Microbial World

Introduction

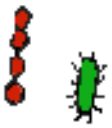
Beyond your level of vision exists a microbial world teeming with life. Bacteria, fungi, and protozoans are the denizens of this microcosmos. First appearing nearly 4 billion years ago, microbes have dominated the world's population ever since. Take a look at your arm. One square centimeter of your skin alone is home to some 100,000 members of this microbe community.

Generally, if we think of microbes at all, we think of them as disease agents-- germs. Though it is true that some microbes cause a wealth of diseases in both animals and plants, many others have an enormous positive impact on industry, science, health, history, and the ecosystem. Microorganisms supply the air with oxygen and other gases, fertilize the soil, purify the water, and are the source of many chemicals and medicines.

Today, microbes are also being used in the rapidly growing biotechnology field. These organisms are invaluable to the process of genetic engineering. Using microbes we can create new forms of medicine as well as agricultural crops with higher productivity and disease resistance.

This unit is an introduction to microbes. Our intent is to provide activities highlighting the diversity and wonder of the microbial world. Listed to the right are the experiments and readings included in the unit as well as a brief summary of their intended objectives.

Microbial Time Line
Review major steps in earth's evolutionary history, discuss the length of time microbes have been in existence.



Microbe Observations
Review classification of microorganisms; use a microscope to discover the diversity of microbes.

Germ Wars
Computer software program providing an introduction to microorganisms and their effects on people and plants.

Microbe Hunters
Introduction to aseptic technique and bacterial plating.

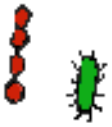
Microbial Brew
Review the beneficial aspects of microbes in the process of fermentation.

Students in grades 5 - 8 have the fine motor skills to work with a light microscope and interpret accurately what they see, enhancing their introduction to cells and microorganisms and establishing a foundation for developing understanding of molecular biology at the high school level.

National Science Education Standards








Below are the National Research Council's life science content standards addressed during this unit:

- Discover that most organisms are single cells.
- Explore the diversity of microorganisms.
- Learn that some diseases are the result of damage by infection of other organisms.
- Understand the role of microorganisms as producers and decomposers.

The microbe unit and accompanying equipment is provided by the Center for Engineering Plants for Resistance Against Pathogens. CEPRAP is a National Science Foundation Science and Technology Center located at the University of California, Davis. All activities were developed during the 1996/7 CEPRAP teacher internship program. Please contact CEPRAP at the address below with any questions regarding this material.

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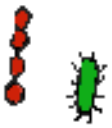
Microbial Time Line

Introduction to the History of Microbes

TEACHER INFORMATION








INTRODUCTION

Dinosaurs, primates, trilobites—all have their place in earth history, but most of the events of the past 500 million years pale in significance to earlier life forms-microbes.

The earth is approximately 4.6 billion years old. During this time microbes have dominated and altered life history. For instance, activity by photosynthetic bacteria, cyanobacteria, has been dated at approximately 3.5 billion years ago. Long before seed plants or even kelp were on earth, the amount of oxygen in the atmosphere increased as a product of photosynthesis by cyanobacteria. The majority of organisms on this planet would never have evolved without this increase in oxygen.

In this laboratory activity, students will discover that most of the life history of the earth has been dominated by microbes and that many of the most significant evolutionary events were fueled by these tiniest life forms.

TIME ALLOTMENT

One 40 minute lab period.

OBJECTIVES

1. To discover that most of earth's history has been dominated by microbes.
2. To understand the timing and sequence of major evolutionary events.

MATERIALS

For Each Lab Group:

- one microbe poster
- roll of lab tape

For teacher:

- 5 lengths of colored ribbon
- 14 laminated microbe posters
- lab tape
- arrows designating billion year increments

ADVANCE PREPARATION

1. Attach colored ribbons to a blank wall in a continuous line with lab tape.
2. Starting from the far left where the first ribbon begins, attach a sign reading '5 billion years ago'. Then at each new ribbon, attach a sign with successive billion year increments, until the end of the time line is reached. The sign at the far right should read 'Today'.

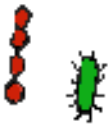
TEACHER NOTES

Background Information

Describe the time line to the class. Show each poster to the class and describe the events depicted, without giving them the time or sequence of events. Ask your students to hypothesize about why each of these events was so important. Descriptions of the timeline events are included at the end of the teacher information section of this activity.








