National Aeronautics and Space Administration

THE ABCs OF EXOPLANETS

A PAINTED EXPLORATION OF THE WHATS AND WHYS OF STAR-ORBITING PLANETS OUTSIDE OUR SOLAR SYSTEM

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Q:

What objects would you be interested
in studying in our universe?

Astronomy

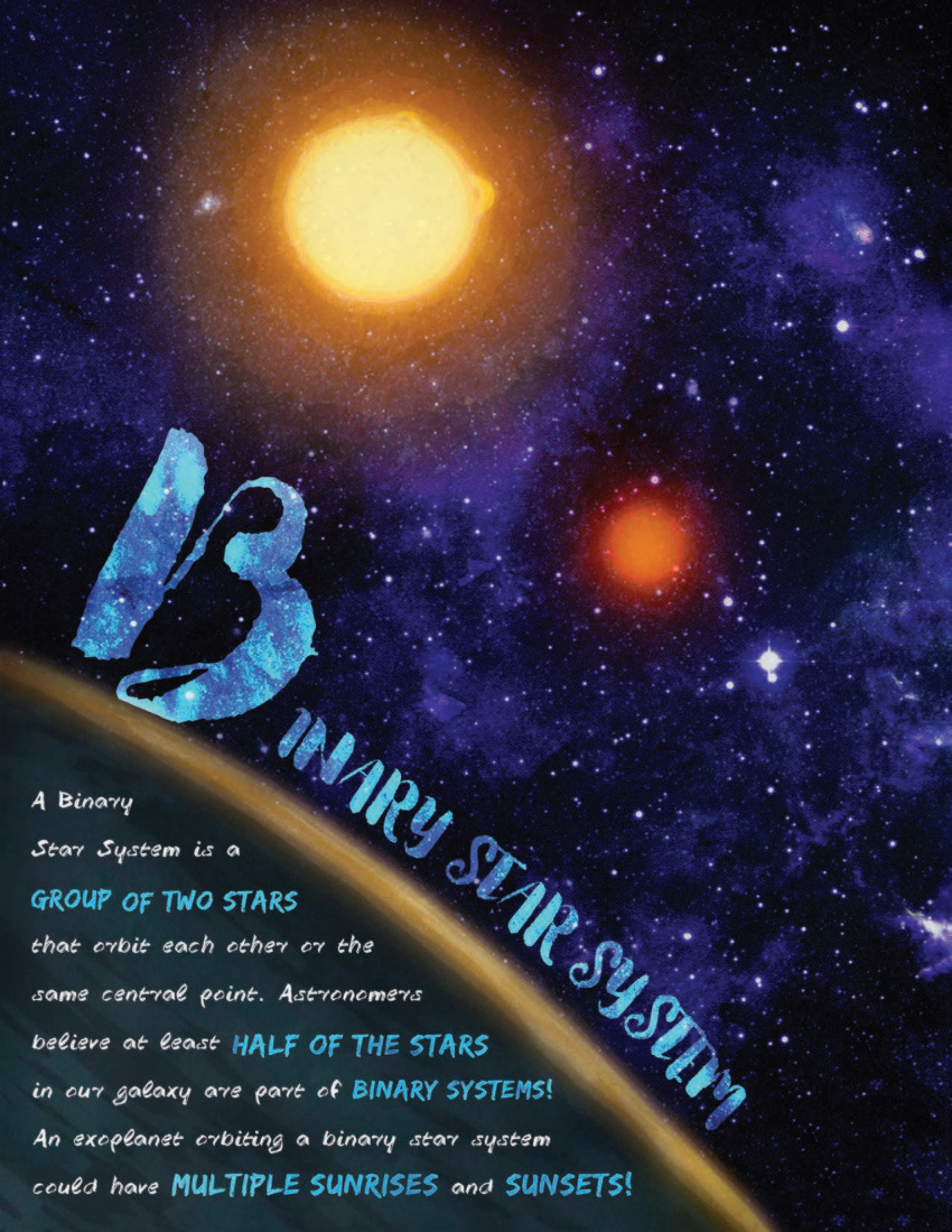
There are **MANY FIELDS** of science to study our world and the rest of the universe.

ASTRONOMY is dedicated to studying the **OBJECTS** and **SPACE** that are outside our planet.

SCIENTISTS who explore, study, learn, and teach others about our **UNIVERSE** and its many objects are called **ASTRONOMERS.**

Q:

Why do astronomers use the term binary to describe these star systems?


B
INARY STAR SYSTEM
A Binary
Star System is a
GROUP OF TWO STARS
that orbit each other or the
same central point. Astronomers
believe at least HALF OF THE STARS
in our galaxy are part of BINARY SYSTEMS!
An exoplanet orbiting a binary star system
could have MULTIPLE SUNRISES and SUNSETS!

Q:

How is the composition of Earth different from the composition of Jupiter? Of Venus?

When an exoplanet is discovered, one of the first things astronomers want to know is its

Composition

or the combination of elements that make up the planet.

exoplanet?

COMPOSITION can help astronomers determine whether an exoplanet could be HABITABLE.

