



 apologia.

EXPLORING CREATION WITH
EARTH SCIENCE
2nd EDITION



Yunis

LESSON 1

THE OBSERVABLE UNIVERSE



worldview

When someone asks you, “Where do you live?” do you think about your neighborhood, your town, or even your country? Most people probably think about their mailing address. But we will learn that our home address extends to the planet we inhabit and even the far reaches of the universe. It’s all connected, and we’ll learn how.

How countless are your works, LORD! In wisdom you have made them all.
Psalm 104:24



WELCOME

You might be reading this book on a swing under a tree in your backyard, or maybe you are sitting on your balcony in a big bustling city. No matter where you are located on the planet Earth, you are home! And home is a great place to be.

We’re going to spend this year together studying our home planet. And while you might think that you know all about your home planet, I hope that you will be surprised by the things you are going to learn. You see, right now, a sloth is moving slowly through a rainforest somewhere deep in the Amazon. You probably don’t think about sloths every day, but they add to Earth’s beauty.



sloth in the rainforest

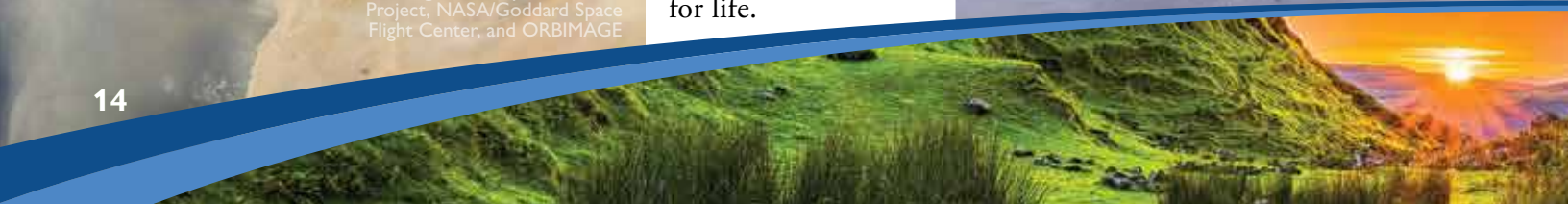
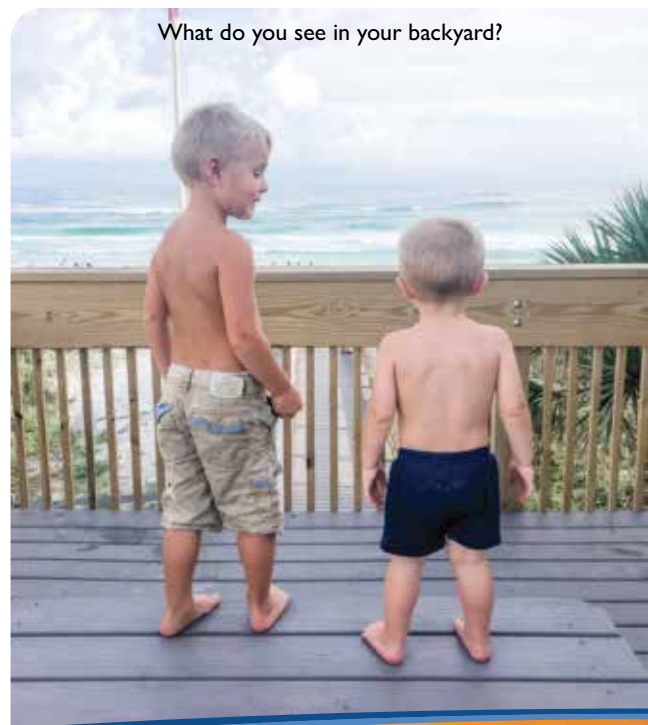
And right now, a whale is swimming in an ocean that you may or may not be able to see from your home. And that ocean is an important part of the Earth.

