Are There Other Neighborhoods Like Our Own?

Grades 9-12

Lesson 3: Sending Messages to Space

Lesson Abstract

In 1974, the Arecibo Radio Observatory in Puerto Rico sent a message into space toward the Globular Cluster M13 in Hercules. The message included information about the human race and our planet, and used the physics and chemistry of the universe as the common language through which extraterrestrials could decipher the message. In this lesson students will be provided the message, attempt to interpret it, and gain a good understanding of the challenges of communicating with other intelligent life in the galaxy.

Grade Level
9-12

Sending Messages to Space

Overview

If there are other civilizations in space, how might we communicate with them?

We could try to send messages to them, and we could try to receive messages from them. One major problem with sending messages is that we don't know in which direction to send the message. Also, if we are going to send a message, what information should the message contain?

Another decision to make is the form of communication to attempt. Should we send messages on spacecraft? We sent messages along on the Pioneer and Voyager spacecraft, but at their speed they will take tens of thousands of years to travel the distance to a nearby star. (In fact, we did not send either spacecraft towards a specific star, so it will take even longer.)

A faster option is to use some form of electromagnetic radiation, since it travels at the speed of light. Radio waves work well because they can get through the Earth's atmosphere, and they can penetrate a lot of the dust in our galaxy that prevents other types of radiation from passing through.

In 1974, we took this approach and sent a message via radio waves from the Arecibo Radio Observatory in Puerto Rico to a cluster of stars. However, even at the speed of light, it will take 27,000 years for the message to reach the star cluster.

In this activity, students will be introduced to this message as an alien would—with no prior knowledge of what it means. They will attempt to interpret the message, and reach a better understanding of the challenges of communicating with other life in the galaxy.

ESSENTIAL QUESTION

How difficult would it be to communicate with alien life?

OBJECTIVES

Students will:

- Interpret a message sent to space using a radio telescope
- Draw inferences from the interpreted message

Procedures

1. Put the class into groups of two. Tell the students that scientists have received what they believe to be an alien message. Give each group a copy of Student Worksheet A. At this point do not hand out the other worksheet. Tell them that scientists pointing a radio telescope (a large radio antenna) towards space have just received an intriguing signal. They were tuned to a particular channel and fed the amplified signal into a speaker. What they heard was a tone that turned on and off in some strange pattern. After carefully analyzing the signal, they found that it could be characterized by a steady stream of 1679 "ons" and "offs". It appears to be a signal in binary, a language with only 2 "letters" in the alphabet. An "on" can be represented as a "1" and an "off" can be represented as a "0". All 1679 characters are reflected on Student Worksheet A. The only reason it is presented in multiple lines is that you can't fit all 1679 characters on the same line. The stream starts with the first line read **left to right**, followed by the second line read **left to right**, and so on. Ask the students to decipher the message.
2. Students will begin to interpret the data. The students most likely will not figure out the solution to this first message. However, it is important for them to see how difficult it would be to interpret an alien message.
3. After giving students some time to interpret the message, or if a student has begun to figure out the key, help them move forward on interpreting the message.
4. Tell students that while they were working on the solution, another group of scientists were also working on the solution and that they have some information that might be helpful.
5. Tell the students that the other group was attempting to arrange this long message into rows and columns. They realized that the message consisted of 1679 characters (consisting of ones and zeros), which, interestingly, is the product of two prime numbers: 23 x 73. [This is a good time to discuss the nature of prime numbers.] This seemed to lend itself to arranging the signal in a two dimensional array of 73 rows and 23 columns or 23 rows and 73 columns. The scientists decided to rearrange the message into 73 rows and 23 columns.
6. At this point give students Student Worksheet B with the rearranged message and give them some time to interpret the message. [Note of interest: the message on Worksheet B was created by writing down the string of 1679 characters with 23 per line, **right to left, top to bottom**.] Instruct the students to "translate" the message on Worksheet B onto a sheet of graph paper where the array is no longer represented as ones and zeros, but as "colored in" and "not-colored in" boxes on the graph paper. In other words,

MATERIALS

- Student Worksheet A
- Student Worksheet B
- Graph paper
- Pencils

wherever there is a "1" in the array on Worksheet B, color in the corresponding box on the graph paper.

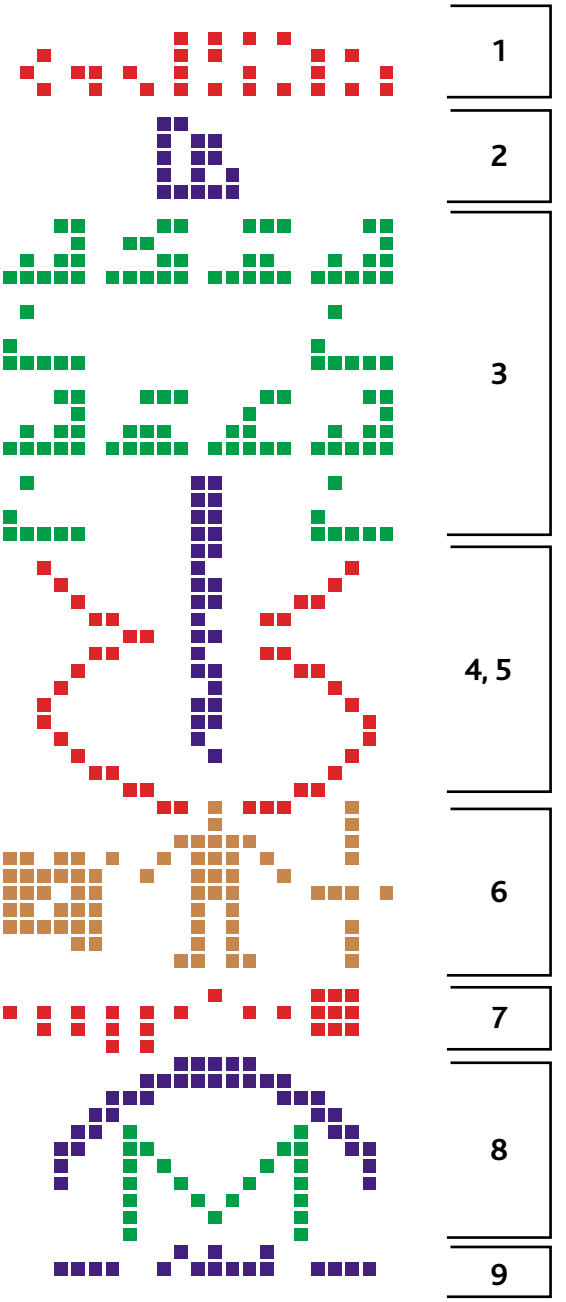
7. Once the students have completely "translated" the binary code, an image should become apparent on the graph paper consisting of a variety of symbols.
8. Have students write and present a report expressing what they feel each of the symbols means and why. This report should also contain a brief conclusion about the civilization that sent the message.
9. Once students have completed all of their presentations let students know that this was actually the Arecibo Message sent out into space in 1974 using the Arecibo Radio Telescope in Puerto Rico.
10. Show students the actual meaning of each of the symbols in the message and lead a class discussion on why it might be difficult for an alien race to interpret our message.

