CURRICULUM CONNECTIONS

GRADE 6 MODULE

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Introduction

In grade six, students learn about the technological advances related to the study, discovery and travel in places outside of the Earth's surface – on space vehicles and the International Space Station; in addition, there is always the possibility for habitation on other planetary surfaces with Mars being the most obvious. This is a fascinating unit of study for most students, as they seem to be inherently interested in everything "space oriented". Specifically, teachers will investigate with their students the technological advances that allow humans to adapt to life in space, with specific emphasis on the development of greenhouses on the surface of Mars.

Teachers need to ensure that classroom learning across all grades and subjects provides ample opportunity for students to learn how to work, cooperate with others, resolve conflicts, participate in class, solve problems, and set goals to improve their work. The science and technology program can also offer opportunities for a variety of career exploration activities, including contacts with career mentors and visits from guest speakers whose occupations make use of scientific and technological knowledge and skills. This topic is examined in Lesson #4 – Careers in the Greenhouse Industry.

Curriculum Expectations

Students will:

- Investigate scientific and technological advances that allow humans to adapt to life in space;
- Explain how humans meet their basic biological needs in space (e.g., obtaining air, water, and food and managing bodily functions);
- Identify the technological tools and devices needed for space exploration (e.g., life-support systems);
- identify career opportunities in the greenhouse industry and relate these opportunities to skills required and educational attainment

Teachers are encouraged to look at the challenges that space presents for humans, and how they might be overcome using existing AND future technologies yet to be developed. The area of robotics is also an area that will be important for space travel and exploration – and it is one that is beginning to be used in the greenhouse industry in Ontario. Just as we consider how robots have changed industry in general, we need to also look at the circumstances that may allow robots to replace humans in space exploration and even "space farming".

Appendices

Teacher Background Information

How Greenhouses Work

Greenhouses create an artificial environment, sheltered from the "outside" environment that may be too cold, too hot or too variable for the growing of plants. Greenhouses use their glass enclosures to trap solar radiation; the radiant heat enters through the glass or plastic covering and warms the air, soil and plants inside. This warm air rises and is replaced by cooler air that in turn is warmed up; this cycle raises the temperature quickly. The heat created by the solar radiation, plants and from the soil is "trapped" by the glass. Sometimes, the air inside can be overheated and has to be vented out. As you drive by a greenhouse, you may see the glass panels on top open to vent out the warm air vertically. Venting can also occur horizontally through side fans and vents. The venting also keeps the air in the greenhouse moving, allowing for a more even temperature throughout and cycling the carbon dioxide that plants need to grow. Most modern greenhouses have automated systems to regulate the temperatures inside.

The "heat" which is generated often comes from the sun. However, in really cold climates, heat is added to the air or to the soil.

In addition to the "heat component", plants in greenhouses also require water. Many greenhouses use an automated irrigation system to keep the growing media moist and flowering plants supplied with needed water. Hydroponic systems, that don't use soil to "hold" moisture, supply water directly to the roots on a more frequent basis.

Although a greenhouse may appear to be a simple structure, the key components of any human-made structure are present; in a greenhouse, these include ....

- a strong foundation,
- a sturdy frame to maintain the glass (or plastic) panels,
- flooring that varies from simple dirt to concrete, wood or stone,
- "glazing" - glass or other synthetic covering to allow in solar radiation and to help to provide insulation,
- a system for watering of the plants and flowers.

[note: this information is available as a one-page supplement for duplication – Appendix 5.1 - How Greenhouses Work]

Teacher Background Information

Life Support Systems

In human history, humans moved from a "hunting and gathering" nomadic life to become inhabitants of a fixed place with the cultivation of plants and the domestication of animals – the beginning of agriculture. The basics of life support – air and water – are provided by the Earth's ecosystem.

In the past ...

However, humans have learned to "modify" small portions of the Earth's biosphere with the creation of GREENHOUSES. It is speculated that the earliest greenhouses may have been developed in ancient Rome, nearly 2000 years ago ... to grow vegetables year-round for the demanding Roman emperors! At this point, glass had not been invented, so small sheets of the mineral mica were used.

In the 13th century, greenhouses were built in Italy to grow the exotic plants that explorers brought back from the tropical areas that they visited.

