LESSON 16: What is our place in the universe?

PREVIOUS LESSON

We looked at a photo taken by the Hubble telescope of the space between stars and saw galaxies. We watched the movie Powers of Ten to visualize how scientists model the universe at various scales. We noticed that the universe appears to be organized into systems held together by gravity, separated by vast emptiness.

THIS LESSON

INVESTIGATION, PUTTING PIECES TOGETHER

2 days

We make a classroom consensus model of the universe to show how gravity organizes the universe and use this model to help quantify the possibility of extraterrestrial life. We learn about the Drake equation and quantify the number of civilizations that might be out there, ready to communicate with us. We return to the DQB to take stock of how far we have come in this unit and then reflect on the unit and Earth's place in the universe.

NEXT LESSON

There is no next lesson.

BUILDING TOWARD NGSS

MS-ESS1-1, MS-ESS1-2, MS-ESS1-3, MS-PS2-4, MS-PS4-2

WHAT STUDENTS WILL DO

16.A Develop a mathematical model to predict the number of communicating civilizations in our galaxy based on what we know about systems in space, including galaxy clusters, galaxies, star systems, and moon systems around planets.

WHAT STUDENTS WILL FIGURE OUT

- The universe is vast, so even if extraterrestrial life is extremely rare, it is still very likely that we are not alone out there.

Lesson 16 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**NAVIGATION** Brainstorm what we need to figure out the probability of life.	A	chart paper titled "Class Consensus Model for the Universe", markers
2	15 min	**THE DRAKE EQUATION** Consider what we would need to know to figure out the probability of life in space and then watch a video about Frank Drake and the Drake equation.	B-D	*The Drake Equation*, https://www.youtube.com/watch?v=6AnLznzljSE&feature=youtu.be
3	10 min	**EVALUATE OUR DQB QUESTIONS** In pairs, students evaluate our list of DQB questions and indicate the progress they think we have made on each. Then students place sticky dots on the questions they think we have made progress on.	E	*Reviewing Our Driving Question Board*, 10 sticky dots
				End of day 1
4	25 min	**REVISIT THE DRIVING QUESTION BOARD (DQB)** Revisit the DQB with the whole class and take stock of all the questions we've now answered.	F-G	*Reviewing Our Driving Question Board*
5	20 min	**REFLECTION ON THE PALE BLUE DOT** Read about the pale blue dot and reflect on our place in the universe.	H	Progress Tracker, *The Pale Blue Dot*
				End of day 2

Lesson 16 • Materials List

	per student	per group	per class
Lesson materials	• *The Drake Equation* • science notebook • *Reviewing Our Driving Question Board* • 10 sticky dots • Progress Tracker • *The Pale Blue Dot*		• chart paper titled "Class Consensus Model for the Universe" • markers • https://www.youtube.com/watch?v=6AnLznzIjSE&feature=youtu.be

Materials preparation (45 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Test the https://www.youtube.com/watch?v=6AnLznzIjSE&feature=youtu.be video and make sure the sound is functional.

Type up or take a high-resolution photograph of all the questions on the DQB *or* type them into *Reviewing Our Driving Question Board*.

Display around the room all previous classroom consensus models for the unit.

Make sure the DQB is displayed and space is available for the class to gather in a Scientists Circle.

Lesson 16 • Where We Are Going and NOT Going

Where We Are Going

This is the final lesson of the unit. Students will develop a consensus model for the universe with the purpose of describing how we can quantify the probability of life in space.

Where We Are NOT Going

Students dabble in the Drake equation but will not spend a lot of time discussing quantitative probability here. The goal is for students to look at the outputs of this quantitative model to get a qualitative sense of how the scale of the universe improves the probability of our not being alone.

Students will have done some work with compound probabilities in CCSS math standards in 7th grade, but that work was limited to finding probabilities of compound events using organized lists, tables, tree diagrams, and simulations. They have not done work with using equations to represent compound probabilities. This is why you will want to keep the focus of the sensemaking related to the Drake equation qualitative.

LEARNING PLAN for LESSON 16

1 · NAVIGATION

10 min

MATERIALS: chart paper titled "Class Consensus Model for the Universe", markers

Brainstorm what we need to figure out the probability of life. Say, *Last time we built a model to show how gravity organizes the universe. We decided that we needed to know more about how many of these systems and parts there are if we want to predict how many planets and moons might potentially host life that we could discover.* Present **slide A**.

