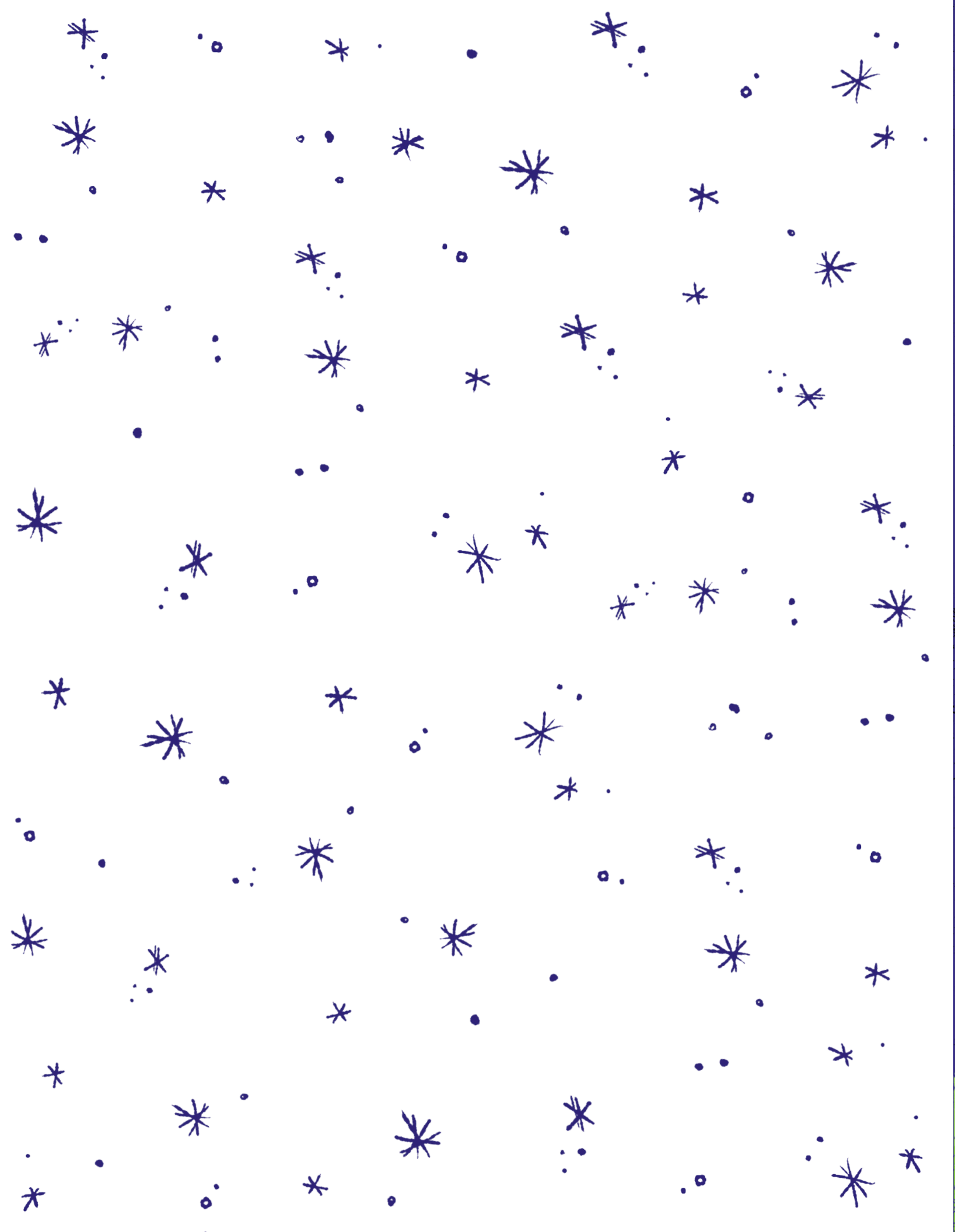
museum of
science+industry
chicago

summer brain games IN SPACE!

PLAY ALONG AT:
MSICHICAGO.ORG/SUMMERBRAIN



summer brain games IN SPACE!

WELCOME, SPACE EXPLORERS!

The Museum of Science and Industry, Chicago has your mission this summer: eight weeks of free and fun at-home experiments for kids of all ages (with a little adult supervision).

Blast off with space-themed science activities in this year's Summer Brain Games program. Learn about astronauts, astronomy and space science and engineering concepts as you launch a rocket, design a protective landing craft, create your own constellations and more.

Register online at msichicago.org/summerbrain and receive a voucher for a free Museum Entry ticket! You'll also get a weekly email with tips and ideas on how to play with science all summer long.

FREE MUSEUM ENTRY VOUCHER

Register at msichicago.org/summerbrain and get one free ticket per household.

Summer Brain Games is sponsored by:

WHOLE FOODS MARKET

COOL CAREERS

If you enjoy space science, check out these careers:

- ☐ Aeronautic Engineer
- ☐ Astronaut
- ☐ Astronomer
- ☐ Biologist
- ☐ Chemist
- ☐ Civil Engineer
- ☐ Computer Scientist
- ☐ Earth and Planetary Scientist
- ☐ Electronics Technician
- ☐ Geologist
- ☐ Information Technology Specialist
- ☐ Mathematician
- ☐ Mechanical Engineer
- ☐ Meteorologist
- ☐ Nuclear Engineer
- ☐ Oceanographer
- ☐ Physicist
- ☐ Pilot
- ☐ Roboticist
- ☐ Structural Engineer

Learn more at https://www.nasa.gov/audience/forstudents/careers/index.html

OUTTA THIS WORLD

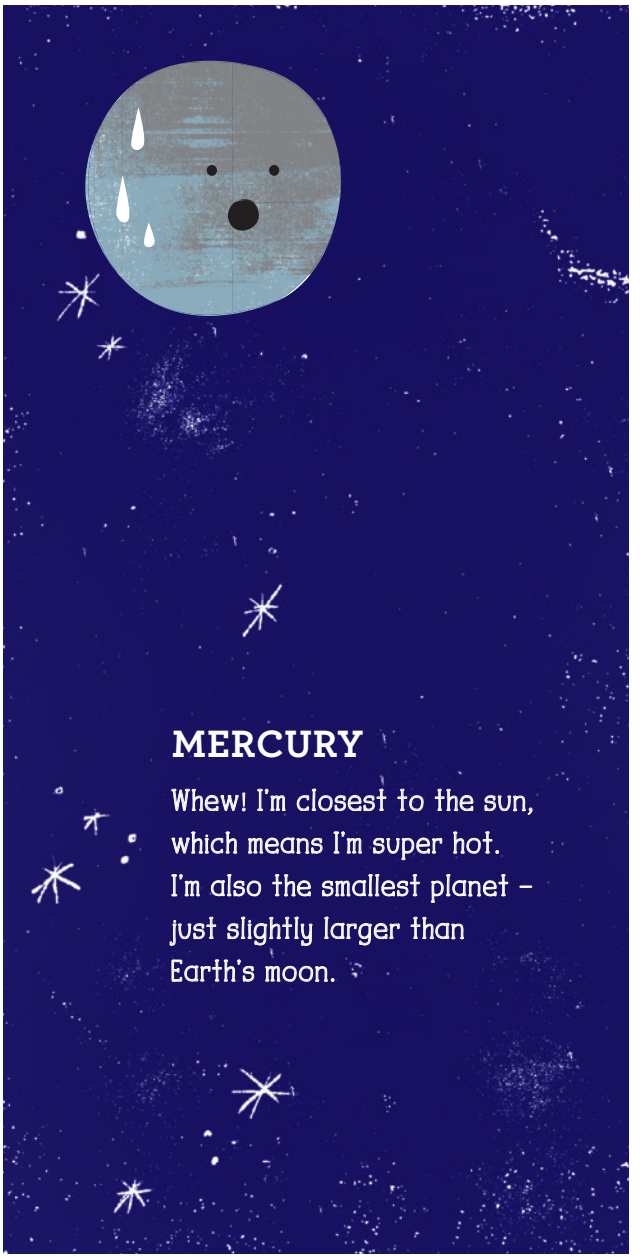
EXPERIMENT: WATER ROCKET

OUTSIDE FUN!

