# GBIFEITH OBSERVATORY ONINE SAHOOL Phothan 

MODULE 4: EXOPLANETS ARE EVERYWHERE STUDENT GUIDE

## Preparing for Your Virtual Visit

We are excited that your class will be participating in Module 4: Exoplanets Are Everywhere of Griffith Observatory's Online School Program. Together we shall join the tradition of observing. Here are some things you'll need to know before your virtual visit.

- You and your class will experience the entire live program in Zoom. Your teacher will send you the steps to follow to join the Zoom webinar session.
- Before joining the webinar, please set your Zoom name to contain your real first and last name.
- When you are admitted into the Zoom webinar, you will enter muted with your video off.
- You and your class will meet a Museum Guide from Griffith Observatory. The Guide will lead you through the live experience.
- During the program, you will be asked to participate in polls. After a question is asked, a poll will pop up on your screen. Select an answer, and remember to click "Submit!"
- You may use Zoom's chat function to communicate with Griffith Observatory staff if you are experiencing technical difficulties.
- You may submit to the Q\&A box any questions about science you might have for Griffith Observatory staff. We shall hold a question-and-answer session at the end of the program and shall try to answer as many of your questions as we can.
- Remember to stay on your best behavior. We encourage you to answer the polls and ask any space or science-related questions you might have, especially those relevant to our discussion. Be polite. Any spamming behavior or inappropriate, rude, or harassing language sent to staff in the chat or Q\&A is not tolerated and may result in being dropped from the Zoom session.
- We hope you have a wonderful time!


## Pre-program Materials

To get the most out of Module 4: Exoplanets Are Everywhere, explore the following materials before your visit.

## Module 4 Glossary

The glossary lists and defines important words used in Module 4: Exoplanets Are Everywhere and the following materials.

## C Listen to the Module 4 Glossary

If listening helps you remember, this audio file will help you remember the words and definitions in the Module 4 Glossary.

## Make a Solar System Model

Are you ready to be blown away by how huge the solar system is? "Make a Solar System Model" is filled with many ideas for projects and activities to help you and your classmates model our cosmic home and planet neighbors.

## Make an Extrasolar Planetary System Model

There are other solar systems out there! After you model our solar system with Make a Solar System
Model, this activity may help you understand how a distant solar system compares to ours.

## Reality vs. Fiction of Worlds Beyond

Learn about the wild ideas people had about other worlds before actual photographs were taken! This compare-and-contrast activity will exercise your observing skills.

## Zodiac Constellation Activity Chart

This chart is a cross between a connect-the-dots game and an actual observing tool! Complete this astronomical tool yourself and then use it outside to reveal the unseen sky.

## Glossary

## MODULE 4: EXOPLANETS ARE EVERYWHERE

astronomy - the study of space and everything in it, including, but not limited to, stars, planets, galaxies, nebulae, black holes, supernovae, asteroids, comets, and the search for extraterrestrial life.
atmosphere - the layer of gas that surrounds Earth. It is often called air. Other planets, and some of their larger moons, also have atmospheres.
atom - a basic unit of matter. An atom has a nucleus containing protons and neutrons and a cloud of electrons surrounding the nucleus.
calculate - to determine something with arithmetic.
carbon dioxide - a compound made of the elements carbon and oxygen. It represents a small fraction of Earth's atmosphere. The atmosphere of Mars is mostly carbon dioxide.
exomoon - a moon that orbits an exoplanet.
exoplanet - a planet that does not orbit our Sun. Most known exoplanets orbit other stars, but some, known as rogue planets, do not orbit any star.
galaxy - a massive collection of stars, gas, dust, and other celestial objects bound together into a single system by gravity. A galaxy may contain from ten million stars to one trillion stars. The Earth and Sun are in the Milky Way Galaxy.

Goldilocks zone - a less technical term for habitable zone that comes from the children's story "Goldilocks and the Three Bears." It refers to the porridge that is not too hot, not too cold, but just right. See "habitable zone."
habitable zone - the distance range from a star in which the temperature permits liquid water to exist on the surface of an orbiting object.


Hubble Space Telescope - a large telescope that orbits the Earth. It takes pictures and makes observations, and astronomers study those pictures and observations to learn about distant objects in space.