Assembling the time line

Each lab group receives a poster and places it on the time line, based on when they think the event took place. After all posters have been placed, lab groups have the option of moving their poster to a new location on the time line.

One by one give the actual time and sequence that these events took place, and move the posters to the appropriate locations. Students will perceive that earth time has not been dominated by events that we are familiar with, but actually by microbes. Begin a discussion about the time line and why we perceive evolutionary time so differently than the actual history of earth time.

Earth Time Line

Poster Title	Event	Years Ago	Billions of Years Ago
When Cosmic Dust Goes Unswept	Origin of the Earth	4,600,000,000	4.600
Extended Forecast for Earth	Change that lead to creation of oceans and other bodies of water	4,200,000,000	4.200
Primordial Soup	Self-copying chemicals form in the hot broth of early Earth, forming the building blocks for life	4,000,000,000	4.000
Bacteria Arrive on the Scene	First cells (no nucleus) appear	3,800,000,000	3.800
Oxygen Factory	Photosynthetic microbes (*cyanobacteria*) produce oxygen	2,200,000,000	2.200
	Oxygen accumulates in the atmosphere and cells evolve to use it	2,000,000,000	2.000
We Want You for the Eukaryotic Cell	First nucleated cell evolves	1,400,000,000	1.400
Let's Get Together	Multicellular plants and animals appear	700,000,000	0.700
	Marine invertebrates abundant	600,000,000	0.600
	Earliest fish appear	500,000,000	0.500
Plants Race Animals to Land	Plants and later animals are able to colonize land	400,000,000	0.400
	Oxygen attains 20% level (current level)	380,000,000	0.380
	First amphibians appear	360,000,000	0.360
Tree Power	Trees appear	350,000,000	0.350
	First reptiles appear	300,000,000	0.300
Dinosaurs Rule	First dinosaurs appear	235,000,000	0.235
Eek Mammals!	First mammals appear	220,000,000	0.220
Trouble in Pangea	The separation of a single land mass into continents	175,000,000	0.175
Down with Dinos – Long Live the Birds	Extinction of dinosaurs, birds appear	65,000,000	0.065
	Flowering plants appear	40,000,000	0.040
	Human-like forms appear	3,000,000	0.003
***Homo sapiens* – Home Sweet Home**	Humans appear	50,000	.00005

FYI--If you were to count to 4.6 billion (one number per second) it would take nearly 150 years.

Microbial Time Line

Introduction to the History of Microbes

STUDENT PAGES

OBJECTIVES

1. To discover that most of earth's history has been dominated by microbes.
2. To understand the timing and sequence of major evolutionary events.

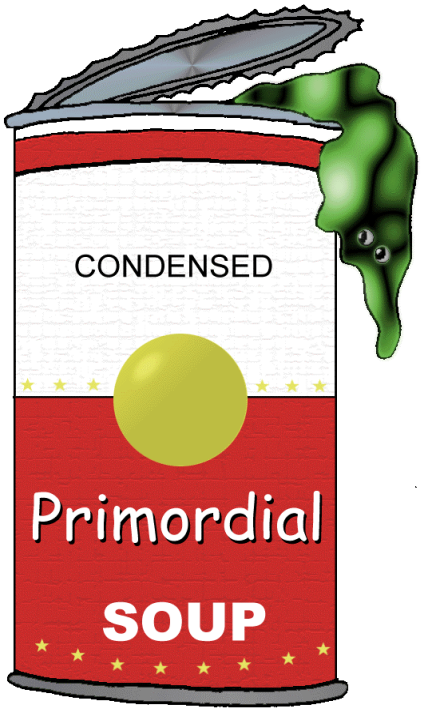
MATERIALS

For Each Lab Group:

- One microbe poster
- Lab tape

PROCEDURE

1. Look at the time line on the wall that your teacher has constructed out of colored ribbon. Each color ribbon represents 1 billion years (1,000,000,000)- that is one thousand millions. Find 5 billion years ago, on the left, and today, on the right.
2. Your teacher will show posters depicting different events in evolutionary history and give descriptions of these events.
3. Your teacher will give your lab group a poster to place on the time line.
4. Think about the image on the poster and the description your teacher gave you. How many millions or billions of years ago did this event occur?
5. Using a loop of lab tape on the back of the poster, attach the poster to the appropriate place on the time line that you think this event occurred.
6. When all lab groups have attached their posters, look at the sequence of events described, and if you think you need to, change the position of your poster on the time line.
7. Your teacher will rearrange the posters and give the actual times that these events occurred.



