Astrobiology

Science Learning Activities for Afterschool

Participants ages 5-12

EDUCATOR RESOURCE GUIDE

Credits & Acknowledgements

Original Activity Sources

Growing Microbes in a Bag by Deborah Bodony, Amberlee Chaussee, and Bonnie Samuelson, NASA Quest and the NASA Astrobiology Institute
http://quest.nasa.gov/projects/astrobiology/fieldwork/lessons/Microbes_3_5.pdf

Life on Earth ... and Elsewhere? by Chris Randall (TERC) with assistance from TERC's "Astrobiology: The Search for Life" staff and the NASA Astrobiology Institute http://teach-spacescience.org/graphics/pdf/10000406.pdf

Destination Mars produced by the Astromaterials Research and Exploration Science (ARES), Johnson Space Center.
http://ares.jsc.nasa.gov/education/activities/destmars/destmars.htm

Produced by the Education Department of the American Museum of Natural History

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Preface

Astrobiology: Science Learning Activities for Afterschool was produced by the American Museum of Natural History (AMNH) as part of a 18 month study and demonstration project funded by NASA. The demonstration project collected a wide range of existing NASA and AMNH educational resources developed for formal school settings. It drew on AMNH's experience to adapt the materials for community-based afterschool program staff working with participants aged 5-12. Materials were tested in afterschool programs operated by the local affiliate of a national youth-serving organization, an independent community-based organization, and a public school. Afterschool participants and staff were engaged as co-researchers with the AMNH staff. Observations were conducted by the AMNH staff, interviews were conducted with the afterschool staff and participants. Written data was collected from instructors in the form of weekly summary sheets and from participants in the form of science journals.

The key findings from the demonstration project were:

- Young people are highly interested in what the universe is like and how it has developed over time.
- The most powerful part of the learning experience in the demonstration project was the opportunity for participants to express their ideas and opinions, and begin to learn to build explanations from evidence.
- Afterschool staff with youth development training have a set of skills that are of great use in leading inquiry and discussion-based science learning experiences.

Astrobiology: Science Learning Activities for Afterschool is one of three prototype curriculum packets produced to capture the work done in the project and make it available to other interested afterschool programs. Each packet contains a collection of activities adapted from existing resources, for use by afterschool instructors with participants aged 5 – 12. These are the activities which were the most successful in the demonstration sites and which build upon the project's findings. The packet is a "prototype" in the sense that it serves as one example of how existing NASA educational resources can be adapted for use in the afterschool setting. Each activity instruction sheet contains a reference to the original activity and an internet link for obtaining the original.

The complete report on the demonstration project and the scan of the field that accompanied it, *NASA and Afterschool Programs: Connecting to the Future* can be downloaded from the NASA Informal Education web portal at the address below.

http://education.nasa.gov/divisions/informal/overview/R_NASA_and_Afterschool_Programs.html

Introduction

Astrobiology consists of eight Activities, each of which may be completed in about one hour. The Activities are targeted for 5-12 year olds, with separate instructions for the different age groups when appropriate.

Navigating Through the Activities

The format is geared towards helping the instructor navigate efficiently through each hour-long Activity. The headings contain brief but pertinent information.

- **The Overview** gives you a quick summary of the Activity and the estimated time for each part.
- **Connections** help you make sense of the flow of the unit by relating the topic of the Activity to those that come before or after it. You may use this section to introduce an Activity and to help participants connect to what they have already done or will be doing in subsequent activities.
- **The Big Ideas** present the background information and the concepts that are addressed in the Activity.
- **The Materials** section lists everything you will need to use that day. In many cases, the materials are commonly available supplies. Most images listed are provided either as handouts or online. There are some items you will need to gather yourself, and these are clearly outlined. Be sure to preview the Materials section in advance. Please see the complete Materials list for the entire unit on page 6.
- **The Preparation** section lets you know what you need to get ready ahead of time.
- **The Activity** is presented in a step-by-step style. The main objective in each step comes first, in bold print as a visual cue. A brief paragraph explains the step in more detail and also provides questions and prompts to use with participants.

Overview

The science of astrobiology is concerned with the question of whether or not life exists on other planets. To date, there is no definitive proof that life does or has in past times existed beyond Earth, but it is important to realize that this is still an open question. Everything we know about life comes from studying our own planet, so the current strategy is to study the life that exists here to find out more about where and how to look for life beyond our own system. Recent discoveries about life forms in extreme environments and about our solar system have renewed scientists' interest in looking for life elsewhere.

Astrobiology presents young thinkers with some intriguing questions about the universe and gives them the opportunity to explore topics related to the search for life beyond their own planet using some of the same strategies that astrobiologists use.

In **Activity 1**, participants begin by surveying their opinions on the possible existence of alien life, and then go on to develop a working definition of what it means to be alive by comparing a living specimen and a non-living object in **Activity 2**. They apply their definitions by taking a field trip to search for living things.

Activity 3 introduces three mystery samples and asks participants to figure out which one contains life by focusing on the observable characteristics of living things.

After participants have reviewed the characteristics of living things, they think about the requirements for life in **Activity 4**. Once they know more about the conditions required for living things to survive, they may be able to narrow their search for alien life to include places in the universe that meet those requirements.

By observing mold growing on potatoes in **Activity 5**, participants expand their thinking to consider microbes as living things. Then in **Activity 6** they match recently discovered microscopic life forms with the extreme environments in which they thrive.

