Canada Aviation
and Space Museum

School Program

Health In Space

Daring To Explore

Ingenium

CANADA AVIATION AND
SPACE MUSEUM

MUSÉE DE L'AVIATION ET
DE L'ESPACE DU CANADA

Canada

Objectives

At the end of this program, students will have been exposed to the following concepts:

- Space explorers are aware of the dangers in their work, and take steps to mitigate them.
- Astronauts are often the subject of experiments studying the effects of Space on the human body.
- The results of these experiments have benefits for people on Earth.

Students will also learn more about the contributions of Canadians to Space exploration, and about the variety of potential future careers in aerospace.

In addition, students will be introduced to the most recent Canadian in Space: David Saint-Jacques (Expedition 58/59; December 3, 2018 to June 24, 2019).

Program Breakdown

Note: Durations given below are suggestions only. The scenario includes more information and more activities than necessary for these timeframes, allowing venues to pick and choose, based on operational preferences.

- Visit to Health in Space exhibition (30–45 minutes)
- Transition to workshop area (5 minutes)
- Experiments (30–45 minutes)
- Clean-up (5 minutes)

Curriculum Links Across Canada

Space is a theme relevant to elementary students across Canada, at approximately the Grade 6 level. A brief table of relevant curriculum links appears as an appendix to this program, providing teachers in any jurisdiction, the most relevant connections between their curriculum objectives and the **Health in Space** exhibition/program.

Tour Sequence

N.B.: This graphic is meant as a visual reference for tour guides, and is not reflective of the layout of the actual exhibition at any given venue.

1-Introduction: Canadarm And The Canadian Astronaut Corps

- Who wants to go to Space?
- Why? What jobs go to Space?

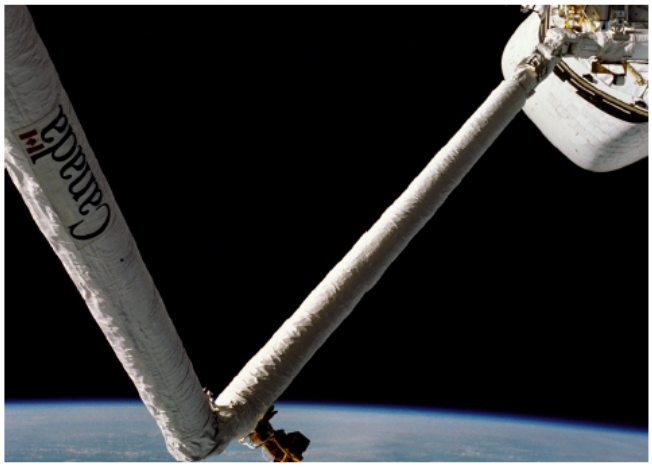
Astronaut is the job most people think of first when we talk about Space exploration. Does anyone know when people started going to Space? (Russian Yuri Gagarin made the first Space flight in 1961.) When did Canada's first astronaut go to Space? (1984, Marc Garneau)

Unlike the Americans and Russians, Canada's early Space exploration efforts did not focus on human Space flight. The federal government had a limited budget, and made the decision to concentrate on building technology such as satellites and rockets.

Of special concern was studying the atmosphere, in particular, the Aurora Borealis. This was important in order to understand how to improve radio communications across the country. But then, in the 1980s, something interesting happened . . .

- Who knows what this is?
- What do you think it does?

Show image of Canadarm. (see Appendix 2 for link to hi-res version)



We call it **“Canadarm,”** but its full name is the Shuttle Remote Manipulator System. Way back in the 1960s—around the same time the first people were walking on the **Moon**— **NASA** (the National Aeronautics and Space Administration of the United States), asked other countries if they wanted to work on various pieces of technology to help with Space exploration in the future.

Canada’s contribution was the Canadarm – a robot arm that could withstand the hostile environment of Space and function just like a human arm! The Canadarm worked better than anyone could have dreamed, and flew on almost all the **Space Shuttle** missions. The Canadarm performed a variety of tasks: it moved cargo in and out of the Shuttle’s cargo bay, captured satellites for repair, rescued the Hubble Space Telescope etc.

The Canadarm is even credited with saving the Space Shuttle program after the Space Shuttle Columbia disaster. A special scanning device was developed and put on the end of Canadarm in order to check the underside of the future shuttles for damage before re-entry.

NASA was so impressed with Canada’s contribution that it offered Canada the opportunity to fly astronauts on the Space Shuttle. But remember, Canada didn’t have any astronauts at the time!