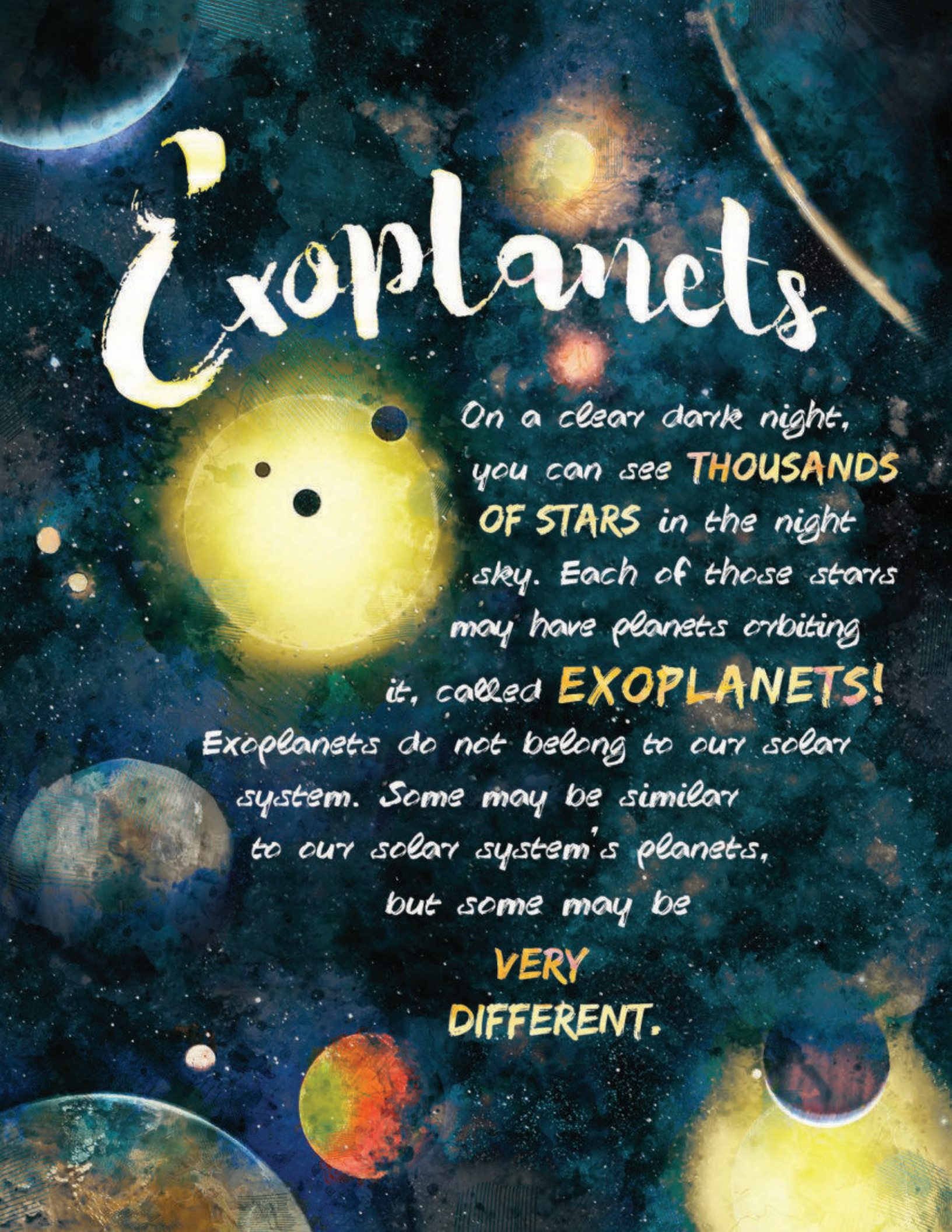
Q:

What tools do astronomers use
to detect exoplanets?


Detecting exoplanets
There are more than 10 PROVEN WAYS TO find exoplanets, using telescopes both on Earth and in space! An exoplanet orbiting a star can cause TINY CHANGES in how the star appears. Astronomers use telescopes to see these changes and then determine if an exoplanet is present. Some of these changes might affect HOW BRIGHT the star appears, WHAT DIRECTION it is moving, and more!

Q:

How are planets in our solar system different from exoplanets? How might they be the same?


Exoplanets
On a clear dark night, you can see THOUSANDS OF STARS in the night sky. Each of those stars may have planets orbiting it, called EXOPLANETS!
Exoplanets do not belong to our solar system. Some may be similar to our solar system's planets, but some may be VERY DIFFERENT.

Q:

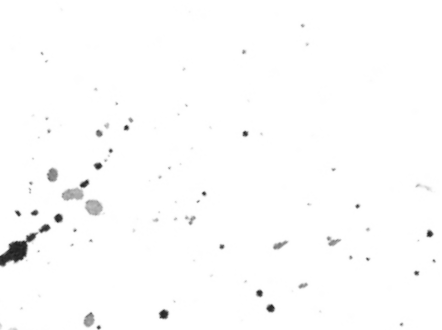
What is one way a planet could become a free-floating planet?

Free Floating Planet

Not every **EXO PLANET** can be bound to orbiting a **STAR**. If an exoplanet is ejected from its star system, that planet **FLOATS FREELY** in space; these exoplanets are also sometimes called **ROGUE PLANETS!** Scientists estimate there could be hundreds of billions of **FREE-FLOATING** planets in the Milky Way.

Q:

What makes a gas giant different
from a rocky world?

