Topic 3.5
How do we benefit from space exploration?

Overview

In this topic, students will learn about some of the many ways space exploration impacts our lives and ideas today. They will explore and develop their own ideas about the benefits and risks involved in space exploration.

Common Misconception

- **Students may think that space exploration is only for adventure.** Explain that although exploring space is exciting, there are many ways space exploration is useful to humanity. It has allowed us to learn many things about Earth, led to medical advances, and led to a huge variety of consumer products that we use every day. You may wish to have students look back at their notes about Canadian astronauts in Topic 3.4 and consider why so many astronauts have medical degrees.

Background Knowledge

Biomimicry is not a new concept, but has recently become more popular. It involves looking to nature for inspiration on how to improve human products or systems, or how to solve human problems. Examples of biomimicry include light-refracting paints inspired by peacock feathers, buildings that stay cool without air conditioning that are based on termite mounds, and airplane wings designed to mimic the wings of birds. A familiar example of biomimicry that was also used in space exploration is Velcro®. Velcro® was inspired by the hook shapes of burrs that "stick" to clothing. In the space program in the 1960s, Velcro® was designed for astronaut's space suits as they were not able to manage complex fasteners wearing bulky gloves.

Terraforming is the term used for transforming a planet or moon into a life-sustaining environment. There are scientists who believe that Mars could be terraformed within 100 years. One theory involves melting Mars's polar ice caps, and releasing the trapped carbon dioxide, a greenhouse gas, into the atmosphere. Like on Earth and Venus, large quantities of carbon dioxide in the atmosphere would trap heat on Mars' surface and warm up the atmosphere. Once Mars is warm enough, the introduction of simple and rugged plant life would release oxygen and nitrogen into Mars's atmosphere. Terraforming Titan, Saturn's largest moon, would be more difficult, due to its high concentration of methane and its distance from the Sun.

The mammoth-ivory carving shown on page 226 was discovered in 1979 in Germany. Carbon dating suggests it is between 32 500 and 38 000 years old. The carving is very small: 38 mm × 14 mm × 4 mm. There are notches along the sides and on the back of the carving that some scientists believe are star charts—maps of the stars. The earliest known lunar calendar was found in caves in southern France. Spectacular paintings of bulls and horses are intertwined with a series of dots. One series shows 29 dots representing the complete phases of the Moon. Another painting shows 13 dots and one empty square representing when the Moon is in its new Moon phase and absent from the night sky. The cave paintings also include star charts that show important star clusters, such as the Pleiades.

More information, including information about the history of space exploration, can be found at **www.scienceontario.ca**.

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
- **D3.6** describe the role of celestial objects in the traditions and beliefs of selected cultures and civilizations

Skills

- identify and locate sources
- select, organize, and record relevant information
- draw conclusions

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.

Literacy Strategies

Before Reading

- Have students preview the text features in the topic before reading. Ask them to flip through the pages and record the headings that appear at the top of each spread in their notebooks. Under each heading, have them scan the images and sidebars and write a prediction of what information each spread will cover.
- DI To engage students' spatial reasoning abilities, have students turn to pages 222 and 223. Ask, "Is the information easier or harder to read because of the design?" "What do you think the artist is trying to convey with this design?"

During Reading

- Have students read the Key Concepts on page 220. Or, read the Key Concepts aloud to the class. Split the class into three groups, one for each Key Concept (or have students choose their favourite Key Concept). Have students make notes as they read though the topic that relate to their chosen Key Concept. For review, have each group of students share their notes in a form of their choosing with the rest of the class.
- ELL To benefit English language learners, have students read each numbered box on pages 222 and 223 separately, and then write jot notes to summarize the key information that relates to space exploration. For example, for box 1, students might write "watch—quartz crystals, used on first Moon mission." You might also provide photocopies of these pages so students can highlight the technology terms.
- The text on pages 224 to 227 is chunked by green subheadings. Encourage students to use these subheadings as pauses and to write jot notes to summarize the key information as they read.

After Reading

- Have students review the notes that they made before reading. Were their predictions accurate? Have them analyze any errors to discover where they went wrong. If they found a title confusing, how could they rewrite it to be clearer? If an image led them astray, which image would be a better choice?

