STARS AND EXOPLANETS | LESSON 5

The Stars Next Door

The nearest stars, how we measure their distance, and the planets that might be habitable.

Grades 6-12 | About 15 minutes of narrated flight, plus discussion stops | 10 stops | Start: learn.allseeing.space/stars-next-door

What students will see and do

Students learn the light-year, visit Alpha Centauri, Proxima and its planet, Barnard's Star, Sirius, Vega and Polaris, then explore the seven-planet TRAPPIST-1 system and the Earth-like Kepler-452 b.

Learning objectives

- Use the light-year to describe distance and look-back time
- Define the habitable zone and explain why it does not guarantee life
- Describe the wobble and transit methods for finding exoplanets
- Explain why Polaris is useful for navigation

NGSS connections

5-ESS1-1	Stars look dimmer or brighter partly because of their distance (Proxima vs Sirius).
MS-ESS1-3	Scale of interstellar distances using light-years and models.
HS-ESS1-1 (extension)	Different stars (red dwarfs, Sun-like stars, giants) have different masses and lifetimes.
DCI ESS1.A	The Universe and Its Stars.

40-minute class plan

1. 5 min: pre-lesson prompt. Before we fly: the nearest star is about forty trillion kilometers away. How could anyone measure a distance that big?
2. 18-20 min: run the lesson. Keep discussion stops short (1-2 minutes each) or turn them off in the Lessons menu.
3. 8 min: whole-class discussion using two of the questions below.
4. 5 min: Exit ticket: Explain in your own words what a light-year is. Then describe one clue scientists use to find a planet they cannot see.

Full exploration (about 60 minutes)

1. 5 min: pre-lesson prompt, recorded so students can revisit it.
2. 25-30 min: run the lesson with every discussion stop at full length.
3. 15 min: follow-up activity. Model the transit method: shine a flashlight at a light sensor app and pass a small ball in front of it.
4. 10 min: revisit the pre-lesson ideas, then the exit ticket.

Before the lesson

Before we fly: the nearest star is about forty trillion kilometers away. How could anyone measure a distance that big?

Discussion stops: timing and key points

At Proxima b (4-6 min): Proxima b is in its star's habitable zone. Does that mean it has life? What else would a planet need?

- The habitable zone is only about temperature.
- Life would also need a protective atmosphere, liquid water, a stable climate and protection from flares (a magnetic field).
- We do not yet know whether Proxima b has any of these.

At Polaris, the North Star (3-4 min): Polaris is not the brightest star in the sky, yet it has guided travelers for centuries. Why does its position matter more than its brightness?

- Polaris sits almost above Earth's North Pole, so it barely moves as Earth turns.
- Its height above the horizon roughly equals your latitude.
- Brightness does not help you find direction; position does.

At TRAPPIST-1 (4-6 min): TRAPPIST-1 has seven Earth-sized planets. If you were choosing one to study for signs of life, how would you decide which one?

- Good criteria: inside the habitable zone, Earth-like size and density, signs of an atmosphere and water.
- Telescopes like Webb test atmospheres when planets pass in front of the star.
- Students should justify a choice with evidence.

More questions for after the lesson

1. If you look at Proxima Centauri tonight, how old is the light you see?
2. Why do scientists think most stars have planets?
3. Would you rather explore Proxima b or a TRAPPIST-1 planet? Defend your choice.

Vocabulary

light-year, red dwarf, binary star, exoplanet, habitable zone, transit, radial velocity, biosignature

Exit ticket

Exit ticket: Explain in your own words what a light-year is. Then describe one clue scientists use to find a planet they cannot see.

Follow-up activities

- Model the transit method: shine a flashlight at a light sensor app and pass a small ball in front of it.
- Habitable zone sort: give students star types and planet distances and have them decide which could hold liquid water.
- Write a travel brochure for a planet around another star, using only facts from the lesson.

Full transcript

Introduction

Welcome to The Stars Next Door. Every star you see at night is a sun, some smaller than yours, some far larger. Many of them have planets. In this lesson we will leave the solar system and visit your nearest stellar neighbors, and a few worlds where liquid water might exist.

Here is our big question. Is Earth unusual, or are there planets like it everywhere? Listen for clues as we travel.

1. Measuring the distance

We start at home, beside the Sun. Before we leave, we need a new ruler. Distances between stars are so large that kilometers stop being useful. Astronomers use the light-year instead: the distance light travels in one year, about nine and a half trillion kilometers.