In **Activity 7**, participants look at fifteen images of planets, moons, and the sun and read about the extreme conditions characteristic of each one. They evaluate each environment in light of what they have already found out about extreme environments, and try to decide if any of the solar bodies might support life.

Activity 8 gives participants the opportunity to revisit their ideas about the possibilities for life beyond Earth. They repeat the survey they took in the opening activity, and examine all their work products to look for information and evidence that influenced their current opinion.

Materials

For Activity 1

- White board, chalk board, or pad of chart paper and chalk or markers
- 1 science journal for each participant (See Preparation Page 7.)
- crayons or colored pencils
- 1 sticky note per participant (optional)

For Activity 2

- A pair of objects, one living (such as an insect, plant, or classroom pet) and one non-living (any inanimate object, preferably one not made from once-living material such as wood or leather)
- Hand lenses
- An outdoor area to investigate

For Activity 3

For each group of 3 to 4 participants:

- 3 clear containers
- 1 container of hot tap water
- 3 tablespoons of sand
- 3 teaspoons of sugar
- 1/2 packet of active dry yeast
- 1 fizzing antacid tablet, crushed
- hand lenses
- 3 small sheets of paper
- 1 spoon

For Activity 4

For each group of 3 to 4 participants:

- 1 large sheet of paper
- pens, colored pencils, crayons, or markers
- 1 picture of a living plant or animal (books, posters, calendars, magazines, catalogues, and greeting cards are all good sources)

For Activity 5

For each group of 3 to 4 participants:

- 1/4 inch slice of raw potato
- 1 resealable plastic sandwich bag
- hand lenses

For Activity 6

For each group of 2 or 3 5-6 year olds and for those without computer access:

- 1 set of cards *Can Living Things Live Here*?
- 1 set of cards Extreme Life

For groups of 7-12 year olds with computer access:

- 1 set of cards *Can Living Things Live Here*?
- 1 set of cards *Extreme Life!*
- Internet access to the website *http://www.amnh.org/exhibitions/halltour/spectrum/flash/*

For Activity 7

- 1 set of NASA images Solar System Lithograph Set for Space Science *http://teachspacescience.org/graphics/pdf/10000605.pdf*

- For those with internet access, images called "Exploring the Planets," available at: *http://www.nasm.si.edu/research/ceps/etp/etp.htm*

For Activity 8

- All participants' work products and all images.

1. Do You Think Aliens Exist?

Overview

Participants discuss the possible existence of alien life and then survey the group to record and graph opinions. They use their science journals to write about and illustrate their ideas.

TIME:
- 15-20 minutes for discussion and survey
- 25 minues for making journal entries

Big Ideas

- The only life we have ever been able to detect exists here on Earth.

- Everything we know about life and living things comes from what we know about our own planet.

Connections

Participant explore their own ideas about the possibility of alien life and make the first entries in their science journals.

Materials

- White board, chalk board, or large piece of chart paper and chalk or markers

- 1 science journal for each participant

- crayons or colored pencils

- 1 sticky note for each participant (optional)

Preparation

Each participant will need a science journal to record thoughts, observations, and findings over the coming weeks. There are a number of ways to create journals if you are not providing ready-made ones. For example:

- Have participants make folders from contruction paper. They can then insert loose leaf paper (both lined and drawing paper) into the folders.

- Fold sheets of large paper in half. Either staple the sheets together or punch holes and tie the sheets together with string or yarn.

1. Do You Think Aliens Exist?

Activity

1. Open a discussion on what participants think about aliens.

Ask:

- Have you ever seen or read anything about aliens, or creatures such, as people or animals from other planets? Tell us a little about it.

- Do you think that there is life in places beyond Earth? Why or why not?

Encourage an open discussion in which everyone contributes ideas and gives reasons.

2. Take a survey of participants' opinions.

Let the group know you will save the survey of what they think now. They will look at it again in a few weeks to see if their ideas changes as they work on science projects about looking for life in other places. Emphasize that in a survey of opinions there is no right answer and all opinions are welcome.

On the board or chart paper, write these three categories along the bottom edge:

YES NO NOT SURE

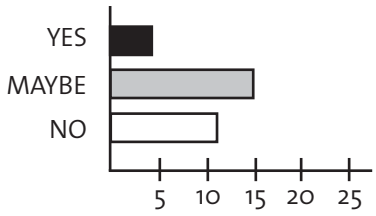
FOR 5-6 YEAR OLDS:

Read off each category, saying for example, "Yes, I think there is life in other placesbeyond Earth." and ask participants to raise their hands if they agree. Have them help you count the number of raised hands and write the totals in each category.

As an alternative, give each participant a sticky note, and as they respond have them place the paper in the appropriate category. Begin at the bottom of the board or chart paper, and have them place one note above the other so that they create a bar graph with their sticky notes.

FOR 7-8 YEAR OLDS:

As you tally the results, ask participants to help you make the information into a bar graph. The three categories (Yes, No, Not Sure) are along the vertical axis. Write the numbers along the horizontal axis and extend the bars as you record responses.



FOR 9-12 YEAR OLDS:

Record the totals in each category. Participants will use the information in the science journal activity.

1. Do You Think Aliens Exist? - Activity

3. Introduce the science journals.

Explain that participants will be keeping journals throughout their investigations. They may record their discoveries, thoughts, and ideas in writing and drawings, the way that working scientists do.

INSTRUCTIONS FOR 5-6 YEAR OLDS:

- Label the journal page #1.
- Draw a picture of what you imagine aliens might look like if they did exist.
- Write down your opinion: Do you think aliens exist?