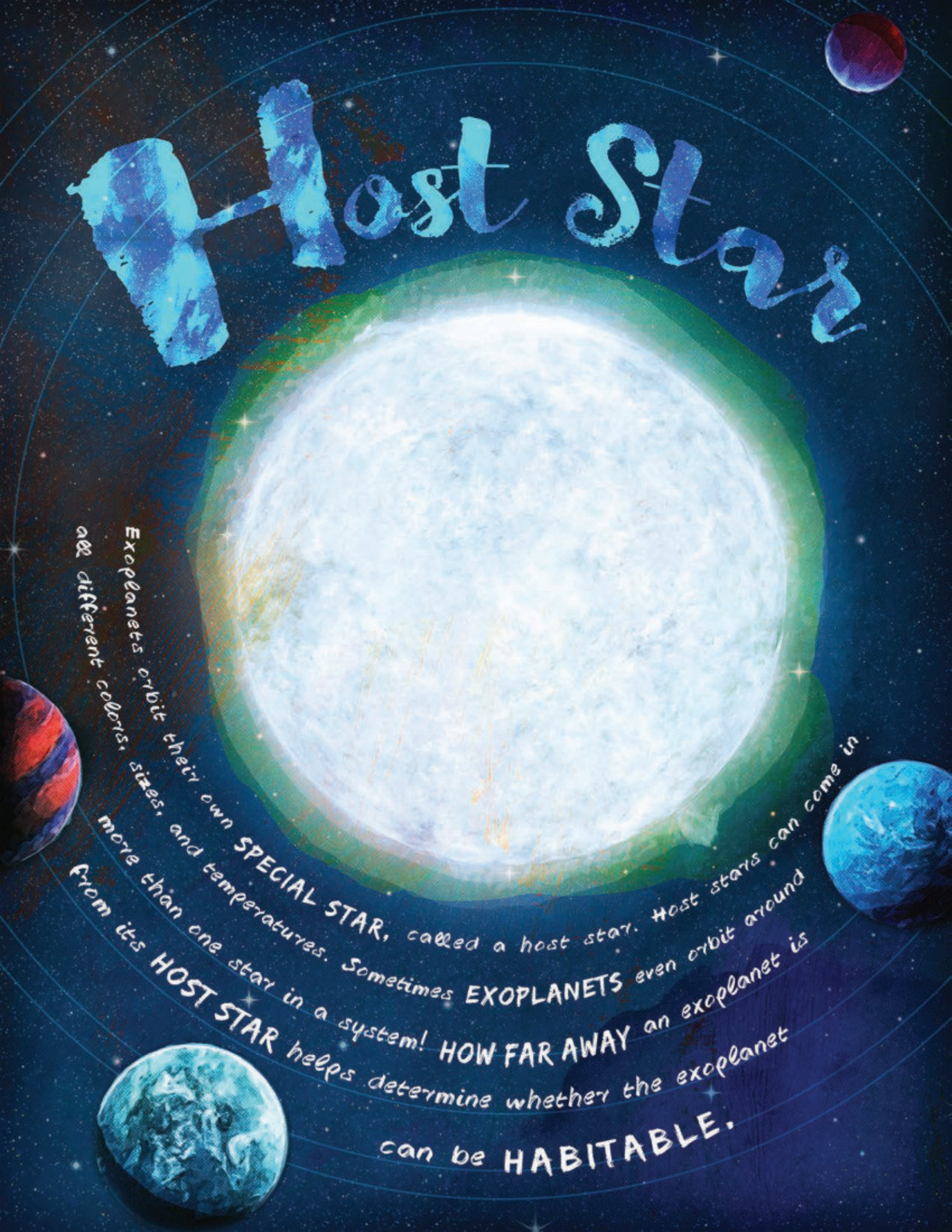



GAS GIANTS are huge planets that are made mostly of gases and do not have a surface made of rocky materials and metals.
G
These planets are MUCH LARGER than Rocky worlds like our Earth. We have four gas giants in our solar system!
GAS GIANTS

Q:

Why do you think an exoplanet's distance from its host star helps determine whether life could exist there?

Host Star



Exoplanets orbit their own **SPECIAL STAR**, called a host star. Host stars can come in all different colors, sizes, and temperatures. Sometimes **EXOPLANETS** even orbit around more than one star in a system! **HOW FAR AWAY** an exoplanet is from its **HOST STAR** helps determine whether the exoplanet can be **HABITABLE.**

Q:

Why is it difficult to count
how many exoplanets exist?

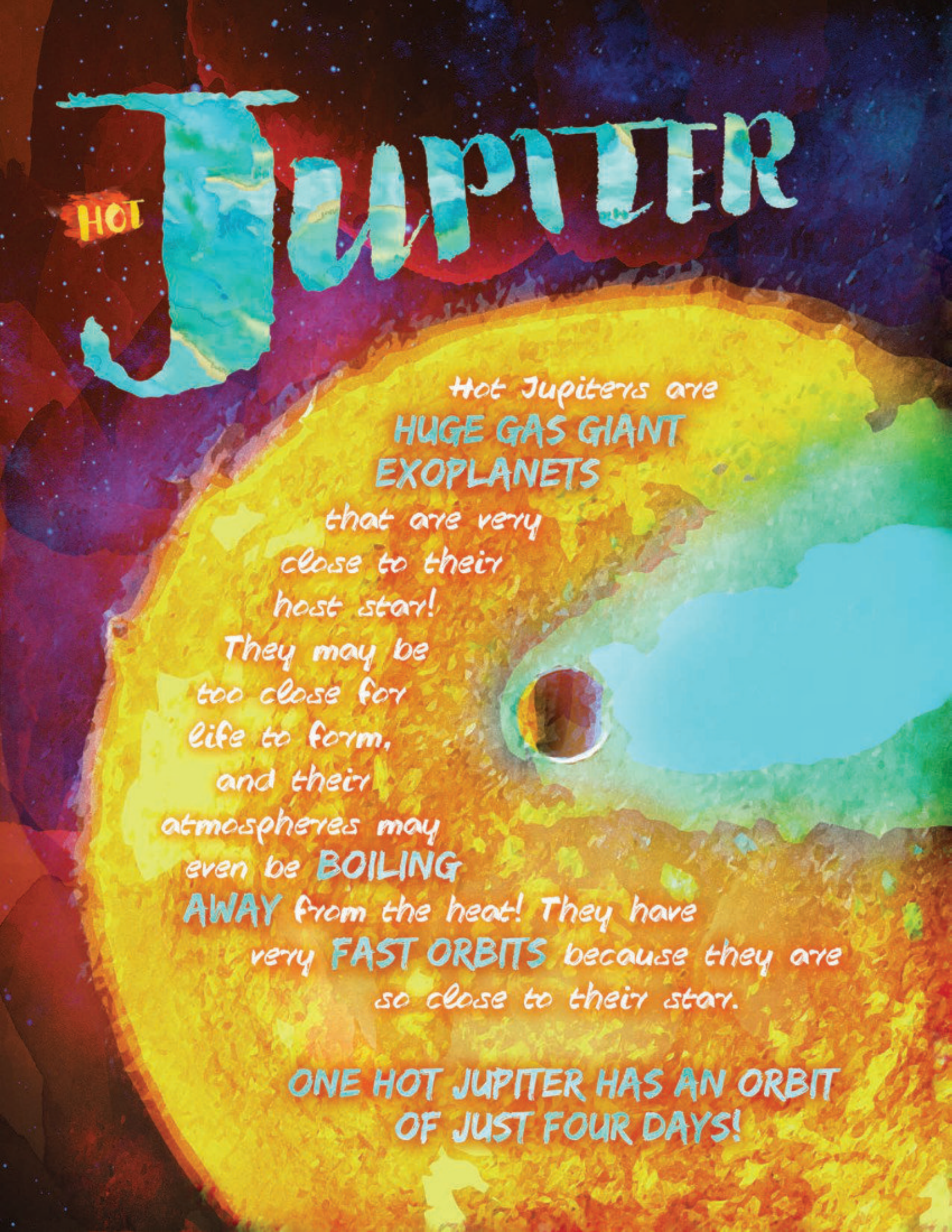
Infinite Worlds

THERE ARE
MANY, MANY GALAXIES

in our universe. In each galaxy, stars are forming **ALL THE TIME!** Planets could be forming around these new stars, too! With so many stars to study and observe, the number of exoplanets is **ENDLESS!**

Q:

If Jupiter moved to be a “hot Jupiter,” what would be the new order of planets in our solar system?


