Sponsored Educational Materials

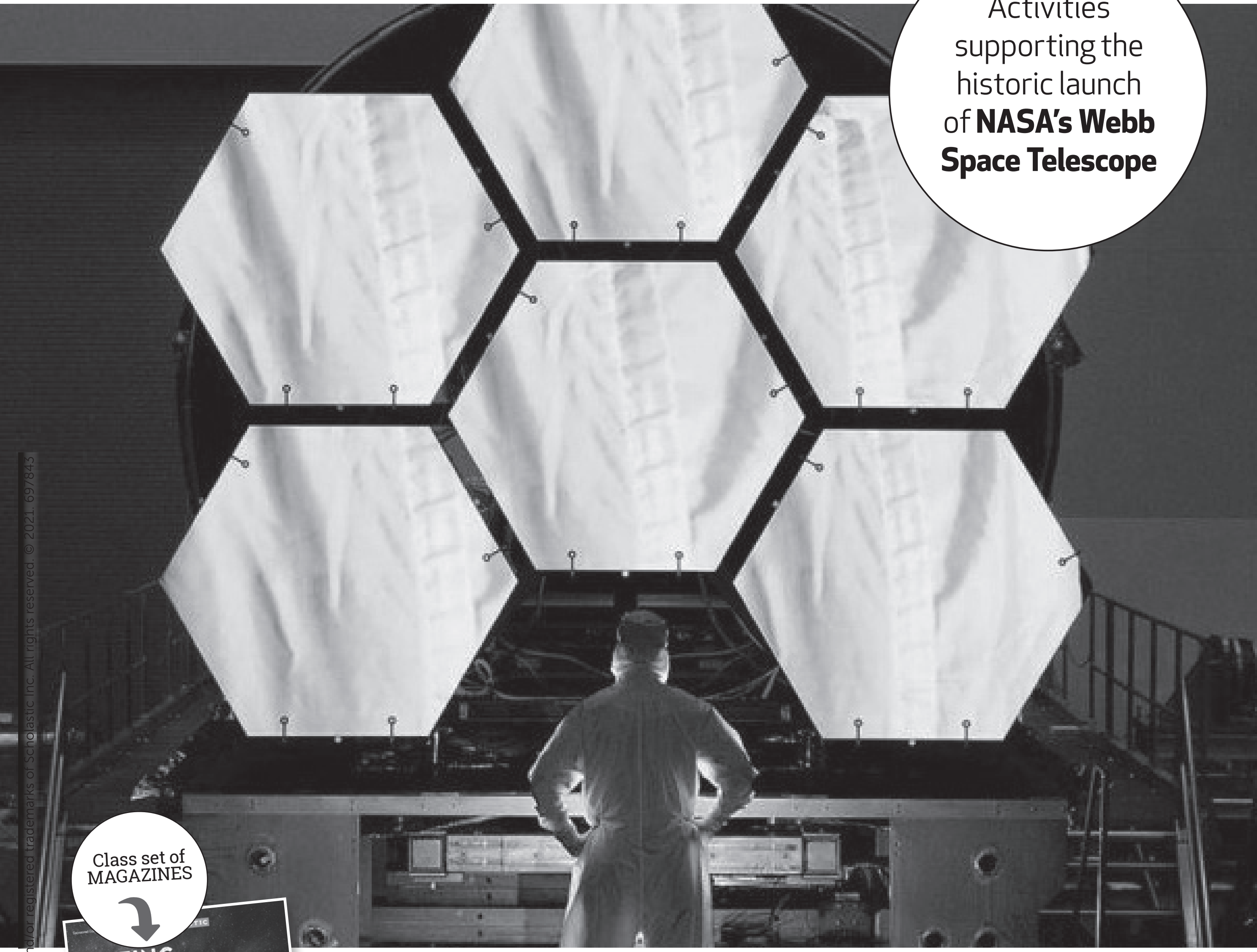
SCHOLASTIC

GRADES 7–10

TEACHING GUIDE

DISCOVERING THE UNIVERSE

Activities supporting the historic launch of **NASA's Webb Space Telescope**



Class set of MAGAZINES

STUDENTS WILL:

- Read about **engineering**, the **solar system**, **light**, **exoplanets**, and more
- Conduct **research** and create **scale models**
- Meet **STEM professionals**

Video Connection

Share the journey to launching NASA's Webb Space Telescope with your students with the documentary ***The Hunt for Planet B***.
Get video clips and bonus articles at: **scholastic.com/nasawebb**.