James Webb Space Telescope - a space-based telescope that was launched on December 25, 2021. It is the largest, most powerful space telescope ever built.

Kepler Space Telescope - a space-based telescope, no longer operational, that looked for and discovered 2,662 exoplanets over its lifetime.
light-year - the distance that a beam of light can travel through space in one Earth year. It is approximately 6 trillion miles.
nebulae - plural form of nebula. Known as "star nurseries," nebulae are made of large clouds of interstellar gas and dust. They look similar to clouds when viewed from far away. Over time, stars and planets can form within some nebulae.
observatory - a place for observing and studying astronomical objects and events.
orbit - a path followed by an object under the influence of gravity from another body. The Earth orbits the Sun. The Moon and the International Space Station orbit the Earth.
planet - A planet is an object that (a) orbits the Sun, (b) is big enough to have enough gravity to be spherical in shape, and (c) has cleared away any objects of a similar size near its orbit. There are eight planets in our solar system: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

solar system - a system of planets, moons, asteroids, comets, and other small objects that orbit a star. The Sun is the star in our solar system.
spacecraft - a vehicle or machine that can carry people, instruments, or cargo beyond Earth's atmosphere into space and back home again or to some other destination.
star - a celestial body of hot, dense gas that generates light and other energy and is held together by its own gravity. The Sun is a star, and while stars look like tiny pinpoints of light to us, many are larger than the Sun. They look tiny because they are so far away.
telescope - an instrument that uses lenses and/or mirrors to gather and focus light for observation. In astronomy, telescopes allow the viewer to study distant objects in detail by making them appear larger, brighter, and sharper than what is seen with the unaided eye. There are two primary types of optical telescopes: Reflecting telescopes, which use mirrors, and refracting telescopes, which use lenses.

TESS - The Transiting Exoplanet Survey Satellite is a space-based telescope that searches for exoplanets.
universe - all of space and time and all of its contents, including the solar system and all stars and galaxies.
visible light spectrum - the band of colors which the eye can see. They include red, orange, yellow, green, blue, indigo, and violet.
water vapor - the gaseous form of water.

## Make a Solar System Model

We often see our solar system in artists' images such as the one below. The Sun and the planets are pretty, but they are not placed at the correct distances from the Sun and are not the correct sizes relative to one another. You may make your own model to demonstrate how far the planets are from the Sun and from one another. Here are websites that show you how.


## EXPLORATORIUM: BUILD A SOLAR SYSTEM

First, you have to calculate the distances between each planet. This is a useful calculator from the Exploratorium (See link below.).

Enter a diameter for the Sun, hit the "Calculate" button, and then see how large all the planets should be and how far you should place them from the Sun. You may enter decimal numbers, too.

Careful, though! If you make the Sun one foot (12 inches) wide, you must put the Earth 107 feet
 away! Try 0.01 inch for the Sun.

This web page may help you understand how big space is, and you may use it to build your own solar system model.

## MAKE A SOLAR SYSTEM MODEL CONTINUED...



At Griffith Observatory, in The Gunther Depths of Space exhibit area, we have models that show the sizes of the planets relative to one another. They are not the right distances apart, however. Can you use the calculator on the previous page to estimate how far the planets, at this scale, should be from one another? In this model, the Sun (represented by the Leonard Nimoy Event Horizon theater on the left) is 62 feet across (744 inches).

REFLECTION: At this scale, how far away would dwarf planet Pluto be from the Sun? Hint: It's the distance from Griffith Observatory all the way to Laguna Beach!

## BUILD IT THE NASA WAY

Here is a solar system-building project from the people at NASA and JPL. They put astronauts on the Moon! For this project you may use almost any kind of craft materials you like.
https://www.jpl.nasa.gov/edu/learn/ project/make-a-scale-solar-system/


At that same website, there is also a video that explains how far away the solar system's planets really are from one another.

## MAKE A SOLAR SYSTEM MODEL CONTINUED...

## GRIFFITH OBSERVATORY'S SOLAR SYSTEM MODEL

At Griffith Observatory there is a model of the solar system on the ground between the Observatory stairs and the lawn. It shows the relative distances from the Sun to each planet. Earth is about four feet from the Sun in this model, and Pluto is about 158 feet away! This is a portion of the model that includes the Sun, Mercury, Venus, Earth, and Mars:


Astronomers measure the distances from the Sun to the planets by comparing those distances to the Earth-Sun distance. The Earth is about 93 million miles from the Sun. We call that distance one "astronomical unit," or "AU." To the right are the average distances to all the other planets plus Pluto, measured in AUs.