HOT JUPITER
Hot Jupiters are HUGE GAS GIANT EXOPLANETS that are very close to their host star! They may be too close for life to form, and their atmospheres may even be BOILING AWAY from the heat! They have very FAST ORBITS because they are so close to their star.
ONE HOT JUPITER HAS AN ORBIT OF JUST FOUR DAYS!

Q:

Can you name any other famous astronomers?


Kepler was the FIRST NASA mission to find EARTH-SIZE PLANETS orbiting nearby stars. The spacecraft was named after JOHANNES KEPLER, a famous mathematician and astronomer who discovered and wrote MATH EQUATIONS explaining how the planets in our solar system travel around the sun. The KEPLER MISSION has found thousands of new EXOPLANETS to study!
Jo. Keplerus
KEPLER - 22B
KEPLER - 69C
KEPLER - 69E
KEPLER - 62F
EARTH

Q:

Why do you think astronomers create other units to measure the distance of objects in the universe?

LIGHT YEARS

Here on Earth, we have many DIFFERENTLY SIZED UNITS to measure how far away something may be or how big something is. Astronomers commonly use the LIGHT YEAR, the distance light travels in one year.

ONE LIGHT YEAR is equal to **5,878,499,810,000 MILES!** One of the CLOSEST known exoplanets to Earth is **4.22 LIGHT YEARS AWAY.**

Q:

Why are exomoons
difficult to detect?

exo Moons

Many planets in our solar system have moons. Astronomers believe exoplanets might have moons, too!

They would be called exomoons and are very difficult to find because they are smaller than planets and **DO NOT PRODUCE THEIR OWN LIGHT.**

Astronomers are developing new techniques to help make finding them easier.

Q:

How can astronomers tell mini-Neptunes are different than super-Earths?

mini NEPTUNE

Some **EXOPLANETS** resemble the **GAS PLANETS** in our own solar system, but they're **MUCH SMALLER!** These planets are called **MINI-NEPTUNES**. They are closer in size to Earth than Neptune, but astronomers can tell they're gas planets because they are much **LESS DENSE** than a rocky world.

Q:

If you have visited an observatory,
what objects did you observe?

Different types of scientists have different places where they conduct their research and collect their data. Astronomers use **TELESCOPES** to collect data and study celestial objects. These telescopes are housed in **OBSERVATORIES**.

Observatory

These ground-based observatories use **VISIBLE LIGHT** and radio, and are located in various locations on the surface of the Earth. Many observatories have special times when guests can **VISIT**! Check out an observatory near you!

Q:

How long do you predict it would take
to travel to Proxima Centauri B?

Proxima Centauri b

The closest exoplanet to Earth orbits the star Proxima Centauri. It's called **PROXIMA CENTAURI B**, and it is only a little over **FOUR LIGHT-YEARS AWAY!** It would take many years to travel to this exoplanet because we cannot move as **FAST AS LIGHT**, but **IMAGINE** what new information we could **DISCOVER**!

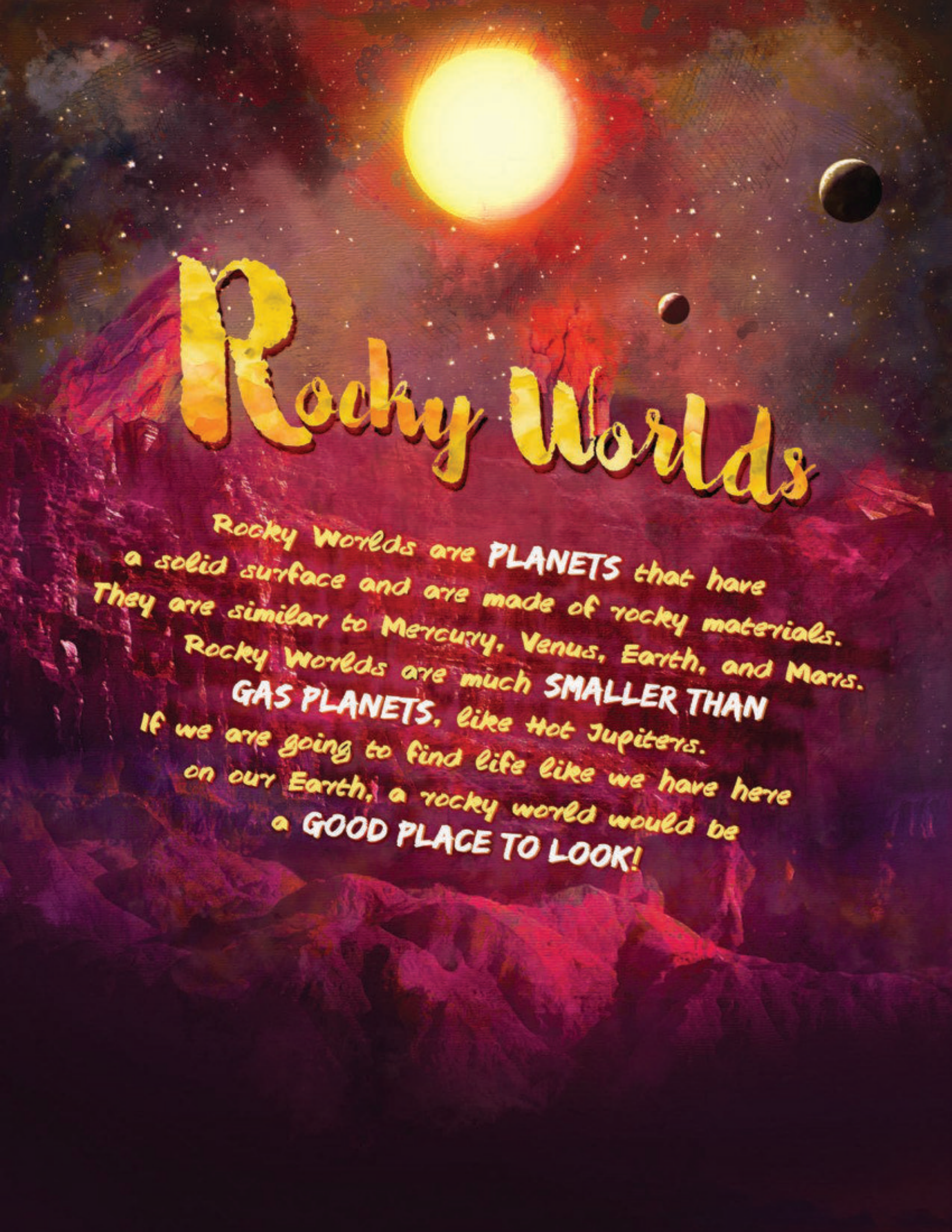
Q:

What questions do you have
about exoplanets?


uestions
With astronomers discovering NEW WAYS to find exoplanets and new observatories being built, the quest for NEW WORLDS is just beginning! Many questions are being asked, scientists are studying data and new missions are being designed to help find ANSWERS.