Your mission to space starts with a rocket launch. Pump air through a water-filled bottle rocket to create enough pressure to push the rocket skyward. Stand back so you don't get soaked on liftoff!

MATERIALS

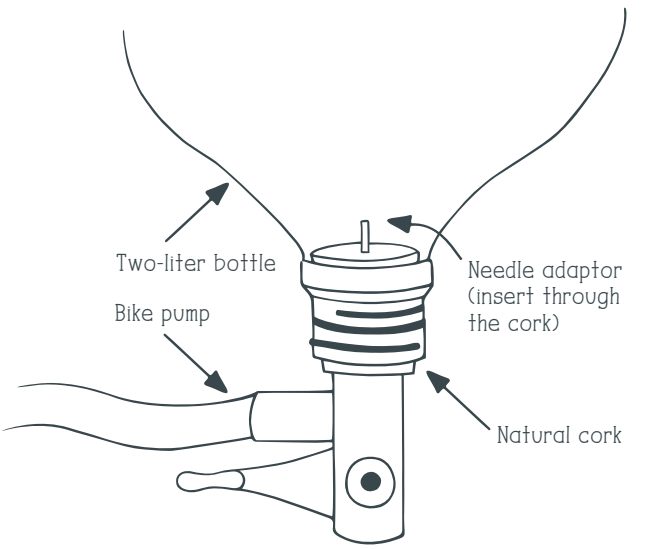
- ☐ Two-liter bottle
- ☐ Natural bottle cork
- ☐ 18-ounce plastic cup
- ☐ Tape
- ☐ Water
- ☐ Scissors or utility knife
- ☐ Bike pump with needle adaptor
- ☐ Materials to decorate your rocket (paper, cardboard, toy figurine)



INSTRUCTIONS

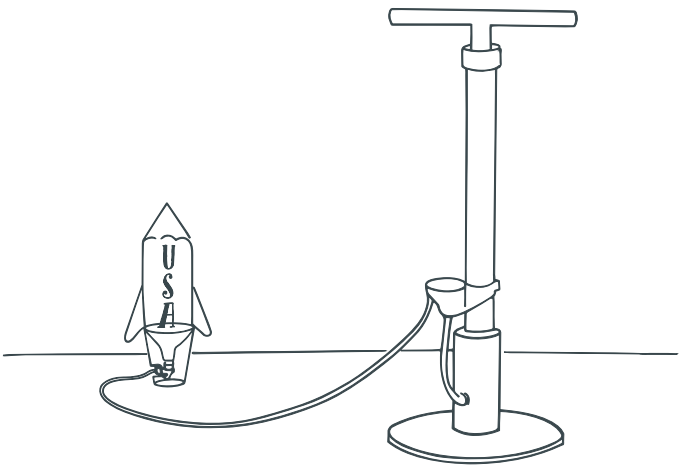
Make sure the cork fits snugly in the bottle opening. Cut the cork in half horizontally – most corks are longer than the bike pump needle, and the needle needs to reach all the way through the cork. Force the needle through the cork and make sure air is able to pass through; you may need to pick some cork bits out of the needle. Attach the needle to the bike pump nozzle.

Prepare your rocket by turning the bottle upside down and removing the label. The bottle opening will be the base of the rocket, so add a paper nose cone to the bottom of the bottle (which will point up) and tape fins to the sides.



Turn the plastic cup into a launch pad by cutting a hole about 2-by-1-inches on one side of the cup near the bottom. The hole should be big enough for the cork and bike pump nozzle to fit through. If the edges of the hole are sharp, cover them with tape. Slide the bike pump nozzle with the cork on it through the hole.

Fill the rocket one-third to one-half full with water (this will be a variable you can change later to see how it effects your rocket). Fit the cork very snugly into the bottle opening. Turn the bottle upside down – it shouldn't leak – and place it onto the cup, with the bike pump tube extending through the hole in the side of the launch pad cup.



To launch, find an open area with no cars, pedestrians or buildings within 50 feet. Pump until the bottle flies into the air and stand back! Make sure no one, including you, is in the the flight path and don't stand over the rocket while you're pumping it.

WHAT'S HAPPENING?

The water rocket demonstrates two basic science concepts: air pressure and Newton's Third Law of Motion. By forcing air into a confined space, you are increasing the air pressure inside the bottle. This happens all the time – when you open a bottle of soda, the "pffft" you hear is pressurized air escaping. When you force air into the bottle the pressure builds until something has to give. In this case, the cork shoots out of the bottom of the bottle and the pressurized air forces the water out. This causes the bottle rocket to lift off due to Newton's Third Law, which says for every action there is an equal and opposite reaction. The water shooting out of the bottom is the action, and the bottle flying up is the opposite reaction.

GAME ON

Rocket science is pretty complex, and this experiment just covers the basics of getting something off the ground. Try changing some of the variables to see if your rocket flies differently. What happens if you add more or less water to the bottle? What if the fins are a different shape or size? No rocket is complete without a payload. Can you add a compartment so a toy astronaut can take a ride on your rocket?

TIPS

Warning: do not aim the rocket at anyone! The rocket launches with quite a bit of force, so make sure the launch area is clear before pressurizing the rocket. Don't stand over the rocket while pumping it.

MORE WAYS TO PLAY WITH ROCKETS

Experiment with air-powered bottle rockets in MSI's Henry Crown Space Center. Don't miss favorite Space Race artifacts like the Apollo 8 spacecraft and the Apollo 11 training mock-up.

RECOMMENDED READING

"On the Launch Pad" by Michael Dahl

"Rocketry: Investigate the Science and Technology of Rockets and Ballistics" by Carla Mooney

GOODNIGHT, MOON (AND STARS)

EXPERIMENT: STARLIGHT FLASHLIGHT AND MOON JOURNAL

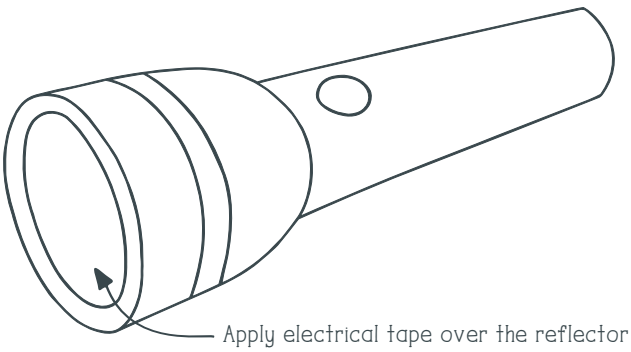
Do you ever notice how the night sky changes above you? The moon's shape changes throughout the month, and the constellations change with the seasons. Make your own constellations shine with a starlight flashlight, and observe the moon's phases by tracking its shape in a journal.

MATERIALS

- ☐ Flashlight
- ☐ Aluminum foil
- ☐ Duct or masking tape
- ☐ Electrical tape
- ☐ Paper
- ☐ Rubber bands
- ☐ Pen or pencil
- ☐ Pushpin
- ☐ 18-ounce cups (Styrofoam, paper or plastic)
- ☐ Scissors or utility knife
- ☐ Moon journal (msichicago.org/summerbrain)

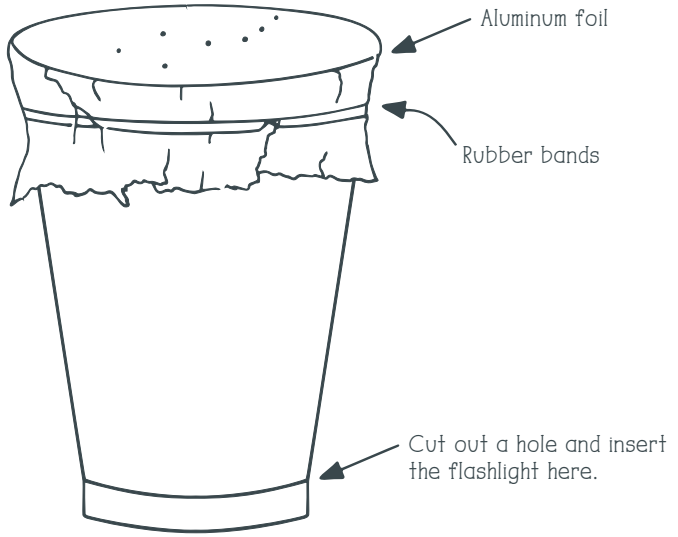
INSTRUCTIONS

Your starlight flashlight will work best with a bright, focused beam of light. If your flashlight has a shiny, reflective surface around the bulb, unscrew the top and remove the lens. Cover the reflector with black electrical tape and reassemble the flashlight without the lens.



