# About the Activity

In the previous lesson What Is Life?, students learned that life is defined mostly by what is happening at the molecular level. This activity begins with a quiz covering the concepts from that lesson. In this activity, students learn how scientists use molecular information to determine evolutionary relationships among organisms. Because bacteria and other single-celled organisms have few morphological characteristics that distinguish them, they are studied on a molecular level to determine relatedness. Students contrast ribosomal RNA base sequences of several organisms and deduce evolutionary relationships from these biochemical data. Students learn that there are portions of the genetic code that are similar in all living things. In the next activity, The Rock and Fossil Record, students learn of other ways that scientists can compare organisms and examine several types of evidence that scientists use to learn about the past - the fossil record.

# Learning Objectives

After completing this activity, students will be able to:

- Explain how RNA sequences are used to determine the degree of relatedness between different organisms.
- Cite evidence that life has a universal biochemistry.

# During the Activity

## Activity Sequence in Brief

Evaluate
Students take a quiz covering lesson 2.

Engage
Students examine an image of extant organisms and discuss ways that scientists could compare organisms.

Explore
Students contrast RNA sequences from different organisms and complete a student activity sheet.

Explain
Students compare responses and view a three-dimensional image of RNA.

Elaborate
Students examine a Tree of Life image.

Evaluate
Teachers collect and evaluate the Student Activity Sheets.

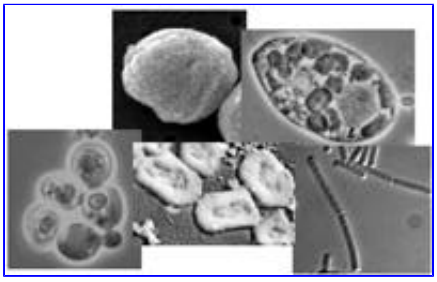
## Evaluate (10 minutes)

1. Distribute a copy of the What Is Life? Quiz to each student.

2. Give students 5 minutes to complete the quiz, then collect quizzes and concept maps that students created for homework from the previous activity. Save the concept maps for 6.1 Post-Assessment, when students will compare them to their final maps.

## Engage (5 minutes)

1. Display the image: Extant Organisms and ask students to point out similarities and differences between the organisms shown. *(Students might suggest that most have a spherical body shape. None of the organisms have arms, legs, or obvious sensory organs; all of the organisms are simple forms of life.)*



2. Ask students to think of ways that biologists could determine the relatedness between these species. *(Students might suggest morphological differences. Some might suggest analyzing genetic material.)* Describe additional methods to them, such as looking at development (mammals possess gill slits during their development, which disappear before birth, indicating a fish ancestor), and comparing molecular information. As students learned in the previous lesson, each organism's genetic code carries instructions for all the functions of life, organisms that are more closely related share more genetic information than distantly related organisms share.

3. Explain that in today's class, students will examine molecular differences between a variety of organisms, including several groups of bacteria.

4. Tell students that in order to infer relationships that cross over the entire diversity of life, it is necessary to look at molecular information that has not changed much over the billions of years of evolutionary history. An example of the information in that category is ribosomal RNA.

## Explore (20 minutes)

1. Explain that in today's activity, students will contrast pieces of ribosomal RNA sequences. Distribute a copy of RNA Sequences to each team of 2-3 students and a Comparing Molecular Data Student Activity Sheet to each student.

2. Ask a student volunteer to read the directions aloud. Direct each team to share the task of contrasting the sequences. It is easier to contrast sequences visually by cutting the sequences into strips that can then be lined up for comparison. Instruct students to leave the names of the organisms attached to the strips of sequences.

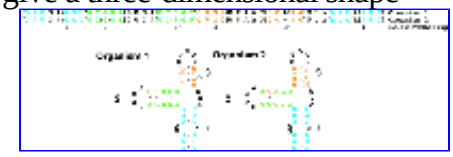
3. Give students 15 minutes to do the activity and answer questions on their Comparing Molecular Data Student Activity Sheet.