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Learning Check question 3, page 223	This is an STSE-related question. Students name two space spinoffs and describe how they have affected society in a positive (or negative) way.	• Provide copies of **BLM 3-24 Space Spinoffs** to help support students. • English language learners could use diagrams in their explanations. You might also choose to bring in real objects to explore and discuss the spinoffs.

Activity 3.15, page 224
Activity 3.16, page 225
	Students state their opinions as either for or against space exploration, list their reasons clearly, and support their opinions with clear evidence.	• Assign Activity 3.15 as group research and use it to build and reinforce skills such as:
		  • stating opinions clearly
		  • gathering supporting data
		  • listing reasons for an opinion
		Then assign Activity 3.16.
		• Have students use **BLM G-14 Research Worksheet, BLM G-15 Worksheet for Investigating Issues,** and **BLM G-16 Decision-Making Organizer** to help them organize their thoughts and ensure they have evidence to support their opinions.

Learning Check question 3, page 227	Students compare ancient and modern explorers.	• Have students use a Venn diagram, or **BLM G-38 Venn Diagram,** to organize their answers.

Topic 3.5
How do we benefit from space exploration?

(Student textbook pages 220–229)

Using the Topic Opener (Student textbook pages 220–221)

- Begin by creating a large concept map together to show all the ways students can think of that space exploration has changed our lives. Include both positive and negative effects. As they work through the topic, encourage students to suggest additions and modifications to the concept map.
- Explain to students that this topic is about science and technology developed for space exploration, which has also been useful to society. We use many of these products, like the sunglasses shown in the topic opener image, in our daily lives.
- Ask students to consider how scientists were able to study the fluid in the eyes of raptors. Ask them if they think any of the birds were harmed, and how they feel about this possibility. Then ask if it is important whether some of the raptors that were studied were endangered species. Finally, ask students if they would use a product, even an excellent one, if they knew it was the result of studies like this. This discussion may raise some strong emotions. Ensure that the discussion remains respectful and supportive of all points of view. Explain that this may be one of the costs of space exploration and other scientific pursuits, which needs to be considered. Tell students that Activities 3.15 and 3.16, on pages 224 and 225, will consider the costs versus the gains of space exploration.
- Enrichment—Interested students can research the brands SunTiger® and Eagle Eyes® and find out more about their research and products. Have them report their findings to the class.
- DI Enrichment—If students are disturbed by the concept of birds of prey being harmed, encourage them to take action. Intrapersonal learners, as well as other students, may want to write a letter to the companies involved, explaining how they feel, or they could write a letter to a newspaper explaining what they know and informing their community. They could also raise funds to support raptors that are endangered and donate their proceeds to an organization, such as the World Wildlife Fund. Students can learn more about how to take action by visiting **www.scienceontario.ca**.
- Students can read ahead to Making a Difference on page 228 and learn about other students who took action on issues that were important to them.

Starting Point Activity (Student textbook page 221)

Pedagogical Purpose

Students consider the benefits and drawbacks of space exploration in terms of technological advances and dollars invested.

Planning	
Materials	Access to the library and/or Internet (optional)
Time	30 min in class

Skills Focus

- formulate hypotheses

Background Knowledge

There are many lobby groups, especially in the United States, which are vocally opposed to space exploration, particularly from an economic standpoint. These groups tally the wastefulness in materials and tax dollars that are invested in space exploration and the dangers to human lives, such as the explosion of the *Challenger* space shuttle. One group, for example, is of the opinion that a crewed mission to Mars is not of significant scientific value, especially in light of its nearly $1 trillion price tag. Visit **www.scienceontario.ca** for more information.

There are also some significant benefits of space exploration, however. In addition to providing information about our solar system history and about Earth, which could mean keeping people on Earth safer in the future, space exploration has contributed to many inventions that we use daily. Some of these inventions include quartz crystal clocks; shock-absorbing materials used in running shoes; components in cellphones; bar codes to track inventory; heat-resistant materials used as brakes in motor vehicles; scratch-resistant sunglasses; and robots used in factories, by police, and by the military.

