

Topic 3.2

Where are the effects of climate change felt, and what is their impact?

Specific Expectations

- **D2.1** use appropriate technology related to Earth's dynamic climate, including but not limited to: *anthropogenic, atmosphere, carbon footprint, carbon sink, climate, greenhouse gases, hydrosphere, and weather*
- **D2.6** compare different tools or systems used by scientists to make informed decisions on global climate change
- **D3.7** identify indicators of global climate changes

Skills

- conduct experiments, using equipment and materials safely and accurately
- plan investigations
- draw and justify conclusions
- communicate using appropriate language, in a variety of formats
- use appropriate modes of representation and units of measurement

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see pages TR-47 to TR-49 for a summary of the materials required in this topic.

Overview

In this topic, students will identify the ways that climate change affects aquatic and terrestrial ecosystems.

Common Misconceptions

- **Some students may think that climate changes only affect areas far away, such as the Arctic and Antarctica, or equatorial countries.** Explain to students that because we live in Ontario, far from oceans and in a temperate climate, we are not yet seeing many dramatic effects of climate change. However, there are still some changes that are affecting us such as the frequency and intensity of storms. Direct students' attention to Activity 3.4. Explain that hurricanes are powerful storms that form in warm ocean waters. In Ontario and even in coastal areas of Canada, hurricanes have not been a big concern in the past. Hurricanes that formed in the Gulf of Mexico were so far away that by the time they reached the Maritimes, most of their force was gone. Now, however, with ocean temperatures rising, hurricanes are larger and much more powerful. These hurricanes have enough power to race up the coast of North America and cause serious damage to coastal areas of Canada. They can even send high winds and torrential rains and flooding in Ontario. Since 1995, Canada has experienced 17 hurricanes, one of which was major. In the previous 44 years, Canada was hit with 50 hurricanes, with six classified as major. For more information on hurricanes in Canada, go to www.scienceontario.ca and follow the links.
- **Students may not be aware of how climate changes affect aquatic ecosystems.** Remind students that approximately 70% of Earth is covered in water, and approximately 97% of that water is in the oceans. There are incredibly diverse ecosystems beneath the ocean that depend on ocean currents, water temperature, salinity, and many other factors for survival. Explain that students will learn more about the effects of climate change on these ecosystems later in this topic. Learn more facts about Earth by going to www.scienceontario.ca and following the links.

Background Knowledge

The island nation of Tuvalu is one of several island nations that may disappear under water within decades owing to the rising oceans cause by global warming. The islands of Kiribati and Vanuatu, and the Marshall Islands are also considered at risk. They have a combined population of over 200 000.

Closer to home, Canada, with over 200 000 km of coastline, is also at risk from rising ocean levels. Areas of the Maritimes and on the coast of the Beaufort Sea are considered areas of high sensitivity and others areas such as Quebec, Newfoundland and Labrador, and British Columbia are considered areas of low sensitivity. These areas will experience flooding, erosion, sedimentation, and other issues related to an increase of the average sea level by a predicted 0.88 m.

In Activity 3.2, students learn how scientists are using elephant seals to study climate change. Elephant seals were once hunted for their blubber, which was rendered and used as oil. The northern elephant seals of the Pacific Ocean were hunted almost to extinction. By 1892, there were less than 100 northern elephant seals left. Since their protection in 1922 by the Mexican government, the population has increased and is now about 160 000.

Southern elephant seals are considerably larger than their northern cousins, weighing up to 4000 kg at a length of 6 m. Southern elephant seals spend their winters in Antarctica and are astonishing divers. They can dive up to 2000 m deep and remain under water for up to 2 hours! They have been tagged and monitored for many years, originally to provide research on their feeding habits, which are otherwise difficult to study. The devices were able to record the seals' diving cycle as well as the water temperature and salinity, and provided valuable information on both elephant seal feeding habits and the Antarctic ecosystem in which they live.