In the 17th century, the first greenhouses made with glass emerged in Europe to propagate tropical plants in the colder environment of the area. Later, greenhouses for people evolved (called solariums), to provide warmer environments for human habitation.

Greenhouses may have been developed in the Far East in the 15th century, in both China and Korea. In Korea, greenhouses were used to grow mandarins using an active soil heating system.

The concept of greenhouses also appeared in Netherlands and then England in the 17th century. Today, the Netherlands has many of the largest greenhouses in the world, some of them so vast that they are able to produce millions of vegetables and flowers every year. The botanist Charles Lucien Bonaparte may have built the first practical modern greenhouse in Leiden, Holland during the 1800s to grow medicinal tropical plants. In France, greenhouses were used to grow both oranges and pineapples, plants that could not withstand the harsh climate of northern Europe without some form of modification.

An elaborate greenhouse was built to accompany the Palace of Versailles just outside of Paris in the 17th Century; it was 150 metres by 13 metres and exceeded 14 metres in height.

At the same time, in the United Kingdom, elaborate greenhouses were established including several in Key Gardens and The Crystal Palace.

In the 20th century, the geodesic dome was added to the many types of greenhouses including the Eden Project In southwest England, and the Climatron in the Missouri Botanical Gardens in St. Louis.

The availability of polyethylene (the most common form of plastic) as a replacement for glass was one of the main developmental features of the late 20th century. The early versions of polyethylene did not stand up to the UV rays of the sun very well; however, their durability was increased with the development of effective UV-inhibitors in the 1970's and 1980's.

In recent years, greenhouses with two or more connected bays have been developed; they use a common wall or a row of support posts. Most of the greenhouses in Southern Ontario are in this form.

In the future ...

Because of the lack of a suitable biosphere on either the Moon or Mars, the habitants of these new environments will have to create their own! This will be a CLOSED life support system that includes plants and microorganism – a greenhouse on Mars. A greenhouse isolates plants from the adverse conditions of the Martian environment.

[note: this information is available as a one-page supplement for duplication -- Appendix 5.2 - Life Support Systems]

Teacher Background Information

The Martian Environment

The "red planet" – Mars does have an environment. However, it is a most unfriendly environment for humans. Due to its smaller size, the force of gravity is much less than that on Earth – about 1/3 the value. An object on Earth that weighed 100 kilos would weigh about 34 kilos on Mars. The limited gravity on Mars has resulted in an atmosphere that is very thin – about 100 times less dense that Earth's atmosphere. The thin atmosphere provides less protection from the ultraviolet (UV) radiation of the sun; in addition, there is nothing similar to Earth's ozone layer in the stratosphere which absorbs much of the UV radiation attempting to enter our atmosphere. These conditions make it very difficult for humans to live on Mars...and we haven't even considered any other factors other than the atmosphere!

The Composition of the Martian Environment	
Carbon Dioxide	95.32%
Nitrogen	2.7%
Argon	1.6%
Oxygen	0.13%

The thin atmosphere and its greater distance from the sun have resulted in much colder temperatures than here on Earth. The average temperature is -60oC with a range from

-125oC (at the poles in winter) to 20oC at the equator in summer. It is the DAILY range in temperature which is the biggest difference to the situation on Earth – usually in the area of 100 Celsius degrees!

As a result of the hostile environment on Mars, it is not possible for humans to survive without permanent residences ... and greenhouses to provide sustenance.

The accompanying chart shows the changes in temperature on a typical day (called a "sol") on the surface of Mars.

SOL (day)	High Temperature (degrees Celsius)	Low Temperature (degrees Celsius)
1	-19	-71
2	-14	-74
3	-14	-70
4	-17	-75
5	-13	-73
6	-14	-73
7	-15	-75
8	-15	-76
9	-16	-75
10	-17	-76

[note: this information is available as a one-page supplement for duplication – Appendix 6.3 - The Martian Environment and charts for Lesson #1 are available as Appendix 6.3]

