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Arecibo Message

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Title: Make Your Own Arecibo Message
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Date: 2019
Material Type: Lab
CS + Astrobiology
Software/Equipment Dependencies: None.
Prior Knowledge Needed (if any): None.
Keywords: Binary Counting, Image Processing and Rendering, Bitmaps,
Approximate time needed: 3 hours
Description: Students are invited to explore the Arecibo Message, its contents, and decode the message. An interactive pen-and-paper (or easily ported to a BlackBoard module or a Homework Management System) laboratory investigation follows.

Make Your Own Arecibo Message

In 1974, astronomers Carl Sagan and Frank Drake sent a radio signal in the direction of the globular cluster M13 a group of 3×10^5 stars at a distance of 2×10^5 light years. The signal was a series of 1679 short bursts (100 ms each) of radio waves with a frequency of either 2.38 or 2.39 GHz representing a binary message. They did this by using the Arecibo radio telescope in Puerto Rico. The number of bits transmitted in the signal is a semiprime (23×73) and, because of the fundamental theorem of arithmetic, these are the only factors of this number. The universality of mathematics means that regardless of how an intelligence invents a counting system, this fact will remain true and this allows for a constrained arrangement of the message into a two-dimensional binary bitmap image shown in the sample slides.

Students can first be introduced to the Arecibo Message, the background of how the message was sent, and how a bitmap image is to be constructed from such a signal should be explored. The Sample slides can be used in a lecture format, for example.

Students should then spend some time deciphering the Arecibo Message. Wikipedia has an excellent crowdsourced deciphering of the message:
https://en.wikipedia.org/w/index.php?title=Arecibo_message&oldid=890927580
To assess students learning, consider using the following question bank (e.g., in worksheet form or via an online test):

1. What if we used a different base for counting instead of base 10? Which part of the Arecibo Message would change?
2. Astrobiologists consider sulfur to be an important element for terrestrial life along with HCNOP (sometimes the metonym "CHNOPS" is used to remember this). although it is not found in DNA. Imagine you wanted to include sulfur in the Arecibo Message. What would its symbol be?
3. Choose a chemical other than DNA to represent in the format used in the Arecibo Message.
4. For an additional challenge, try to represent RNA instead of DNA.
5. For an additional additional challenge, try to represent XNA.
6. According to the most accurate accounts from the Human Genome Project, there are 3,088,286,401 DNA base pairs rather than the 4,294,441,822 Drake and Sagan indicated. How would you modify the Arecibo Message to indicate this?
7. The average height of humans today (according to unofficial sources) is approximately 165 centimeters. How would you modify the Arecibo Message to indicate this?
8. How would you modify the Arecibo Message to take into account the actual population of the world today?
9. How would you modify the Arecibo Message to take into account that Pluto is no longer a planet?

As a final activity, have students construct their own Arecibo Message. Here there are some options for directing this:

A. Have the students modify the Arecibo Message still constrained to use 1679 bits. The above questions can serve as a model for how to modify it.
B. Have students construct their own Arecibo-type message using graph paper and a bitmap construction. Have them submit a string of 1s and 0s without any spaces, arrangements, or even so much as pressing the enter key. Require that students submit strings of lengths that are a semiprime. Because images that are too small are generally unintelligible, a minimum size larger than roughly 10x10 is preferable. (Note that 100 binary digits is NOT an acceptable size because 100 is not a semiprime!) Software that can read an Arecibo-type message is developed by Joshua Tan (please contact him for a full version), and student development of such is the basis of the Week 2 assignment. Using such software, either the instructor or the student can interpret such a message and confirm compliance with the requirements for such a message.

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