Mission 10
The Search for Extraterrestrial Intelligence

The Needle in the Celestial Haystack

Notes

In Mission 9, students became proficient at finding a signal in a background of radio static. In Mission 1 of Project Haystack, students were told that they would be challenged with finding the point of origin of an extraterrestrial signal–the needle in the celestial haystack. That time has come!

Overview

In this mission, students call upon their new skills and knowledge about different types of stars to decide which stars (from a list) they would like to "listen" to with a radio telescope. In Mission 10.1, student teams simulate a "targeted search," hoping to detect a distinct radio signal that might signify the presence of life outside Earth. Each team is given only enough time on the simulated radio telescope to listen to three stars. The radio data they receive is mostly noise. When they *do* receive a signal that stands out against this background of noise, the signal is not clear. In Mission 10.2, students attempt to verify the reception of a signal from Mission 10.1, learning that even when a signal is found, any interpretation will be very uncertain.

Mission 10.1
Materials

For a Class of 30

- "Radio Signal Search Data, Day One" worksheet (pages xxxxxx)
- 16 file folders
- Box to store file folders

For Each Team

- "SETI Star-List" worksheet (page xxx)
- "Stellar Facts" (page xxx)

For Each Student

- "Searching for a Signal" worksheet (page xxx)
- Pencil

Getting Ready

1. Label 16 file folders with the star numbers and names taken from the “SETI Star List” worksheet.

2. Copy the “Radio Signal Search Data, Day One” for all 16 of the stars. Four have been put on a page to save paper. Cut the sheets apart, and place the appropriate data in each labeled folder. You will need to put more than one copy into each folder because more than one team might ask for data for the same star at the same time. If students are good at selecting the more promising stars, many students will choose to listen to the same ones, while other stars are never selected because they are obviously unlikely candidates.

   Important: Each “Radio Signal Search Data, Day One” page is labeled with the name of four of the 16 stars. Of the 16 stars, 13 do not provide any radio signal, only background static. Only three of the stars, Tau Ceti, Beta Pictoris, and Epsilon Eridani, have a signal within the static background noise.

3. Put all the data folders into a file box and place it in the classroom for easy access and distribution.

4. Copy the “Stellar Facts” pages and the “SETI Star-List” worksheet for each team. Copy the “Searching for a Signal” worksheet for each student.

Classroom Action

1. **Discussion.** Divide the class into teams of two to three students each. Remind students that there are millions and millions of stars in just a small portion of the Milky Way Galaxy and that the list of 16 stars that you are giving them for this mission is indeed a very, very small selection of the total possible.

   Explain that radio telescopes cannot see the entire hemisphere of the sky as our eyes do. To achieve high sensitivity, radio telescopes are focused on a very small area of the sky much like the field of view in a camera or a telephoto lens. This is like one of us looking at the sky through a straw, with one eye closed. We are forced to look at one, or at best a few, stars at a time. Typical radio telescopes must be pointed in entire sky.

   There are two ways to conduct a SETI search: an “all sky survey” and a “targeted search.”

   - In the all sky survey, radio telescopes are rapidly scanned across blocks of the sky in both the northern and southern hemispheres until the entire sky has been covered. Computers using sophisticated software programs are needed to search through millions of simultaneous frequency channels to see if a signal is present and persisting from a single point in the sky. Try listening to millions of channels at the same time on your radio!

- The targeted search uses a different approach. SETI scientists have chosen 1,000 stars with qualities similar to our Sun. They will dedicate a certain amount of the limited listening time available on very large radio telescopes to each of these stars.

2. **Facts.** Hand out the “Stellar Facts” pages to each team. Give students time to read their “Stellar Facts” pages.

3. **Worksheet.** Hand out the “SETI Star-List” worksheet to each team and the “Searching for a Signal” worksheet to each student. Explain that each team must pick only three stars from the list of 16 stars. This simulates the fact that time on a radio telescope is very expensive and many others want to use the telescope for their research projects.

   Students must decide: What stars are the most likely candidates to have planets from which intelligent life might be broadcasting radio signals? What star characteristics are important in suggesting that they might have planetary systems? Students can obtain this information from their “Stellar Facts” pages.

4. **Discussion.** Review the kinds of information given on the “SETI Star-List.” Be sure that students understand that the mass and radius of a star are given as ratios to the mass and radius of the Sun. The temperature is given in degrees Kelvin. Some stars in the list belong to a multiple-star system.

