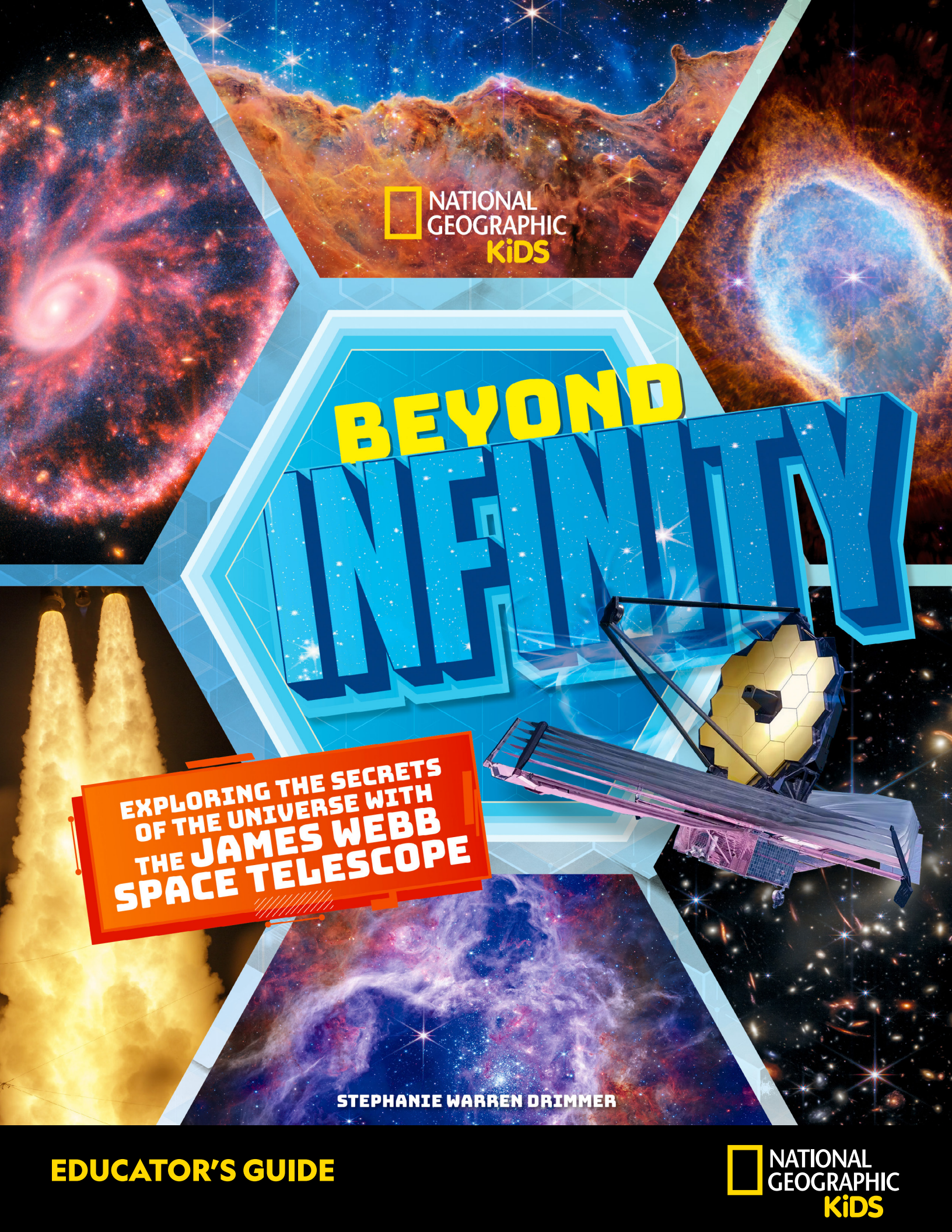
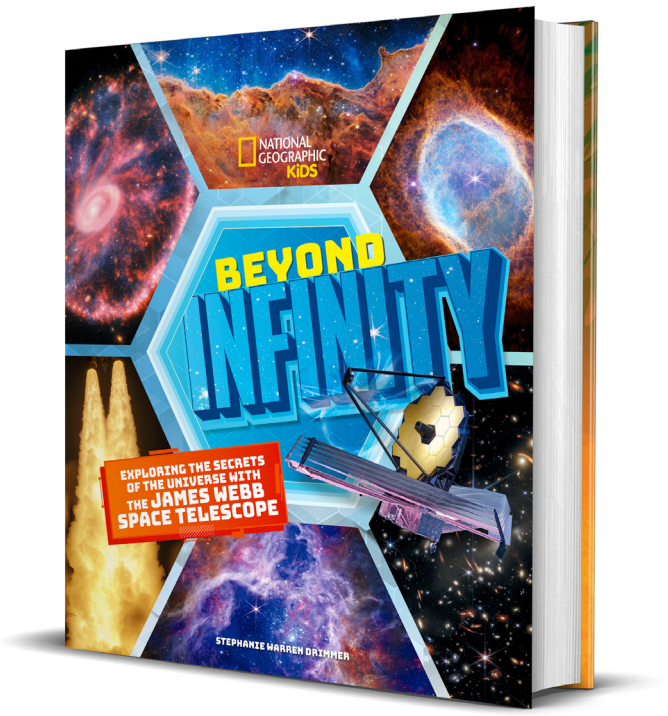


