Topic 3.4
What role does Canada play in space exploration?

Specific Expectations

- **D1.1** research the challenges associated with space exploration, and explain the purpose of materials and technologies that were developed to address these challenges and how these materials and technologies are now used in other fields of endeavour
- **D1.2** assess the contributions of Canadians to space exploration

Skills

- identify and locate sources
- draw conclusions
- communicate in a variety of formats
- identify and describe related careers
- identify space scientists, including Canadians

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-46 for a summary of the materials required in this topic.

Overview

In this topic, students will learn about Canadians who contribute to space exploration in a variety of ways, both directly, in the case of astronauts, and indirectly, by developing technology to study space.

Common Misconceptions

- **Students may not realize that many astronauts are Canadian.** Ensure that students are aware of the contributions of Canadian astronauts to space exploration. Have them read page 210 to learn about Canadian astronauts. You may also wish to discuss the space contributions of astronauts from other countries as well.
- **Students may not realize that Canadians have contributed in many different ways to space exploration.** Remind them that there are many careers related to space exploration (for example, astronauts, meteorologists, engineers, scientists, photographers), and that many Canadian companies are involved in space exploration. The Canadian Space Agency has a searchable directory on its website for Canadian companies that are part of Canada's space industry. The directory can be searched by province, type of organization, and type of expertise. Visit **www.scienceontario.ca** for more information.

Background Knowledge

The mission of the *Phoenix Mars Lander* is to determine whether the climate on Mars has ever been suitable for microbes to exist. The Canadian-supplied weather station on board the *Phoenix* will help determine that. It was launched on August 4, 2007, and landed near Mars's northern polar cap on May 25, 2008. The lander exceeded expectations by continuing to operate for over five months instead of its expected 90-day lifespan. The *Phoenix* Mission is the first time that a Canadian contribution landed on Mars.

- Dr. Roberta Bondar is a physician (neurologist), a scientist, an author, a photographer, an inspirational public speaker, and an astronaut. She has published several books of her photography, primarily of Canadian landscapes, but other landscapes as well. (View some of her photographs at **www.scienceontario.ca**.) On her first mission on the *Discovery* space shuttle in 1992, she was Canada's first female astronaut. She is also one of the first six Canadian astronauts.
- Dr. Marc Garneau is a highly skilled and trained engineer. Originally a member of the Canadian Armed Forces, he began his training with NASA in 1992. Dr. Garneau took part in three space missions and has spent over 677 hours in space. He is one of the first six Canadian astronauts.
- Col. Chris Hadfield has degrees in mechanical engineering and aviation. During his time in the Armed Forces, he won awards as a test pilot and did research and development for NASA. Col. Hadfield was one of four new Canadian astronauts, selected in 1992. In 2006, he became Chief of International Space Station Operations at NASA.
- Dr. Steven MacLean is a laser physicist and the president of the Canadian Space Agency. On the mission to install trusses and deploy solar panels on the International Space Station (ISS), he was the first Canadian to operate *Canadarm2* in space. During this same mission, Dr. MacLean also became the second Canadian to walk in space. He too is one of the first six Canadian astronauts.

- Captain Julie Payette has degrees in electrical engineering and computer engineering. Her academic scholarships and awards are too numerous to mention. She received her military captaincy and commercial pilot licence, and was certified as a one-atmosphere, deep-sea diving suit operator. She has sung with the Montréal Symphony Orchestra; the Piacere Vocale in Basel, Switzerland; and the Tafelmusik Baroque Orchestra in Toronto.
- Dr. Robert Thirsk, mechanical engineer and medical doctor, began astronaut training in 1984. He served as backup for Dr. Marc Garneau and then flew many missions, some as crew commander. He received certification as a flight engineer for the Russian *Soyuz* spacecraft at the Yuri Gagarin Russian State Science Research Cosmonaut Training Centre near Moscow. In May, 2009, Dr. Thirsk became the first Canadian to take part in a long-duration (six months) mission, staying on board the ISS as part of the crew of Expedition 20/21.
- Bjarni Tryggvason was born in Iceland and moved to Canada at a young age. He is a pilot and flight instructor with degrees in engineering physics and postgraduate work in engineering with specialization in applied mathematics and fluid dynamics. He was selected as one of Canada's original six astronauts.
- Dr. Dave Williams (Dafydd Rhys Williams) has degrees in science and biology and is a physician and surgeon with particular experience in emergency care. Dr. Williams completed his astronaut training in 1996 and in 2001 became the first Canadian astronaut **and** aquanaut. Dr. Williams is also the first Canadian to receive NASA's Outstanding Leadership medal.

Students can visit **www.scienceontario.ca** for more information about these Canadian astronauts.