Suggested prompt	Sample student response
What do we need to know to calculate an estimate about how many planets and moons are out there that could support life?	*How many exoplanets and moons there are.*
We might be able to estimate how many exoplanets there are in our galaxy based on how many stars there are. What else do we need to know other than how many stars there are?	*How many exoplanets there are around each star.* *How many moons are around each exoplanet.*
What else do we need to know on average about planetary systems if we want to know if we could find life specifically? What about if we want to find life that could communicate with us?	*How many planets have water (and the other chemicals needed for life).* *How much life is intelligent and communicating, and how much is not.*

As students suggest their ideas, point to the place on the Class Consensus Model for the Universe poster corresponding to their suggestion. For example, if a student suggests, "We need to know how many galaxies there are in the universe," point to the galaxies on the model. Then write down the suggestion on the Class Consensus Model for the Universe poster. Your list may look something like this, but do not worry if it is incomplete:

- How many exoplanets are in a star system on average
- How many stars are in a galaxy on average
- How many exoplanets in a star system have water (and other chemicals for life) on average
- About how many galaxies there are in the universe

Some students might suggest these advanced ideas:

- How likely it is for life to arise if there is water on a planet
- The length of time that life exists on a planet

2 · THE DRAKE EQUATION

15 min

MATERIALS: *The Drake Equation*, https://www.youtube.com/watch?v=6AnLznzIjSE&feature=youtu.be

Make an estimate of how many civilizations are out there. Present **slide B** and organize students into groups of 3-4. The slide contains this information:

- 250 billion stars in our galaxy
- 9/10 stars have planets
- 3/10 planets and moons per star system could host life
- 2 trillion galaxies in the universe

Give students 5 minutes t to follow the directions on the slide in their groups:

1. Use these numbers to estimate how many planets and moons might be out there that could have life on them.
2. Are there any additional numbers you wish you had to make your estimate better?
3. What additional numbers would you need to estimate how many intelligent, communicating civilizations could be in the universe?

Play a video about the Drake equation. Present **slide C**. Say, *Astronomers have been playing around with numbers like this since the 1960s, trying to figure out what the probability is for life in space and, in particular, the probability that there is life out there that we can communicate with. Until we started getting evidence for how common exoplanets are, it was harder to calculate the probability of life out there because we simply didn't have a reliable way to estimate the number of places that life might have developed. But you just calculated an estimate of the number of places in the universe where there might be life. What you did is a kind of modeling called mathematical modeling. Scientists have developed similar models estimating not just the number of places out there with life, but the number of intelligent, communicating civilizations. Let's see how their models compare to ours.* Play https://www.youtube.com/watch?v=6AnLznzIjSE&feature=youtu.be for students.

Present **slide D** with rough estimates for the solution to the Drake equation. Then hand out *The Drake Equation* so that students can try it out themselves at home with their families. Ask the class, *Do any of these numbers surprise you? Why or why not?*

3 · EVALUATE OUR DQB QUESTIONS

10 min

MATERIALS: science notebook, *Reviewing Our Driving Question Board*, 10 sticky dots

Have students work in pairs to evaluate what questions the class has answered from the DQB.✱ Display **slide E**. Provide students with *Reviewing Our Driving Question Board*, which you created to contain all the student questions from the DQB, and have students tape it into their science notebooks. Have students work with a partner to mark questions they think the class has answered:

- We did not answer this question or any parts of it yet: **O**
- Our class answered some parts of this question, or I think I could answer some parts of this question: ✓
- Our class answered this question, or using the ideas we have developed, I could now answer this question: ✓+

✱ ATTENDING TO EQUITY

Revisiting the DQB is important for students to feel as though their questions are valued and recognized. While not all questions will have been addressed (it's more likely that 50–75 percent will be at least partially answered), this helps students see that they have done this hard work to answer many of their own questions.

End of day 1

4 · REVISIT THE DRIVING QUESTION BOARD (DQB)

25 min

MATERIALS: science notebook, *Reviewing Our Driving Question Board*

Review and share the questions that students think we have answered. Present **slide F** and have students mark the class DQB with sticky dots on the questions that they think we have made progress on.✱

Look for patterns using the sticky dots. Move into the Scientists Circle and focus on the questions that have the most number of sticky dots.