Winds in Africa blow huge amounts of dust across the ocean where that whale is swimming, and that dust fertilizes the rainforest home of that sloth. And believe it or not, you are connected to it all! It’s true. That rainforest is producing oxygen for you to breathe. Clouds that form over the forest will rain in different places on our planet, and that rain will give us water to drink and keep plants alive. No matter where you look, it’s a beautiful planet that we call home, and it has *everything* necessary for life.



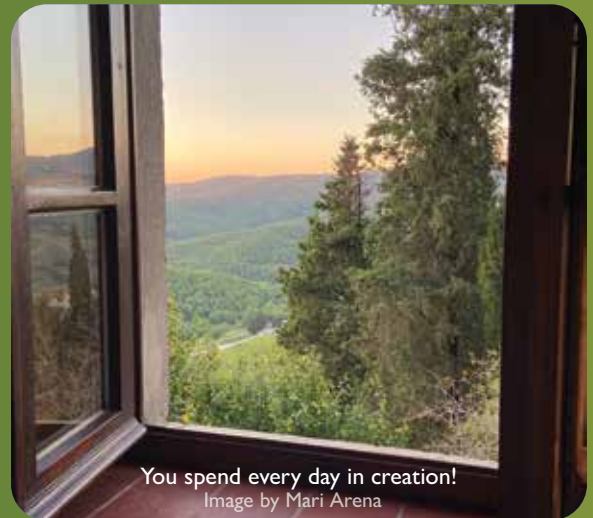
dust storm off the coast of Africa

Image courtesy of SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE



creation confirmation

Did you know that science can help you grow in your understanding of God? You see, everything that we study and learn, God already knows. There's a world of awesome science that we are about to discover, but as we learn new things together, the most important fact to remember is that God created it all out of nothing. God knows everything! And that everything includes the science of all that you see, like trees and clouds and even things that you cannot see, like air or even the tiny atoms that make up everything. When we study the science of the Earth, you can think about it as another way to get to know God's creation and His love for you.



You spend every day in creation!
Image by Mari Arena

I made the earth, and created humans on it. It was my hands that stretched out the heavens, and I commanded everything in them. (Isaiah 45:12)



Even the heavens declare the glory of God.

In fact, as we study Earth science together, we can confidently say that we are submerged in God's presence, surrounded by all things that bring us closer to our Creator. And the more you learn about our amazing Earth, the more amazing God becomes.

Oh, Lord God! You yourself made the heavens and earth by your great power and with your outstretched arm. Nothing is too difficult for you! (Jeremiah 32:17)

Let's get started exploring creation together! Along the way, be sure that you don't get so busy with the science facts that you forget that we take this journey with God as our guide!

Trust in the LORD with all your heart, and do not rely on your own understanding. (Proverbs 3:5)

Always see the wonder around you.



As we start our journey together, I want you to know that it is okay for you to question everything in science. In fact, I encourage you to do just that. Asking questions is what scientists do. We're going to explore together as scientists, turning over rocks and peering underwater to see what makes our planet such a great place to live.

To understand our home planet, we have to take a look at the bigger picture of creation.

LESSON 1

And I mean really big! Think about you, then keep thinking bigger by including your family, your street, your city, your state, your country, Earth, other planets, the Sun, other stars, and finally everything that you cannot see. All these things together make up our huge **universe**, which some scientists call the **cosmos**. Since the cosmos is everything, the Earth is part of the universe.

The spacecraft *Cassini* captured this image of our home planet, Earth, through the rings of Saturn.



Image courtesy CICLOPS team.



Tools, like binoculars, help us in our science studies.

with the best technology, they can only see so far. After that distance, we don't know what is out there in space. What we do know is that our observable universe is getting bigger with time. Let's do an activity to help you understand our expanding universe.

THE OBSERVABLE UNIVERSE

Let's start our studies with the biggest address we know something about; it's called the **observable universe**. Why do we call it that? Well, that is a good question, and the answer is simple. Our universe is so big that we can't see it all, even with the best technology we have. Think about it. You can see what is in your backyard. If you use binoculars, you can see even farther. But you can't see what's beyond that, right? Some things are just too far away.