EDUCATOR'S GUIDE

NATIONAL GEOGRAPHIC KIDS

ABOUT THE BOOK



See farther into the universe than ever before and discover how NASA's James Webb Space Telescope is unlocking the mysteries of space!

Have you ever wondered what the universe looked like billions of years ago, or asked yourself what might happen if galaxies collided? The James Webb Space Telescope gives us never-before-seen glimpses of the answers to these questions, showing us the birth and death of stars and galaxies, helping scientists find Earthlike planets, and even revealing asteroids closer to home. This book explains the amazing science of the James Webb Space Telescope in a fun and accessible way, helping kids understand the big questions the telescope will help us answer.

In this book, you'll find tons of beautiful photographs taken by the telescope, all with kid-friendly captions. You'll learn how the telescope works and how it was built, hear stories about the team behind it and the science that made it possible, discover fun facts about the telescope, and meet real NASA scientists. Above all, you'll delve into the mysteries of the universe and find out just how much more there is to discover.

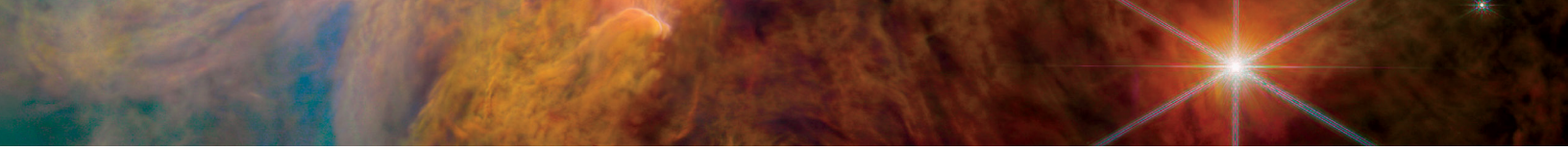
ALIGNED FOR GRADES 2–7 IN BOTH COMMON CORE ELA AND NEXT GENERATION SCIENCE STANDARDS

2nd grade: CCSS: ELA.RL.2.1,3,5,6,7; RI.2.1,2,3,4,6,8,9; W.2.1,2,3; SL.2.1,2,5; L.2.1,2,3,4; NGSS: K-2-ETS1-2; K-2-ETS1-3
3rd grade: CCSS: ELA.RL.3.1,3,4,7; RI.3.1,2,3,4,6,7; W.3.1,2,3,4,7,8; SL.3.1,2,3,4,5; L.3.1,2,3,4; NGSS: 3-5-ETS1-1; 3-5-ETS1-3
4th grade: CCSS: ELA.RL.4.1,2,3,4,6; RI.4.1,2,3,4; W.4.1,2,3,4,7; SL.4.1,2,5; L.4.1,2,3,4; NGSS: 3-5-ETS1-1; 3-5-ETS1-3
5th grade: CCSS: ELA.RL.5.1,2,3,4,6; RI.5.1,2,3,4; W.5.1,2,3,4,7; SL.5.1,2,5; L.5.1,2,3,4; NGSS: 3-5-ETS1-1; 3-5-ETS1-3; 5-ESS1-1
6th grade: ELA: RI.6.1-5, 7-8; W.6.1-4, 7-9; SL.6.1-5; L.6.4-5; NGSS: MS-ETS1-2; MS-ETS1-3; MS-ETS1-4
7th grade: ELA: RI.7.1-4, 8; W.7.1-4, 6-9; SL.7.1-5; L.7.4-5; NGSS: MS-ETS1-2; MS-ETS1-3; MS-ETS1-4