ACTIVITY 1: Modeling the Scale of the Universe

Objective
Students will create a model to represent the scale of the universe.

Time 30 minutes

Materials
- Magazine pages 2–4
- Photos of Jupiter: **bit.ly/Webb01A** and **bit.ly/Webb01B**

Lesson

1 **Hook** students by showing an image of Jupiter. Challenge students to guess what they think the red spot might be. (A storm—that has been observed raging for centuries.) Ask them to guess its size. Tell them it's bigger than Earth! Display the composite image that shows scale.

2 **Ask** students to share examples of models they have used in the past. How did the model help them? Explain that models can help us explore difficult concepts like the scale of the universe.

3 **Have** students create a live model of the universe with their bodies by calculating relative distances between objects (e.g., our solar system; Earth; Alpha Centauri; and Proxima Centauri) and measuring where they should stand in the classroom or schoolyard. Students should conduct online research to find the distances of their chosen objects.

- What happens if students try to add Alpha Centauri to their scale model of the solar system? Discuss how the scale needs to shift when transitioning from modeling relatively close objects (the Sun) to more distant objects (Alpha Centauri) so students can stay within sight of each other!

Remote modification: Students can create and photograph a model using objects at home, or draw a scale model. **High school extension:** Students can use 2D and 3D methods to model the same concept and compare the merits and limitations of each type of model.

ACTIVITY 2: What We Learn From Telescopes

Objective
Students will use a model to explain how scientists learn about faraway objects in the universe.

Time 20 minutes

Materials
- Magazine pages 3, 6–7
- Round objects and a light source
- Optional: NASA video of transit graph: **bit.ly/Webb02A** and photo of Mercury transiting the Sun **bit.ly/Webb02B**
- High School: "Exploring Redshift" article (**scholastic.com/nasawebb**)

Lesson

1 **Explain** that telescopes not only help us see what faraway objects look like, but we can also observe how celestial objects change our perception of other objects to infer more about outer space.

2 **Model** how a transiting planet blocks light from a star by holding up round objects of different sizes in front of a light source at different speeds and distances. **If possible**: Show the NASA video and/or image, referenced above. Ask: *How could this concept help astronomers?*

3 **Ask** students: *How does the object's size affect the amount of light it blocks? What about the distance between the object and the light source?* Explain that scientists also make these sorts of observations in order to calculate the mass of a transiting planet and to investigate the planet's orbit.

4 **Point out** that NASA has found more than 1,000 exoplanets by looking for the drop in brightness that transiting planets cause to our view of faraway stars!

5 **For high school:** After reading page 3 of the magazine, ask students to share questions they have about redshift. Then have students read the "Exploring Redshift" article and respond to the questions.

ACTIVITY 3: Galactic Exploration

Objective
Students will conduct guided research about an object in the universe and share their findings.

Time 90 minutes

Materials
- Magazine pages 6–7
- Middle School: Research Activity A and sample research source (**bit.ly/Webb03A**)
- High School: Research Activity B , sample source (**bit.ly/Webb03B**), and "Star Power" article (**scholastic.com/nasawebb**)

Lesson

1 After reading magazine pages 6–7, **ask** students to discuss the following questions with a partner: How can studying exoplanets help us better understand our own planet? If there is other life in space, what would you want to know about it?

2 **High school:** Have students read the "Star Power" article and answer the questions about how stars form helium and other elements. Then, ask: *Why do people say we are "made of stardust"?*

3 **All grades:** Distribute the research activity sheet (and sample research sources if desired). Students can work with a partner or independently.

Remote modification for limited internet: Print text from sample sources to add to student packets.

4 **Have** students complete Part 3 of the activity sheet by creating a podcast, blog post, multimedia presentation, or infographic. Invite students to share their projects with their classmates.

Writing Extension: The planets in the TRAPPIST-1 system are likely tidally locked, meaning one side of the planet is in perpetual day and the other is in perpetual night. Have students imagine what it might be like to live on such a planet and write a creative story about it.

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NGSS STANDARDS

Grs. 7-8: MS-ESS1-1: Model the Earth-Sun-Moon system. MS-ESS1-3: Determine scale properties of solar system objects.

NGSS, Grs. 9-10: Practice 2: Models: Evaluate merits and limitations of two different models of the same system.

Name ______________________________

EXPLORE THE SOLAR SYSTEM

There is a lot that scientists have learned about objects in our solar system—and a lot they still don't know! Follow the prompts below to guide your research about one object in our solar system.

