ME: Hi and welcome to Cataloging the Universe! In this 7 part series, we'll be taking a journey through time and space to try to find our *own* answers to giant questions about the universe. Along the way, we'll have some help from scientists, experts, and our imagination. I'm Marshall, and I'll be your guide on this journey.

This is Lesson 5: Brightness and Distance. In this episode, we're going to do some sky-watching, but before that–if you want to–you can conduct a little experiment. To do that, you're going to need a few supplies: your star journal, a pencil, and possibly a few different lights you can take outside. You can use flashlights, the light on your phone, maybe a camping lantern, or even a glow stick. The most important thing is that each light source has a different brightness that you can tell with your eyes.

PAUSE

ME: When Harlow Shapley and Heber Curtis met to present their opinions about spiral nebulae in the 1920s, the main thing they disagreed about was exactly how far away these objects were. Were they thousands of light-years away, or were they *millions* of light-years away? Were they cloudy objects on the edge of the massive Milky Way as Shapley thought, or were they entire distant universes of their own as Curtis thought?

ME: In order to figure out who was right, astronomers needed an accurate way to figure out *how far away* things in the night sky were. Nowadays, of course, you can just look up information you don't know using Google–but remember, people didn't always have that. And also, all that information on Google had to come from *somewhere,* right? So how did we figure it out?

PAUSE

ME: There isn't a lot in space for us to measure by. We can't exactly go up to the sun and use a tape measure. What we are able to see and use is light. Remember in the last lesson, when we were looking up at the sky… it's not always easy to figure out even *where* something might be in the sky, let alone learn anything about it just by looking. So how could we do it? Let's try… a little experiment.

Imagine with me two friends standing across a dark room from you, each one holding a flashlight. One flashlight is super small with a dim light. The other is one of those super big, super strong flashlights that can light up a whole room. Do you think it would be

easy to figure out which friend was where, and which one was holding the bigger flashlight, if they were in the same room with you?

ME: Go ahead and open to a fresh page in your star journal, and **<ding>** write down your answer. Maybe draw a diagram of what it might look like if both flashlights were turned on and pointed right at your face at the same time. Or just write down some notes. How would it appear? Would you be able to tell which is which?

PAUSE

ME: Now, consider for a second if your friends, instead of being in the same room with you, were in a window across the street. Would their flashlights be just as bright as when they're in the room with you? Or have they gotten dimmer? And would you still be able to tell which was the bright one and which was the dim one? How would you do that?

<ding> Take some notes–could you still tell which is which? If you're not sure, check out the resources we've included with this episode… or, just look out your window. How can you tell which lights are actually super bright, and which ones are dim?

MUSIC PAUSE

ME: Now, imagine something else. What if the dim flashlight stayed where it was, and the brighter one moved to be a block away? Assuming you could still see it, how do you think it would look then? Would the brighter light still seem brighter?

<ding> Write down your answer in your notebook.

ME: Now that we've thought this through, we can make a prediction, or what scientists call a *hypothesis.* As lights get further from you, what happens to them? Does it matter if they're super bright lights, or super dim? Is there a way to tell just from looking at a far-off light, how bright it is, and how far away it is?

For now, we're not going to give you the answers to these questions. Make your own prediction, and then–if you want–you can test it out with some friends or with your parents once it gets dark out. Think about what happens to lights as they get further away from you, and how different they might look if they're bright, or dim. **<ding>** Write down your prediction or hypothesis.

PAUSE

ME: If you want to try this experiment yourself, go ahead and pause here. And if you want more instructions on how to do this exercise, we've got resources attached to this lesson on our website.

PAUSE

ME: Now, just like our last episode, we're going outside to take some observations of the night sky. By now, you already know what to do when taking observations, turn to another fresh page in your star journal and let's get started. First, as always **<ding>** make a note of the date and time.

PAUSE

ME: Next, **<ding>**, take a note about the weather. Is it clear? Cloudy? Hot? Cold?

PAUSE

ME: Now, **<ding>** re-draw your diagram with your landmarks indicated.

PAUSE

ME: Now, what about the moon? Is it out tonight? What does it look like? Is it really bright? **<ding>** Take notes about the moon in your notebook, and draw where it is, relative to your landmarks.

PAUSE

ME: And now, see if you can find all the stars you've found the last two times we went out. Do you recognize any constellations from before? **<ding**> Draw the position of all the stars you've found on your diagrams.

PAUSE

ME: As you might already know, all these stars you're seeing are *extremely* far away. In your notebook, with your list of stars, try to take a guess how far each of the things you're seeing might be from Earth. Think about the flashlights, from a minute ago. How

many of these stars are dim things that are close up. And how many do you think are super bright things that are *extremely* far away? Take a minute to think about it.

PAUSE

ME: Now, think again about those flashlights. If you look up at the sky, do you think you could tell the difference between very bright stars that are far away and very dim stars that are close up? How would you tell? And how do you think scientists would find out? **<ding>** Answer this question in your notebook.

PAUSE

ME: As it turns out, one answer to this question of distance was discovered a little more than a hundred years ago, right before the Great Debate by a scientist named Henrietta Leavitt, working as a “computer” in an observatory in Boston, long before there were computing machines. And her answer to that question of distance ended up being the thing that made Harlow Shapley think that everything we thought we knew about the galaxy was wrong.

This lesson is the last time we will be watching the sky together–but that doesn’t mean you have to stop for good! You can keep going out every night, making observations in your star journal, and sharing them with your friends, your family, or maybe a local astronomer! Next time, on Cataloging The Universe, we’ll learn how Henrietta Leavitt figured out how far away certain stars were–and how her discovery finally led scientists to understand what spiral nebulae were. We’re going to be applying the skills you’ve been applying in your observations in your star journal, to that question. See you next time!