REFLECTION: A pretend comet is 186 million miles away from the Sun. How many AUs is that?

| Mercury | 0.4 AU |
| :--- | ---: |
| Venus | 0.7 AU |
| Earth | 1.0 AU |
| Mars | 1.5 AU |
| Jupiter | 5.2 AU |
| Saturn | 9.6 AU |
| Uranus | 19.2 AU |
| Neptune | 30.0 AU |
| Pluto | 39.5 AU |

## MAKE A SOLAR SYSTEM MODEL CONTINUED...

## SOLAR SYSTEM MODEL PROJECTS

PROJECT A: Here's one way to make your own solar system model: You will need ten objects. You may use any objects you'd like to represent the planets and the Sun: Pennies, pebbles, rocks, balls, dolls-whatever you have. You will also need a ruler or measuring tape and a large open space to place your Sun and planets.

Put your Sun object on the ground. Then measure four inches away from the Sun, and place your Mercury there. Then measure another three inches out from Mercury and place your Venus there. Do the same with all the other planets by adding inches according to the chart below. Each inch represents 9.3 million miles ( 0.1 AU ).

| PLANET | ADD INCHES | TOTAL | PLANET | ADD INCHES | TOTAL |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Mercury | 4 | 4 | Saturn | 44 | 96 |
| Venus | 3 | 7 | Uranus | 96 | 192 |
| Earth | 3 | 10 | Neptune | 108 | 300 |
| Mars | 5 | 15 | Pluto | 95 | 395 |
| Jupiter | 37 | 52 |  |  |  |

Note: Pluto ends up about 33 feet from the Sun!

## After you complete PROJECT A, visit Make an Extrasolar System Model (two pages forward) to make an extrasolar system model and compare it to ours!

PROJECT B: Another way to do this requires adult supervision and a big space, such as a park, beach, schoolyard, or baseball field. Find a landmark at which to start, such as a tree, person, or home plate. That landmark is the position of the Sun. Take four steps away from the landmark and look back at it. That's the distance to Mercury. Then take three more steps away from the Sun, and you are at Venus's distance. Take three more to get to Earth, then five more to get to Mars, then 37 more to get to Jupiter, then 44 more to get to Saturn, 96 more to get to Uranus, 108 more to get to Neptune, and finally, 95 more steps to arrive at Pluto. At each planet's spot, note how far away the tree looks. It should be pretty tiny at Pluto!

PROJECT C: You may also try this with nine of your friends. Have one friend be the Sun, and have each friend take the number of steps away to stop and stand as each of the planets. If you have a camera, take a picture at each planet distance, or if you have ten people to mark the Sun-to-planet distances, take a picture of your friendmodel! Now we should talk about the sizes of the planets and the Sun...

## MAKE A SOLAR SYSTEM MODEL CONTINUED...

## HOW BIG ARE THE PLANETS?

How large is each planet compared to the Sun? We can use diameter (a straight line that passes from one side to the other) as our unit of measurement. For instance, the diameter of the Sun is about 864,000 miles, while Earth is only 8,000 miles across, as you can see in this size comparison image. Earth isn't really this close to the Sun!

The image below illustrates a
 portion of the Sun with all eight planets in order of their distances from it: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Even dwarf planet Pluto is pictured; it's the tiny little dot at the far right. As you have learned, these are not the correct distances between the objects, but the relative sizes are correct. Note how enormous the Sun is compared to Earth and the other planets. If you don't count Saturn's rings, Jupiter has the largest diameter of all the planets.


REFLECTION : Did you know that light takes time to travel? Light travels faster than anything we know, at 186,000 miles per second. Because the Moon is about 238,900 miles away from us, it takes about 1.3 seconds for the light reflected off of the Moon to reach us $(238,900 / 186,000=1.3)$. When we look at the Moon, we are seeing back in time 1.3 seconds! The Sun is about $93,000,000$ miles away from Earth. How many seconds does it take for its light to reach Earth?