Cut out the bottom of a cup so there's a hole. Check to make sure the flashlight fits snugly inside the hole. If needed, apply some tape around the edges of the hole to help the cup fit more snugly; this can also smooth any sharp edges if you're using a plastic cup.

Cut a piece of aluminum foil big enough to fit over the open mouth of the cup. Place it over the cup and secure it in place with a rubber band. Use a pushpin to poke holes in a constellation pattern. You can make a real constellation, or design your own!



Insert the flashlight into the hole at the bottom of the cup. Turn on the flashlight in a darkened room and aim the starlight flashlight at the wall. Make several constellation cups so you can change what you see in your night sky!

Check out the real night sky and track the phases of the moon in a moon journal (available at msichicago.org/summerbrain). Find the moon on a clear night and shade in the part of the moon that appears dark. You can also note the date and time of your observation. Make an "X" if it's cloudy or rainy and you can't see the moon. As you make your observations, notice how long it takes for the moon to return to the same shape.

WHAT'S HAPPENING?

A constellation is a group of stars that appears to form a pattern or picture. There are 88 official constellations, many of which were named after animals or mythological characters by ancient Greek astronomers. Constellations seem to move across the sky but it's actually the movement of the Earth rotating on its axis that causes the constellations to shift positions.

The moon changes shape because of its orbit around the Earth. It takes about four weeks to go through all its phases: waxing crescent, first quarter, waxing gibbous, full moon, waning gibbous, third quarter and waning crescent before the next new moon. The moon doesn't give off its own light; the bright part of the moon you see is light reflected from the sun.

GAME ON

Create your own constellation design for your starlight flashlight, and give it a name. Make up a story about it, and tell your friends. Create other constellation designs for the other characters in your story. Or try turning yourself into a constellation – just lay down on the sidewalk in an interesting pose and have a friend use chalk to make dots at your head, shoulders, elbows, hands, feet, knees, etc. Stand up and connect the dots to create your constellation!

TIPS

The full moon on July 31 will be a "blue moon" – the second full moon in a month (the first is on July 2). The last blue moon was in 2012. There will be a total lunar eclipse on September 28. This is also called a "blood moon" because the moon glows red.

MORE WAYS TO PLAY WITH THE NIGHT SKY

Use sky maps (skymaps.com) to help you find your way around the night sky.

RECOMMENDED READING

"Find the Constellations" by H. A. Rey

"Zoo in the Sky: A Book of Animal Constellations" by Jacqueline Mitton

TOUCH DOWN!

EXPERIMENT: EGG DROP CHALLENGE

Get your payload safely to the surface. NASA engineers use different strategies and materials to carefully land rovers and other equipment on planets they want to explore. Your challenge is to design and build a lander that protects a raw egg that's dropped from up high.

MATERIALS

- ☐ Raw egg
- ☐ Pen or pencil
- ☐ Paper
- ☐ Tape
- ☐ Container, like a cardboard tube, cup, box or plastic fruit basket
- ☐ External protection, like balloons, straws, craft sticks or rubber bands
- ☐ Internal padding, like paper, cotton balls, packing peanuts or fabric
- ☐ Scissors

INSTRUCTIONS

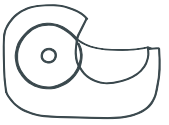
Keep your "egg-stronaut" from breaking by designing and building a landing device. Use the engineering design cycle for this experiment: design your landing craft, test it to see if it works, change your design to make it better and re-test to get new results.

Collect your materials. You'll need a container, some internal padding and external protection to safely land your craft. Draw your design ideas on paper before you start to build. Be creative! Try using just one container, one type of internal padding and one type of external protection.

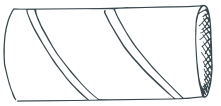
You can get some ideas from NASA engineers. They use different materials and strategies depending on the size, weight and design of the robot they need to land on a distant planet. One design uses more than 20 huge airbags that surround the payload – when the airbags inflate it looks like a giant bunch of grapes! NASA's newest and biggest rover, Curiosity, was too heavy for airbags when it landed on Mars in 2012. So NASA invented a "sky crane" that slowly lowered the rover to the ground using nylon ropes. Engineers are working on new ideas, like a giant balloon that can lift a 7,000 pound vehicle.

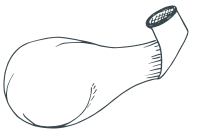
Possible Materials

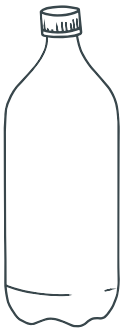
Newspaper


Tape


Yogurt cup


Cardboard tube


Balloon


Plastic bottle


Popsicle sticks

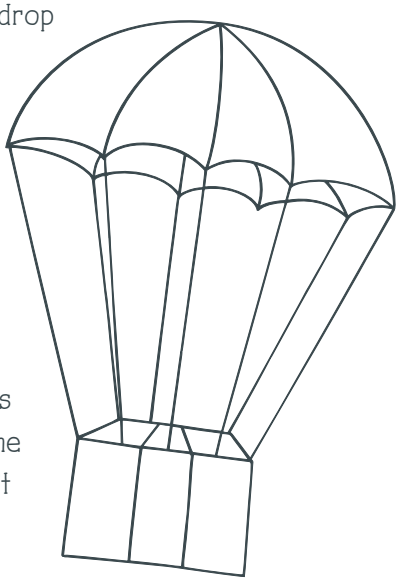

Aluminum foil


Drinking straws

Build your landing device and put your egg inside. Test it out by dropping your device from up high. If the egg doesn't crack, your design is a success! If the egg cracks, make changes to your design and re-test it.

WHAT'S HAPPENING?

Gravity is a force of attraction – it pulls on a mass, which is how much "stuff" something is made of. Earth's gravity pulls on you and keeps you on the ground; it also holds the atmosphere and the moon in place. When you drop your landing craft, gravity pulls it to the ground. The internal padding that surrounds your egg-stronaut cushions the payload inside the container, like airbags in a car that protect passengers in an accident. The external protection on the outside of the container protects the egg-stronaut by absorbing the impact felt when the landing craft hits the ground.



GAME ON

Once you're successful, try dropping the egg from a higher height or increasing your payload to two eggs. Try landing your craft on different types of surfaces like grass, pavement, or water. How does the surface affect your landing? How might this change your vehicle design?

Have a friendly competition: who can get their egg-stronaut to the surface the fastest? The slowest? From the farthest distance? With the fewest bounces?

TIPS

For a little less mess, use a hard-boiled egg (you'll still see the cracks). You can also cover the landing surface with a garbage bag, or put the raw egg in a sealed plastic bag before putting it in the landing craft.

MORE WAYS TO PLAY WITH LANDERS

Watch the exciting "Seven Minutes of Terror" video about the Curiosity rover landing on Mars at http://tinyurl.com/kzh8u4p. Learn more about NASA's designs for landing craft at http://tinyurl.com/NASAairbags and http://tinyurl.com/NASAskycrane.