Thinking had changed since the 1960s, and key officials saw the benefits of having a Canadian Astronaut Corps and so Canada very quickly decided to hold a recruitment competition. Six

astronauts were chosen and, just one year later, in 1984, Marc Garneau became the first Canadian astronaut to go into Space.

Today, Canada's astronaut training program is much more extensive than it was in the 1980s. It takes years before you are trained enough to go into Space. Astronauts come with a variety of backgrounds, but most notably they tend to have experience in science, engineering, medicine and / or aviation.

Ask the students if they can name any other astronauts and mention a few others including Julie Payette who is our current Governor General, and David Saint-Jacques who is the most recent Canadian to go to Space.

NOTE

If your introduction takes place away from the exhibition area, now would be a good time to move the students closer to the exhibition entrance. Depending on your group, you could do a countdown and blast off as a fun transition.

2- Entrance To Exhibition

NOTE

This is a brief pit-stop to "land" and calm the group if you've "rocketed" from another area of the Museum to the exhibition entrance.

- What do astronauts do in Space? (Answers will vary.)

Among other things, astronauts conduct hundreds of experiments in Space that are designed by scientists around the world. Often, the astronauts ARE the experiment, conducting tests on their own bodies to measure the effects of living in Space.

- Is living in Space dangerous?
- If so, why do people go there anyway?

Space is dangerous, but people go there because they see the value in the exploration as well as the benefits for the rest of us here on Earth. But, as with any extreme activity, all of the people involved—whether they themselves are going to Space or working in an Earth-based role— want to be certain that Space exploration is as safe as possible for everyone, by taking the appropriate precautions.

- What kinds of safety equipment or procedures do you use when you do something that might be considered dangerous?

When we do activities that might be a bit dangerous—like skateboarding, or riding a bike, or swimming—we try to make sure we are as safe as possible by taking precautions such as wearing padding and helmets and using the buddy system when swimming. We do this because there are benefits to these activities (exercise, fun) but we want to minimize the risk to ourselves.

Explain the term “risk mitigation”.

As we go through the exhibition, we are going to look at a few of the dangers astronauts face in Space. We will also learn about some ways people try to make it as safe as they can, and how scientists have used Space exploration to help people here on Earth.

NOTE

After the tour, students will be recreating some of the conditions/experiments conducted in Space by Canadian astronauts

3-Isolation

- Where is “Space”? Is it far?
- Can astronauts come home after work each day? Have you ever been away from home? Was it lonely?
- What helped you feel better?

When astronauts go to the International Space Station, they are really far away and can’t come home every day. This can make them feel sad and lonely.

Luckily, they have a lot of work to keep them busy. And they do get free time, as well as calls from home and emails. They also get to bring a few things with them into Space to remind them of home. Staying connected to life back on Earth is very helpful for their mental health and wellbeing.

- But what about their physical health? Have you ever been sick while away from home?

It can be kind of scary to be far from your family, but getting sick while away from home can be even more upsetting.

- So what do astronauts do when they get sick in Space?

Some astronauts, like Canadian Space Agency (CSA) astronaut David Saint-Jacques, were doctors before they became astronauts. Other astronauts get some basic medical training before going to the International Space Station (ISS).

If an astronaut gets really, really sick, they could be sent back to Earth. But for less serious issues, they can also get help from doctors on Earth, who will talk them through what to do. In addition, each astronaut has a special doctor, called the “flight surgeon”, who follows them throughout their training, as well as during their missions. The same doctor makes sure they are taken care of when they get home, too.

Learning how to help astronauts with medical problems in Space has also helped us learn how to better help people who live in remote communities here on Earth. Before David Saint-Jacques was an astronaut, he worked as a doctor in Puvirnituq, Nunavik, a remote community in Northern Quebec.

David had to make work with minimal resources, just like in Space. One thing he relied on was technology – in particular, the ability to connect by video, in real time, to medical specialists in larger, urban centers. This experience helped him prepare for possible future remote-medical situations he might encounter while in Space.

HIGHLIGHT: NEUROARM

Remember this? (Show image of Canadarm again.)

Canadarm is a great example of technology that has had a big impact when it comes to improving life for Canadians here on Earth.

On the ISS, the Canadarm is operated remotely by an astronaut inside the Station. Canadian astronaut (and now Governor General) Julie Payette is one of the most skilled Canadarm operators ever—and certainly the most skilled Canadian operator!

NeuroArm is a similar robot arm. It was developed by a team of Canadian researchers and engineers, and was inspired by the same technology and principles as Canadarm. NeuroArm allows surgeons to do very delicate operations while the patient is inside an MRI (Magnetic Resonance Imaging) machine. An MRI allows surgeons to see really clearly where they are working—for example, inside the brain.

