EDUCATOR GUIDE

MOON TO MARS AND BEYOND

INTUITIVE® PLANETARIUM

at the U.S. Space & Rocket Center®

HOW TO USE THIS GUIDE

This resource is a guide to the solar system for the adventurous traveler. It is designed to serve as a companion to "Moon to Mars and Beyond", the online, guided presentation led by an *INTUITIVE*® Planetarium Specialist, as well as prepare your students for their cosmic excursion. Here's how it works:

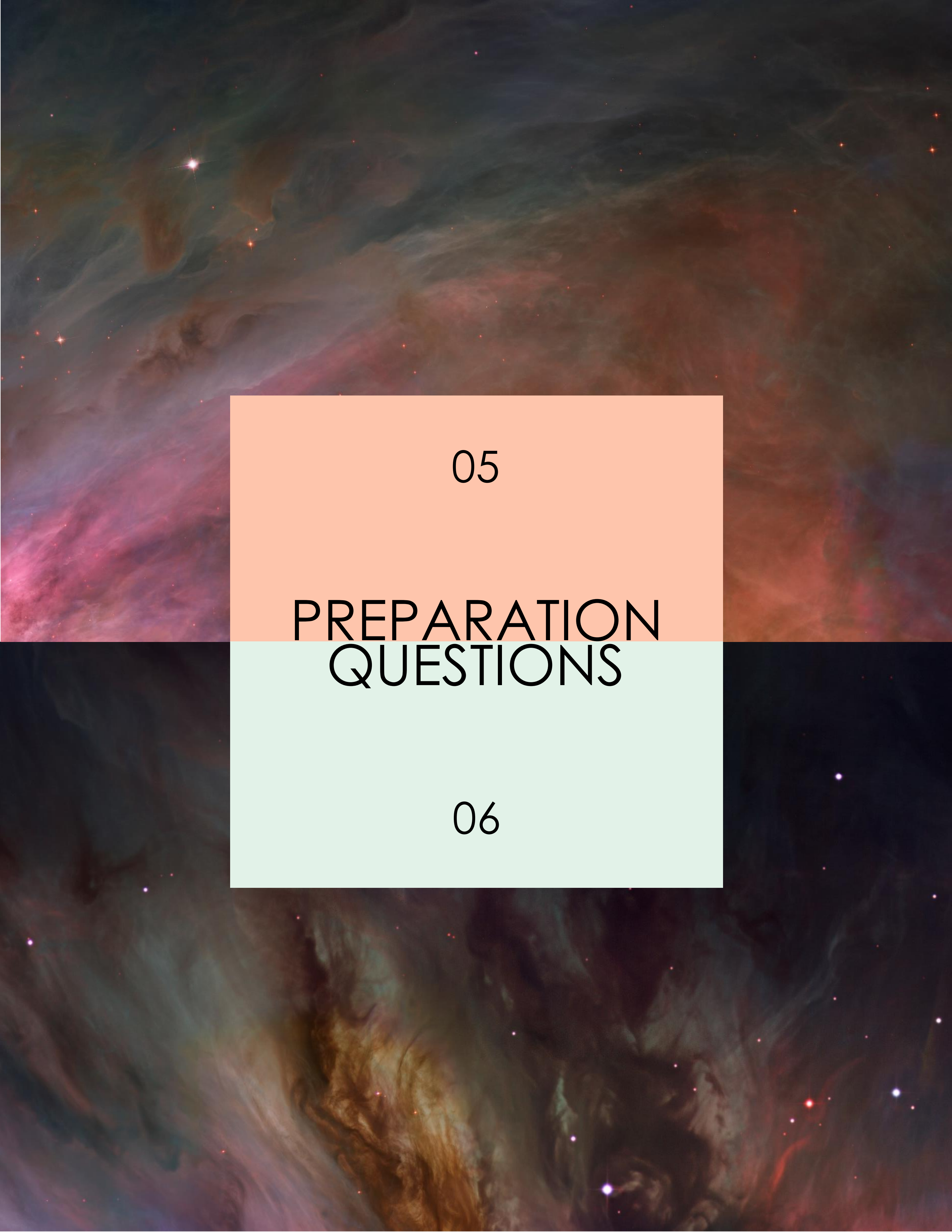
"Moon to Mars and Beyond" is an online and live tour through our past, present, and future of space exploration. We start in the present, introducing the International Space Station currently in orbit, then fly to our closest neighbor, the Moon. There we talk of the past and future challenges of exploration and introduce our next goal: Mars. We end the tour closer to home, comparing two of the most well-known telescopes to date, and discuss what possibilities lie beyond our solar system.

Before your presentation, the "Planet Overview" will introduce the planets and delve into the habitability of each of the worlds your students will explore with us and give tips for what to expect.

The "Curriculum" sections include preparation questions and lesson plans designed for your classroom for before and after the show. The pre-show activity will introduce students to the essentials of surviving in outer space and invite them to engage with the broader implications of the material. The post-show activities will foster a deeper understanding of space exploration by prompting students to think critically about the ideas they have encountered during the presentation.

The "References" section provides a glossary to consult for definitions of certain scientific terms, a list of online resources to help shape your lesson plans, and a reference page of the education standards fulfilled by the field trip and activity guides.

CONTENTS



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PREPARATION QUESTIONS

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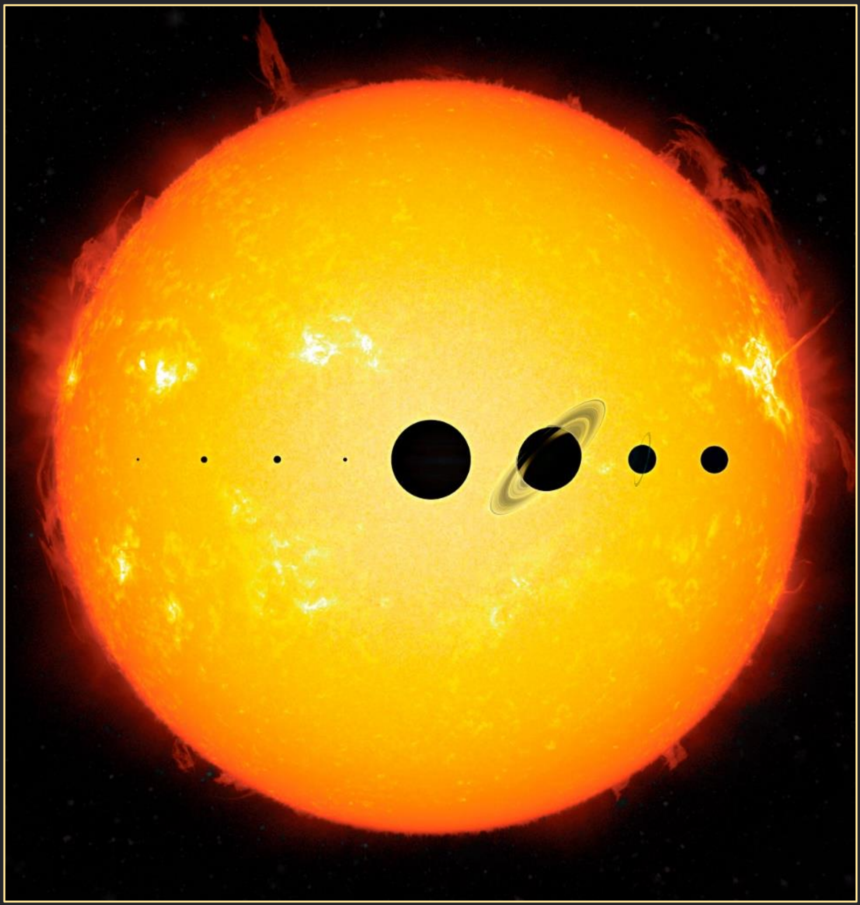
PREPARATION QUESTIONS

These questions will encourage your students to begin thinking creatively about the broader implications of the material. Give them the opportunity to think and answer the questions for themselves before sharing the provided answers with them.



This artist's rendering shows the eight planets lined up as if they were transiting the sun. This view would not be possible in reality, but it is intended to show an accurate scale of the planets' relative size. Image credit: NASA / Moore Boeck

WHERE DOES SPACE BEGIN AND HOW IS THIS DETERMINED?

The general answer to this is that Earth's atmosphere ends and space begins at 100 kilometers above the surface of the earth. This line is called the "Kármán line," named for Theodore von Kármán, the Hungarian scientist who determined that this is the altitude at which the atmosphere becomes too thin to support aeronautical flight.

WHAT IS A PLANET?

According to the International Astronomical Union's most recent definition (2006), a planet is a body that orbits a star, is big enough to have enough gravity to force it into a spherical shape and is big enough that its gravity clears away any other objects of similar size near its orbit around the sun. This does not mean that scientists unanimously agree on this verdict—the subject is still a source of great debate. Science is constantly changing according to new discoveries and new ideas, and there is nothing in the field of science that we can know is absolutely true. So, what does the definition of a planet really mean? Why is it important to define these things if their definitions are not unanimously agreed upon?

ARE THERE OTHER UNIVERSES BESIDES OUR OWN?

It is actually not a controversial idea among physicists that multiple universes exist. Some theories suggest an infinity of universes, and some even suggest that if you travelled far enough, you would eventually encounter a parallel version of yourself living in a parallel version of our world.

WHAT DOES IT MEAN TO SAY THAT SPACE IS A VACUUM?

