SCIENCE 3D

LIFE IN THE TREES

In this packet, sample student answers are provided in red and notes to teachers are in blue.

In this **STEM Project** students will learn about sorting algorithms. They will use this knowledge to suggest ways to program a computer to automate the sorting of calls made by bats and other rainforest animals.

Engineers and scientists are constantly developing new and less expensive technologies. Cameras that cost $5,000 a few decades ago now cost $50! Phones have more memory to store data than huge computers used to have. That means scientists can collect more data than ever. But, gathering lots of data means there is more work to do to understand patterns. Computers can help!

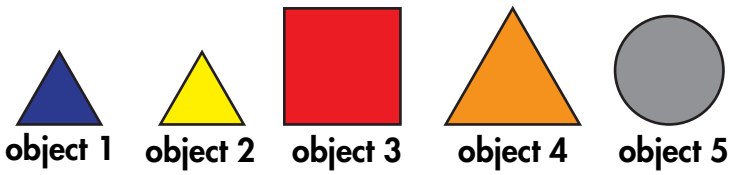
Extend the Lesson: Have students choose a computing or digital technology. Have them develop a presentation or report on how that technology has changed over time. Have them investigate the power, size, and price.

ACTIVITY I: WORKING WITH ALGORITHMS

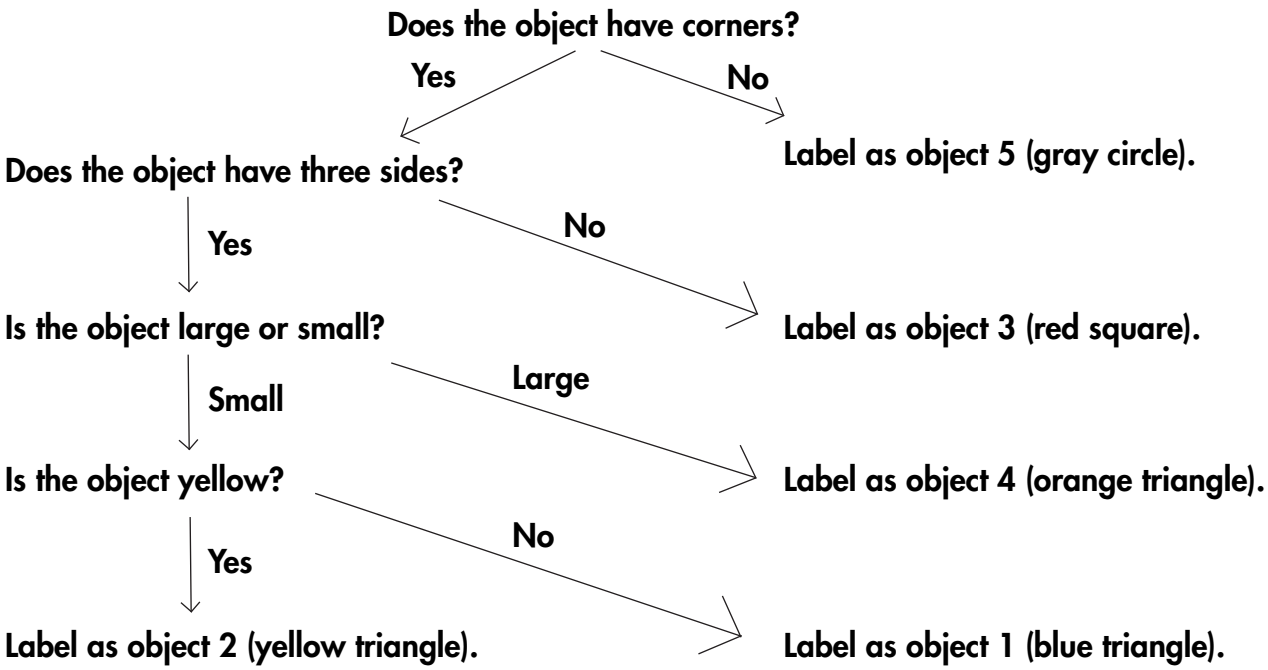
In computer science, an algorithm is a set of rules that computers use to solve problems or make calculations. It is a bit like a recipe in a cookbook. If you follow the recipe, you will end up with the right dish!