## Make an Extrasolar Planetary System Model

Now that you made a model of our solar system with Make a Solar System Model, let's make a model of a solar system beyond ours!

The TRAPPIST-1 extrasolar planetary system is 41 light-years away from us (about 241 trillion miles). It has seven near-Earth-size rocky planets, three of which are in the habitable zone. Its sun, TRAPPIST-1 a, is only 12 percent the size of our sun.

The TRAPPIST-1 extrasolar planetary system is also much smaller than our solar system. If you did PROJECT A from Make a Solar System Model, this next project is a great way to put the size of the TRAPPIST-1 system into perspective! You will need a regular $8.5-\mathrm{in} . \times 11-\mathrm{in}$. piece of paper, a drawing tool, and a ruler or tape measure.

Make a dot close to the edge of your paper to represent star
 TRAPPIST-1 a. Then measure 1.2 inches away from the star, and make a dot that represents planet TRAPPIST-1 b. Then measure another 0.4 inch out from TRAPPIST-1 $b$, and make a dot that represents TRAPPIST-1 c. Do the same with all the other planets. Add inches according to the chart below. Each inch represents 9.3 million miles ( 0.1 AU ).

| PLANET | ADD INCHES | TOTAL |
| :---: | :---: | :---: |
| TRAPPIST-1 b | 1.2 | 1.2 |
| TRAPPIST-1 c | 0.4 | 1.6 |
| TRAPPIST-1 d | 0.6 | 2.2 |
| TRAPPIST-1 e | 0.7 | 2.9 |
| TRAPPIST-1 f | 0.9 | 3.8 |
| TRAPPIST-1 g | 0.9 | 4.7 |
| TRAPPIST-1 h | 1.5 | 6.2 |

Yes, the TRAPPIST-1 extrasolar planetary system is that compact compared to ours. Still, three planets are within its habitable zone because the star is much cooler and dimmer than our sun. The planets must be much closer in order to receive heat.

Imagine yourself on one of these planets and looking up... the other planets would look large in the sky.

To learn more about the TRAPPIST-1 extrasolar system, visit: https://exoplanets.nasa.gov/eyes-on-exoplanets/\#/system/TRAPPIST-1/

## Reality vs. Fiction of Worlds Beyond A COMPARE-AND-CONTRAST EXERCISE

Over the years, as people attempted to understand the sky, they told stories and imagined what otherworldly places are like. Some people used observational evidence to describe these places. Some based their predictions on cultural beliefs. Others illustrated dramatic, terrifying, or beautiful worlds simply because they hoped these things could be possible beyond Earth.

Let's take a look at what people predicted other worlds are like and compare these images to pictures taken by spacecraft. How right were we?

## MARS

Our planetary neighbor has been the subject of many wild ideas. Before satellites and rovers provided true images of the landscape, many people believed that "canals" are on the surface of Mars. This idea began with observations by an Italian astronomer, Giovanni Schiaparelli. In 1877 he believed he saw a system of straight lines on the surface of Mars, which he called canali.


1999 Hubble
Space Telescope image of Mars, upside-down

Compare and contrast this drawn map of Mars (left) with a photographic image of Mars (right). What is similar and what is different?

## REALITY VS. FICTION OF WORLDS BEYOND CONTINUED...

Even after we were able to capture actual images of Mars, our imaginations still ran wild. Many people believed that the "Face on Mars," a rock formation photographed by the Viking 1 and 2 missions in the late 1970s, was evidence of an ancient civilization.

We finally obtained better pictures of the same feature in 1998, when Mars Global Surveyor and other Mars missions saw that the "face" is just a trick of the light when viewed under certain conditions and from a certain angle.


What new details are present in the right picture that are not present in the left picture?

## THE MOON

In Georges Méliès’s 1902 film Le Voyage dans la Lune ("A Trip to the Moon"), Méliès imagined that we would shoot a bullet-like spacecraft into the Moon with a large cannon and that once on the Moon, the voyagers would walk around freely without any protection and would also run into a society of aliens.


## REALITY VS. FICTION OF WORLDS BEYOND CONTINUED...

Why do you think we use rockets instead of canons to launch into space?