Teacher Preparation and Materials

1. Prior to the beginning of the unit, ask the students to keep records of the highest and lowest temperatures for the local community for ten days in a row. This information is available on-line or in local newspapers. Develop a chart of these temperatures using Appendix 6.2 – High and Low Temperatures. As part of your mathematics unit, you can have the students graph the data that they have collected and develop specific mathematics-related operations such as averaging.
2. You may wish to review the concept of photosynthesis with students. A fact sheet on photosynthesis is included as Appendix 6.5 – Photosynthesis.
3. The chart below (also enclosed as Appendix 6.6 – The Martian Environment Compared to Earth's Environment) examines the atmosphere and surface of Mars compared to Earth.
4. You may wish to reproduce or share visually with the students the two images of Mars – Photo 6.1 and Photo 6.2. used in Lesson #2 – Growing Plants on Mars.
5. One teaching technique that you may wish to use, since this is such a foreign environment for most students, is a KWL (know .. want to know .. learned) chart (see appendix 6.8). This can be used to begin the unit and then revisited when the unit has been completed. To involve parents in this unit, send the KWL chart home and have the students complete the chart with parent supervision.

	Mars	Earth
Atmosphere components	Carbon Dioxide – 95.3% Nitrogen – 2.7% Argon – 1.6% Oxygen – 13%	Nitrogen – 77% Oxygen – 21% Argon – 1%
Atmospheric Pressure	7.5 millibars (average)	1013 millibars (average)
Gravity	0.375 of Earth's gravity	2.65 times the gravity of Mars
Length of Day	24 hours 37 minutes	Just less than 24 hours
Length of a Year (one orbit of the sun)	687 Earth days	365.25 days
Tilt of the axis	25 degrees	23.45 degrees
Satellites (natural)	2 – Deimos and Phobos	1 - Moon
Relationship with the Sun	Thin atmosphere – high levels of radiation	Earth's atmosphere is similar to a greenhouse – blocking radiation and moderating temperatures
Surface Temperatures	Average -63°C Range -12°C to +20°C Daily range - 100 Celsius degrees	Average 14°C Range -88°C to +58°C Daily range – usually less than 30 Celsius degrees
Largest Volcano	Olympus Mons – 26 km high and 602 km in diameter	Mauna Loa (Hawaii) – 10 km high and 121 kilometres in diameter
Deepest Canyon	Valles Marineris – 7 km deep and 3000 km long; as much as 600 km across	Grand Canyon – 1.8 km deep and 800 km long; as much as 30 km across
Surface Material	No organic material – mostly silicon dioxide, iron oxide and "rocks" similar to those on Earth; no permanent surface water	Varies with region – soil contains both organic and inorganic materials.

LESSON #1

The Martian Environment

1. Examine the charts of high and low temperatures on Earth (students collected the data for the previous ten days). Complete the temperature RANGE for each day. What was the average high temperature, low temperature and range?

2. Compare the high and low temperatures and the daily range of temperatures on Earth to those on Mars using Appendix 6.3 High and Low Temperatures (surface of Mars). Compute the average high and low temperatures and the range of temperature and compare to Earth.