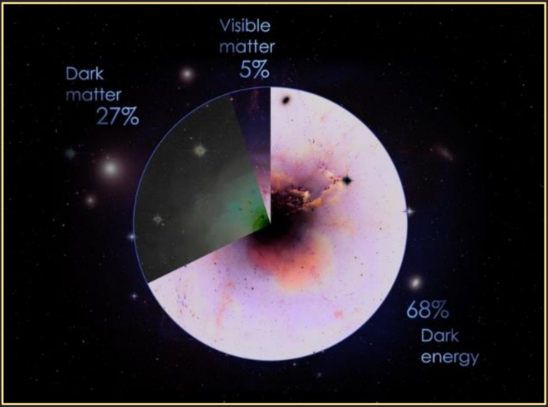
In the field of physics, a vacuum is a space in which there is no matter or in which the pressure is so low that any particles in that space do not affect any processes occurring there. What we really mean in saying "space is a vacuum" is that the parts of space that are far away from objects such as planets, stars, etc. are almost a vacuum—the concentration of particles in that space is miniscule in comparison to the concentration in our atmosphere.

ARE THERE PLACES OTHER THAN EARTH THAT MAY BE HABITABLE FOR HUMANS?

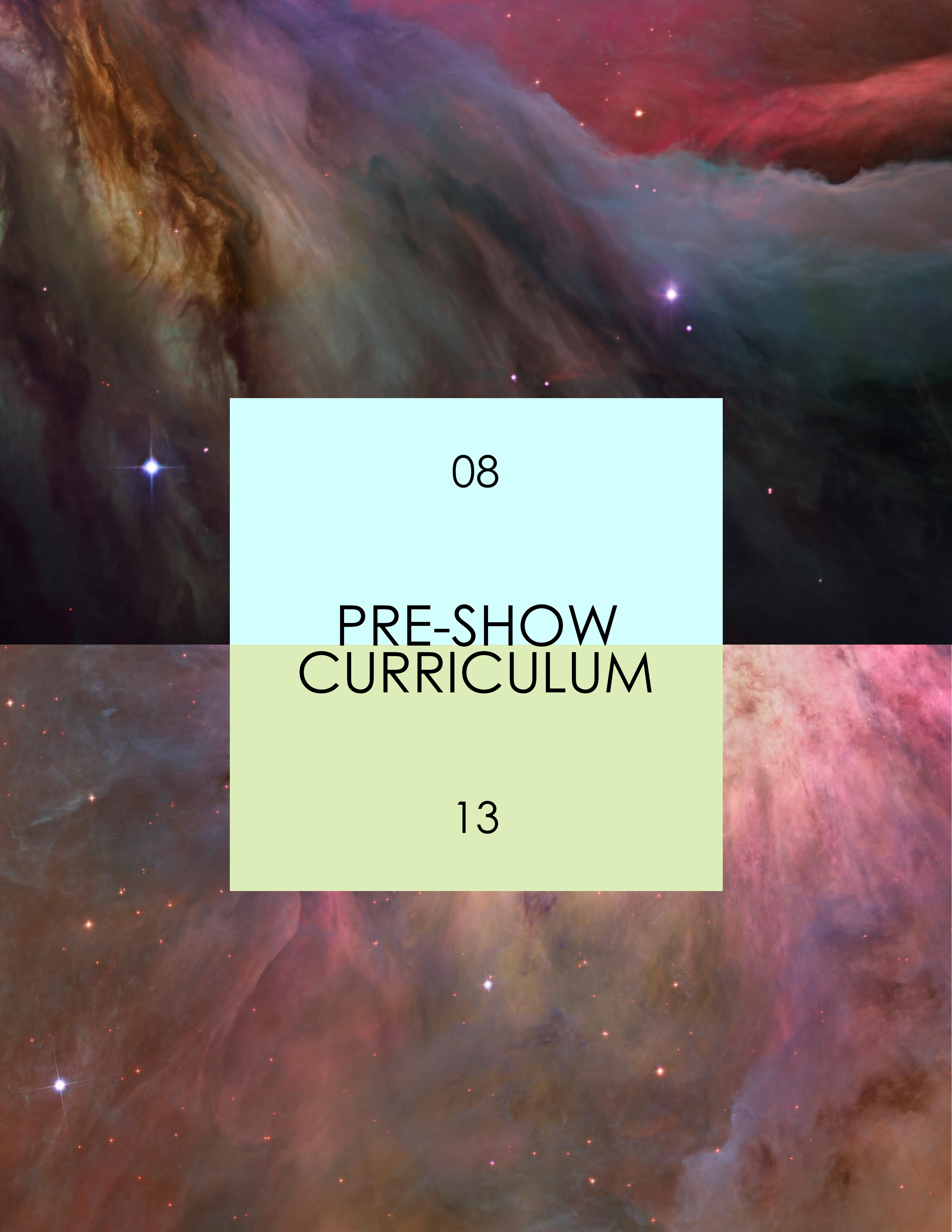
Though we do not currently know of a place where we could live as comfortably as we do on Earth, there are places that have potential. For example, if we created a floating habitat that hovered in the atmosphere of Venus, we would avoid the extreme temperatures of the surface. Can you think of any possible habitats we could construct in other cosmic locations?

WHAT IS THE UNIVERSE MADE OF?

It is thought that the universe is made up of three kinds of substance, including normal matter, dark matter, and dark energy. Most scientists believe that dark energy accounts for about 68% of the universe, dark matter accounts for 27%, and normal matter (what stars, planets, you, and I are made of) accounts for 5%. Dark matter is a mysterious substance that has gravitational pull but does not give off or absorb light. Given these limiting characteristics, how might scientists detect the presence of dark matter in space?



This pie chart shows rounded values for the three known components of the universe: normal matter, dark matter, and dark energy.
Image credit: NASA



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PRE-SHOW CURRICULUM

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DRESSING FOR THE OCCASION

CREATING, INVESTIGATING, AND CRITIQUING

OVERVIEW

In this activity, students will work in teams to analyze conditions at either the moon or mars and establish criteria for designing a space suit with the accommodations appropriate for that environment. Teams will then draw and label a space suit design.

OBJECTIVES

· Students will research the environment of their chosen world and location.
· Students will identify and analyze the spacesuit features necessary for that area.
· Students will design, draw, and label a diagram of their space suit.

MATERIALS

Various drawing materials
Paper or poster board for each team
USSRC Another World Resource Sheet (see pg. 13)
USSRC Space Suit Fact Sheet
USSRC Dressing for the Occasion Worksheet

NATIONAL EDUCATION STANDARDS

NGSS: ESS1.A; ESS2.A; ESS3.A; LS2.B; ETS1.A
CCSS ELA-Literacy: RI.4.4; RI.5.4; RST.6-8.4; SL.4.1; SL.4.4; SL.4.5; SL.5.1; SL.5.4; SL.5.5; SL.6.1; SL.6.5

INTRO:

WHAT TO WEAR IN OUTER SPACE

THE ESSENTIALS OF SURVIVAL

If you travel to a location on Earth with a different climate than the one you're used to, you must consider what clothes to pack for these new environmental conditions. Depending on your destination, there could be other needs to consider as well. For example, at the top of Mount Everest, not only would you need clothing appropriate for the extreme weather, but you would also need an oxygen supply in order to survive the high altitude. On the ocean floor, not only would you need an oxygen supply, but you would also need equipment that could help you contend with the intense pressure. What protection would you need in order to leave Earth and venture out into space? What would you need to bring along?

Astronauts use space suits to provide the necessary environmental elements of Earth that are required to survive in space or on another world. At a minimum, this suit must provide oxygen, a way to expel the toxic CO_2 that we breathe out, atmospheric pressure, protection from space debris and harmful radiation, and a comfortable temperature. This can be easily remembered by using the acronym **SPORT**:

- o **Space debris protection:** for human-made or naturally occurring objects
- o **Pressure:** provide atmospheric pressure (~14.7 lbs./sq. inch on Earth)
- o **Oxygen:** for breathing
- o **Radiation:** protection from solar and magnetic radiation
- o **Temperature:** provide a moderate, comfortable temperature

In addition, a space suit must provide necessities for other things such as bodily functions, communications, food, and water. Other considerations include mobility and function, depending on what you want to do while you are in your space suit. If you are going to climb a mountain, would you prefer to do it while wearing 12 coats and 20 pairs of pants, or perhaps something more flexible and lightweight that would provide the same protection from the cold weather? If you are performing tasks that require dexterity, such as collecting small samples or using a touch pad, would you prefer to do it with a baseball catcher's glove or something more form fitting?

Discuss with the class:

· What makes places such as Mt. Everest, Antarctica, and the bottom of the ocean inhospitable? How do we adapt to these places?
· How are conditions in these places similar to the harsh conditions of space?
· How does the **Space Suit Fact Sheet** demonstrate ways that astronauts adapt to the harsh environment of space?

ACTIVITY INSTRUCTIONS

PHASE 1
Project Planning

· Divide the class into groups.
· Have each group choose between the moon or Mars to explore with their space suit.
· Have each group pick a mission. You can use the suggestions below or have them make up their own:
  · Climbing and repelling on mountains or craters to do geological surveys
  · Collecting surface samples for analysis
  · Cutting and processing ice for water
  · Extracting resources such as hydrogen or methane for fuel
  · Fixing a broken rover or repairing a robot

PHASE 2
Designing the Space Suit

· Using the **Dressing for the Occasion** Worksheet and **Space Suit Fact Sheet**, have each group draw a representation of their space suit and label all the parts. Include descriptions with as much detail as possible.
· The drawing should be labeled with the world they have chosen. A representation of the location may be included in the drawing.
· Have each team briefly explain the rationale for their selections.