Activity Notes and Troubleshooting

- Students can work with a partner or in small groups and discuss the activity questions. Ensure that students know how to discuss topics appropriately and respectfully with each other.
- Introduce students to Science Skills Toolkit 1: Analyzing Issues—Science, Tehcnology, Society, and the Environment on page 335 of the student textbook. This toolkit includes suggestions for analyzing issues with many points of view. Students will be able to make use of it throughout this topic, as well as in other topics.
- For this activity and for other activities in this topic, you can distribute **BLM G-15 Worksheet for Investigating Issues**, and demonstrate how students can use it to sort out the many points of view and supporting evidence that can surround STSE issues.
- Have students read page 220 before assigning this activity.
- For question 1, you may prefer to have a class discussion, rather than assigning this question for students to work on individually. Question 2 could be assigned as homework or for students to discuss in pairs, then record ideas.
- Enrichment—Have students research a specific product that originated from space exploration. Have them find out the product's or service's origin and report their findings to the class in a presentation format of their choice.

Additional Support

- Some students may not be aware of the products or services that result from space exploration. You may wish to provide some articles or access to the school's resource centre or the Internet for students to do some research.
- ELL Some students, including English language learners, may prefer to use photographs of the products and services, instead of words, to explain their answers. If possible, provide magazines or newspapers that can be cut up, or provide access to the Internet and printers for students to research and print the images they find. Keep in mind that some English language learners may not be familiar with some of the products or services, so an explanation may be required.
- DI Linguistic and interpersonal learners may enjoy having a discussion about students' opinions on space exploration. Ensure students are respectful of one another's opinions.
- ELL Students, including English language learners, could organize their results in a T-chart, concept map, or word web. Encourage students to use sketches to help explain their answers.

Answers

1. Students' answers will vary, but some examples of products or services that come from space missions are the protective padding inside helmets, the technology used in heart-rate monitors, the material used in gloves, memory foam, the space pen, freeze-dried food, and scratch-resistant lenses.
2. Students' answers will vary. Some students will feel that the money should be spent on Earth's problems; however, some students will feel that exploring space is important to benefit people on Earth in the long run. Students should clearly explain and defend their opinions.

Instructional Strategies for Topic 3.5

We develop technologies that shape our lives. (Student textbook pages 222–223)

- Read the opening paragraph (in the beige box) on page 222 as a class. Then, have students read the numbered boxes individually. Circulate to answer any questions that students might have about the unfamiliar vocabulary. Make dictionaries available to students as they are required. You may want to allow students to use a dictionary and look up the term *spinoff* for Learning Check question 1 on page 223 **after** they have made an attempt to work out the definition on their own.
- Together, list all the space spinoffs that appear in the story.
- DI Have students read the caption on page 223. Ask students what they know about satellite technology. Ask if they have ever used an Internet map program to find a location. Explain that the satellites orbit Earth regularly, taking pictures. These pictures can be threaded together, like a quilt, to show a map of Earth's entire surface. Tell students that although this is very useful technology, it can also invade privacy. If possible, ask a spatial learner to demonstrate using an Internet map program (see **www.scienceontario.ca**) to find the location of your school via satellite. See how detailed a resolution you can access. In many locations, it is possible to increase the resolution to the point that individual cars are visible in the parking lot.
  - Enrichment—Have students search for their own home on an Internet map program. How close can they get? Are they able to tell when the satellite image was taken?

We are challenged to think and act locally, globally, and universally.
(Student textbook pages 224–225)

- DI Activities 3.15 and 3.16, on pages 224 and 225, are both debate-style inquiries about the pros and cons of space exploration. You may wish to assign one as a group research project and organize the other as a class debate with students selecting sides and supporting their position with research. Ensure each group includes some logical-mathematical learners who may enjoy coming up with logical reasoning to support or refute the opinions, as well as interpersonal learners who can facilitate a respectful discussion.
- If you assign the group research first, take the opportunity to develop and reinforce research skills such as identifying the question and gathering sufficient, relevant data to support their opinion as students work.
- Read through Activities 3.15 and 3.16, on pages 224 and 225, with students. Explain to students that the activities on these pages require them to choose sides. Have students consider the questions in the activities and keep them in mind while you read pages 224 and 225 as a class. If necessary, write the questions on the board or on chart paper so students can refer to them quickly as they are reading. After reading, assign the activities and allow students to choose which opinion they will support.

