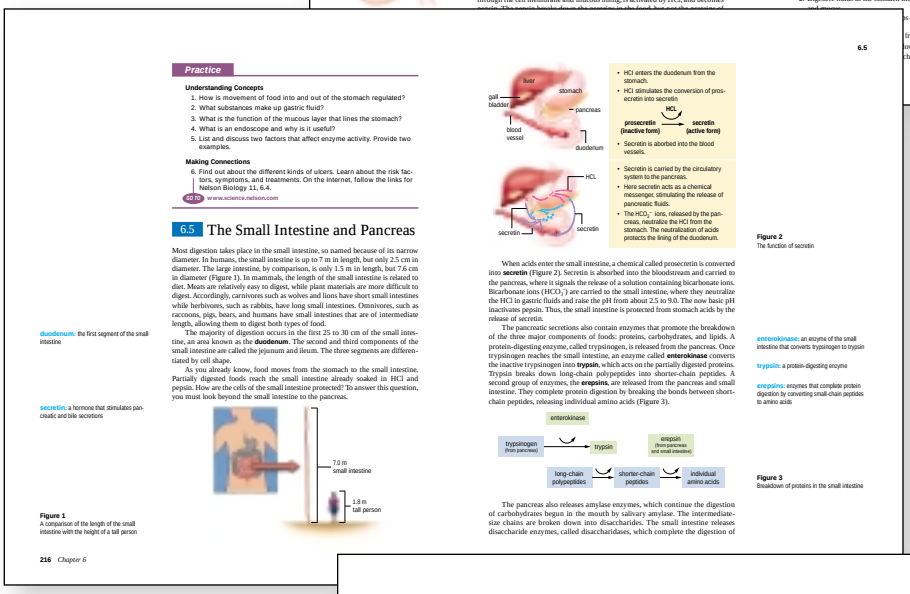
SUMMARY **Digestion in the Stomach**

1. Sphincter muscles regulate the movement of food into and out of the stomach.
2. Digestive fluids in the stomach include hydrochloric acid (HCl), pepsinogens, and mucus.
3. convert pepsinogen into pepsin.
4. from the above two fluids.
5. own of the mucous lining in the stomach, ch acids. Ulcers are linked to *Heliobacter*

DID YOU KNOW ?

The stomach capacity of a newborn human baby can be as little as 60 mL. An adult stomach has a maximum capacity of about 1.5 L, while the stomach of a cow is divided into 4 compartments and may hold up to 300 L.

*Digestion and Nutrition* 215



Practice

**Understanding Concepts**

1. How is movement of food into and out of the stomach regulated?
2. What substances make up gastric fluid?
3. What is the function of the mucous layer that lines the stomach?
4. What is an endoscope and why is it useful?
5. List and discuss two factors that affect enzyme activity. Provide two examples.

**Making Connections**

6. Find out about the different kinds of ulcers. Learn about the risk factors, symptoms, and treatments. On the Internet, follow the links for Nelson Biology 11, 6.4.

GO TO www.science.nelson.com

## 6.5 The Small Intestine and Pancreas

Most digestion takes place in the small intestine, so named because of its narrow diameter. In humans, the small intestine is up to 7 m in length, but only 2.5 cm in diameter. The large intestine, by comparison, is only 1.5 m in length, but 7.6 cm in diameter (Figure 1). In mammals, the length of the small intestine is related to diet. Meats are relatively easy to digest, while plant materials are more difficult to digest. Accordingly, carnivores such as wolves and lions have short small intestines while herbivores, such as rabbits, have long small intestines. Omnivores, such as raccoons, pigs, bears, and humans have small intestines that are of intermediate length, allowing them to digest both types of food.

The majority of digestion occurs in the first 25 to 30 cm of the small intestine, an area known as the **duodenum**. The second and third components of the small intestine are called the jejunum and ileum. The three segments are differentiated by cell shape.

As you already know, food moves from the stomach to the small intestine. Partially digested foods reach the small intestine already soaked in HCl and pepsin. How are the cells of the small intestine protected? To answer this question, you must look beyond the small intestine to the pancreas.

duodenum: the first segment of the small intestine

secretin: a hormone that stimulates pancreatic and bile secretions

7.0 m small intestine, 1.8 m tall person

Figure 1
A comparison of the length of the small intestine with the height of a tall person

216 *Chapter 6*

6.5

liver, stomach, gall bladder, pancreas, blood vessel, duodenum

- HCl enters the duodenum from the stomach.
- HCl stimulates the conversion of prosecretin into secretin

HCl: prosecretin (inactive form) → secretin (active form)

- Secretin is absorbed into the blood vessels.
- Secretin is carried by the circulatory system to the pancreas.
- Here secretin acts as a chemical messenger, stimulating the release of pancreatic fluids.
- The $HCO_3^-$ ions, released by the pancreas, neutralize the HCl from the stomach. The neutralization of acids protects the lining of the duodenum.