Aside from being made to function inside an MRI machine, one of the other benefits is that a robot arm doesn't get tremors like a human hand might (steady is good when operating on brains!). The robot arm is operated by a surgeon much like the Canadarm was operated by an astronaut.

The first surgery with NeuroArm was on a 21-year- old woman in 2008. She had a brain tumour that would normally be inoperable, which affected
her sense of smell. Since her successful surgery, NeuroArm has been used to help dozens of people who couldn't otherwise be helped.

Teams of other Canadian researchers and engineers are now working on similar systems to allow surgeons to complete operations with more precision, and ultimately save more lives.

4-David Saint-Jacques

Position group near the image of David Saint-Jacques in the exhibition.

- Does anyone recognize this gentleman?

This is David Saint-Jacques, the most recent Canadian to go to Space. (Expedition 58/59; December 3, 2018 to June 24, 2019.) While there, he conducted dozens of science experiments including seven for Canadian researchers. He also set a record for the longest space voyage by a Canadian, at 204 days.

Before he was an astronaut, he was a family doctor and an astrophysicist. He is also an engineer, and has a commercial pilot's license. He also loves to learn! Among his many accomplishments is learning to speak not only French and English, but also Russian, Spanish and Japanese!

- So what do astronauts actually DO in Space anyways?

Astronauts spend the bulk of their time working. It is a huge undertaking to send people to Space, so the while they are there, they make the most of every moment.

Scientists on Earth design experiments to be conducted in Space by astronauts. Their findings are then analyzed by the scientists back on Earth. David Saint-Jacques was involved in experiments such

as “At Home in Space,” a Canadian experiment studying how astronauts from different backgrounds adapt to living together on the ISS.

This study could help future astronauts prepare for longer-duration missions—such as a mission to Mars. The study could also help people on Earth who live together in remote locations, including people working on oil rigs, and people on scientific expeditions to the Far North and Antarctica. Another Canadian experiment he participated in was Bio-Monitor. This was a smart shirt with sensors that sent information on an astronaut’s vital signs back to Earth.

Explain the term “wearable technology"

He also worked on a couple of different studies looking at aspects of bone health and the effects of microgravity on our bones (MARROW and Tbone), and experiments studying heart health and perception in Space.

NOTE

Use this as your segue to the Gravity section, where you will discuss bone health and the effects of microgravity in more detail.

5-Gravity

Gravity is the force that attracts two objects with mass to one other. It is also the force that pulls us toward the Earth, and is the force that keeps our Moon orbiting around our planet, and keeps our planet orbiting around the Sun.

- So, if gravity keeps us on Earth, and astronauts float in Space, does that mean there’s no gravity in Space?

Not really! It is true that the farther apart two objects are, the less gravitational force there is but, in the case of astronauts on the International Space Station, they aren't actually far enough away to avoid gravity entirely. The pull of gravity is a little less—about 90% of what we feel on Earth—and yet they still "float".

- Why do you think that is?

It has to do with something called free fall. Think of it this way: the ISS is travelling super-fast, and gravity is pulling it towards Earth. But, its forward motion has been calculated to match the curve of the Earth which basically means the ISS just keeps falling and falling but always missing the Earth!

Because the downward force and the forward motion of the Station are pretty much the same, the astronauts are not being pulled in any particular direction which is why they appear to "float".

- It looks like fun to float in Space—but do you think it could be dangerous for astronauts?

Being in microgravity affects the health of astronauts in many ways. Some effects are temporary, but others can last, to varying degrees, even after astronauts return to Earth.

Let's think about the body for a moment.

- What is inside the body? (Answers will vary but looking for fluids.)

Normally, gravity pulls the fluids in our bodies down into our legs, but the fluids in our bodies move inside us differently when we are in Space.

When astronauts first get into Space, there is more fluid going "up" into their faces and heads, and less staying "down" in their legs, ankles and feet. This gives them what they call "Puffy Head Bird Legs" syndrome.

Show pictures of Canadian astronaut Bob Thirsk.

Bob Thirsk on Earth

Bob Thirsk in Space

After a few days, their bodies adapt to the microgravity environment of Space.
Their fluids then move more evenly throughout their bodies and this effect disappears.

As you can imagine, when people first started living on the International Space Station, scientists needed to study this effect so they could determine whether this was safe for the astronauts. They needed to understand what changes happen to the human body in Space, how it adapts while in Space and what happens once astronauts return to Earth. This is one of those times when astronauts became the experiment!

NOTE

This will be done as a demonstration/ experiment in the workshop space, so the concept can be introduced here and then expanded upon in the workshop. All the information is presented here to keep it together.