Part 1: Brainstorm and Plan

1. Choose a research topic. You can use one of the options listed or select your own.

☐ Jupiter ☐ Comet 238P/Read ☐ Eris (dwarf planet) ☐ Other: ______________________

2. If you are working with a partner, assign research tasks for each person to complete.

Part 2: Research

Record your notes and sources in the following chart, or make a similar one on a separate sheet..

Question	Notes	Source
How far away from Earth is this object?		
What size is this object relative to Earth's size?		
How does gravity affect this object?		
What questions about this object will the James Webb Space Telescope explore?		
What is another question about this object that you would like to explore?		

Part 3: Share and Reflect

Choose a way to share your findings with the class:

podcast

blog post

multimedia presentation

infographic

If you worked with a partner, how did teamwork help you to complete this project? What strengths did each partner bring to the team?

Name ______________________________

RESEARCH EXOPLANET SYSTEMS

Exoplanets are planets outside our Solar System. There is a lot that scientists have uncovered about exoplanet systems—and a lot they still don't know! Use the prompts below to conduct your own research.

Part 1: Brainstorm and Plan

1. Choose an exoplanet system to research. You can use one of the options listed or select your own.

- ❑ TRAPPIST-1
- ❑ Kepler-452
- ❑ 55 Cancri
- ❑ Other:

2. If you are working with a partner, assign research tasks for each person to complete.

Part 2: Research

Record your notes and sources in the following chart, or make a similar one on a separate sheet.

Question	Notes	Source
How far away, in lightyears, is this exoplanet system?		
Have scientists estimated how old it is?		
Choose one of its exoplanets. How does it compare to Earth?		
What questions about these exoplanets could NASA's Webb Space Telescope explore?		
What is another question about this exoplanet system that you would like to explore?		

Part 3: Share and Reflect

Choose a way to share your findings with the class:


podcast


blog post


multimedia presentation


infographic

If you worked with a partner, how did teamwork help you to complete this project?

SCHOLASTIC

GAZING ACROSS GALAXIES

Could there be life on other planets?

There's still so much we don't know about the universe—but engineers and scientists around the world are working together on a superhero telescope that will see vastly farther than ever before. In fact, it will record light given off billions of years ago—essentially acting as a time machine.

EYE IN THE

A powerful new telescope is about to launch—and it could

Try to imagine yourself as a dot in our immense universe, surrounded by space dust, areas of deep darkness, and fiery stars fanning out in all directions. It's mind-boggling—but cool! For as long as humans have existed, we have been mesmerized by the universe and the questions it stirs up: How big is the universe? Is there life on other planets? How did the universe even begin—and is it changing? Read on to find out how an amazing team of diverse scientists are working together to find answers.

A CLOSER LOOK

One of the oldest ways of exploring our galaxy is through the use of telescopes. When you were little, you may have made pretend telescopes out of paper towel rolls and aimed them at the ceiling. Real telescopes use curved mirrors to gather and focus light from the night sky.

The first known telescope to be pointed at the sky was designed in 1609 by an Italian scientist known today by his first name, Galileo. He was able to detect moons orbiting Jupiter, leading him to the conclusion that not all celestial objects revolve around Earth—upending astronomy at the time.

Over time, astronomers and scientists built bigger, more complex instruments to explore space. More sophisticated telescopes have led to the discovery of fundamental facts about our universe. Before telescopes, close observation led to theories that planets orbit (or go around) our Sun, but telescopes proved it. Telescopes demonstrated that stars are not solid, they are spheres of gas—and our closest star is the Sun. Telescopes also proved that there are hundreds of billions of stars in our galaxy, and hundreds of billions of galaxies in the universe! More sensitive telescopes showed us that practically every star has at least one planet around it—and many have multiple planets, like our solar system. Telescopes also helped us uncover the scale of the solar system—how big each planet is, and how far it is from other planets and the sun.

> **"I was always fascinated by extremes in the universe, places where we reach the end of our knowledge."**
>
> —Nora Luetzgendorf, Telescope Scientist

But how did the first stars and planets form? Are there other habitable planets out there?

NASA'S WEBB SPACE TELESCOPE

MIRROR This perfectly smooth mirror consists of 18 separate pieces that can unfold after launch to about 21 feet in length. Each mirror is made of a lightweight yet strong material called beryllium, which can hold its shape in the extreme cold of space. The mirrors are coated in a microscopically thin layer of gold to better reflect infrared light.

SUNSHIELD The five-layered sunshield is the size of a tennis court! Its job is to minimize the heat from the sun—by more than a million times!