PHASE 3
Reflection and Adjustments

· After the show have the teams reexamine their data sheets and fill out a new one.
· Have each team briefly explain the rationale for any modifications or additions to their original space suit. Alternately, if there are no modifications, have them present a justification.
· Follow up with a classroom discussion:

· Why do humans need to wear space suits on other worlds?

· What basic functions does a space suit need to include?

· In what ways do space suits make it more difficult to complete work?

· What innovations did the class discover that they think were good ideas for future space suits?

SPACE SUIT FACT SHEET

Helmet:
· Hard shell for protection from space debris
· Lights to make vision possible in the dark
· Special visor for protection from solar rays
· Communications (listening/talking to other crew members)
· Food & drink built in (food in edible wrappers)

Display and Control Module (*On Chest*)**:**
· Controls for power and spacesuit function monitor

Life Support System (*Backpack*)**:**
· Oxygen and battery power
· CO_2 scrubber

Hard Outer Torso:
· Top & bottom connect for airproof seal
· Many layers for warmth and protection from space debris and radiation

Gloves:
· Many layers for temperature control & space debris protection
· Flexible for working

Temperature Control Garment (*Under Suit*)**:**
· Looks like long underwear
· Many layers for warmth and tubes of flowing water for cooling

Pressure Control Garment (*Under Suit*)**:**
· Looks like long underwear
· Inflatable for pressure

Boots:
· Airtight & insulated
· Specialized soles depending on terrain

The image above shows Astronaut Buzz Aldrin on the moon in his spacesuit (1969).
Image credit: NASA

DRESSING FOR THE OCCASION WORKSHEET

1. Research the conditions on the place you have chosen and complete the chart below:

Name of solar system location: ____

CONDITION Describe the condition of your world	**EFFECT** Describe how the condition affects the body
Atmosphere	
Space debris	
Temperature	
Atmospheric Pressure	
Radiation	

2. In the chart below, list the bodily functions that need to be accounted for and the parts of your space suit that will sustain those functions:

BODILY FUNCTION	**SPACE SUIT PART**

3. List any other functions your space suit will supply on the chart below:

FUNCTION	SPACE SUIT PART

4. List at least ten space suit parts that you will draw and describe, and list the features and function of each part in the chart below:

SPACE SUIT PART	PART FEATURES

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PLANET OVERVIEW

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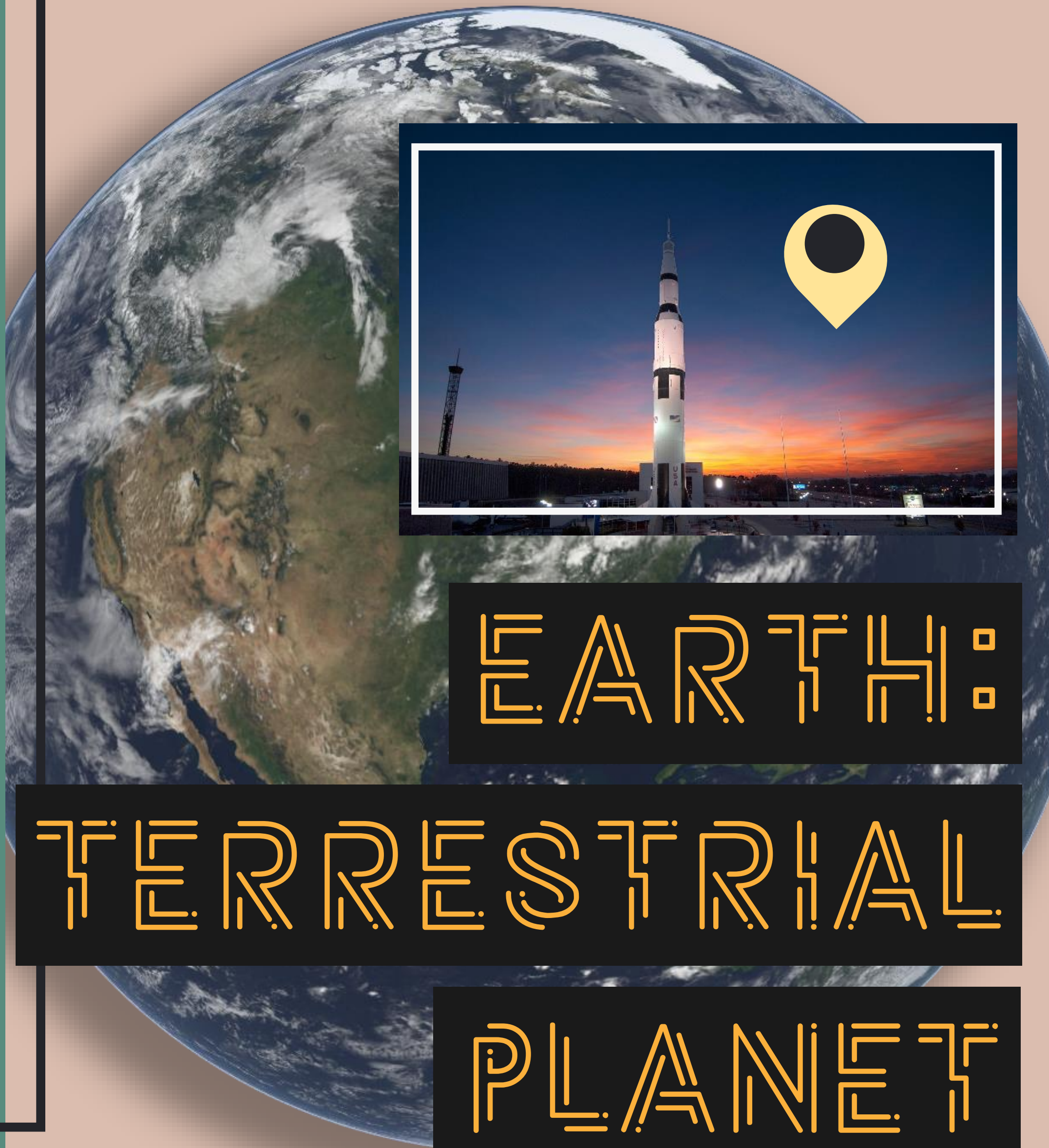
EARTH

OUR PLACE IN SPACE

EARTH: TERRESTRIAL PLANET



LOCATION OF INTEREST: U.S. SPACE & ROCKET CENTER

Located in Huntsville, AL, the U.S. Space & Rocket Center is a gem that offers visitors the opportunity to learn about space exploration history and engage in interactive exhibits. It holds one of the largest collections of rockets and space memorabilia on display anywhere in the world, including its most well - known feature and the largest Smithsonian artifact, the Saturn V Rocket.

DID YOU KNOW?

1. Though we often think of the Earth as a sphere, it bulges out a little at the equator, meaning it is an oblate spheroid.
2. The Earth is the only place we know of where water can stably exist in solid, liquid, and gaseous form.
3. Until the 1600s, the Earth was generally believed to be the center of the solar system due to the apparent movement of the sun.

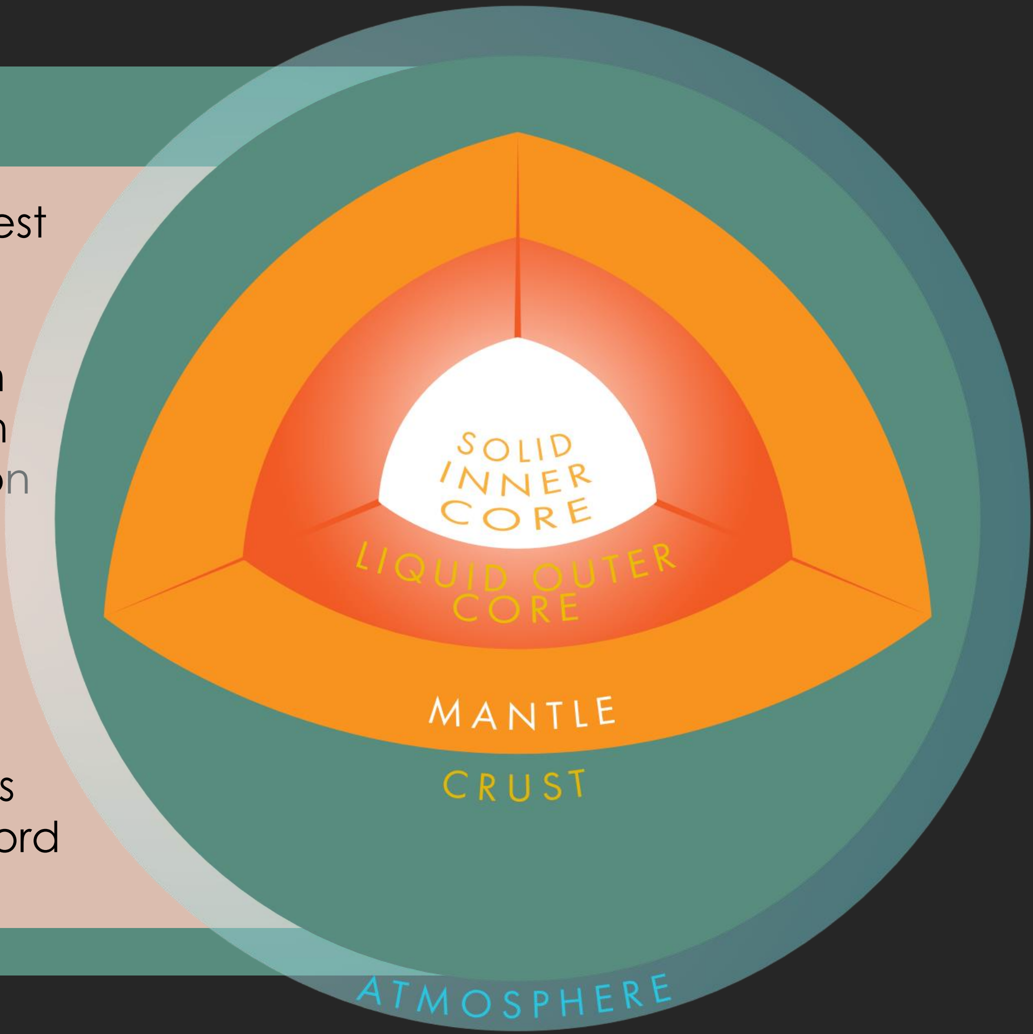
CURRENT CONDITIONS

Alabama, like most of Northern America, experiences a temperate climate, meaning that it does not see extreme conditions such as polar temperatures or summer droughts. There are four seasons that Alabama cycles through annually: summer, autumn, winter, and spring.