Photo credit: Nataliya Burnley

ABOUT THE AUTHOR

STEPHANIE WARREN DRIMMER is a longtime writer for *National Geographic Kids* magazine and has written several books for Nat Geo Kids, including *Hey, Baby!*; *The Book of Heroines*; *Surprising Stories Behind Everyday Stuff*; and *Mastermind*.



BEFORE READING

Before reading *Beyond Infinity: Exploring the Secrets of the Universe with the James Webb Space Telescope*, consider: What questions do you have about outer space, space exploration, or astronomy? Record these questions in the **QUESTIONS I/WE HAVE** column on the next page.

While reading, take notes in the **THINGS I/WE LEARNED** column.

Pause before each page turn to continue to fill out the chart, either individually or working as a class with the chart on the board.

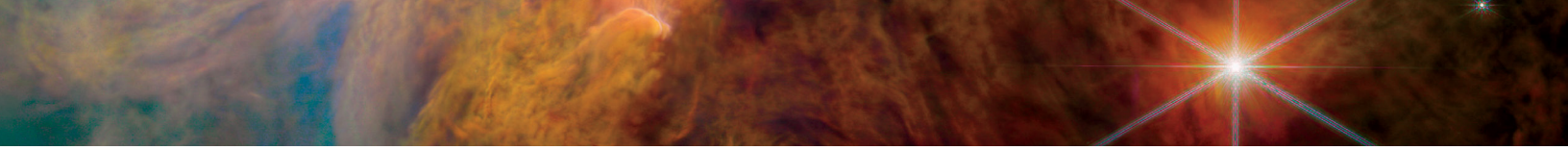
- Once finished reading, look closely at the **QUESTIONS I/WE HAVE** column.
  - Were any of these questions answered as the book went along?
  - If so, find the answer within the text.
  - Record the answer next to the question in the third column, labeled **ANSWERS I/WE FOUND**.
- For all unanswered questions in the **QUESTIONS I/WE HAVE** column, take the steps to find answers, either through internet or book research.
  - What was the most difficult part about finding answers?
  - Was it easier to find answers on the internet or in a book?
  - Which source is more reliable, the internet or a printed book? Why?
  - How can you determine whether to trust a source?
  - What tips would you give someone who is about to do research?

DESIGN AN ILLUSTRATED POSTER

BASED ON *BEYOND INFINITY: EXPLORING THE SECRETS OF THE UNIVERSE WITH THE JAMES WEBB SPACE TELESCOPE* REPRESENTING EACH QUESTION, FACT, AND RESEARCHED ANSWER.

OUTER SPACE

UNIVERSE-SPACE EXPLORATION-ASTRONOMY



QUESTIONS I/WE HAVE	THINGS I/WE LEARNED (FACTS)	ANSWERS I/WE FOUND

DISCUSSION QUESTIONS

CHAPTER 1: SEEING INTO THE PAST

1. Chapter 1 suggests that telescopes are like time machines, allowing scientists to see into the past. How so?
2. "The farther into space we look, the further back in time we are looking." Use examples from the text to explain this statement.
3. What are some of the big questions researchers hope the James Webb Space Telescope will help answer? Why might answers to these questions be important?
4. Imagine that you are one of the scientists who helped develop the James Webb Space Telescope. It is Christmas Eve 2021, and you are anticipating the launch of the telescope the next morning. Write a diary entry detailing your thoughts and feelings at this time. Use details from the text to support your writing. Then write a second diary entry taking place after the successful launch, once again using details from the text to support your writing.
5. Once in space, the James Webb Space Telescope began its "two weeks of terror." What does this mean? Name at least three of the 344 things that had to go exactly right for the telescope to function as intended.
6. What is the difference between the type of light detected by the Hubble Space Telescope and the type of light that can be detected by the James Webb Space Telescope?
7. How does the position of the James Webb Space Telescope allow for it to see faint heat coming from distant stars and galaxies?