Literacy Strategies

Before Reading

- Have students consider page 211. Ask why they think this page looks different from the other pages. Ask, "What was the designer's intention?" (It is designed to look like a magazine.)
- Have students read the headings for the articles on page 211. Ask them to predict, based on the headings, what each article is about. Have them record their predictions, and then read the articles. Were their predictions correct? Have them write a different heading for one of the articles that is more descriptive of its content.
- Have students consider the title for the third article on page 211, "Earth, We Stand on Guard for Thee." Ask, "What does this heading refer to?" (*O Canada*) Ask students why the author may have chosen to refer to Canada's national anthem in this way. (The article refers to guarding, not just Canada, but Earth; using *O Canada* gets attention and emphasizes the fact that this topic is about Canadian contributions.)

During Reading

- Draw students' attention to the many acronyms and initialisms in this topic (MOST, NEOSSat, ISS, NASA, and so on). Explain that an acronym is a word formed from the first letter or letters of a name or a group of words, for example, radar is *r*adio *d*etection *a*nd *r*anging. An initialism is a group of letters from a name or a group of words, which are used as an abbreviation, but with each letter pronounced separately, for example, CBC and CEO. Ask students why people use acronyms and initialisms. (It is an easy way to refer to long or complicated names that are used often.) Have them create an acronym or an initialism for Topic 3.4, for example, CRISE (Canada's Role in Space Exploration). Have students create a personal glossary of each acronym and initialism that they find in the topic. Students can use **BLM 3-20 Personal Glossary** for this activity.

- ELL Assess if students understand how to use a dictionary correctly. Help English language learners by bringing attention to the multiple meanings of words and the importance of context in determining meaning. Have them choose five unfamiliar words from Topic 3.4 and record what they think the definition of the word would be, taken from the context. Then, have them look up each word in the dictionary and record the definition in their personal glossary.

After Reading

- Topic 3.4 is already "chunked" for students. After they read each "chunk," have students write a one- or two-sentence summary.
- After reading the article "Let's Boast the MOST" on page 211, ask why the astronomer thinks Canadian children are his collaborators. Ask students what "Betelgeuse" means to them. (the 1988 Tim Burton film *Beetlejuice*; a nearby planet to the home of Ford Prefect, a character from Douglas Adams' *The Hitchhiker's Guide to the Galaxy*; the bright star in the Orion constellation)
- Enrichment—Provide a collection of different dictionaries for students, including on-line dictionaries. Have them select one or two of the five unfamiliar words that they looked up as they read, and ask them to look up the words in each dictionary. Are the definitions all the same? Why or why not?
  - ELL You might have English language learners use a dictionary in their first language and look up the words in it. They can translate the definitions into English and compare them to the definitions in the other English dictionaries.
- Enrichment—Students could select the three contributions they think are the most important and be prepared to defend their choices in a class discussion.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Learning Check question 3, page 211	Students identify the space capsule that carried the first American into space, the 1839 observatory built to study magnetic fields, *Canadarm2*, and *MOST* as Canadian contributions to space explorations.	• Have students reread copies of pages 210 and 211. Have them use sticky notes to mark the four contributions.
Activity 3.13, page 210	Students' research reveals the answers to the questions listed in a clear, organized format.	• Have students use **BLM 3-21 We Grow Astronauts, Too** to help them answer the puzzle-questions.
Topic 3.4 Review, question 1, page 217	Students describe four examples of Canadian contributions to space exploration using appropriate terminology.	• Provide students with a graphic organizer, such as **BLM G-33 Concept Map, BLM G-34 Flowchart**, **BLM G-35 Main Idea Web**, or **BLM G-36 Spider Map** to help them organize their answers.

Topic 3.4 (Student textbook pages 208–219)

Using the Topic Opener (Student textbook pages 208–209)

- Download the latest weather report from the *Phoenix Mars Lander* from **www.scienceontario.ca**. Bring in the weather report for your area as well, and display both reports for the class. Begin a class discussion on the importance of knowing weather conditions on Earth and on Mars. Ask, "Why do scientists want to know the weather on another planet?" (It is the first step in determining if there was ever life on that planet. Also, it is an important part of finding out how to get people to Mars.)
- Have students read the opening paragraph. Explain to students that the *Phoenix Mars Lander* contains the first Canadian technology to ever land on another planet.
- Have students read paragraphs 2 and 3, and then assign the Starting Point Activity.

Starting Point Activity (Student textbook page 209)

Pedagogical Purpose

Students consider what characteristics of particular planets would most interest researchers (for example, atmospheric conditions on Venus or the composition of the dark spot on Neptune). Then, they design logos that suit a mission to that planet.

Planning	
Materials	Paper Coloured markers or pencil crayons Computers with graphics program (optional)
Time	40–60 min in class

Skills Focus

- communicate in a variety of formats

Background Knowledge

The eight planets in our solar system each have distinct characteristics. Mercury is the smallest planet, and has an almost non-existent atmosphere, although it does have water vapour. Venus is the hottest planet with an average temperature of 457°C. Earth's atmosphere includes mostly nitrogen and oxygen, and some carbon dioxide, and it is the only planet known to have life. Mars is called the red planet due to rust in its soil, and its temperature ranges from –140°C to 20°C. Jupiter is the largest planet with a diameter of 142 800 km. Saturn has rings around it, and its atmosphere is mostly hydrogen and helium. Uranus is called the tilted planet because its axis is tilted about 90 degrees. Neptune is called the deep-blue planet, and its atmosphere is mostly hydrogen and helium with a small amount of methane.