EARTH

OVERVIEW

- Earth is the fifth largest planet in our solar system.
- It is the only place in our solar system with stable liquid water on its surface.
- Though all the other planets are named after Greek and Roman gods, the earth's name comes from a Germanic word meaning "ground."



COMPOSITION

<u>PLANETARY</u>
Core: iron and nickel
Mantle: molten rock
Crust: oxygen, silicon, and aluminum

<u>ATMOSPHERE</u>
Primarily nitrogen and oxygen

DATA

<u>MASS</u>
5.97 x 10^{24} kg
<u>RADIUS</u>
6,370 km
<u>VOLUME</u>
1.08 km^3
<u>ATMOSPHERIC PRESSURE</u>
1010 millibars

<u>TEMPERATURE</u>
average: 14° C
<u>ORBITAL PERIOD</u>
365.24 days
<u>ROTATIONAL PERIOD</u>
24 hours
<u>KNOWN MOONS</u>
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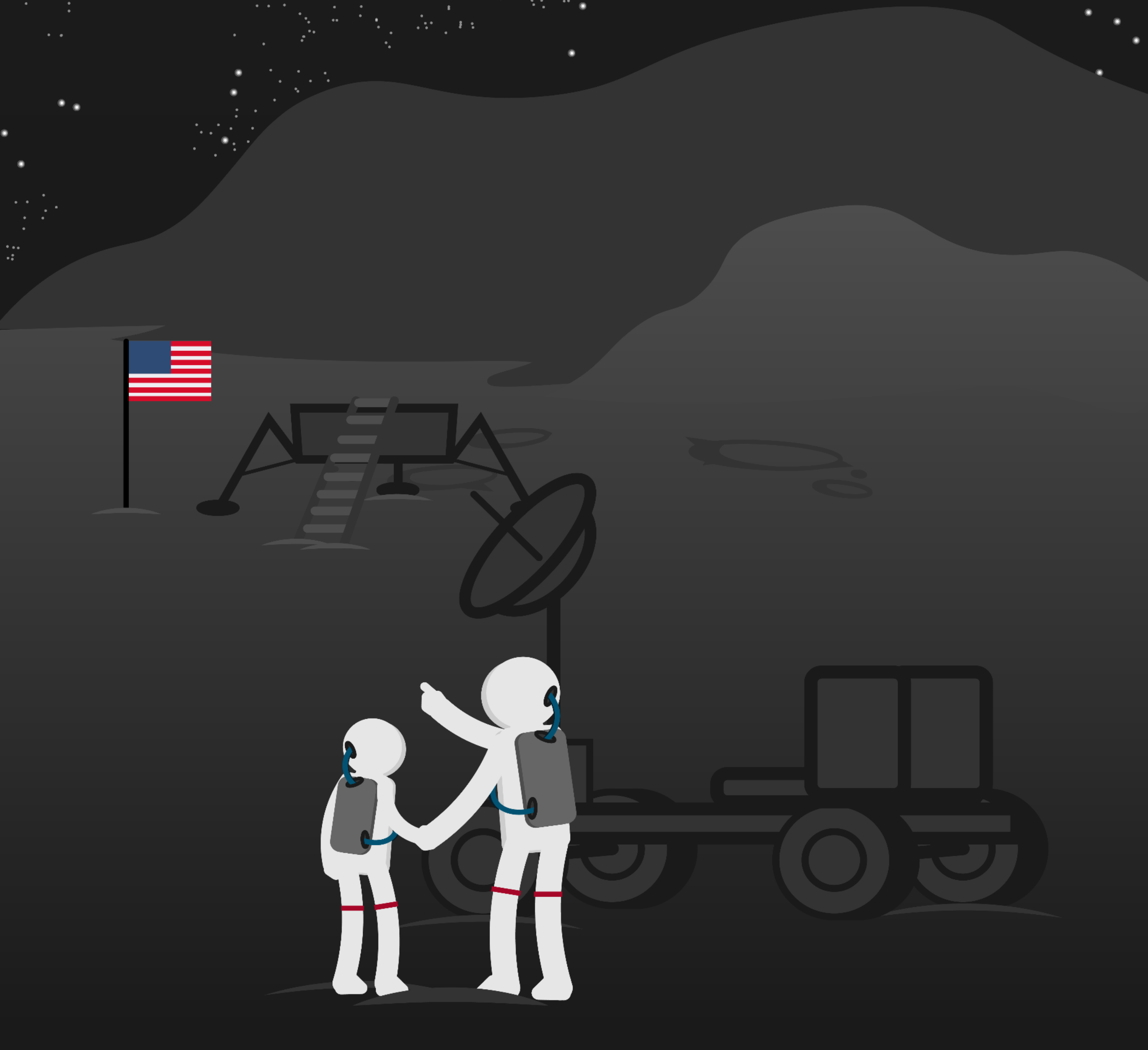
VISIT APOLLO 15
at the
APENNINE MOUNTAINS



THE MOON: EARTH'S MOON

LOCATION OF INTEREST: APENNINE MOUNTAINS

The image below shows the Apennine Mountains, a lunar feature that runs over 595 km long and includes more than 3,000 peaks. Whereas it takes thousands of years for mountain ranges to form on the earth, these were formed in a matter of minutes by the shock waves from a huge impact.

CURRENT CONDITIONS

The tallest peak in the Apennine Mountains, called Mons Huygens, stretches 5.5 km high. The range is very sharp and rugged in general, so consider landing your spaceship in a valley as Apollo 15 did in 1971.

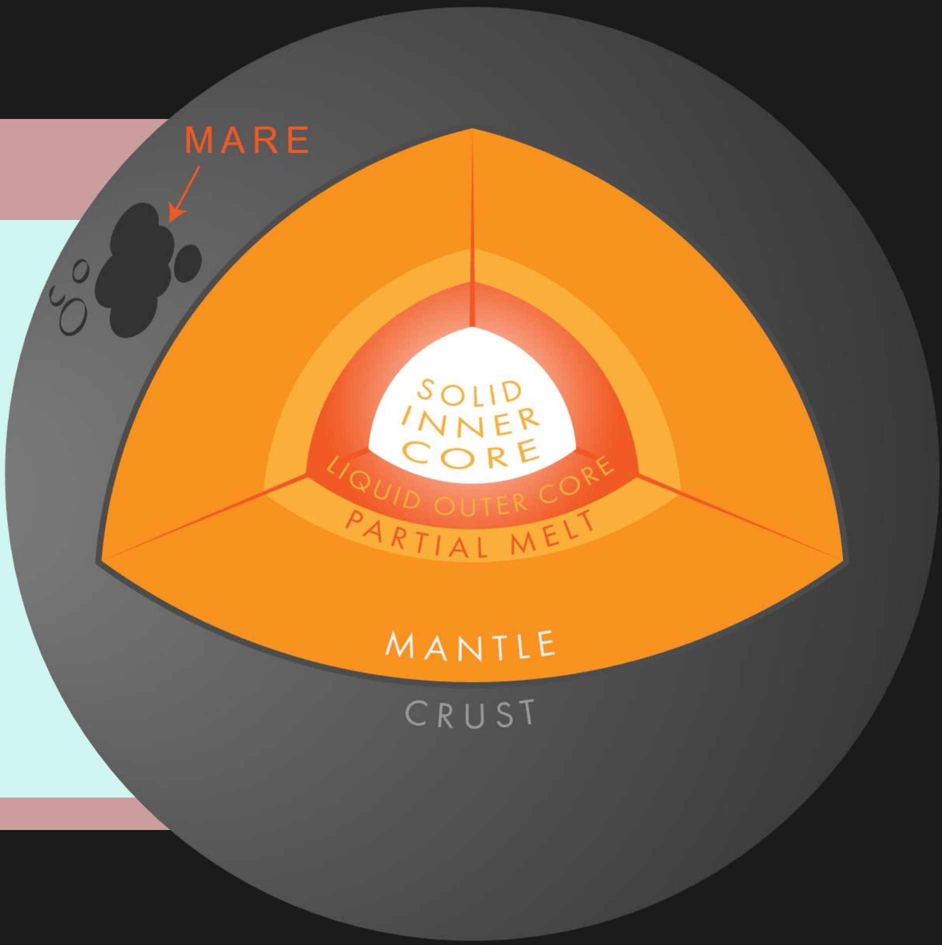
DID YOU KNOW?