Astronomers are scientists who study outer space. They use telescopes and spacecraft to explore deep into space, and what they observe and share with us is breathtaking! But even



star cluster in space

X-ray: NASA/CXC; Infrared: ESA/Webb, NASA & CSA, P. Zeidler; E.Sabbi, A. Nota, M. Zamani; Image Processing: NASA/CXC/SAO/L. Frattare and K. Arcand

Activity 1.1

EXPANDING UNIVERSE PUTTY

You will need:

- Bottle of clear craft glue
- 2 small mixing bowls
- Borax powder
- Water
- Spoon
- Blue and red food coloring
- Silver sparkles (the more the better)
- 2 marbles or other small objects
- Small zipper-style plastic bag
- Gloves (optional) to keep your hands from staining



You will do:

1. Place about $\frac{1}{4}$ cup of clear glue into a bowl, dilute it with $\frac{1}{4}$ cup of water, and stir. The glue will get thinner.
2. Add 6 drops of blue food coloring and 3 drops of red food coloring and stir to get a nice deep dark color.
3. In the second bowl, put 1 tsp. of borax. Add $\frac{1}{2}$ cup of water to cover the powder and stir. It's OK if it doesn't completely dissolve.
4. Tilt the borax solution bowl to keep any undissolved crystals at the bottom. One spoonful at a time, add the borax liquid to the glue mixture and stir. You will see it thicken with each spoonful. You want the final material to be goeey and able to flow; you do not want it to be too thick and rubbery.
 - a. If your mixture gets too thick, add only water and knead your material until it breaks down a bit.
 - b. If your mixture doesn't get thick enough, add a little more borax to the water bowl and slowly add that to your glue bowl.
5. Mix in your sparkles (add a lot) and knead them throughout your putty. They should become part of your putty and not be loose.
6. When you have a good consistency, add your 2 marbles and mix them into your putty. Look at their distance from each other and then stretch out your putty. Note what happens to the marbles (and even the sparkles) as your putty expands. Do this a couple of times.
7. Enjoy playing with your expanding universe putty. Please keep it away from small children and pets who might mistake it for food. Also, keep it away from carpeting and furniture where it could create a goeey mess or stain.
8. Store your putty in a zipper-style plastic bag to keep it soft.



EXPANDING OUR MINDS

What did you learn from the expanding universe putty activity? Well, I hope you noticed 3 things.