HCl, secretin

Figure 2
The function of secretin

When acids enter the small intestine, a chemical called prosecretin is converted into **secretin** (Figure 2). Secretin is absorbed into the bloodstream and carried to the pancreas, where it signals the release of a solution containing bicarbonate ions. Bicarbonate ions ($HCO_3^-$) are carried to the small intestine, where they neutralize the HCl in gastric fluids and raise the pH from about 2.5 to 9.0. The now basic pH inactivates pepsin. Thus, the small intestine is protected from stomach acids by the release of secretin.

The pancreatic secretions also contain enzymes that promote the breakdown of the three major components of foods: proteins, carbohydrates, and lipids. A protein-digesting enzyme, called trypsinogen, is released from the pancreas. Once trypsinogen reaches the small intestine, an enzyme called **enterokinase** converts the inactive trypsinogen into **trypsin**, which acts on the partially digested proteins. Trypsin breaks down long-chain polypeptides into shorter-chain peptides. A second group of enzymes, the **erepsins**, are released from the pancreas and small intestine. They complete protein digestion by breaking the bonds between short-chain peptides, releasing individual amino acids (Figure 3).

enterokinase: an enzyme of the small intestine that converts trypsinogen to trypsin

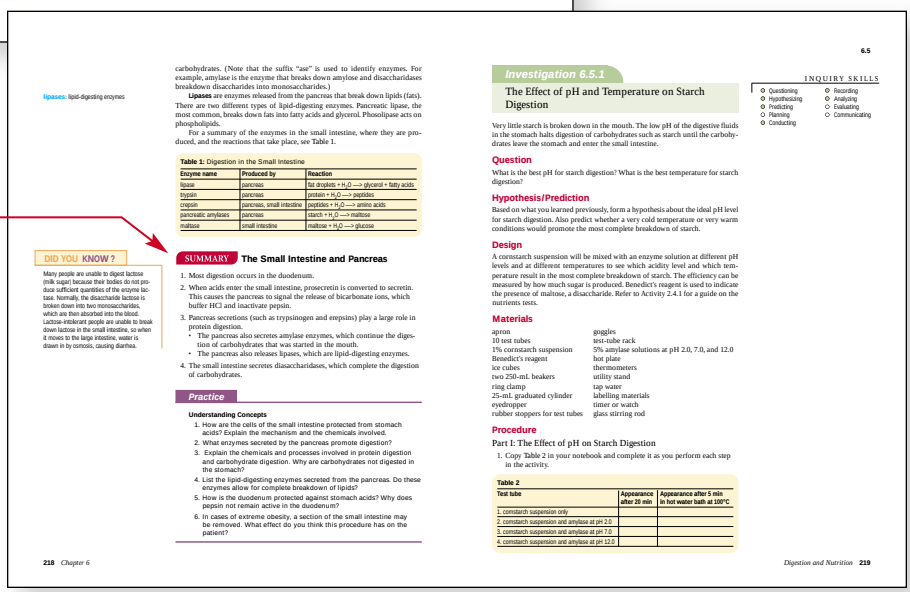
trypsin: a protein-digesting enzyme

erepsins: enzymes that complete protein digestion by converting small-chain peptides to amino acids




Figure 3
Breakdown of proteins in the small intestine

The pancreas also releases amylase enzymes, which continue the digestion of carbohydrates begun in the mouth by salivary amylase. The intermediate-size chains are broken down into disaccharides. The small intestine releases disaccharide enzymes, called disaccharidases, which complete the digestion of



6.5

carbohydrates. (Note that the suffix "*ase*" is used to identify enzymes. For example, amylase is the enzyme that breaks down amylose and disaccharidases breakdown disaccharides into monosaccharides.)

lipases: lipid-digesting enzymes

**Lipases** are enzymes released from the pancreas that break down lipids (fats). There are two different types of lipid-digesting enzymes. Pancreatic lipase, the most common, breaks down fats into fatty acids and glycerol. Phospholipase acts on phospholipids.

For a summary of the enzymes in the small intestine, where they are produced, and the reactions that take place, see Table 1.

**Table 1:** Digestion in the Small Intestine

| Enzyme name | Produced by | Reaction |
|---|---|---|
| lipase | pancreas | fat droplets + $H_2O$ ⟶ glycerol + fatty acids |
| trypsin | pancreas | protein + $H_2O$ ⟶ peptides |
| erepsin | pancreas, small intestine | peptides + $H_2O$ ⟶ amino acids |
| pancreatic amylases | pancreas | starch + $H_2O$ ⟶ maltose |
| maltase | small intestine | maltose + $H_2O$ ⟶ glucose |

DID YOU KNOW ?