CRYOCOOLER Basically a sophisticated refrigerator in space, the cryocooler behind the mirror uses helium gas and advanced machinery to cool the MIRI (one of the instruments that observes space) to -448 degrees Fahrenheit. (That's COLD!)

Photos: NASA/Chris Gunn, courtesy of Northrop Grumman

SKY

change everything.

Are we alone in the universe? To search for answers, NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA) brought together a diverse group of scientists and engineers—from all backgrounds and areas of expertise—to invent and build the most sophisticated telescope ever made: NASA's Webb Space Telescope.

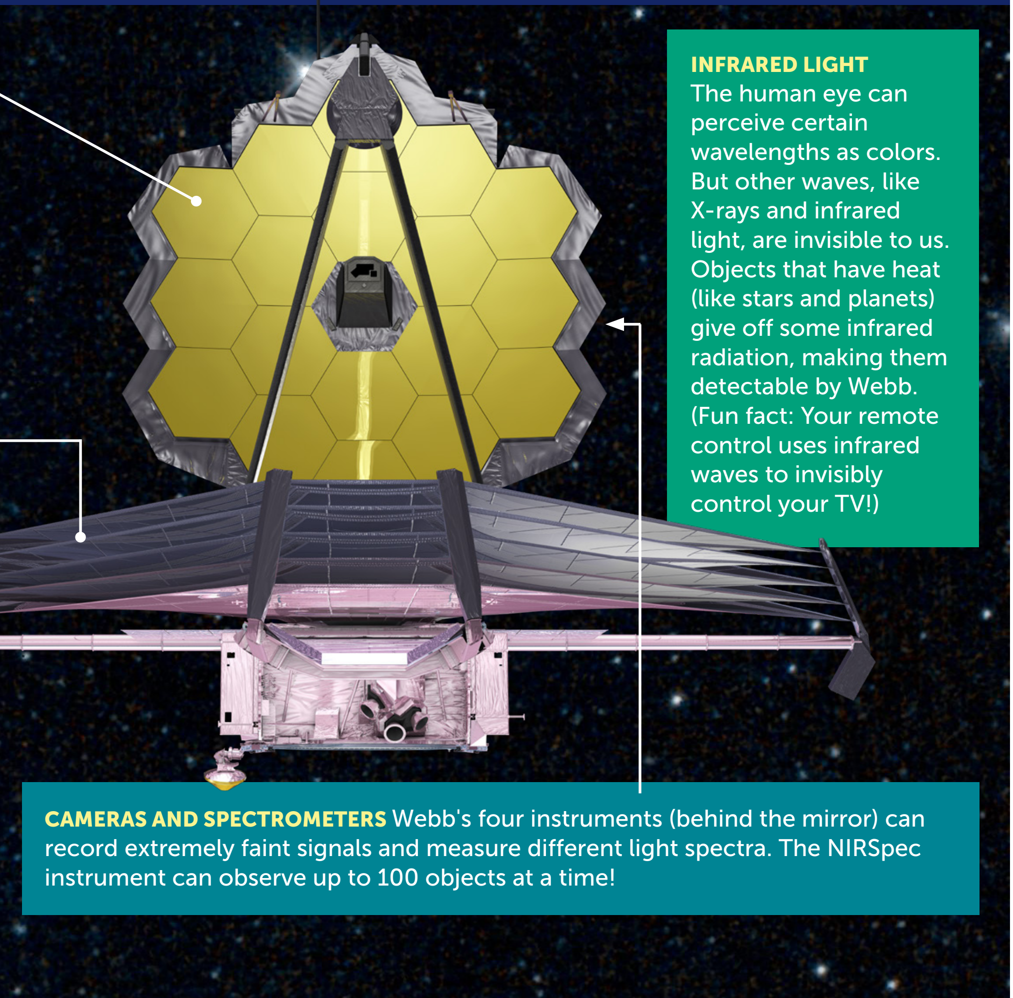
It took thousands of engineers and scientists working together for years to build NASA's Webb Space Telescope.

NEXT FRONTIER

NASA's Webb Space Telescope is expected to launch into space from French Guiana (in South America). With the largest light-reflecting mirror ever launched into space, it will be *100 times more powerful* than our current largest space telescope, Hubble! NASA's Webb Space Telescope will be able to observe bodies previously unseen by other telescopes—including some that formed *billions* of years ago. Understanding how early galaxies formed can tell us more about how our own galaxy began. The telescope will be able to show scientists how far other galaxies are from each other—and from our galaxy—by measuring something called **redshift**, the phenomenon in which an object's light waves turn redder as they stretch farther and farther away.