In Activity 3.4, students see how hurricanes work. Hurricanes, also called *cyclones* or *typhoons*, form in the warm tropical ocean zones just north and south of the equator. Warm water, through convection, provides the energy required to create these massive storms. Surface temperatures of the water must be at least 26.5°C for a hurricane to form. When a storm's winds reach 119 km per hour, the storm is classified as a hurricane. A hurricane creates a low pressure area, drawing surrounding water upward into a mound-like shape. When a hurricane hits land, this mound, in conjunction with ocean water pushed ahead of the storm by high winds, creates a storm surge, an increase in the ocean level. Storm surges cause massive flooding in the hurricane's path. It is often the storm surge that causes the most destruction, such as when Hurricane Katrina struck New Orleans on August 29, 2006. Once a hurricane strikes land, it tends to slow down and lose energy since it has lost the source of its energy: the warm ocean waters. To download videos of storm surges and hurricanes go to www.scienceontario.ca and follow the links and instructions.

Literacy Strategies

Before Reading

- As a class, have students read the main headings of the topic. Then, have them review the Key Concepts on page 202. Students should note that they are the same.
- Have students examine the photographs in the topic opener. Conduct a class discussion on why these particular images were selected. Ask leading questions such as: "Why do you think the image of the beach in Tuvalu was selected for the opener of this topic? What do the small, circular photo insets mean? How are they related to the larger image?"
- **ELL** English language learners need time to practise English vocabulary. Allow English language learners to play brief games with peers to reinforce vocabulary, for example, *impact*, *effect*, *ecosystem*, *aquatic*, and so on. One such game is "slap it". Key terms are written on cards, and placed face up on a table. One student calls out a word or phrase related to one of the terms, and others attempt to be the first to slap the correct card. The player with the most cards wins.

During Reading

- Draw students' attention to the images as they read through the topic. Ask them to consider what the images are intended to convey. Encourage them to make notes on the images as well as jot notes on the content to refer to during their review.
- **ELL** **DI** Encourage English language learners and visual learners to use diagrams or sketches in their notes. English language learners may wish to use their first language for their notes and then create an English translation. When you ask students to take notes, consider providing English language learners with a copy of the notes, or asking a classmate to assist when writing requirements are extensive.

After Reading

- Encourage students to use the key concepts to help them navigate through the topic when reviewing.

Assessment FOR Learning

Tool	Evidence of Learning	Supporting Learners
Learning Check, page 205	Students identify how climate change affects aquatic ecosystems.	<ul style="list-style-type: none"> For question 1, you may wish to provide students with BLM 3-10 Impacts of Climate Change on Aquatic Ecosystems, or have them create their own table, to record the information on page 204 in point form. For question 2, have students use BLM 3-11 Aquatic Food Chains to show the changes to a food chain graphically.
Learning Check, page 207	Students identify how climate change affects terrestrial ecosystems and humans.	<ul style="list-style-type: none"> For question 1, encourage students to re-read the last point of page 206 and make jot notes to help them. Students could brainstorm the issue of how climate change affects human health. Ensure that students record their ideas and concepts. Have them work with a partner or in small groups to write a summary statement of the ideas in the brainstorming session. For question 3, have students use a food chain diagram to illustrate their answers graphically. You may wish to have them use BLM 3-12 Food Chains or have them draw their own.
Learning Check, page 209	Students identify positive and negative affects of climate change.	<ul style="list-style-type: none"> Provide students with BLM 3-14 Positive and Negative Impacts of Climate Change. Students could work independently or with a partner or in small groups. Assign each group a different area to analyze on the blackline master. Have groups share their results with the class.
Review, question 7, page 211	Students interpret the image of a flooded farm and identify negative and positive factors.	<ul style="list-style-type: none"> Students may require guidance in analyzing the photograph. Students with visual disabilities could have the image described to them by a classmate. As a class, or working in small groups, have students make jot notes about what they notice in the photograph. ELL English language learners could use diagrams or sketches or write jot notes in their first language to translate into English later.

Topic 3.2 (Student textbook pages 202-211)

Using the Topic Opener

- Draw students' attention to the photographs of Tuvulu and the small insert photographs. Point out to students that the boy is actually running toward the road (the black paved area on the right with the white dotted line). Ask them to consider what this implies (The waves are so high now, that they wash over the roadways. This shows that climate change is already having a negative impact.) Have students consider the two small inset photographs. Ask them to discuss how much higher the high tide waters would have to rise to threaten the house. Have them consider what would happen in this neighbourhood if the island were struck by a storm.
- Have students read the text individually. Then, as a class, ask students to consider the last two sentences. Point out Tuvulu on a world map (about 1000 km north of Fiji). Ask students where the 11 000 people of Tuvulu would go if their homes were under water. Point out that several more islands are threatened with flooding as well. In all, about 200 000 people are at risk. Return again to the world map. Ask students to speculate where all these people could live. Ask questions such as: "Who would pay for their relocation? Who would pay to feed and house these refugees?" There are no right or wrong answers. Keep an open, thoughtful discussion. Ask if students would want to help the refugees and have them move to Canada. Do they think Canadian taxes should be increased to pay for this?