Circulate among the group and talk to them about their opinions as they work. Help them record their ideas in their journals.

INSTRUCTIONS FOR 7-8 YEAR OLDS:

- Label the journal page with today's date.
- Record your opinion: Do you think aliens exist? You may use both words and drawings to record your i deas.

INSTRUCTIONS FOR 9-12 YEAR OLDS:

- Use the information from our survey to create a bar graph or pie chart to show the results. Remember to include labels. (If necessary, model a graph for participants to get them started.)
- Record your opinion: What are your ideas about the possibility of alien life? You may want to illustrate your journal entry,

4. Wrap Up

Mention that it is interesting to explore our ideas about the possibility of life on other planets and to imagine what those lifeforms might look like. But so far, we have not discovered living creatures beyond our own planet, so we don't really know whether or not there is life anywhere else in the universe. Right now scientists are studying this question and conducting research to look for answers. Since the only life we know about is here on Earth, scientists who study astrobiology are interested in finding out more about life forms here to see what that might tell us about where and how to look for life elsewhere.

REMINDER:
Please save all the surveys, graphs, and journal pages from this activity. Participants will revisit them again in Activity 8.

2. Is It Living?

Overview

Participants compare a living and a non-living object to begin defining life. They go outdoors to search for living things.

TIME:
- 15-20 minutes for discussion
- 45-60 minutes for field exploration

Connections

Before we can look for life in other places, we need to develop a working definition of what life is and learn how to recognize living things.

Big Ideas

- Scientists define life in different ways, but agree that certain characteristics are common to living things. These are the ability to use energy, to grow, and to reproduce.

- Life as we know it on Earth requires water, a source of energy, and a stable environment to exist. Sources of energy vary with the type of life: for animals, the source is food; for plants, a combination of nutrients in the soil and sunlight; for deep sea ocean life, heat from underwater volcanoes and nutrients in the water. An environment that is "stable" has conditions (temperature, moisture levels, etc) that stay within a set range over time.

Materials

- White board, chalk board, or large piece of chart paper and chalk or markers

- A pair of objects, one living (such as an insect, plant, or classroom pet) and one non-living (any inanimate object, preferably one not made from once-living material such as wood or leather)

- Hand lenses

- An outdoor area to investigate

- 1 science journal for each participant

Preparation

Scout the area in advance of the outdoor field trip. Try to select a site that is in easy walking distance, has a variety of living things, and is safe.

2. Is It Living?

Activity

1. Discuss characteristics of living and non-living objects.

Write the names of the pair of objects you have selected on the board or paper. Show the group the pair of objects, and say that one is living and the other is non-living. Ask:

- Which one of these is alive? Explain how you know that.
- What characteristics do living things have?

As participants respond, record their ideas about what tells them whether the object is living or not.

2. Prepare for the field exploration.

Explain the purpose of the field trip: to practice looking for life on this planet.

Establish safety rules. These might include:
- Walk. Stay within eyesight of the leader.
- Use your sense of sight, smell, and hearing to investigate, but do not touch or taste.
- Leave the site exactly as you found it.

Have participants set up entries in their science journals.

FOR 5-6 YEAR OLDS:

- Label the page #2.

FOR 7-8 YEAR OLDS:

- Label the page "Living Things I Found At (name of the site)"

Distribute hand lenses and demonstrate how to use them.

3. Go outdoors to investigate.

Once outside, encourage participants to make records of as many living things as they can find, using both words and pictures.

2. Is It Living? - Activity

4. Discuss findings.

Back indoors, hold a group discussion about what participants found. As participants respond, record their findings on the board or paper. Ask:

- What did you find that was alive?
- How did you decide it was alive?
- Were there any objects that puzzled you? Were you unsure of whether or not any objects were living? How could you find out more?

REMINDER:
Please save the journals and charts for the Activity 8.

This activity adapted from "*Activity 1: What is Life?" in Life on Earth ... and Elsewhere?* by Chris Randall (TERC) with assistance from TERC's "Astrobiology: The Search for Life" staff and the NASA Astrobiology Institute. The original activity can be found at.
http://teachspacescience.org/graphics/pdf/10000406.pdf

3. Do The Mystery Samples Contain Life?

Overview

Participants explore the properties of three mystery samples and try to find out which one contains life. Then they review what they have learned so far about the characteristics of living things.

TIME:
- 20-30 minutes for exploration
- 15-20 minutes to review learning

Connections

Participants apply the definitions of life they have developed in previous activities to this new situation.

Big Ideas

- Scientists define life in different ways, but agree that certain characteristics are common to living things. These are the ability to use energy, to grow, and to reproduce.
- Life as we know it on Earth requires water, a source of energy and a stable environment to exist.
- Sometimes we cannot see living things, but we can observe evidence of their presence.

Materials

For each group of 3-4 participants:
- 3 clear containers
- 1 container of warm tap water
- 3 tablespoons of sand
- 3 teaspoons of sugar
- 1/2 packet of active dry yeast
- 1 fizzing antacid tablet, crushed
- hand lenses
- 3 small sheets of paper
- 1 spoon
- White board, chalk board, or large piece of chart paper and chalk or markers

Preparation

1. Label three jars for each group and fill them with the dry ingredients as listed on the chart below.

Jar	Sand	Other Ingredients
#1	3 tablespoons	None
#2	3 tablespoons	1/2 pkg. Active dry yeast
#3	3 tablespoons	1 fizzing antacid tablet, crushed

2. Have a small cup with several teaspoons of sugar or several packets of sugar ready for each group.

3. Fill one container of warm tap water for each group, but do not distribute it yet. (See Step 4 in the Activity.)

4. Set out hand lenses, sheets of paper, and spoons at each station.

3. Do The Mystery Samples Contain Life?

Activity

1. Focus the activity with a brief discussion.

Explain that sometimes it is difficult to tell whether or not something is alive. If appropriate, quickly review what participants have discovered about the characteristics of living things.