We gain a deeper appreciation for ourselves and our home planet.
(Student textbook pages 226–227)

- Before beginning pages 226 and 227, have students review their notes and/or reread Topic 3.1 on constellations. Ask why humans organize the stars into patterns, such as ladles, bears, dragons, and hunters. Then, assign the reading.
- ELL You may want to provide concept maps for English language learners to organize their notes about each subsection of text. They could write the title of the spread in the middle of the concept map, and then include words or sketches about each chunk of text in the spaces that branch off.
- Some students may wish to use a Venn diagram to answer Learning Check question 3.

Learning Check Answers (Student textbook page 223)

1. A spinoff is a product or a technology that is originally developed for one use but is modified for other uses.
2. Students' answers could include any five of the following, or others:
   - quartz crystal clocks
   - shock-absorbing materials for moon boots used in running shoes
   - miniature components in cellphones, which were originally created for the shuttle program to save space and weight
   - bar codes to keep track of the components of the space shuttle now used to track inventory and in cash registers
   - heat-resistant materials used in space material now used as brakes in motor vehicles
   - scratch-resistant glass now used in sunglasses
   - robots designed for space now used in factories, by police, and by the military
3. Students' answers will vary but they may describe how the spinoff has made society better (for example, with the use of cellphones).

Activity 3.15 Travelling Bombs–Worth the Risk?
(Student textbook page 224)

Pedagogical Purpose

Students consider the benefits and risks of space exploration.

Planning	
Materials	library or Internet access **BLM G-14 Research Worksheet** (optional) **BLM G-15 Worksheet for Investigating Issues** (optional) **BLM G-16 Decision-Making Organizer** (optional) **BLM G-32 Cause and Effect Map** (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-5 Investigating an Issue Checklist** (optional)
Time	30–40 min in class

Skills Focus

- identify and locate sources
- select, organize, and record relevant information
- draw conclusions

Background Knowledge

On June 30, 2004, the *Cassini* spacecraft entered Saturn's orbit and began exploring. Some of the discoveries include Titan's Earth-like processes and evidence of liquid water beneath the surface of the small moon Enceladus. Titan's environment is similar to Earth's environment before life developed, which makes it an interesting place to study; however, the total cost of the *Cassini-Huygens* mission is about $3.26 billion.

Activity Notes and Troubleshooting

- Depending on how much time you have available, you may decide to assign only one of activities 3.15 or 3.16. If possible, have students choose which of the two activities they would like to research. In both activities, students will need to research the risks and benefits and make decisions about the value of the mission versus the costs.
- Students can use **BLM G-14 Research Worksheet** or **BLM G-15 Worksheet for Investigating Issues** to help them organize their research.
- To formulate their final decision on the issue, have students use **BLM G-16 Decision-Making Organizer**.
- Students could hand in their completed **BLM G-16 Decision-Making Organizer** for assessment. If you wish, you can also use **BLM A-5 Investigating an Issue Checklist** to assess students' work.

Additional Support

- Students who are struggling with organizing their thoughts and research on the issue may benefit from using a graphic organizer, such as **BLM G-32 Cause and Effect Map, BLM G-33 Concept Map**, **BLM G-35 Main Idea Web**, or **BLM G-36 Spider Map**.
- Allow students to present and support their decision in a format of their choice. Some may wish to give an oral presentation, while others create a diagram or an annotated list.
- ELL Create a list of words that might be difficult for English language learners, and provide synonyms for, or definitions of, these words. For words like *probe, planet,* and *atmosphere,* you could provide photographs or sketches to explain the meaning. English language learners could match the words with their definitions. To ensure that students understand the concept of the word and are able to transfer the word into a different context, have students say the word and then use the word in a unique sentence.
- ELL Provide an analogy to help students, including English language learners, understand the type of decision to be made. For example, a possible analogy might include a college student who would like to travel to Europe over the summer and explore her European roots; however, the trip will cost more money than she has. Should she visit museums in her community and read books on European history, or should she give up her social life to earn enough money to go on the trip?

Activity 3.15 Answers

Students should be able to support their opinions with appropriate and clear reasoning.