Starting Point Activity (Student textbook page 202)

Pedagogical Purpose

This activity provides an opportunity for students to share and expand on their knowledge of climate change.

Planning	
Materials	large world map selection of different coloured stickers
Time	15-20 min in class

Activity Notes and Troubleshooting

- Create a climate change map centre for students to post their stickers and to refer to as they work through the topic and the unit.
- Rather than stickers, students could use coloured grease pencils or erasable markers on a laminated world map. If the map is mounted on a bulletin board, students could also use coloured pushpins instead of stickers.
- If you wish, have students select the materials to use as part of the activity. Students can discuss and vote on which option is the best use of resources. For example, pushpins are plastic, but can be reused. Stickers are paper but can only be used once, and render the map unusable.
- Before students begin brainstorming, ensure that they understand the rules of brainstorming. Then circulate as they work and make a note of any misconceptions that need to be addressed.

Additional Support

- **ELL** English language learners and students who have difficulty expressing themselves verbally may find this activity challenging. Consider having students work in groups, or have students write or draw their contributions to the climate change map.
- **DI** To foster intrapersonal work, you may wish to provide students with individual copies of a world map and have them mark their maps individually first. Then, have a class discussion and have students contribute their ideas.

Starting Point Activity Answers

Answers may vary. For example, melting polar ice, stronger storms, and droughts.

Instructional Strategies for Topic 3.2

Student textbook pages 204-207

- These two spreads have parallel concepts: the effects of climate change on aquatic ecosystems and on terrestrial ecosystems. You may wish to have students read the whole section then work on the Reading Checks and Activity 3.2 and Activity 3.3.
- Draw parallels between the aquatic and terrestrial effects to link the knowledge and improve retention. For example, on page 206, the text refers to bird migration and on page 204, there is a reference to the migration of aquatic species.
- **ELL** **DI** Have students use **BLM G-49 Venn Diagram**, or another graphic organizer of their choice, to compare the effects of climate change on aquatic ecosystems and terrestrial ecosystems.
- After students read pages 204 and 206, assign the Learning Check questions. Provide **BLM 3-10 Impacts of Climate Change on Aquatic Ecosystems** for question 1 and **BLM 3-11 Aquatic Foods Chains** for question 2 on page 205, if needed. Provide **BLM 3-12 Foods Chains** for question 3 on page 207, if needed.
- After students complete the reading, you may wish to have them complete either Activity 3.2 or Activity 3.3. Students should share their learning with the rest of the class.
- Enrichment—For Learning Check question 3, page 205, interested students may wish to research the Gulf Stream in more detail. Students could take one of two approaches.
 - Students could research ocean currents, and the Gulf Stream in particular. They should identify the route of the Gulf Stream and the effect it has on neighbouring coastal areas. Then, they should provide a hypothesis about how a change in the Gulf Stream could affect those areas.
 - Students could research climate changes in areas that would be affected by the Gulf Stream. Students should focus on dramatic weather patterns changes, such as heat waves or cold snaps, changes in precipitation, and so on. Students should present their findings to the class, followed by a class discussion on how the Gulf Stream is already changing and affecting the climate in the surrounding areas.

Student textbook pages 208-209

- Before assigning the reading and Learning Check questions, review the world map as a class. Ensure students are aware of how to use the legend at the bottom right of page 209. Provide **BLM 3-14 Positive and Negative Impacts of Climate Change** for question 2, if needed.
- As a class, have students identify the areas on the world map that correspond to the colours in the legend. For example, melting land ice (brown) affects Antarctica, Greenland, Iceland, parts of the Arctic, parts of Scandinavia, China, South America, and so on. Have students speculate as to why these areas are affected. (They all have glaciers.)