Microbe Observations

Introduction to the Subvisible World

TEACHER INFORMATION

INTRODUCTION

Microbes were first glimpsed in the 17th century through the eyepiece of a light microscope. Until the first description of this microscopic world by Anthony van Leeuwenhoek, no one guessed the colossal size and diversity of the subvisible world.

In this laboratory, students will set up several types of media in which to grow their microbe samples. Several days later, they will explore different types of microbes with the aid of a microscope. Organisms in the kingdoms Monera, Protista, and Fungi may be seen.

Finally, by observing and answering some fundamental questions about the organisms they see under the microscope, students fill in squares on a "micro-bingo" game card.

TIME ALLOTMENT

Two to three 40 minute lab periods.

Note: a two to three day growing period is required between Part 1 and 2.

OBJECTIVES

1. Utilize microscope to observe, identify, and illustrate fungi, monerans, and protists.
2. Recognize the wide diversity of microorganisms.
3. Understand differences in microbe structure, habitat, and movement.

MATERIALS

For Each Lab Group:

- microscope
- 5 slides and coverslips
- 1 paper cup
- plastic wrap
- microbingo game card
- set of microbingo image cards
- blank cards
- colored pencils or pens

Common Materials:

- disposable pipettes
- distilled water
- 500 mls pond water
- small samples of:
  yeast
  hay
  oatmeal flakes
  bread or cheese
  plain yogurt
- hot plate
- methylene blue stain
- prepared slides

For Teacher:

- microbingo card identification key
- 10 bingo cards
- 10 microbe card packets

ADVANCE PREPARATION

Obtain Pond Water

It works best if you have several pond water samples collected from various locations. Collect some samples from the top layer of water and others from the bottom of the pond surface.

Yogurt Culture

Prepare a stock solution of 50% water, 50% yogurt the day students will complete Part 2. Make sure the yogurt you purchase contains active cultures. Add a few drops of methylene blue so the bacteria can be seen.

Yeast Culture

Five to ten minutes before class (part 2), mix a small amount of yeast (1/2 package) with a cup of luke warm water. Add a tablespoon of sugar and mix gently. You should begin to see bubbles of carbon dioxide forming, indicating the yeast is alive.

Whatever it is, it's very, very tiny.
New Yorker Magazine inc. 1985

TEACHER NOTES

Disposal of Microbe Cultures:

Results are best if cultures are grown for 3 - 4 days.

When lab is complete, collect all microbial samples and pipettes and immerse in a 10% bleach solution to kill all microbes. Allow materials to stand in bleach solution for 15 minutes or more. Drain excess solution, seal materials in a plastic bag and dispose in the regular garbage.

At the end of lab, have students wipe down lab bench with bleach solution and wash hands before leaving.

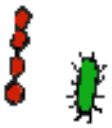
Microbe Observations

Introduction to the Subvisible World

STUDENT PAGES








BACKGROUND READING

All living things can be grouped into five kingdoms. You are already familiar with the animal and plant kingdom. The other three kingdoms—monera, fungi, and protista—are easy to overlook because their members are so incredibly small. In this laboratory, we will observe some of the microscopic members of these three kingdoms.

Monera consists entirely of bacteria, the oldest and simplest of all true living organisms. These organisms are prokaryotes, having no nuclei in their cells. Most bacteria are decomposers, feeding on dead material, but some can harvest the energy of sunlight for their growth. Bacteria are responsible for a wide range of diseases and other nasty conditions like tooth decay and body odor. However, many types of bacteria are very beneficial, making possible things like cheese, yogurt, and a variety of medicines.

Fungi are eukaryotes (nucleated cells) that grow from spores. Fungi never move around by themselves and always absorb nutrients from water or from the tissues of protozoa, animals, or plants. You are probably familiar with some types of fungi like mushrooms, yeast, or athlete's foot.

Protozoa are microscopic life forms that live in water. This is a catchall group that contains those organisms that do not fall in any of the other groups. Some members of this group can cause diseases like dysentery. Others, like diatoms, are used in the production of scouring powder and toothpaste.

OBJECTIVES

1. Utilize microscope to observe, identify, and illustrate fungi, monerans, and protists.
2. Recognize the wide diversity of microorganisms.
3. Understand differences in microbe structure, habitat, and movement.

