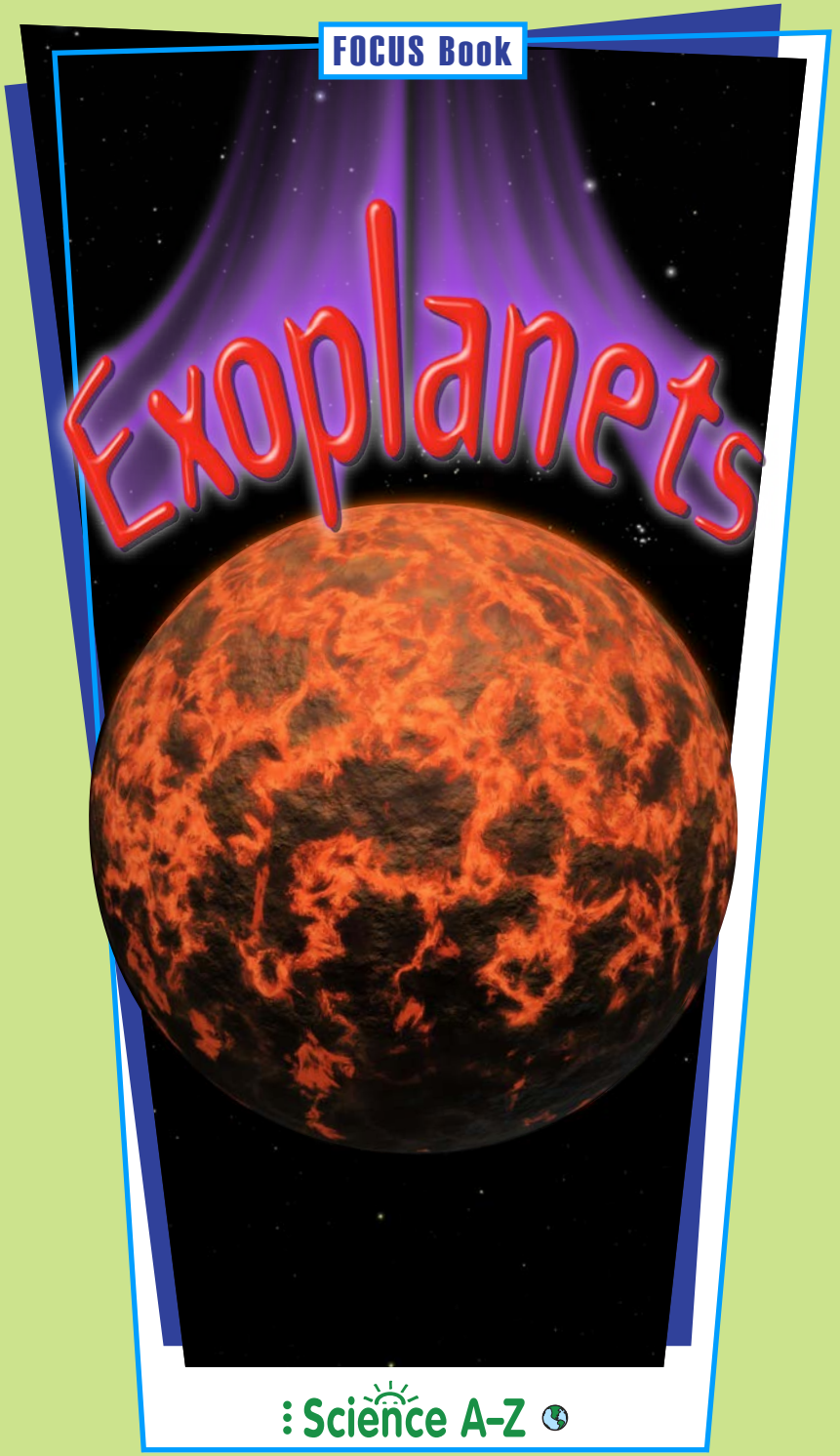
Be a Scientist!

At the bottom of page 4 is an example of a transit graph. A transit graph shows changes in the brightness of a star's light as a planet crosses in front of the star as seen from Earth.

Suppose you are an astronomer who finds two exoplanets using the transit method. One exoplanet is very large and orbits the planet slowly. The other is smaller and quickly zips past the star. Think about how the transit graphs will be different. Draw a transit graph for each planet to show how we would see its star dim as the planet passes in front of it. Be sure to label all parts of each graph. Then explain how the graphs are similar and how they are different.