RECOMMENDED READING

"Aerospace Engineering and the Principles of Flight" by Anne Rooney

"Rosie Revere, Engineer by Andrea Beaty"

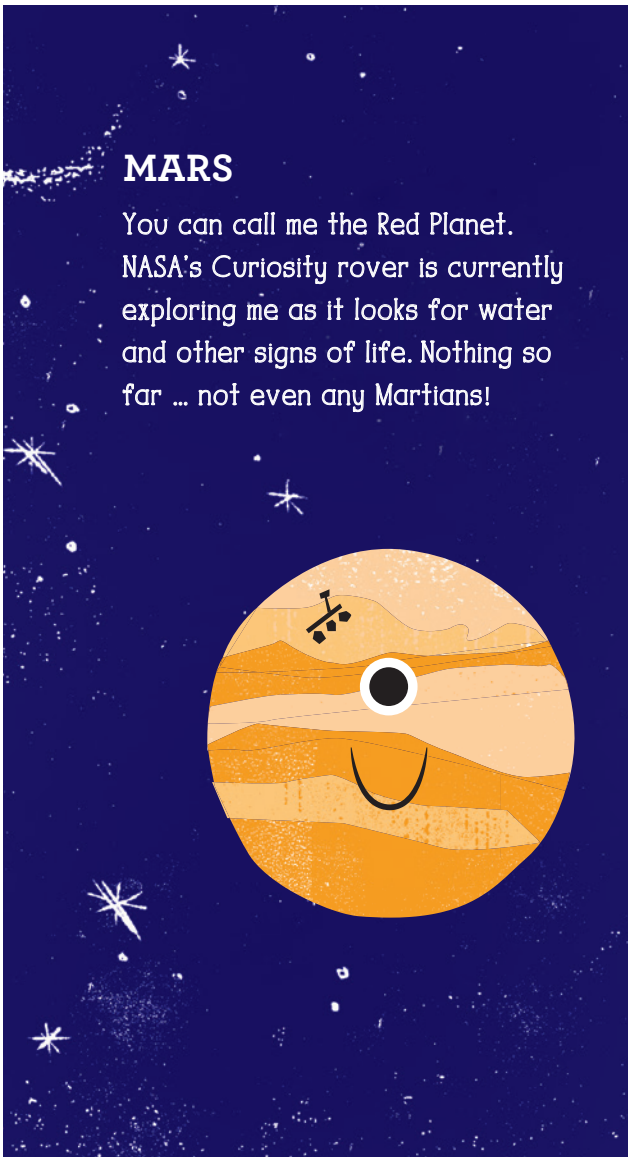
MISSION: MEALS

EXPERIMENT: PLANT AND FISH SYSTEM

If you are going to live on Mars, you will need to be able to grow your own food. But the soil and air on Mars are not like that on Earth. Greenhouses control the environment so you can get fresh, healthy food. Try building a special type of greenhouse that also provides a home for fish in this simple system.

MATERIALS

- ☐ Dirt
- ☐ Gravel
- ☐ Two clear, two-liter bottles
- ☐ Betta fish, or a toy fish
- ☐ Scissors
- ☐ Utility knife
- ☐ Duct tape
- ☐ Small plant or seeds
- ☐ Cotton wick, like a piece of fabric, rope or yarn
- ☐ Aquarium plant, real or fake (optional)
- ☐ Clear, wide tape
- ☐ Thermometer

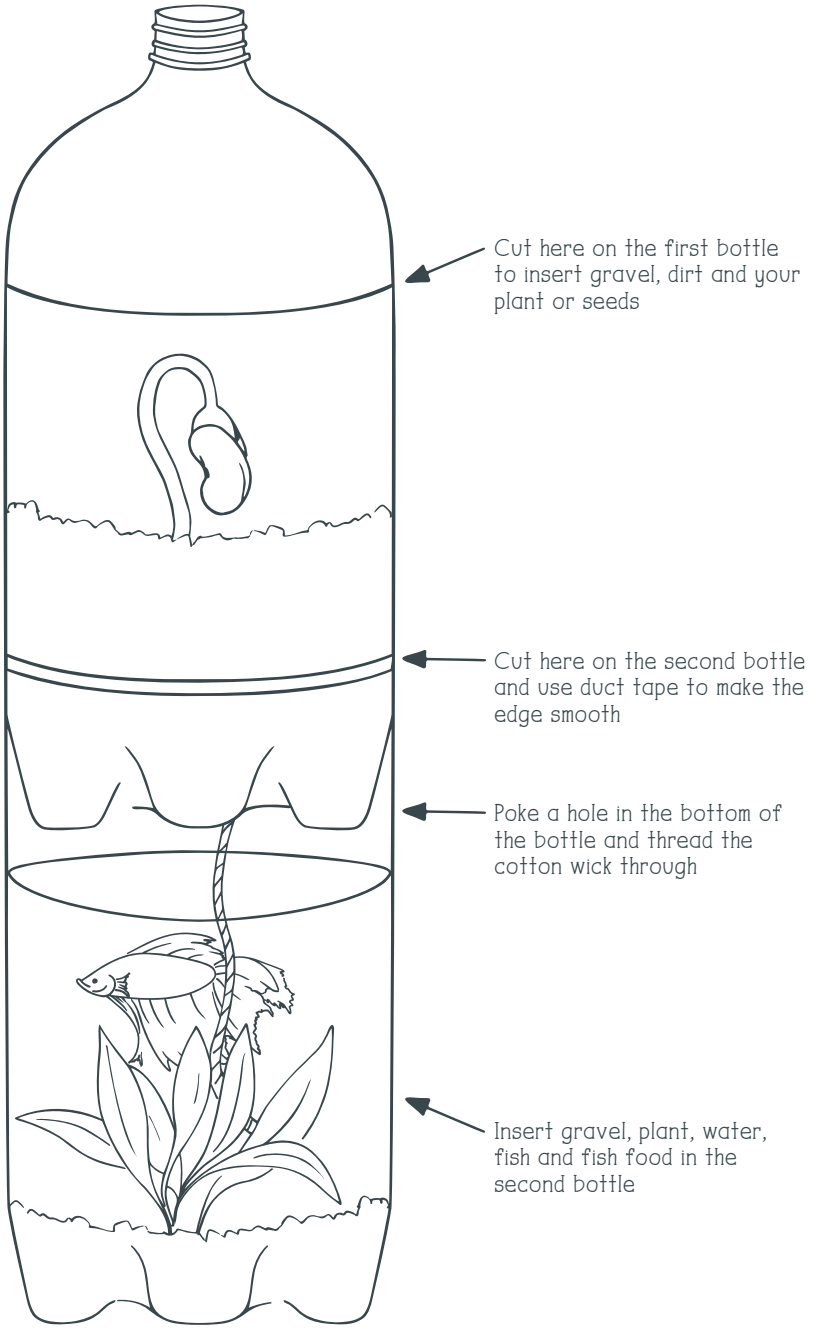


INSTRUCTIONS

Remove the label and cutting off the top third of one two-liter bottle to make the greenhouse. Poke a hole in the bottom of the bottle and thread the cotton wick through, leaving several inches hanging outside. Add a layer of gravel to the bottom of the bottle and then a layer of dirt, winding the cotton wick throughout. Place a small plant like lettuce or herbs in the dirt, or bury some seeds. Place a thermometer inside facing outward, so you can read it. Water the dirt so it's moist. Put the top of the bottle back on and use clear, wide tape to hold it in place. Leave the bottle cap off.

Make the aquarium by removing the label and cutting the top third off of the other two-liter bottle. Duct tape around the top edge so it's smooth and discard the top of the bottle. Add a layer of gravel to the bottom and, if you'd like, a real or fake aquarium plant. Fill with water that reaches about two inches below the top. Add a fish and some fish food. We even used a toy robotic fish in our aquarium.

Place the greenhouse bottle snugly on top of the aquarium bottle with the cotton wick reaching into the water. Remove the greenhouse bottle to feed the fish as needed.



WHAT'S HAPPENING?

A greenhouse protects plants by letting sunlight in and preventing heat from escaping. That's necessary on a planet like Mars, which is very cold and has a thin atmosphere that's mostly carbon dioxide, not suitable for plants to grow. You can tell your greenhouse is warm inside because of the condensation that collects on the sides; you also can check the thermometer to see just how warm it is. The water in the aquarium below travels up the cotton wick to help keep the dirt damp. A similar system that doesn't use dirt is called aquaponics: raising fish is called aquaculture, and growing plants in water is called hydroponics.

GAME ON

Keep track of the temperature inside your greenhouse, and see how it compares to the daily temperature outside. Or try growing your plants hydroponically – instead of dirt, place your plant in a growing medium like perlite or even shreds of cardboard. Make sure the roots are covered (they grow best in the dark) and the cotton wick is wound throughout so they get enough water.

TIPS

Don't put your system in direct sunlight, because that will make the water too warm for your fish. Bettas prefer water between 75 – 80 degrees. Keep the cap off the greenhouse bottle so air can circulate. Change the water in the aquarium bottle as needed.