Activity Notes and Troubleshooting

- Before beginning the activity, have students reread paragraph 3 on page 208. Then, have students study the logo. Ask why the "o" in *phoenix* has an arrow on it. (It is the symbol for Mars.) Ask why the phoenix may have been chosen to represent the mission. (A phoenix is a symbol of rebirth, renewal, and new life.)
- Students can work with a partner or in small groups for this activity.
- Have students select a planet first, then brainstorm characteristics that a mission might focus on. After selecting a mission, then have students brainstorm design ideas.
- Encourage students to refer to Topic 3.3 for details on the planets in our solar system.

Additional Support

- Students with fine motor challenges may prefer to use a computer graphics program to create their logos.
- ELL English language learners should enjoy this activity. They may benefit from having the instructions read aloud or from working with a classmate who has strong reading skills. Encourage the use of gestures by the reader, which will add meaning to unfamiliar words.
- DI Pair spatial learners with students who are having trouble coming up with design ideas.

Answers

Students' logos should clearly show their knowledge and understanding of the planet's characteristics, and how the mission relates to the planet.

Instructional Strategies for Topic 3.4

Canada contributes people and technology to explore space.

(Student textbook pages 210–211)

- Before reading, have students preview the photographs on this spread. Encourage them to discuss what they think this section will be about. Then have them read the opening paragraph.
- Ask students what countries are involved in space exploration. Make a list on the board or on chart paper. Explain that more than 80 countries are now involved in exploring space and developing technologies used to explore space. In the 1950s, very few countries were involved—only the United States and Russia, and they were in competition with each other. Now, many countries are involved and are co-operating. In fact, the ISS is testimony to what can be accomplished with co-operation between nations. Canada, the United States, Japan, Russia, and 11 countries represented by the European Space Agency worked together to build and inhabit the ISS.
- Before students read "Earth, We Stand on Guard for Thee" on page 211, have them review Topic 3.3 on asteroids and meteoroids.
- ELL Have students collect and bring in news articles about recent missions involving Canadian astronauts. Post the articles on a class bulletin board. Encourage English language learners to share what they know about space exploration from their country of origin, as well.
- DI Activity 3.13 on page 210 and Activity 3.14 on page 213 are both research-based projects. You may wish to choose one for individual work and one for partner or group work, and assess them appropriately. Activity 3.13 may be more suited to group work as each student could focus on a few questions, or a few astronauts, only. For Activity 3.13, you might group linguistic learners with students who are struggling. Ensure that students are delegating work appropriately.

Canada helps build the future of space exploration.

(Student textbook pages 212–213)

- As a class, read the opening paragraph on page 212. Then, have students read the "Canadarm2," "Dextre," and "Mobile Base System" articles on pages 212 and 213.
  - DI Have students work with a partner to summarize the articles, with one partner summarizing one article and the other partner summarizing the other. Then, have the partners share notes. It would be beneficial for linguistic learners to work with students who need assistance.
  - DI Bodily-kinesthetic learners will enjoy learning about robotics that mimic human movements. Have students observe their own shoulder, elbow, and wrist movements and joints, and consider what technology would be required to mimic these motions. Consider assigning Investigation 3B on page 216 at this time to reinforce the idea that making robots to mimic human movement is extremely difficult.
  - You may wish to have students read Science at Work on pages 218 and 219, and complete the questions before they begin answering the Topic 3.4 Review questions.

Activity 3.13 We Grow Astronauts, Too (Student textbook page 210)

Pedagogical Purpose

Students will learn about the contributions of Canadian astronauts to space exploration.

Planning	
Materials	Access to the library and the Internet **BLM 3-21 We Grow Astronauts, Too** (optional) **BLM G-4 Group Roles** (optional) **BLM G-12 Scientific Research Planner** (optional) **BLM G-14 Research Worksheet** (optional)
Time	120 min in class 60 min for research 60 min for recording and presenting One week before this activity, reserve time at your school's resource centre for students to conduct their research.

Skills Focus

- identify the contributions of space scientists, including Canadians
- identify relevant print sources
- communicate ideas

Background Knowledge

Canada's astronauts include Dr. Roberta Bondar, who is also a physician, an author, a photographer, and an inspirational speaker; Dr. Marc Garneau, who has spent over 677 hours in space; Col. Chris Hadfield, who became Chief of International Space Station Operations at NASA in 2006; Dr. Steven MacLean, who is the president of the Canadian Space Agency and was the first Canadian to operate *Canadarm2* in space; Captain Julie Payette, who received her military captaincy and her commercial pilot license, is certified as a one-atmosphere, deep-sea diving suit operator, and has sung with many well-known orchestras; Dr. Robert Thirsk, who was the first Canadian to take part in a long-duration mission onboard the ISS on Expedition 20/21; Bjarni Tryggvason, who was born in Iceland and moved to Canada at a young age, becoming a pilot and flight instructor as well as one of Canada's original six astronauts; and Dr. Dave Williams, who was the first Canadian to receive NASA's Outstanding Leadership medal.