1. The moon is a terrestrial body and the only permanent satellite of the Earth, completing one orbit every month.
2. Earth's moon does not have a name like other planets' moons do because people did not know other planets had moons until 1610.
3. One theory of the origin of the Moon is that a Mars - sized planet collided with the Earth, scattering debris into a ring that eventually collected into a single, solid body.

THE MOON

OVERVIEW

- The Earth's moon is the fifth largest of all the moons in our solar system and about a quarter the size of the earth.
- It is also the brightest and largest object in our night sky.



COMPOSITION

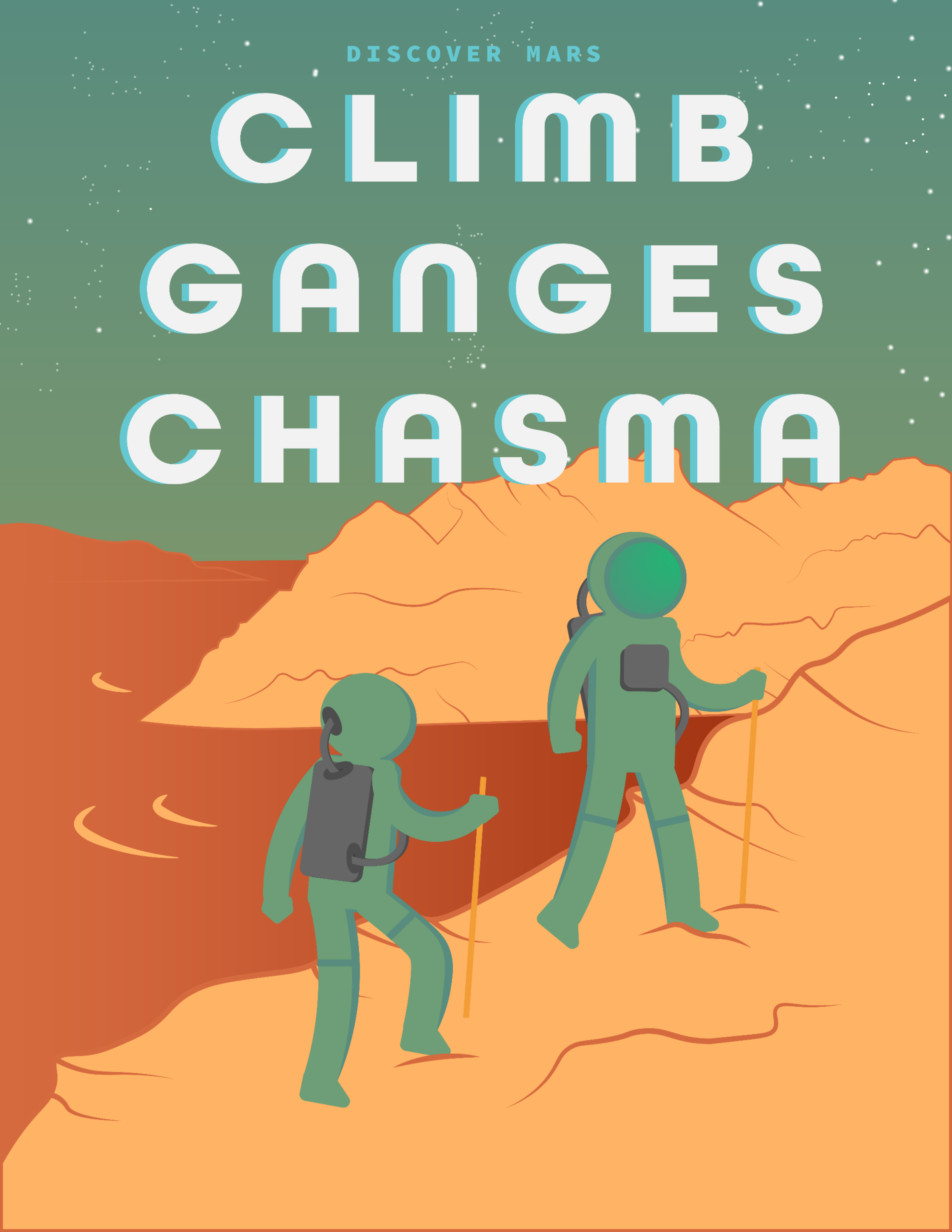
<u>PLANETARY</u>
Core: solid iron surrounded by a layer of liquid iron
Mantle: olivine and pyroxene
Crust: oxygen, silicon, magnesium, iron, calcium, and aluminum.

<u>EXOSPHERE</u>
Primarily helium and neon

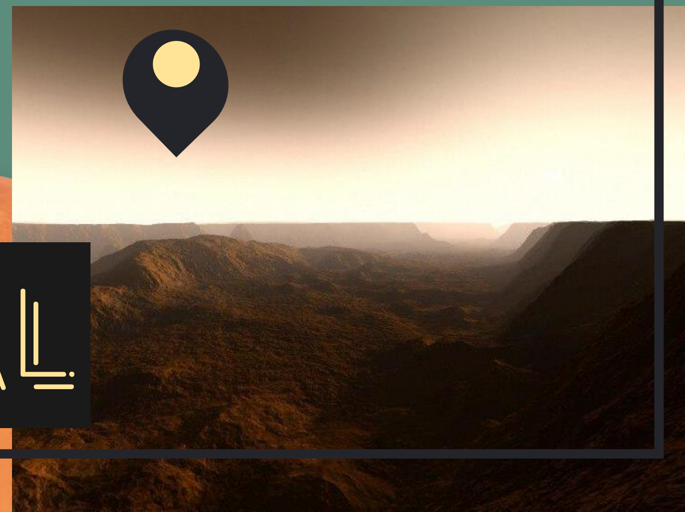
DATA

<u>MASS</u>
7.35×10^{22} kg
0.01 x Earth mass
<u>RADIUS</u>
1,740 km
0.27 x Earth radius
<u>VOLUME</u>
2.20×10^{10} km^3
0.02 x Earth volume
<u>EXOSPHERIC PRESSURE</u>
3×10^{-15} bars

<u>TEMPERATURE</u>
-173 to 127° C
<u>ORBITAL PERIOD</u>
27 days
<u>ROTATIONAL PERIOD</u>
27 days
<u>GRAVITY</u>
0.17 x Earth gravity


DISCOVER MARS
CLIMB
GANGES
CHASMA

MARS: TERRESTRIAL PLANET



DID YOU KNOW?

1. Water has been found on Mars in ice form, and there is even evidence to suggest that Mars once held a significant amount of liquid water on its surface.

2. One of the most famous features of Mars is Valles Marineris, a valley as long as the United States is wide and five times deeper than the Grand Canyon in some points.

3. The atmosphere on Mars is very thin and changes dramatically with height, such that if you stood at the equator, it could be 24° Celsius at your feet and 0° Celsius at your head at the same time.

LOCATION OF INTEREST: GANGES CHASMA

Shown in the image above is Ganges Chasma, a deep canyon located on the eastern side of Valles Marineris. Running 3 or 4 km deep, it is thought to have been formed by the flow of water and CO_2.

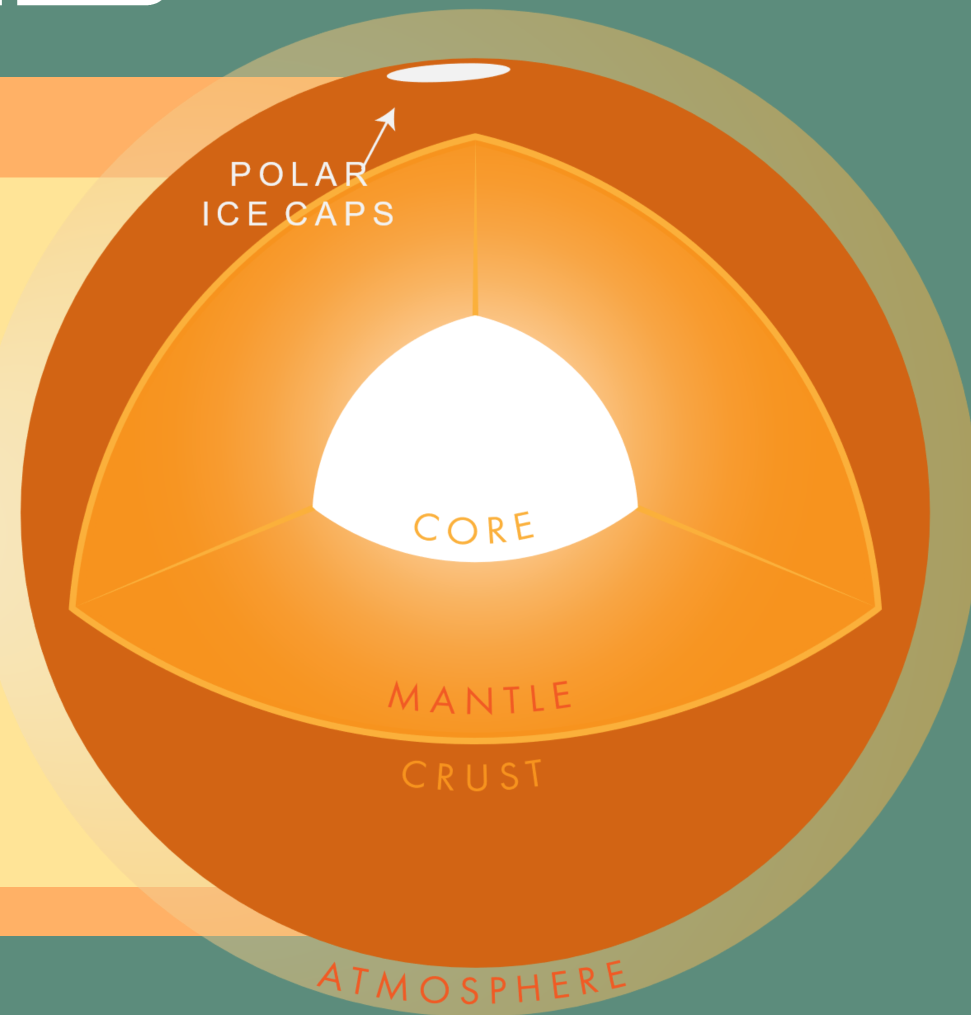
CURRENT CONDITIONS

Look no further for your favorite new summer vacation spot! Summertime in the lower **latitudes**, such as Ganges Chasma, would make for a quite comfortable stay at a balmy 24˚ Celsius. However, dust storm season is intense, and storms can range from the size of a small tornado to a planet-wide squall.