MORE WAYS TO PLAY WITH PLANTS

Learn about vertical farms in MSI's *Fast Forward … Inventing the Future* exhibit and the latest in farming crops in *Farm Tech*.

RECOMMENDED READING

"How Do You Burp in Space? And Other Tips Every Space Tourist Needs to Know" by Susan E. Goodman

"Potatoes on Rooftops: Farming in the City" by Hadley Dyer

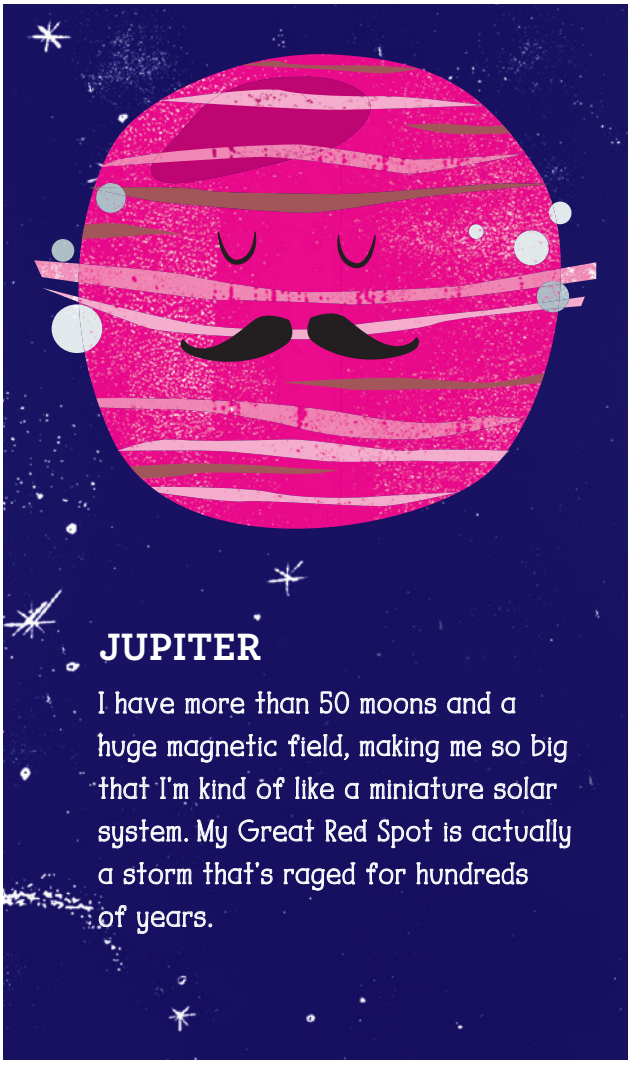
HELPING HANDS

EXPERIMENT: ASTRONAUT GEAR

In space, you need a suit that protects you from the cold, harsh environment. Astronauts making repairs to the International Space Station on spacewalks must wear gloves that protect them but allow their fingers to move easily. Design your own space gloves and use them to try to use tools to complete various tasks.

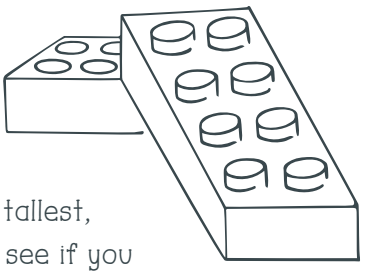
MATERIALS

- ☐ Tape
- ☐ Rubber bands
- ☐ LEGO bricks
- ☐ Water
- ☐ Large tub or bin
- ☐ Nuts
- ☐ Bolts
- ☐ Screws
- ☐ Pennies or other small items
- ☐ Tools, such as a screwdriver, pliers or wrench
- ☐ A variety of large gloves, such as gardening gloves, winter gloves and rubber gloves
- ☐ Protective materials like aluminum foil, plastic bags, bubble wrap, fabric, etc.



INSTRUCTIONS

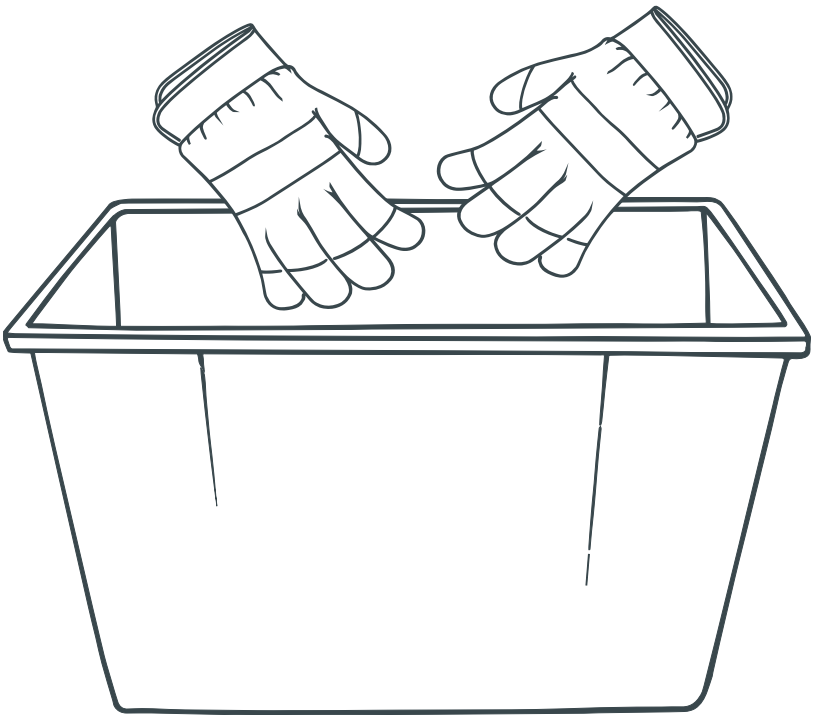
The gloves that astronauts must wear while on a spacewalk are difficult to design. They need to be airtight for protection, but also flexible so the astronaut can use his or her hands. Try wearing some oversized gloves to do simple tasks and see how difficult it can be to get the job done.



Put on an oversized pair of gloves and try to build a wall of LEGO pieces in 60 seconds. Race against a friend to see whose wall is the tallest, or challenge yourself to see if you can do better than your first try. Make it more challenging by building a wall in just 30 seconds, or using only the smallest LEGO bricks. What did you notice?

Prepare the supplies for the next challenge. Fill a bin with cold water and put the tools, nuts, bolts, screws and pennies inside. Now make a pair of gloves that will keep your hands dry and warm while

they're in the water using the tools. Be creative! Try layering different types of materials, or several different gloves.



Test your glove design by putting your hands in the water and using the tools. Thread a nut on a bolt, wind a screw with a screwdriver, pick up pennies with pliers. Give yourself a time limit, or see how long it takes you to complete all the tasks. Make sure your hands remain underwater during the entire challenge! When you're done, take off the gloves and see if your hands are dry and warm.

WHAT'S HAPPENING?

Astronaut gloves are even harder to maneuver than the gloves you designed. They're like an inflated balloon, and the fingers resist bending. Astronauts must fight against that pressure just to use their hands, which can make them tired quickly and even cause injuries. Gloves are just one part of a space suit. Space suits provide astronauts oxygen to breathe and water to drink while they're working in space.

GAME ON

Design your own space suit by putting on different layers of clothing, from tight-fitting inner layers to heavy outer layers like snow pants and winter coats. Try physical activities, like jumping jacks, sit ups or climbing stairs to see how easily you can move around. Or experience a little bit of what it feels like to walk in space by walking across a bouncy air mattress. See if you can walk across while balancing something on your head!

MORE WAYS TO PLAY WITH ASTRONAUT GEAR

Train like an astronaut with fun activities from NASA at http://tinyurl.com/space-training. You can also see a real NASA space-suit and astronaut tools like tongs and a hammer in MSI's Henry Crown Space Center.

