Level	The Importance of Radio Astronomy
Middle School	

Time Required	Lesson Summary
5 Class Periods (45 minutes each)	In this lesson, students will learn about the importance of radio astronomy to the study of space. After reviewing radio waves students will participate in a hands-on activity that models how radio telescopes work. Once they understand how the data is collected students will investigate one of the telescopes and learn about the important work done at that location.

Standards

NGSS

MS.PS4.2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

MS.PS4.3 Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

HS.PS4.5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Vocabulary	Objectives
Telescope Astronomy	• The students will be able to understand the role of radio astronomy in the study of space. • The students will be able to describe how radio astronomers use technology to collect their data.

Materials

- Radio Astronomy Google Slides Presentation
- Cosmic Coloring https://public.nrao.edu/color/?composite_id=8767 (Last accessed 5/12/23)
- Jigsaw cards for Radio Telescope Research Groups
- What's It Like to Be a Radio Telescope Lab Sheet

- Ball pit balls (5 colors)
- 5 large umbrellas
- Radio Telescope Jigsaw Worksheet
- Headphones or ear buds
- Student computers

Pre-Requisites

Students should have already learned the Electromagnetic spectrum and Properties of waves.

Safety Considerations

When completing the **Modeling a Radio Telescope** activity have students holding umbrellas wear protective eyewear just in case they get hit in the eye during activity.

Pacing Notes

Day 1: Students will be introduced to how humans study space with EM waves. They will view slides and complete a group drawing activity to simulate how different waves are used to give us the images we see of space.
Day 2: Students will be introduced to radio astronomy and its benefits with telescopes being able to be on earth to receive signals more easily than other waves. Students will explore with Cosmic Coloring digital activity.
Day 3: Students will complete the Modeling a Radio Telescope activity.
Day 4: Students will begin research for specific radio telescopes in Jigsaw groups to be experts on one radio telescope.
Day 5: Students will go back to home Jigsaw groups to share what they learned and listen to other students and learn about other radio telescopes.
***Days 4 and 5 could be combined depending on how much time you want students to spend researching.

Before the Lesson

Check to make sure that all of the links work. Be sure that students can access all the materials either digitally or in print format.

Prepare ahead of time how you want your jigsaw groups (this is a great place for differentiation based on student needs)

Assessments	Classroom Instructions
Pre-Activity	**Introduction**

Assessments	
Collect writing and grade.	Page one of the presentation. How do humans study space? Have students write their thoughts in their notebook or on a sheet of paper. Students should then share with a partner then discuss as a whole group.
Activity Embedded Assessments	**Activities**
As students are in this group walk from one group to another. Monitor behavior but also answer any questions they have. As students are working in this group. Walk around to be sure students are following directions. Ask if they have any questions. Ask: What makes this activity difficult?	**Day 1** 1. After the bell-ringer, complete pages 2 – 5 of the presentation and discuss. Stress that since space travel is still really difficult humans use EM waves to study space. 2. Group Drawing Activity a. Split Students into 5 groups (these will be used as their Jigsaw groups for a future activity). Count off each student 1-5. b. Then all the 1's, 2's, 3's, etc. will meet to see an image at a lab table and draw exactly what they see. a. Group 1 will draw a house with no windows or door, Group 2 will draw 4 windows with space for a door, Group 3 the ground with a sun in the sky, Group 4 a door with a window, and Group 5 a welcome mat. Each group should not see the other's drawings. b. There are versions of these pictures available for your to download. Feel free to make changes to these images or change them all together. c. Have the groups come back to their original group. In the group, there should be two people who are willing to do the drawing. One of the non-drawers will describe what they drew to the first drawer. That person will recreate the drawing from the description given to them. The drawer cannot ask clarifying questions but simply must do their best. Then another non-drawer will describe what they drew earlier and the drawer will add that image to the first one. Again the drawer may not ask any questions. Then the other person who was selected to be a drawer will describe their earlier drawing to the current drawer. After that person's