Activity Notes and Troubleshooting

- You could assign this activity as homework or as a topic project. To help students organize their research, you could distribute **BLM G-12 Scientific Research Planner** or **BLM G-14 Research Worksheet** to them before they begin. Read through the blackline master with students to familiarize them with it.
- You could assign this activity as a group project. Ensure students delegate the workload fairly so all members will contribute equally. Have students refer to **BLM G-4 Group Roles** to help them organize their groups.
- You might choose to have students present their findings to the class. Encourage them to find creative ways to share their findings.
- Caution students who plan to research Dr. Dave Williams that an Internet search may reveal several people with the same name and to check their sources carefully.
- Students can use **BLM 3-21 We Grow Astronauts, Too** to help them answer the questions.

Additional Support

- DI All students will enjoy the opportunity to present their findings using a method of their choice. Spatial learners may choose to create a visual presentation, and linguistic learners may choose to create a written or verbal presentation.
- ELL Encourage English language learners to use graphic organizers to help them present their research. Ensure their choice of organizer is suitable.
- ELL Library and Internet research may be challenging to some English language learners. Pair these students with students who have strong literacy and research skills.
- DI Enrichment—Have interested students and students with musical intelligence research the rock band Max Q, whose members are all NASA astronauts. Have them find out what "Max Q" stands for, determine what roles Canadian astronauts play, and listen to a sample of their music. They can begin their search at **www.scienceontario.ca**.

Activity 3.13 Answers

- Who knows all about Moon trees? (Dave Williams)
- Who has done missions in inner space (underwater) as well as in outer space? (Julie Payette)
- Who has made more trips to space than any other Canadian astronaut? (Marc Garneau)
- Who was the first Canadian to walk in space? (Chris Hadfield)
- Who has a passion for taking photos of Earth from ground level as well as from space? (Roberta Bondar)
- Who was the first Canadian to operate the *Canadarm2* robotic arm? (Steven MacLean)
- Who was the first Canadian to board the International Space Station? (Robert Thirsk)
- Who was the first Canadian trained as a mission specialist for both the space shuttle and the International Space Station? (Bjarni Tryggvason)

When students choose one astronaut to explore in greater detail, they should present their research clearly and accurately by choosing an appropriate presentation format.

Learning Check Answers (Student textbook page 211)

1. The *Phoenix Mars Lander* includes Canadian weather technology designed to study Mars's polar climate.
2. *NEOSSat* (Near-Earth Object Surveillance Satellite) is a small telescope-equipped satellite used to monitor asteroids and provide an early warning of possible asteroid collisions with Earth.
3. Students' answers could include any four of the following:
   - Canadian scientists and engineers helped design the space capsule that carried the first American astronaut into space.
   - The oldest scientific institution in Canada was an observatory built to study Earth's magnetic field.
   - Canada built and launched the third satellite to orbit Earth.
   - Canadians designed, built, and operated the robotic arms *Canadarm* and *Canadarm2*.
   - Canada designed a weather station on the *Phoenix Mars Lander*.
   - Canada designed the *MOST* satellite to study the inside of stars such as the Sun.
   - The Canadian *NEOSSat* satellite tracks asteroids that could collide with Earth.

Learning Check Answers (Student textbook page 213)

1. The three Canadian-made components of the Mobile Base System are a moveable platform that acts as a base for *Canadarm2* and *Dextre,* a work platform and storage area for astronauts on space walks, and a track system that covers the length of the ISS.
2. *Canadarm* retrieved and released satellites from the space shuttle. *Canadarm2* is installed on the ISS, is larger and more flexible that *Canadarm;* can reach most outer parts of the ISS; and has helped build and maintain the space station. It provides a stable platform for astronauts to perform tasks in space, and has advanced vision systems and touch sensors so it can be controlled from inside the station or by remote control.
3. The jointed arms of this robot let *Dextre* perform tasks that could once only be completed by astronauts outside of the ISS. It is much safer for the astronauts to remain inside the ISS than to it is for them to be walking or working in space.

Activity 3.14 Canadians Exploring Space (Student textbook page 213)

Pedagogical Purpose

Students build on their knowledge of Canada as a contributor of people and technology to the exploration of space.

Planning	
Materials	Access to the library and Internet **BLM G-12 Scientific Research Planner** (optional) **BLM G-13 Citing Sources** (optional) **BLM G-14 Research Worksheet** (optional) **BLM G-33 Concept Map** (optional) **BLM G-34 Flowchart** (optional) **BLM G-35 Main Idea Web** (optional) **BLM G-36 Spider Map** (optional) **BLM A-11 Concept Map Checklist** (optional)
Time	60 min in class A week beforehand, reserve your school's resource centre. Several weeks beforehand, research a list of Canada's space exploration contributing organizations for students to choose from.