Answer Key

1. The first set of symbols represent the numbers from 1 to 10 reading from right to left. This is the basis for our counting system. The lowest row of dots in this portion of the message are simply markers for the numbers 1 through 10. Each number is then written vertically above the corresponding marker in binary: 001=1, 010=2, 011=3, 100=4, 101=5, 110=6, 111=7, 1000=8, 1001=9, 1010=10. Notice that the numbers 8, 9, and 10 require two columns to write out completely.
2. Directly below the numbers 1 through 10, which provide the key for interpreting the meaning of this next portion of the message, are a list of five numbers which give the atomic numbers of the five chemical elements of which DNA is composed, and which are the principal components of all of our biological molecules. From right to left we have:

Atomic Number	
1	Hydrogen
6	Carbon
7	Nitrogen
8	Oxygen
15	Phosphorus

3. The next patterns represent formulas for sugars and bases in the nucleotides of DNA.
4. The vertical bar in the center specifies the number of nucleotides in DNA using the binary system. Here, two columns are used to write out this rather large number.
5. The double helix of DNA is represented by the curving lines that go from the (sugars/bases) formulas to the human figure.
6. The next set of symbols represent the human population (on the left) on Earth, a figure of a human (in the center), and (on the right) the height of a human in units of the radio wavelength used for the message.
7. Our Solar System is displayed next with the size of the darkened areas giving a very rough estimate of the relative size of the planets. The dot representing Earth is displaced toward the human being.
8. The Arecibo telescope dish is transmitting the message near the bottom of the picture.
9. The last set of symbols give the diameter of the Arecibo Radio Telescope in units of the radio wavelength used for the transmission.



Transfer and Extension

Based on the knowledge they have amassed in this activity, have your students generate their own message to send to an alien race, and explain it to the class.

ASSESSMENT

Students' work can be evaluated using the following rubric:

4 Points

The responses provide a well developed clear position reflecting the following:

- Addressed intended audience
- Information fully describes all symbols and the position taken is explained
- Relevant and specific information was used
- Effective language was used in influencing the audience

3 Points

The responses provide a well-developed clear position. Responses reflect the following:

- Addressed intended audience
- Information partially describes all symbols and the position taken is explained
- Relevant and specific information was used
- Effective language was used in influencing audience

2 Points

The responses provide a partially developed position. Responses reflect:

- An attempt to address intended audience
- Information partially describes all symbols and the position taken is explained
- Some relevant and some specific information was used
- Adequate language was used in influencing audience

1 Point

The responses fail to provide a position. Responses reflect the following:

- Does not address intended audience
- Information does not describes all symbols and the position taken is not explained
- Not relevant or specific information used
- No influencing language was used

0 Points

- No response.
- Response off topic.
- Unable to read response.

Student Worksheet A

0000001010101000000000000010100000101000000010010001000100010010110010101

0101010101010010010000000000000000000000000000000000000000011000000000000000

0000110100000000000000000000110100000000000000000001010100000000000000000000

1111100000000000000000000000000000000011000011100011000011000100000000000

0011001000011010001100011000011010111110111110111110111110000000000000000

0000000000010000000000000000100000000000000000000000000000010000000000000

0000111111000000000000011111000000000000000000000000011000011000011100011 0

0010000000100000000010000110100001100011100110101111101111101111101111 0

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1000001100000000001111110000110000001111100000000001100000000000010000

0000100000000100000100000011000000010000000011000011000000100000000001100

0100001100000000000000011001100000000000001100010000110000000011000011 0

0000010000000100000010000000010000010000000110000000010001000000001100 0

0000100010000000001000000010000010000000100000001000000010000000000011 0

0000000011000000001100000000010001110101100000000000100000001000000000 0

0001000001111100000000000010000101110100101101100000010011100100111111 10

1110000111000001101110000000001010000011101100100000010100000111111001 00

0000101000001100000010000011011000000000000000000000000000000000000111000

0010000000000000011101010001010101010100111000000000101010100000000000 0

0001010000000000000111110000000000000000111111111000000000000111000000 0

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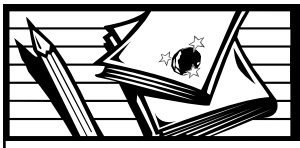

Student Worksheet B

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