3. In words, describe the differences in temperature range on Earth to those on Mars.

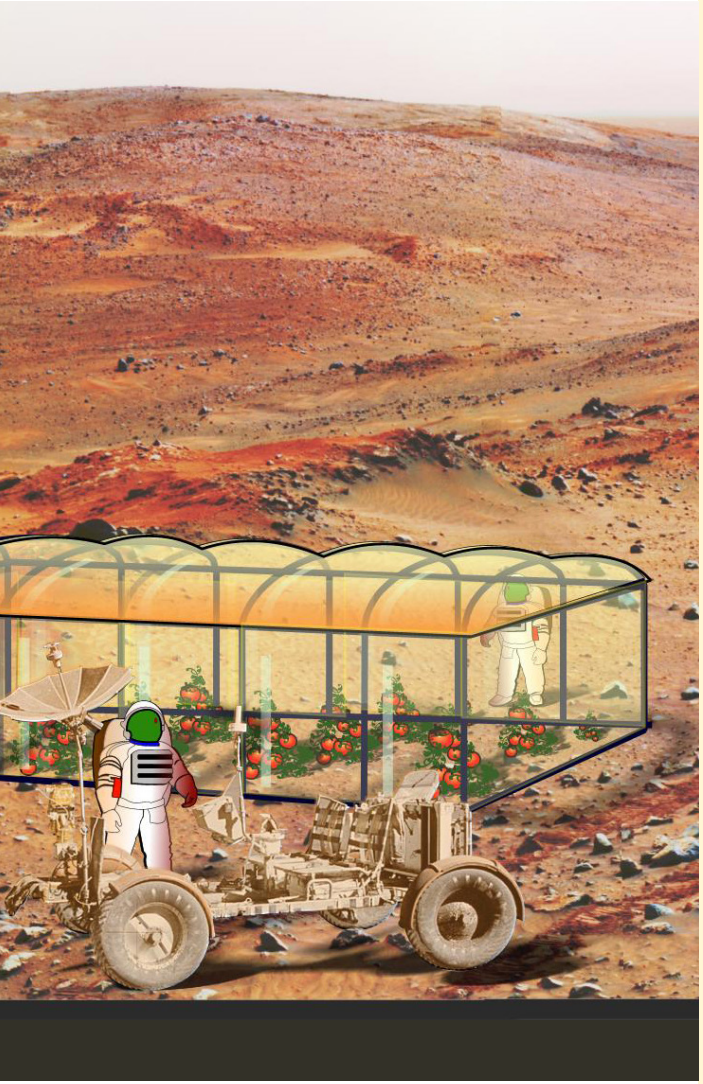
4. How would a high range of temperatures and the very low temperatures found on Mars, affect the ability to grow plants?

5. Greenhouses are constructed on Earth to modify the conditions outside the greenhouse in order to grow vegetables, flowers and potted plants.

    5.1 Suggest reasons why greenhouses could be used to grow plants on the surface of Mars.
    5.2 Suggest problems related to using greenhouses on Mars.
    5.3 How might the problems associated with growing plants in greenhouses be solved – give some practical suggestions.

LESSON #2

Growing Plants on Mars



1. Examine photo 6.1 – Growing Plants on Mars and indicate whether you think that this drawing by an artist could be reality in the future. Why or why not?
(See Photo 6.1 – Growing Plants on Mars).

2. Examine photo 6.2 – Martian Landscape. This is an illustration of how greenhouses might look on Mars. (See Photo 6.2 – Martian Landscape).

   2.1 How is the shape of the greenhouses different from those on Earth?
   2.2 Suggest reasons why the shape is different.
   2.3 The "pipes" between the greenhouses are sometimes called "utilidors" on Earth. Suggest what the utilidors are used for on Mars. Research to find areas in Canada where "utilidors" are used. In terms of what they do, how might the utilidors on Mars be different from those on Earth?

3. The first seed germination on Mars may take place in the next 10 years in a small transparent cube that will be a mini-greenhouse. Scientists will compare the growth of a flowering plant related to mustard and cabbage to a control group on Earth. They will want to know how the gravity, light and radiation levels on Mars affect the plants' growth.

   3.1 Why would the scientists not just plant the seeds on the Martian surface, cover them and water them?
   3.2 Plants absorb Carbon Dioxide and "give off" Oxygen; how could this be beneficial to growing plants in a closed environment (like a greenhouse) on Mars?

4. We know that astronauts will be growing some of their own food on Mars. Although we do not eat flowers, there might still be some of the advantages for the astronauts to grow flowers and potted plants on Mars. When humans provide common houseplants and blooming potted plants, they help fight pollution indoors.

   4.1 How might flowers and potted plants assist in an artificial environment (greenhouse) on Mars?
   4.2 We also know that flowers and potted plants have a positive effect on how we feel – raising our spirits, making us cheerful. Why might this be a really important aspect of living on another planetary body?

5. Go to the PickOntario website – www.po.flowerscanadagrowers.com and look under "Our products".

   5.1 The plants are listed alphabetically. Choose one cut flower and one flowering houseplant from the list that you might suggest as a "candidate" for a greenhouse on Mars.
   5.2 Justify your choice of plant (i.e. I chose this one because.....)
   5.3 Get more details about the plant (colours, height, space required, temperature, amount of light) and verify that you have made a sound choice.
   5.4 If your plant of choice seems like it might not be suitable for a greenhouse on Mars (for whatever reason), choose a different plant and justify your choice.

LESSON #3

Life Support Systems on Mars

1. Basic life support systems need to provide air (oxygen), water, and a reasonable level of pressure for both inhabitants and plants. Examine the chart in Appendix 6.6 – The Martian Environment compared to Earth's Environment.

