OVERVIEW

In this activity, students consider the challenges of defining life by sorting cards of living and nonliving things and comparing their characteristics. This activity includes a set of 42 cards. You can use this activity to introduce a lesson on the definition of life or the characteristics of living organisms.

Additional information can be found on this resource’s webpage, including suggested audience, estimated time, and curriculum connections.

KEY CONCEPTS

- Living and nonliving things share some characteristics and not others.
- Identifying the characteristics unique to living organisms informs the definition of life.
- (optional) The definition of life can vary depending on context and goals.

STUDENT LEARNING TARGETS

- Identify the characteristics that biologists use to define living organisms.
- Explain why it’s important for biologists and society to be able to define life.

PRIOR KNOWLEDGE

Students should be familiar with:
- what cells and tissues are
- the basic concepts of metabolism, photosynthesis, reproduction, and evolution

MATERIALS

- “What is Life?” cards

TEACHING TIPS

- You can implement this activity either before or after a lesson on the characteristics of life.
  - Doing this activity before allows students to bring forward what they already know and think about it critically. It also ensures that they contribute more than repeating what they heard or read about.
  - Doing this activity after allows students to apply their knowledge and share their thinking with others in the class. You can cut down on the steps in the procedure in this case.
- The “What is Life?” cards can be printed or shared digitally.
  - A PDF for printing the cards is provided on this resource’s webpage. Print the cards, cut them out, and shuffle them. You may wish to laminate them for repeated use.
  - Individual card images (JPGs) are provided in the “Card Images” ZIP file. You can use a virtual whiteboarding or collaboration software (e.g., Google Slides, Miro, Mural, Whiteboard.fi) in which students can move and annotate card images.

PROCEDURE

1. Ask the class, “Why do we need a definition of life?”
   a. Examples of reasons that students may mention are:
      - To be able to study the origin of life on Earth
What is Life?

b. You can use different strategies to encourage broad participation. For example:
   - Have students raise their hands and wait 3–5 seconds before calling on a student. This will give students more thinking time before they are ready to answer. You can also let students know you will wait for at least five students to raise their hands before calling on anyone in order to promote more class participation (Tanner 2013).
   - Use polling software and allow all students to contribute their answers.
   - Have students discuss the question in small groups, then assign one student from each group to share the group’s discussion.

2. Once students have contributed their ideas, inform them that they will participate in an activity to come up with a definition of life that includes all known life on Earth.

3. Form groups of two to four students. Give each group a set of “What is Life?” cards to sort into two piles: living and nonliving.
   a. There are 42 cards total. You can give each group of students a set of 6–42 cards, depending on your class size and how long you would like to spend on this activity. Each group can have a different set of cards, but ensure that each set includes both living and nonliving things.
   b. Stress that the goal of this activity is to think critically about the characteristics of living things and how they can be applied to things around us. There is no right or wrong answer at this stage.
   c. Let students know that placing some of these cards in one pile or the other is difficult. For this activity, they should try to pick a pile for each card even if they are unsure. They will revisit their piles later.
   d. Possible piles are listed below. Things marked with an asterisk (*) may be particularly debated.
      - **Living**: bacteria, bread yeast, cactus, cancer cells*, cat, chicken, diatom, grapevine producing seedless grapes, houseplant, human sperm*, jumping spider, kangaroo, mule, monozygotic twins, moss, *Plasmodium falciparum*, red blood cell*, shark, slime mold, snake, sockeye salmon, unfertilized chicken egg*, worker bees
      - **Nonliving**: butterfly chrysalis* (the protective covering is nonliving, but the pupa inside is living), can of sardines, car, computer virus, crystal, DNA, fire, hurricane, lightning, nuclear power plant, ocean waves, protein, snowflake, Spam, stalactites and stalagmites, steak*, Sun, tornado, volcano

4. Once all groups have made their piles, have them write down as many characteristics of living things as possible. These characteristics should be shared by all the “living” cards, but not all the “nonliving” cards.

5. In a whole-class discussion, ask each group to describe one characteristic of living things that they identified in their discussion. Write each group’s characteristic on the board (or other location that all the students can view), then allow other groups to “object.”
   a. For example, suppose a group lists “cellular structure” as a characteristic of living things. In that case, another group might object because one of their nonliving objects (Spam) also shares that characteristic.
   b. Add an asterisk or otherwise note whenever another group objects to a characteristic on the board.

6. Have students discuss in their groups whether one characteristic would be necessary or sufficient to determine that something is living. (If no one characteristic is sufficient, would two suffice? If so, which two? What about three?) Each group should write down the minimum number of characteristics needed to determine whether something is living.
7. Ask each group to share their characteristics. As a class, agree on the list of characteristics that would be sufficient to determine that something is living.

8. Once you have made a list of characteristics of living things, share with students that most biologists have identified the following characteristics of living organisms:
   - organization, with the cell being the basic unit of life
   - regulation, maintaining constant internal conditions
   - reproduction, which involves passing down genetic information
   - energy processing, which involves obtaining and using energy for various activities
   - response to the environment
   - growth and development
   - adaptation

9. Note where the characteristics identified by biologists overlap with the list made as a class. Also, let students know that individuals don’t need all these characteristics to be considered living. For example, an individual who cannot reproduce is still a living organism. However, these characteristics are useful for capturing most living things on Earth.

10. Allow students to review their “living” and “nonliving” card piles. Ask whether they would make any changes based on the list of characteristics they made as a class and the characteristics identified by biologists.
   a. Students may still debate some cards even after having all the characteristics. Let them know that biologists and philosophers also debate these criteria. Sometimes, whether something is considered to be living or nonliving depends on whether it’s viewed as part of an organism or removed from an organism.
   b. Another point you may raise with students is the distinction between facts and evidence vs. claims and interpretations. For example, sperm is a cell that contains half the genetic information of a body cell. It can use energy, fuse with an egg to produce a zygote, and does not divide on its own. These are all facts. Depending on how you interpret these facts, you can claim that sperm is living or nonliving.

**OPTIONAL EXTENSIONS**

- Have students complete a reflection assignment using prompts like “I used to think...” and “Now I think...”
- Have students watch Episode 1 of Crash Course Biology, which also discusses the characteristics of living things, to review the content.
- Have students discuss whether viruses are alive based on the characteristics discussed in class. The Educator Voices article “Argumentation With Virus Explorer” presents one approach.
- Ask students to identify the main characteristics of life indicated in this definition from the National Aeronautics and Space Administration (NASA): “Life is a self-sustaining chemical system capable of Darwinian evolution.” Ask them to consider why NASA may want to limit the definition of life to these characteristics, but biologists may want to refine this definition a bit more.

**REFERENCES**

This activity was adapted from:
Prud‘homme-Généreux, Annie. 2013. “What Is Life? An Activity to Convey the Complexities of This Simple Question.” *The American Biology Teacher* 75, 1: 53–57. [https://doi.org/10.1525/abt.2013.75.1.11](https://doi.org/10.1525/abt.2013.75.1.11).

Joyce, G. F. 1994. Foreword to *Origins of Life: The Central Concepts*, xi–xii. Edited by D. W. Deamer and G. R. Fleischaker. Boston: Jones and Bartlett, 1994.

Tanner, Kimberly D. 2013. “Structure Matters: Twenty-One Teaching Strategies to Promote Student Engagement and Cultivate Classroom Equity.” *CBE—Life Sciences Education* 12, 3: 322–331. [https://doi.org/10.1187/cbe.13-06-0115](https://doi.org/10.1187/cbe.13-06-0115).
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