## THE NIGHT SKY

Ancient people from around the world filled the sky with stories. The Greeks populated the sky with gods. The Chumash of southern California thought that the Sun is a god who carries a torch from east to west. People who lived during the Tang dynasty (A.D. 618-907) in China thought that Mercury, Venus, Mars, Jupiter, and Saturn are deities associated with five primary elements: Wood, fire, earth, water, and metal.


Painting derived from a Tang dynasty composition of the five planet deities

Why do you think many cultures thought that planets, stars, and constellations are different gods, animals, objects, or people?

Pictured below to the left is an illustration by Peter Apian, a sixteenth century German astronomer who thought, as others did during his time, that the heavens rotate around Earth. From the second century to the seventeenth century, this idea was mostly unchallenged.


## REALITY VS. FICTION OF WORLDS BEYOND CONTINUED...

Can you explain some reasons why the model on the right is more correct than the one on the left?
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

## COMETS

Comets were objects of mystery and terror to many cultures before modern astronomy revealed their true nature. The illustration on the lower left, from 1942, shows a comet that was said to have "stampeded the terrified citizens and to have caused numerous deaths." (Don't worry. It definitely didn't.) The pictures below on the right show comet 67P/Churyumov-Gerasimenko. The images were taken by the Rosetta spacecraft in 2015.


What is similar between the illustration on the left and the photographs on the right, and what new details can we observe in the photographs on the right?

## Zodiac Constellation Activity Chart

The signs of the zodiac come from the constellations through which the Sun passes during the year. Each day, the Sun is in front of a particular zodiac constellation that is always present but invisible to our view because the Sun is so bright. Complete the constellation connect-the-dots. Then cut out the dial $\bigcirc$ and pin it with a paper fastener to the $\otimes$ on the chart. Reveal the unseen sky today!


## Post-program Materials

We hope you enjoyed Module 4: Exoplanets Are Everywhere of Griffith Observatory’s Online School Program. To continue your lifelong journey as observers, here are some activities and resources.

## Module 4 Crossword

This worksheet reinforces the new words you learned in Module 4: Exoplanets Are Everywhere and in the program materials. Refer to the Module 4 glossary if you get stuck.

## Goldilocks Zone Cut-outs

This hands-on astronomy-craft invites you to think like an astronomer and make observations about other solar systems that have been discovered.

## Make Your Own Exoplanet and Extraterrestrial Life

It's alive! This creative activity helps you spawn an original exoplanet and an alien lifeform. How will you help your creature survive on the world you created?

## The Edible Solar System

Can you solve this brain-buster to figure out which food item corresponds to the size of each planet?

## Coloring the Cosmos

We have included three coloring book activities for a quiet moment. Two of them offer a science-
fiction spin on real exoplanets HD 189733 b and KOI-55 b.

## Exoplanet Websites

This resource lists some extra websites and citizen science projects that involve exoplanets and are way too cool to miss.

## Internet Resources

The Internet may be helpful. This resource lists a variety of websites that will help you expand your astronomical knowledge and have fun doing it.

## Module 4 Crossword

Solve the crossword to discover the hidden word.


Why did the restaurant on Mercury get poor reviews?
There was $\qquad$ !
[HIDDEN WORD]

1. all of space, time, and everything in it
2. a planet that orbits another star
3. a celestial body of gas held together by gravity that generates light and energy
4. a regular, repeating path that one object takes around another object in space
5. a moon that orbits a planet outside of our solar system
6. the area around a star where it is not too hot and not too cold for liquid water to exist on the surface, also known as the "Goldilocks zone"
7. a star and all the objects that are bound to it by gravity
8. an instrument designed to make distant objects appear nearer
9. a unit of distance that is equal to the distance that light travels in one year
10. a vehicle or machine designed to fly in outer space
11. the study of space and everything in it
12. a place for observing that houses a telescope and/or other scientific equipment

## Goldilocks Zone Cut-outs

## WHAT IS A GOLDILOCKS ZONE?

A Goldilocks zone is the habitable area around a star where it is not too hot and not too cold for liquid water to exist on the surface of surrounding planets.