For Each Lab Group:

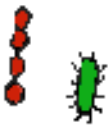
- microscope
- 5 slides and coverslips
- 1 paper cup
- plastic wrap
- microbingo game card
- set of microbingo image cards
- blank cards
- colored pencils or pens

Common Materials:

- disposable pipettes
- distilled water
- 500 mls pond water
- small samples of:
  rice
  hay
  oatmeal flakes
  bread or cheese
  plain yogurt
- hot plate
- methylene blue stain
- prepared slides








SAFETY PRECAUTIONS

When lab is complete, collect microbe samples and pipettes and immerse in a 10% bleach solution to kill all microbes. Allow materials to stand in bleach solution for 15 minutes or more. Drain excess solution, seal materials in a plastic bag and dispose in the regular garbage.

Wipe down lab bench with bleach solution at the end of lab

PROCEDURE

Part 1

1. Obtain 1 paper cup and label with group name. As your teacher directs, label your cup with **one** of the following letters:

   A: pond water + hay

   B: pond water + oatmeal

   C: bread mold

2. Follow the directions below that match your group's plate description.

   A: Add 6-7 small pieces of hay. Add 20 mls of pond water and cover with plastic wrap.

   B: Add about 20 flakes of oatmeal. Add 20 mls of pond water and cover with plastic wrap.

   C: Add a small piece of bread or cheese. Apply a few drops of water and cover with plastic wrap.

Your teacher will give you instructions on where to store plates.

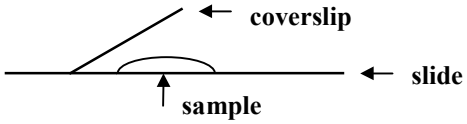
3. Clean your lab station and wash hands before leaving classroom.

Part 2

1. Get a microbingo board and a set of microbe cards from your teacher.

2. Collect your microbe culture cup. **Samples should have had two-three days of growing time.**

3. Place 1-2 drops of culture from your plate on a clean microscope slide (using a pipette). Place a cover slip on your sample.



4. Observe your sample under low power. Increase power as required for improved visibility.

5. Look through the microbe cards to see if you can spot an organism viewed under the microscope.

6. When you find a match, search the game board for an appropriate square to place the card.

7. Trade samples with other groups and continue your search.

8. Your teacher has placed samples of cultured yogurt solution, yeast solution, and prepared slides on the counter. Be sure to look at these samples as well.

9. If you are looking at an organism that is not represented on the cards, get a blank card and draw the microbe.

10. The first team to get five cards in a straight line vertically, horizontally, or diagonally wins.

11. Clean your lab station and wash hands prior to leaving classroom.

Microbe Hunters

Introduction to Aseptic Technique

TEACHER INFORMATION

INTRODUCTION

The three exercises in this laboratory introduce students to bacteria and aseptic lab techniques. A pre-lab activity is provided to assess students' prior knowledge in this area. This lab write-up assumes that students are working in groups of two.

Part 1: Students practice aseptic technique by cleaning an area covered with "Glo-Germ". The fluorescent material glows when the area is illuminated with a UV light, indicating areas that were not properly disinfected.

Part 2: Students learn how to pour an agar plate for culturing bacteria.

Part 3: Students culture bacteria found in the classroom. Samples are collected, plates inoculated and incubated overnight.

TIME ALLOTMENT

Two 40 minute lab periods and one 15 minute lab period to record results.

OBJECTIVES

1. Predict the conditions necessary for bacterial growth
2. Understand the importance of aseptic technique.
3. Learn how to obtain and culture a bacterial sample on an agar plate.

MATERIALS

For Each Lab Group:

- squirt bottle containing 10% bleach
- paper towels
- cotton swabs
- 1 sterile petri dish
- 50 ml beaker
- permanent markers
- parafilm

Common Materials:

- "glo- germ" powder
- hand held UV light
- hot plate
- nutrient agar solution
- safety glasses

ADVANCE PREPARATION

"Glo-Germ" Powder (Day 1)

Prior to student arrival, spread the powder on a few areas of each lab station. Rub the powder onto the table surface and brush off any excess so it is not noticeable.

Disinfectant Solution (Day 1)

Prepare a 10% bleach solution. Fill the squirt bottles with the disinfectant.

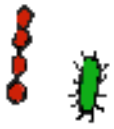
Nutrient Agar (Day 2)

Microwave the nutrient agar gel after removing the cap.

Place the bottle on a hot plate to prevent the agar from solidifying. Students will need to handle the bottles so have potholders available.