With all the data from the sound recorders that Dr. Bernal and the team have collected, they need a computer to help them sort the information. Going through it by hand would be impossible! But, how would a computer do that? First, we need to understand what the data look like.

For example, we might want to create a simple algorithm to sort and count shapes if we have millions of images of shapes. Let's say that all the objects look like one of the five pictured below:

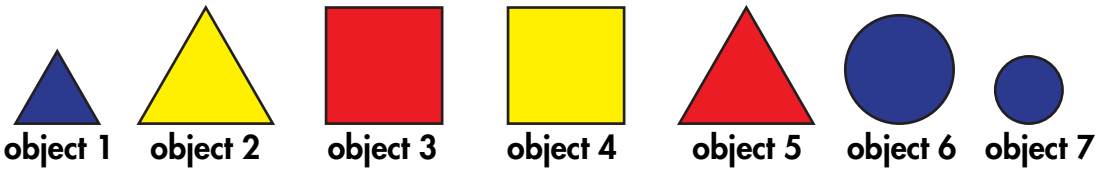


Now, let's write an algorithm that would let us identify which specific object each image is.

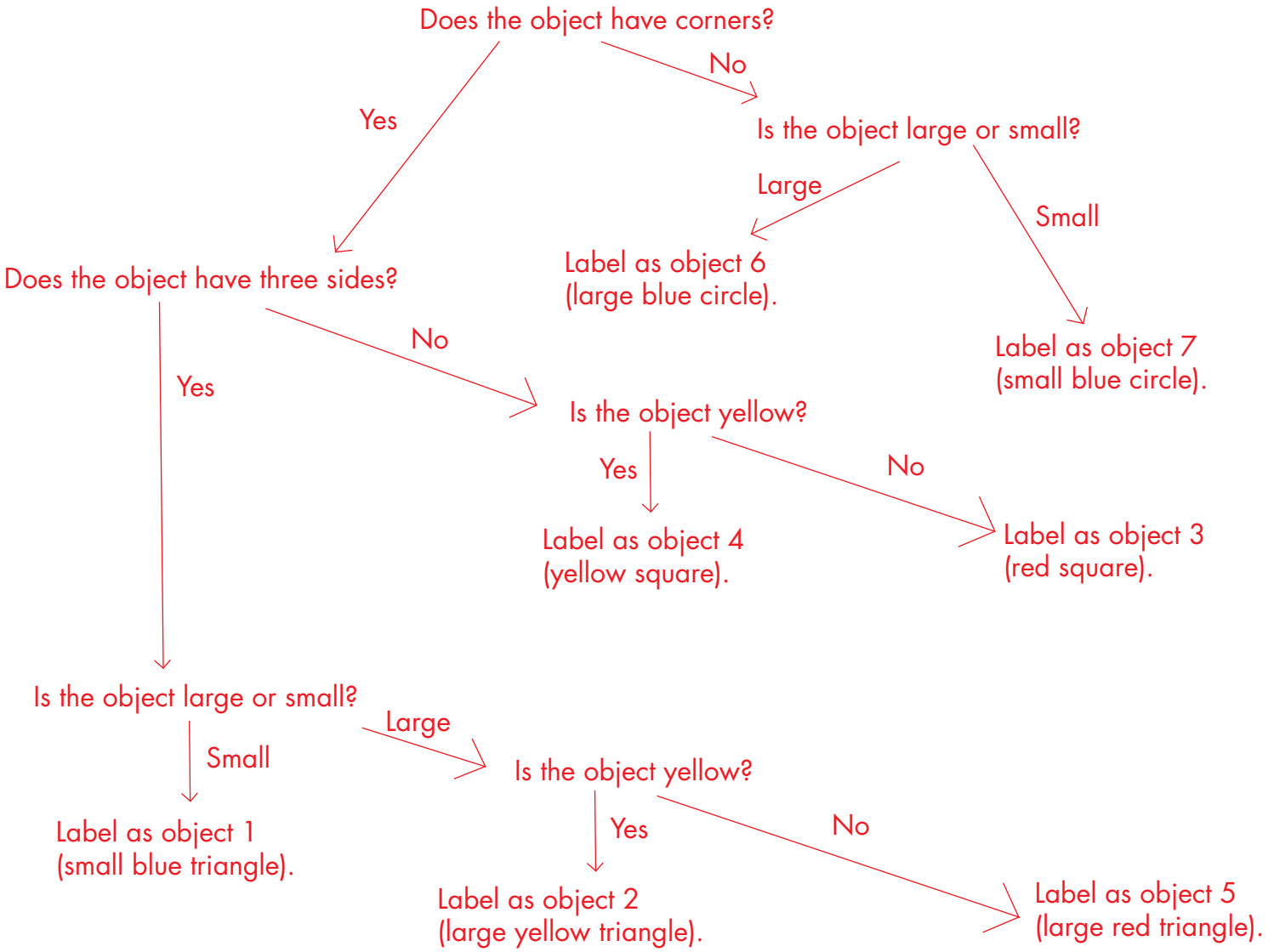


This project can be done as group work or individually. However, ask students to do their algorithms independently first, even if they are in a group. Tell them they will help each other to come up with the best solution in the next steps.

Now, it's time for you to give it a try. Here are the objects to sort:



1. **Create** a sorting algorithm, using the previous example as a guide.
   Accept reasonable answers. The important part is that the algorithm makes sense rather than its order.



An important part of programming a computer is checking your work! Having other people look at your solution can help you make improvements. Teamwork can help you identify problems or errors. Other times working together will lead to simpler algorithms. When you are sorting through a huge amount of data, limiting the number of steps in a solution can save a lot of time!

2. **Compare** your solution to those of other students. Were your solutions the same? Did they have the same number of steps? Were there any possible errors that you want to fix in your algorithm?

Answers will vary. Students might emphasize different ways to sort or possible errors in their "code." This exercise is more about emphasizing process than getting the best answer possible.

ACTIVITY 2: BATS IN THE NIGHT

Collecting data on bats can be difficult. The team at Tirimbina has recorded many of their calls, but how do you figure out which type of bat is calling?

One way to look at sounds is to use a spectrogram. This shows the frequencies of sounds over time. The lower part of Figure 1 below shows the spectrograms for the echolocation calls of seven types of bats at Tirimbina. But sound waves have more than just a frequency and a wavelength. They also have an amplitude. The amplitude determines how loud a sound is. The larger the amplitude, the louder the sound. The upper panel of Figure 1 shows the amount of energy (amplitude) in the bat calls over time.