> WHY GOLDILOCKS ZONES MATTER: If Earth were where Pluto is, the Sun would be barely visible (about the size of a pea) and Earth's ocean and much of its atmosphere would freeze. If Earth took Mercury's place, it would be too close to the Sun, and its water would form a steamy atmosphere and quickly boil off. Earth's location relative to the Sun is just right for water to remain a liquid. This is why our distance from the Sun is called the habitable zone, or the Goldilocks zone. Rocky exoplanets found in the habitable zones of their stars are more likely to have liquid water on their surfaces. Life on Earth started in water, and water is a necessary ingredient for life as we know it.

## DIRECTIONS

Can you find out which exoplanets could be habitable? The next two pages contain Goldilocks "zones" and "solar systems" that represent actual solar systems that astronomers are studying. Cut out the Goldilocks zones on the "Zones" page. Then place them on top of the solar systems on the "Solar Systems" page using this key:

## Zone 1 - Solar System 1 <br> Zone 2 - Solar System 2 <br> Zone 3 - Solar System 3 <br> Zone 4 - Solar System 4

Make sure to place the zones on top of the solar systems so that the stars ( $\boldsymbol{\leftarrow}$ ) are exactly in the center of the zones. A ruler may help you measure equal distances between one inner-side of the zone to the other. Once you've matched up the Goldilocks zones to their corresponding solar systems, go to the "Reflections" pages and answer the questions!

## Zones

Cut along the dotted lines to free the Goldilocks zones from the page.


GOLDILOCKS ZONE CUT-OUTS CONTINUED...

## Solar Systems

Place the zones on top of their solar systems so that the stars are exactly in the center.

SOLAR SYSTEM 1


SOLAR SYSTEM 2



SOLAR SYSTEM 4


## GOLDILOCKS ZONE CUT-OUTS CONTINUED...

## Reflections Part 1

## SOLAR SYSTEM 1

Solar System 1 represents our solar system, with Sun "a" marked in the center.
Which planet of our solar system completely falls within the Goldilocks zone?
O planet b
Oplanet c
O planet d
O planet e

What is that planet called? $\qquad$
Do you think planet b, which is the closest planet to the Sun outside the Goldilocks zone, is hotter or colder than planet d?
O hotter
O colder
Do you think the planets on the far side outside the Goldilocks zone are hotter or colder than planet d?
O hotter
O colder

## SOLAR SYSTEM 2

Solar System 2 represents the Proxima Centauri solar system.
Does planet $b$ fall within the Goldilocks zone of star Proxima Centauri $a$ ?
O yes
O no
O partially

Star Proxima Centauri a has another exoplanet orbiting on the far side outside the Goldilocks zone, so far away it could not be pictured. Do you think it would be hotter or colder than planet b?
O hotter
O colder

## SOLAR SYSTEM 3

Solar System 3 represents the upsilon andromedae solar system.
Which planet is captured in upsilon andromedae a's Goldilocks zone?
O planet b
O planet c
O planet d

What's unusual about planet d? $\qquad$

## Reflections Part 2

## SOLAR SYSTEM 3 CONTINUED...

What do you think the temperatures are like on planets band cin Solar System 3? O too hot $\quad$ O too cold $\quad$ just right

## SOLAR SYSTEM 4

Solar System 4 represents the TRAPPIST 1 solar system.
Which planet (or planets) orbit in star TRAPPIST 1 a's Goldilocks zone?
Oplanet b Oplanet c Oplanetd Oplanete Oplanetf Oplanetg Oplaneth
Do you find anything usual about the above answer, compared to the other zones in other solar systems?

Which planet do you think has the best chance for liquid water?
Oplanetb Oplanet c Oplanetd Oplanete Oplanetf Oplanetg Oplaneth

## Conclusion

From these four examples, it's interesting to see how unique each solar system's Goldilocks zone is compared to the planets that orbit the star. Try mixing the zones to other solar systems and see how they don't match up. Planets too close to their star, outside the Goldilocks zone, will burn up or be too hot. Planets too far from their star, outside the Goldilocks zone, will freeze. The universe has so many possibilities for planets with liquid water and the possibility of life.

FUN FACT: The four solar systems are actually not to scale with each other. For instance, our Sun is much larger, hotter, and brighter than star TRAPPIST 1 a, and so this means the two solar systems' Goldilocks zones are very far away from each other. Exoplanets in the TRAPPIST 1 system must be much closer to its star in order to be inside the zone. Compare other solar systems with ours by visiting https://exoplanets.nasa.gov/eyes-on-exoplanets. Search for a star, view its system, and then click "COMPARE TO OUR SOLAR SYSTEM."