MARS

OVERVIEW

- Mars is the fourth planet from the Sun and about half the size of the Earth.
- It is home to both the deepest canyon (Valles Marineris at 7 km deep) and highest peaks (Olympus Mons at 21,000 m) in the solar system.



COMPOSITION

PLANETARY
Core: iron, nickel, and sulfur
Mantle: silicon, oxygen, iron, and magnesium
Crust: iron, magnesium, aluminum, calcium, and potassium

ATMOSPHERE
primarily carbon dioxide, nitrogen, and argon

DATA

MASS
6.42×10^{23} kg
0.11 x Earth mass

RADIUS
3,390 km
0.5 x Earth radius

VOLUME
1.63×10^{11} km^3
0.15 x Earth volume

ATMOSPHERIC PRESSURE
0.006 bars

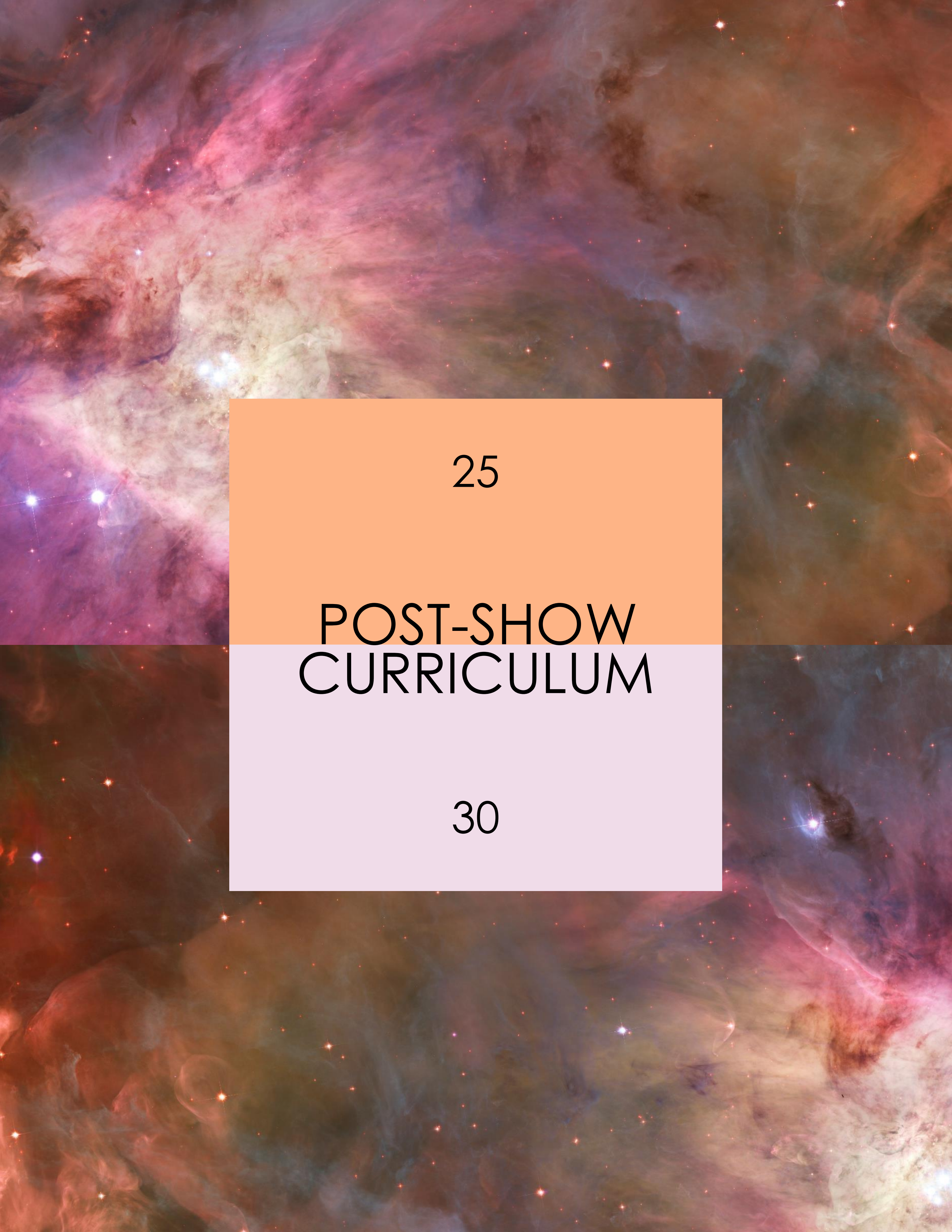
TEMPERATURE
Average: -28° C

ORBITAL PERIOD
687 Earth days

ROTATIONAL PERIOD
24.6 hours

GRAVITY
0.38 x Earth gravity

KNOWN MOONS
2



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POST-SHOW CURRICULUM

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MOON to MARS and BEYOND PRESENTATION ACTIVITY

THINKING CRITICALLY TOGETHER

OVERVIEW

Students will demonstrate the relative size of and distance between solar system objects and give a brief presentation of their findings. There are two options for this activity: design a tour presentation using WorldWide Telescope (a virtual telescope application at www.worldwidetelescope.org) or design a poster presentation.

OBJECTIVES

· Students will construct representations of solar system planets and fact sheets.
· Students will demonstrate knowledge of the relative size of and distance between solar system objects.
· Students will demonstrate communication skills by creating a presentation based on their research.

MATERIALS

(Option 1)
Computers with internet access

(Option 2)
Poster boards
Drawing materials: rulers, compass, pencils, markers, etc.

NATIONAL EDUCATION STANDARDS

NGSS: ESS1.B; ESS3.A; ESS3.B; PS2.B; LS2.A
CCSS ELA-Literacy: RI.4.4; RI.5.4; RI.5.9; RST.6-8.4; SL.4.1; SL.4.4; SL.4.5; SL.5.1; SL.5.5; SL.6.1; SL.6.4; SL.6.5

ACTIVITY INSTRUCTIONS

PHASE 1
Project Planning

· Divide class into groups (four students per group is recommended). For larger classes, a group working on asteroids and the asteroid belt or planetary moons is an option to lower the number of students in each group.

· Assign a solar system object to each group.

· Explain the project to the students, including expectations of their report and presentation. Have each group spend some time discussing their project and working together to distribute tasks (research, poster design, presentation, project management, etc.).

· Posters and presentations should include information on the group's assigned solar system object such as mass, composition, distinguishing surface features, habitability, science or commercial potential, etc.

PHASE 2
Research, Tour or Poster Design, and Presentation

Option 1: WorldWide Telescope Presentation

· Go to www.worldwidetelescope.org, a virtual telescope application called WorldWide Telescope

· Have each group conduct research on their object and prepare their presentation by selecting the "Create a New Tour" option in WorldWide Telescope. Presentations should incorporate 10 – 20 facts about the solar system object.

Option 2: Poster and Graphic Arts Presentation

· View the Solar System Overview section of this guide.

· Have each group assemble materials, conduct research, and design their poster. Presentation should include at least 10 – 20 facts about the solar system object.

· Have each team give a short presentation on their solar system object.

SPACE BASE: EXPLORING OTHER WORLDS

THINKING CRITICALLY ABOUT EXPLORATION

OVERVIEW

Students will work in small groups and practice critical thinking to investigate the possibilities of creating an outpost on other worlds in our solar system. In addition, they will design and construct an outpost on a solar system world.

OBJECTIVES

· Students will examine exploration of other worlds in the solar system based on their environmental conditions and natural resources.
· Students will examine the physical, psychological, and logistical factors involved in human habitation and exploration of other worlds and give a presentation based on their research.

MATERIALS

· Paper or poster board
· Construction paper
· Cardboard
· Grid paper
· Rulers, tape, scissors
· Straws, pipe cleaners
· Drawing materials such as pens, markers, crayons, etc.

NATIONAL EDUCATION STANDARDS

NGSS: ESS1.A; ESS1.B; ESS2.A; ESS3.A; PS1.B; PS2.B; PS3.D; PS4.C; LS2.A; ETS1.A
CCSS ELA-Literacy: RST.6-8.4; RST.9-10.4; RST.11-12.4; SL.7.1; SL.7.4; SL.7.5; SL.8.1; SL.8.4; SL.8.5; SL.9-10.1; SL.9-10.4; SL.11-12.1; SL.11-12.4

INTRO:

COLONIZING IN SPACE

HOW TO MAKE YOUR HOME AWAY FROM HOME

In the near future we can expect to see humans in permanent residence on other celestial bodies, such as the Moon and Mars. Before we can take up residence on another world we need a base, a place to live and work. Currently humans live and work on the International Space Station in low Earth orbit (LEO), 250 miles above the Earth. But what will a base farther from the Earth look like?