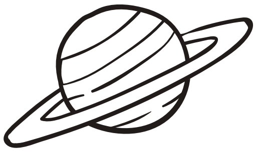
If this sounds complex, just remember: These scientists grew up just like you—filled with curiosity, and working hard to find answers that could change the world.

Check out the unique features that make this telescope a jaw-dropping feat of engineering. The team must be meticulous with construction and testing because the stakes are high—if even the slightest thing goes wrong during or after launch into space, the whole mission could fail!



INFRARED LIGHT The human eye can perceive certain wavelengths as colors. But other waves, like X-rays and infrared light, are invisible to us. Objects that have heat (like stars and planets) give off some infrared radiation, making them detectable by Webb. (Fun fact: Your remote control uses infrared waves to invisibly control your TV!)

CAMERAS AND SPECTROMETERS Webb's four instruments (behind the mirror) can record extremely faint signals and measure different light spectra. The NIRSpec instrument can observe up to 100 objects at a time!



THE SPEED OF LIGHT

The universe is far too enormous to measure in miles. What do scientists do instead?

When you flip a light switch, light seems to fill the room instantly. Light moves faster than anything else in the universe, at 186,000 miles per second. That's astonishingly fast—but it's not instantaneous. In fact, it takes 8 minutes for a beam of light to travel the 93 million miles from the Sun to your eyes. Over vast distances, you can wait years and years to see the light from faraway stars.

Scientists use a measure of distance called a **light-year**, or the distance light can travel in a year. Our nearest galactic neighbor, the Andromeda Galaxy, is 2.5 million light-years away—so the light we see from it is reaching us now, but it left the Andromeda Galaxy 2.5 million years ago. That means we're seeing the Andromeda Galaxy as it was 2.5 million years ago. We don't know what it looks like now because that new light hasn't reached us yet.

This means that if you look far enough away, you can see light from billions of years ago. Read on to find out why that's especially important to the mission of NASA's Webb Space Telescope, which will allow humans to see farther than ever before.

Think *you* have a long to-do list? Check out the ambitious goals scientists have for NASA's Webb Space Telescope:

Time travel: Using infrared vision, NASA's Webb Space Telescope will act as a "time machine" by looking so far away that it will detect light from 13.5 billion years ago to see the first stars and galaxies forming in the early universe. Incredible!

How stars and planets are born: NASA's Webb Space Telescope will be able to see through and into massive clouds of dust in greater detail than even the Hubble Space Telescope! These dust clouds are where stars and planetary systems are formed.

Galaxy formation: To help reveal how galaxies form over billions of years, NASA's Webb Space Telescope will detect extremely faint infrared signals so astronomers can compare the earliest galaxies to today's galactic structures, like ellipticals and grand spirals.

And there's one last, special goal...check it out on page 6!

Photo (in background): NASA, ESA, and the Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration

UNDERSTANDING THE BIG BANG

By combining math and observation, astronomers have determined that the universe began 13.8 billion years ago in a mind-bendingly smaller volume than what we observe now. A remarkable event known as the Big Bang caused the universe to begin expanding dramatically. And scientists have found evidence that the universe still continues to expand, right now, as you're reading these pages!

In the first second after the Big Bang, the temperature was a toasty 10 billion degrees Fahrenheit, and the universe was a "cosmic soup": a dense mix of tiny particles of matter, energy, and light. As this "soup" spread out and took up more space, it cooled down. (Just like if you spilled hot soup on the floor, it would cool down as it spread out.)

The tiny particles began to combine to form atoms; atoms grouped together to form stars and galaxies. The first stars created groups of atoms called molecules. More stars were born! Stars died. Asteroids, comets, planets, and black holes formed too! And through it all, galaxies continue to move away from each other, as the universe continues to expand outward.

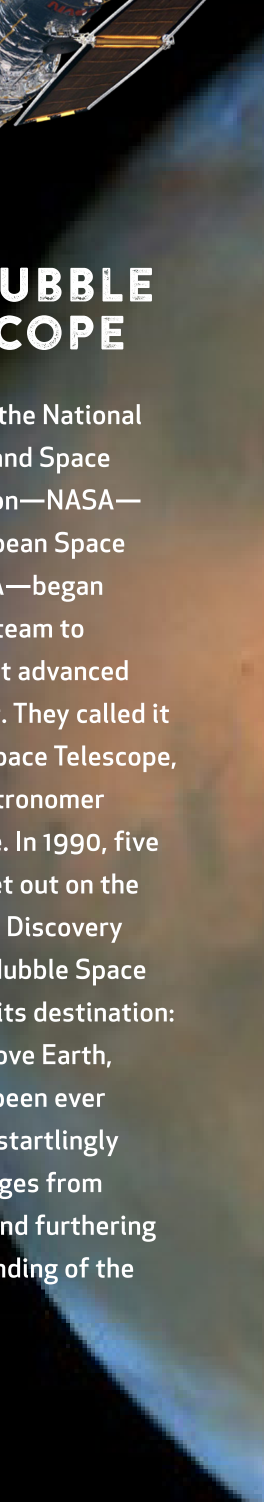
"If you'd asked an earlier version of me about the (real!) planets with metal snow or where the surface temperature would melt steel, I might not have believed it. I sometimes think my imagination is more limited than the universe, so there are even more interesting surprises waiting!"