    1.1 For each of the components listed, identify what changes would have to be made to the environment in a greenhouse on Mars. (e.g. the amount of carbon dioxide in the air would have to be reduced). Show your results in chart form using Appendix 6.7 – Changes to the Environment.
    1.2 Suggest HOW you might change the component (e.g. To reduce high levels of radiation, the greenhouse would have to….)
    1.3 Draw a diagram of what your idea of a "Martian greenhouse" would look like.

2. Assume that you are going to Mars as a visitor for a year. You are in the first group of humans to go to Mars to live. You will need a greenhouse to provide some of your basic needs while there.

    2.1 What materials would you need to build a greenhouse on Mars?
    2.2 How would the atmosphere on Mars be a problem for building?
    2.3 Are there any aspects of the atmosphere that might make building a greenhouse (or any other structure) easier?
    2.4 What would be the advantages of sending materials to build a greenhouse to Mars in advance of YOUR arrival?
    2.5 What would be the disadvantages of sending materials in advance?
    2.6 Robots work on Mars today – taking photographs, sampling rocks and Martian surface materials. What role could robots play in the construction of a Martian greenhouse?
    2.7 Research to find how greenhouse operators today are using robotics (and other elements of advanced technology) in their greenhouses. Predict what other tasks might be done by robotics in the future.

3. The Earth's ecosystem provides the basics for life – water, air, and heat.

    3.1 How is life inside a greenhouse a mini-ecosystem?
    3.2 How do flowers and potted plants assist in the maintenance of a working eco-system in a greenhouse?
    3.3 How would the mini-ecosystem in a greenhouse on Mars have to be modified in order to provide proper growing conditions for food, flowers and other plants?
    3.4 What would be the benefits (as well as providing basic food and plants) of the mini ecosystem inside a greenhouse on Mars?

LESSON #3

Life Support Systems on Mars

Culminating Activity

Many parts of the Lessons listed above could be expanded to create a culminating activity – building a mini-greenhouse for the surface of Mars, developing models to reduce carbon dioxide in a closed environment, growing (germinating) seeds in a model greenhouse, using LEGO to develop a robot to perform a specific task in a greenhouse.

For a written assignment, teachers could ask student to write a diary about their first few days on Mars as the initial explorers who must get to work on a greenhouse for their own survival and enjoyment.

Assessment

This rubric suggests ways in which the teacher could assess the culminating activity noted above. It could also be modified for use with other teacher-developed culminating activities.

Rubric for Assessing a Diary on Establishing a Greenhouse on Mars

Indicator	Novice	Apprentice	User	Specialist
Indicates the problems associated with arriving on new planetary body	Is unaware of the large number of problems humans face when landing on a new planetary body	Provides a minimal number of problems to be solved when arriving	Provides an understanding of the complexities of living in space and arrival on Mars	In written material provides many examples of the problems to be solved as soon as the vehicle arrives
Shows knowledge of the Martian atmosphere	Misses the basic concepts of a different environment on planetary bodies such as Mars	Provides examples of problems related to the air and water components of the environment on Mars	Indicates understanding of the basic issues of the atmosphere and the surface conditions on Mars	Shows evidence of knowledge of the atmosphere, surface conditions and the effects of these on human survival on Mars
Is able to set priorities for tasks	Lacks the ability to identify what is most important about setting foot on a new planetary body	Indicates a basic understanding of the priorities that need to be tackled	Lists the priorities of tasks to be accomplished when settling into the new environment on Mars	Provides a sequential list of tasks and a rationale for dealing with the tasks in a logical manner

[This rubric is also available as Appendix 6.9 – Rubric for Assessing a Diary on Establishing a Greenhouse on Mars]

LESSON #4

Careers in the Floriculture Industry

Introduction

After looking at the growing of plants in a greenhouse setting (and on the surface of Mars), students will have a better understanding of some of the problems and opportunities involved in the operation of a greenhouse. Teachers are encouraged to lead students through the Virtual Tour of a Greenhouse to get a better understanding of the how the industry might offer career opportunities. Part 1 – Introduction, Part 6 – How does it work? and Part 6 – Products and People will be the most appropriate sections to review with students.