Many people are unable to digest lactose (milk sugar) because their bodies do not produce sufficient quantities of the enzyme lactase. Normally, the disaccharide lactose is broken down into two monosaccharides, which are then absorbed into the blood. Lactose-intolerant people are unable to break down lactose in the small intestine, so when it moves to the large intestine, water is drawn in by osmosis, causing diarrhea.

SUMMARY **The Small Intestine and Pancreas**

1. Most digestion occurs in the duodenum.
2. When acids enter the small intestine, prosecretin is converted to secretin. This causes the pancreas to signal the release of bicarbonate ions, which buffer HCl and inactivate pepsin.
3. Pancreas secretions (such as trypsinogen and erepsins) play a large role in protein digestion.
   - The pancreas also secretes amylase enzymes, which continue the digestion of carbohydrates that was started in the mouth.
   - The pancreas also releases lipases, which are lipid-digesting enzymes.
4. The small intestine secretes disaccharidases, which complete the digestion of carbohydrates.

Practice

**Understanding Concepts**

1. How are the cells of the small intestine protected from stomach acids? Explain the mechanism and the chemicals involved.
2. What enzymes secreted by the pancreas promote digestion?
3. Explain the chemicals and processes involved in protein digestion and carbohydrate digestion. Why are carbohydrates not digested in the stomach?
4. List the lipid-digesting enzymes secreted from the pancreas. Do these enzymes allow for complete breakdown of lipids?
5. How is the duodenum protected against stomach acids? Why does pepsin not remain active in the duodenum?
6. In cases of extreme obesity, a section of the small intestine may be removed. What effect do you think this procedure has on the patient?

**Investigation 6.5.1**

### The Effect of pH and Temperature on Starch Digestion

INQUIRY SKILLS

- Questioning
- Hypothesizing
- Predicting
- Planning
- Conducting
- Recording
- Analyzing
- Evaluating
- Communicating

Very little starch is broken down in the mouth. The low pH of the digestive fluids in the stomach halts digestion of carbohydrates such as starch until the carbohydrates leave the stomach and enter the small intestine.

**Question**

What is the best pH for starch digestion? What is the best temperature for starch digestion?

**Hypothesis/Prediction**

Based on what you learned previously, form a hypothesis about the ideal pH level for starch digestion. Also predict whether a very cold temperature or very warm conditions would promote the most complete breakdown of starch.

**Design**

A cornstarch suspension will be mixed with an enzyme solution at different pH levels and at different temperatures to see which acidity level and which temperature result in the most complete breakdown of starch. The efficiency can be measured by how much sugar is produced. Benedict's reagent is used to indicate the presence of maltose, a disaccharide. Refer to Activity 2.4.1 for a guide on the nutrients tests.

**Materials**

apron
10 test tubes
1% cornstarch suspension
Benedict's reagent
ice cubes
two 250-mL beakers
ring clamp
25-mL graduated cylinder
eyedropper
rubber stoppers for test tubes
goggles
test-tube rack
5% amylase solutions at pH 2.0, 7.0, and 12.0
hot plate
thermometers
utility stand
tap water
labelling materials
timer or watch
glass stirring rod

**Procedure**

Part I: The Effect of pH on Starch Digestion

1. Copy Table 2 in your notebook and complete it as you perform each step in the activity.

**Table 2**

| Test tube | Appearance after 20 min | Appearance after 5 min in hot water bath at 100°C |
|---|---|---|
| 1. cornstarch suspension only | | |
| 2. cornstarch suspension and amylase at pH 2.0 | | |
| 3. cornstarch suspension and amylase at pH 7.0 | | |
| 4. cornstarch suspension and amylase at pH 12.0 | | |