In this activity, you will design and construct your base on another solar system world.

In order to build your outpost, refer to your previous experience and discussions of the other activities in the *INTUITIVE®* Planetarium Moon to Mars and Beyond Educator's Guide (i.e. Dressing for the Occasion Activity).

Many factors must be considered when designing an outpost for human exploration on another world in our solar system. Remember to think outside of the box. For example, water (H_2O) can also be converted into hydrogen for fuel and oxygen for breathing. Oxygen can be extract-ed from CO_2 and the carbon can be used in the pro-duction of many useful items or products. Moving liquids and surface wind can be converted into power. Solar energy might be an option, but remember that the farther you are from the sun, the less viable this becomes.

REMEMBER TO CONSIDER HUMAN NEEDS:

· How will food and water be provided?

· How will you generate power and electricity for your outpost?

· Communications will need to be maintained with planet Earth and possibly other outposts. Beyond the obvious safety factors, consider the psychological effects of long duration missions, far from home, confined to a relatively small space, and only a few people to interact with.

· Exercise is necessary, especially in places with less gravity than Earth, for well-being and physical health. Are there adequate facilities?

· Are sleeping quarters communal or private? Keep in mind, everyone needs alone time every now and then for psychological health.

· Science laboratory and workshop areas are necessary for any scientific or commercial endeavor.

· Is an area for recreation provided? Where will you spend your downtime? Is there a place for relaxation, hobbies, and creativity?

· Do you need transportation? Are you going to walk everywhere or use something else?

· Your outpost must be realistic. You are encouraged to incorporate cutting-edge and theoretical technology that might be developed in the near future. However, keep in mind that this is the 21st century, and not the 521st. No Dyson spheres or anti-matter reactors. Assume ~30% boost in efficiency / capability.

· Be creative and use your imagination. Your outpost is a long way from Earth. What other things do you want or need to make it more like home-sweet-home?

5 BASIC NEEDS

On any other world in the solar system, it will be necessary to re-create the life-supporting environment that we take for granted on planet Earth. There are five basic essentials that can be easily remembered using the acronym "SPORT":

· Space debris protection: for human-made or naturally occurring objects
· Pressure: provide atmospheric pressure (~14.7 lbs / sq. inch on Earth)
· Oxygen: for breathing (also a way to remove toxic CO_2)
· Radiation: protection from solar and magnetic radiation
· Temperature: provide a moderate, comfortable temperature

NATURAL RESOURCES

Whether your outpost is primarily scientific in nature or commercial, you will want to take advantage of local natural resources:

· Water (or water ice)
· Oxygen
· Fuel
· Raw materials (surface and sub-surface elements and minerals)
· Possible compounds that can be derived from local elements and minerals
· Wind
· Solar power
· Moving liquid

LOCAL RESOURCES

The local environment of the world you choose will heavily influence the structure of your outpost.

· Atmosphere
· Gravity
· Radiation
· Pressure
· Temperature
· Magnetic field

ACTIVITY INSTRUCTIONS

PHASE 1

Activity

· Divide the class into groups (four students for each group is recommended).

· Explain the project to the students, including content expectations of their report and presentation. The depth of this activity will largely depend on the age group and available classroom time; the important thing is that they work together as a team and think critically and creatively about their project.

· Have each group assemble materials, conduct research, create a poster or model, and prepare their presentation. Presentations should include as much detail as possible on their concept of their base.

PHASE 2

Post Activity

· Have each team give a brief presentation on their concept of their base.

· Open class discussion as time permits.

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REFERENCES

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GLOSSARY

ACCELERATION DUE TO GRAVITY:
The rate at which velocity of a freely falling object changes over time, expressed in terms of the rate of increase of velocity per second: on Earth, it is 98.0665 meters per second per second is the standard.

ANTICYCLONE:
A large-scale circulation of winds around a central region of high atmospheric pressure, spinning clockwise in the Northern Hemisphere of a body and counter-clockwise in the Southern Hemisphere.

ASTERISM:
Any grouping of stars into a shape or pattern. Asterisms are not officially recognized and often vary from culture to culture. For example, Ursa Major is an official constellation, while the Big Dipper is a prominent and well-known asterism contained within it.

ASTEROID:
A small, rocky body orbiting the Sun. Large numbers of these are found in the asteroid belt, especially between the orbits of Mars and Jupiter. They can range in size from nearly 262 km across (Vesta) to dust particles.

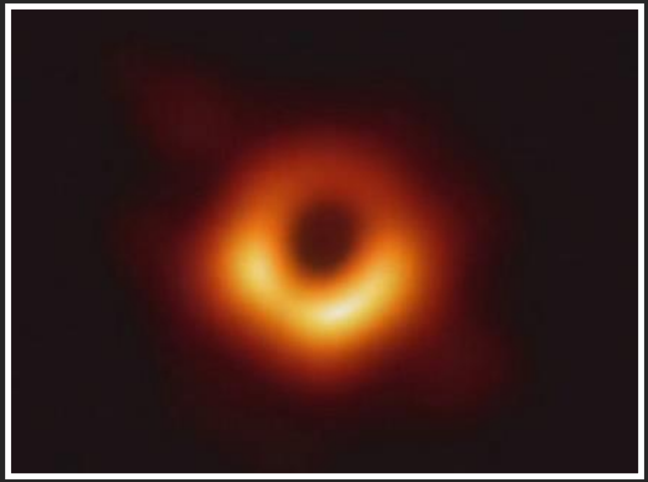
ASTEROID BELT:
A region of space between the orbits of Mars and Jupiter where most of the asteroids in our solar system are found orbiting the Sun.

ASTRONOMICAL UNIT (*AU*):
The unit of measurement that represents the mean distance between the Earth and our Sun. An AU is approximately 150 million km.

ATMOSPHERE:
The envelope of gases surrounding the Earth or another planet.

ATMOSPHERIC PRESSURE:
The force exerted against a surface by the weight of the air above the surface.

BLACK HOLE:
A region of space having a gravitational field so intense that no matter or radiation (light) can escape.



Pictured above: The first image taken of a black hole
Image credit: Event Horizon Telescope collaboration et al

COMET:
Celestial object consisting of a nucleus of ice and dust. When near the Sun, a "tail" of gas and dust particles form pointing away from the sun.

CONSTELLATION:
A group of stars forming a recognizable pattern that is traditionally named after its apparent form or identified with a mythological figure. Modern astronomers divide the sky into eighty-eight constellations with defined boundaries.

CORE:
Consists of the innermost layer(s) of a planet. Cores of specific planets may be entirely solid, entirely liquid, or a mixture of solid and liquid layers as is the case in the Earth. In our solar system, core size can range from about 20% (moon) to 85% of a planet's radius (Mercury).

CORONA:
The corona is the outermost part of the sun's atmosphere.

Pictured right: an image of the solar corona during a total solar eclipse, August 21, 2017

Image credit: NASA/Aubrey Gemignani

CRATER:
A bowl-shaped depression, or hollowed-out area, produced by the impact of a meteorite, volcanic activity, or an explosion. Craters produced by the collision of a meteorite with the Earth (or another planet or moon) are called impact craters.

CYCLONE:
A circulation of winds around a central area of low atmospheric pressure, spinning counterclockwise in the Northern Hemisphere of a body and clockwise in the Southern Hemisphere.

CRUST:
The outermost solid shell of a rocky planet, dwarf planet, or natural satellite

DENSITY:
A measurement that compares the amount of matter an object has to its volume. An object with a large amount of matter in a certain volume has high density.

DWARF PLANET:
A celestial body that orbits a star and is massive enough to be rounded by its own gravity, but has not cleared its neighboring region of planetesimals.

EFFECTIVE TEMPERATURE:
The temperature of a body's surface in the absence of an atmosphere.

ELECTROMAGNETIC SPECTRUM:
The entire range of wavelengths or frequencies of electromagnetic radiation extending from gamma rays to the longest radio waves and includes visible light.

EQUINOX:
The time or date (twice each year) at which the sun crosses the celestial equator, when day and night are of equal length (around September 22 and March 20 each year).

EXOSPHERE:
A thin, atmosphere-like volume surrounding a planet or natural satellite where molecules are gravitationally bound to that body, but where the density is too low for them to behave as a gas by colliding with each other.

GALAXY:
A system of millions or billions of stars, gas, and dust held together by gravitational attraction.

GAS GIANT:
A large planet of relatively low density consisting predominantly of hydrogen and helium, such as Jupiter and Saturn.

GRAVITY:
The force that attracts a body toward the center of the Earth or toward any other physical body having mass.

HELIOSPHERE:
The region of space that encompasses the solar system and in which the solar wind has a significant influence.

ICE GIANT:
A planet composed mainly of elements heavier than hydrogen and helium, such as oxygen, carbon, nitrogen, and sulfur. There are two ice giants in the solar system: Uranus and Neptune.

IONIZATION:
The process by which an atom or a molecule acquires a negative or positive charge by gaining or losing electrons.

KUIPER BELT:
A region of our solar system that exists beyond the eight major planets, extending from the orbit of Neptune (at 30 AU) to approximately 50 AU from the sun. It is similar to the asteroid belt in that it contains many small bodies, all remnants from the formation of our solar system.

LATITUDE:
The lines circling a celestial body that run parallel to its equator. Usually expressed in degrees north or south of the equator.

LIGHT YEAR (*ly*):
A unit of astronomical distance equivalent to the distance that light travels in one year, which is 9.46×10^{12} km.