Another way being in Space affects the body is that astronauts become “taller” in Space. This is because there is less force pulling on them in microgravity, and structures like the spine stretch out.

A microgravity environment can also affect eyesight by causing changes to the shape of the eyeballs. Canadian astronaut Bob Thirsk’s eyesight changed so much that NASA had to send him eyeglasses during his six-month mission in 2009 because his sight changed so much it was becoming hard to read manuals etc. This was the first time an astronaut had noticed a significant change to their eyesight but it has happened
to more astronauts since and is something that scientists are studying so they can understand it better.

Microgravity also affects the muscles and bones of astronauts.

- Why would microgravity affect muscles and bones?

In microgravity, our muscles and bones don’t have to work as hard as they do on Earth. On Earth, our bodies have to fight the effects of gravity just to stand up and move around and our bodies have adapted to this environment. When we go to Space, we aren’t subject to the same degree of constant pull, so our bodies don’t have to work as hard. This has the effect of weakening our bones and muscles.

- Has anyone ever heard the term muscle atrophy?

Imagine if you were in a hospital bed for a really long time, and you couldn’t get up and move around. After a while, your muscles would get used to not moving. They would lose their muscle tone and get weaker. This is what we call muscle atrophy.

In Space, because astronauts' muscles don't have to work as hard as on Earth, they suffer an effect similar to being inactive for a long time. Their muscles get weaker. From studying the effects on astronauts over the years, we have
learned that they need to exercise in Space to keep their muscles strong and avoid muscle atrophy.

Position group near bone density interactive in the exhibition.

- So that explains our muscles, but what happens to our bones in Space?

Normally, our bodies are continually making, absorbing and rebuilding our bone tissue.
This replenishing cycle happens with other parts of our bodies too. With our skin cells for example. When we damage our skin, we know new cells grow but in fact the body sloughs off and replaces skin cells at a rate of roughly every couple weeks.

In Space, we've noticed that, while our bodies are still absorbing old bone tissue, they don't replenish it with new bone tissue at the same rate. This causes an overall loss of bone density, making bones brittle, and more likely to break.
This is very similar to what happens to elderly people on Earth because, as our bodies age, that natural replenishing process slows down.

- Have you ever heard that older people can break their bones more easily?

As we age, our bones can become weaker which means they can break more easily. On Earth, it generally happens because the body slowly becomes less able to store and use key vitamins and minerals—especially calcium, which helps keep bones strong.

Some elderly people develop a disease called osteoporosis, which is characterized by low bone mass and the deterioration of bone tissue.

Scientists are not yet sure exactly why being in microgravity causes our bodies to not replenish our bone tissue at the same rate as it is absorbed. Scientists continue to conduct experiments on the ISS in order to figure out what is happening, and possibly determine ways to prevent this effect on astronaut's bones.

One of the neat things about this work is that scientists can study the astronauts before they go into Space, monitor what happens to them while they are in Space, then study their rehabilitation progress once they return to Earth. Luckily, they do regain some—although not all—of their bone density once they are back home.

What this means for people on Earth is that this information can be used to figure out how to help people who have lost bone tissue. We may be able to help them regain some bone tissue, and perhaps one day prevent bone tissue loss altogether. This would improve the lives of our elderly by preventing a lot of the suffering they experience due to brittle bones.

NOTE

This will be done as a demonstration/ experiment in the workshop space,
so the concept can be introduced here and then expanded upon in the workshop.
All the information is presented here to keep it together.

- Do you think these physical effects are the only things astronauts experience as a result of living in microgravity?

Microgravity actually affects astronauts in many other ways. Another interesting effect that scientists are studying is changes to an astronaut's perception.

Use as segue to move to Disorientation section.

6-Disorientation

On Earth, our brains are adapted to us being rooted to the ground (down) and we perceive “up” as being anything in the opposite direction.

- But if astronauts are floating around inside the ISS, do they experience an “up” and a “down”?

Show picture of Bob Thirsk and Julie Payette.

Not exactly. Remember, on the ISS, the astronauts are in free fall. They don’t experience that same downwards pull of gravity as we do on Earth. With nothing to pull their bodies “down”, their brains can lose track of where they are.

- Can you think of an activity that you might do on Earth, that could give you a similar sensation?

Scuba diving. When you are in the water, gravity is still pulling you down but there is another force that is working in the opposite direction, helping you to float.

- Does anyone know what that force is? (Buoyancy.)

Buoyancy is the force exerted by the water which pushes you up and works against the downward pull of gravity.