TEACHER NOTES

Use of the Blacklight

The blacklight is only effective if the room is fairly dark.

Illustrate the glowing bacteria prior to students cleaning their desks by shining the black light over one of the “infected” workspaces.

Have groups using the UV light wear UV safety glasses.

Disposal of Microbes

Do not allow the plates to grow longer than 4 days before sterilizing.

When lab is complete, collect nutrient agar petri dishes and immerse in a 10% bleach solution to kill all microbes. Allow materials to stand in bleach solution for 15 minutes or more. Drain excess solution, seal materials in a plastic bag and dispose in the regular garbage.

Wipe down lab bench with bleach solution and wash hands prior to leaving lab.

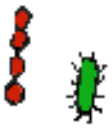
Microbe Hunters

Introduction to Aseptic Technique

STUDENT PAGES








BACKGROUND READING

Bacteria are the oldest and simplest of all true living organisms. They are found everywhere imaginable on the planet. In the last few years, scientists have even found bacteria miles deep within the rocks of the earth's crust.

Most bacteria feed on dead material, recycling it for use by plants and other bacteria. Other bacteria are like plants and can harvest the energy of sunlight for their growth. In fact, these light harvesting bacteria are thought to be the primitive ancestors of today's plants. Many bacteria even live harmlessly inside people, plants and animals. Did you know that bacteria living inside your intestines actually provide you with certain vitamins!

Unfortunately, some bacteria also feed on other living things, causing diseases on plants, animals and people. These bacteria are called pathogens. Some bacteria cause serious diseases such as diphtheria, tuberculosis, leprosy and blood poisoning. They also cause annoying but less serious complaints such as pimples and tooth decay.

When culturing bacteria in the classroom, it is important to use the proper procedures to ensure sterile work surfaces and minimize the risk of contamination. This is often called aseptic technique. You will practice some elements of aseptic technique in this bacteria laboratory.

OBJECTIVES

1. Predict the conditions necessary for bacterial growth
2. Understand the importance of aseptic technique.
3. Learn how to obtain and culture a bacterial sample on an agar plate.

MATERIALS

For Each Lab Group:

- squirt bottle containing 10% bleach
- paper towels
- cotton swabs
- 1 sterile petri dish
- 50 ml beaker
- permanent markers
- parafilm

Common Materials:

- hand held UV light
- hot plate
- nutrient agar solution
- safety glasses

PROCEDURE

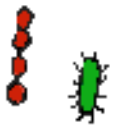
Part 1: Aseptic Technique

1. Your lab station has been infected with glowing bacteria. Your job is to disinfect your workspace and eliminate all traces of the bacteria. Before you begin cleaning, your teacher will illustrate what an infected area looks like when exposed to the correct type of light.

2. Obtain paper towels and a bottle of disinfectant from your teacher.






3. Carefully wipe down your entire lab area with the disinfectant.

4. Your teacher will use a special detector light to inspect your lab area.

5. When your lab station is clean, begin the pre-lab activity sheet.

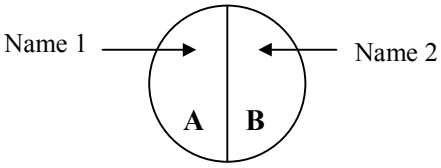
Part 2: Pour an Agar Plate

1. Bacteria are grown and isolated on a Jell-O-like nutrient substance called agar. Before collecting your microbe samples, you will pour an agar plate.

2. Wipe down your lab space with a 10% bleach solution.

3. Obtain a sterile petri dish and a small beaker for your lab group. **Keep the lids on the dish.**

4. Turn the plate upside down and draw a line down the center of the dish. Label as shown in the diagram below.



5. Bring your beaker to the hot plate and get 20 ml of nutrient agar. The nutrient agar bottle may be hot. Use a potholder to lift bottle out of hot water bath.

6. Return to your lab station and pour 20 ml of nutrient agar into the petri dish. Lift the lid at about a 30°angle with one hand while you pour with the other. Close the lid and leave the agar dish at your lab station to cool and harden.

Part 3: Microbe Hunt

1. Check to make sure the agar has hardened. Remember that each lab member should have his/her own plate.

2. You are now ready to "hunt" bacteria. Locate an area of the room you believe will have a lot of bacteria. Collect cells by rubbing the fixture or object with the cotton swab.

3. One partner will gently streak the surface of side A of the petri dish. Be very careful when swabbing the surface so as not to tear the agar.