Discuss as a class the questions that students can now answer. Present **slide G** if needed. Have the class discuss the answers to those questions as a group. If you have space, you might make a Take Aways board that has a record of the answers the class comes up with.

ASSESSMENT OPPORTUNITY

Building towards: 16.A Develop a mathematical model to predict the number of communicating civilizations in our galaxy based on what we know about systems in space, including galaxy clusters, galaxies, star systems, and moon systems around planets.

What to look/listen for: While students are answering questions from the DQB, notice how students are responding to these questions and compare to the pre-assessment opportunities in Lesson 1.
What to do: Take this opportunity to address any gaps you notice by asking students what evidence they have to support their answers. They can use their progress trackers and other data collected during lessons to help them support their answer.

ALTERNATE ACTIVITY

Another option is to have students work either individually or in pairs on answering their own questions they posed in Lesson 1 and 9. This could be done similarly to what they did in Lesson 8 where they attached the question to a sheet of paper and answered in words and/or pictures. A focus on those questions that we have not answered but feel we could now (or partially could) with the ideas we have developed can help students feel like they made progress on their own questions.

Additionally, some teachers start a Wonder board, where questions are housed that have not yet been answered but students are still interested in pursuing. These questions are available for students to pursue independently or as time allows.

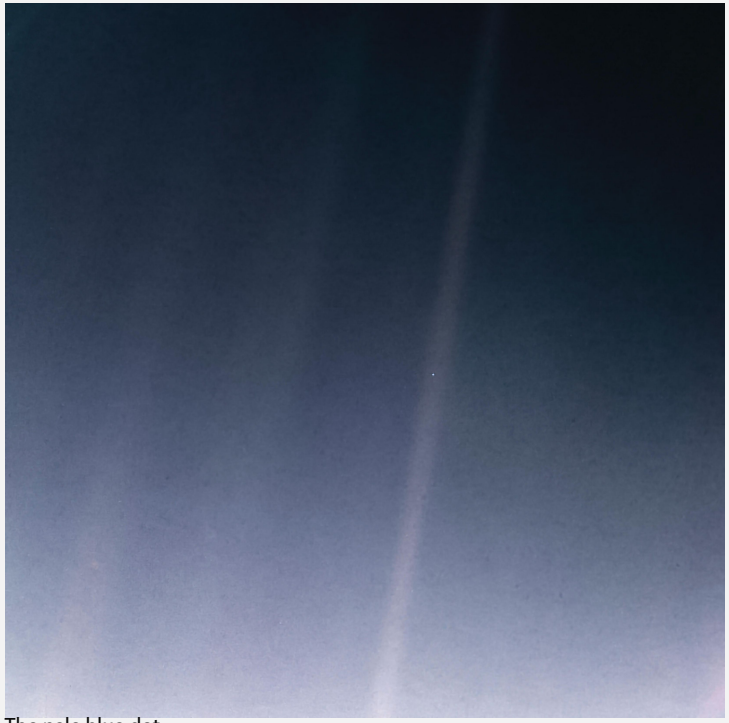
✱ SUPPORTING STUDENTS IN ENGAGING IN ASKING QUESTIONS AND DEFINING PROBLEMS

Revisiting the DQB at the end of the unit helps students see the progress they have made toward answering questions that were important to them at the onset of the unit. Students were tasked with asking questions "that require sufficient and appropriate evidence to answer." Through the investigations in the unit and individual and whole-group sensemaking, they can now answer many of the questions. This final visit to the DQB also allows students to see how their hard work toward a shared learning goal helps them figure out the phenomenon and can also explain a lot of other phenomena in the world.

5 · REFLECTION ON THE PALE BLUE DOT

20 min

MATERIALS: Progress Tracker, *The Pale Blue Dot*



The pale blue dot.

Present **slide H** and pass out *The Pale Blue Dot*. Ask students to use the handout to reflect on the unit and Earth's unique place in the universe. If there is time, ask students to share their reflections with a partner or with the whole class. You might also consider posting these reflections around the room for a gallery walk or having students pass them around so that others can read them.