2. Introduce the three mystery samples.

Invite participants to observe the mystery samples in the three jars to find out if they contain anything living. Use these prompts to encourage close observations:

- You may use all of your senses except taste. Be sure to look closely with the hand lenses, touch, listen, and smell.

- Take a small sample out of each jar, one jar at a time, and put it on the small piece of paper. After you observe, put the sample back in the right jar.

3. Discuss conclusions.

After participants have made their observations, ask:

- Do any of the mystery samples contain living things? Why do you think so?

4. Add sugar to the mystery samples.

Give each group the small cup or several packets of sugar. Have them add one teaspoon or onepacket of sugar to each sample. Ask:

- You've just added a food source to the sample. Do you see any changes to any sample yet?

5. Add warm water to the mystery samples. Look for changes.

Give one container of hot water to each group and tell them to pour enough water into each jar to just cover the mystery samples. Then ask them to observe changes.

For the Leader: What to Expect

Jar 1: no activity
Jar 2: will begin to show activity after about 5 minutes, and will continue to bubble
Jar 3: will fizz vigorously at first, slow down, and finally stop

3. Do The Mystery Samples Contain Life? - Activity

6. Discuss new conclusions.

Ask:

- Now do you think that any of the mystery samples contain living things? Give your reasons.
- What else might you want to know about the samples in order to figure out if they contain living things?

7. Add more sugar to each jar.

Have the participants add more sugar to each jar.

- Does adding more food (sugar) re-start the fizzing in Jar 3? What is happening in Jar 2?
- Try adding more water to Jar 3. Does that re-start the reaction you saw before?
- Has your opinion about which jar contains the living thing changed at all? Why or why not?

For the leader: What to expect

Jar 1: Still no activity
Jar 2: Activity will continue
Jar 3: Once the fizzed has stopped, it can't be restarted by the addition of either sugar or water. The fizzing antacid tablet has completly dissolved in the water.

8. Reveal the contents of the jars.

Tell students what was in Jars 1 and 3. Then talk about Jar 2. Ask:

- Have any of you ever used yeast? What for?
  Explain that yeast is a tiny living thing that stays dormant (kind of like staying asleep) until it is given water and food – in this case, sugar. Yeast is used to make bread rise, as it grows on the ingredients and makes bubbles and air pockets, just as it did in your jars.
- How was the yeast activity different from the fizzy antacid activity?
  Explain that the antacid fizzed because it combined in a chemical reaction with the water. Once the chemicals got used up and all the bubbles escaped, the fizzing stopped, just like when you leave a can of soda out and it goes flat. There was nothing alive in the chemicals. But with yeast, the bubbling will continue as long as there is food for it to eat.

3. Do The Mystery Samples Contain Life? - Activity cont'd

8. Wrap up: How can you tell if something is alive?

Ask students to share what they have learned so far about how to tell if something is living or non-living. Encourage everyone to contribute, and record their responses on the board or chart.

REMINDER:
Please save the chart for Activity 8.

This activity adapted from "Searching for Life on Mars" in *Destination Mars* produced by the Astromaterials Research and Exploration Science(ARES), Johnson Space Center. The original can be found at:
http://ares.jsc.nasa.gov/education/activities/destmars/destmars.htm

4. What Does Life Need?

Overview

Working in small groups, participants determine, write about, and/or draw what a particular living organism needs to survive.

TIME:
- 30-40 minutes

Big Ideas

- Life as we know it on Earth requires water, a source of energy and a stable environment to exist.

Connections

Now that we have thought about the characteristics of living things, we need to think about what life needs in order to survive. If we know more about the conditions required for life to exist, we may be able to narrow our search for life in the universe to include only those places that meet the requirements.

Materials

For each group of 3-4 participants:
- 1 large sheet of paper
- pens, colored pencils, crayons, or markers
- 1 picture of a living plant or animal (books, posters, calendars, magazines, catalogues, and greeting cards are all good sources)

Preparation

For this activity, you will need to collect images of living things to be used by each group. These images can be found in books, posters, calendars, magazines, and greeting cards. You can either collect these yourself before doing the activity, or have the participants collect images for you.

4. What Does Life Need?

Activity

1. Focus the activity.

Explain that the group has worked to develop a very good idea of what life is and can recognize living things and non-living things. Now we need to think about what living things need in order to survive. That might help us figure out where life might possibly exist beyond planet Earth.

2. Draw and/or write about what an organism needs to survive.

Give each small group a picture of a living organism. On a large sheet of paper, ask the group to work together to draw and/or write about what their organism needs to survive.

3. Discuss.

Invite each group to share their ideas about their living thing and its requirements for life. Some groups may list "requirements" that are not absolutely necessary for survival, such as "someone to take care of it" listed as a requirement for a cat. Encourage the participants to discuss which of their requirements are necessary for basic survival and which add to the quality of life of the living thing.

4. Summarize.

Ask:

- What are some of the requirements that many of these living things have in common?
- Which ones have needs that are similar? Which ones are different? Why couldn't they all live in the same place?

REMINDER:
Please save the large sheets of paper for Activity 8.

