National Aeronautics and Space Administration


# #STEM on Station

## International Space Station Activity Kit


20 Years on the International Space Station

www.nasa.gov

National Aeronautics and Space Administration

# Welcome!

STEM on Station is an education activity that leverages the International Space Station to engage students and educators in NASA's missions and to encourage students to study and pursue science, technology, engineering and mathematics (STEM) interests. This booklet and the accompanying activities help tell the story of the space station to a wide range of learners.

This kit highlights twenty years of continuous human habitation on the International Space Station. After November 2, 2020, every person under the age of 20 will have always lived in a world where humans have continuously lived and worked off the planet. These students are a part of the **#ArtemisGeneration** of young learners and future explorers!

Over the past twenty years, the International Space Station has hosted more than 240 people from 19 different countries and more than 2,800 experiments. The space station's unique microgravity environment allows for research breakthroughs not possible on earth and remains the sole space-based proving ground and stepping stone for NASA's Artemis program.

When the twentieth anniversary celebration ends, the learning continues! All of the activities in this booklet easily adapt to current space station crews and operations – extending its usefulness throughout the life of the space station. Be sure the check out the STEM on Station website at nasa.gov/stemonstation to stay up-to-date with the latest space station news, resources and opportunities.

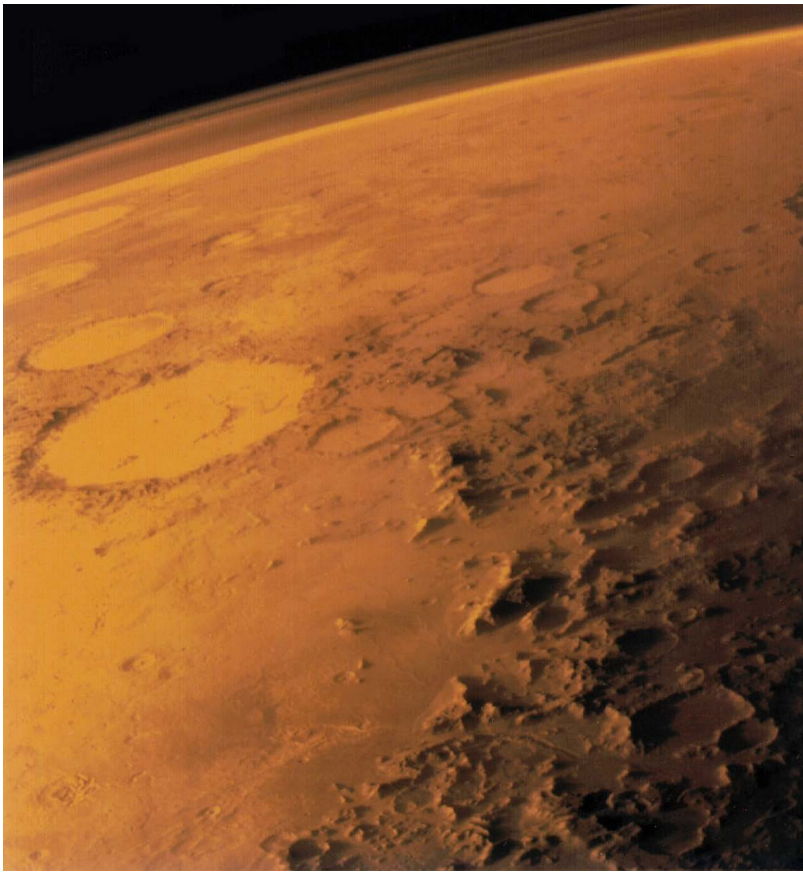
ISS20

20 Years on the International Space Station

# ISS 20th Anniversary

# ISS 20th Anniversary

- NASA and its partners have successfully supported humans living in space aboard the International Space Station since November 2, 2000.
- The space station has hosted more than 240 people from 19 countries, more than 2,800 experiments from 4,000+ researchers in 108 countries, and a variety of international and commercial space craft.
- The ISS remains the sole space-based proving ground and stepping stone for achieving the goals of the #Artemis lunar exploration program.
- The space station was built in orbit over 41 assembly flights between 1998 and 2011.
- The ISS orbits the Earth 16 times per day and its orbital path covers 90% of the Earth's population.
- On December 28, 2019, NASA astronaut Christina Koch broke the record for the longest continuous female spaceflight; her record stands at 328 days.
- Scott Kelly holds the record for the longest single spaceflight by a NASA astronaut at 340 days where he participated in the One Year Mission with Russian cosmonaut Mikhail Kornienko.
- It took a collaborative effort by 15 nations to construct the space station in orbit, and that collaboration continues today. The principal space agencies are the United States' NASA, Russia's Roscosmos, ESA (European Space Agency), Japan Aerospace Exploration Agency (JAXA), and the Canadian Space Agency (CSA).