CREATE YOUR OWN JAMES WEBB SPACE TELESCOPE

Using readily available materials at home or at school, create your own three-dimensional model of the James Webb Space Telescope. The diagram on pages 16–17 can be referenced for guidance.

Be sure to correctly label all parts of the telescope and be able to speak to how each part operates.

For inspiration, visit NASA's website at **https://science.nasa.gov/mission/webb/build-a-model-of-webb/**. When finished, you can even submit your model to NASA's gallery.

CHAPTER 2: HOW DID THE UNIVERSE BEGIN?

1. What is a galaxy? Define it in your own words, using information from the text to support your answer.

2. What do scientists hope to learn from studying the farthest and oldest galaxies?

3. Designing and engineering the James Webb Space Telescope proved to have its challenges. Using the information in chapters 1 and 2, fill in the chart below.

ELEMENT	PURPOSE	CHALLENGES	SOLUTIONS
MIRROR			
SUNSHIELD			

4. Scientists have found that there are a multitude of galaxies—some of which are just being discovered. Record information about the four different types of galaxies in the chart below.

TYPE OF GALAXY	DESCRIPTION	ILLUSTRATION
SPIRAL		
IRREGULAR		
ELLIPTICAL		
LENTICULAR		

5. Who is Quyen Hart? Hart explains that before the James Webb Space Telescope, it was like astronomers had a book about the history of the universe but the first chapter was missing. Why might this first chapter be important? What do astronomers hope to learn?

BE A STARRY NIGHT OBSERVER

Stargazing is an easy way to teach yourself how to recognize the stars and constellations.

On a clear night, go outdoors and see if you can find the constellations in the sky. A star chart found online or in a book at the library can be helpful. The stars move throughout the year, so you'll see different constellations at different times of the year.

In the northern hemisphere, locate the North Star, also called Polaris, first. It's the only star that does not visibly move. It's also the last star on the handle of the Little Dipper.

To use your star chart outside, cover a flashlight with red cellophane. That way you can still see the stars when you look back up at the sky.

All stars may look the same, but if you become a starry night observer, you'll see that they vary in color and brightness. Stars have dozens of distinctive qualities and characteristics based on age, distance, and light pollution.

- Take time to study the night sky and write down notes of the different colors and levels of brightness you see.
- Can you find some stars that are bigger, brighter, or more colorful than others?

CONSULT A STAR CHART

TO FIND OUT WHICH LIGHTS IN THE SKY ARE STARS. SOME MAY BE PLANETS.

MAKE A SIMPLE STAR BRIGHTNESS DETECTOR TO MEASURE AND CATEGORIZE THE BRIGHTNESS OF STARS.

MATERIALS NEEDED:

Scissors
Cardboard
Ruler
Colored cellophane
Tape

1. Cut four 1¾-inch rectangles in a piece of cardboard, placing them next to each other like windows in a single-story house.
2. Tape one piece of cellophane over all four rectangles.
3. Tape a second sheet of cellophane over the last three rectangles.
4. Tape more cellophane over the last two rectangles, and finally a last overlapping sheet of cellophane on the last rectangle only. Each window will have a different number of cellophane layers.
5. View the night sky using your brightness detector. Notice how you see more stars through fewer cellophane layers. Only the light from the brightest stars is able to penetrate all four sheets.

Record your observations in the following chart.

# OF CELLOPHANE SHEETS	# OF STARS SEEN	ADDITIONAL DETAILS

CHAPTER 3: WHAT SECRETS HIDE IN OUR SOLAR SYSTEM?