LONGITUDE:
The lines circling a celestial body that run from pole to pole. Usually expressed in degrees east or west of a designated prime meridian.

MAGNETIC FIELD:
Produced by churning motions of liquids at a planet's core that conduct electricity and have an electric charge. The magnetic fields act like giant bar magnets and can be offset from the rotation axis of a planet.

MANTLE:
A layer inside a planetary body between the core and the crust. Mantles are made of rock or ices and are generally the largest and most massive layer of the planetary body.

MASS:
The quantity of matter in a body, regardless of its volume or any forces acting on it.

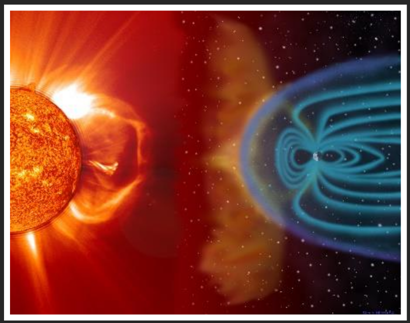
MATTER:
Anything that has mass and takes up space.

METEOROID:
A small, rocky or metallic body moving in the solar system that would become a meteor if it were to enter the Earth's atmosphere.

MOON:
A celestial body that makes an orbit around a planet, including the eight major planets, dwarf planets, and minor planets.

Pictured right: an illustration of radiation from the sun meeting Earth's natural protection, the magnetosphere

Image credit: NASA/SOHO



OORT CLOUD:
A theoretical spherical cloud of predominantly icy planetesimals that surrounds the sun at a distance up to 100,000 AU (2 lightyears).

PLANET:
A celestial body that (a) is in orbit around the sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighborhood around its orbit.

PROMINENCE:
A large, bright, gaseous feature extending outward from the sun's surface, often in a loop shape.

RADIATION:
The emission of energy as electromagnetic waves or as moving subatomic particles, especially high-energy particles, which cause ionization.

RADIUS:
A straight line from the center to the circumference of a circle or sphere.

REGOLITH:
A layer of loose, unconsolidated material covering solid rock. It includes dust, soil, broken rock, and other related materials and is present on Earth, the Moon, Mars, some asteroids, and other terrestrial planets and moons.

SIDEREAL DAY:
The time required for a planet to rotate once relative to the background of the stars, i.e., the time between two observed passages of a star over the same meridian of longitude.

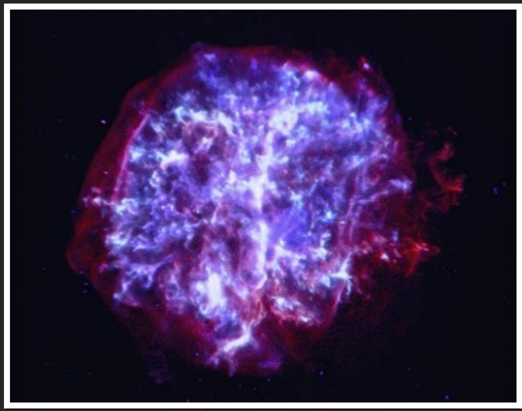
SILICATE ROCK:
Rock types that consist predominantly of silicate minerals and belong to one of three major classes: igneous, metamorphic, or sedimentary rock.

SOLAR DAY:
The time it takes for a planet to rotate about its axis so that the sun appears in the same position in the sky. On Earth, because the orbital motion of the Earth makes the sun seem to move slightly eastward each day relative to the stars, the solar day is about four minutes longer than the sidereal day.

SOLAR FLARE:
A brief eruption of intense high-energy radiation from the sun's surface, associated with sunspots and causing electromagnetic disturbances on the Earth, such as with radio frequency communications and power line transmissions.

SPEED OF LIGHT:
The distance light can travel in a unit of time through a given substance. Light travels through a vacuum at about 300,000 kilometers per second.

STAR:
A luminous ball of gas, mostly hydrogen and helium, held together by its own gravity.



Pictured above: a young supernova remnant about 20,000 light years away, catalogued as G292.0+1.8.

Image credit: NASA/CXC/SAO

SUNSPOTS:
Darker, cooler areas on the surface of the sun in a region called the photosphere. They are caused by interactions with the sun's magnetic field.

SUPERNOVA:
A star that suddenly increases greatly in brightness because of a catastrophic explosion that ejects most of its mass.

SUPERSONIC:
Involving or denoting a speed greater than that of sound (~340 meters per second).

TERRESTRIAL PLANET:
Composed primarily of silicate rocks or metals. Within the solar system, the terrestrial planets are the inner planets closest to the sun, i.e. Mercury, Venus, Earth, and Mars.

VOLUME:
A measure of the amount of space occupied by that object, not to be confused with mass.

WEIGHT:
The force of gravity on an object, defined as the mass times the acceleration due to gravity.

ONLINE RESOURCES

The following is a list of websites that can help shape and strengthen the educator's lesson plans for studies in space and science. These resources are free, safe, and will bring science to the classroom in an exciting and powerful way.

ASTRONOMY ACTIVITIES

American Museum of Natural History
https://www.amnh.org/explore/ology/astronomy
This site offers a variety of activities for students ages 7+, including crafts, informational articles, and space trivia quizzes.

DOCUMENTARIES

American Museum of Natural History
https://www.amnh.org/explore/videos
This resource displays links to an assortment of short documentaries regarding astronomy, Earth science, biology, and social perspectives.

INFORMATIVE SITES

NASA
https://science.nasa.gov/learners/wavelength
This link offers a collection of resources for science educators, peer-reviewed by educators and scientists.

INTERACTIVE STUDIES

Exploring By the Seat of Your Pants
http://www.exploringbytheseat.com/
This site is the homepage of an organization called Exploring By the Seat of Your Pants. They help teachers arrange virtual meetings with speakers and field trips with experts around the world.

Skype a Scientist
https://www.skypeascientist.com/
This program gives students the opportunity to interact via Skype with a real scientist.

NASA
https://solarsystem.nasa.gov/planets/earth/overview/
This link will take you to an interactive page where your students can explore, learn facts, study pictures, and gain a deeper understanding of each of the planets in our solar system.

WorldWide Telescope
https://worldwidetelescope.org
This program is basically a virtual telescope, allowing users to interact with and explore the universe via a browser on a computer or mobile device.

LESSON PLANS

NASA
https://www.nasa.gov/audience/foreducators/index.html
The link above will take you to a page where NASA provides detailed lesson plans updated weekly to enrich your STEM curriculum.

EDUCATION STANDARDS

The *INTUITIVE*® Planetarium strives to offer an educational experience that both fulfills the content requirements set by Next Generation Science Standards (NGSS) and fosters a lasting engagement with the material. The fulfilled standards include the following:

Dressing for the Occasion Activity

NGSS: ESS1.A; ESS2.A; ESS3.A; LS2.B; ETS1.A
CCSS ELA-Literacy: RI.4.4; RI.5.4; RST.6-8.4; SL.4.1; SL.4.4; SL.4.5; SL.5.1; SL.5.4; SL.5.5; SL.6.1; SL.6.5

Space Base Activity

NGSS: ESS1.A; ESS1.B; ESS2.A; ESS3.A; PS1.B; PS2.B; PS3.D; PS4.C; LS2.A; ETS1.A
CCSS ELA-Literacy: RST.6-8.4; RST.9-10.4; RST.11-12.4; SL.7.1; SL.7.4; SL.7.5; SL.8.1; SL.8.4; SL.8.5; SL.9-10.1; SL.9-10.4; SL.11-12.1; SL.11-12.4

"Moon to Mars and Beyond" Planetarium Presentation

NGSS Earth and Space Science: 1-ESS1-1; 2-ESS2-1; 2-ESS2-2; 2-ESS2-3; 4-ESS2-1; 4-ESS2-2; 5-ESS1-1; 5-ESS1-2; MS-ESS1-1; MS-ESS1-2; MS-ESS1-3; MS-ESS2-2; MS-ESS2-4; HS-ESS1-4; HS-ESS2-5

NGSS Physical Science: K-PS3-1; 2-PS1-1; 5-PS1-3; 5-PS2-1; MS-PS1-1; MS-PS2-4; HS-PS2-4

"Moon to Mars and Beyond" Presentation Activity

NGSS: ESS1.B; ESS3.A; ESS3.B; PS2.B; LS2.A
CCSS ELA-Literacy: RI.4.4; RI.5.4; RI.5.9; RST.6-8.4; SL.4.1; SL.4.4; SL.4.5; SL.5.1; SL.5.5; SL.6.1; SL.6.4; SL.6.5

Football Field Solar System Scale Activity

NGSS: ESS1.B
CCSS ELA-Literacy: RI.3.4; RI.3.5; RI.4.4; RI.5.4; RI.5.9; RST.6-8.4; WHST.6-8.2; RST.9-10.4;
RST.11-12.4; SL.K.1; SL.K.5; SL.1.1; SL.1.5; SL.2.1; SL.2.5 SL.3.1; SL.3.4; SL.3.5; SL.4.1; SL.4.4;
SL.4.5; SL.5.1; SL.5.5; SL.6.1; SL.6.4; SL.6.5; SL.7.1; SL.7.4; SL.7.5; SL.8.1; SL.8.4; SL.8.5; SL.9-10.1; SL.9-10.4; SL.9-10.5; SL.11-12.1; SL.11-12.5

Optional Phase 2 STEAM activity: CCSS Mathematics – 4.MD.1; 5.NBT.5; 5.NBT.7; 5.MD.1; 6.NS.2; 6.NS.3; 7.NS.3; 7.G.1