5. Are Microbes Alive?

Overview

Participants observe mold growing on potatoes, and then look at magnified images of several different microbes.

TIME:
• 30-40 minutes

Big Ideas

This activity connects to the previous one about the requirements for life and serves as a bridge to upcoming activities in which participants speculate on the possibilities of life (possibly microbial life) on other planets in our solar system.

Connections

- Scientists define life in different ways, but agree that certain characteristics are common to living things. These are the ability to use energy, to grow, and to reproduce.
- Life as we know it on Earth requires air, water, nutrients, and some form of energy to exist.
- Some microscopic forms of life are too small to be seen individually with the naked eye, although we can see colonies of them growing together.

Materials

For each group of 3-4 participants:
• 1/4 inch slice of raw potato
• 1 resealable plastic sandwich bag
• hand lenses
• Images of microbes (downloaded from Web sites listed on Page 21.)

Preparation

1. About a week before the activity, slice the potato and leave the pieces out in the air for about an hour to collect microbes.

2. Place one piece of potato in each baggie. Store the baggies at room temperature out of direct sun.

5. Are Microbes Alive?

Activity

1. Discuss prior knowledge of microbes.

Ask:

- What happens when you leave food out for too long?
- Why do you think it spoils?

Explain that there are many kinds of living things that are too small for us to see. They are called microbes, and they are all around us in the air, the soil, the water, and even inside us. It's only when a lot of these microbes grow together in one place (called a colony) that we can see them. Most microbes are not harmful and many microbes are beneficial, but some cause food spoilage and disease.

2. Observe the moldy potatoes.

Distribute the bags of moldy potatoes and ask participants to observe them with their naked eyes. Caution them not to open the bags because some people are allergic to molds.

3. Share observations.

Ask:

- What did you observe? Describe the colors and shapes of what you saw.

4. Observe again with magnification.

Distribute the hand lenses and ask participants to observe again.

5. Share new observations.

Ask:

- What new information did you gather by looking at microbes with a hand lens?
- How could you get an even closer look at microbes? What tools would you need?
  Explain that scientists have microscopes that are powerful enough to let them see individual microbes, not just whole colonies like we are able to see on the potatoes.

5. Are Microbes Alive? - Activity

6. Explore microbes on the internet.

If you have access to computers for your participants, bookmark the sites listed below and have them explore the images and information on those sites. For younger participants, or for participants without internet access, print out some of the images and information from these websites to examine as a group.

Microbe Mysteries:
http://www.microbe.org/microbes/mysteries.asp
The first mystery "What is a microbe?" contains images and information for several different kinds of microbes you can print out and share with participants.

Microbe Gallery:
http://www.microbeworld.org/htm/aboutmicro/gallery/gallery_start.htm
Microbe World also has a gallery of microbe images to share with your participants.
Bacteria Rule: http://www.nationalgeographic.com/ngkids/0010/bacteria/quiz.html
This National Geographic site has an interactive quiz on bacteria your older participants can take

Bacteria Cam:
http://www.cellsalive.com/cam2.htm
The Cells Alive! site has a "bacteria cam" that give participants a view through a microscope at bacteria multiplying.

7. Wrap Up

Discuss the fact that microbes are living things. Ask:

- Are microbes alive? How do you know?
- What did you learn about what microbes eat, how they move, how they grow, and where they live?

This activity adapted from *Growing Microbes in a Bag* by Deborah Bodony, Amberlee Chaussee, and Bonnie Samuelson, NASA Quest and the NASA Astrobiology Institute. The original can be found at:
http://quest.nasa.gov/projects/astrobiology/fieldwork/lessons/Microbes_3_5.pdf

6. Where Does Life Live?

Overview

Participants use cards and/or computer images to look at some extreme environments and then match the environments with life forms they support. On large sheets of paper, participants summarize what they have learned about where life can exist.

TIME:
- 30 minutes to view and match images
- 15-30 minutes to summarize

Big Ideas

- Specialized life forms are adapted to live in some very extreme environments on Earth.

Connections

This activity expands participants' thinking about where on Earth life can exist by introducing several extreme environments and the microscopic life forms they support.

Materials

For each group of 2 or 3 5-6 year olds and/or for those without computer access:
- 1 set of cards Can Living Things Live Here? (environment cards)
- 1 set of cards Extreme Life! (life form cards)

For groups of 7-12 year olds with computer access:
- 1 set of cards Can Living Things Live Here?
- 1 set of cards Extreme Life!
- Internet access to the web site http://www.amnh.org/exhibitions/halltour/spectrum/flash/
- 1 science journal for each participant

For each group of 3-4 participants:
- 1 large sheet of paper labeled "Where Does Life Live?"
- Pens, crayons, markers

Preparation

Decide if you will use the Cards Only Activities (recommended for 5-6 year olds but also suitable for older groups) or, if you have internet access, the Computer Activities (suitable for 7-12 year olds). Two sets of directions are provided.

6. Where Does Life Live?

Activity - Cards Only

1. Sort the cards called *Can Living Things Live Here?*

Distribute one set of cards to each group of 2-3 participants. Have them sort the cards into three piles: Yes (life could live in this environment), No, and Not Sure. If necessary, help young learners to read the information on the cards.

2. Match the first set of cards with a new set called *Where Does Life Live?*

Distribute one set of new cards to each group. Have them match up the environment cards with the life form cards.

3. Discuss the matches participants made.

Ask:

- What matches did you make? Which life forms matched up with which environments?
- Were they any environments that had no matching life forms?
- Did any of the matches between environments and life forms surprise you? Why or why not?