218 *Chapter 6*

*Digestion and Nutrition* 219

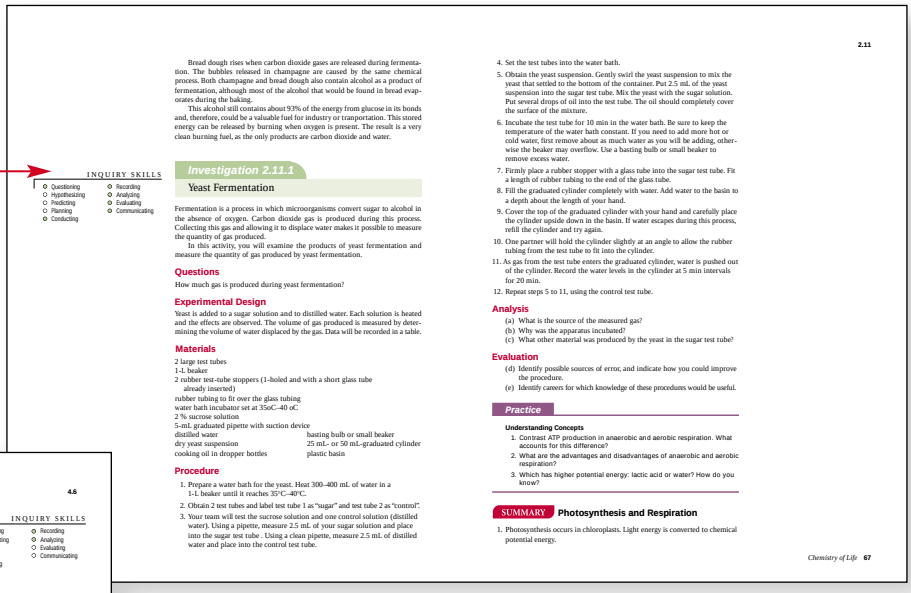
## Concept/Skill Summary

A point-form summary of the major concept(s) or skills presented in the section intended to aid in study. It could be a summary of the steps required to solve a particular class of problems.

# B Develop the Skills, Strategies, and Habits of Mind Required for Scientific Inquiry

*Investigations, Activities, Lab Exercises ("Dry labs")*, and *Try This Activities* give students the opportunity to develop scientific inquiry and communications skills. "Directed" investigations strategically integrated throughout the text engage students in observing and experimenting. "Open-ended" investigations require students to plan and conduct their own investigations, form hypotheses, or choose their own questions to investigate. *Inquiry Skills Menus* indicate the skills being developed in investigations. Additional lab-based activities including computer interface labs are provided in the teacher support materials.

Inquiry Skills Menu



2.11

Bread dough rises when carbon dioxide gases are released during fermentation. The bubbles released in champagne are caused by the same chemical process. Both champagne and bread dough also contain alcohol as a product of fermentation, although most of the alcohol that would be found in bread evaporates during the baking.

This alcohol still contains about 93% of the energy from glucose in its bonds and, therefore, could be a valuable fuel for industry or transportation. This stored energy can be released by burning when oxygen is present. The result is a very clean burning fuel, as the only products are carbon dioxide and water.

INQUIRY SKILLS

- Questioning
- Hypothesizing
- Predicting
- Planning
- Conducting
- Recording
- Analyzing
- Evaluating
- Communicating

**Investigation 2.11.1**

**Yeast Fermentation**

Fermentation is a process in which microorganisms convert sugar to alcohol in the absence of oxygen. Carbon dioxide gas is produced during this process. Collecting this gas and allowing it to displace water makes it possible to measure the quantity of gas produced.

In this activity, you will examine the products of yeast fermentation and measure the quantity of gas produced by yeast fermentation.

**Questions**

How much gas is produced during yeast fermentation?

**Experimental Design**

Yeast is added to a sugar solution and to distilled water. Each solution is heated and the effects are observed. The volume of gas produced is measured by determining the volume of water displaced by the gas. Data will be recorded in a table.

**Materials**

2 large test tubes
1-L beaker
2 rubber test-tube stoppers (1-holed and with a short glass tube already inserted)
rubber tubing to fit over the glass tubing
water bath incubator set at 35oC–40 oC
2 % sucrose solution
5-mL graduated pipette with suction device
distilled water
dry yeast suspension
cooking oil in dropper bottles
basting bulb or small beaker
25 mL- or 50 mL-graduated cylinder
plastic basin

**Procedure**

1. Prepare a water bath for the yeast. Heat 300–400 mL of water in a 1-L beaker until it reaches 35°C–40°C.
2. Obtain 2 test tubes and label test tube 1 as "sugar" and test tube 2 as "control".
3. Your team will test the sucrose solution and one control solution (distilled water). Using a pipette, measure 2.5 mL of your sugar solution and place into the sugar test tube . Using a clean pipette, measure 2.5 mL of distilled water and place into the control test tube.
4. Set the test tubes into the water bath.
5. Obtain the yeast suspension. Gently swirl the yeast suspension to mix the yeast that settled to the bottom of the container. Put 2.5 mL of the yeast suspension into the sugar test tube. Mix the yeast with the sugar solution. Put several drops of oil into the test tube. The oil should completely cover the surface of the mixture.
6. Incubate the test tube for 10 min in the water bath. Be sure to keep the temperature of the water bath constant. If you need to add more hot or cold water, first remove about as much water as you will be adding, otherwise the beaker may overflow. Use a basting bulb or small beaker to remove excess water.
7. Firmly place a rubber stopper with a glass tube into the sugar test tube. Fit a length of rubber tubing to the end of the glass tube.
8. Fill the graduated cylinder completely with water. Add water to the basin to a depth about the length of your hand.
9. Cover the top of the graduated cylinder with your hand and carefully place the cylinder upside down in the basin. If water escapes during this process, refill the cylinder and try again.
10. One partner will hold the cylinder slightly at an angle to allow the rubber tubing from the test tube to fit into the cylinder.
11. As gas from the test tube enters the graduated cylinder, water is pushed out of the cylinder. Record the water levels in the cylinder at 5 min intervals for 20 min.
12. Repeat steps 5 to 11, using the control test tube.