Ask: What have you learned about the importance of communication? You can collect the observation pages and grade if you will. Alternatively, this could just be a participation grade.	image is added to the picture the two drawers will switch places. The new drawer will continue to add to the picture as they listen to the descriptions of the other two students in the group. d. Relate this back to how we get images from space using telescopes. Astronomers use more than one type of EM wave to get a more complete picture of features in space. 3. Closure a. Display page six "Multiwavelength Whirlpool Galaxy" on the board. Have students jot down observations of how all the pictures are the same and how they are different. After students have had approximately 5 minutes to work hold a class discussion. Go around the room and allow students to share their observations. Then ask why the images are different. The answer has to do with the type of EM wave they are using to create the image. **Day 2** 1. Bellringer a. Put page 6 back on the board. Have students get out their observations from yesterday and add anything they may have missed. 2. Slides 7 – 16 Go through the slides quickly, no more than 30 seconds per slide. The point of this is not to lecture but to preview what students will be seeing during the stations activity.
Walk around during the activity. Observe student behavior and correct as needed. If there are students who are finished with the questions and just waiting to move on ask them some of the following questions: What was interesting about this video? Is astronomy	3. Stations a. During this activity students are going to watch videos about five different kinds of astronomy and then answer a few questions. Each of the videos is short (between 4 and 5 minutes) which makes this perfect for a station activity. Instead of having students sit in their seats and watch the videos they will walk to specific areas in your classroom to watch a video. Print the station cards and place in five separate areas of your classroom. b. Instruct students that they will be working independently on this activity. Tell them that they will carefully carry their laptop to each area of the room and watch the indicated video and answer the questions. c. Count students off in groups of five. The student number will indicate their first station. Have students remain at that station until you tell them to move. When it is time to rotate have the

something you are interested in? why or why not? What don't you understand? Can you summarize the video for me?	students go to the next number with the students at station 5 moving to station 1. When all stations are complete have students return to their seats. d. Discussion After everyone is in their seats ask some closure questions. You may decide to use the ones below or some of your own creation. What do you think of astronomy after this activity? Were there any similarities between the types of astronomy? How is radio astronomy different from x-ray astronomy? What questions do you have?
Ask: How is this image different in the radio picture as compared to the x-ray picture? (change the different types of EM energy when you ask the question to a different student)	4. Cosmic Coloring Activity To give students more direct experience with the differences between the types of astronomy have them go to the cosmic coloring page (https://public.nrao.edu/color/?composite_id=8767 Last accessed 5/14/23). Students should spend about 10 minutes investigating how the type of EM energy affects the appearance of celestial bodies.
Collect the paragraph and grade.	5. Wrap-Up Students should write a paragraph that compares and contrasts the many ways to study space.
	Day 3
	1. Play the short video which introduces Radio Astronomy while you take care of administrative tasks (use either link they take

	you to the same video) https://live.myvrspot.com/iframe?v=fMjFkMzhhNGM2NWI0YzU1NGMzZTVlMmY3ZjE3NjAyN2U https://www.youtube.com/watch?v=NKvnuvQZMTM 2. Modeling Radio Astronomy Activity a. Pass out the student page b. Go over the following instructions with your students. **Say**: Today we are going to model Radio Astronomy using umbrellas and ball pit balls. As with any model this is not a perfect representation of how the process works but a good proximity. One member of your group will act as the radio telescope by holding an open umbrella upside down so it resembles a bowl. That person has to stand perfectly still because radio telescopes don't move. You may tilt to one side before the round starts but you have to remain in that position the entire round (demonstrate this posture). One person will be recording the data and the rest of you will be emitting radio waves. Radio waves are emitted or released from objects in space. Those emissions travel toward Earth and a few are collected by radio telescopes. So the emitters will stand behind the line I indicate and gently throw the ball pit ball toward your "telescope". It is OKAY if the balls don't go in, remember telescopes only collect a small amount of the waves. At the end of the round you will only count the balls inside the umbrella. At the end of each round you will switch roles so everyone has the opportunity to do most tasks. **Ask**: Are there any questions? c. Divide students into five groups and pick team leaders. The team leaders will be responsible for keeping their group under control as you move from the classroom to the large space you are using. The team leader is also responsible for carrying the umbrella and the balls. It is best if this activity takes place either outside or in a large indoor space where groups can spread out and nothing will be accidentally broken as student throw balls. d. There are six rounds to this activity. You should control when each round starts and when it stops. Remind students that they
Walk between groups during the activity. When they are tallying up the ball numbers ask the following questions. What are you doing? What do the balls represent? Why aren't you counting all the balls? Explain the model to me.	