   Teacher’s Note: *Make sure your students are familiar with measuring temperature in the Kelvin scale. Degrees on the Kelvin scale are the same size as the Centigrade scale. The Kelvin scale starts at absolute zero (-273°C) and always has a positive value. Water freezes at 273K and boils at 373K. Kelvin does not use the degree (°) symbol.*

   Point out that each team must write their reasons for the star choices they make before requesting the radio data. It is up to each team to interpret the radio data and judge if a signal is present. Tell the class that they will need to verify the signal of any star they think has a signal on day one via a second observation on day two. Discuss why scientists think it is necessary to verify their findings. Each team must be ready to report their findings to the entire class.

5. **Activity.** After students read their “Stellar Facts” pages and confer with their team members, teams should come up to your desk and request “Radio Signal Search Data.” You should either initial or rubber stamp the verification column. This will be sure to limit each team to only three choices. Encourage teams to keep quiet about any discoveries until they have a chance to report their findings after the second day. Make sure that students return their “Radio Signal Search Data” and turn in their completed “Searching for a Signal” worksheets.

Mission 10.2
Materials

For a Class of 30

- PowerPoint projector
- PowerPoint slide of “Radio Signal Search Data, Day Two” worksheet (page 208)
- PowerPoint slide markers or grease pens

For Each Team

- “Radio Signal Search Data, Day Two” worksheet

For Each Student

- “Finding the Needle” worksheet (page xxx)
- Pencil

Getting Ready

1. Set up the overhead or data projector.

2. Copy the “Radio Signal Search Data, Day Two” worksheet for each team. Only one of the three stars on this worksheet, Tau Ceti, has a confirmed signal.

3. Copy the “Finding the Needle” worksheet for each student.

4. Reassemble the class into their teams from Mission 10.1.

Classroom Action

1. **Discussion.** Begin by listing on the whiteboard all 16 stars and recording how many teams chose to look at each one. Were there any stars that were not looked at? Should they have been? Discuss what makes a star a good choice or a bad choice as a candidate in our search.

2. **Team Reports.** Survey student signal detection discoveries by asking if there were any teams that did not find a signal at all during day one. Ask those students to report to the class first. If appropriate, tell them, “Good job, just bad luck! In this mission, several likely star systems are not sending any signals!” What are their conclusions? How did they conduct their search? Do they feel that there are no signals at all? The point here is that it is all right to observe and not find the phenomenon for which you are looking. That, too, is information.

   Ask if there are any teams that looked at a star and noticed a signal. “Good job! And good luck!” Ask teams to report to the class. This will tell you if all three Day One signals were found and, more importantly, if the one real signal was found. (If not, you may wish to show it as a transparency.)

3. **Discussion.** Ask students if, based on the information that has been collected so far, they will make a confident declaration that there is intelligent life in the universe. Maybe the signal(s) detected were from an unknown radio source on Earth, or maybe the signal(s) were just the unlikely result of the random radio noise. Perhaps it was the result of some new phenomenon that produces a steady, loud, narrow band signal.

   Ask for suggestions on how to be more sure about a signal. Students will probably suggest it, but reinforce the importance of experimental verification in science. Facilitate the discussion to the point where the class reaches a consensus. Tell the class that all teams will be given radio data from each of the stars that the class agrees might have an actual signal. This will allow all students to examine signals, even those teams that did not find signals during day one.

   Teacher's Note: *Two of the apparent signals from day one will not be verified: Epsilon Eridani and Beta Pictoris. Only the signal from Tau Ceti will be verified during day two.*

4. **Transparency or PowerPoint slide.** Show the image of the "Radio Signal Search Data, Day Two" worksheet–the radio data from the three stars that show signals–and let others in the class look for a signal. Ask a member of one of the discovery teams to come up and highlight the pattern with a marking pen. Follow the same process with the other perceived signals. This assures that all students will see all three apparent signals.

5. **Activity.** Hand out the "Radio Signal Search Data, Day Two" worksheet, which contains radio data from each of the three stars that might have an actual signal, to each team. Tell the class that all teams will be given an opportunity to verify the apparent signals received by the class during day one. Reassemble day one's teams. They must determine if the signal is still there. If the signal *is* still there, 24 hours later, then they have a verified detection! Allow time for observations.