**Analysis**

(a) What is the source of the measured gas?
(b) Why was the apparatus incubated?
(c) What other material was produced by the yeast in the sugar test tube?

**Evaluation**

(d) Identify possible sources of error, and indicate how you could improve the procedure.
(e) Identify careers for which knowledge of these procedures would be useful.

**Practice**

**Understanding Concepts**

1. Contrast ATP production in anaerobic and aerobic respiration. What accounts for this difference?
2. What are the advantages and disadvantages of anaerobic and aerobic respiration?
3. Which has higher potential energy: lactic acid or water? How do you know?

**SUMMARY** **Photosynthesis and Respiration**

1. Photosynthesis occurs in chloroplasts. Light energy is converted to chemical potential energy.

*Chemistry of Life* 67

4.6

**Activity 4.6.1**

**Genetics of Corn**

Corn is one of the world's most important food crops. It has been subject to selective breeding techniques and hybridization for many years, which have resulted in vigorous, high-yielding varieties. Nearly all corn grown today is hybrid corn. Some varieties of corn are chosen for their sweet flavour while the mixed coloration of the Indian corn varieties makes them popular decorations during the autumn months.

In this activity, you will determine the probable genotypes of parents by examining the phenotypes of corn for two different and independently assorted traits.

INQUIRY SKILLS

- Questioning
- Hypothesizing
- Predicting
- Planning
- Conducting
- Recording
- Analyzing
- Evaluating
- Communicating

**Materials**

dihybrid corn ears (sample A, sample B)

**Procedure**

1. Obtain a sample A corn ear from your instructor (Figure 8). The kernels display two different traits whose genes are located on different chromosomes.
2. Describe the two different traits: colour and shape. Predict which phenotypes are dominant and which are recessive.
3. Assume that the ear of corn is from the $F_2$ generation. The parents of the $F_1$ corn were pure-breeding homozygous for each of the characteristics. Assign the letters *P* and *p* to the alleles for colour, and *A* and *a* to the alleles for shape. Use the symbols *PPaa* and *ppAA* for the parents of the $F_1$ generation. Describe the phenotype of the *PPaa* parent and *ppAA* parent. The cross for the $F_1$ generation is *PPaa* × *ppAA*.
4. Count 100 of the kernels in sequence; describe the phenotypes and record the number of each in a table similar to Table 1.

**Figure 8**
Sample A

**Table 1**

| Phenotype | Number | Ratio |
|---|---|---|
| dominant alleles for colour and shape | | |
| dominant allele for colour, but recessive allele for shape | | |
| recessive allele for colour, but dominant allele for shape | | |
| recessive alleles for colour and shape | | |

5. Obtain sample B. Assume that this ear was produced from a test cross. Count 100 kernels in sequence and record your results as in step 4.

**Analysis and Evaluation**

(a) What are the expected genotypes and phenotypes of the $F_1$ generation resulting from a cross between the parents *PPaa* and *ppAA*?
(b) Use a Punnett square to show the expected genotypes and the phenotypic ratio of the $F_2$ generation. Compare your results with what you obtained in step 4. What factors might account for discrepancies? Would your results be any different if you took larger samples or took multiple samples and averaged the results?

*Genes and Heredity* 155

Specific Expectation Addressed

• solve basic genetic problems involving monohybrid crosses, incomplete dominance, co-dominance, dihybrid crosses, and sex-linked genes using the Punnett method.

Ontario Curriculum, Grades 11 and 12 Science, p. 15

Try This Activity

## The Effect of Salt Water on Potato Strips

- Take a potato and slice it into 5 thin strips, each about 2 cm wide and 5 cm long. Try to make all of the strips the same width and length.
- Obtain salt solutions with the following concentrations: 0% salt, 1% salt, 2% salt, 5% salt, and 10% salt.
- Place a potato strip in each of 5 test tubes. Label the test tubes with the above salt concentrations.
- Pour equal volumes of each salt solution into their respective test tubes, so that each strip is completely covered.
- Allow the strips to remain in the solutions for 20 min and then remove and measure the length of each strip.
- Prepare an observation chart to record the original and final measurements.
- Calculate the change in length. Remember to use negative numbers to show a strip that became shorter

(a) Describe the changes in the length of the potato strips as salt concentration increases. Suggest an explanation for the observed changes.

Try This Activities are short hands-on activities using readily available materials. These activities appear periodically throughout each chapter and give students an informal opportunity for skill development.