## Explain (10 minutes)

1. Compare answers as a class using the Comparing Molecular Data Teacher Answer Key as a guide. Emphasize to students that although there are numerous differences in the sequences they contrasted, there are also many similarities. Point out that even the least related organisms on Earth share nucleotide sequences, evidence that all life evolved from a common ancestor.

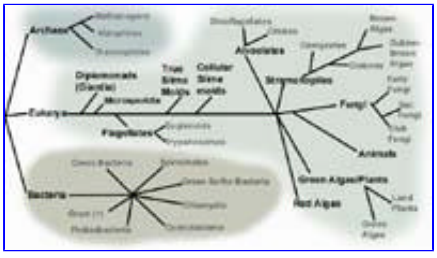
2. Display the image: Extant Organisms (labeled) to show students the domains to which the organisms that they saw earlier in class belong.


3. Remind students that they were only contrasting very small fragments of rRNA. Ask students how they would see their task if they had thousands of sequences to compare for each animal. *(Comparing thousands of sequences would either take much more time or require a computer. Comparing longer sequences would also provide a clearer picture of relatedness of species.)* Explain that, in addition to base sequences, ribosomal RNA has loops and helices that fold to give a three-dimensional shape which conveys additional information. Show the image: RNA Three-Dimensional Structure, which shows a computer projection of RNA three-dimensional structure. Scientists also take the molecular shape into account when comparing rRNA of different organisms to determine relatedness.



## Elaborate (5 minutes)

1. Display the image: Tree of Life. Explain that this "Tree of Life" is based solely on ribosomal RNA. Tell the students that some of the sequences they contrasted are reflected in this tree. The lengths of the individual lines do NOT measure how much time it has taken for the changes in the RNA to occur, but they do reflect the number of changes in the sequences. By examining many biochemical and physical features, scientists have grouped all living things into three large groups or domains.




2. The three domains are:

   **Bacteria:** most of the organisms that we think of as bacteria

   **Archaea:** organisms that were thought to be "Bacteria" for a long time, but are now

known to be biochemically very different from "Bacteria"

**Eukarya:** all other organisms, including animals, plants, fungi, and single-celled organisms that are not included in the first two groups

3. Direct students to examine the Tree of Life and find plants, animals, and fungi. Based upon their positions on the tree, are animals more like fungi or plants? Why? *(Animals are more closely related to fungi than plants because they have a more recent common ancestor on the Tree of Life. This implies that rRNA of animals and fungi have more similar base sequences than rRNA of animals and plants.)*

4. What interpretation can you make about the relationships between yeast (a fungus), corn, and humans, versus their relationship to bacteria, based upon the ribosomal RNA sequences that you recorded in the table? *(Yeast, corn, and humans are very different organisms. However, based on their rRNA, they are more closely related to one another than to bacteria; they have a more recent common ancestor.)*

## Evaluate

1. Collect and evaluate the Comparing Molecular Data Student Activity Sheet.

| Materials | Preparation |
|---|---|
| **For Each Student**<br>• None<br>**For Each Student Team**<br>• Scissors<br>**For Teacher**<br>• Overhead projector<br>• What Is Life? Quiz Teacher Answer Key<br>• Comparing Molecular Data Teacher Answer Key<br>**Student Handouts**<br>• What Is Life? Quiz (one per student)<br>• RNA Sequences (one per team) | 1. Prepare any necessary handouts and transparencies. Familiarize yourself with the media. For background information on the topics covered in this activity, review "The Science & Resources" section (accessed from the menu bar above). |

- Comparing Molecular Data Student Activity Sheet (one per student)

## Student Reader Articles

- None

## Media

- Image: Extant Organisms
- Image: Extant Organisms (labeled)
- Image: RNA Three-Dimensional Structure
- Image: Tree of Life

The scale in the scaled images is approximate and was added for purposes of comparison.