A light-year is a distance, not a time. But it also tells you something about time. If a star is ten light-years away, the light you see from it tonight left that star ten years ago. Looking out into space always means looking back in time.

Light from the Sun takes about eight minutes to reach Earth. Light from the nearest other star takes more than four years. That gap shows how empty space is. If the Sun were the size of a grain of sand, the nearest star would be another grain of sand about thirty kilometers away.

We also need one more idea before we go: the habitable zone. Around every star there is a band of distances where a planet would be not too hot and not too cold for liquid water on its surface. Scientists sometimes call it the Goldilocks zone. Earth sits inside the Sun's. Venus is just inside the hot edge, and Mars is near the cold edge.

2. Alpha Centauri A and B

This is Alpha Centauri, about four point four light-years away. It looks like one bright star to your eyes, the third brightest in the night sky. But a telescope shows two stars, Alpha Centauri A and B, orbiting each other about every eighty years.

Alpha Centauri A is a little bigger and brighter than your Sun. Alpha Centauri B is a little smaller and cooler. They are about the same age as the Sun, too. Stars like these are some of the best places to look for planets similar to Earth.

You can only see Alpha Centauri from the southern hemisphere, or from places close to the equator. It sits near the Southern Cross, and sailors used it for navigation for centuries.

Could we ever send something here? One proposal, called Breakthrough Starshot, imagines launching thousands of tiny probes, each weighing about a gram, on very thin sails. Powerful lasers on Earth would push them to about one fifth the speed of light, fast enough to reach Alpha Centauri in about twenty years. It is only an idea for now, and the engineering challenges are enormous.

3. Proxima Centauri

And this is Proxima Centauri, the closest star to the Sun, about four point two four light-years away. Its name means nearest. It is a small red dwarf, only about one eighth the mass of the Sun, and so faint that you need a telescope to see it, even though it is next door.

Proxima orbits around Alpha Centauri A and B, very slowly, taking hundreds of thousands of years for each trip. So the Alpha Centauri system actually has three stars.

Red dwarfs are the most common kind of star in the galaxy. They burn their fuel so slowly that they can shine for trillions of years, far longer than the universe has existed so far. But many red dwarfs, including Proxima, are flare stars. They suddenly brighten with bursts of radiation that could strip the air from nearby

planets.

How long would it take to get here? Voyager one, one of the fastest spacecraft ever launched, travels about seventeen kilometers every second. At that speed, the trip to Proxima would take more than seventy thousand years.

4. Proxima b

In twenty sixteen, astronomers announced a planet orbiting Proxima. They found it by watching the star wobble very slightly, back and forth, as the planet's gravity tugged on it. This is called the wobble method, or radial velocity.

Proxima b has at least about the mass of Earth. It is very close to its star, finishing a whole orbit in only about eleven days. But because Proxima is so dim and cool, that close orbit puts the planet in the habitable zone, the range of distances where a planet could be warm enough for liquid water on its surface.

Being in the habitable zone is not a guarantee of life. A planet also needs the right kind of atmosphere, and Proxima's flares might have blasted it away. The planet is probably tidally locked too, with one side always facing its star in endless day and the other side in endless night. Scientists are still trying to find out what it is really like.

How could we ever know if a far-away planet has life? One idea is to study the starlight that passes through its atmosphere. Different gases absorb different colors of light. If a planet's air showed oxygen, methane, and water vapor together, that mix could be a sign of living things, a biosignature. No such sign has been confirmed anywhere yet.

Discussion stop: Proxima b is in its star's habitable zone. Does that mean it has life? What else would a planet need?

5. Barnard's Star

This is Barnard's Star, about six light-years away, another red dwarf. It is famous for moving across the sky faster than any other star, about the width of the full Moon every hundred and eighty years. That fast motion is a clue that it is very close to us.

Barnard's Star is also very old, perhaps twice the age of the Sun. Astronomers spent decades arguing about whether it had planets. Recently, very precise measurements found several small rocky planets orbiting it, each a fraction of Earth's mass and all too close to their star, and too hot, for liquid water.

The story of Barnard's Star teaches something important about science. Claims of planets here were made, tested, and rejected for years before better instruments gave clear answers. Science corrects itself by checking results again and again.

6. Sirius

Now a very different neighbor. This is Sirius, the brightest star in Earth's night sky, about eight point six light-years away. Sirius is about twice the mass of the Sun and shines about twenty five times brighter. It burns hot and blue-white.