Learning Check Answers (Student textbook page 205)

1. Answers may vary. For example: Warmer oceans lead to the destruction of coral reefs. Coral reefs protect sea life and depend on algae for food. With warmer waters, corals expel the algae and eventually die of starvation. Increased water temperatures make water molecules move more quickly, so the water expands and sea levels rise. Increased sea levels mean low-lying regions are flooded, forcing humans and animals to find land at higher elevations. Warmer water causes some species to move from their traditional waters to colder regions. Animals that are dependant on these species for food will starve if they cannot also migrate.
2. When sea ice melts, the food chain in aquatic ecosystems change. For example, krill eat plankton that live under sea ice. Less sea ice means fewer plankton and fewer

krill. Krill are eaten by many of sea creatures, including whales. Fewer krill means some of these sea creatures will starve.

3. If oceans continue to warm, the currents of the Gulf Stream will slow down, reducing the steady stream of warmth usually experienced by Europe. As a result, the average temperature of Europe will decrease during the winter months.
4. As the Antarctica gets warmer, species that normally live in warmer regions can adapt to living in Antarctica and will migrate down toward the South Pole.

Activity 3.2 Elephant Seal E-Mail (Student textbook page 205)

Pedagogical Purpose

This activity hones students' abilities to think analytically and consider both sides of a complex issue.

Planning	
Materials	Internet access or research materials BLM A-35 Communication Rubric (optional)
Time	60-90 min in class

Skills Focus

- communicate using appropriate language, in a variety of formats

Activity Notes and Troubleshooting

- You could have students examine the scientists' research methods in more detail before beginning this activity.
- To improve students' understanding of the process of tagging and how harmful it may be to the seals, students could watch the YouTube video of the tagging process. Go to www.scienceontario.ca.
- Reserve time in the computer resource centre or library ahead of time for students to do their research. You may wish to review your school's policy for Internet safety. Ensure that students report any sites that have inappropriate content. You may also wish to review your school's policy on plagiarism with students and remind them that information on the Internet is copyright protected and if copied, is considered plagiarism.
- Students might want to include the IPCC website in their research Go to www.scienceontario.ca for the details.
- Students could work with a partner or in small groups. This activity could be assigned as homework. Ensure that students write a rough draft of the e-mail and submit it for your approval before sending it to the IPCC.
- Alternatively, you may wish to have students work together as a class to compose a class e-mail to the IPCC. Ensure that students contribute their research to the discussion and that all students participate in the e-mail-writing.
- You may wish to use **BLM A-35 Communication Rubric** to assist you in assessing your students. If you plan to assess students' work in this activity, ensure you distribute copies of the assessment criteria beforehand so students are aware of your expectations.

Additional Support

- **DI** Students with linguistic and/or musical intelligences may wish to expand on this activity by composing a poem or a song that conveys their research on this issue. Students may share their composition with the class "live" or in a recorded format.
- **ELL** English language learners may benefit from using a graphic organizer for this activity. **BLM G-48 T-chart** or **BLM G-49 Venn Diagram** may be helpful.
- **DI** To develop interpersonal skills, have students work in small groups for this activity.

Activity 3.2 Answers

Answers may vary. For example:

Pros	Cons
Seals can dive to depths of 2000 m, so researchers can gather a lot of data about the ocean.	Scientists cannot use this method to learn about ocean conditions at depths greater than 2000 m.
There are many seals, so there is an unlimited source of test subjects.	Tagging may be painful and stressful to the seals.
Seals will dive and explore the oceans more efficiently than the underwater technology scientist currently use.	The side effects of the glue used to attach the tags to the seals are not known.
Tagging seals is inexpensive compared to the cost of using humans and equipment to study the ocean.	Scientists cannot determine if tag data are accurate if the tag is malfunctioning or damaged.

E-mails may vary. Students should refer to their tables and justify their reasoning.

Learning Check Answers (Student textbook page 207)

1. Answers may vary. For example: Less rainfall leads to desertification of once arable land. Fewer crops are grown, farmers earn less money, and there is less food for the population. This can lead to food and water shortages, which affect human health. Extreme weather events become more frequent, causing property and crop damage, and flooding. This can result in homelessness, the spread of water-borne diseases, and famine.
2. Permafrost is soil that is at or below 0°C for two or more years. Because of climate change, the ground is thawing and not refreezing. Therefore, the permafrost is not permanent anymore.
3. Answers may vary. For example: Climate change is affecting bird migration. Some birds stop flying south each year because the warmer summer temperatures trick them into thinking the winter will be mild enough to survive. These birds die, leaving a hole in their ecosystems. If they were insect eaters, there will be more insects. These insects might cause destruction to plants or might eat other insects' food, which will affect other species. If the birds were preyed on by other animals, those animals will have less food. The loss of one species will affect all the other species that depend on it, which might lead to the loss of more species. If too many species disappear from an ecosystem, the whole ecosystem might collapse.