Skills Focus

- identify and locate sources
- communicate in a variety of formats

Background Knowledge

Many government agencies (such as the Canadian Space Agency), educational establishments (such as the University of Toronto Institute for Aerospace Studies, or UTIAS), research companies (such as the Institute for Space and Atmospheric Studies in Saskatoon), and media organizations (such as SpaceRef Canada) are involved in space exploration. A list of resources can be found at **www.scienceontario.ca**.

Activity Notes and Troubleshooting

- The scope of available information for this activity is vast. There are hundreds of companies, research facilities, government agencies and programs, and universities and colleges that are involved in the space industry. For example, there are 35 Canadian universities that offer space-related programs. Refer to the information provided in Background Knowledge to compile a reasonable list of Canadian organizations. You may even want to limit the searches to Ontario only. When doing an Internet search, you could use key words such as *Canada, aerospace, space technologies, satellite communications, navigation systems, space robotics, automation, Earth observation,* and *remote sensing.*
- Students may have specific companies or organizations in mind that may not appear on your master list. If possible, accommodate any reasonable request.
- For example, the Canadian Space Agency operates the David Florida Laboratory. Located in Ottawa, this facility specializes in spacecraft assembly, integration, and testing, and is considered world-class.
- To assist students with their Internet research, you could distribute **BLM G-12 Scientific Research Planner**, **BLM G-13 Citing Sources**, and **BLM G-14 Research Worksheet**.
- If students are struggling with how to present their information, direct them to the Literacy Skills Toolkit 5: Organizing Your Learning: Using Graphic Organizers on page 390 of the student textbook.
- Have students work with a partner for this activity.
- If you plan to assess students' work for this activity, you may wish to use **BLM A-11 Concept Map Checklist** to assist you. This blackline master can be adapted to suit other graphic organizers for assessment, if necessary.
- Have students cite sources they used at the end of their presentation.

Additional Support

- You could provide a graphic organizer for students who are struggling to organize their work. Several blackline masters are available to assist students: **BLM G-33 Concept Map**, **BLM G-34 Flowchart**, **BLM G-35 Main Idea Web**, and **BLM G-36 Spider Map**.
- ELL English language learners may struggle with the volume of information available on the Internet. You might choose to prepare one or two options, such as the Canadian Space Agency or the University of Ontario Institute of Technology (UOIT), and provide printouts for students to work through with a highlighter, or have them visit only these specific websites. Provide these students with a list of important questions to answer with their research, such as What kind of organization is it? What do they do? Why is it important?
- DI Logical-mathematical students will enjoy finding and organizing information for this activity. These students can share their strategies with other students who are having difficulty.

Activity 3.14 Answers

Students' methods of presentation should be clear and organized. The information they include should be accurate and appropriate, and sources should be listed.

Using Strange Tales

The Phantom Torso (Student textbook pages 214–215)

Literacy Support

Before Reading

- For students who are unfamiliar with the comic-book format, photocopy this section for them. Using a marker, draw arrows between the call-outs to show the order in which students should be reading them. Alternatively, you could number the call-outs 1, 2, 3, and so on. Point out that the text in the beige boxes is narrative and background information that sets the scene for the story. The information in the white word balloons is spoken text. The reader can tell who is speaking by where the arrows point. You might relate this concept to quotation marks used in text to indicate spoken words.
- Some students will enjoy the reading in this section because it is in a comic-book format. You can pair these students with others who are having difficulty with the style.

During Reading

- Ask students to explain how you can tell what to read and when. Ask, "What clues has the artist and designer used to show you how the text flows?" (left-to-right flow, overlapping text boxes, word balloon arrows)
- Refer students to the image of the delivery workers in the lower right panel on page 214. Ask, "What has the artist done to convey that these workers are surprised?" (open mouths and little dashes around their heads). Explain that this is a common style used in comic books to show surprise.
- Have students consider the image of the news reporter on page 215. Ask them what the artist did to show that it was a news reporter. (front view of person, person sitting at a desk, box with curved edges behind him looks like a video monitor, TV station call-out on bottom right of image)
- You might invite confident readers to read aloud this story and assign parts for them to role-play. Hearing the story read in this format may help others who are unfamiliar with the style.

After Reading

- Ask students to guess what country the artist might be from. Ask them to look at the images for clues. (The title shows red, white, and blue with a star, similar to the American flag; the TV station call-out is an American station; and both astronauts on page 215 have visible American flags on their sleeves.) Conduct a class discussion on whether students' findings constitute bias or a realistic view of a space shuttle mission. (Since *Atlantis* is an American space shuttle, it is reasonable to show a newscaster from an American news station; however, astronauts who are not American could have also been represented, rather than showing only American astronauts. In actual fact, the artist is British; however, students may still feel that American bias is shown.)