Beyond the Book

Use the Internet to find out how many confirmed exoplanets and how many unconfirmed candidates there are now. What evidence have astronomers found that some of these planets could support life?



Exoplanets

FOCUS Question

How do we find planets outside of our solar system?

Patterns

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Exoplanets
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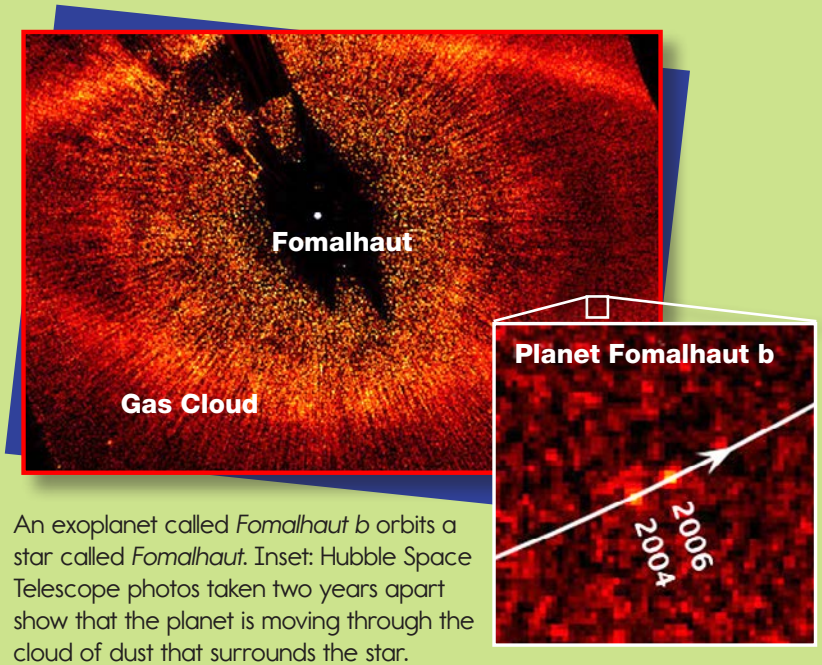
What Is an Exoplanet?

People who lived long ago could look up at night and see Mercury, Venus, Mars, Jupiter, and Saturn—planets of our solar system. After telescopes were invented, astronomers discovered Uranus, Neptune, dwarf planets like Pluto, and many moons. Then people wondered: Are there more planets beyond our solar system?

We now know that the answer is *yes!* A planet is a large object, made of rock or gas, that orbits a star. An *exoplanet* is any planet outside our solar system. Exoplanets do not orbit the Sun.



An exoplanet called *Fomalhaut b* orbits a star called *Fomalhaut*. Inset: Hubble Space Telescope photos taken two years apart show that the planet is moving through the cloud of dust that surrounds the star.

Astronomers look for exoplanets because they want to know what the universe is made of and how it works. There is another reason people are interested in exoplanets. They want to know: Are we alone? It would be amazing to discover planets in other solar systems with kinds of life different from those that exist on Earth.

Scientists think that this exoplanet is blue because it's raining drops of *silica*, or glass. The glass scatters blue light. In telescope images, it looks like a blue dot. An artist added possible details.

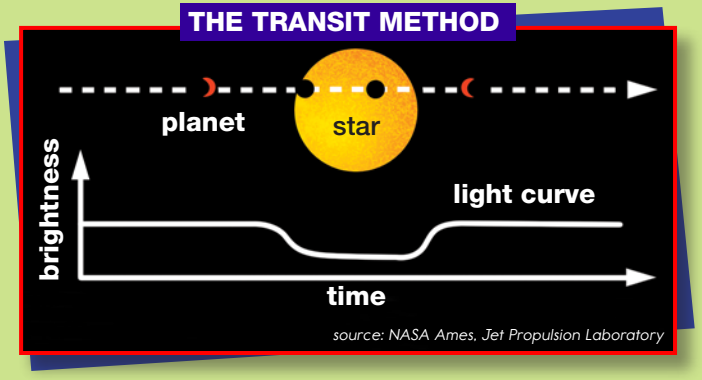
Astronomers have discovered thousands of exoplanets. Some of them are small and rocky, like Mercury, Venus, Earth, and Mars. Others are large and made of gas, like Jupiter, Saturn, Neptune, and Uranus. Some seem to have watery atmospheres like Earth's. Others appear black, with atmospheres full of dark particles that are rich in carbon.