Activity 3.3 Worrying about Water (Student textbook page 207)

Pedagogical Purpose

Students develop an appreciation for North America's abundance of fresh water and an understanding of our wasteful water habits.

Planning

Time 15-20 min in class

Skills Focus

- use appropriate modes of representation and units of measurement

Activity Notes and Troubleshooting

- Note: the volume of water to generate 1 kg of rice should be 3000 L not 3400 L as indicated in the first printing of the student textbook.
- You could introduce this activity with a class discussion on water usage. Have students brainstorm when they used water in their daily life from the time they woke up on the morning to the end of the day. Answers could include bathing, using the toilet, preparing food, drinking from the water fountain or drinking bottled water, water added to the car's radiator and so on.
- Students could copy the information into their notebooks and answer the question graphically by drawing lines to connect the quantities.

Additional Support

- Extension—Have students track their daily water use for a period of time, such as one week. Then, have them research how much water they used over that time, and calculate their average annual water usage. Have students compare their water usage to that of a person in an African or South American nation, especially one threatened by desertification. Students can refer to the world map on pages 208 and 209 for this information. Go to www.scienceontario.ca and follow the links for an online water usage calculator and for more information on water usage.
- **ELL** **DI** You may wish to have English language learners or students who are struggling use **BLM 3-13 Activity 3.3 Matching** for this activity.
- Extension—Students could do additional research on the amount of water it takes to produce other foods. Go to www.scienceontario.ca and follow the links.

Activity 3.3 Answers

1 apple = 70 L

1 kg of rice = 3000 L (not 3400 L)

1 kg of soybeans = 1800 L

1 hamburger = 2400 L

1 kg of chicken meat = 3900 L

1 cup of coffee = 140 L

1 L of milk = 1000 L

Learning Check Answers (Student textbook page 209)

1. Climate change is raising sea levels, so the ocean is covering beaches that were normally used as spawning grounds for sea turtles and other species. As a result, fewer of these animals can breed. It is also changing the temperature of the ocean water, causing some fish species to migrate. The animals that depend on the fish for food are often unable to adapt to the loss of their food source and face starvation.
2. Positive effects: more water for crops and a decreased risk of famine
Negative effect: increase in cholera and other water borne diseases
3. Rising sea levels lead to flooding, which can cause property and crop damage, homelessness, injury, death, and disease. Rising sea levels change beaches and other coastal regions, which can lead to a decrease in tourism revenue for countries that offer tropical beach vacations and countries where tourist go to see marine animals such as puffins and seals.

Activity 3.4 How a Hurricane Works (Student textbook page 210)

Pedagogical Purpose

Students use their knowledge of climate change and its effect on storm intensity to conduct an experiment that models the formation of a hurricane.

Planning

Materials	<p>Per group:</p> <p>Pyrex™ test tube Bunsen burner large flat tray tongs china pencil ruler</p> <p>BLM 3-15 Activity 3.4 Data Table (optional) BLM A-1 Making Observations and Inferences Checklist (optional) BLM A-4 Laboratory Report Checklist (optional) BLM A-26 Co-operative Group Work Rubric (optional)</p>
Time	<p>30–40 min in class 60 min preparation</p>
Safety	<p>Only use Pyrex™ test tubes. The sudden temperature changes will cause regular test tubes to shatter. Ensure students follow safety precautions for working with Bunsen burners. Students must wear safety goggles for this activity. Have students tie back loose clothing and long hair. Ensure students are cautious when working with glass. Have a glass clean-up kit available.</p>

Skills Focus

- conduct experiments, using equipment and materials safely and accurately
- draw and justify conclusions

Activity Notes and Troubleshooting

- To conserve materials and time, have students work in small groups for this activity. You can set up stations for students ahead of time to save class time.
- Have students use **BLM 3-15 Activity 3.4 Data Table** to record their answers.
- If you conduct this activity as a demonstration, make sure students are prepared to observe and take notes. If you wish to assess them on their observation skills, use **BLM A-1 Making Observations and Inferences Checklist**. Provide students with a copy of this assessment blackline master beforehand so they are aware of how they will be evaluated.
- To assess students' group work, you can use **BLM A-26 Co-operative Group Work Rubric**. To assess students' individual work, you can use **BLM A-4 Laboratory Report Checklist**.