   Optional: If a team wants verification of one of their three stars that did not show a signal yesterday (maybe they want to give their favorite star another chance), give them the data from day one for that star and just tell them that it is a repeated observation of the same star. This is basically accurate, as the situation has not changed; there is still no signal.

6. **Discussion.** Reassemble the class to share findings. Did an apparent signal disappear? *(Two are gone: Beta Pictoris and Epsilon Eridani.)* What could explain the detection of a signal one day, but not the next? *(Random, stray radio signals of Earth origin may have been picked up.) As another possibility, the ET transmitter may have been off when the students took a second look.)* These might not reappear when the signal was being verified with a second look.

   Is any signal still there? *(One will be: Tau Ceti.)* Would this discovery of one verified signal be conclusive evidence for intelligent life outside Earth? *(Indicative, but not conclusive!)*

Tell students that, in Mission11, now that the star with a signal has been located, they will try to interpret the signal. Make sure that students realize that this whole exercise is a simulation. So far none of the SETI searches has ever found a signal that has been verified, but they are still looking.

7. **Activity.** Hand out the “Finding the Needle” worksheet to each student. Ask students to answer the questions in their teams during class or individually as homework.

Going Further

Research: SETI in Action

Ask students to do research on some of the actual SETI searches that have been conducted, or those that are happening now. From where are searches conducted? Examples include Project Ozma, SERINDIP, META 1 & 2, and some 50-60 others. What percent of the sky has been searched? Are positive results (real signals) expected?

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SETI Star- List–Teacher's Key

Table 10.1.

Star	Mass (Sol = 1)	Radius (Sol = 1)	Temp (K)	Distance (Light Years)	Will You Scan It? (Give Your Reason)
Sol	1	1	5,500	8 light minutes	Scan for comparison
Alpha Centauri A	1	1	6,000	4.3	Multiple star system
Epsilon Eridani	0.7	0.8	4,800	10.7	Signal
Spica	17	7	26,000	220	Supergiant
Betelgeuse	16	550	2,900	310	Red giant
Sirius B	1	0.2	Unknown	8.6	Binary
Altair	3	1.6	7,400	17	Good choice, but no signal
Aldebaran	5	25	3,700	68	Red giant
Alpha Centauri C	0.2	0.3	Cooling	4.3	Multiple star system
Antares	16	500	2,400	520	Red giant
Bd +50 1725	0.7	0.75	4,130	14	Good choice, but no signal
Sirius A	3.5	2.5	9,800	8.6	Binary
Arneb	12.5	63	7,300	950	Supergiant
Alpha Centauri B	0.2	0.85	4,900	4.3	Multiple star system
Tau Ceti	0.8	0.9	5,100	11.9	Signal
Saiph	18	7.4	27,000	68	Sipergiant
Beta Pictoris	3	2	7,800	59	Signal

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Searching for a Signal–Teacher's Key

1. See the "SETI Star-List" teacher's key.

2. Answers will vary but should be in accord with the "Stellar Facts" pages.

3. Answers will vary.

4. Yes, with unlimited resources there is no reason to limit your search. Because SETI scientists currently do not have unlimited resources, they must decide which stars are more likely to have signals.

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Finding the Needle–Teacher's Key

1. Answers will vary.

2. Yes. Epsilon Eridani, Beta Pictoris, and Tau Ceti all have signals.

3. It is important for scientists to verify and confirm their data so they do not announce incorrect information. It is a process of checking one's results and is part of the process of science. Spurious signals could be produced by Earth-based sources or by the equipment used in the radio telescope itself.

4. For Epsilon Eridani or Beta Pictoris, students will find that their second observation does not confirm a signal.

5. They are no longer present. Without further investigation it is impossible to tell if the signals came from these stars and are simply no longer present, or if they came from an Earth-based source that is no longer producing a signal. These stars were good choices, but their false signals were included to show the need for verification and confirmation.

6. Only the star Tau Ceti has a verified signal on the second day of this simulation.

7. No, just finding a signal of this nature does not confirm that there is intelligent life out there. It could still be a signal associated with the telescope, or it could even be a deliberate hoax. Independent confirmation by another group at another telescope would give more confidence that it really was an extraterrestrial signal. Finding a message would prove that it was an intelligent source. Also, because of the time it would take the signal to travel from a distant star to Earth, the life that sent the signal might not be alive now.