How We Find Exoplanets

There are billions of stars in the Milky Way galaxy, and billions of galaxies in the universe. With so many stars in the universe, it seemed certain that there *must* be other planets out there. Until the 1990s, however, there was no evidence.

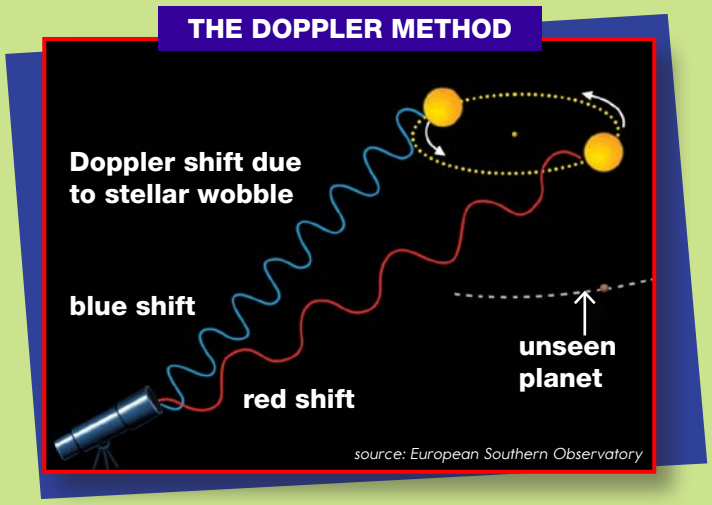
Exoplanets are hard to see. They are relatively small and they are very far away. Planets do not give off their own light. In order to see them, we must see starlight that they reflect. If we look toward a star to see a planet, the light from the star usually hides it.

Scientists have come up with ways to search for exoplanets. One way is known as the *transit method*. As astronomers observe a star, it dims slightly when a planet passes between the star and the telescope. The planet blocks some of the starlight. Astronomers look for stars that dim and brighten in a regular, repeating pattern. This tells them that a planet is orbiting the star.



As a planet orbits a star, the gravitational pull of the planet causes the star to move as well. In the *astrometric method*, astronomers measure the exact position of the star in space and how it wobbles in a repeating pattern over time.

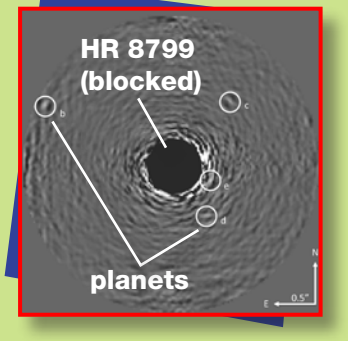
The *Doppler method* observes this wobble by recording the color of light from the star. Stars moving toward Earth appear bluer, and those moving away appear redder. A star with a nearby planet may appear bluer as it wobbles toward us and redder as it wobbles away.



It is sometimes possible to observe an exoplanet directly. Astronomers block the light from the planet's star so that they can see objects around it. They can also observe planets directly by looking through more than one telescope at the same time, and combining information from the telescopes.

Scientists are not satisfied with simply detecting planets, however. For each planet they discover, they want to know: *How big is it? How far from its star is it? What is it made of? Does it have an atmosphere? What is the surface like?* Knowing these things about planets increases our understanding of the universe.

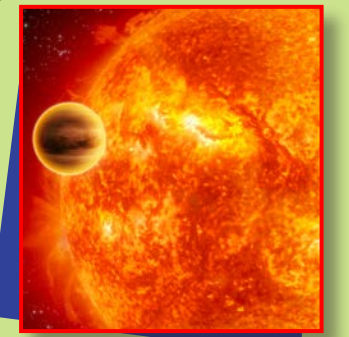
To answer these questions, scientists observe different forms of light coming from the planets, using many different ground-based telescopes and space telescopes. They watch carefully to see how the planets move in space.



Telescope image of HR 8799 with light blocked

Astronomers used the Keck and Gemini telescopes in Hawaii to find four giant, red planets that orbit a star called HR 8799. The planets were found by blocking the starlight coming from HR 8799.