Scuba divers wear weights and learn to control their breathing so they can explore under water without either sinking to the bottom or floating to the surface. The experience of being underwater like that is close enough to what it feels like in Space, that astronauts do a lot of underwater training in order to get used to it.

But scuba diving, like Space exploration, has its dangers.

One of the dangers of scuba diving is that if you go too deep or are diving in murky water or at night, you can get disoriented and confused and may no longer know which way is up.

- How do divers mitigate that danger and keep themselves safe?

Divers do several things to mitigate this risk. For example, if they can't see the Sun and use it as a point of reference, they can follow the bubbles from their equipment, since bubbles will rise to the surface. They watch out for one another using the buddy system. They also pay attention to little things like the position of the weights they wear in a belt on their waist. If they are facing downwards, they will feel the pressure of the weights on their rib cage. If they are facing up, they will feel the pressure on their hips. This helps them to understand which way is up.

- So what about in Space? How do astronauts determine which way is up on the ISS?

Something that makes it even harder is that the ISS is a relatively small space and in order to make the best use of every surface, all four walls are workable walls, lined with equipment. So not only are astronauts not experiencing the downward pull of gravity, they also don't have floors or ceilings to use as a point of reference!

Show photo of the station interior with all its working walls.

In general, on the ISS, whichever way your head is pointing is considered “up” for you!

- But doesn’t that get confusing?

In a word, yes! And that confusion can actually lead to astronauts feeling ill. Sometimes they also have a hard time judging where their arms and legs are when they are moving about the station or trying to do tasks.

The problems caused by disorientation in space are why many studies done on the ISS involve looking at the human brain and perception, and what happens to us in this very different environment.

One of the experiments David Saint-Jacques worked on during his mission, involved how the brain understands what it sees, how it uses that information to create a map of its environment and then uses that information to help the body move around safely in that space.

On Earth, our brains—unless somehow impaired— do all of this naturally. In Space, the brain must relearn how to draw a map of its environment, as well as how to tell the body where to move within that environment.

Aside from helping astronauts adjust to Space, this information could also help people on Earth who suffer from various conditions. This includes the elderly who are more prone to falls as they age, due to disorientation caused by age-related deterioration of the brain.

7-Radiation

- Who has heard of radiation? What is it?

In simple terms, radiation is energy moving through Space.

- Are we exposed to radiation on Earth? What is it, and where does it come from?

There are many types of radiation that occur naturally in our world, some of which can be very harmful. Fortunately, Earth is protected from the bulk of that radiation by its magnetic field which is like a protective bubble surrounding the Earth. The type of radiation you have probably heard about the most is Ultraviolet Radiation (UV).

- Where does UV radiation come from?

UV radiation comes from the Sun. And it isn't all bad! We need the Sun's warmth and light. Our bodies also need it to make Vitamin D, which is essential to our survival.

- What happens to our skin when it is exposed to too much sun?

Exposure to too much UV radiation from the Sun can cause sunburn. This is damage to our skin cells and is known to cause some types of cancer. We protect ourselves by using sunscreen, wearing clothing to block the Sun's rays, and by staying out of the Sun when it is strongest—in other words, when it is highest in the sky.

- What about astronauts?
- Are they exposed to radiation?

Yes! The farther into Space we go, the more exposed we are to different types of radiation. And the Sun can be volatile—remember, it is a big ball of hot gas! There can be explosions (solar eruptions) and solar flares, which send out even more radiation at times. These can be particularly dangerous to astronauts.

- How do astronauts protect themselves?

Astronauts use several things to mitigate the risks of exposure to radiation, both on the ISS and during spacewalks.

Space suits are designed to protect against certain kinds of radiation. Spacewalks are not scheduled (or will be cancelled) if there are signs of events like a solar storm that could send excessive radiation their way.

There is an area on the ISS Space Station (the Kibo module) where there are water storage tanks. In the event of a bad solar storm, astronauts can take refuge in that area. The water in the tanks will serve as an extra layer of protection against radiation, by slowing down or even blocking dangerous particles.

Scientists also keep track of how much radiation astronauts are exposed to by using devices called dosimeters.

Refer to examples in exhibition display

While on his recent mission, David Saint-Jacques helped Canadian scientists with an ongoing experiment called Radi-N2, designed to help monitor radiation on the ISS. As part for the experiment, he placed a type of dosimeter called a bubble detector in locations throughout the station.

These monitors detect a type of radiation called neutron radiation. The data collected will help scientists figure out more ways to mitigate the effects of this type of radiation. This is important, of course, for astronauts in Space, especially as we plan for longer missions, farther away, where there will be more exposure. But it is also important for people on Earth working in places like cancer clinics and nuclear power stations, where they can be exposed to similar kinds of radiation.