## Make Your Own Exoplanet \& Extraterrestrial Life

Earth has many environments and different features. There are deep oceans, arctic areas, mountains, forests, deserts, hot springs, and caves, and we have found life in all of these places. The universe is filled with planets that have landscapes ranging from pleasant and familiar to harsh and unfamiliar. We know that organisms may survive only in environments in which their particular needs are met, but we also know that life is diverse and resilient. In this activity, create your own exoplanet by picking characteristics from each category. Later, you will create an alien life form that could potentially survive on the exoplanet you created.

## MAIN CLIMATE (SELECT ONE)

O Desert - hot, very little water, mainly parched sand
O Ocean - mainly water with only a few land masses
O Forest - $\mathrm{CO}_{2}$-rich environment that allows tree growth
O Polar - cold, with most of the elements frozen


## GRAVITY (SELECT ONE)

O Low - everything weighs less, less muscle mass is needed
O Earth-like - things fall normally
O High - creatures need more muscle mass

## LIGHT / ENERGY FROM STAR (SELECT ONE)



O Low - creatures need a different energy source or a clever way to conserve/maximize sunlight
O Earth-like - creatures don't need special adaptations unless light does not reach their habitat
O High - creatures need an adaptation that helps them survive radiation


EXTRA MODIFIERS
O Liquid atmosphere $\mathbf{O}$ Active land volcanoes
O Helium atmosphere
O Stinky sulfur seas
0
Frequent dust storms
O Active undersea
O Strong winds volcanoes

O Hot rains
0

## MAKE YOUR OWN EXOPLANET \& EXTRATERRESTRIAL LIFE CONTINUED...

Describe your planet using the characteristics you picked. You may be as descriptive as you like. Write about what it would be like to live on your world. Details are encouraged describing what vegetation (if any) would look like or if the seas would cover the planet, and so forth. Have fun with this; explain your planet.
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$

Draw your planet. You may choose to draw what it looks like from space, and/or what its landscapes look like up close.

Name your exoplanet:

## MAKE YOUR OWN EXOPLANET \& EXTRATERRESTRIAL LIFE CONTINUED...

What kind of life form would be able to exist on your exoplanet? Choose some different characteristics below that can help your creature survive depending on the planet environment characteristics you picked.


## HABITAT

O Surface
O Underground
O Shallow-water or swamp
O Deep-sea
O Air/sky
O Cave
0 $\qquad$

## TOPICAL

## EXTREMITIES // How many?

O Wings - allows for flying
O Legs or arms with joints - may run or climb
O Fins - provides thrust, steering, and balance in water
O Hooves - supports weight, provides traction
O Claws - allows protection, digging, and climbing
O Flowers/fruits/branches/twigs
O Tail(s) - provides balance, supports communication
O Tentacles - flexible, allows for grasping and sensing

O Fur - protects from cold
O Scales - improves speed, protects, and/or reduces water loss
O Bio-luminescence - produces light to communicate
O Slime - improves grip
O Feathers - allows for flying, protects from cold
O Tough shell/exoskeleton - protects from a harsh environment
O Plant-matter - feeds on air and sunlight, responds slowly
O Fluorescence - protects against radiation, glows
O Skin - regulates body temperature in a variety of climates

## EXTRA FEATURES / ABILITIES

O Antennae - senses touch, air motion, heat, vibration (sound), smell, and taste
O Blubber - stores energy, insulates heat, improves buoyancy
O Echolocation - may detect objects in their environment by sensing echoes
O Metal features - makes stronger and more durable
O Compressible lungs - may survive in extreme pressures
O Chemo-synthetic - gets energy from chemical reactions instead of sunlight
O Super-smell - may detect objects/creatures in their environment by smell

## MAKE YOUR OWN EXOPLANET \& EXTRATERRESTRIAL LIFE CONTINUED...

Describe your alien life form. Explain why your creature would be able to survive on the exoplanet you made.

Draw what your life form would look like using the characteristics you chose.