Q:

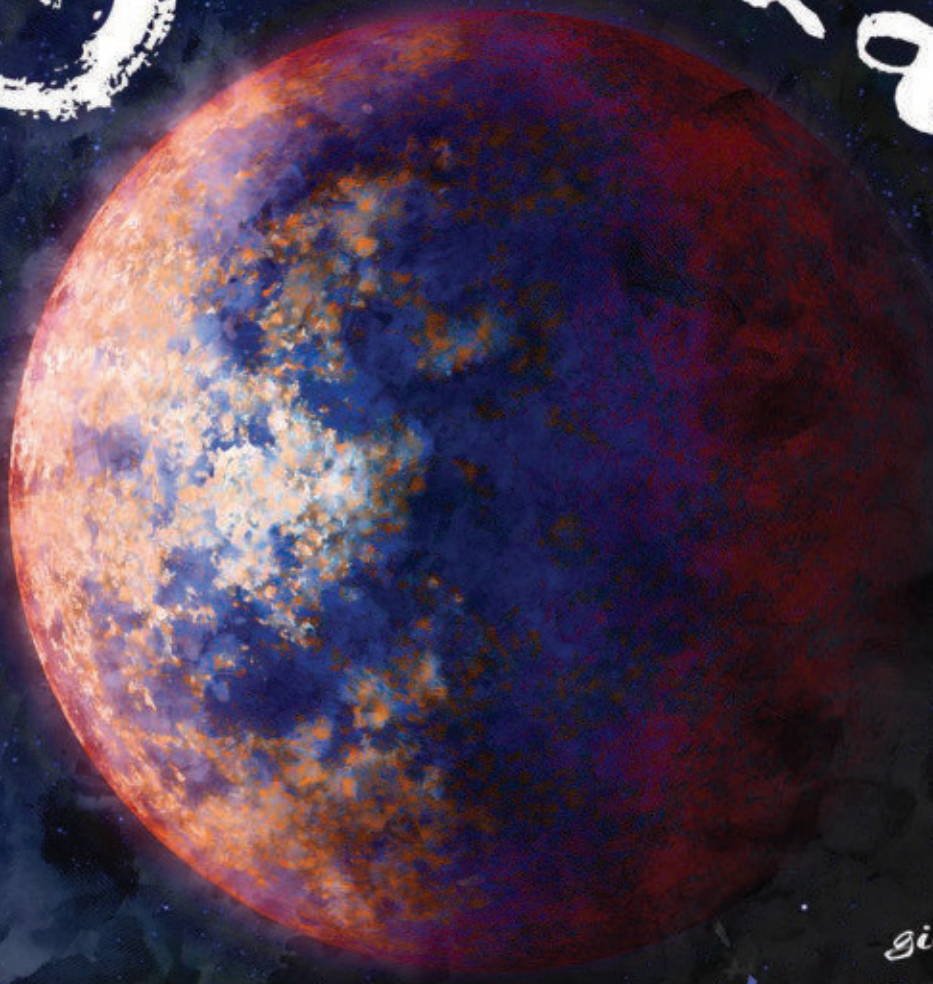
Why would a rocky world be
a good place to look for life?


Rocky Worlds
Rocky Worlds are PLANETS that have a solid surface and are made of rocky materials. They are similar to Mercury, Venus, Earth, and Mars. Rocky Worlds are much SMALLER THAN GAS PLANETS, like Hot Jupiters. If we are going to find life like we have here on our Earth, a rocky world would be a GOOD PLACE TO LOOK!

Q:

What makes a super-Earth similar to Earth?
What makes a super-Earth different from Earth?