Instructional Strategies

- Have students read through pages 214 and 215 individually. You could assign the questions as homework. (Or you may decide to assign both the reading and the questions as homework.)
- Enrichment—Have interested students learn more about the Phantom Torso and report their findings to the class. They could present their report in a format of their choice, such as a recorded video, a poem, a song, or a poster.
- DI Enrichment—Spatial learners and other artistic students might like to create their own comic-book story about space exploration. Have them choose one of Canada's contributions to space exploration and present the information in the form of a comic-book story.

Answers

1. The human torso has to have human components in order to successfully measure the amount of radiation that enters the human body during space travel.
2. The radiation that can harm astronauts in space includes galactic cosmic rays, particles of high energy and high charge, protons, and neutrons. Space radiation produces more complex DNA that may lead to health risks.
3. Students' designs will vary, but their plans should be well thought out and provide an accurate form of testing.

Investigation 3B You, Robot (Student textbook page 216)

Pedagogical Purpose

Students investigate the need for robots in space exploration and the challenges of doing simple tasks in space.

Planning	
Materials	tongue depressor heavy gloves masking tape two pairs of pliers blindfold shoes with laces stopwatch **BLM 3-22 Investigation 3B, You, Robot**
Time	40–60 min in class Remind students several days before and the day before to wear or bring shoes with laces for this investigation.
Safety	Ensure that students take care not to walk around while wearing blindfolds. Have students keep pliers away from their faces and use the pliers responsibly. Pliers can pinch and even cut when handled poorly. Remind students not to put the tongue depressors into their mouths.

Skills Focus

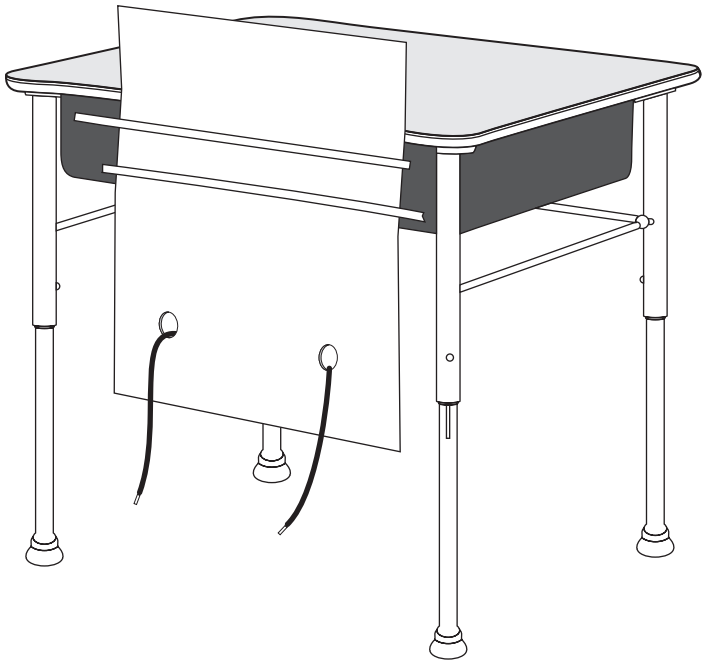
- perform inquiries
- draw conclusions

Background Knowledge

Astronauts must wear space suits to protect them from radiation and the heat, cold, and vacuum of space. Early suits were thin and flexible, but NASA is developing new hard suits that will be more comfortable for astronauts in the future, especially for missions to Mars. A detailed look at the development of the space suit can be found at **www.scienceontario.ca**.

Activity Notes and Troubleshooting

- Students could work in small groups for this activity to conserve materials.
- Dollar stores and garden or home centres will have inexpensive gardening gloves or work gloves. You may also wish to have students bring their own gloves or mittens from home for this activity, depending on the time of year. The bulkier gloves or even mittens are preferable for this activity. If the gloves seem too thin, have students wear two pairs at a time to make them more bulky.
- Using blunt pliers is preferable to using needle-nose pliers. Needle-nose pliers will provide additional control and also be more prone to accidents if students do not take care.
- It might be helpful to provide a standard presentation of the shoelaces for this investigation. For each pair or group, use a heavy piece of cardboard with two holes punched through. Thread a shoelace through the holes so the two long ends are facing the students and the lace is looped securely on the cardboard. Secure the piece of cardboard to provide resistance for when students are tying the lace. Ensure all the laces are equal length.



- You may wish to set up trial stations for this investigation and have students rotate through the stations.

Additional Support

- Students with fine motor challenges will find this activity challenging. Allow them the opportunity to act as a scribe or official timer for their group.
- ELL Ensure that English language learners and others understand the reason for the investigation and what they are learning. Ask them to paraphrase what they understand.
- DI Students with bodily-kinesthetic intelligence will enjoy the physicality of this activity. If they are very enthusiastic, encourage them to try other tasks as an entension. They could try doing a simple calculator computation or writing their name on a piece of paper.