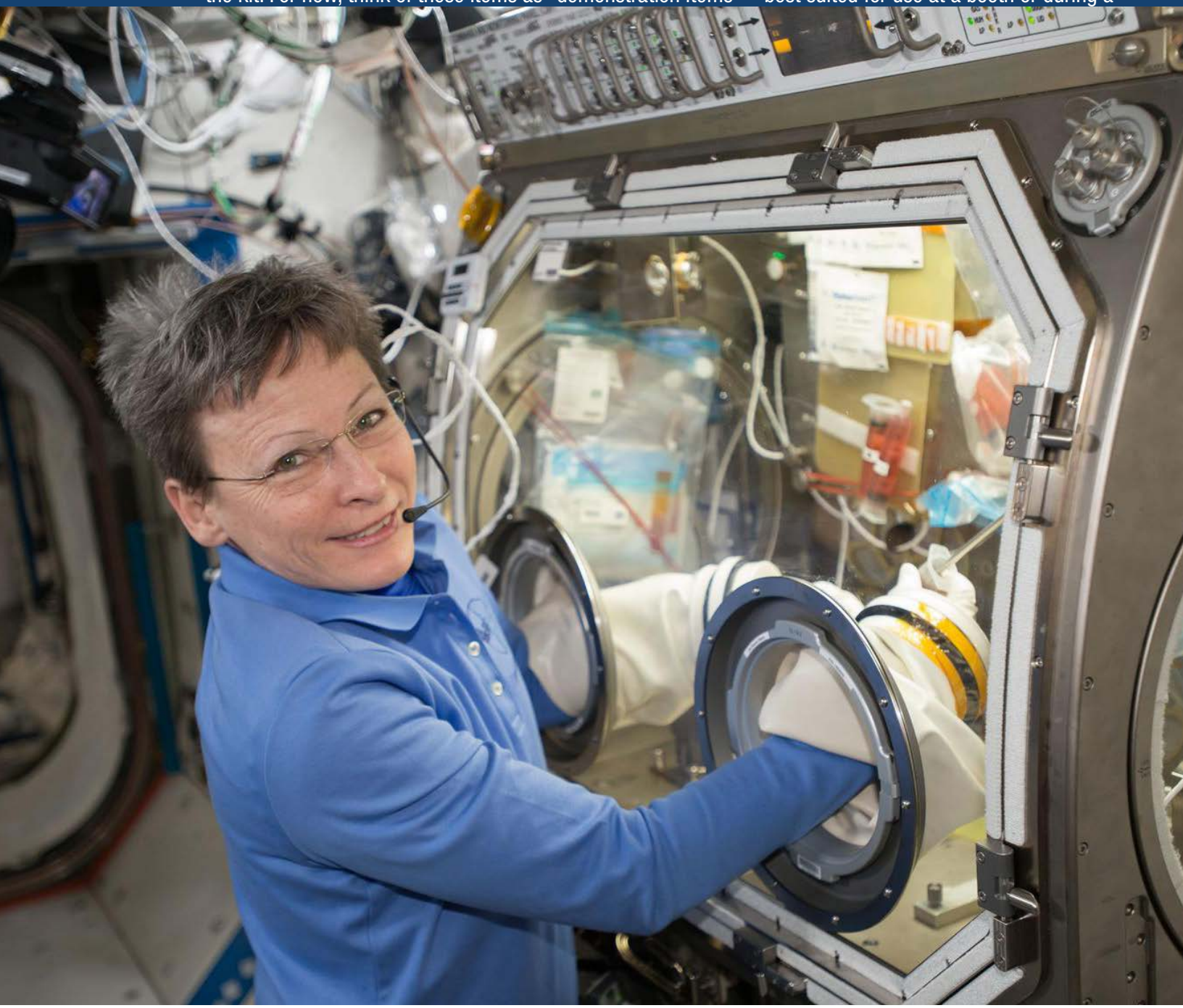


- Around 250 scientific investigations are conducted on station at any given time. The Space Station serves as a test bed for innovative technologies like recycling plastic waste and carbon dioxide filtration that are critical for long-duration missions to the lunar surface in the Artemis program.
- Crew member safety is also important for lunar missions, so data collected from bone scans and eye exams helps inform what happens to the human body in space.

Learn more about the 20th Anniversary of the space station at www.nasa/website.gov

# Demonstration Items

Time to have some fun! In this section, you will find talking points and suggested uses for the main items in the kit. For now, think of these items as “demonstration items” – best suited for use at a booth or during a



# Earth, Moon, Mars and the International Space Station

## What Do I Do?

The Earth, Moon, Mars and International Space Station models can help give audiences a better understanding of the distance between these places. Use the talking points to help audiences understand the space station and some of the research conducted onboard. You could also talk about the space station's role in the **#Artemis** missions. To get your audience in on the action and set up a model showing the distances between the items, check out the activity on **Page 17.** These items also make great photo props!

## Talking Points

- The International Space Station is a like a big house and laboratory in low-Earth orbit where astronauts live and work.
- Scientists all over the world use the space station to conduct experiments that help us prepare for deep space exploration and improve life on Earth.
- NASA used to take astronauts to the space station on the Space Shuttle. Now that the Space Shuttle has retired, astronauts go back and forth on a Russian vehicle called a Soyuz and the commercial vehicles designed with NASA's Commercial Crew Program.
- Commercial companies will begin launching American astronauts in American rockets from American soil to the space station in 2020.
- NASA is developing the Orion spacecraft to take astronauts into deep space.
- The space station is not as far from Earth as most people think – only about 250 miles away.
- When NASA goes beyond the space station (low-Earth orbit) and into deep space – the challenges become much greater. What we are learning on the space station is preparing us for future exploration.

## ITEMS NEEDED

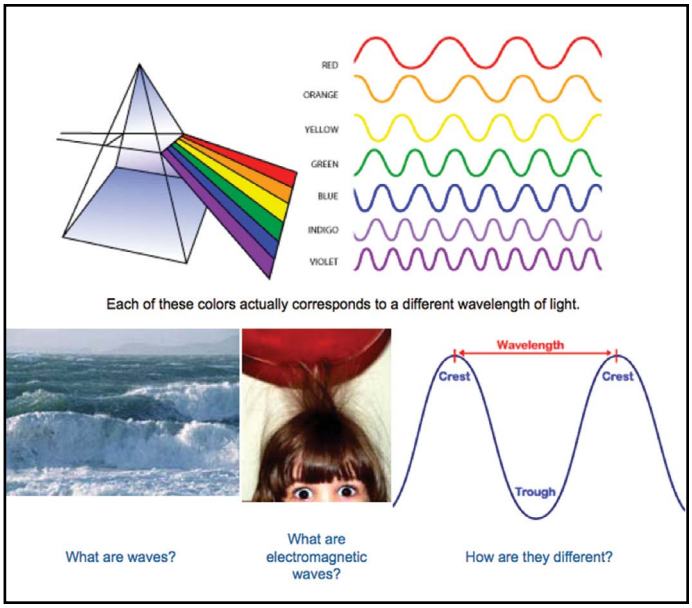
1. **Plush Earth model with Velcro enclosed Moon**
2. **Plush Mars model**
3. **Rope**
4. **International Space Station image**