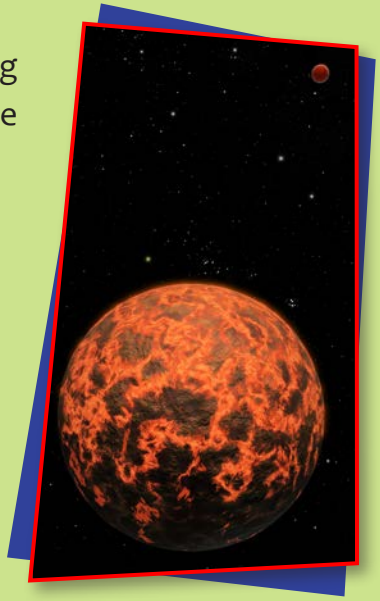
Observers found planet HD 189733b when it made a transit in front of its star. Astronomers used the Spitzer Space Telescope to study the infrared light coming from the planet. They discovered that there is water vapor in its atmosphere.


Artist's drawing of HD 189733b transit

An artist's drawing showing two planets that orbit a double star.

The Kepler Space Telescope was designed to look for planets using the transit method. The telescope revealed that some exoplanets orbit more than one star.

One of the smallest planets detected is just two-thirds the size of Earth. It orbits so close to its star that it must have no atmosphere, and might even have a molten surface. At right is an artist's drawing.



Wowser!

In 2013, a black hole suddenly gave off a flare of X-rays. Astronomers think the X-rays were a sign that it was tearing apart and pulling in a planet much bigger than Jupiter—in just a few seconds!

Searching for Life

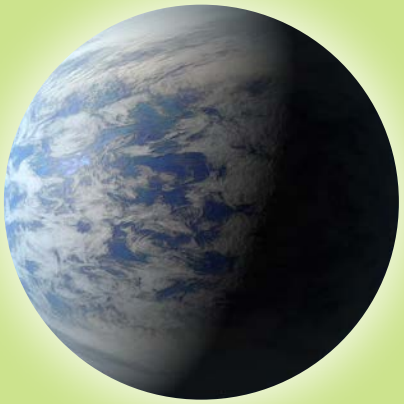
Although we know that exoplanets exist, we still wonder: Is Earth the only place in the universe with life? Since these planets are too far away to visit, it is very difficult to answer that question. Answering other questions may give us clues:

- *Are there planets about the same size as Earth?*
- *Do any planets have a similar atmosphere?*
- *Do any planets have liquid water on the surface?*
- *Do any planets orbit a star like the Sun?*

Astronomers look for planets in the *habitable zone*, also known as the *Goldilocks Zone*. The Goldilocks Zone is not too hot and not too cold. It is just right for liquid water, and maybe even for life. Several exoplanets might be similar to Earth.

Gliese 667C is a star that is part of a three-star system with at least seven planets. Three of these seem to be in the habitable zone, where liquid water could exist. This is an artist's impression of what the sky might look like from one of the planets.

Kepler-69c is a planet that is 70 percent larger than Earth, and is located in the habitable zone of a star like the Sun. It takes about 242 Earth-days to make one orbit. Exoplanets this size are known as "super-Earths."



An artist's drawing of Kepler-69c

Kepler-62e is a "super-Earth" orbiting a star that is smaller and cooler than the Sun. It takes about 122 Earth-days to complete one orbit.

An artist's drawing of Kepler-62e

Although scientists have studied hundreds of exoplanets, there is still a lot that we do not know about them. What exactly are they made of? How old are they? Do they have oceans and continents? Is there life outside our solar system? With today's technology, it would be impossible to visit a planet orbiting a distant star. It is fun, however, to imagine communicating with someone who lives on a very different, alien world.

Read-Think-Write

Write your answers on separate paper. Use details from the text as evidence.

1. An *exoplanet* is a planet that exists outside our solar system. What do you think the prefix "exo" means?
2. Give two reasons why it is hard to observe exoplanets directly.
3. Explain the relationship between a star that wobbles and its planets.
4. Identify three features of exoplanets that astronomers look for when they try to find habitable exoplanets.
5. What should people on Earth do if we discover life on an exoplanet? Support your suggestion with reasons.

FOCUS Question

How do we find planets outside of our solar system? Explain why most of the exoplanets found so far have been very large, and why they orbit close to and quickly around their stars.