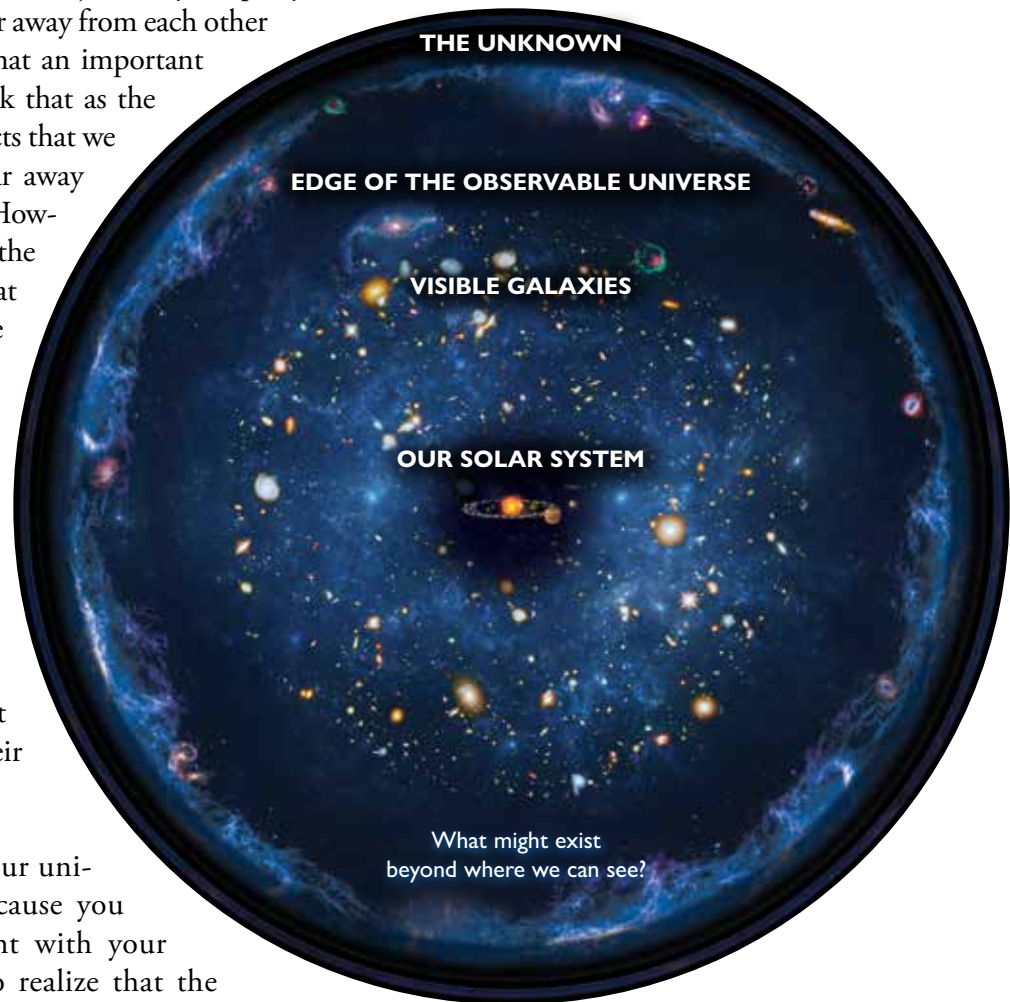
1. You should have been able to see that objects in your putty, like the marbles and sparkles, got farther away from each other as your putty expanded. Why is that an important observation? Well, you might think that as the universe expands, it will cause objects that we can see today to one day be so far away that they become unobservable. However, as long as there are objects in the sky emitting or reflecting light that we can see today, we will always see them no matter how far away they move. The light is always traveling toward us faster than the objects are moving away.

So why do we care that the universe is expanding if we can still see the lights in the night sky? Well, what we may never see would be the lights in the current unknown parts of our universe that will always be too far away for their light to ever reach us.

2. You might have observed that your universe got flat as it stretched because you could only pull it left and right with your hands. It's important for you to realize that the universe is expanding in every direction sort of like a balloon that is inflating in all directions at the same time.

And it wasn't just the sparkles and the marbles moving, was it? Your putty was moving too. If the marbles and sparkles represented objects in the universe, what is the putty? That's a great question to ask! Scientists currently don't understand a lot about what they call the *fabric* of the universe. In fact, they use terms like *dark matter* and *dark energy* to describe it. Why do you think that might be? Scientists call it *dark* because they currently can't see it or measure it. When you get older, perhaps you will investigate dark matter and dark energy.

3. Lastly, it's important to know that we look out into the universe from our position on Earth, and it looks as if we are the center of everything. But pretend one of the marbles is Earth. If you were standing on the marble, it would look like everything is moving away from you. We must be in the middle of the expansion, right? No! It looks the same from every position. You can see this if you now look at the other marble. From that point of view, it feels like we are at the center because that is the only **frame of reference** that we have. You're smart enough to know that they can't both be the center. So where is the center? As far as we know, no matter where you are in the universe, it looks like it is expanding so there is no true center. Let's do a quick activity to understand frame of reference.



Activity 1.2

UNDERSTANDING FRAME OF REFERENCE

You will need:

- Yourself
- Several different rooms in your home

You will do:

1. We are going to pretend that each room is a different galaxy in the universe, and you are a star in that galaxy. Stand in the center of your first room and look around. It looks like you are the center of everything, right? If you are at the center of this room, then everything outside this room must center on you too. But is that really true?
2. Stand in the next room and look around. You are once again the center even though you have changed your position to a completely different room. Hmm, you've found 2 centers. What's going on here?
3. Pick a third room a little farther away from the first 2 rooms and stand in the center of it. It should still feel as if you are in the center of it all. How is that possible?