4. Record the collection site information for sample A on the attached activity sheet.

5. Partner two will select a new area of the classroom and collect a sample to swab on side B. Be sure to use a clean cotton swab for each sample.

6. Record the information for sample B on the activity sheet.

7. Seal your plate with a strip of Parafilm.

8. Turn the plates upside down and place in the incubator to grow overnight. Plates are stored upside down so any moisture will collect on the top of the plate and not flood the bottom part where your bacteria are growing.

9. Clean lab station and wash hands before leaving lab.

NOTE: You will most likely collect some fungus as well as bacteria in this experiment. Be sure to not let your plates grow more than 4 days before sterilizing as per your teacher's instructions.

Microbe Hunters

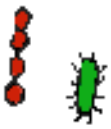
Introduction to Aseptic Technique

PRE-LAB SHEET

Answer the following questions.

1. Where do bacteria grow?

2. List four areas in this classroom you think would be good places to search for bacteria.



3. How can bacteria be harmful?

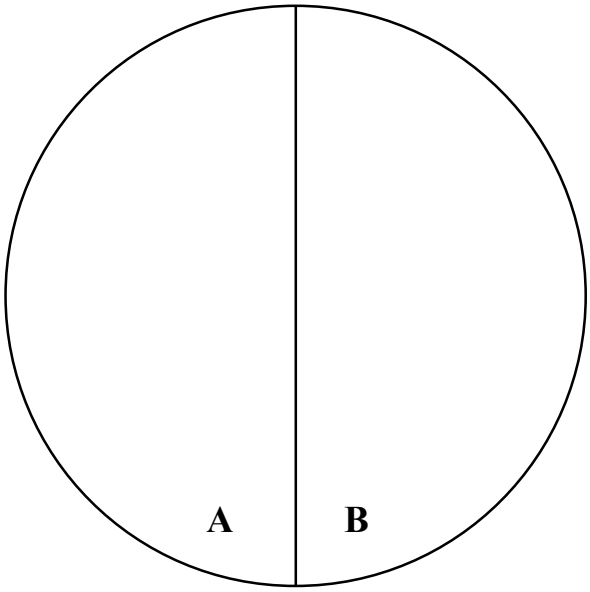
4. How can bacteria be beneficial?

5. Make a simple sketch of what you think bacteria look like.

Microbe Hunters

Introduction to Aseptic Technique

ACTIVITY SHEET



Sample A

1. Collection location:

   _____

2. Conditions:

   light- _____

   moisture- _____

   temperature- _____

3. Degree of human contact:

   ☐ Much ☐ Some ☐ None

4. Growth?

   ☐ Yes ☐ No

5. If there was growth, draw results above.

Sample B

1. Collection location:

   _____

2. Conditions:

   light- _____

   moisture- _____

   temperature- _____

3. Degree of human contact:

   ☐ Much ☐ Some ☐ None

4. Growth?

   ☐ Yes ☐ No

5. If there was growth, draw results above.

Microbial Brew

Introduction to Fermentation

TEACHER INFORMATION

INTRODUCTION

By making root beer, students will discover how yeast converts sugar into glucose, creating carbon dioxide as a byproduct. This fermentation process is illustrated further by a teacher demonstration prior to the lab activity.

TIME ALLOTMENT

One 40 minute lab period

OBJECTIVES

1. Learn that some microbes are beneficial.
2. Recognize that microbes are responsible for fermentation.
3. Understand that yeast produces carbon dioxide as a byproduct of fermentation.

MATERIALS

For Each Lab Group:

- 1 500 ml plastic bottle of water
- 250 ml beaker
- plastic spoon or stirring rod
- 10 ml graduated cylinder
- 100 ml graduated cylinder
- weigh boat
- permanent marker

Common Materials:

- root beer extract
- 1 liter warm water
- 5 lbs sugar
- 2 balances
- yeast solution

For Teacher:

- 4 Erlenmeyer flasks
- 4 rubber stoppers with holes
- 2 pieces of tubing
- water bath
- phenol red

ADVANCE PREPARATION

Obtain bottles

Have one student in each lab group bring a 500 ml bottle of water to class. Make sure the bottles are not glass.

Yeast Preparation

Mix 1.25 g of yeast (1/2 pkg.) with 600 ml luke warm water. Add a small amount of sugar. This step should be done just a few minutes prior to root beer creation. If the water is too hot, you will kill the yeast.