- The distance from Earth to the Moon is about 250,000 miles.
- The average distance from Earth to Mars is 140 million miles, but these planets can be as far apart as 250 million miles when they are on opposite sides of the sun. This variation in distance determines when we can launch to and return from Mars.
- We know that microgravity has many effects on astronauts, and research is conducted to help study those effects and determine appropriate countermeasures.
- Based on blood and urine samples collected from astronauts, scientists have developed a theory that a diet with a lower ratio of animal protein to potassium will help to avoid bone loss during spaceflight. This could mean that a diet with too much meat and not enough fruits and vegetables is unhealthy for our bones.
- This helps us know which foods to take with us to space, and this research may help us prevent or mitigate the effects of osteoporosis on Earth.
- What happens when astronauts get sick? NASA is experimenting with ultrasound technology that will help us evaluate and diagnose 250 medical conditions that could affect exploration crews.
- Currently, medical procedures on the space station require real-time remote guidance from experts on the ground.
- As humans travel farther from Earth, communication delays will increase, eventually making real-time guidance by experts on Earth impossible.
- The Autonomous Medical Officer Support Software Demonstration (AMOS Demonstration) enables crew members to autonomously (and without preflight training) perform ultrasounds on another crew member.
- What would it be like to stay in your classroom for months at a time – without coming home? The "Journals" experiment, where astronauts record their thoughts and feelings, provides information on behavioral and human issues that teach us about the effects of isolation, confinement and other stressors.

Learn more about the space station and the research onboard at **https://www.nasa.gov/mission_pages/station/research/experiments/explorer/index.html**.

Learn more about NASA's #Artemis at **nasa.gov/artemis**.

# Radiation




## What Do I Do?

Radiation is one of the main challenges associated with long-duration exploration. The UV detecting beads can be used to explain how we can detect radiation and what we can do to protect astronauts and equipment, such as shielding areas of the spacecraft. The UV detecting beads will turn colors when they are exposed to UV and will return to white when they no longer detect UV. This is always a crowd pleaser - you just need the sun! Check out the different items you can use to "shield" your UV detecting beads in the activity on Page 18. You can also use the fishing line and scissors to make UV detector bracelets for your participants to take away! Check out the talking points for more information on how to talk all about radiation.

## Talking Points

- When astronauts travel through space, the space vehicle helps provide protection from many dangers, including space radiation.
- Space radiation comes from the sun and sources outside our solar system. This is sometimes called space weather.
- Radiation is a form of energy that travels in waves.
- Different types of energy have different wavelengths.
- The full range of wavelengths is called the electromagnetic spectrum.
- The shorter the wavelength, the greater the potential for harm to both humans and mechanical or electrical systems.
- Some radiation can be felt as heat (infrared) and some radiation can be seen (visible light). Other types of radiation cannot be seen, such as ultraviolet (UV) light.
- Space radiation is difficult to block and can damage human tissue as well as equipment.
- The greatest source of radiation for Earth is the sun.
- Most radiation from the sun does not reach the Earth's surface because of the magnetosphere – the magnetic field surrounding Earth and the atmosphere.
- Even though the atmosphere protects us from most of the sun's harmful rays, there is still an abundance of UV rays all around us.
- We can see the effects of UV rays on our skin like a sunburn but can protect ourselves by wearing sunscreen or taking other actions like staying indoors or wearing long clothing.
- Outside low-Earth orbit, the protection of the Earth's atmosphere and magnetosphere is no longer available.
- NASA uses a suite of instruments to monitor the radiation environment on the space station.
- If necessary, crewmembers may seek shelter in a shielded area, such as the space station's Destiny laboratory, during a radiation event.

## ITEMS NEEDED

1. **UV detecting beads**
2. **Fishing line**
3. **Scissors**

Learn more about radiation at https://science.nasa.gov/ems.

# Sleep Restraint

## What Do I Do?

The sleep restraint is a great item for a photo opportunity! Encourage students to try it out for themselves and think about how it compares to their bed back home. Use the talking points below to talk more about how astronauts sleep on the space station, and check out the activity on Page 20.

## Talking Points

- Microgravity is the condition in which people or objects appear to be weightless.
- Some people think there is no gravity in space, but a small amount of gravity (microgravity) can be found everywhere in space.
- There is no up and down in space so astronauts can sleep in any orientation.
- Astronauts don't sleep in beds – they would float out! Instead, they sleep in sleep restraints that look like sleeping bags with arm holes.
- Astronauts must attach their sleep restraints to the walls of the station so they do not float around or bump into something.
- Astronauts may use Velcro straps to attach their heads to a pillow to help simulate the feeling of sleep on Earth.

International Space Station crewmembers usually sleep in small crew cabins. Each cabin is just big enough for one person.

Just like on Earth, astronauts may wake up in the middle of sleep to use the bathroom or stay up late to look out the window.

Different things such as excitement or motion sickness can disrupt an astronaut's sleep pattern.

Data shows astronauts do not get enough sleep, even though many take sleep medication during missions.

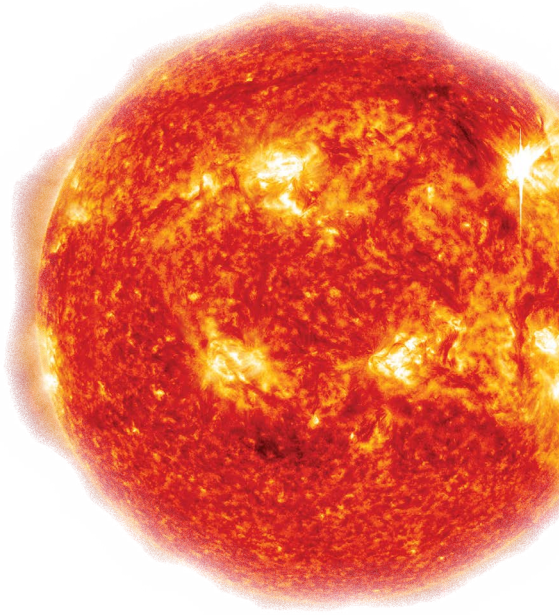
- Researchers are looking to find effective ways for astronauts to sleep well such as changing daily schedules or using sleep-promoting lighting.
- Adequate sleep is essential for health, performance and safety.
- A better understanding of how microgravity affects sleep and wake cycles could not only help astronauts, but the millions of people on Earth who suffer from insomnia.