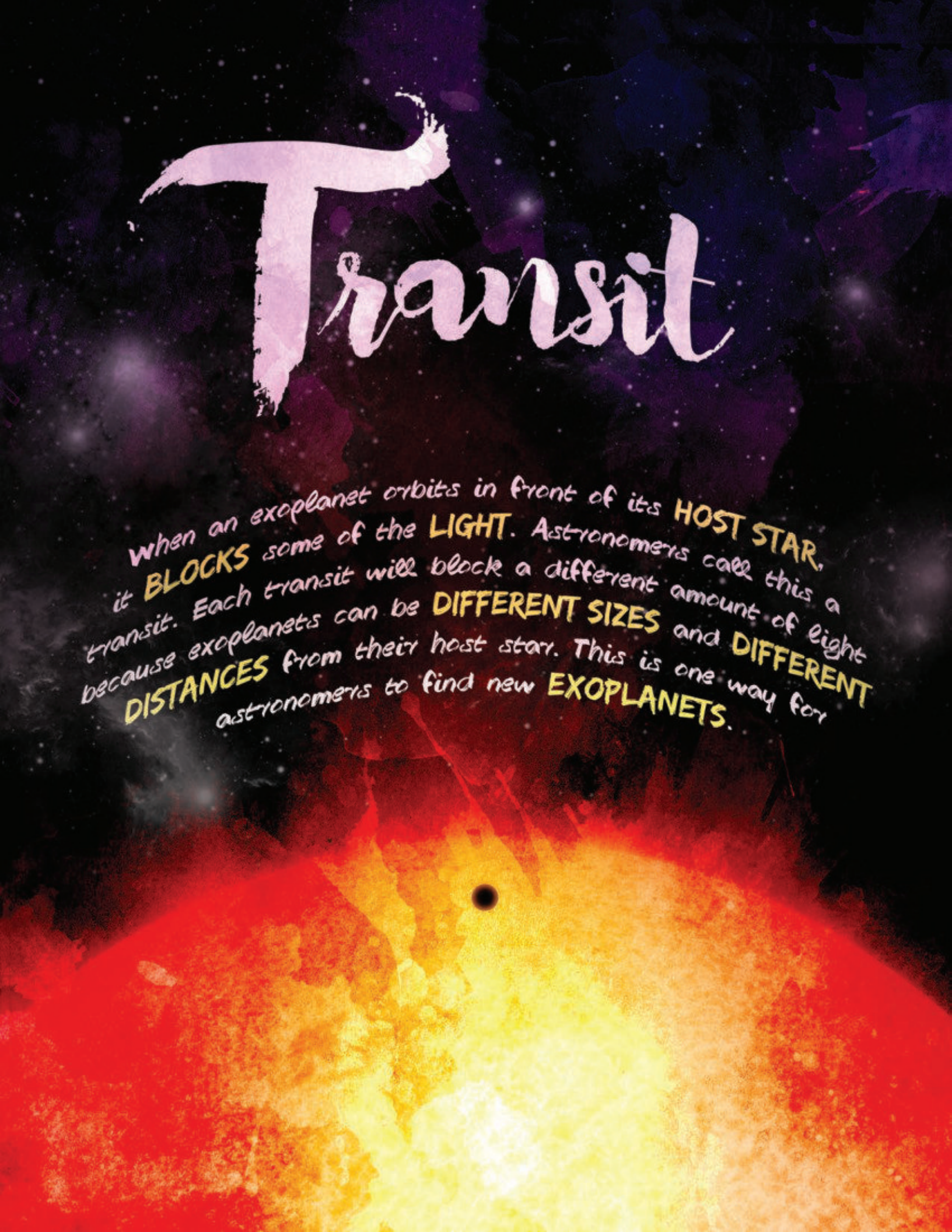
A Super-Earth



is a planet that is **much, much larger** than Earth but not as large as a gas giant. **Don't let the name super-Earth fool you!** A super-Earth might not have features and composition similar to Earth's, but it gets its name because it is closer in size to Earth than a gas giant.

Q:

What planets do we see
transiting our sun?


Transit
When an exoplanet orbits in front of its HOST STAR, it BLOCKS some of the LIGHT. Astronomers call this a transit. Each transit will block a different amount of light because exoplanets can be DIFFERENT SIZES and DIFFERENT DISTANCES from their host star. This is one way for astronomers to find new EXOPLANETS.

Q:

How many different objects in the universe
can you name in 30 seconds? Go!

Uni

Everything we know that exists is located in the **UNIVERSE.**

The universe is the term astronomers use to describe all of space.

Astronomers believe it is **GROWING AND GROWING!**

HOW BIG WILL THE UNIVERSE GET?

Our galaxy, the **MILKY WAY**, is one part of the universe.

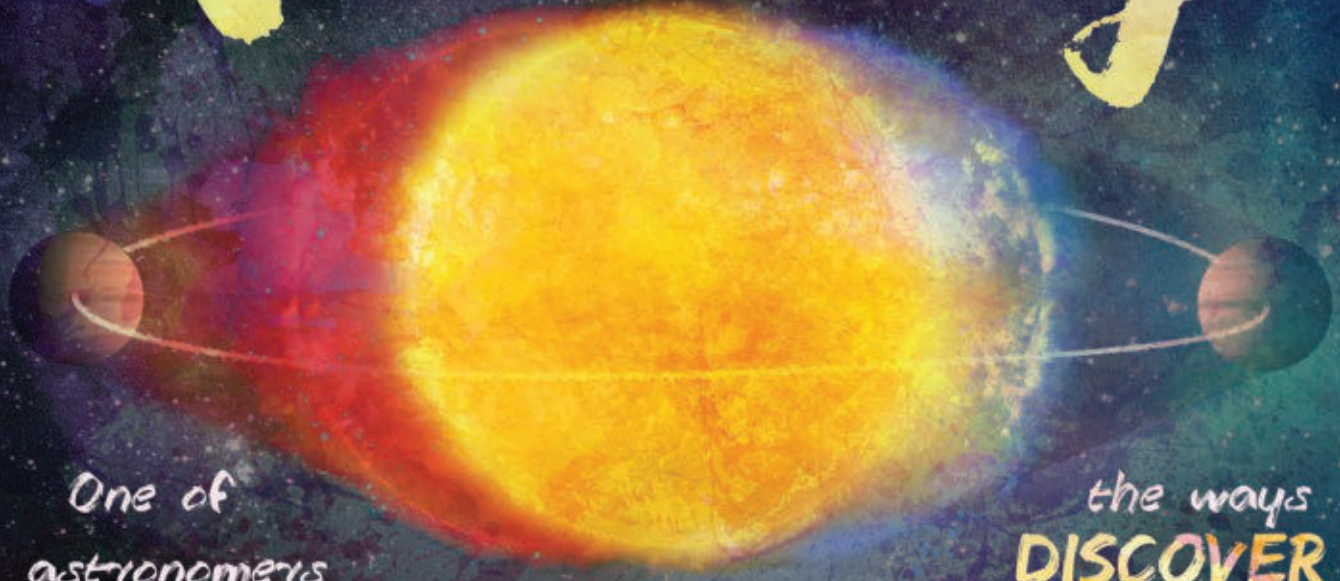
How many exoplanets are in our galaxy?

verse

Q:

What colors show that stars are moving due to an exoplanet's orbit?

radial velocity



One of the ways astronomers DISCOVER exoplanets is called RADIAL VELOCITY. STARS aren't completely still in space when an exoplanet is orbiting them. The planet TUGS on the star ever so SLIGHTLY, causing it to move in a small circle. These movements affect a star's LIGHT SPECTRUM. When the planet is moving TOWARD US, the COLORS will appear SHIFTED toward the color BLUE. When moving AWAY from us, the color spectrum is SHIFTED toward RED. These shifts can be measured and show a planet is in ORBIT.