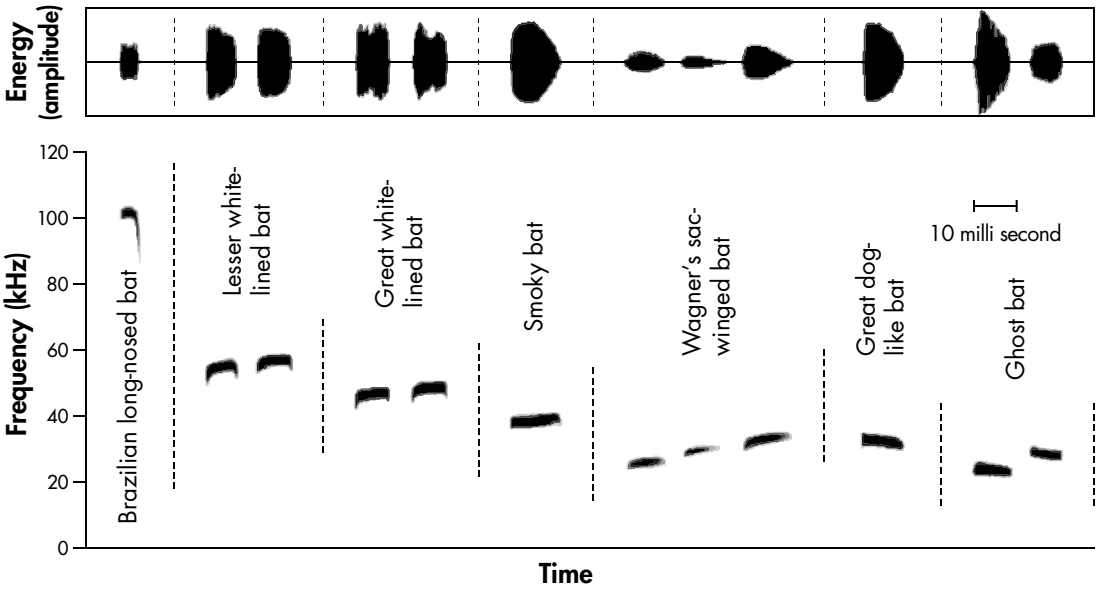


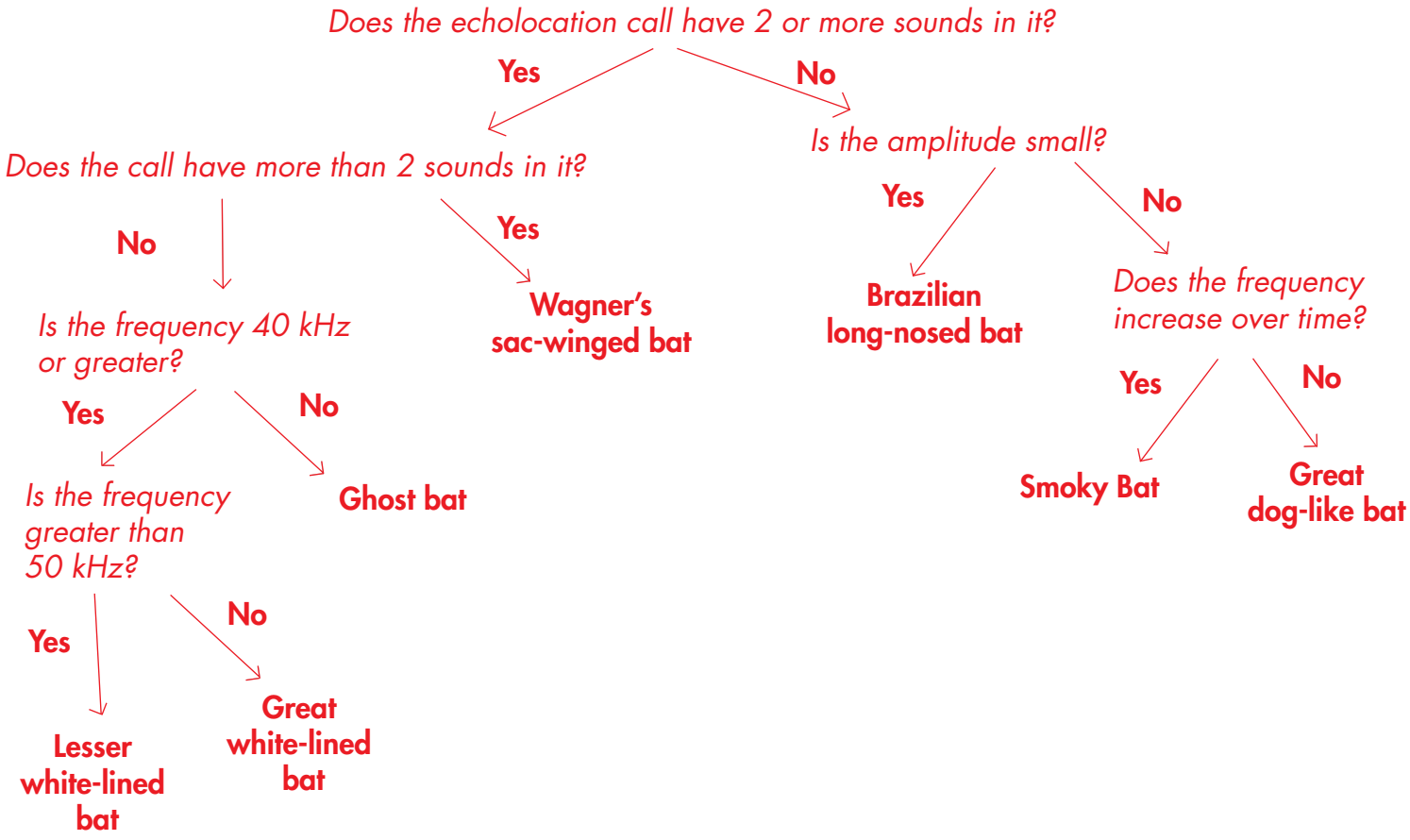
Figure 1. Echolocation calls of seven bat species found in Costa Rica
The top panel shows the amplitude (or energy) in the call over time for each species. The bottom panel shows the frequency of the calls. The black bar represents 10 ms of time. These calls are short.