Learn more about sleep on the space station at **http://www.nasa.gov/audience/foreducators/stem-on-station/ditl_sleeping/**.

## ITEMS NEEDED

1. **Sleep restraint (You can easily create a sleep restraint using a sleeping bag!)**

# Solar Energy



## What Do I Do?

The International Space Station gets its power from solar arrays, and you can show how this works with the Solar Science Kit. Set the disk into motion with just a little help from the sun. Use the activity on **Page 22** to discover how well solar cells work under different conditions. Check out the talking points below for more on how solar cells work and how we use them on the space station.

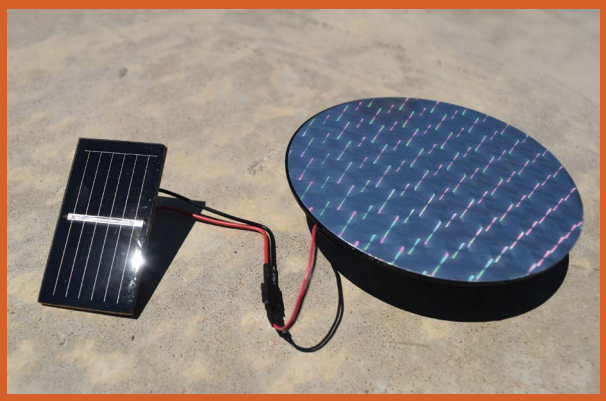
## Talking Points

- It is possible to collect and use energy from the sun, known as solar energy.
- Solar energy is useful because it can be turned into electricity.
- A solar cell is an electronic device that converts sunlight into electrical energy.
- The space station uses solar cells to capture sunlight and turn it into electricity.
- Thousands of solar cells make up the solar arrays on the International Space Station.
- The solar arrays contain 262,400 solar cells and cover about 27,000 square feet – that's almost six basketball courts!
- The solar arrays produce more power than the space station needs at one time so the extra power is used to charge batteries that power the station when it is not in the sunlight.
- A solar cell becomes less efficient when there is not enough light to convert to electricity.
- NASA has tested solar cells that continue to produce power all the way out to the orbit of Jupiter where sunlight is only 4% as bright as the sunlight on Earth. This is less sunlight than a very rainy day on Earth!
- Solar cells produce electrical energy with no requirement for fuel, no emissions and no moving parts – good news for spacecraft and people on Earth.
- Solar cells can create energy anywhere there is sunlight, which is critical for spacecraft since there are no places in space for spacecraft to plug in and recharge or refuel!

Learn more about the space station's solar arrays at https://www.nasa.gov/mission_pages/station/structure/elements/solar_arrays-about.html

## ITEMS NEEDED

1. **Solar Science Kit**
2. **Colored plastic sheets**

# Space Food

## What Do I Do?

Packaging and transporting food for astronauts to eat in space is a big job. You can use the various food samples in your kit, or pictures available online, to talk about the different kinds of food astronauts eat. Just remember, don't eat your samples! Use the activity on **Page 23** to have students build their version of a "space cup" for drinking in space. Check out the talking points to learn special rules for space food.

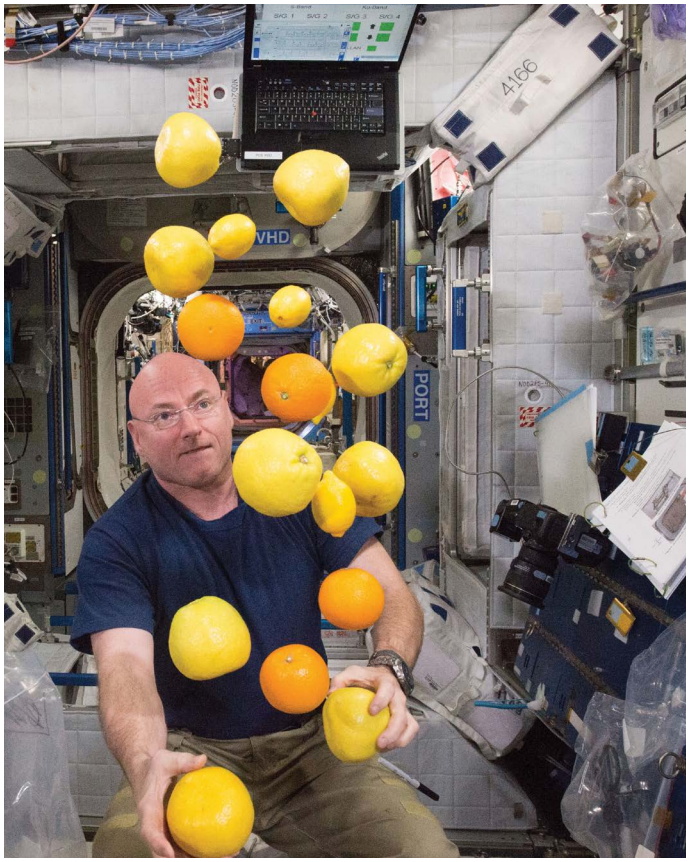
## Talking Points

- Food on the International Space Station is very similar to what we eat on Earth.
- The biggest difference is how food is stored and prepared. Most of the food has been specially treated so harmful bacteria will not grow.
- NASA has a Food Lab at the Johnson Space Center in Houston where scientists work to find and develop foods that meet special rules, taste good and provide the nutrition the astronauts need.
- Special rules for creating new space food include:
    1. Minimize crumbs: Crumbs can be dangerous because they can float into someone's eye or nose or into equipment on board, including air vents.
    2. Minimize packaging and weight of food: Room onboard the space station is limited, so the weight and waste from food must be limited. In addition, trash can only be removed from the space station about once a month.
    3. Taste and texture: Taste and texture (how food feels in your mouth) is important, which is why taste tests are conducted on Earth. When in space, some astronauts have reported that their tastes changed. Many prefer spicier foods.
    4. Shelf life: Shelf life (how long foods stay fresh) matters because food can spoil and/or lose nutritional value.
- Since the 1980's, tortillas have been used instead of bread because they are easier for the astronauts to handle when making meals and because tortillas do not produce crumbs as bread does. In addition, tortillas still taste good for up to 18 months.