8-Experiments In Workshop Area

Zoom over to the area chosen for conducting the workshop

NOTE

The activities outlined below are modular— venues can choose to do as many or as few as they wish. The activities lend themselves well to being presented as experiments conducted by students (working alone or in groups), or as demonstrations delivered by the guide with student volunteers.

EXPERIMENT/ DEMONSTRATION #1: BONE DENSITY

Objective

- Understand that holes weaken a structure, and that this is what happens to an astronaut's bones in Space, as well as to people suffering bone loss or osteoporosis on Earth.

Materials

- Styrofoam cup
- Pencil (or similar item—e.g., small wooden dowel)

Methodology

- Remind students (by asking questions) of bone-loss problem in Space.
- Show students a Styrofoam cup, and explain that this represents our bones.
- Invert the cup, and press gently on the base of the cup to show that it is relatively strong.
- Poke holes in the cup with the pencil/dowel (these holes represent lost bone density).
- Now press on the inverted cup and see what happens (the cup is much weaker and will collapse).

Additional Information

- If allowing the students to do the activity for themselves, divide them into groups and give each table one cup. Have them test its strength by pressing down gently on the bottom of the cup. Caution students not to smash the cup and ruin the experiment.
- Students can take turns each putting several (four or five) holes in the cup until it collapses.
- Remind them about taking safety precautions to mitigate risks, (e.g. being careful not to poke themselves).

EXPERIMENT/ DEMONSTRATION #2: “PUFFY HEAD BIRD LEGS”

Objective

- Understand that fluids move around the body, and how they are affected by microgravity.

Materials

- String, cut in lengths of approximately 10” / 25.4 cm (avoid yarn as it is too elastic)
- Washable markers

Methodology

- Remind students of the “Puffy Head Bird Legs” effect that astronauts experience.
- Tell students about Canadian astronaut Bob Thirsk, who was instrumental in doing research around the effects of microgravity on the body.
- Have students work in pairs, taking turns being the subject and scientist.
- Have the “scientist” measure their “subject’s” ankle or wrist (subject can choose) with
- the string, by wrapping it around their ankle/ wrist and marking the appropriate spot on the string with a marker.
- Have the “subjects” sit with their feet in

- the air (up against a wall is most comfortable) or with their arm raised, for one minute.
- Have the “scientist” measure them again (while the “subject’s” feet/arms are still elevated).
- If one minute is not sufficient to notice any effect, repeat with legs up for two minutes. Have the students swap roles.
- **Note:** Students may only see a slight change, but it should be enough to illustrate the point.
- **Safety Note:** Monitor students and ensure that the ones who were lying down stand up slowly.

IMPORTANT

This experiment could be done using measuring tapes to provide precise numerical results. We recommend using the string method, however, in order to prevent any students from feeling awkward about the size of their ankles/wrists in relation to their peers

EXPERIMENT/ DEMONSTRATION #3: RADIATION DETECTION

Objective

- Understand that radiation can be detected.
- Understand that radiation can be blocked.

Materials

- Pipe cleaners
- Regular pony beads
- UV colour changing pony beads
- Aluminum foil cut into small squares
- Optional: additional materials (tissue box, coffee filters, etc.) to test whether some will/ won’t block UV rays

Methodology

- Use pipe cleaners to create a stick-figure (tip: twist, rather than cut, the pipe-cleaners to shorten them more easily).
- Suggested construction: Use 1/3 of the pipe- cleaner to make the head and arms. Use the next 1/3 for the body—attach it to the head, then string on five or six beads, with the UV bead in the middle of the group. Attach the final 1/3 to the body to make the legs/feet (which will also ensure that the beads stay on the body).
- Place the figure in the sun (at a window works) and wait a few minutes until the UV bead
- has had a chance to absorb sufficient light to change colour.
- Remove the figure from the light and use the aluminum foil to cover the figure (or at least the bead)—basically an EVA suit for your pipe- cleaner person!
- Ask the students what they think will happen—will the bead still change colour when covered with foil?
- Test their theory (of course it won't change colour). You can then discuss how the aluminum foil blocked the UV rays from the Sun, and draw the parallel with astronauts using EVA suits to protect themselves on spacewalks, how astronauts block radiation on the Station, etc.)
- **Optional:** Have the students test various everyday items (tissue boxes, etc.) to see whether these have any effect. Encourage them to theorize first about what they think will happen and then have them test it to see the results.

Additional Information

- Some brands of UV colour changing beads are mixed colours. The ones that change to purple or pink work fairly well indoors, but the ones that change to yellow really need to be used outside for the effect to be seen.