Additional Support

- **ELL** **DI** English language learners and students with bodily-kinesthetic challenges may prefer to record their findings with diagrams or in their first language.
- **ELL** **DI** Pair English language learners and students with bodily-kinesthetic skills challenges in groups with students who can mentor them.

Activity 3.4 Answers

What Did You Find Out?

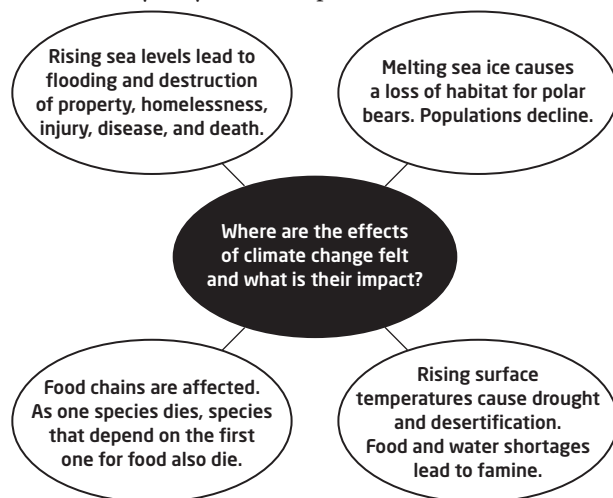
1. independent variable: trial number; dependent variable: height of water
2. Answers may vary. For example: Each time the water was heated, the height of the water in the test tube increased. The heat from the water heated the air, causing the air to expand or move faster. This caused a decrease in air pressure in the test tube and produced a slight vacuum, which sucked the water up.
3. Warmer water would result in a greater storm surge during a hurricane. Warm water increases the temperature of the air around the water. The air expands or moves faster with more space between molecules, causing a decrease in air pressure.
4. A decreased air pressure means that as the warm air mass reaches land, there are fewer molecules for a great volume of space, so a vacuum occurs. This causes water to be pulled up into the air as wind drives the water over the land.

Topic 3.2 Review (Student textbook page 211)

Please see also **BLM 3-16 Topic 3.2 Review (Alternative Format)**.

Answers

1. Answers may vary. For example:



2. Answers may vary. For example: Climate change affects terrestrial ecosystems by increasing precipitation, which causes flooding; decreasing precipitation, which causes desertification; and heating surface temperatures, which cause drought.

3. Bangladesh will experience more flooding owing to rising sea levels and increased storm activity pushing more water onto land.

4. As temperatures increase, water sources dry up, leading to water shortages for countries that are already vulnerable to drought.

5. An increase in storm activity or precipitation can cause flooding. When the flood waters become stagnant, they provide a breeding ground for malaria-carrying mosquitoes.

6. Warmer temperatures could drive away fish that usually live in the Arctic. Fewer fish will mean a loss of revenue for the fisheries.

7. Climate change that causes flooding could be positive if farmers can switch to crops that grow in water, such as rice and soybeans. Flooding would also make people living in that community more aware of the impact of climate change. This might motivate them to change how they live so they contribute less to global warming. Negative effects of flooding include crop loss, damage to property and livestock, and loss of income for farmers.

8. Answers may vary. Canada and China are the two leading food producers in the world. Desertification in these countries will greatly reduce the amount of food available, leading to shortages, increased food prices, economic and social unrest, and possibly famine.

9. a) Other costs could include labour costs, transportation costs, supplies costs, and energy costs.

b) Concept maps could include the following points:

- Goods are transported shorter distances, reducing air pollution and carbon emissions.
- Farmland is used for farming instead of urban use, preserving rural habitats and ecosystems.
- Buying local supports local farmers, which keeps them in business and contributes to the local economy.
- Buying local can reduce the amount of packaging needed and reduces waste in landfill sites.

c) Answers may vary. For example: The 100 km diet is not practical because there are not many locally grown fruits and vegetables in the winter in Ontario. Many foods, such as chocolate, coffee, tea, spices, rice, and fruits like bananas are grown in tropical countries and would be excluded from this diet. Learning to cook locally grown foods might make this diet more practical.