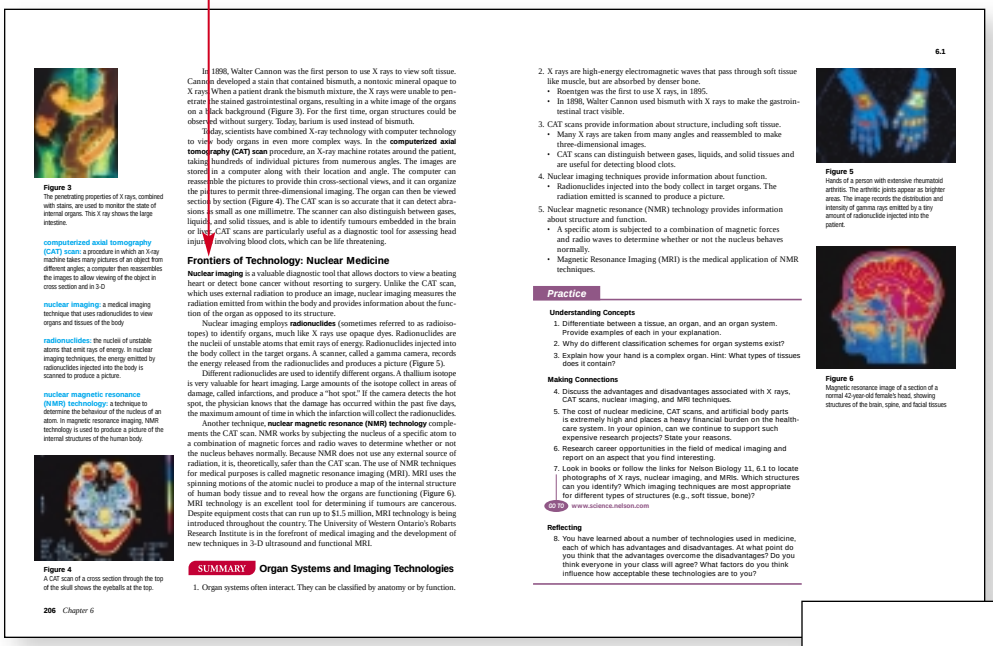
# C Relate Science to Technology, Society, and the Environment

The important goal of relating science to technology, society, and the environment (STSE) is integrated throughout the student text and is linked to students' learning of scientific concepts and skills in real-world contexts.

## Specific Expectation Addressed

• identify examples of technologies that have enhanced scientific understanding of internal systems.

Ontario Curriculum, Grades 11 and 12 Science, p. 18



6.1

Figure 3
The penetrating properties of X rays, combined with stains, are used to monitor the state of internal organs. This X ray shows the large intestine.

**computerized axial tomography (CAT) scan:** a procedure in which an X-ray machine takes many pictures of an object from different angles; a computer then reassembles the images to allow viewing of the object in cross section and in 3-D

**nuclear imaging:** a medical imaging technique that uses radionuclides to view organs and tissues of the body

**radionuclides:** the nuclei of unstable atoms that emit rays of energy. In nuclear imaging techniques, the energy emitted by radionuclides injected into the body is scanned to produce a picture.

**nuclear magnetic resonance (NMR) technology:** a technique to determine the behaviour of the nucleus of an atom. In magnetic resonance imaging, NMR technology is used to produce a picture of the internal structures of the human body.

Figure 4
A CAT scan of a cross section through the top of the skull shows the eyeballs at the top.

In 1898, Walter Cannon was the first person to use X rays to view soft tissue. Cannon developed a stain that contained bismuth, a nontoxic mineral opaque to X rays. When a patient drank the bismuth mixture, the X rays were unable to penetrate the stained gastrointestinal organs, resulting in a white image of the organs on a black background (Figure 3). For the first time, organ structures could be observed without surgery. Today, barium is used instead of bismuth.

Today, scientists have combined X-ray technology with computer technology to view body organs in even more complex ways. In the **computerized axial tomography (CAT) scan** procedure, an X-ray machine rotates around the patient, taking hundreds of individual pictures from numerous angles. The images are stored in a computer along with their location and angle. The computer can reassemble the pictures to provide thin cross-sectional views, and it can organize the pictures to permit three-dimensional imaging. The organ can then be viewed section by section (Figure 4). The CAT scan is so accurate that it can detect abrasions as small as one millimetre. The scanner can also distinguish between gases, liquids, and solid tissues, and is able to identify tumours embedded in the brain or liver. CAT scans are particularly useful as a diagnostic tool for assessing head injuries involving blood clots, which can be life threatening.

### Frontiers of Technology: Nuclear Medicine

**Nuclear imaging** is a valuable diagnostic tool that allows doctors to view a beating heart or detect bone cancer without resorting to surgery. Unlike the CAT scan, which uses external radiation to produce an image, nuclear imaging measures the radiation emitted from within the body and provides information about the function of the organ as opposed to its structure.