4. Play "Concentration" using the two sets of cards.

Explain how to play the game:

- Shuffle the cards and place them face down on the table in rows.
- The person to the left of the dealer turns over two cards. If the cards represent a life form and the environment in which the life form can exist, the person takes the pair and then turns over two more cards. But if the cards don't match a life form with its environment, the person turns them face down again, and the next person to the left continues the play.
- The game continues until all cards have been matched. The winner is the player with the most pairs of cards.

6. Where Does Life Live?

Activity - With Computers

1. Sort the cards called *Can Living Things Live Here*?

Distribute one set of cards to each group of 2-3 participants. Have them sort the cards into three piles: Yes (life could live in this environment), No, and Not Sure.

2. Connect to the website to search for life forms that might live in each of the environments pictured on the cards.

Ask participants to view the life forms exhibit online and try to match the living things with the environments pictured on their cards. Have them record the matches in their journals.

If time permits, let participants explore the website on their own.

3. Discuss the matches participants made.

Ask:
- What matches did you make? Which life forms matched up with which environments?
- Were they any environments that had no matching life forms?
- Did any of the matches between environments and life forms surprise you? Why or why not?

4. Use the *Extreme Life* cards to complete the matching.

If participants did not find life forms to match some of the environments, show them the *Extreme Life* cards (used in the non-computer activities) to point out that there are recently discovered life forms that can live in each of the extreme environments.

5. Summarize: Where does life live?

Distribute large sheets of paper (labeled Where does life live?), pencils, crayons, and/or markers to each group of 3-4 participants. Ask them to write and draw their answers to the question at the top of the paper.

6. Wrap up: Discuss where life exists on Earth.

Hang the large sheets of paper around the room and invite participants to share their findings with the group.

REMINDER:
Save the large sheets of paper and the sets of cards to revisit in Activity 8.

Adapted from "Activity 4: What can life tolerate?" in *Life on Earth... and Elsewhere?* by Chris Randall (TERC) with assistance from TERC's "Astrobiology: The Search for Life" staff and the NASA Astrobiology Institute. The original activity can be found at.:
http://teachspacescience.org/graphics/pdf/10000406.pdf

7. Could Life Exist in Other Places in the Solar System?

Overview

In their science journals, participants record what they already know about our solar system. Then they examine NASA images of moons, planets, and the sun to evaluate them as possible places for life to exist.

TIME:
• 45 minutes

Connections

In the last activity, participants expanded their thinking about where life can live on Earth. Now they expand their thinking even further to consider other planets as possible places for life to exist.

Big Ideas

• Earth is a habitable planet because it is within the correct distance from the sun to receive enough energy to keep the climate in the range where water will remain liquid. Earth also has an atmosphere to regulate temperature and protect us from the sun's most damaging rays, and a magnetic field to protect us from the solar wind.

• Other planets in our solar system do not have the same combination of factors to make them good hosts for life. But the recent discoveries of life in extreme environments on Earth have led us to consider Mars, Europa (a moon of Jupiter), and Titan (a moon of Saturn) as the best candidates for places in the Solar System where life might exist.

Materials

• 1 set of Solar System Lithograph Set downloaded from: *http://teachspacescience.org/graphics/pdf/10000605.pdf*

• For those with internet access, images called Exploring the Planets are available at: *http://www.nasm.si.edu/research/ceps/etp/etp.htm*

• 1 science journal for each participant

Preparation

If possible, arrange for computer access for the group.

7. Could Life Exist in Other Places in the Solar System?

Activity

1. Record prior knowledge about our solar system.

FOR 5-6 YEAR OLDS:

Have participants label their journal entry #3 and ask them to write about and/or draw everything they already know about the planets, moons, and the sun.

FOR 7-12 YEAR OLDS:

In their science journals, ask participants to label a page "What I already know about the solar system" and have them write about and/or draw everything they already know about the planets, moons, and the sun.

2. Share prior knowledge.

Invite participants to share with the group what they already know about our solar system.

3. Search for other places in the solar system that might possibly support life.

Distribute the set of NASA images or send participants to the website. Ask them to do the following:

FOR 5-6 YEAR OLDS:

- Look carefully at all the pictures. Which suns, moons, or planets do you think might have life? Why do you think so? What did you see in the pictures that gave you clues?

FOR 7-12 YEAR OLDS:

- Look carefully at the images. Just by looking at the images, which (three) bodies in the solar system do you think might be able to support life? Why do you think so? What visual clues did you discover? Record your ideas in your journal.

7. Could Life Exist in Other Places in the Solar System? - Activity

4. Read for information.

FOR 5-6 YEAR OLDS:

Display the images of Mars, Europa, and Titan. Help young learners gather information about them, perhaps by reading the relevant information to them. Explain that scientists choose these three places as having possibilities for life. Ask:

- Why do you think scientists picked these three places?
- Do you agree with their choices?

FOR 7-12 YEAR OLDS:

Distribute all the images to groups of 3 or 4 participants, or assign groups to focus on several images each on the computer. After they have examined the images again ask them to read the information provided about each solar body. When they have finished reading, ask:

- Does the new information about the temperature, the presence or absence of water, or the materials that make up the different solar bodies change your opinion about which ones might support life?
- What have scientists concluded to date about the possibility of life in places beyond Earth?

5. Wrap Up

Explain again that we still don't know if life exists anywhere else in the universe, and we won't know for sure until we collect more information. In fact, the NASA missions to Mars have focused on that very question: Was there once life on Mars that has now died out? What do you think?