RECOMMENDED READING

"Astronaut Handbook" by Meghan McCarthy

"Astronaut: Living in Space" by Kate Hayden

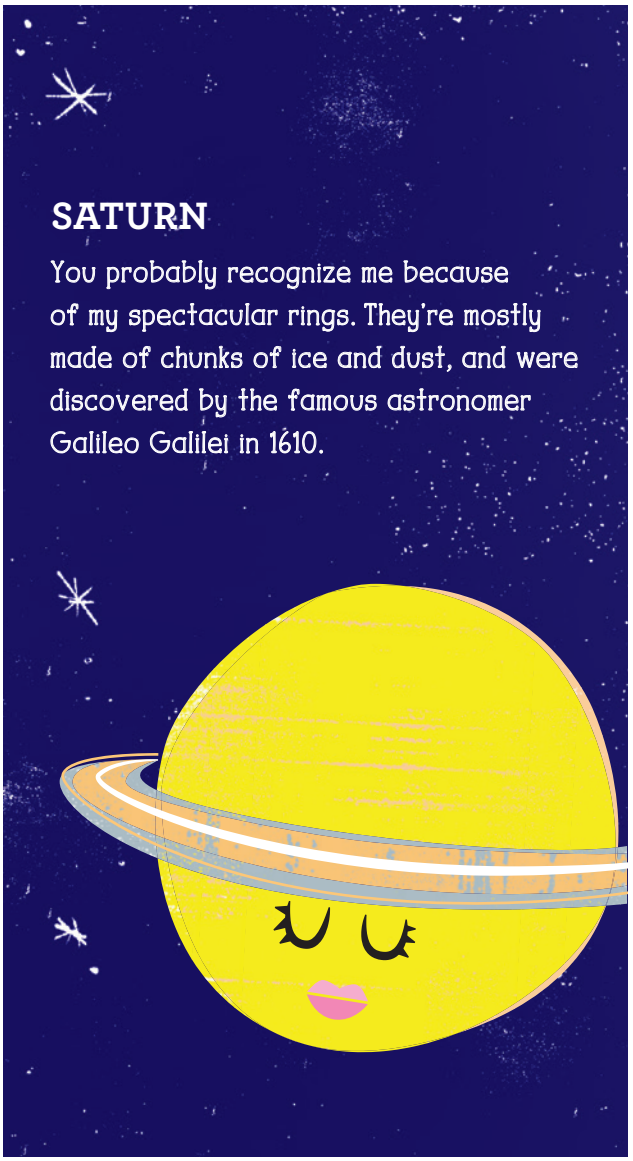
ART-O-MATIC INTELLIGENCE

EXPERIMENT: SCRIBBLE BOT

One way that you can explore hard-to-reach places is by using a robot. Robots are sophisticated machines that can sense, plan and act. The Curiosity rover is a robot that's exploring Mars. Make a simple drawing machine that uses vibrations to move and see what artistic patterns it creates.

MATERIALS

- ☐ Batteries
- ☐ Pool noodle
- ☐ Markers
- ☐ Rubber bands
- ☐ Tape
- ☐ Paper
- ☐ Battery-powered toothbrush
- ☐ Scissors or utility knife
- ☐ Cardboard and paper clips (optional)
- ☐ Craft supplies, like pipe cleaners, construction paper, craft sticks, googly eyes, feathers, etc.



INSTRUCTIONS

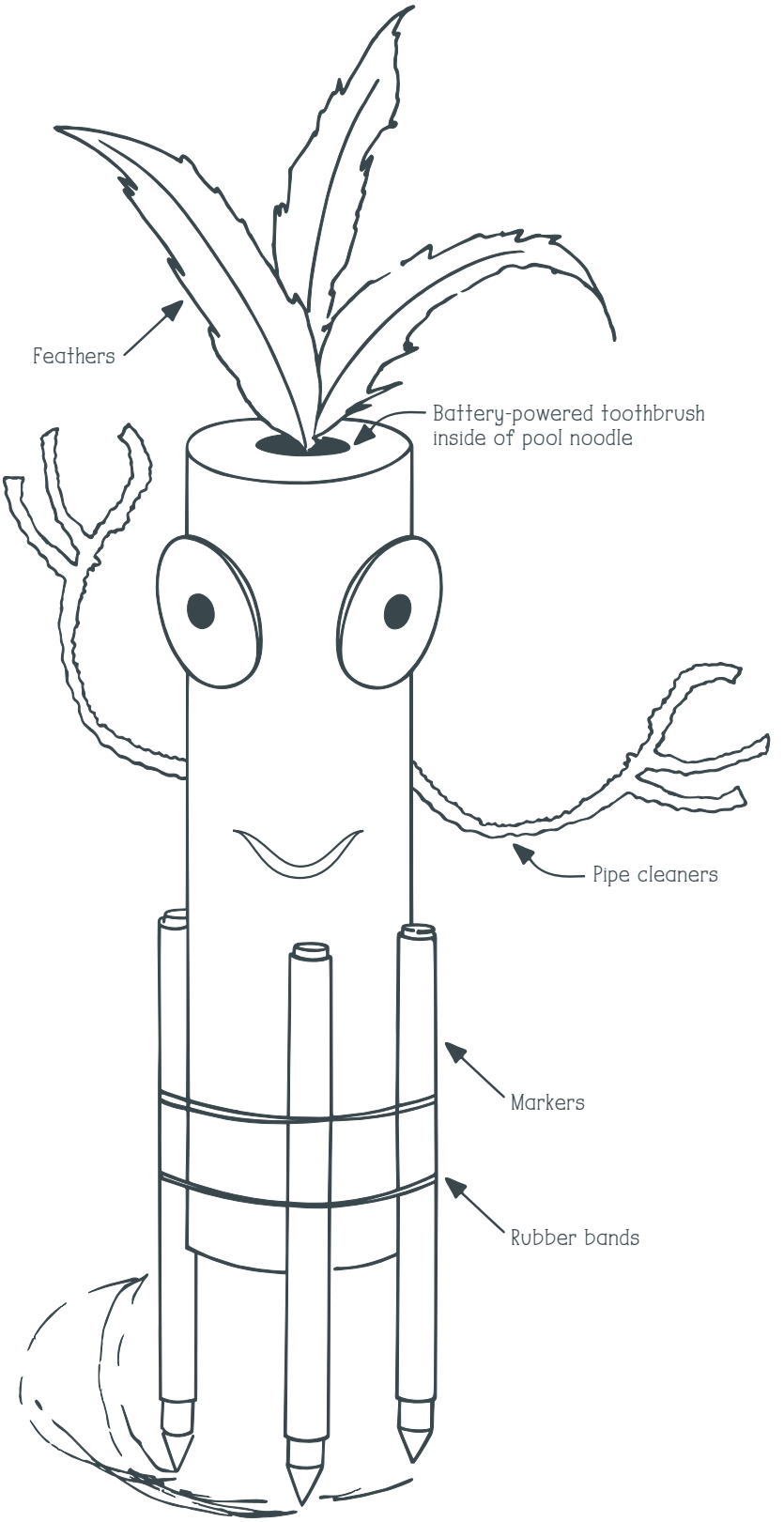
Cut a piece of pool noodle that's a bit longer than the battery-powered toothbrush. Insert the toothbrush into the middle of the pool noodle. Make sure you can reach the on/off switch. This is the body of your scribble 'bot. Make the legs by attaching several markers to one end of the pool noodle with rubber bands. The markers should point outward and extend past the pool noodle body.

Personalize your scribble 'bot by using craft supplies to give it hands, a face, hair, clothing – be creative! Attach arms by making small slits on the sides of the pool noodle and inserting bent pipe cleaners.

Put some paper down on the table and uncap the markers. Turn on the toothbrush and set the scribble 'bot on the paper. You may need to adjust the marker "legs" if it's unbalanced. Watch it go, and see what designs it makes.

WHAT'S HAPPENING?

The scribble 'bot is a type of bristlebot, which is a simple robot easily built with a brush and other household items. The vibration of the toothbrush causes the pool noodle to move. This energy of motion is called kinetic energy.



GAME ON

Try making a different vibrating robot by removing the brush and neck from your battery-powered toothbrush (this is easily done on models with twist-off tops). Cut a square of cardboard big enough to fit the toothbrush base. Shape four feet from paper clips and attach them to the corners, bending them to point down and angling them slightly in the same direction. Tape the toothbrush base on top and decorate it to look like a bug. When you turn on the battery, the vibrations will make your bug skitter around.

TIPS

Affordable battery-powered toothbrushes are available at dollar stores. A more powerful motor means the scribble 'bot will vibrate and move more vigorously. A body that's too heavy makes it harder to move.