Make sure the yeast begins to bubble slightly in the warm water. If no foam appears, the yeast is probably dead—try a new package.

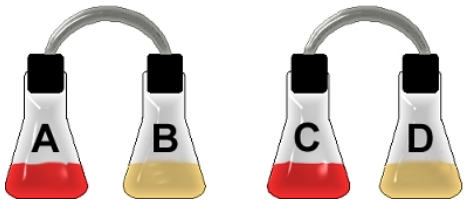
TEACHER NOTES

Yeast

Many strains of yeast are used in the production of beer, wine, and champagne. For our root beer, we will be using the yeast strain *Saccharomyces cerevisae*. This is the same strain used in manufacturing bread.

Since fermentation is an anaerobic process, make sure your students' bottles are well sealed.

DEMONSTRATION SET UP



1. Attach rubber stoppers to the ends of two pieces of tubing.

2. Label 4 flasks as follows:
   phenol red + water
   yeast
   phenol red + water
   yeast + sugar

3. Add 50 ml of water and 5 drops of phenol red to flasks A and C.

4. Place approx. 2 g of sugar into flask D.

5. In a beaker, mix 1 g of yeast with 100 ml of warm (35°C) tap water.

6. Put 50 ml of the yeast-water mixture into flasks B and D

7. Connect flasks A and B with a piece of tubing.

8. Connect flasks C and D with a piece of tubing.

9. Place the flasks into a warm water bath to speed the reaction.

10. Check the appearance of the phenol red every five to 10 minutes. The reaction will be complete by the end of the class period (about 30 – 40 minutes).

Phenol red turns yellow in the presence of carbon dioxide. In the flask where the yeast are provided with sugar, fermentation can take place, creating carbon dioxide. In the flask with no sugar, the yeast will eventually die.

Microbial Brew

Introduction to Fermentation

STUDENT PAGES

BACKGROUND READING

Microbes have played an important role in mankind's history. Nowhere is this more evident than in the kitchen. Listed below are some foods whose creation depends on microbes:

Bread
Cheese (Swiss, Roquefort, Camembert)
Rice
Soy sauce
Tofu
Vinegar
Wine
Yogurt

In order to make the above foods, bacteria or fungi break down complex sugars into simpler substances like carbon dioxide and alcohol. This process is called fermentation. For centuries, fermentation baffled people because the microbes responsible for the process could not be seen.

In this lab, you will explore fermentation by making root beer with the help of a microbe-- yeast. Yeast is actually a one-celled fungus. When you make root beer, you are creating a very friendly environment for yeast to grow and multiply by adding lots of sugar (food) and cutting off the oxygen supply. Yeast, like many microbes, is anaerobic. That means they grow best without oxygen.

The carbon dioxide produced through fermentation in the thriving yeast cells results in the bubbly characteristic of the soda.

MATERIALS

For Each Lab Group:

- 1 500 ml plastic bottle of water
- 250 ml beaker
- plastic spoon or stirring rod
- 10 ml graduated cylinder
- 100 ml graduated cylinder
- weigh boat
- permanent marker

Common Materials:

- root beer extract
- 1 liter warm water
- 5 lbs sugar
- 2 balances
- yeast solution

OBJECTIVES

1. Learn that some microbes are beneficial.
2. Recognize that microbes are responsible for fermentation.
3. Understand that yeast produces carbon dioxide as a byproduct of fermentation.

PROCEDURE

1. Obtain a 500 ml plastic bottle and label it with your name and group number.

2. Weigh 75 g of sugar into your weigh boat.

3. Discard 75 mls of water from the plastic bottle.

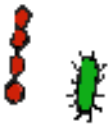
4. Fill a 250 ml beaker with 100 mls of water from the bottle.

5. Pour 75 g of sugar into the water in the beaker and stir.

6. Obtain 3 ml of root beer extract and pour into the 500 ml bottle. Swirl lightly to mix.

7. Measure 30 ml of yeast solution from the equipment station and transfer the solution into the plastic bottle.

8. Fill bottle with sugar water. Add water from the equipment station until there is a 5 cm space left at the top of the bottle.



9. Be sure to twist the cap on your bottle securely.

10. Clean up your lab station.

11. Allow your bottle to sit undisturbed in a dark place for two days. After day two, refrigerate for one day before testing. When pouring the root beer tilt the bottle slowly so as not to disturb the yeast that has settled on the bottom.