## ITEMS NEEDED

1. **Variety of space food samples**

- International food is available to crewmembers through our Russian, Japanese, Canadian and European partners.
- Water is recycled onboard the space station. There are systems in place to collect and purify urine and other wastewater produced or used by crewmembers. This process allows wastewater to be safely reused by crewmembers to rehydrate foods.
- NASA is doing research on the space station to learn more about how nutrients in food affect our bodies, but nutritional research can be tough in space because getting basic measurements, such as body weight, is challenging in a weightless environment.
- NASA looks at the relationship between what astronauts ate and how well their bodies used each nutrient by analyzing blood and urine samples.
- NASA is doing research on how calcium in our diet can counteract bone loss, which is a serious concern for astronauts and people on Earth.




Learn more about eating in space at **http://www.nasa.gov/audience/foreducators/stem-on-station/ditl_eating/**.

# Vacuum Chamber

## What Do I Do?

Get to pumping! You can put different items like a balloon or a marshmallow inside the chamber and use the pump to pull out air and create a vacuum. What happens to the items next will get the crowd's attention! Watch the temperature, too – notice anything? Use the activity on Page 25 to have students learn about pressure, temperature and volume.

## Talking Points

- Space is a vacuum – but not like the kind of vacuum you use to clean your floors.
- In science, a vacuum means a space void of matter – solids, liquids and gases.
- Space is not a perfect vacuum because a few air molecules do exist in space, but the number of molecules is not significant. This means there is almost no air pressure in space.
- Atmosphere (air) pressure is the amount of force exerted over a surface area, such as Earth. It is caused by the weight of air molecules.
- The higher you go, the less air molecules there are. For example, if you were to ride in an airplane, the air pressure would be lower than it is on the ground because there are fewer air molecules higher in the sky.
- The International Space Station protects astronauts from the vacuum of space, but when astronauts go outside the space station, they must wear a specialized spacesuit.
- The pressurized volume of the International Space Station is 32,333 cubic feet – astronauts have about as much space as a five-bedroom house.
- Spacesuits also use pressurization to protect astronauts from the vacuum.
- Molecules expand in a vacuum, which means they can spread out over a large area.
- This expansion can cause the human body to swell and lead to major problems, which is why crewmembers must wear pressurized spacesuits.
- Spacesuits also shield the body from the extreme temperatures of space and provide oxygen to the crewmember.

Learn more about NASA's spacesuits at **https://www.nasa.gov/suitup**.

## ITEMS NEEDED

1. **Vacuum chamber**
2. **Vacuum pump**
3. **Balloons**
4. **Thermometer**

# Safety Procedures

# Safety in the Educational Classroom and Laboratory

Safety is important for all areas of education. Safety issues are a special concern for STEM-based activities and courses. Many national and state academic standards address the need for schools and subject areas to promote student development of knowledge and abilities in a safe learning environment. It is the responsibility of the educational organization's administration to provide a learning environment that is safe, up-to-date and supportive of learning. Additionally, educators / facilitators are responsible for their students' welfare in the classroom and laboratory.