CLEANUP/END

Appendix #1 Glossary

- **Astronaut:**
  An astronaut is a person who is trained (or is training) for Space travel.
- **Atrophy:**
  The slow wasting-away of tissue or organs; to cause something to degrade from disuse.
- **Bone Density:**
  The amount of bone tissue in a given volume of bone.
- **Bubble Detector:**
  A device used to detect exposure to neutron radiation.
- **Canadarm:**
  A remote-controlled robotic arm designed for use in Space.
- **Canadian Astronaut Corps:**
  A section within the Canadian Space Agency that recruits, hires and trains Canadian astronauts for participation in international Space exploration efforts.
- **Canadian Space Agency (CSA):**
  A Canadian federal agency established in 1990 to promote the peaceful use and development of Space for the social and economic benefit of Canadians.
- **Dosimeter:**
  A device used to measure exposure to radiation.
- **Free Fall:**
  A downward motion in which gravity is the only force acting upon the object that is falling.
- **Fluid:**
  A state of matter; any substance that flows.
- **Gravity:**
  A natural force that pulls two bodies towards one another.
- **Hubble Space Telescope:**
  A telescope that has been in Space since 1990, taking pictures of the cosmos, (stars, planets, etc.).
- **International Space Station (ISS):**

A space station orbiting Earth, constructed between 1998 and 2011 through the cooperation of 16 nations.

- **Microgravity:**
  A small enough amount of gravity that people and objects appear weightless.
- **(The) Moon:**
  Earth's only natural satellite.
- **(Earth's) Magnetic Field:**
  An invisible field that forms a protective bubble around Earth.
  Also known as the magnetosphere.
- **Magnetic Resonance Imaging (MRI):**
  A medical technique that uses high-frequency radio waves and a strong magnetic field to create images of organs and tissues inside the human body.
- **National Aeronautics and Space Administration (NASA):**
  An agency of the United States government, created in 1958 and given responsibility for Space exploration and aeronautics.
- **NeuroArm:**
  The world's first surgical robot capable of conducting procedures inside an MRI machine.
- **Neutron:**
  A sub-atomic particle with no electrical charge.
- **Neutron Radiation:**
  The energy (radiation) produced by the movement of neutrons.
- **Osteoporosis:**
  A medical condition characterized by the loss of bone mass, resulting in fragile bones.
- **Radiation:**
  A type of energy that can move in the form of electromagnetic waves, as rays or particles.
- **Risk Mitigation:**
  A strategy of taking preventative steps to lessen the impact of possible negative results of an action/activity.
- **Satellite:**
  An object in Space that moves round a planet or star.
- **Space:**

The area beyond Earth’s atmosphere.

- **Space Shuttle:**
  A spacecraft designed and used by NASA for low-Earth orbit missions from 1998 to 2011, and featuring a reusable orbiter module.
- **(The) Sun:**
  The star at the centre of Earth’s solar system, around which Earth and the other planets orbit.
- **UV (Ultraviolet) Radiation:**
  A type of electromagnetic radiation (energy) generated by the Sun and certain human-made sources (e.g., tanning beds).
  Exposure to UV radiation is known to cause damage to human tissue.
- **Wearable Technology:**
  Pieces of technology that can be worn (clothing, accessories, etc.), implanted or tattooed, containing a microprocessor and connected to the Internet for the purpose of gathering, transmitting and analyzing data, or completing other practical tasks.

Appendix #2 Image Links

Links to the original (hi-res where available) versions of the images suggested in the tour document are presented in the order they appear in the program.

- **Canadarm**
  https://www.nasa.gov/mission_pages/shuttle/behindscenes/rms_gallery.html
- **Bob Thirsk on Earth**
  https://www.nasa.gov/mission_pages/station/expeditions/expedition20/preflight_briefing_050609.html
- **Bob Thirsk in Space**
  https://www.nasa.gov/mission_pages/station/expeditions/expedition22/butterflies_images.html
- **Julie Payette and Bob Thirsk**
  https://nara.getarchive.net/media/s127e009685-sts-127-payette-and-thirsk-pose-in-the-european- columbus-module-cb8197
- **ISS Interior**
  https://www.nasa.gov/image-feature/astronaut-david-saint-jacques-explores-how-to-produce-high-quality-semi-conductor

Curriculum Connections

ALBERTA

Grade 6

Science>Sky Science

- **Science Inquiry:** Design and carry out an investigation in which variables are identified and controlled, and that provides a fair test of the question being investigated.
- **Understandings: Topic C: Sky Science**: Understand that the Sun should never be viewed directly, nor by use of simple telescopes or filters, and that safe viewing requires appropriate methods and safety precautions.