—Dr. Prabal Saxena, Astronomer, NASA

SPOTLIGHT

THE HUBBLE TELESCOPE

In the 1970s, the National Aeronautics and Space Administration—NASA—and the European Space Agency—ESA—began working as a team to build the most advanced telescope yet. They called it the Hubble Space Telescope, named for astronomer Edwin Hubble. In 1990, five astronauts set out on the space shuttle Discovery to bring the Hubble Space Telescope to its destination: 380 miles above Earth, where it has been ever since, taking startlingly beautiful images from outer space and furthering our understanding of the universe.



The Hubble Space Telescope (above) captured this view of Mars.

Photos: Hubble and Mars, courtesy of NASA

MEETING THE NEIGHBORS

You're probably familiar with the other planets that orbit around our Sun—like our nearest neighbor, Mars, or the ringed planet, Saturn. But there are also extrasolar planets, or **exoplanets** for short—they're planets that orbit (or circle around) other stars.

For centuries, scientists have not been able to observe these exoplanets with telescopes, because they're blocked by the light given off from the stars they orbit. They've had to rely on other ways to learn about them, such as studying the way they affect nearby celestial bodies.

NASA's Webb Space Telescope will take our understanding of exoplanets to a whole new level. With Webb, we can not only find these planets but really understand what they are and where they came from.

Illustration of the possible surface of one of the TRAPPIST-1 planets, with hoped-for water on the surface and other planets visible in the sky

ASTRONOMICAL DISCOVERIES

One planetary system scientists are eager to learn even more about is called the **TRAPPIST-1 system**, which is believed to have seven Earth-sized planets orbiting its central star 39 light-years away.

Using a combination of telescopes, astronomers discovered that most of the planets in this system are rocky and solid (versus being made of gases like hydrogen or helium). This is a big deal because a rocky planet could hold water, a "building block of life." Scientists generally search for **liquid water** to determine if a planet could sustain life. So far, Earth is the only planet we know of that has liquid water on its surface (though some other planets have ice). We haven't observed signs of life anywhere else yet, but the universe is vast and we have searched only a tiny bit of it.

Photo: exoplanet, NASA Goddard; Illustrations: NASA/JPL-Caltech

"The possibility that we could one day be living on the surface of another planet is truly inspiring."

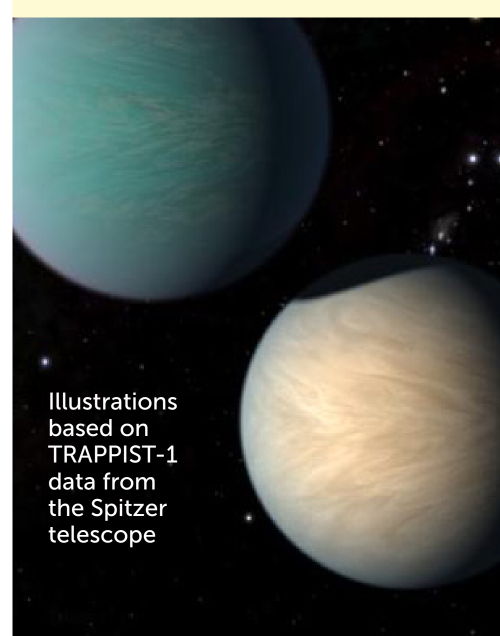
—Dr. Geronimo Villanueva, NASA Planetary Scientist

One of the most exciting astronomical discoveries of the last few years is that three of the TRAPPIST-1 planets are orbiting in the possible **habitable zone**, where rocky planets are most likely to hold liquid water (like on Earth). This is a remarkable possibility! Could there be signs of life, or "fingerprints of life" on any of these planets? Without leaving Earth, scientists will use NASA's Webb Space Telescope to search the **atmospheres** of faraway planets for certain molecules, like oxygen, that sustain life!