REMINDER:
Keep the images handy to display again in the next activity.

This activity was adapted from "Activity 4: What can life tolerate?" in *Life on Earth ... and Elsewhere?* by Chris Randall (TERC)
Location of original: http://teachspacescience.org/graphics/pdf/10000406.pdf

8. Now What Do You Think About the Possibility of Life in the Universe?

Overview

Participants reexamine their own thinking, then take a new survey to find out if they have changed their opinions because of new information.

TIME:
- 45 minutes

Big Ideas

- At the present time, there is no positive evidence that life exists beyond Earth.
- Scientists continue to research the question

Connections

Participants look back at all they have learned to decide if or how their opinions have been influenced by new information.

Materials

- All the products participants have created during the course of the study (journal entries, surveys, charts)
- All images participants have examined
- White board, chalk board, or large piece of chart paper and chalk or markers

Preparation

Display all student products and images around the room.

1. Now What Do You Think About the Possibility of Life in the Universe?

Activity

1. Reexamine the evidence.

Give participants about 5-10 minutes to look back at what they have done and what they have learned over the past few weeks. Encourage them to revisit all their products: journal entries, charts, and the survey.

2. Take another survey.

Focus attention on the survey that participants took during the very first activity. It asked: Do you think there is life in other places beyond Earth? Then ask:

- Reexamine your thinking. What do you think about that question now? Yes, No, or Not Sure?

Poll the group as you did in the first activity, and record their responses on a chart or on a new graph.

3. Take another survey.

Ask:

- How is this survey different from our first one?
- Did you change your mind? Or did you stick with your original opinion?
- Why? Look around the room. Point to evidence that influenced your opinion.

4. Final reflections.

- Mention that it is interesting to trace our thinking on a question, and to notice how our opinions sometimes change when we gather new information. But there is still more evidence to be collected by scientists who study the universe, and we don't have a real answer to the questions yet.
- Ask participants what they learned during this unit that they never knew before. How did they learn it? How might scientists be working to learn more about life in other places?

Congratulate participants on their progress

Astrobiology Resources

Books

For ages 5-8

Moore, Jo Ellen. *Learning About the Earth. Science Works for Kids Series*. Monterey, CA: Evan-Moor Educational Publishers, 2000.

Rau, Dana Meachen. *Fantasy Field Trips: Moon Walk*. Washington, D.C.: Smithsonian *Soundprints Series*, 2003.

For Ages 9-12

Fraknoi, Andrew and Dennis Schatz, Editors. *The Universe at Your Fingertips: An Astronomy Activity Resource Notebook*. San Francisco, CA: Astronomical Society of the Pacific. 1995

Jackson, Ellen. *Looking for Life in the Universe*. Boston, MA: Houghton Mifflin, 2002.

Smith, P. Sean. *Project Earth Science: Astronomy*. Arlington, VA: National Science Teachers Association Press, 2001.

Websites to Explore

- About NASA's work on Astrobiology:
  Astrobiology: Exploring the Living Universe
  http://astrobiology.arc.nasa.gov/

- Astro-Venture! Search for and Design a Habitable Planet
  http://astrobiology.arc.nasa.gov/

- About the mission to Mars
  http://jpl.nasa.gov/

- Latest images from Titan
  http://saturn.jpl.nasa.gov/home/index.cfm

- About extreme life on Earth:
  American Museum of Natural History Expeditions: Black Smoker
  http://www.amnh.org/nationalcenter/expeditions/blacksmokers/

- About Microbes
  The International society for Microbial Ecology
  http://www.microbes.org

Relevant National Science Education Standards

The National Science Education Standards (National Research Council, The Academic Press, Washington, D.C., 1996) relevant to the activities in this educator resource guide are listed below.

As a result of activities in grades K-4, all students should develop understanding of:

Standard C: Life Science

- Characteristics of organisms: Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms.

Standard G: History and Nature of Science

- Science as a Human Endeavour: Although men and women using scientific inquiry have learned much about the objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished.

Standard F: Science in Personal and Social Perspectives

- Personal Health: Individuals have some responsibility for their own health. Students should engage in personal care--dental hygiene, cleanliness, and exercise--that will maintain and improve health. Understandings include how communicable diseases, such as colds, are transmitted and some of the body's defense mechanisms that prevent or overcome illness. Note: The link to this standard comes from the discussion of microbial life. Most young people best connect to the idea of microbes through their understanding of germs and how germs are transmitted and can effect their health.

Standard A: Science as Inquiry

- Abilities necessary to do science inquiry:
    - o Conduct a simple investigation
    - o Employ simple equipment and tools to gather data and extend the senses
    - o Use data to construct a reasonable explanation
    - o Communicate investigations and explanations
- Understandings about science inquiry:
    - o Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world
    - o Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).
    - o Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses

Astrobiology: Science Learning Activities for Afterschool

Can Living Things Live Here?

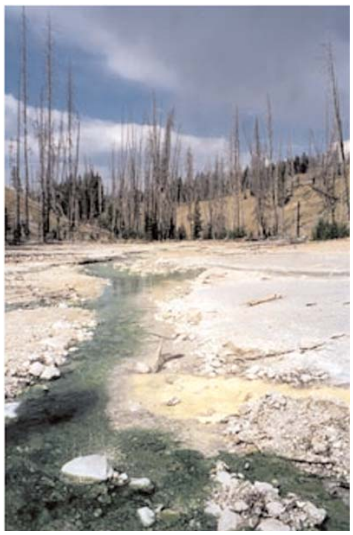


Image by Kathy Shehan
Courtesy of Micro*scope http://microscope.mbl.edu

Lemonade Spring in Yellowstone park has acidic (acid-like) water that can burn your skin.