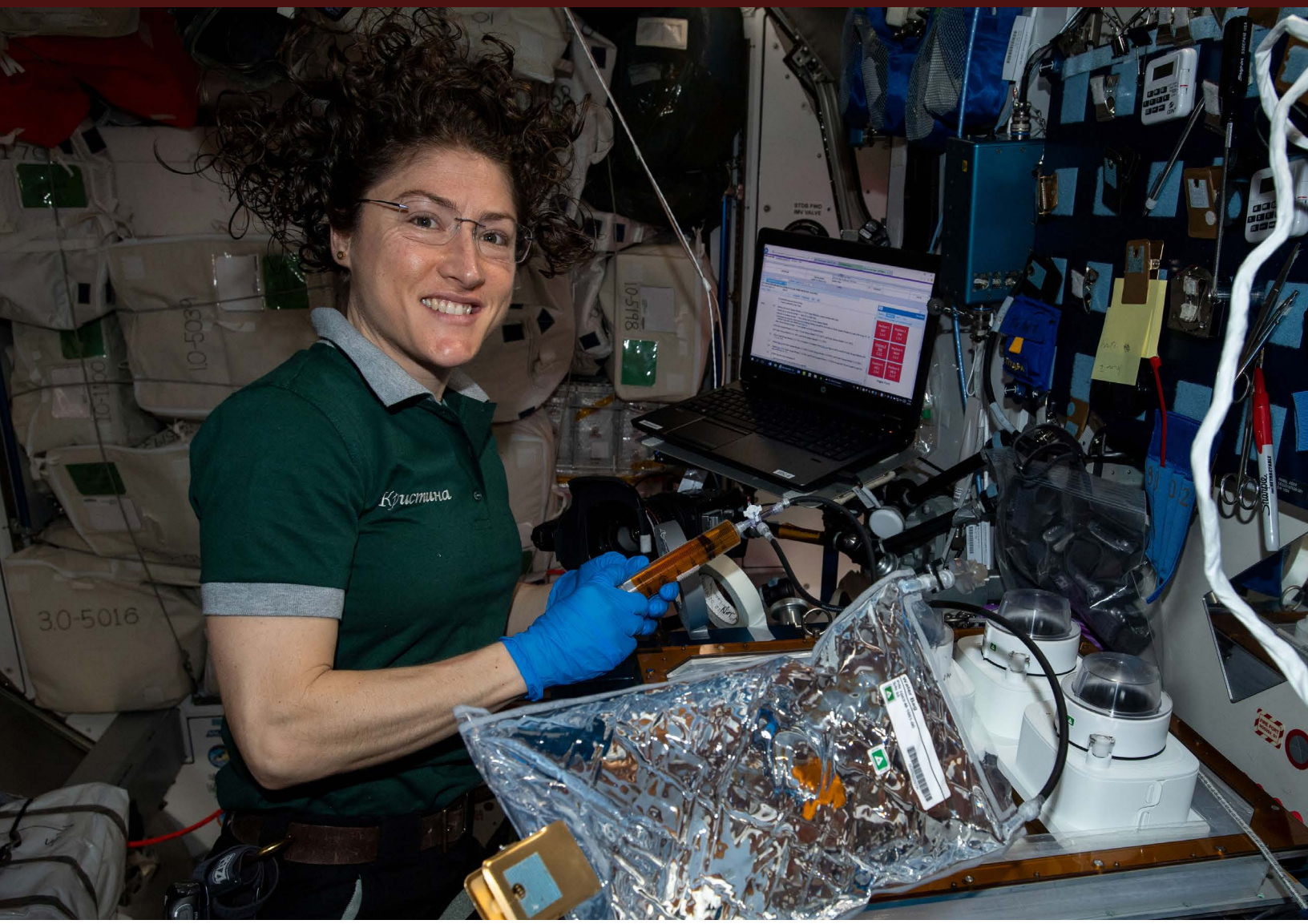
**Safety Rules:**

Below are examples of safety rules that may be used. Educators / facilitators should develop their own safety rules to fit the needs of their classroom or laboratory.

1. Conduct yourself in a responsible and safe manner at all times.
2. Follow all written and verbal instructions carefully. If you do not understand a procedure or how to use a tool, ask before proceeding.
3. Keep your work area clean at all times.
4. Use proper safety protection, i.e. gloves, goggles or proper clothing.
5. Notify your educator/facilitator in an emergency.

# Activities

Have some time with your audience? Conducting a workshop? These hands-on activities are a great way to dive further into the concepts discussed on previous pages with your student (or educator) scientists and engineers. These activities are geared towards an audience of 5th – 9th graders, but could be scaled appropriately to almost any grade level. If you don't have the kit, most of the items for these activities can be easily obtained or improvised.



# Student Scientists
## Earth, Moon, Mars and the ISS

### Background

Deep space exploration brings many challenges because the astronauts will be away from the Earth for a very long time – probably more than two years. Astronauts are currently onboard the International Space Station, but the space station is only about 250 miles away from Earth. Astronauts can travel there, spend a few months, and return to Earth. The Moon is much further from the Earth - about 250,000 miles away. Compare the distance to the places we have been – the space station and the Moon – with the place we are headed to – Mars. The distance from Earth to Mars is much further than the distance from Earth to the Moon.

The Earth, Moon, Mars and International Space Station activity will allow students the opportunity to construct a scale model of the Earth-Moon-Mars system, both in terms of planetary sizes and distances. Additionally, students will discover how far astronauts have to travel to visit the space station.

### Materials

- Plush Earth model with Velcro enclosed Moon ***(included)***
- Plush Mars model ***(included)***
- Rope ***(included)***
- International Space Station image ***(included)***

### Procedure

1. Give the Earth to one volunteer and the Moon to another.
2. Ask them to stand where they feel is the right distance between the Earth and the Moon.
3. Ask one volunteer to wrap the rope around the Earth about 9.5 times. This approximates the distance between the Earth and the Moon.
4. Ask two more volunteers to stretch the rope between the Earth and the Moon and make any adjustments to where the Moon volunteer is standing.
5. Give another volunteer the image of the space station and ask them to place it where they think it orbits the Earth. At this scale, the actual typical orbit is about as high above the Earth as the thickness of the rope. Make any corrections needed to where the space station volunteer is holding the photo.
6. Give Mars to another volunteer and ask them to stand where they think Mars is in relation to the Earth and Moon. At this scale, the volunteer would actually end up standing almost three miles away for the average distance between the Earth and Mars. Don't let them go that far!
7. Engage students in conversations about their observations. Some questions to consider:
    - What challenges must be addressed before we can send humans to deep space?
    - Would you go on a mission to Mars?

### Extension Ideas

Have the students "spot the station" from their homes. The International Space Station is the second brightest object in the night sky and is easy to see without a telescope. Go to **http://spotthestation.nasa.gov** where you can register for alerts to learn when the space station will pass over your hometown.

# Student Scientists
## Radiation

### Background

Space radiation can place the crew at significant risk for radiation sickness and increased lifetime risk for cancer, central nervous system effects and degenerative diseases. On the International Space Station, a suite of instruments monitors the radiation environment. If necessary, the crew can take action to protect themselves during a period of high radiation.

This activity allows students to detect radiation and determine the effectiveness of countermeasures to protect against it. Using Ultraviolet (UV) detecting beads, students will detect the existence of ultraviolet radiation. Each bead contains a special pigment, which will change color when exposed to ultraviolet radiation from the sun. The beads are not affected by visible light and will remain white when not exposed to ultraviolet radiation.

### Materials

- UV detecting beads ***(included)***
- Container or covering to prevent the sun from hitting beads prior to the activity
- Sun and shade
- Sunglasses
- Sunscreen ***(You only need one type of sunscreen, but you can also use different brands or SPF rating for further experimentation)***
- Cup with water
- Zip-lock bags ***(optional)***
- Fishing line ***(included)*** to connect the beads
- Science journal for recording predictions and data
- Pencil

### Preparation

Set up five stations:

1. Sunny spot
2. Shady spot
3. Cup with water ***(in the sun)***
4. Sunglasses ***(in the sun)***
5. Sunscreen ***(in the sun)***

### Procedure

1. Ask students to make predictions in their journal. Some questions to consider:
    - Where do you think the bead will turn the darkest?
    - What will happen to the bead in the cup of water?
    - Do sunglasses protect your eyes from UV? What about regular glasses?
    - What do you think happens to UV rays on a cloudy day?
    - Is shade free of UV rays?
    - What do we do to protect ourselves from UV rays?
2. At each station, students will expose the UV detecting beads to the condition. Have students create a data table and record the results in their journal.
3. Rotate students through all five stations.
4. Engage students in conversation about their observations. Some questions to consider:
    - Was UV radiation detected? Where?
    - Were there any results that surprised you?
    - Do you think there are other conditions that would block UV rays?