Nuclear imaging employs **radionuclides** (sometimes referred to as radioisotopes) to identify organs, much like X rays use opaque dyes. Radionuclides are the nuclei of unstable atoms that emit rays of energy. Radionuclides injected into the body collect in the target organs. A scanner, called a gamma camera, records the energy released from the radionuclides and produces a picture (Figure 5).

Different radionuclides are used to identify different organs. A thallium isotope is very valuable for heart imaging. Large amounts of the isotope collect in areas of damage, called infarctions, and produce a "hot spot." If the camera detects the hot spot, the physician knows that the damage has occurred within the past five days, the maximum amount of time in which the infarction will collect the radionuclides.

Another technique, **nuclear magnetic resonance (NMR) technology** complements the CAT scan. NMR works by subjecting the nucleus of a specific atom to a combination of magnetic forces and radio waves to determine whether or not the nucleus behaves normally. Because NMR does not use any external source of radiation, it is, theoretically, safer than the CAT scan. The use of NMR techniques for medical purposes is called magnetic resonance imaging (MRI). MRI uses the spinning motions of the atomic nuclei to produce a map of the internal structure of human body tissue and to reveal how the organs are functioning (Figure 6). MRI technology is an excellent tool for determining if tumours are cancerous. Despite equipment costs that can run up to $1.5 million, MRI technology is being introduced throughout the country. The University of Western Ontario's Robarts Research Institute is in the forefront of medical imaging and the development of new techniques in 3-D ultrasound and functional MRI.

**SUMMARY** **Organ Systems and Imaging Technologies**

1. Organ systems often interact. They can be classified by anatomy or by function.
2. X rays are high-energy electromagnetic waves that pass through soft tissue like muscle, but are absorbed by denser bone.
   - Roentgen was the first to use X rays, in 1895.
   - In 1898, Walter Cannon used bismuth with X rays to make the gastrointestinal tract visible.
3. CAT scans provide information about structure, including soft tissue.
   - Many X rays are taken from many angles and reassembled to make three-dimensional images.
   - CAT scans can distinguish between gases, liquids, and solid tissues and are useful for detecting blood clots.
4. Nuclear imaging techniques provide information about function.
   - Radionuclides injected into the body collect in target organs. The radiation emitted is scanned to produce a picture.
5. Nuclear magnetic resonance (NMR) technology provides information about structure and function.
   - A specific atom is subjected to a combination of magnetic forces and radio waves to determine whether or not the nucleus behaves normally.
   - Magnetic Resonance Imaging (MRI) is the medical application of NMR techniques.

Figure 5
Hands of a person with extensive rheumatoid arthritis. The arthritic joints appear as brighter areas. The image records the distribution and intensity of gamma rays emitted by a tiny amount of radionuclide injected into the patient.

Figure 6
Magnetic resonance image of a section of a normal 42-year-old female's head, showing structures of the brain, spine, and facial tissues

**Practice**

**Understanding Concepts**

1. Differentiate between a tissue, an organ, and an organ system. Provide examples of each in your explanation.
2. Why do different classification schemes for organ systems exist?
3. Explain how your hand is a complex organ. Hint: What types of tissues does it contain?

**Making Connections**

4. Discuss the advantages and disadvantages associated with X rays, CAT scans, nuclear imaging, and MRI techniques.
5. The cost of nuclear medicine, CAT scans, and artificial body parts is extremely high and places a heavy financial burden on the health-care system. In your opinion, can we continue to support such expensive research projects? State your reasons.
6. Research career opportunities in the field of medical imaging and report on an aspect that you find interesting.
7. Look in books or follow the links for Nelson Biology 11, 6.1 to locate photographs of X rays, nuclear imaging, and MRIs. Which structures can you identify? Which imaging techniques are most appropriate for different types of structures (e.g., soft tissue, bone)?

GO TO www.science.nelson.com

**Reflecting**

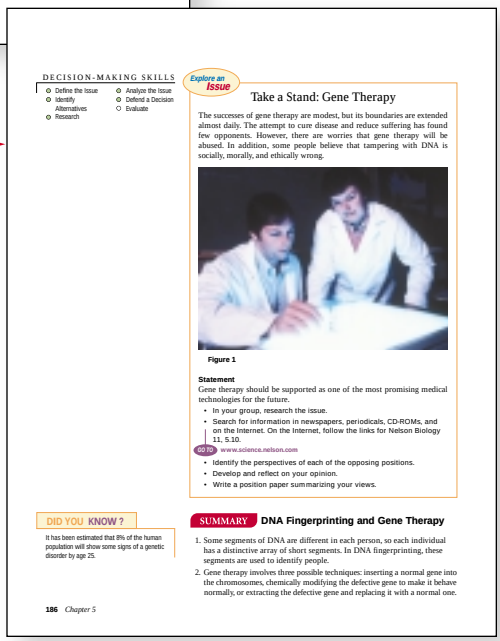
8. You have learned about a number of technologies used in medicine, each of which has advantages and disadvantages. At what point do you think that the advantages overcome the disadvantages? Do you think everyone in your class will agree? What factors do you think influence how acceptable these technologies are to you?