8. It would take 11.9 years for a signal from Tau Ceti to reach Earth. Because radio waves are part of the electromagnetic spectrum, they travel at the speed of light.

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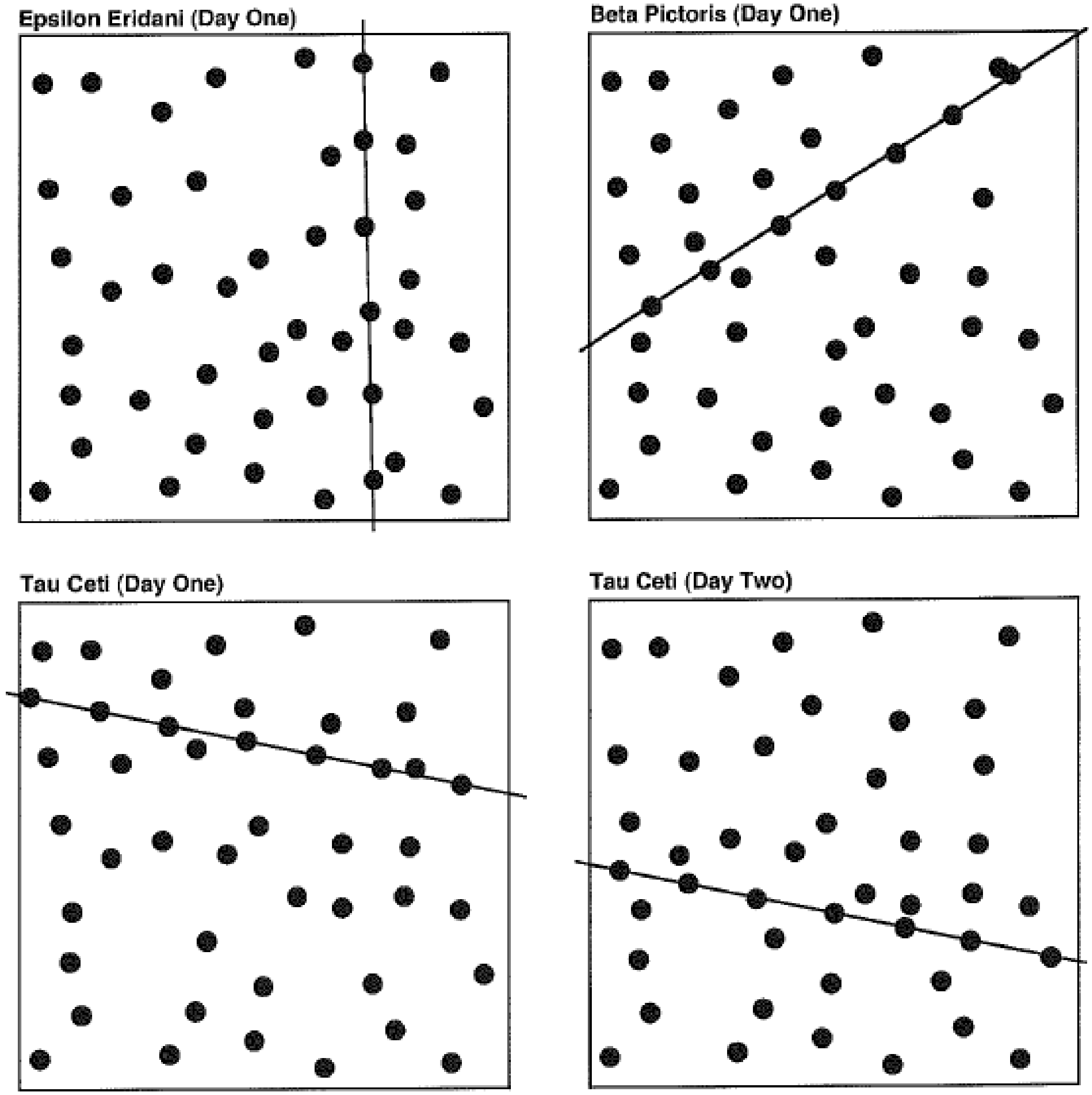
Radio Signal Search Data–Teacher's Key

Figure 10,1.



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