### Helpful Hints:

1. *In order to help minimize a mess at the sunscreen station, you have the option of squeezing a little sunscreen into the zip-lock bag and dropping in the bead.*
2. *You may want to have multiple beads at each station so a supply can remain unexposed to UV rays and ready for the next group of students.*

**Extension Ideas**

1. Have students construct and test their own radiation shield prototypes for astronauts in space. They could use an assortment of materials such as clothing, paper, boxes, etc. and use their beads to test its effectiveness. Check out **https://science.nasa.gov/ems** to learn more about radiation and get resources to help students build their prototype.
2. Use the UV detecting beads and fishing line to create bracelets so students can continue to detect UV rays in their daily lives.

# Student Scientists
## Sleep Restraint

**Background**

Most of us sleep about the same number of hours each night and wake up about the same time each morning, even without an alarm. Some people vary their sleep patterns by using external alarm clocks to meet school, work or travel schedules. An internal clock, which consists of about 10,000 nerve cells located deep inside the brain, governs daily wake-up times in human beings. This internal clock is called a circadian clock. It appears to control or initiate various biological processes, including sleep, wakefulness, digestion and hormonal activity for a set number of hours unique to each individual.

On Earth, the circadian clock is set to the 24-hour light/dark cycle, or what we call day and night. This light/dark cycle, or day/night cycle, is a function of the rotational period of the Earth. Each planet or moon has a distinctive light/dark cycle related to its rotational period. The circadian system is set so that a person is best prepared to be alert and awake during the biological day and to sleep during the biological night. When people are required to perform activities at the wrong biological time, they may not function at their best. Each day the circadian clock is reset by cues received from the light of the sun.

A person's environment and situation can have a great effect on the quality and quantity of sleep he or she gets. Abrupt changes in sleeping times, such as those caused by air travel or changes in work schedules, can cause difficulty falling asleep or staying awake because external cues conflict with messages sent by the body's internal clock. The brain may be signaling, "Sleep!" while outside conditions may be saying, "Be active, it's morning!" Adjusting to a new time zone may take several days. Other factors can also affect the sleep cycle. Excessive physical exercise right before bedtime, medicines, mealtimes and stimulants (such as caffeine in coffee, tea and soft drinks) can all contribute to disrupted sleep schedules.

# Student Scientists

## Sleep Restraint (continued)

Astronauts experience changes in their environment and sleeping habits while they are in space. Researchers are looking for ways to address these problems. In space, astronauts commonly experience difficulty sleeping because of several factors—excitement, stress, noise, different environmental light and dark cues and apparent weightlessness. Resulting alterations in sleeping patterns can lead to deterioration of alertness and cognitive performance during the active hours of the workday. NASA researchers intend to evaluate the altered sleep patterns of astronauts during long-duration spaceflight to prepare for exploration of Mars and beyond. This study should lead to a better understanding of sleep mechanisms during space exploration and possibly to the development of new treatments for sleep disturbances associated both with space flight and for people with sleep disorders on Earth.

### Materials

- Science journal for recording predictions and data
- Pencil

### Procedure

After reading the background information, have students respond to the following prompt in their journals and discuss:

- Working in groups, discuss how astronauts must deal with disruptions in their light/dark (or day/night) cycles. Astronauts orbiting the Earth experience a period of light and dark every 90 minutes because they are moving so quickly around the Earth. Just as our light/dark cycle on Earth is about half dark and half light, the space station experiences 45 minutes of light and 45 minutes of dark. In addition, astronauts also deal with lights on the station that are constantly on. How do you think these disruptions would affect your sleep? What effects could a lack of sleep have on the astronauts? What countermeasures might NASA use to help astronauts overcome these problems?

### Extension

1. Have students design a new way to sleep on the space station. They could design a "bed" or new crew quarters – which is like a crewmember's bedroom. Have students present their ideas to the group.
2. Have students learn more about how a lack of sleep can affect reaction times with this NASA lesson plan - **http://www.nasa.gov/pdf/544715main_How_Quick.pdf**.
3. Check out the Sleep Science STEMonstration to learn more about sleeping on the space station - **https://www.nasa.gov/stemonstrations-sleep-science.html**

*Note: This activity was adapted from NASA CONNECT: The Right Ratio of Rest: Proportional Reasoning*

# Student Scientists
## Solar Energy

### Background

How do you get electricity more than 220 miles above Earth? No extension cord or power cable is available for that job, so the best source of energy for spacecraft is sunlight. More than an acre of solar arrays provide power to the International Space Station and make it the second brightest object in the night sky. This investigation allows students to explore one of the variables that might affect how much energy a solar cell can produce. A solar cell will provide energy for a small electric motor to do work. The motor will turn a disk. More energy will make the motor and the disk turn faster. By covering the solar cell with different color plastic sheets, you can test whether one color of light provides more energy to the solar cell.

### Materials

- Solar Science Kit **(included)**
- Colored plastic sheets **(included)**
- Black construction paper
- Black marking pen
- Stopwatch **(included)**
- Science journal for recording predictions and data
- Pencil

**Helpful Hint:**

*If you do not have black construction paper, you can use any material that will completely block light from reaching the solar cell.*

### Procedure

1. Assemble the Solar Science Kit per package instructions.
2. Make a small dot on the edge of the disk.
3. Place the solar cell and motor in bright sunlight. The motor should cause the disk to spin. If no spinning occurs, check the connections.
4. Watch the dot on the cardboard disk. Start the stopwatch when it gets to the top. Count the number of times the cardboard disk spins in 15 seconds. Multiply this number by four to get the revolutions per minute. Create a data table and record the figure in your journal.
5. Cover half the solar cell with black construction paper and repeat Step 4.
6. Cover the solar cell with different colors of colored plastic sheets and repeat Step 4.
7. Engage students in conversation about their observations. Some questions to consider:
    - What happened when you covered part of the solar cell with black paper? Why?
    - What is the relationship between the amount of solar cell that is covered and the speed at which the disk turned?
    - How is the energy provided by the solar cell related to the disk?
    - How did the colored plastic sheets affect the solar cell's ability to function?
    - Were there any results that surprised you?