206 *Chapter 6*

## Specific Expectation Addressed

• describe and analyse examples of genetic technologies that were developed on the basis of scientific understanding (e.g., the improvement of an experimental procedure to extract DNA from bacterial or plant cells)

Ontario Curriculum, Grades 11 and 12 Science, p. 16



DECISION-MAKING SKILLS
Define the Issue · Identify Alternatives · Research · Analyze the Issue · Defend a Decision · Evaluate

*Explore an Issue*

### Take a Stand: Gene Therapy

The successes of gene therapy are modest, but its boundaries are extended almost daily. The attempt to cure disease and reduce suffering has found few opponents. However, there are worries that gene therapy will be abused. In addition, some people believe that tampering with DNA is socially, morally, and ethically wrong.

Figure 1

**Statement**
Gene therapy should be supported as one of the most promising medical technologies for the future.

- In your group, research the issue.
- Search for information in newspapers, periodicals, CD-ROMs, and on the Internet. On the Internet, follow the links for Nelson Biology 11, 5.10.

GO TO www.science.nelson.com

- Identify the perspectives of each of the opposing positions.
- Develop and reflect on your opinion.
- Write a position paper summarizing your views.

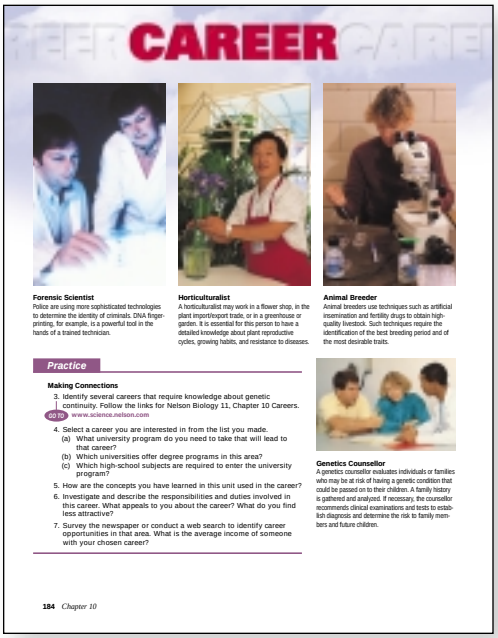
**DID YOU KNOW ?**

It has been estimated that 8% of the human population will show some signs of a genetic disorder by age 25.

**SUMMARY** **DNA Fingerprinting and Gene Therapy**

1. Some segments of DNA are different in each person, so each individual has a distinctive array of short segments. In DNA fingerprinting, these segments are used to identify people.
2. Gene therapy involves three possible techniques: inserting a normal gene into the chromosomes, chemically modifying the defective gene to make it behave normally, or extracting the defective gene and replacing it with a normal one.

186 *Chapter 5*



CAREER

**Forensic Scientist**
Police are using more sophisticated technologies to determine the identity of criminals. DNA fingerprinting, for example, is a powerful tool in the hands of a trained technician.

**Horticulturalist**
A horticulturalist may work in a flower shop, in the plant import/export trade, or in a greenhouse or garden. It is essential for this person to have a detailed knowledge about plant reproductive cycles, growing habits, and resistance to diseases.

**Animal Breeder**
Animal breeders use techniques such as artificial insemination and fertility drugs to obtain high-quality livestock. Such techniques require the identification of the best breeding period and of the most desirable traits.

**Practice**

**Making Connections**

3. Identify several careers that require knowledge about genetic continuity. Follow the links for Nelson Biology 11, Chapter 10 Careers.

GO TO www.science.nelson.com

4. Select a career you are interested in from the list you made.
   (a) What university program do you need to take that will lead to that career?
   (b) Which universities offer degree programs in this area?
   (c) Which high-school subjects are required to enter the university program?
5. How are the concepts you have learned in this unit used in the career?
6. Investigate and describe the responsibilities and duties involved in this career. What appeals to you about the career? What do you find less attractive?
7. Survey the newspaper or conduct a web search to identify career opportunities in that area. What is the average income of someone with your chosen career?

**Genetics Counsellor**
A genetics counsellor evaluates individuals or families who may be at risk of having a genetic condition that could be passed on to their children. A family history is gathered and analyzed. If necessary, the counsellor recommends clinical examinations and tests to establish diagnosis and determine the risk to family members and future children.

184 *Chapter 10*

## Specific Expectation Addressed

• identify and describe science and technology based careers related to Genetic Continuity.

Ontario Curriculum, Grades 11 and 12 Science, p. 12