If each room is a different galaxy, how can each one be the center of your model of the universe? The answer is that it can't. It just looks and feels that way. And I hope that you understand frame of reference a little more now.

I also hope you could see that no matter which "galaxy room" you were in, the rest of the "universe" seemed like it centered on you. The fact for you to remember is that we don't know if the universe has an actual center or where we should even begin to look for one. The universe is so large, and there is more than we can observe with the technology currently available to us.

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Take a minute to think about all of this. We can only see so far with the technology we currently have, and the universe is expanding. What might be beyond the observable universe? Is there more universe that is expanding? Scientists currently believe that the unobservable universe probably looks like our observable universe. But we may never know for sure, or maybe one day you'll be the first scientist to find out what is there! We certainly do live in a universe full of mystery, wonder, and awe. The one thing we can be certain of is that God is the Creator of all things, even the things we don't understand.



By faith we understand that the universe was created by the word of God, so that what is seen was made from things that are not visible. (Hebrews 11:3)

In your own words describe what the observable universe is, why we say it is observable, and how it is expanding. What do you think is beyond the observable universe?



OUR PLACE IN SPACE

It is important for you to realize that our Earth is part of the universe, so you are a part of the universe! **Astronomy** is the branch of science that studies the observable universe beyond Earth's atmosphere.

Let's work our way in from the edge of what we can see. We'll start with lots and lots of observable galaxies. What is in a galaxy? Well, a **galaxy** is a group of billions of stars, planets,

dust, and gas all moving together. From far away, a galaxy can look like one star. Think back to your expanding universe putty. You can imagine

that each piece of silver sparkle was a separate galaxy. That seems like a lot, right? Well, some scientists think that there could be as many as 2 trillion galaxies in our observable universe. That's a huge number! If you were going to count nonstop to 2 trillion, it would take you more than 60,000 years! I don't know anyone who has that many candles on a birthday cake. The observable universe has more galaxies than we can count in our lifetime.



These look like stars, but they are actually galaxies.

Image courtesy NASA, ESA, CSA, and STScI



Andromeda galaxy

Three Galaxy Shapes

We are going to talk about 3 main galaxy shapes. **Elliptical galaxies** are shaped like an elongated sphere and are brightest at their centers. **Spiral galaxies** have a bright center like the elliptical galaxies, but they also have arms that spiral out from their centers. Spiral galaxies are the most common form of galaxy found in the observable universe. **Irregular galaxies**, as you might suspect from their name, have no regular shape. If you study astronomy, you'll learn about lenticular galaxies which are like a mix between elliptical and spiral galaxies.

ELLIPTICAL GALAXY



SPIRAL GALAXY



IRREGULAR GALAXY



Elliptical galaxy image by NASA, ESA, and the Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration; Acknowledgment: M. West (ESO, Chile), Spiral Galaxy by NASA, ESA, Benne Holwerda (University of Louisville), Irregular galaxy by NASA, ESA, and the Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration; Acknowledgment: R. O'Connell (University of Virginia) and the WFC3 Scientific Oversight Committee

Activity 1.3

CREATE A GALAXY MOBILE

You will need:

- 3 wire hangers
- Metallic chenille sticks
- Thread
- Tape

You will do:

1. Use a chenille stick to attach the 3 wire hangers together.
2. Turn the base of the 3 hangers to form a 3D shape, and use another chenille stick to hold them in place. Set this aside.
3. Cut a piece of thread (between 12 and 18 inches) and use one end to tie a knot in the middle of a chenille stick. Twist the chenille stick around to form a galaxy shape—either elliptical, spiral, or irregular. Set it aside.
4. Repeat step 3 until you have made lots of galaxies in lots of shapes. Remember that the spiral galaxy shape is the most common, so make lots of them.
5. Find a place where you can hang and easily access your project and use tape to attach the threads of your galaxies at different heights around your hangers.
6. Display your galaxy mobile where you can share your knowledge about the mysteries of our universe.