Answers

What Did You Find Out?

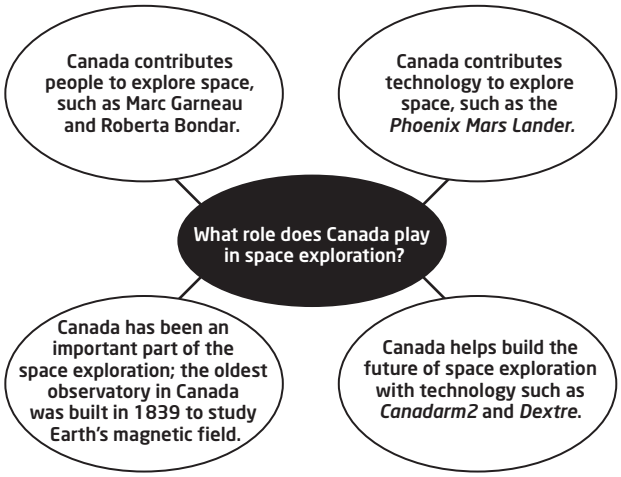
1. Students will likely find that their impaired abilities made the task take longer to complete. Some students may find that wearing gloves, taping tongue depressors to their fingers, or holding pliers hindered their ability to tie the laces more than the blindfold.
2. Students may say that although the robot may experience the same difficulties that they did, or even more (that is, increased time to complete a task; awkwardness; possibility for error), outer space is extremely dangerous so it is safer to send robots than to send humans.

Topic 3.4 Review (Student textbook page 217)

Please see **also BLM 3-23 Topic 3.4 Review (Alternative Format)**.

Answers

1.



2.

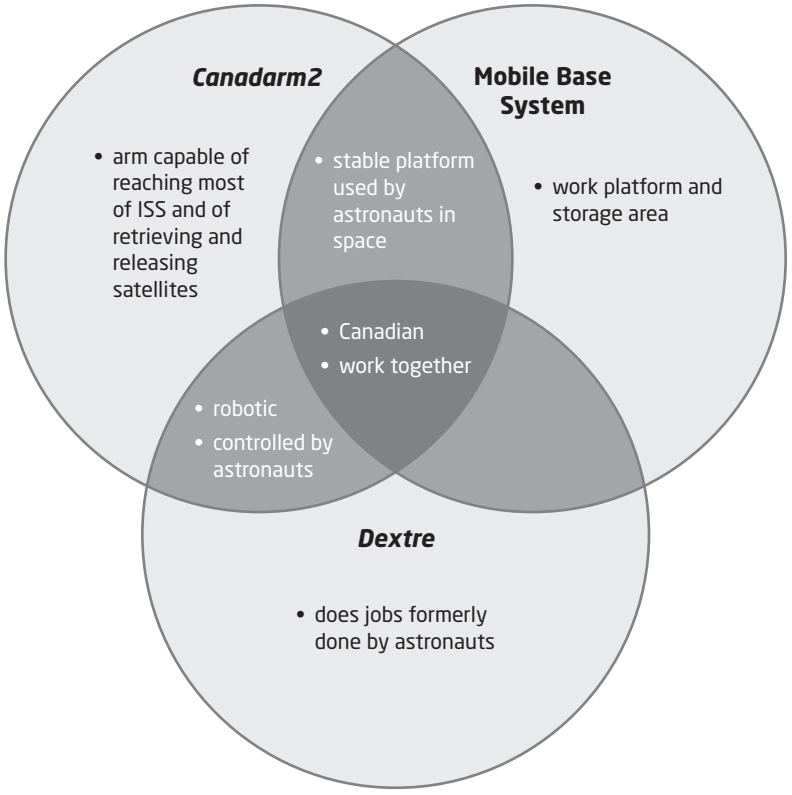
Canadian Astronauts on Space Missions

Astronaut	Mission	Mission Date	Launch Vehicle
Marc Garneau	• STS-41-G • STS-77 • STS-97	• October 5 to October 13, 1984 • May 19 to May 29, 1996 • November 30 to December 11, 2000	• Space Shuttle *Challenger* • Space Shuttle *Endeavour* • Space Shuttle *Endeavour*
Roberta Bondar	• STS-42	• January 22 to January 30, 1992	• Space Shuttle *Discovery*
Steven MacLean	• STS-52 • STS-115	• October 22 to November 1, 1992 • September 9 to September 21, 2005	• Space Shuttle *Columbia* • Space Shuttle *Atlantis*
Chris Hadfield	• STS-74 • STS-100	• November 12 to November 20, 1995 • April 19 to May 1, 2001	• Space Shuttle *Atlantis* • Space Shuttle *Endeavour*
Robert Thirsk	• STS-78 • Russian Soyuz Flight TAM-6/10S • Expedition 20/21	• June 20 to July 7, 1996 • April 15 to April 25, 2005 • May 2009	• Space Shuttle *Columbia* • *Soyuz* Spacecraft • *Soyuz* Spacecraft
Bjarni Tryggvason	• STS-85	• August 7 to August 19, 1997	• Space Shuttle *Discovery*
Dave Williams	• STS-90 • STS-118	• April 17 to May 3, 1998 • August 8 to August 21, 2007	• Space Shuttle *Columbia* • Space Shuttle *Endeavour*
Julie Payette	• STS-96 • STS-127	• May 27 to June 6, 1999 • July 15, 2009	• Space Shuttle *Discovery* • Space Shuttle *Endeavour*