But NASA's Webb Space Telescope won't just study objects in other star systems and galaxies—it will explore our solar system, too. It will observe planets like Mars and dwarf planets like Pluto and Eris, as well as asteroids, comets, and Kuiper Belt Objects (which make up the large ring circling our solar system). It will tell us about weather on Mars and Saturn, identify the minerals in asteroids, and much more. By studying our cosmic neighbors, we can get to know our universe better.

LOOKING AHEAD

Once NASA's Webb Space Telescope launches into space, it will conduct some 180 maneuvers to unfold itself, a process that takes about two weeks. (Wow!) Scientists and curious people everywhere are looking forward to celebrating this revolutionary feat of engineering. And then—breakthrough cosmic discoveries await!



Illustrations based on TRAPPIST-1 data from the Spitzer telescope

MEET THE TEAM

Get to know some of the thousands of scientists and engineers working on NASA's Webb Space Telescope.

NORA LUETZGENDORF

Instrument Scientist, European Space Agency

It was Nora Luetzgendorf's grandfather who first got her into astronomy. "He'd tell me about black holes at the breakfast table," she recalls. Now, she and her team are making sure that the NIRSpec instrument on NASA's James Webb Space Telescope will be ready for scientists to use once the telescope is launched—and she's eager for what we'll find out. "I'm mostly interested in black holes, and JWST will observe the most massive and the oldest black holes in the universe."

Luetzgendorf's road to scientific success was "100 percent worth it," she says. **"When I decided to study physics I had some people (even in my own family) telling me that this might be too hard, and that many people fail. Don't listen to things like that. I had to work hard, but I love what I do so much."**

Her favorite part of the job is the hands-on aspect, "like when we stick the telescope in a giant fridge and simulate space in the different NASA centers."

DANNY MANUEL

Mechanical Engineer, Northrop Grumman

Growing up, there was one thing Danny Manuel loved more than anything else: playing basketball with his friends. But he was also interested in math, which ultimately led him to become a mechanical engineer.

"A *lot* of kids used to complain about learning so much math, or thought they'd never use it again," he says. "The way I saw it, math trains us to solve problems critically."

Now, he compares his role as a mechanical engineer on Webb to "putting together LEGO sets, but with huge spacecraft components." His team spends a ***lot*** of time on testing, to ensure that everything will go well in space. "We've only got one chance to get this right!" he says.

Manuel hopes Webb will shed light on whether we're alone in the universe and what caused the Big Bang to happen the way that it did. And looking ahead, he believes scientific discovery will shape our lives. **"It's an incredibly exciting time to be alive," he says. "The future is waiting to be built by young, sharp minds."**

NESTOR ESPINOZA

Astronomer, Space Telescope Science Institute (STScI)

From the time Nestor Espinoza was in 7th grade, science has always seemed wondrous. "I found it a bit magical that one could predict things like the movement of the world around us, using math," he says.

His biggest inspiration came from his physics teacher. "Before she reached out to me, I thought I had no chance of doing science, because I didn't fit in to the 'TV scientist' stereotype," he says. "And growing up in Chile, I had no idea science was a thing I could do for a living. But she told me that I could not only be a scientist—she believed I could actually be a pretty good one."

In his job, Espinoza makes sure that instruments onboard Webb will be able to extract all kinds of signals from the universe. His particular scientific focus: how scientists can use Webb to study distant exoplanets.

"*Anyone* can do science," he insists. "Science is for everyone. You don't need to be a straight-A student or a genius. You—yes, *you*—can become a scientist."

AMBER STRAUGHN

Astrophysicist, NASA

Amber Straughn grew up in rural Arkansas where the night sky was very dark, setting off her curiosity about the stars from a young age. Now, she researches how stars form in distant galaxies, how galaxies evolve, and how gigantic black holes affect galactic growth.

There are still many unanswered questions. Straughn explains, "We are missing a crucial piece of the story of how galaxies change over time: seeing how it all got started. With Webb, we hope to see the very first galaxies born after the Big Bang—the first page in the cosmic book. I think the universe is full of surprises we'll discover with Webb."

Her advice for teens and professionals alike? Don't be afraid to ask for help! **"One scientific stereotype I really dislike is the one of the 'lone genius' working away at their research…this just doesn't happen. Diverse teams of people who think about things in different ways inevitably come up with more creative ideas."**

Photos: courtesy of Nora Luetzgendorf, Danny Manuel, Nestor Espinoza, and Amber Straughn

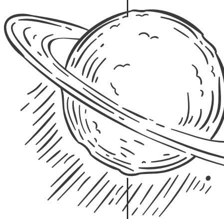
EXPLORING REDSHIFT (AND THE UNIVERSE!)