I hope you made a lot of galaxies for your mobile. I added about 20 galaxies to mine. Can you imagine what it would look like if you added 200 galaxies? That would be a lot! It's hard to imagine that there could be 2,000,000,000,000 galaxies in the observable universe.

The Milky Way Galaxy

Does Earth reside in a specific galaxy? You bet it does! Our galaxy is a spiral-shaped galaxy called the **Milky Way**. You might think that our galaxy must be rather small since it seems like a dot in the universe. Nothing is further from the truth. It's really hard to imagine just how large our galaxy is, but let's try.

The fastest thing we know is the speed of light. How fast is it? Let's just say that light can go from Earth to the Moon in about 1 second. Light is fast! How far can you run in a second? If we could travel as fast as light, it would take us 100,000 years to go from one end of our galaxy to the other end of our galaxy. We can't travel as fast as light. We can't even get close to its speed. How fast can we travel?



Image by NASA/JPL-Caltech

LESSON 1

Well, the astronauts who went to the Moon were moving pretty fast in their spacecraft. Let's look at some numbers and try to figure this out.

Speed of light
671,000,000 mph
(miles per hour)

Astronaut speed
25,000 mph

Race car speed
200 mph

Just by looking at the size of the numbers, you can see that even though race cars are fast and fun to watch, they're actually pretty slow. The astronauts traveling to the Moon were moving pretty fast, but they were not anywhere near the speed of light! If it takes light 100,000 years to go from one end of our galaxy to the other, it would take a human being a lot longer to explore that distance! And until we have the technology to travel those distances, we will enjoy learning about the universe from the comfort of our home planet.

If you are ever outside on a really dark, clear night, you might be able to see a tiny portion of our galaxy. It can look like a blurry line of stars in the sky. It is estimated that our Milky Way galaxy could be made up of about 400 billion stars!



Explain whether you could count all the galaxies in the observable universe. Can you name the 3 main shapes of galaxies? What is the name of the galaxy we live in?

Earth →

The *Pale Blue Dot* is a photo of Earth that *Voyager 1* took when it was about 4 billion miles from the Sun.

Image by NASA

and even walked on it! That trip took 3 days to get there. Perhaps one day in your lifetime you will see humans exploring further out in space.