### Extension Ideas

1. Have students think about what could possibly change the performance of solar cells in space. Have students design an experiment to test different variables that might affect how much electrical energy a solar cell will produce. For example, they could test different angles of the solar cell, debris (bits of paper), etc.
2. Get students all charged up as they create their own podcast featuring astronauts demonstrating solar arrays. Check out **https://www.nasa.gov/audience/foreducators/diypodcast/sa-video-index-diy.html** to get started!
3. Learn more about solar energy on the space station with this STEMonstration - **https://www.nasa.gov/stemonstrations-solar-energy.html**

# Student Scientists
## Space Food

### Background

Space food has come a long way over the past few decades, and innovations continue to make eating and drinking more Earth-like. For example, the European Space Agency partnered with two Italian companies to create ISSpresso in 2015, which allows astronauts to have freshly brewed coffee for the first time!

Astronaut Don Pettit also worked on an invention to improve drinking coffee on the space station. He designed and constructed a new kind of drinking cup while in space. In microgravity, liquids like coffee are tricky to handle. Liquids will form large spheres that drift around the spacecraft and make big messes if permitted to get loose. Consequently, liquids like coffee, tea, juice and water are contained in foil-coated plastic pouches with straws to keep them under control.

Astronaut Pettit thought it would be nice to have a different kind of drink container for drinking hot liquids. He constructed a cup from plastic sheets and tape. By squeezing the narrow edge, coffee moved up from the bottom of the cup to his mouth.

While the cup worked great, it did have a few problems:

- Astronaut Pettit had to cut and tape the cup together. A premade cup would save lots of time.
- Astronaut Pettit had to "brew" his coffee in a regular drink bag, transfer the coffee to the new cup and throw away the drink bag. A way to fill the cup directly with coffee without the intermediary drink bag would save time and waste.
- The shape of the cup makes removing the last drops of coffee and cleaning the cup difficult. An easy-to-clean cup would keep it sanitary and save time.

Now there is a "Space Cup" onboard for astronauts to use. The experiment, Capillary Effects of Drinking in the Microgravity Environment, studies the process of drinking from the specially designed Space Cups that use fluid dynamics to mimic the effect of gravity. Now, astronauts can make fresh coffee and drink it from a cup instead of a pouch.

### Materials

- Science journal to draw diagrams and document notes
- Pencil
- Drink bag and straw **(included)**

# Student Scientists

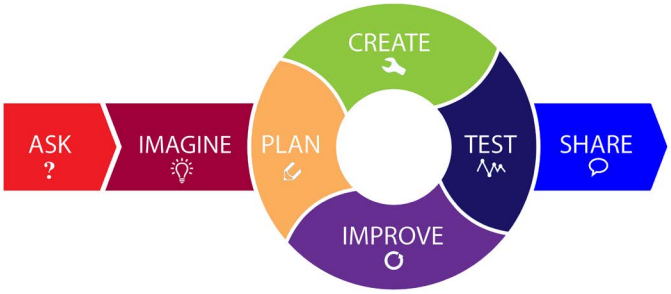
## Space Food (continued)

### Procedures

1. Engage students in a conversation. Some questions or discussion points to consider:
   - What will happen if a straw is placed into a drink bag containing liquid?
   - Show the straw clamp and ask what they think it is used for (keeping the bag sealed so liquid can't escape through the straw).
2. Have students design a new microgravity cup in their science journal using these NASA design requirements:
   - Compact for easy pre-launch packaging
   - Lightweight to keep launch costs low
   - Directly fillable with liquids
   - Easy to clean and reuse
3. Have students include a detailed explanation of their design.
4. Have students give a sales presentation on their design describing how it works, what its good points are and why NASA should use it.
5. Have students compare their designs to the "Space Cup".

### Extension

1. Have students use the Engineering Design Process to redesign other packaging for other items of food on the space station or a new tool - perhaps a bowl for cereal or a fork that also helps astronauts open the packaging.
2. Check out NASA's Food for Thought Educator Guide at **https://www.nasa.gov/stem-ed-resources/food-for-thought.htmlThought.pdf** for more resources and lesson plans.




*Note: This activity was adapted from the NASA Food for Thought Educator Guide – Now That's a Cup of Coffee*

# Student Scientists
## Vacuum Chamber

### Background

Astronauts must wear spacesuits when they go outside the International Space Station and are exposed to the vacuum of space. In space, there is no air to breathe and almost no air pressure. Without protection from the spacesuit, an astronaut would not be able to survive. In this activity, you will create a vacuum here on Earth and watch what happens to the volume of a balloon. This will help demonstrate just how critical a functioning spacesuit is to an astronaut.

### Materials

- Vacuum chamber **(included)**
- Vacuum pumper **(included)**
- Balloons **(included)**
- Ruler or measuring tape
- Marker
- Science journal for recording predictions and data
- Pencil

### Procedure

1. Blow up a balloon that will fill up half of the vacuum chamber.
2. Draw a 1cm line on the balloon.
3. Place the balloon in the vacuum chamber and close the lid tightly.
4. Ask students to make predictions in their journals as to what will happen to the balloon.
5. Use the vacuum pumper to pump out as much air as possible.
6. Make observations and have students record in their journals:
    - How long is the 1cm line? Did it get longer or shorter?
7. Engage students in a conversation about their observations and future predictions:
    - What will happen when you let the air back in? (Go ahead and see if they are right – just press on the sides of the lid to release the vacuum!)
    - Why do you think items like shampoo or lotion sometimes "explode" on airplanes?

### Extension

1. Astronauts wear pressurized suits, but all that pressure can make it difficult to move around. Check out NASA's Bending Under Pressure activity at **https://www.nasa.gov/pdf/188959main_Bending_Under_Pressure.pdf**. Everything you need for this demonstration is already included in the kit!
2. Have students explore the relationship between pressure and temperature. Use a thermometer strip to see what happens to the temperature when you create a vacuum.

### Helpful Hint:

*Why did this happen? A balloon gets bigger because of the air you blow into it. This air pushes on the walls of the balloon, but there is also air pressure pushing on the balloon from the outside. When you take away some of the outside air pressure, the air inside the balloon has an easier time expanding and starts pushing on the balloon walls. This makes the balloon expand.*

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