Find out about the phenomenon of redshift below, then answer the questions.

How can an ice cream truck help us understand the universe?

Imagine an ice cream truck playing a cheerful tune. When the truck is parked, the tune you hear is the same as the tune coming from the truck's speakers—the **wavelength** of the sound doesn't change as it travels. However, when the truck is approaching you, you will notice that the **pitches** that you hear become higher and higher. The same number of sound waves leaves the ice cream truck, but because the truck is moving, the waves become closer together. Consequently, the **frequency** of the sound waves increases, so you hear a higher pitch. The opposite is true as the truck drives away—the wavelength decreases and the frequency decreases, so you hear the pitch become lower and lower.

This phenomenon, known as the **Doppler effect**, is also observed in light waves. As an object moves away from you, the light waves it emits are stretched farther apart, and the wavelength increases. On the **spectrum** of visible light, red has the longest wavelength, and blue and violet have shorter wavelengths. Therefore, as the object moves farther away, its light appears to shift to the red end of the spectrum. While the object itself emits the same light as always, **redshift** occurs by the time that light reaches you. (You would not be able to observe redshift with your eyes alone; instead, you would need to use scientific tools to separate the light into its component wavelengths.)



Redshift is a particularly important concept in understanding the universe. In 1929, astronomer **Edwin Hubble** used his observations of redshift from faraway galaxies to determine that galaxies were moving away from each other—and the farther away they were, the faster they were moving away. This discovery provides evidence to support the **Big Bang** theory.

Today, scientists continue to investigate the redshifted light from distant galaxies to better understand the origins of the universe. Light from so long ago, that is so far away, has redshifted out of the visible light spectrum and into the **infrared spectrum**, invisible to the human eye. That's why powerful telescopes like NASA's Webb Space Telescope are built to detect infrared light, to better study how the first galaxies formed.

Think It Through

Answer the following questions on a separate sheet.

1. Based on what you've learned about redshift, predict what blueshift is. What situations would cause blueshift?
2. Draw a diagram to demonstrate the concept of redshift in space observation.

Learn more or check your work with diagrams of redshift at: **go.nasa.gov/2PDPVN9**.

STAR POWER

Read the article to learn about how stars produce elements, then answer the questions.

Stars aren't just nice to look at—check out these other claims to fame!

☆ Stellar Energy

Stars shine because they give off a huge amount of energy—but where does this energy come from? The answer lies with the hydrogen atoms in the star's core. The heat and pressure within a star, along with the star's gravity, are great enough to drive two hydrogen atoms together in the process of **nuclear fusion**. Through this process, multiple hydrogen ions combine to form a single helium ion. Because the protons in each hydrogen atom have the same positive charge, this reaction requires a great deal of energy to get started. The result of the process is one helium nucleus, particles known as positrons and neutrinos, and a vast amount of energy in the form of gamma rays.

☆ Hydrogen, Helium, and the Big Bang

The Big Bang theory states that the universe rapidly expanded from its early hot, dense state. Within the first 20 minutes after the Big Bang, hydrogen and helium nuclei formed as protons and neutrons collided. As time passed, neutrons began to decay, and there were no longer enough neutrons to form additional helium nuclei. Scientists calculate that based on the rate of expansion suggested by the Big Bang theory, the universe should be **approximately ¾ hydrogen and ¼ helium**. And indeed, this is the proportion that we observe in the universe today!

In 1925, **Cecilia Payne** was the first to determine that stars are primarily made of hydrogen and helium.

☆ The Other Elements

If hydrogen and helium began to form just after the Big Bang, where do the other elements on the periodic table come from? These atoms are produced by stars as well. In older stars known as **red supergiants**, the hydrogen supply becomes depleted, and the star becomes hotter. The increase in energy allows helium atoms to start to fuse into new elements such as carbon, oxygen, magnesium, and silicon—all of the elements in the periodic table up to iron. At that point, iron atoms will not continue to fuse with other atoms because the reaction would require more energy. Eventually, however, the star will collapse, then explode in a **supernova**, creating a variety of elements that are heavier than iron and will be dispersed in the universe.

Questions

Answer the following questions on a separate sheet.

1. Explain how the universe would be different without the existence of stars.

2. Create a visual model for how stars produce helium and other elements.

Want to find out more about how a star is born, lives, and dies? Visit: **go.nasa.gov/3sTKS9A**.