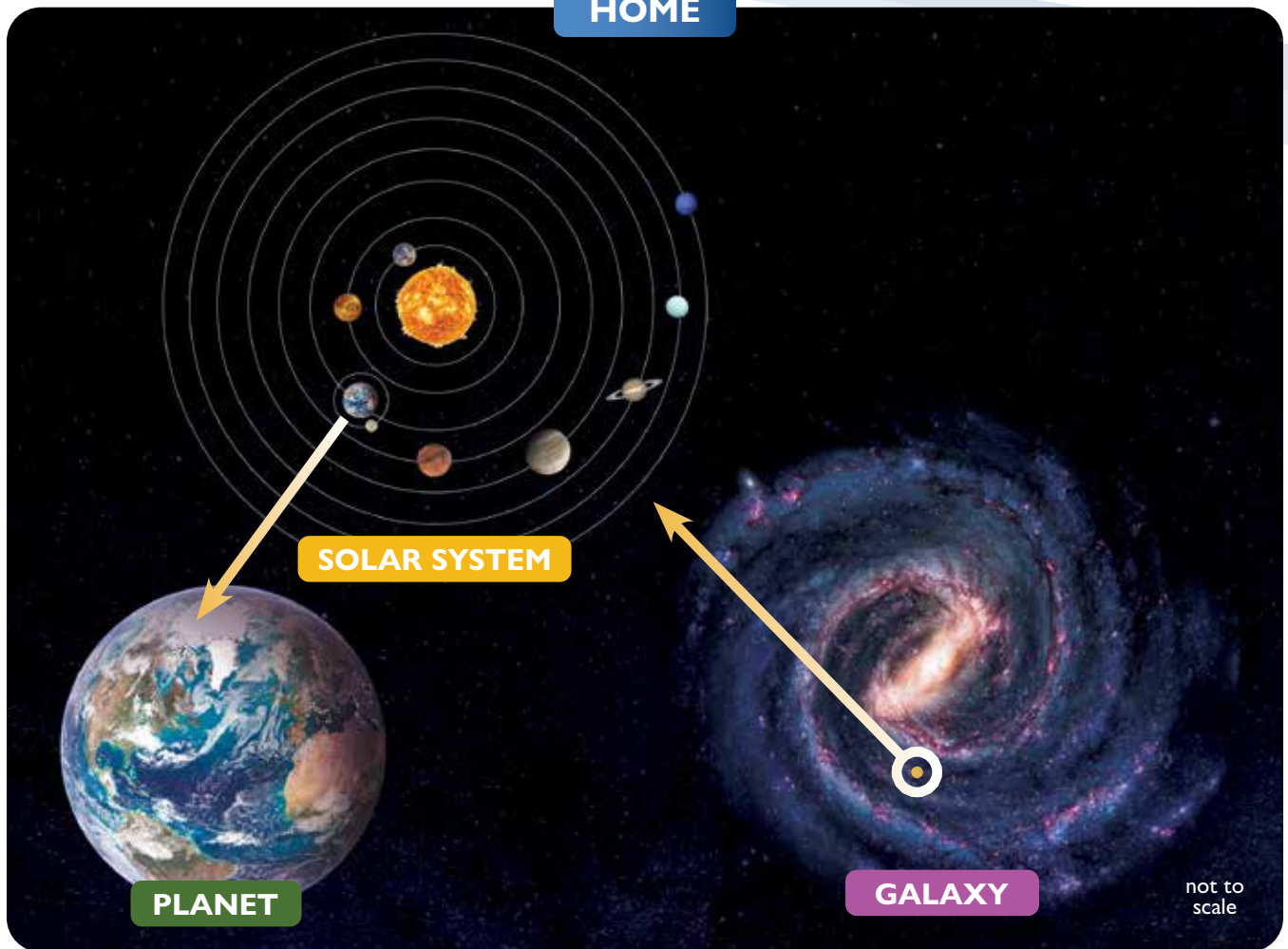
Our Solar System

We're getting closer to home now. Inside our Milky Way galaxy, our **solar system** consists of our Sun and the planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

Even though we are getting closer to home, our solar system is still very large. The spacecraft we have sent farthest away from Earth are called *Voyager 1* and *Voyager 2*. It took 40 years for them to go beyond the edge of our solar system. So while we can explore our solar system, it's not that easy. Still, over the last 50 years, many spacecraft have visited the other planets in our solar system. These trips sometimes take years. We have landed spacecraft on planets, moons, and asteroids. Each one of these is different from Earth, so we still have much to learn.

Do you know the farthest any human being has gone so far? Well, astronauts have traveled all the way to the Moon

HOME



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Have you noticed that in this book we have chosen to capitalize the words *Sun* and *Moon*, which are usually lowercase? We did that to differentiate them from other stars (suns) and moons beyond Earth.

The star in our solar system is officially named Sun. All of the other stars in the universe are given different names. The next closest star to Earth is called Proxima Centauri.

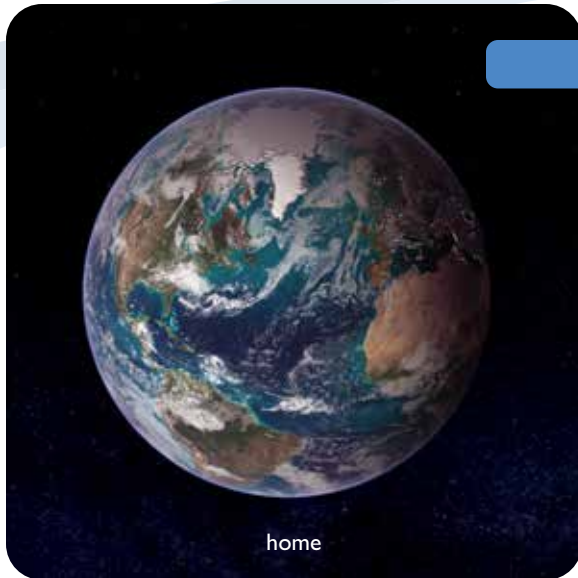
Likewise, the moon that orbits our planet is officially called Moon. Every other moon discovered is given a different name. For instance, the moons around Mars are called Phobos and Deimos.