Q:

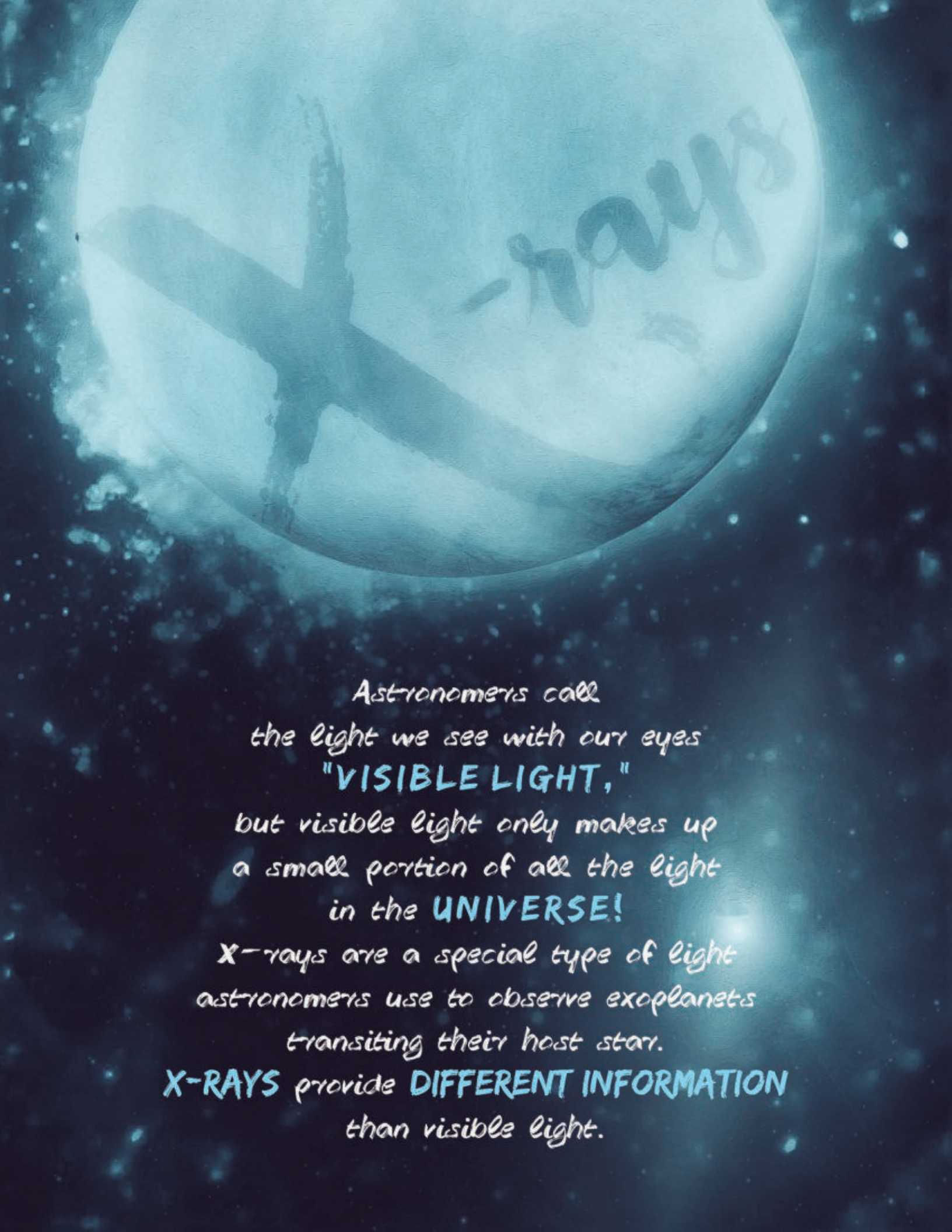
What types of life forms do you think live on a water world?

WATER WORLD

A WATER WORLD, or an ocean planet, is a planet that astronomers think could be entirely COVERED BY WATER. With all of that water, it may be hard to have LAND-BASED life forms. However, if the planet could have life, imagine all of the new types of WATER LIFE that could be discovered!

Q:

How are X-rays used
to study objects on Earth?



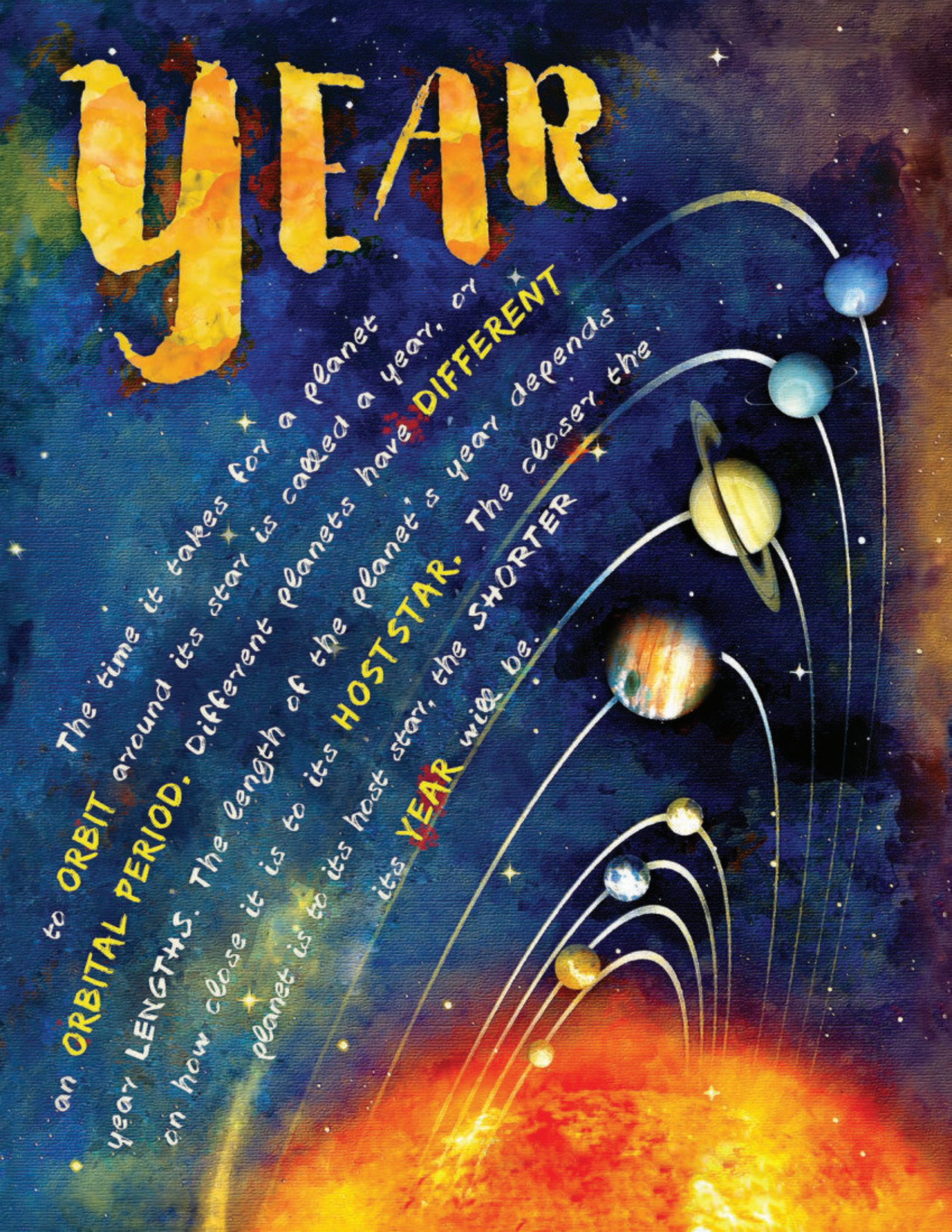
Astronomers call
the light we see with our eyes
"VISIBLE LIGHT,"
but visible light only makes up
a small portion of all the light
in the UNIVERSE!
X-rays are a special type of light
astronomers use to observe exoplanets
transiting their host star.
X-RAYS provide DIFFERENT INFORMATION
than visible light.