1. How is the James Hubble Space Telescope's ability to see infrared light important to further discoveries and exploration of space?
2. Page 39 states that "work began on the cameras in 2002, almost 20 years before the telescope launched." Why did completing the telescope take so long? What challenges did engineers face in developing the camera?
3. Telescopes are not new. Several different iterations of the telescope have been aiding stargazers for centuries. Read pages 40–41 and record information about the telescopes that preceded the James Hubble Space Telescope in the table below.

JWST'S MIRRORS ARE SUPER REFLECTIVE, CAPTURING ABOUT 98 PERCENT OF INCOMING LIGHT.

TELESCOPE	HISTORICAL DETAILS & DESCRIPTION	WHAT WE LEARNED FROM ITS USE
GALILEO'S TELESCOPE		
NEWTON'S TELESCOPE		
HUBBLE SPACE TELESCOPE		
KEPLER SPACE TELESCOPE		

4. There are so many mysteries scientists hope the James Hubble Space Telescope will help find answers to. Choose one mentioned in chapter 3 that you are most intrigued by and write a 500-word essay about why this mystery intrigues you and why finding the answer could be helpful to those of us on Earth.

5. What do you think it means to think like a scientist?
   a. What does it mean to *see* like a scientist?
   b. What does it mean to *stick with it* like a scientist?
   c. How do you stick with it when you face challenges and want to give up?
   d. How are the following important to scientists?

o Curiosity	o Observation
o Passion	o Gathering
o Hard work	o Analyzing evidence
o Belief in oneself	o Drawing conclusions

WHAT ELSE REMAINS UNKNOWN ABOUT OUR PLANETARY NEIGHBORHOOD? EXPERTS ARE USING JWST TO FIND OUT.

USING THE SCIENTIFIC METHOD TO DESIGN A SPACE CAPSULE

This challenge allows students to test out the scientific method as they brainstorm a way to create a space capsule that can protect an egg when landing. Of course, a little imagination is going to go a long way here, too!

The scientific method is an eight-step series that engineers, scientists, and inventors use to solve problems.

Step 1: Ask a Question
Step 2: Do Research
Step 3: Suggest an Answer (also called a Make a Hypothesis)
Step 4: Draw a Conclusion. Did it work? Could it be better?
Step 5: Write a Written Report of Your Results
Step 6: Retest

After introducing the steps to the class:

- Provide the students with several craft items (rulers, paper, cardboard tubing, empty boxes, tape, glue, etc.). Check the recycling for other ideas of materials.
- Provide each group with an egg. Hardboiled eggs can be used for testing so that they will show cracks but won't make a mess.
- Instruct each group to create a space capsule that can protect an egg from a five-footfall. (Most groups will want to create something that the whole egg will fit inside for ultimate protection.)
- Instruct each group to create an eight-page "Scientific Notebook" for their space capsule and carefully document their use of the scientific method throughout the process of creating their space capsule.

Once all space capsules have been prototyped, test them out one by one as a class.