MORE WAYS TO PLAY WITH ROBOTS

Step into a visionary world where robots are not just a curiosity, but a vital asset, in MSI's world-premiere exhibit *Robot Revolution*, supported by Google.org.

RECOMMENDED READING

"Curiosity's Mission on Mars: Exploring the Red Planet"
by Ron Miller

"Ricky Ricotta's Mighty Robot"
by Dav Pilkey

WEEK 7

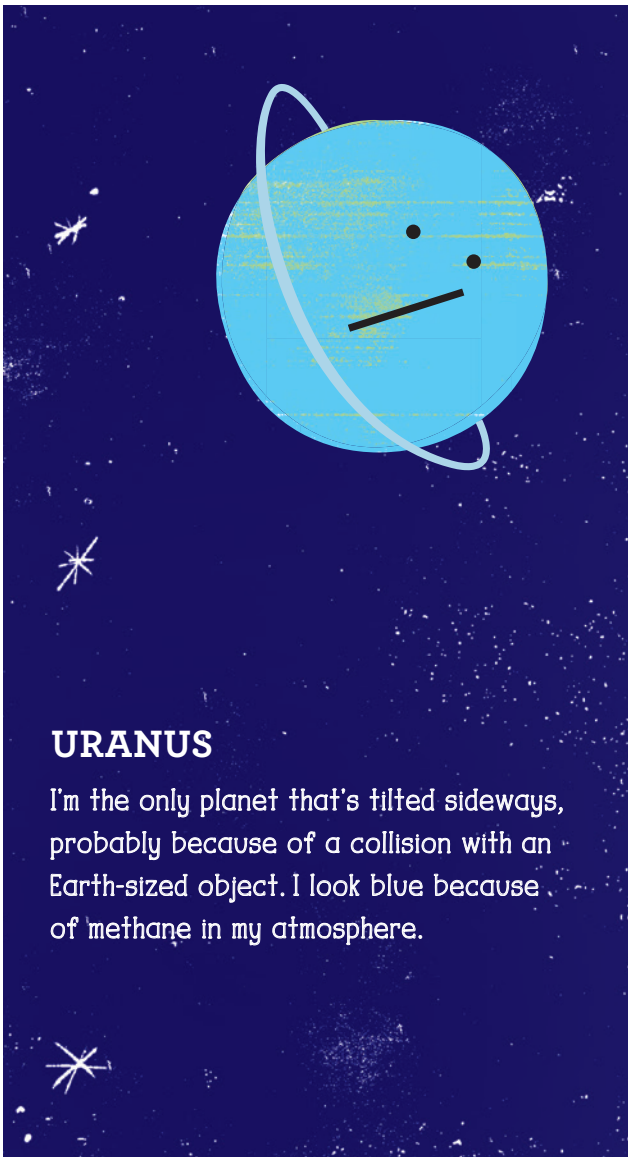
SHEDDING LIGHT ON LIGHT

EXPERIMENT: SPECTROSCOPE

You can learn about stars and other objects in space by using tools to study them. A spectroscope measures the color of light that's reflected from a distant object, then analyzes that information to discover the object's chemical makeup. Build your own spectroscope and use it to examine different sources of light.

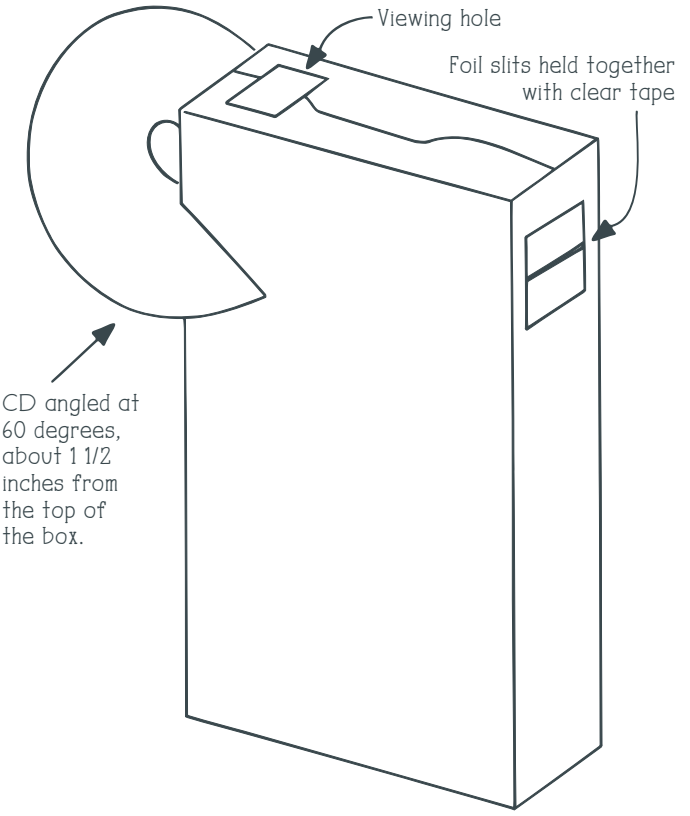
MATERIALS

- ☐ Cereal Box
- ☐ Aluminum foil
- ☐ Utility knife
- ☐ Scissors
- ☐ Ruler
- ☐ Pen
- ☐ Duct tape
- ☐ Clear packing tape
- ☐ CD that you don't mind ruining
- ☐ Protractor (msichicago.org/summerbrain)



INSTRUCTIONS

Light enters the spectroscope through a tiny slit on one of the long sides of the cereal box. From the bottom of the box, measure about 2 inches down and use a utility knife to cut out a narrow rectangle that's about an inch wide and 1/4 inch deep.



The slit where the light enters needs to be narrow with clean edges. Cut two 1-inch-square pieces of aluminum foil from an edge of the roll, so at least one side is straight. Place a piece of clear packing tape about 2 inches long, sticky side up on the table. Put a piece of foil on the tape so the straight part from the edge is in the middle of the tape. There should be no wrinkles in the foil. Place the second piece of foil so that its straight edge is lined up parallel – and very close – to the foil already in place. There should be a very small gap between the pieces of foil that looks like a narrow line. Tape the foil slit horizontally over the rectangular hole.

On the side of the box opposite the slit, measure about 1 1/2 inches down from the bottom of the box and make a horizontal cut, then make a diagonal cut on the front and back of the box at about a 60 degree angle. Slide a CD into the angled cut so the shiny, playable side points up. Use duct tape to hold the CD in place and keep light from entering the box.

Cut out a viewing hole on the bottom of the box about an inch from the edge and directly above the angled CD. The hole should be about 1 inch wide and 1/2 inch deep. The CD acts like a reflector, so the viewing hole needs to be located where the light ends up after it bounces off the disc. Use duct tape to cover the top of the cereal box so that no light enters the box.

Point the slit at a bright light source like a light bulb and look through the viewing hole at the CD. You should see a rainbow. Try pointing the spectroscope at different types of lights, such as LED bulbs, street lights, neon lights or a computer monitor (but not the sun!). How does the rainbow pattern change?

WHAT'S HAPPENING?

Tiny grooves in the CD plastic act as a diffraction grating. A diffraction grating splits white light into its individual colors – the same way crystals or prisms make rainbows when sunlight shines through them. The colors present depend on how the light is made. Different types of light give off different combinations of colors (or wavelengths). Sunlight is made up of all different wavelengths, so you see a complete rainbow when split up. But some lights, like the neon signs on some storefronts, are only made up of one color wavelength.

GAME ON

Use your iPhone to analyze spectra with the SpectraSnapp app from the American Physical Society, available for free on iTunes.

TIPS

Don't use your spectroscope to stare at the sun!

MORE WAYS TO PLAY WITH LIGHT

Spectroscopes work on a similar principle as prisms, so check out the giant prisms in MSI's *Science Storms* exhibit.