Q:

What planets have longer years than Earth in our solar system?

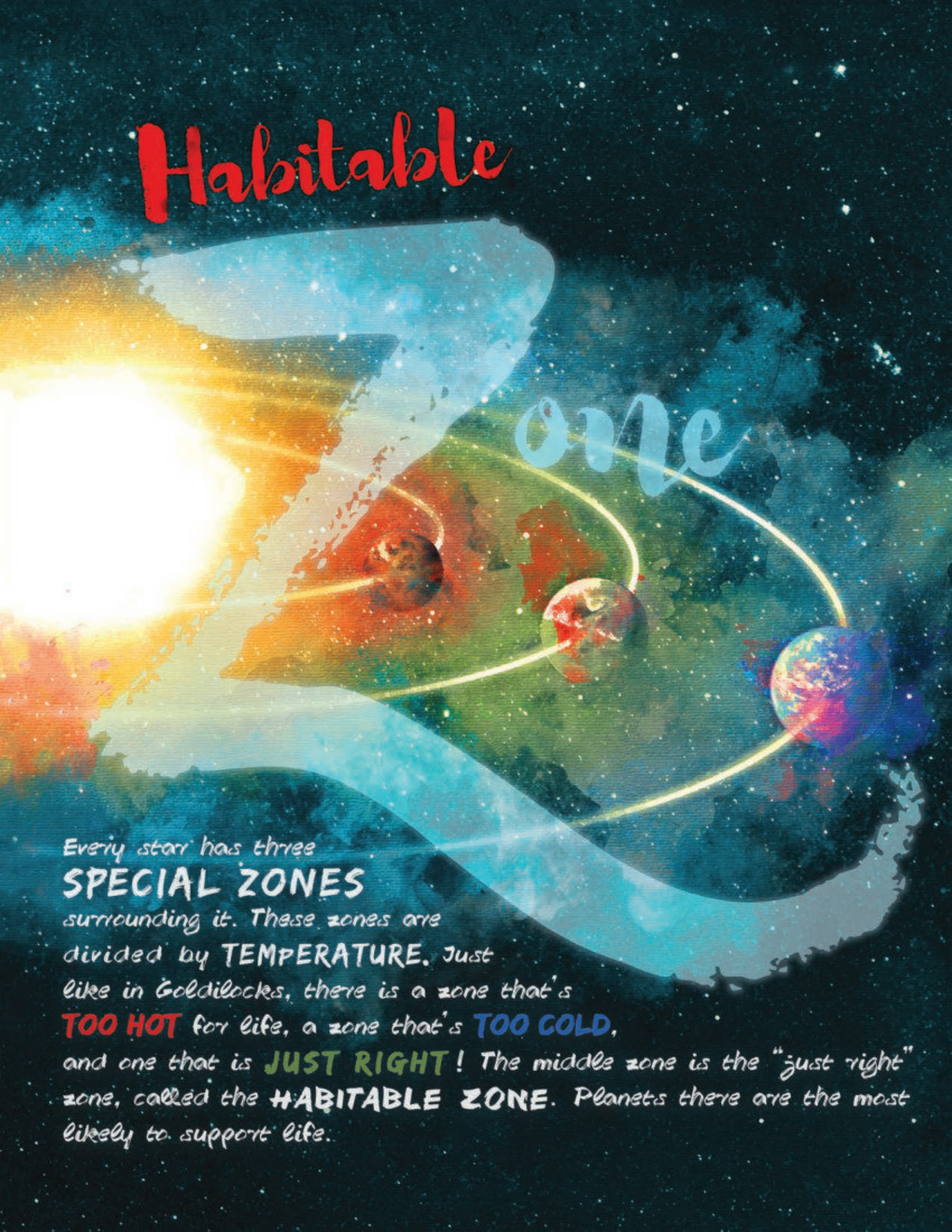
YEAR

The time it takes for a planet to **ORBIT** around its star is called a year, or an **ORBITAL PERIOD.** Different planets have **DIFFERENT** year **LENGTHS.** The length of the planet's year depends on how close it is to its **HOSTSTAR.** The closer the planet is to its host star, the **SHORTER** its **YEAR** will be.



Q:

Which planets do you think are in
the habitable zone in our solar system?



Every star has three **SPECIAL ZONES** surrounding it. These zones are divided by **TEMPERATURE**. Just like in Goldilocks, there is a zone that's **TOO HOT** for life, a zone that's **TOO COLD**, and one that is **JUST RIGHT**! The middle zone is the "just right" zone, called the **HABITABLE ZONE**. Planets there are the most likely to support life.

National Aeronautics and Space Administration

Goddard Space Flight Center
8800 Greenbelt Road
Greenbelt, MD 20771
tess.gsfc.nasa.gov

www.nasa.gov

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