Sirius has a hidden partner, Sirius B. It is a white dwarf, the leftover core of a star that already died. Sirius B packs about as much mass as the Sun into a ball roughly the size of Earth. A teaspoon of its material would weigh several tonnes on Earth.

Ancient Egyptians watched for Sirius rising just before dawn, because it arrived around the time the Nile River began its yearly flood. Stars have been calendars and clocks for people for thousands of years.

7. Vega

This is Vega, about twenty five light-years away, one of the brightest stars in the summer sky of the northern hemisphere. In eighteen fifty, Vega became the first star other than the Sun ever photographed.

Vega spins so fast, about once every twelve and a half hours, that it bulges at its equator and is flattened at its poles. In nineteen eighty three, a space telescope discovered a disk of dust circling Vega, a sign of rocky material that could one day be part of planets, or the rubble left over after planets formed.

Here is a surprise. Earth's axis slowly wobbles like a spinning top, tracing a circle once every twenty six thousand years. Because of that wobble, about twelve thousand years from now Vega will be close to the north celestial pole. It will be Earth's North Star.

8. Polaris, the North Star

This is the North Star today, Polaris, roughly four hundred and thirty light-years away. Many people think it is the brightest star in the sky. It is not. It is only around the fiftieth brightest. What makes it special is its position, almost directly above Earth's North Pole.

As Earth turns, every other star seems to circle across the sky, but Polaris barely moves. Find it, and you have found north. And the height of Polaris above your horizon is almost exactly equal to your latitude, which is how navigators found their position at sea.

Polaris is actually a system of at least three stars. The main star is a yellow supergiant that gently pulses, getting slightly brighter and dimmer every four days. Stars that pulse like this are called Cepheids, and astronomers use them as measuring sticks to find distances to other galaxies.

Discussion stop: Polaris is not the brightest star in the sky, yet it has guided travelers for centuries. Why does its position matter more than its brightness?

9. TRAPPIST-1

We travel farther now, about forty light-years. This is TRAPPIST-1, a cool red dwarf only a little larger than the planet Jupiter. In twenty seventeen, astronomers announced that it has seven rocky planets, all roughly the size of Earth.

These planets were found with the transit method. When a planet passes in front of its star, it blocks a tiny bit of light, and the star dims for a moment. By measuring how much it dims, astronomers can tell how big the planet is. By timing how often it happens, they learn how long the planet's year is.

All seven TRAPPIST-1 planets orbit closer to their star than Mercury orbits the Sun. Their years last from about one and a half to nineteen Earth days. Standing on one of them, you would see the other planets in the sky, some appearing bigger than the Moon looks from Earth.

The planets are named with letters, b through h, in order outward from the star. Like Proxima b, they are probably tidally locked, each keeping one face toward its star. On such a world, the best place to live might be the ring of twilight between the hot day side and the frozen night side.

Three or four of these planets are in the habitable zone. The James Webb Space Telescope has been studying them. So far, the innermost planets seem to have little or no thick atmosphere, but scientists are still testing the ones farther out.

Discussion stop: TRAPPIST-1 has seven Earth-sized planets. If you were choosing one to study for signs of life, how would you decide which one?

10. Kepler-452 b

Our last stop is much farther away, more than a thousand light-years. This is Kepler-452 b, a planet orbiting a star very much like the Sun, but older. Its year lasts three hundred and eighty five days, very

close to Earth's.

Kepler-452 b is about one and a half times as wide as Earth. Scientists are not sure whether it is a rocky planet like Earth or a world wrapped in thick gas. It was discovered by NASA's Kepler Space Telescope, which stared at one patch of sky for years, watching more than a hundred thousand stars for tiny dips in their light.

Kepler found thousands of planets. Thanks to Kepler and many other telescopes, astronomers have now confirmed more than six thousand planets around other stars. Statistics suggest that most stars in the galaxy have at least one planet.

Wrap-up

So, is Earth unusual? Planets turn out to be everywhere. Small rocky planets are common, and many orbit in their star's habitable zone. What we do not yet know is how many of them have air, water, and life. Finding out is one of the biggest goals in science today.

Maybe someone in this room will help answer it. Press L to choose another lesson.

Positions are computed live from real orbits. Narration is checked against public scientific sources; full credits at learn.allseeing.space/credits.html. Standards are listed as connections to NGSS, not formal alignments. Report an issue: info@allseeing.space