1. **List** some characteristics of the echolocation calls that a computer might be able to use to categorize the different bats at Tirimbina. Use evidence from Figure 1 to support using these characteristics.

The number of calls in a group: Some, like the smoky bat and great dog-like bat have one call at a time. Others have two or three. The frequency of the call: Different bats have different frequencies of their calls. How the energy (amplitude) of the call change: The ghost bat has a very different call amplitude than the Brazilian long-nosed bat.

2. **Create** a sorting algorithm to classify echolocation calls into the different bat species. Use the same style as the shape sorting example.

Answers will vary. One example is below.



3. **Compare** your solution to those of other students. Were your solutions the same? Did they have the same number of steps? Were there any possible errors that you want to fix in your algorithm?

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In the rainforest, there are many species that produce soundwaves. And, their calls are very different than those of bat echolocation. Figure 2 shows a spectrogram of the songs of three clay-colored thrushes. Some sounds are complex; they have more than one frequency produced at a time. Think about music. There are many different frequencies of sound, which we hear as different pitches at the same time. In the rainforest, an example of a call with more than one frequency is the moo call of the howler monkey shown in Figure 3.

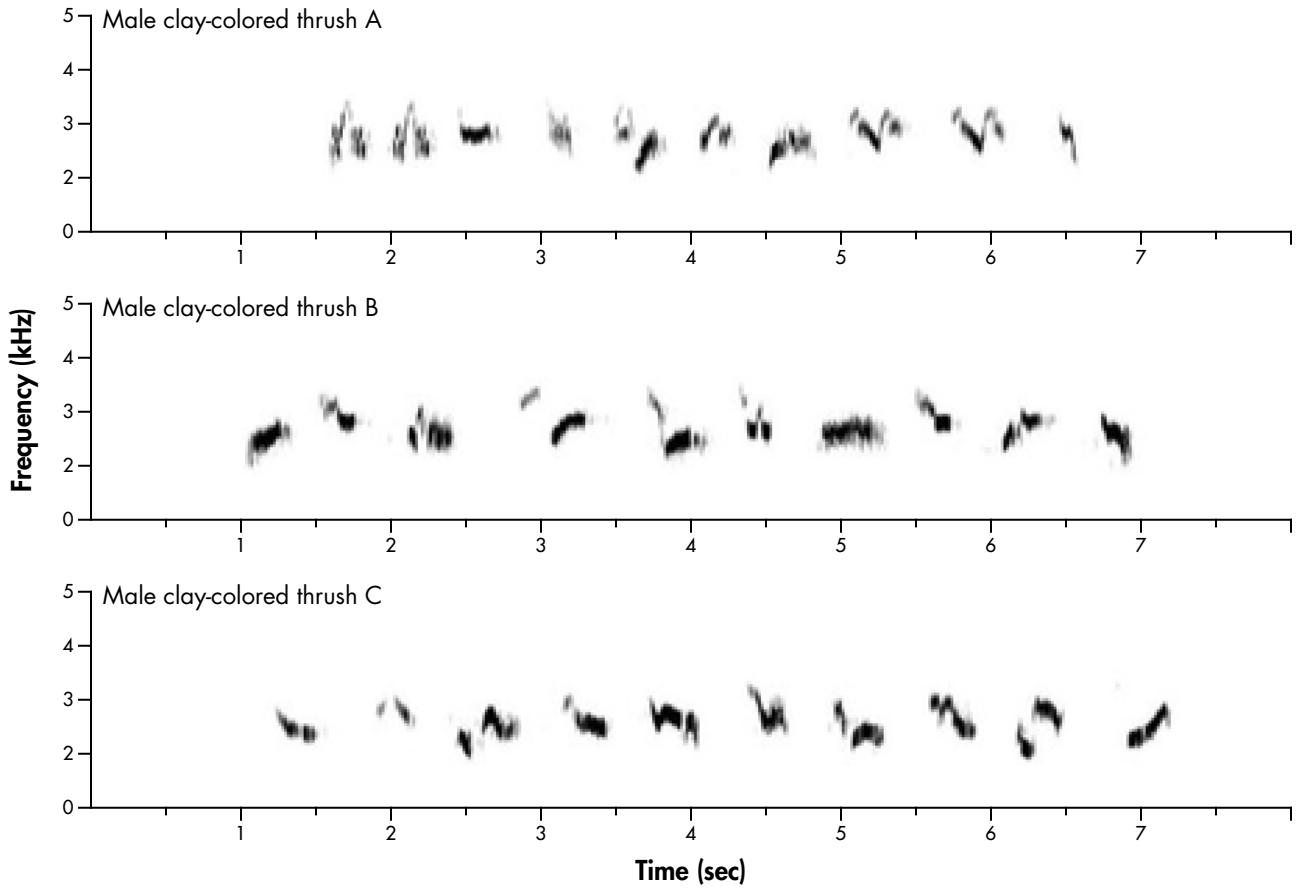


Figure 2. Spectrogram of song of male clay-colored thrushes (Costa Rica's national bird)