The key word in career studies is "opportunities" – and it is in this area that students often do not get exposed to what "opportunities" are out there for their consideration as career paths. When they get to secondary school, they will have the chance to take part in co-operative education courses where they work part-time in a potential career setting. In the elementary grades, it is important to make students aware of the vast number of options available to them. In the greenhouse industry, there are many opportunities for employment; this will continue in the future as the industry becomes even more involved in high technology – at the production level, at the marketing stage – basically, throughout the industry.

Students in grade six should not feel under any kind of pressure to make career decisions, but should be made aware of the "opportunities"; at the same time, the skills that we look for in the classroom – how to work, problem solving, setting goals, and resolving conflict – can be emphasized with their application to future career opportunities.

Lesson Plan

1. From our learnings about the flower component of the Greenhouse Industry, what importance does this industry have for Ontario (and for Canda)?

2. What career opportunities have we seen in the industry?

3. What skills would you need to work in the floriculture?

4. What educational levels will be required for jobs in this area in the future?

5. What do these careers have in common with others (e.g. high technology)?

6. What are the implications of these opportunities in terms of what subjects to take in secondary school?

7. What do you think would be the most satisfying element of working in a career in the floriculture industry?

8. In small groups, forecast to the future what you think will be the opportunities for working in greenhouses – what might be the changes in the workplace that will provide career opportunities?

9. Have students complete the careers survey, Appendix 6.10 – Career Survey, and share their results with others in small groups. The questions are listed here, but available on a separate page for photocopying as Appendix 6.10

LESSON #4

Careers in the Floriculture Industry

For each of the following five questions, choose one of A, B, C, D, to indicate the topic that interests you most.

1.
   A. Selling a product (like flowers) or a service (like advertisements for the media).
   B. Studying living things and their structure (like genes)
   C. Working with plants and/or animals
   D. Learning about different topics and things

2.
   A. Marketing a product or a service
   B. Designing or building structures (like greenhouses), using engines or machinery
   C. Farming
   D. Working with or for government agencies

3.
   A. Using your creative skills in new situations
   B. Doing experiments
   C. Working outdoors
   D. Using social media to promote ideas and products

4.
   A. Developing your own business – being your own boss!
   B. Learning more about plants.
   C. Planting trees
   D. Using your knowledge and skills to improve the environment and contribute to dealing positively with climate change.

5.
   A. Being a manager – working with people to get a task completed
   B. Using your knowledge of science and the scientific method in different situations.
   C. Gardening
   D. Using your knowledge and skills to teach others.

After they have shared their results with others, ask students to count up the number of each letter that they chose. Now, you can indicate how their responses relate to the following career opportunities in floriculture....

Letter Chosen the Most	Possible Career Path	Career opportunities in floriculture
A	Business and/or Management	Market research · Planning · Advertising Business Manager · Product Management
B	Science and Engineering	Plant breeding · Research Geneticist (study of genes in plants) Entomologist (study of insects and their effects on flowers and plants in greenhouses) Robotics specialist
C	Agriculture and Forestry	Greenhouse Manager· Plant Operator Maintenance Technician · Seed specialist Agronomist (person who studies soil management and crop production, including irrigation and the use of herbicides, pesticides, and fertilizers.
D	Education, Communication or Public Administration	Plant inspector · Public Relations specialist Plant Manager

LESSON #4

Careers in the Floriculture Industry

Extensions

1. Choose a specific career in the Greenhouse Industry and research that career. Find out the pre-requisites (skills and educational requirements), job tasks, work location and salary.

2. Make a contact with someone who currently works in the Greenhouse Industry, particularly floriculture. To understand the person's career choice, the following questions could be asked:

    - What was your educational background (courses/subjects in high school, major areas of study in college or university)?
    - What extra-curricular activities were you involved in that helped you in an appreciation and understanding of your career?
    - Did you participate in any co-operative learning programs in high school, college or university that helped in your career choice?
    - Was their a particular person who helped you (a mentor) to understand more about possible careers in floriculture?
    - Why is your job important?
    - What do you love about your job?
    - What does a typical day look like for you?
    - What skills and talents are most important for you in being successful in your career?
    - Why should students consider a career in the floriculture industry?