Collect and grade the student sheet. While students are working walk around and observe. Ask: What are you researching? What did you just read? What webpage did you choose? Why? Did you find any webpages that were questionable? Why do you think so?	should only be counting the balls inside of the umbrellas at the end of a round. e. When the six rounds are complete have students clean up all the balls and return to the classrooms. Just like when you left the team leader should be carrying the equipment and keeping their group under control. f. Once back in the classroom have students complete the activity by coloring in the image according to the data they collected. 4. Closure – data collection differences Put a data table on the board and have each group add their total numbers to the correct box. These numbers will probably be very different. Hold a discussion about these differences. Consider using some of the questions below. **Day 4** 1. Bellringer a. Display page 21 of the presentation. Have students identify where there are no radio telescopes. b. Ask students why they think radio telescopes are missing from those locations. c. Remind students that these telescopes are sensitive to outside signals which means that they cannot be located in a populated area. 2. Radio Telescope Jigsaw a. Count students off into five groups. The group will research the telescope that corresponds to the group number (page 22 of presentation). b. Hand out the jigsaw paper and go over the directions. c. Give students 30 minutes to research independently. d. Students should return to their group and take turns sharing what they learned. The group should decide as a whole what will and what will not be shared about their telescope. **Day 5**

	1. Create new groups that contain one person from each telescope group. (Your numbers probably will not allow this to be a perfect division. It is okay if there are two people who have researched the same telescope but it is not okay if a group doesn't represent all telescopes. 2. In the groups students should take turns sharing about their telescopes. Students are expected to write down the facts about the other telescopes on their piece of paper.
Post Activity Assessments	**Closure**
	1. At this point, you can introduce students to Event Horizon, which is bringing together a global network of astronomers with a global telescope. https://eventhorizontelescope.org/

Educator Resources

Optional Activity Lesson 3 from ALMA https://almaobservatory.org/wp-content/uploads/2016/11/edu_0072.pdf (last accessed 5/15/23)

Background: https://imagine.gsfc.nasa.gov/science/toolbox/emspectrum_observatories1.html (last accessed 5/15/23)

Optional Activity: Try to arrange a virtual tour of the Very Large Array (It is best to reach out to the Education or Outreach Depts. To get a response). You can also take a virtual tour at the following link https://public.nrao.edu/explore/vla-explorer/ (last accessed 5/15/23)

Background information on telescopes and arrays: https://public.nrao.edu/telescopes/radio-telescopes/ (last accessed 5/15/23)

How to use Jigsaw groups: https://www.jigsaw.org/ (last accessed 5/15/23)

Acknowledgment

The creation of the lessons in this series was funded by a generous grant from the National Science Foundation (NSF). The lessons were created as part of the SpectrumX project at the National Radio Astronomy Observatory (NRAO).

Below is a list of the lesson titles included in the series. All lessons can be accessed from this web page, https://superknova.org/educational-resources/.

Middle School

Introduction to Satellites
Weather Predicting
Introduction to Radio Wave Communication
The Importance of Radio Astronomy
Cubesat Model Building
Understanding FM Radio
Radio Frequency Technology
Diffraction of Radio Waves
Who Decides if You Get 5G?

High School

The Uses of Radio Waves and Frequency Allocation
Is Radio Technology Safe?
Diffraction of Radio Waves
Measuring Sea Surface Temperatures with Satellites
Marine Animal Tracking and Bathymetry
How to Design Your Own Crystal Radio
How Radio Waves Changed the World
Simple Wireless Communication
Seeing and Hearing the Invisible
Local Wireless Radio Frequency Communication
Investigating the Internet Connection
The Geometry of Radio Astronomy

Informal

Modeling Radio Astronomy

SPECTRUMX
An NSF Spectrum Innovation Center