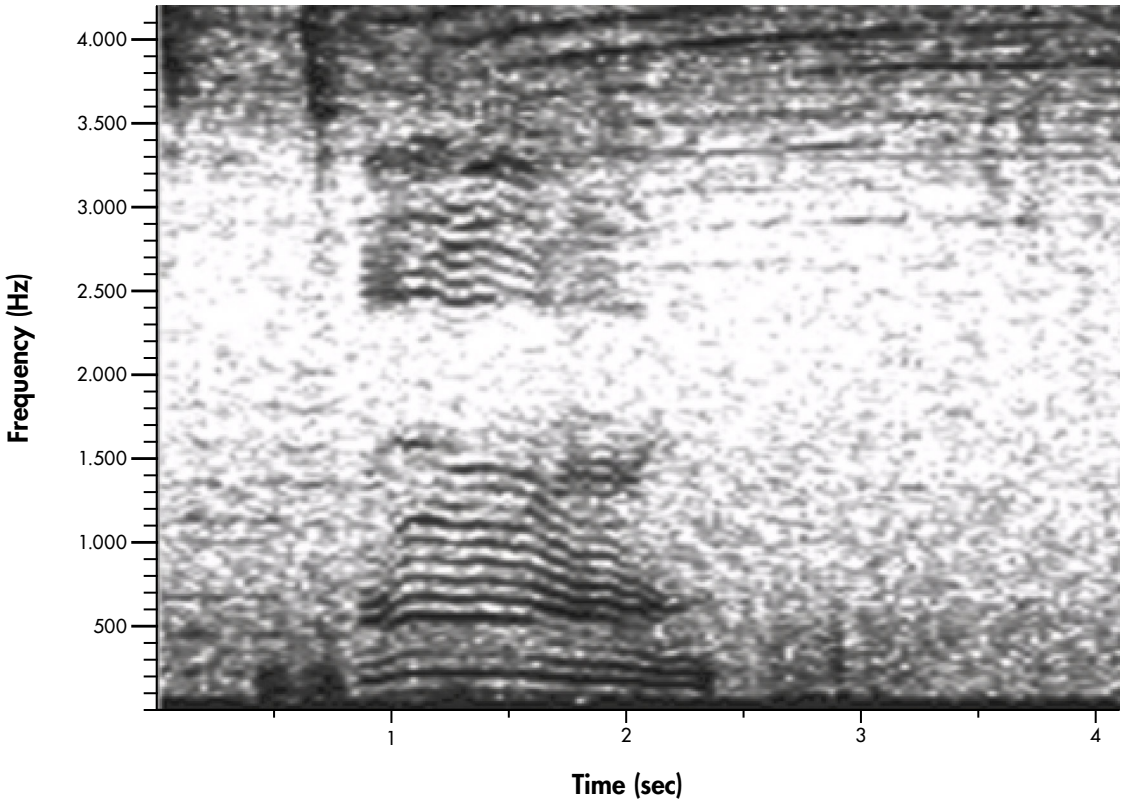


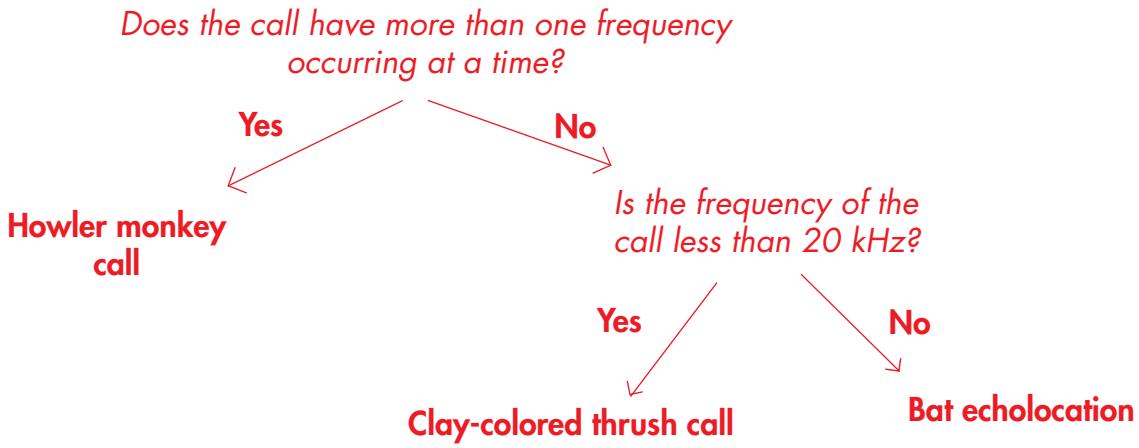
Figure 3. Spectrogram of a howler monkey "moo" call

4. **Compare** and **contrast** the bat echolocation calls, the song of the thrush, and the call of the howler monkey. Hints: Look at the time the calls take and their frequencies. Be sure to look at the units on the axes of all the figures!

Some things students should notice include: Bat echolocation calls are much faster than the calls of howler monkeys and thrushes. But monkeys and thrushes are fairly similar. The frequency of bat calls is much higher than thrushes, and thrush calls are much higher than howler monkey calls. Bat calls tend to stay at a similar frequency (except Brazilian long-nosed bats) but bird calls change. Bird and bat calls tend to stay in a small range of frequencies at any one time, but howler monkey calls have many different frequencies at one time.

5. **Create** a sorting algorithm to classify calls into the different bat species, thrushes, and howler monkeys.

Answers will vary. One example that classifies the different kinds of animal groups is below.



6. **Compare** your solution to those of other students. Were your solutions the same? Did they have the same number of steps? Were there any possible errors that you want to fix in your algorithm?

Answers will vary. Students might emphasize different ways to sort or possible errors in their "code." This exercise is more about emphasizing process than getting the best answer possible.