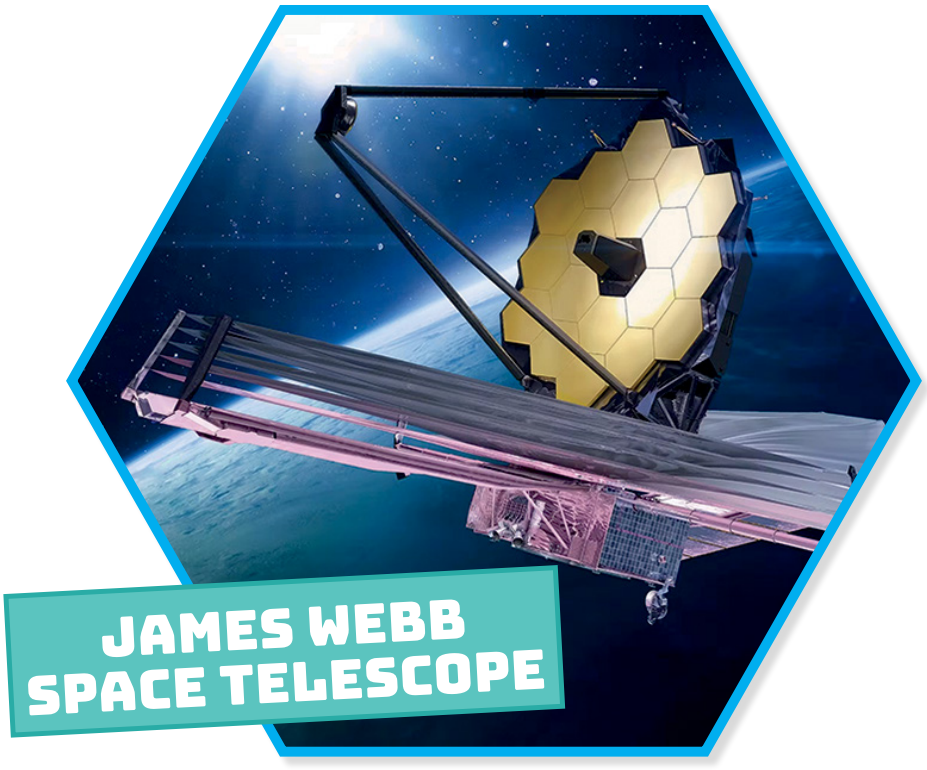
Did they work? If they didn't work, head back to the drawing board like a real inventor.

Offer up the following awards to increase the competition:

o Strongest Capsule	o Most Materials Capsule
o Most Attractive Capsule	o Least Materials Capsule

CHAPTER 4: HOW ARE STARS BORN?

1. What is a spectrograph and how does it work? What hidden messages can be discovered using spectroscopy?
2. Using both the information found on pages 54–55 and any further internet research that might be helpful, create a visual depiction of the lifespan of a star. Label all essential elements and actions clearly.
3. Carl Sagan, the American astronomer and planetary scientist, famously said, "We are made of stardust." Megan Reiter touches on this on page 56. Can you explain this statement in your own words? Conduct further research to support your answer if necessary.
4. According to Megan Reiter, what do scientists hope to learn from stars? How does the James Hubble Space Telescope make these discoveries possible?
5. The James Hubble Space Telescope ended up fourteen years behind schedule and costing twenty times the budget. Imagine that you are part of the James Hubble Space Telescope team. Write four different diary entries about your experience with challenges along the way, drawing inspiration from pages 60–61. Feel free to use a broad range of emotions to express how you feel.



MAKE AN ASTROLABE

Astronomers and scientists describe the position of a star by measuring its position relative to the horizon. An astrolabe measures how high above the horizon a star is in degrees.

MATERIALS NEEDED:

12-inch piece of string
Plastic protractor
Weight (washer, rock, or fishing weight)
Pen and paper

Q: HOW CAN YOU TELL WHAT THE WEATHER IS LIKE ON A PLANET MILLIONS OF MILES AWAY?

1. Tie the string to the hole in the middle of the crossbar on the protractor. Tie the weight to the other end.
2. Hold the protractor so that the curved part is down and the zero-degree mark is closest to you.
3. Sit on the ground and look along the flat edge of the protractor with your eye at the zero mark. Point the flat edge at the star whose position you want to measure.
4. Once you have the star at the end of your sight, hold the string against the side of the protractor.
5. Note which degree mark the string crosses. This number tells you how many degrees above the horizon your star is.
6. Take the measurements of several stars.
7. Return every thirty minutes and take new measurements. Notice the pattern in which the stars seem to move across the sky as the Earth turns.

CHAPTER 5: ARE WE ALONE?

1. What is an exoplanet?
   a. Describe the transit method of spotting exoplanets in your own words.
   b. What information can be gathered using the transit method?
   c. How does the James Hubble Space Telescope give scientists another way to spot exoplanets?

2. Why are scientists interested in studying the weather and chemical reactions on exoplanets?
   a. Describe the information the James Hubble Space Telescope has provided about the atmosphere on the following exoplanets:
      - WASP-39 b
      - LHS 475 b
      - VHS 1256 b
   b. Imagine that you were able to visit one of these exoplanets and report conditions firsthand. Write a report detailing what you experience.