RECOMMENDED READING

"Night Sky by Giles Sparrow"

"Space Atlas: A Voyage of Discovery for Young Astronauts" by Jiří Dušek and Jan Píšala

FAR, FAR AWAY

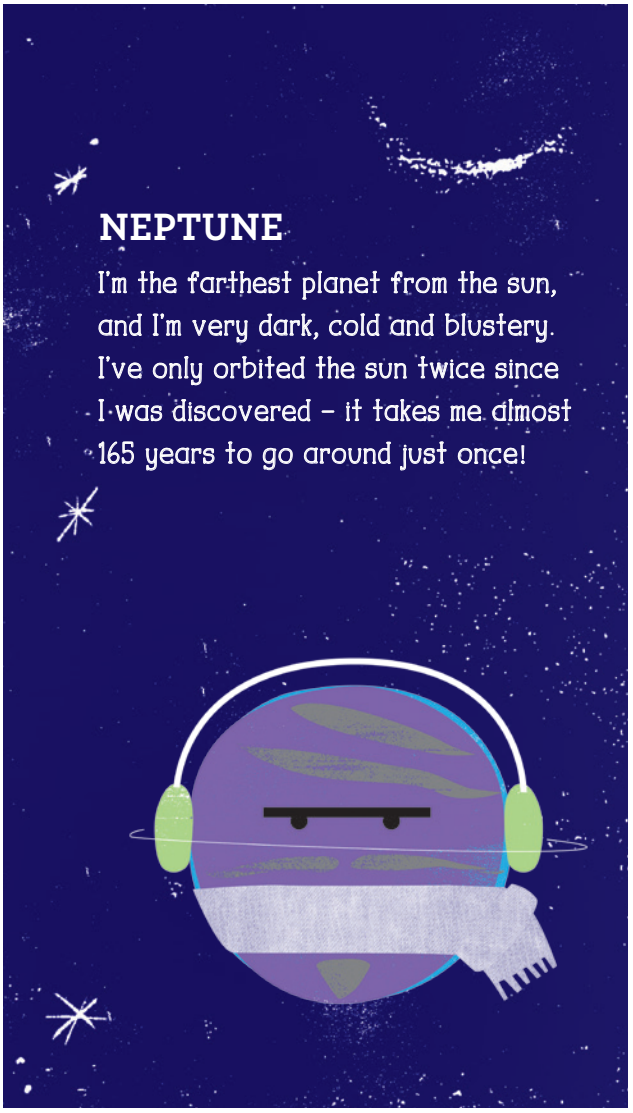
EXPERIMENT: SOLAR SYSTEM SCALE MODEL AND JETPACK

OUTSIDE FUN!

The distances between planets in our solar system are so far they're hard to imagine. It takes about eight months for a spacecraft to reach Mars, which is 78 million kilometers (or 50 million miles) from Earth. Try to imagine the size of the solar system with this fun game.

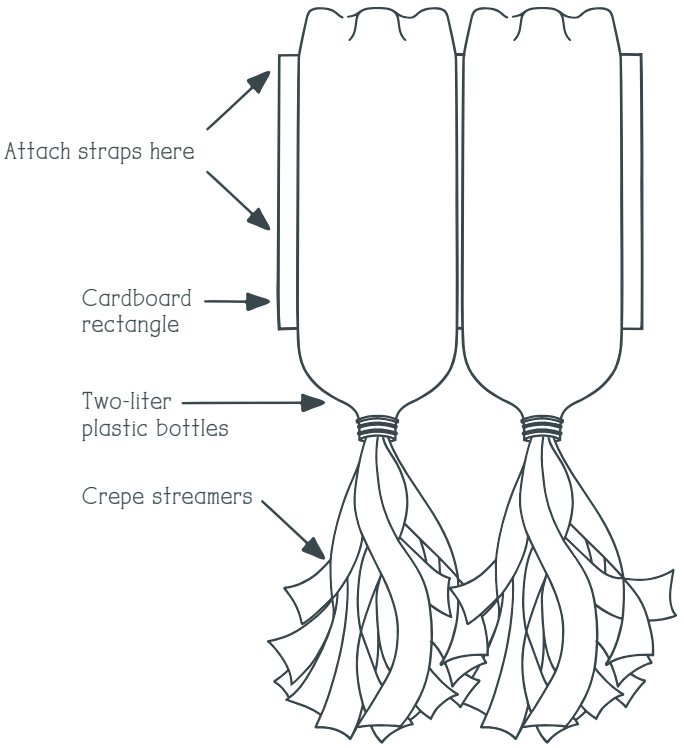
MATERIALS

- ☐ Tape measure
- ☐ Tape
- ☐ Markers or crayons
- ☐ Wide ribbon or straps
- ☐ Scissors
- ☐ Craft sticks
- ☐ Two two-liter bottles
- ☐ Cardboard
- ☐ Hot glue gun
- ☐ Stapler
- ☐ Silver spray paint or aluminum foil
- ☐ Crepe streamer (red, orange or yellow)
- ☐ Planet markers (msichicago.org/summerbrain)
- ☐ Modeling clay or Play-Doh (optional)



INSTRUCTIONS

Assemble your jetpack so you can fly across the solar system: Remove the labels from two two-liter bottles and spray paint them silver or cover them in foil. Cut a cardboard rectangle that's about 6 by 10 inches, or big enough to hold the bottles. When the bottles are dry, use hot glue to attach them to the



cardboard side by side. Make the straps by stapling ribbon to the top and bottom of both sides of the cardboard. Leave the ends open so you can tie the straps once the jetpack is on.

Prepare your fuel cells. Cut the crepe streamer into 10 pieces that are about a foot long and secure them together at one end with tape. Cut them in half lengthwise so there are 20 pieces of streamer in a bundle. Make eight bundles.

Print and decorate the planet marker templates. Cut out the markers and attach them to craft sticks like flags. Use the chart to make a solar system model to scale. Pluto isn't a planet (it's a dwarf planet), but it's a good reference point because it helps show the immense size of the solar system.

Planet/ Celestial Body	Distance From the Sun	Distance to Next Planet/Celestial Body
Sun	0	1.0
Mercury	1.0	0.8
Venus	1.8	0.7
Earth	2.5	1.4
Mars	3.9	9.3
Jupiter	13.2	10.9
Saturn	24.1	24.4
Uranus	48.5	27.6
Neptune	76.1	23.9
Pluto	100.0	---

Use these numbers with any unit of measurement – steps, inches, feet, sidewalk squares, etc. If your unit is a foot, measure 1 foot from the sun and place the marker for Mercury. For Venus, measure 1.8 feet (or 22 inches) from the sun or 0.8 feet (10 inches) from Mercury. Earth is 2.5 feet from the sun.

GAME ON

Strap on your jetpack. Exploration takes fuel, so you'll need to stop at Earth to refuel and drop off the planet markers. Load some fuel bundles into the open end of your jetpack. Here's how much fuel you'll need to reach each planet starting from Earth: Mercury 1, Venus 1/2, Mars 1, Jupiter 5, Saturn 10, Uranus 20, Neptune 40. Tear off the proper number of fuel streamers to reach each planet, collect the planet marker and stop off at Earth. Add more fuel as needed so you can visit all the planets.

WHAT'S HAPPENING?

Our solar system includes the sun, eight planets, more than 140 moons, several dwarf planets like Pluto, asteroids and comets. Scientists believe the outer limit of the solar system is the Oort Cloud, a spherical shell of icy objects. It's so far away that a comet from the Oort Cloud might take thousands of years to orbit the sun.

TIPS

Put each planet marker into a base of modeling clay so it can stand upright on the ground.

MORE WAYS TO PLAY WITH THE SOLAR SYSTEM

The hallway leading to MSI's Henry Crown Space Center shows pictures of the planets scaled in size to each other. For comparison, the sun is as big as the dome on the Omnimax Theater!

RECOMMENDED READING

"Get Started: Astronomy by DK"

"How Many Planets Circle the Sun?" by Mary Kay Carson

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INSPIRING THE INVENTIVE GENIUS

The Museum of Science and Industry, Chicago (MSI), one of the largest science museums in the world, offers world-class and uniquely interactive experiences that inspire inventive genius and foster curiosity. From groundbreaking and award-winning exhibits that can't be found anywhere else, to hands-on opportunities that make you the scientist-a visit to MSI is where fun and learning mix. Through its Center for the Advancement of Science Education (CASE), the Museum offers a variety of student, teacher and family programs that make a difference in communities and contribute to MSI's larger vision: to inspire and motivate children to achieve their full potential in science, technology, medicine and engineering.

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