Activity 3.16 Off-World Earths–Worth the Risk?

(Student textbook page 225)

Pedagogical Purpose

Students consider the benefits and risks of terraforming another planet or moon in order for human colonies to live there.

Planning	
Materials	**BLM G-31 English Word Study** (optional)
Time	30–40 min in class

Skills Focus

- identify and locate sources
- select, organize, and record relevant information
- draw conclusions

Background Knowledge

Mars is thought to be the best planet for terraforming because it is the most like Earth. It is believed by some that it is very likely that signs of ancient life could be found on Mars. If life did exist on Mars in the past, it would be beneficial to find out what caused the planet to change so much, in case the same phenomenon happened to Earth. Terraforming Mars, however, would be difficult, would take an extremely long time, and would cost a lot of money.

Activity Notes and Troubleshooting

- Depending on how much time you have available, you may wish to assign only one of activities 3.15 or 3.16. If possible, have students choose which of the two activities they would like to research. In both activities, students will need to research the risks and benefits and make decisions about the value of the mission versus the costs.
- Enrichment—Have students research which science fiction movies or books include the idea of terraforming. Ask students to choose one example and answer the following questions: "Was terraforming portrayed positively or negatively?" "Why do you think the author or writer decided to portray terraforming in that way?"

Additional Support

- ELL To help English language learners, have students add the term *terraforming* to their glossary, or add the word to the class word wall. Students could also complete **BLM G-31 English Word Study**.
- DI Have logical-mathematical learners help students who are having difficulty providing relevant evidence to support their opinion.
- ELL To benefit English language learners, read the activity together as a class, and create a concept map on the board that focusses on the big idea: Is it a good idea for humans to alter another planet so that it can support life? Surrounding the big idea, include the supporting ideas found in the activity (for example, research opportunity, second home for humans, costs, ethics, chance of something going wrong) and ensure that students understand what each one relates to.

Activity 3.16 Answers

Students should be able to support their opinions with appropriate and clear reasoning.

Learning Check Answers (Student textbook page 227)

1. Students may predict that these civilizations used the patterns of the stars and the Moon for navigation, to determine the best times to plant crops, to determine when seasons would begin and end, and for religious ceremonies.
2. Students' answers could identify how space exploration has helped us develop and define our sense of ourselves. Their answers could include how space exploration has helped us gain a better understanding of the origin of the universe and the origin of life on Earth. Or students could look at this question in terms of finding life on other planets.
3. Students' answers might include the following points:

Ancient Explorers	Both	Modern-day Space Explorers
• were not able to travel to space • created stories about the constellations	• had an interest in space • created star maps • used the sky patterns to create calendars and tell time	• can travel to space • exploration is more likely to be motivated by science

Using Making a Difference (Student textbook pages 228–229)

Literacy Support

Before Reading

- Have students review their notes from Topic 3.1 about the number of visible stars in the sky (3000), and from Topic 3.4 about robots designed for space exploration.
- Have students read the questions in the blue boxes and brainstorm ideas. Record the ideas on the board or on chart paper. (Possible answers for the question in the first blue box: turn off unnecessary lights at night, use special lights that point down; Possible answers for the question in the second blue box: On Space—a robot that fixes the space shuttle, prepares food, performs experiments; On Earth—a robot that does household chores or helps with homework)

During Reading

- Have students use **BLM 3-25 Unit 3 Making a Difference** while they are reading.
- Have students record words that are unfamiliar and ask a classmate or consult a dictionary for the definitions.
- Have students work with a partner. One partner can read and make notes on one of the topics while the other partner can read and make notes on the other topic. Then, students can share their notes. Encourage them to read the notes carefully and ask their partner any questions in order to clarify the information.

After Reading

- After students have read the two topics, ask them to review their answers to the questions that they brainstormed before reading, and to make revisions or add information if they wish. They can share their answers with a partner or in a class discussion.