Astrobiology: Science Learning Activities for Afterschool

Can Living Things Live Here?

Photograph by: Kristan Hutchison
National Science Foundation

McMurdo Dry Valleys in Antarctica have average temperatures of -20°C (-4°) and get less than 10 cm (4 inches) of rain each year.

Astrobiology: Science Learning Activities for Afterschool

Can Living Things Live Here?

Image by Linda Amaral-Zettler Courtesy of Micro*scope
http://microscope.mbl.edu

Rio Tinto (River of Fire) in Spain is one of the most naturally acid-like rivers in the world.

Astrobiology: Science Learning Activities for Afterschool

Can Living Things Live Here?

National Park Service
U.S. Department of the Interior

Hot springs in Yellowstone. Water underground can be heated to boiling by nearby magma (the word for lava that's underground).

Can Living Things Live Here?

Photo by Brett Leigh Dicks Courtesy of Micro*scope
http://microscope.mbl.edu

Mono Lake in California is two and a half times saltier than the ocean.

Astrobiology: Science Learning Activities for Afterschool

Can Living Things Live Here?

OAR/National Undersea Research Program (NURP); NOAA

Under water volcanoes known as black smokers add extremely hot water (as high as 400°C, 725°F) to the ocean environment.

Astrobiology: Science Learning Activities for Afterschool

Can Living Things Live Here?

NASA Image Exchange

Salt domes in Iran. These domes of salt are usually found over underground stores of oil and gas.

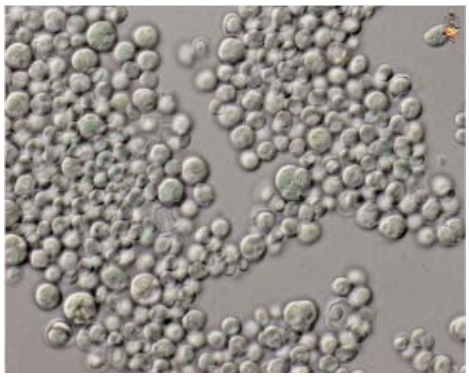
Astrobiology: Science Learning Activities for Afterschool

Can Living Things Live Here?

Radiation is a kind of energy that can be harmful to people in large doses. In space, radiation from the Sun is stronger than on Earth and spaceships must be built to protect astronauts.

Astrobiology: Science Learning Activities for Afterschool

Extreme Life!



Courtsey of Micro*scope http://microscope.mbl.edu

This algae was found in acidic (acid-like) springs in Yellowstone National Park. They can live in water acidic enough to burn human skin.

Astrobiology: Science Learning Activities for Afterschool

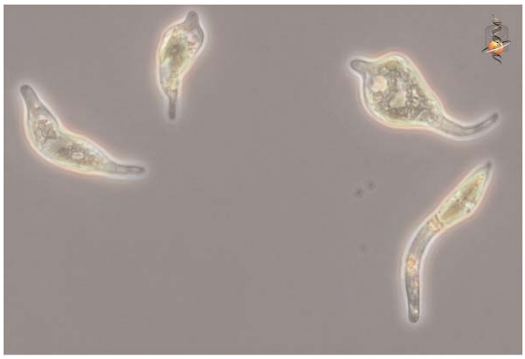
Extreme Life!

Courtsey of Micro*scope http://microscope.mbl.edu

Algae can be found under the ice in lakes in the Arctic and Antarctica.

Astrobiology: Science Learning Activities for Afterschool

Extreme Life!



Courtsey of Micro*scope http://microscope.mbl.edu

These microscopic creatures, known as euglenia mutablis, were found in the acid-like Rio Tinto in Spain.

Astrobiology: Science Learning Activities for Afterschool

Extreme Life!

Courtsey of Micro*scope http://microscope.mbl.edu

Some bacteria, like these found in Yellowstone National Park, can live in boiling water (100°C, 212°F).

Astrobiology: Science Learning Activities for Afterschool

Extreme Life!

Courtsey of Micro*scope http://microscope.mbl.edu

This microscopic life form, Artemia monica, can be found in the "hypersalinic" (high salt to water ratio) waters of Mono Lake.

Astrobiology: Science Learning Activities for Afterschool

Extreme Life!

NOAA

Tube worms like these grow near hydrothermal vents in the ocean.

Astrobiology: Science Learning Activities for Afterschool

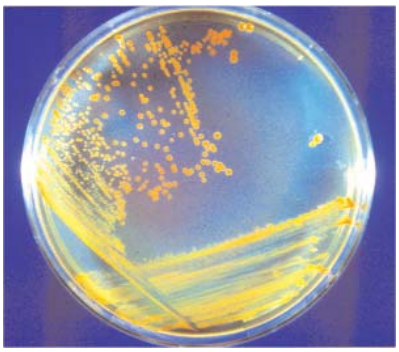
Extreme Life!

U.S. House of Representatives Committee on Resources
http://resourcescommittee.house.gov/subcommittees/emr/usgsweb/

Very old bacteria has been found living inside salt crystals.

Astrobiology: Science Learning Activities for Afterschool

Extreme Life!



NASA

Deinococcus radiodurans (shown on an agarplate) can survive radiation levels thousands of times greater than what would kill humans.