BRITISH COLUMBIA

Grade 6

Sciences 6>Earth and Space

- **Questioning and Predicting:** Make observations in familiar or unfamiliar contexts; identify questions to answer or problems to solve through scientific inquiry; make predictions about the findings of their inquiry.
- **Planning and Conducting:** Observe, measure, and record data, using appropriate tools, including digital technologies.
- **Content:** The force of gravity; gravity is the force of attraction between objects that pulls all objects toward each other.

MANITOBA

Grade 6

Science>Exploring the Solar System

- **Learning Outcomes:** Identify technological developments that enable astronauts to meet their basic needs in space; identify Canadians who have contributed to space science or space technology, and describe their achievements; investigate past and present space research programs involving astronauts, and explain the contributions to scientific knowledge; describe positive and negative impacts arising from space research programs.

NEW BRUNSWICK

Grade 6

Anglophone Sector and French Immersion Program Science>Earth and Space Science: Space

- **Outcomes:** Provide examples of Canadians who have contributed to the science and technology of space exploration; describe examples of improvements to the tools and techniques of exploring the solar system that have led to discoveries and scientific information; identify examples of scientific questions and technological problems about space and space exploration that are currently being studied.

NEWFOUNDLAND AND LABRADOR

Grade 6

Science 6>Space

- **Outcomes:** Describe examples of improvements to the tools and techniques of scientific investigation that have led to new discoveries; describe instances where scientific ideas and discoveries have led to new inventions and applications; provide examples of Canadians who have contributed to science and technology.

NORTHWEST TERRITORIES

Grade 6

Science & Technology>Earth and Space Systems: Space

- **Specific Learning Outcomes:** Describe how humans have improved the tools and techniques used in space exploration; identify Canadians who have contributed to space science and technology; identify the technological tools and devices needed for space exploration; recognize problems arising from space exploration; identify the ways in which the development of materials and technology for space exploration has led to the use of new technologies and materials on earth.

NOVA SCOTIA

Grade 6

Science P-6>Earth and Space Science: Space

- **Indicators:** Investigate Canadian and global innovations in space exploration; How has technology permitted the exploration of space?; How have Canadian scientists contributed to space exploration?; How are the needs of humans in space different from those on Earth?

NUNAVUT

Grade 6

Science & Technology>Earth and Space Systems: Space

- **Specific Learning Outcomes:** Describe how humans have improved the tools and techniques used in space exploration; identify Canadians who have contributed to space science and technology; identify the technological tools and devices needed for space exploration; recognize problems arising from space exploration; identify the ways in which the development of materials and technology for space exploration has led to the use of new technologies and materials on earth.

ONTARIO

Grade 6

Science & Technology>Understanding Earth and Space Systems: Space

- **Specific Expectations:** assess the contributions of Canadians to the exploration and scientific understanding of space; evaluate the social and environmental costs and benefits of space exploration, taking different points of view into account; use appropriate science and technology vocabulary; identify the technological tools and devices needed for space exploration.

PRINCE EDWARD ISLAND

Grade 6

Science>Earth and Space Science: Space

- **Outcomes:** provide examples of Canadians who have contributed to the science and technology of space exploration; describe examples of improvements to the tools and techniques of exploring the solar system that have led to discoveries and scientific information;

identify examples of scientific questions and technological problems about space and space exploration that are currently being studied.

QUEBEC

Elementary Cycle Three Science and Technology

- **Earth and Space Science:** Space Essential Knowledges: effect of gravitational attraction on an object; technologies related to the Earth, the atmosphere and outer space; terminology related to an understanding of the Earth and the universe.

SASKATCHEWAN

Grade 6 Science

- **Earth and Space Science:** Our Solar System Outcomes: Evaluate past, current, and possible future contributions of space exploration programs including space probes and human spaceflight, which support living and working in the inner solar system. Indicators: Describe instances where scientific ideas and discoveries have led to new inventions and applications that support human exploration of space and which have extended scientific knowledge related to living and working in space; identify potential personal, societal, technological, and environmental barriers to living and working in space.

YUKON

Grade 6 Science

- **The Solar System and the Universe Questioning and Predicting:** Make observations in familiar or unfamiliar contexts; identify questions to answer or problems to solve through scientific inquiry; make predictions about the findings of their inquiry. Planning and Conducting: Observe, measure, and record data, using appropriate tools, including digital technologies. Content: the force of gravity; gravity is the force of attraction between objects that pulls all objects toward each other.

This lesson plan was produced by the Canada Aviation and Space Museum.

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