Name your species:

## The Edible Solar System

## A BRAIN-BUSTER GAME

The edible objects pictured below, arranged from largest to smallest, are scaleddown representations of the sizes of each planet in our solar system. Solve the word deduction game to figure out which edible object represents the size of each planet in our solar system. This may help: Write the planet names on small pieces of paper that you can re-arrange.



- Saturn is bigger than Earth, but smaller than Jupiter.
- Neptune is bigger than Mars, Earth, Venus, and Mercury, combined!
- Uranus is slightly bigger than Neptune.
- Venus is bigger than Mars, but slightly smaller than Earth.
- Uranus is smaller than Saturn.
- Mercury is the smallest of all.


## WORKSPACE

PUMPKIN =
HONEYDEW =
RED GRAPEFRUIT =
YELLOW GRAPEFRUIT =
CHERRY =
BLACKBERRY =
BLUEBERRY =
PEANUT =

## The Sun




Jupiter


Saturn


Uranus Neptune
Earth
Venus
Mars Mercury


Experience the MOLTEN GLASS RAIN on


## Exoplanet Websites

## EYES ON EXOPLANETS

"Eyes on Exoplanets" is a scientifically accurate 3D universe that allows you to zoom in on more than 1,000 exoplanets and their solar systems. The program is updated daily with the latest finds from NASA's Kepler mission and from ground-based observatories around the world as they hunt for planets like our own.
https://eyes.nasa.gov/apps/exo/\#/

## NASA EXOPLANET EXPLORATION PORTAL

This site is your gateway to explore NASA's exoplanet news and content. There are videos, pictures, articles, posters, timelines, and activities that involve exoplanets, stars, space telescopes, the search for life, and the latest discoveries.
https://exoplanets.nasa.gov/

## NASA CITIZEN SCIENCE - EXOPLANET EXPLORATION

Help make actual scientific discoveries with data from NASA. The following projects are still active as of January, 2022. Check NASA’s Exoplanet Exploration page for future updates.
https://exoplanets.nasa.gov/citizen-science/

## PLANET HUNTERS TESS

Search for undiscovered worlds using data from NASA's TESS mission.
https://zooniverse.org/projects/nora-dot-eisner/planet-hunters-tess

## BACKYARD WORLDS: PLANET 9

Search the realm beyond Neptune for new brown dwarfs and planets.
https://zooniverse.org/projects/marckuchner/backyard-worlds-planet-9

## DISK DETECTIVE

Spot the disks around nearby stars where planets form and dwell.
https://zooniverse.org/projects/ssilverberg/disk-detective

## Internet Resources

## ASTRONOMY CLUBS

Astronomy clubs are wonderful resources. Amateur (and some professional) astronomers are happy to share their telescopes, their enthusiasm, and their knowledge. Find an astronomy club near you! A list of local clubs and more information may also be found on our website:
https://griffithobservatory.org/explore/observing-the-sky/astronomy-resources/

## CITIZEN SCIENCE PROJECTS

You may make a real contribution to astronomy by participating in these scientific projects.

Help scientists with their research into stars, Mars, Earth, galaxies, astronautics, the Sun, and black holes! Multiple projects are listed at this website:
https://spacehack.org/

Another useful site that lists multiple Citizen Science projects: https://www.zooniverse.org/

## GREAT WEBSITES FOR SPACE FANS

Check out games and projects for budding space scientists:
https://spaceplace.nasa.gov/menu/play/
Explore space with NASA's remarkable app, "NASA's Eyes:"
https://eyes.nasa.gov/

Watch NASA on television (or on another device with an internet connection): https://www.nasa.gov/multimedia/nasatv/\#public

## GREAT WEBSITES FOR SPACE FANS CONTINUED...

Visit websites dedicated to learning for grades 5 through 8: https://www.nasa.gov/stem-at-home-for-students-5-8.html

Meet the astronauts on the International Space Station (ISS). Make your own rocket out of a straw, or test your driving skills - on Mars:
https://www.nasa.gov/kidsclub/index.html

## RESOURCES ON THE GRIFFITH OBSERVATORY WEBSITE

Sky Report:
https://griffithobservatory.org/explore/observing-the-sky/sky-report/

Give yourself a tour of the Observatory, and check out the exhibits:
https://griffithobservatory.org/explore/exhibits/
Watch the All Space Considered space news update:
https://griffithobservatory.org/visit/calendar/all-space-considered/