3. How could detections of the following point to possible life on another planet?
    a. carbon dioxide
    b. oxygen
    c. phosphine
    d. ammonia
    e. methane
    f. an unstable atmosphere

4. The Giant Magellan Telescope will be located on Earth on a mountaintop in Chile. Do some research on when that telescope will be operational and how it will continue to break barriers in space science.

Q: WHAT ARE YOU MOST EXCITED ABOUT?

ASK THE EXPERT

Invite someone who works on the space program or studies outer space to your class or ask them to visit via video chat to teach about what they do. Contacting your local space museum can be a great resource in finding a speaker.

What do you want to know about? As a class, come up with a list of questions ahead of time and provide them to the guest speaker.

During the visit, practice taking notes and creating follow-up questions.

After the visit, draft a written report and present what you learned.

"ARE WE ALONE?" PERSUASIVE ESSAY

After reading *Beyond Infinity: Exploring the Secrets of the Universe with the James Webb Space Telescope*, do you believe humans are alone in the universe or do you think there is life somewhere out there that we have yet to discover? Write a persuasive essay to convince others of your thoughts. Use specifics from the text to support your conclusion.

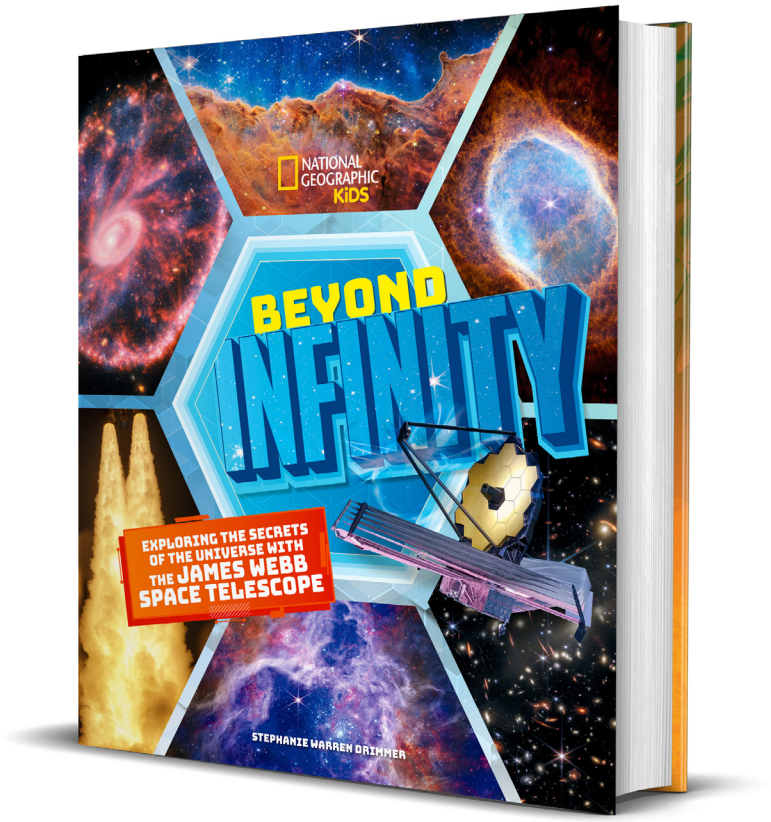
If it's helpful, use the following structure:

1. Start with a topic sentence that tells the reader what you think or believe. Example: *I believe humans are / are not alone.*

2. Give at least three reasons why you believe what you believe with three to four sentences supporting each reason.

3. Wrap it up with a conclusive sentence.

This guide was written by **MARCIE COLLEEN**, an expert on creating highly acclaimed Teacher's Guides that align picture books and middle grade novels with the Common Core and state mandated standards. She is a frequent presenter at conferences for the Society of Children's Book Writers and Illustrators, as well as a faculty member for the Writing Barn and the University of California San Diego Extension. Her educational work in children's literature has been recognized by *School Library Journal*, *Publisher's Weekly*, and the Children's Book Council.



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