Instructional Strategies

- Ask students why the issue of light pollution is important. If they need prompting, ask why it matters if we can see stars in the night sky. (important for navigation, night animals and birds, stargazing and learning more about astronomy) Ask if they think that light pollution has an effect on space exploration and what effect that might be.
- Enrichment—Have interested students research the effects of light pollution and report their findings to the class. They can begin their search at **www.scienceontario.ca**.
- Review the concept of biomimicry with students (the art and science of using the natural world for inspiration to solve human problems). Write the word *biomimicry* on the board or a sheet of chart paper. Have students consider the word and make educated guesses as to its meaning. Ask students how the Leech Bot is an example of biomimicry. (Balakrishnan was inspired by the movement of earthworms and leeches.)
- Encourage students to provide examples of biomimicry from other areas of culture, if possible. Our clothing and vehicles, for example, are often based on designs from nature. Encourage students to provide examples from a variety of cultures.
- Have students think of one challenge of space exploration, or a challenge in their daily lives. Have students brainstorm a situation from the natural world that could inspire a solution. For example, astronauts will have to travel at least nine months to reach Mars. Polar bears hibernate for nine months over the Arctic winter. Could astronauts hibernate for the long Mars journey?

Answers

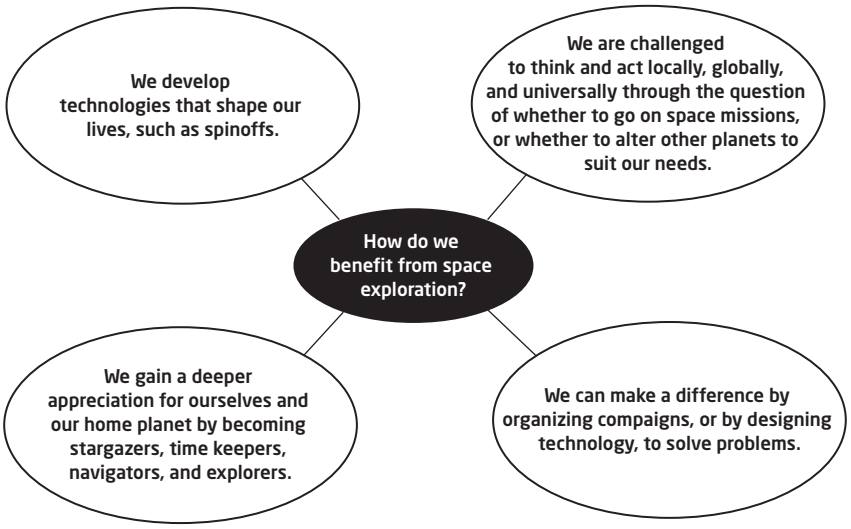
Students' answers to the two questions on page 228 will vary. Ensure they provide appropriate explanations to support their answers.

Topic 3.5 Review (Student textbook page 229)

Please see also **BLM 3-26 Topic 3.5 Review (Alternative Format)**.

Answers

1.



2. Students' cartoons should depict one of the spinoffs indicated on pages 222 and 223, or could refer to other spinoffs of space exploration. A searchable spinoff database is available at **www.scienceontario.ca**.

3. a) Answers could include a technician at a water treatment plant or a technician for pure water at a hospital. The water purification technology could help the technician ensure the water was being treated effectively.

b) Answers could include a carpenter or other tradesperson or a homeowner. The technology could help the carpenter do a better job, possibly in better time, and would help homeowners complete their own renovations themselves and therefore save money.

c) Answers could include a person in the armed forces; mountain climber, guide; salesperson at a camping/outfitting store; search and rescue individual; or emergency rations person. The technology would allow these people to carry lighter loads, as well as feed themselves or provide food for others.

d) Answers could include firefighters, search and rescue individuals, or a health-care worker screening individuals for fevers. The technology would help these workers save lives.

e) Answers could include a technician in a hospital or other building responsible for ensuring air quality in a building, or armed forces protection against bio-warfare. The technology would help these workers increase people's quality of life and save lives.

4. Students' answers will depend on their opinion. You might suggest that they research space junk, at **www.scienceontario.ca**.

5. Students' answers will depend on their opinion. However, they should make reference to the discussion on nuclear-powered planetary probes on page 224 of the textbook.

6. Possible answers could include information from Topic 1 including building an atmosphere that has sufficient carbon dioxide and other greenhouse gases to moderate the climate; carbon dioxide for plants (photosynthesis); oxygen for most living things (respiration); way to unlock water that is locked as ice on Mars.