3. Students may include any of the following:

Observation Satellites	Communications Satellites	Exploratory Satellites
RADARSAT-1	MSAT	ALOUETTE I
RADARSAT-2	NIMIK	ALOUETTE II
RADARSAT Constellation	ANIK A	CASSIOPE
SCISAT	ANIK B	MOST
ODIN	ANIK C	HERSCHEL
CLOUDSAT	ANIK D	INTERBALL-2
ENVISAT	ANIK E	JWST
TERRA	ANIK F1	FUSE
UARS	ANIK F2	NOZOMI
VIKING		PHOENIX
		PLANCK
		AKEBONO
		ISIS I
		ISIS II

4.



5. a) Students' answers will vary, but they may say that their life would be affected because their cellphones and the Internet would not work. They also would not be able to watch TV or listen to the radio.

b) Students' answers will vary, but they may mention that the benefits of the camera outweigh the costs of developing it because of the importance of communications in today's world (for example, safety and economy).

6. Students should make reference to the concepts they have learned in this topic, for example, studying weather patterns to investigate the possibility of life on other planets. They may also mention space travel for tourists or building another International Space Station on the Moon.

7. Students' answers could include global warming, melting glaciers/ice sheets, spread of pine beetles in Canadian forests, and environmental disasters such as oil spills, erosion problems in agricultural areas, and flooding.

Using Science at Work

Canadians in Science (Student textbook pages 218–219)

Literacy Strategies

Before Reading

- Engage students in a discussion about what this section will be about. Ask them if they know what a digital compositor does (puts together images to make one final image), and how they think this career is related to space exploration. (Since it is not easy to get to outer space to capture images that correspond to research and discoveries, a digital compositor can put together other images to show a concept or phenomenon.
- ELL To benefit English language learners, try to find pictures that show, or are related to, the careers listed on page 219, and post them, with labels, in the classroom.

During Reading

- To help students understand the question-and-answer section, have students role-play. Working with a partner, have students take on the roles of the interviewer and Jason Kolodziejczak. They may wish to write out their notes or simply use the text.
- Students may struggle with the pronunciation of the name Jason Kolodziejczak. Break down the name for students into manageable parts: kolo/dzie/jczak. Jason writes, "As for my name, well, the easiest phonetically is cola-jay-chuck."

After Reading

- For question 1 on page 219, as a continuation of the role-play, students could script their questions for Jason Kolodziejczak, and work with a partner to role-play their questions and (possible) answers.
- Have students consider the graphic organizer on page 219. Ask students to assess whether this graphic organizer is an appropriate choice to display this information. What might they have done differently? If the statement were switched to "These careers and many more contributed to the study of space," how might the organizer be arranged? (Perhaps the word *space* could be in the centre, with arrows pointing out to the careers listed around the outside of the circle.)

Instructional Strategies

- Have students read the opening paragraph to themselves. Or, read it aloud to the class.
- Begin a class discussion about Jason's work. Ask students if computer graphics, animation, or visual effects are things that they are interested in or have thought about possibly pursuing in a career.
- If possible, arrange for a viewing of the documentary *Planet Storm*. The movie is available through the Discovery Channel for under $10. Or, encourage students to see the movie at home. Perhaps ask one or two students to view the movie and prepare a summary for the class.

- Footage of Earth dust devils and comparisons to Martian dust devils are available for viewing at **www.scienceontario.ca**. Some of the special effects on this footage were created by Jason Kolodziejczak. Arrange to view some video clips with the class. Ask why it is important for scientists to understand dust devils on Earth and on Mars. Ask, "What do scientists hope to accomplish?"
- Assign the Over to You questions. For question 3, students will need access to the Internet. Reserve your school's resource centre or computer lab for students to research a career in space science.
- Ask students in what ways they think that visual effects would be useful for space exploration. Have them brainstorm ways in which this "movie" technology could be useful for space explorers and exploration. (simulation machines for astronauts, presentations to gain funding or at science exhibits to teach people about space, to help scientists and astronauts understand what things would look like on other planets or celestial bodies, or even on the ISS or in space ships). Create a concept map or another type of graphic organizer on which students can add their ideas, either using words or sketches.

Answers

1. Students' answers will vary, but they might want to ask Jason about how he became interested in this career and the path he took to get to where he is now.
2. Digital compositors should have good problem-solving skills because they use complex computer programs.
3. Students may choose a variety of careers to research, including astronauts, pilots, engineers, meteorologists, and photographers.