Earth's beautiful full Moon

Your Cosmic Address

We started this lesson asking the worldview question, “Where do you live?” Do you still think of your home address in the same way you did before you started this lesson? I hope not. Your cosmic address doesn’t end with your country or even your planet. Let’s end our lesson traveling outward as we see what we can say about our address if we start with our planet, Earth.

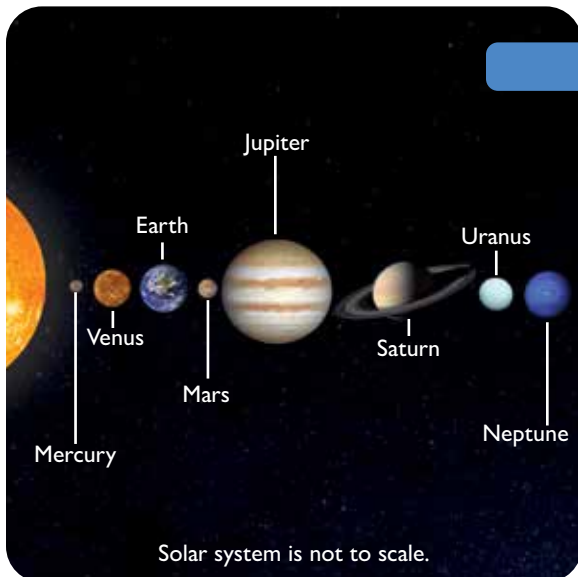


EARTH

Earth is our home planet. It's the only home we have. We can explore the other planets in our solar system, but humans haven't yet walked on their surfaces or tried to live there. As far as we know, nothing lives on any planet in our solar system except Earth. We have not found bacteria, plants, animals, or intelligent beings. Earth is a special planet; it is a gift from God.

The earth and everything in it, the world and its inhabitants, belong to the LORD.

Psalm 24:1




SOLAR SYSTEM

Earth looks tiny when you compare it to the size of our solar system. The Sun is the star at the center of our solar system. Did you know that you could fit over one million Earths inside the Sun? The Sun is that big! Eight planets orbit the Sun. They are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. We explore the planets in our solar system by sending spacecraft to orbit them or land on their surfaces.



INTERSTELLAR NEIGHBORHOOD

At this point, we use telescopes to explore space. Our solar system resides in an area known as an **interstellar neighborhood**. There are other stars besides our Sun in this neighborhood. Remember how fast light travels? Well, you would have to travel as fast as light for over 4 years to get to the next closest star. That might seem reasonable to you, but you know we can't travel as fast as light. With our current speeds, the Earth would age about 80,000 years before we could get there. That's a long time, and we are still on one of the spiral arms in our Milky Way galaxy. Our interstellar neighborhood would just be a small dot of light among many in our Milky Way galaxy.

 approximate location of our solar system within the Milky Way galaxy

OTHER GALAXIES

Our galaxy is very big, but the universe has trillions of galaxies. In fact, the Milky Way galaxy's closest neighbor is called the **Andromeda galaxy**. It is also a spiral galaxy, and it is the farthest object in the sky that you can see with your own eyes, although it will look like a tiny twinkle of light. How far away do you think it is? Well, if you turned on a really powerful light and aimed it at the Andromeda galaxy, it would take that light 2.5 million years to get there!



Andromeda galaxy

OBSERVABLE UNIVERSE

It's hard to comprehend how many galaxies there just might be in the observable universe! Maybe 2 trillion galaxies isn't even a big enough number. And each one of these galaxies has billions of stars and planets to explore.



The Hubble Space Telescope captured infant stars forming in the Small Magellanic Cloud.

THE UNIVERSE

And now we're back where we started at the beginning of this lesson. What do you think is out there beyond what we can see?



our observable universe

