Sizing Up the Microbial World

Two Preparative Explorations for the "Microprise" (a.k.a. Microscope)

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Entering the microbial world is a giant step away from our every day reality. Students need preparative steps to help them deal with the major shifts in size and dimensions they are about to encounter...
A QUICK LOOK

Part I

- **Time required:** One class period

- **Appropriate grade level:** 6–12

- **Process skills:**
  - Comparison/Contrast
  - Creative Thinking & Expression
  - Following Directions
  - Measurement/Calculation
  - Observation/Description
  - Record keeping
  - (Verbal Communication)

- **Prerequisites:** Not necessary, but helpful if the students have begun the "Observation Exercises" exploration as described in this guidebook.

- **Additional resources:**
A QUICK LOOK

Part II

- *Time required:* One to two class periods

- *Appropriate grade level:* 9–12

- *Process Skills:*
  Creative Thinking and Expression
  Following Directions
  Interpretation
  Measurement/Calculation
  Observation/Description
  Record-keeping
  Use/Care of Equipment/Materials

- *Prerequisites:* Students should be familiar with basic use and care of the microscope prior to beginning this activity. It would be useful to begin the “microfishing” activity as described in the curriculum guidebook.
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OBJECTIVE

Students become more familiar and comfortable with the microscope and how to use it for investigation.

CONTENT

Welcome to the "Microprise"! The Microprise microscope will transport you to new worlds within the microcosmos in an exciting adventure of discovery and communication. Your mission is to guide the Microprise through a new dimension of sight, encountering varied, exciting worlds.

Your application for Mission Guide has been received and reviewed... your qualifications are outstanding! The Microprise is yours to control! Before you begin your trip into the microcosmos, it is a good idea to review some ship control procedures. The exercises within Part I: "Sizing Up..." will help you measure the sizes of worlds that you will visit in the microcosmos. Once you are comfortable with these exercises you will move on to Part II: "...the Microbial World"!

Illustrated in Part I are two training exercises that use the "microdish" and some common objects. These exercises help the viewer to deal with size relationships that are encountered while using the Microprise. The manual helps you visualize your work by providing drawings, measurements, and calculations. Keep records of all your work by making drawings in a journal—an example of a good journal drawing is given at the end of Part II on page 21.

Let's go discover the unusual dimensions of inner space!
Part 1: "Sizing Up..."
GETTING STARTED: TRAINING WITH COINS

COUNTDOWN

As you do this exercise, consult the visual diagrams on page 7. The measurements given on the diagrams are accurate for the drawings only. Your real-life measurements using the microdish and coins will be different, but the technique for measuring and calculating size is exactly the same! It is important to make drawings that accurately represent what you see—show any measurements and calculations that you make. Check the journal entry example on page 12 to see what type of information is important to record.

The following equipment is needed:

✔ One "microdish" (petri dish top)
✔ One "micrometer" (small metric ruler)
✔ One piece of notebook paper
✔ Various coins (penny, nickel, dime, quarter)
✔ Kidney beans
✔ Miscellaneous small, odd-shaped objects

TAKEOFF

1. First, measure the diameter of the microdish. The diameter is the widest possible line from one side to the other. Measure the diameter by laying the micrometer across the microdish at the widest possible point. Record your measurement in millimeters (mm). Is your diameter measurement the same as others' in your class? Come to an agreement on the diameter measurement (Hint: It is somewhere between 85 and 95 mm).

2. Begin the exercise by dropping a coin on a piece of paper in front of you. Once it has been dropped, you cannot move it! Now place the microdish over the coin. The circle of the microdish represents the "field of vision,” or circle of light that you see when looking inside the microprisn (microscope). Hold the microdish steady in one place, and slide the paper around underneath it. Notice that you can move the coin around inside the microdish by moving the paper. This sliding is exactly what the microprisn does to move an object inside your field of vision. You can place an object at the edge of your vision...
MICRODISH MANIPULATIONS

A. THE COIN EXERCISE

1. **Measuring the Microdish**
   
   D = microdish diameter
   
   D = 50 millimeters (mm.)

2. **Estimating Coin Number**
   
   X = number of coins to cross microdish diameter
   
   X = 5

3. **Calculating Coin Diameter**
   
   d = diameter of the coin
   
   d = D/X
   
   d = 50 mm./ 5 coins
   
   d = 10 millimeters!
or in the center of your vision. This ability to move what you see will help you when you are making drawings!

3. Next, draw what you see: a drawing of the microdish and the coin inside it. Do not simply trace the microdish and coin—your drawing will be too big and there won't be enough room in your journal for many drawings. Make your drawings smaller than the objects you are actually using. If you make a small circle to represent your microdish, you will have to make a smaller circle to represent your coin inside the dish. Be sure that the difference in size between the microdish and coin stays the same, even when you make a much smaller drawing. Check the diagrams on page 7 for an idea of what your drawings should look like.

4. The challenge now is to calculate how big your coin is without actually measuring it. You have everything you need. Keep track of what happens next by recording all your measurements and calculations next to your drawing.

   The first step is to find out how many coins will fit across the microdish diameter (the widest crossing). You can do this by estimating the number (your best guess), or by using your drawing to make “ghost drawings” of the coins like those on page 7. Record the diameter of the microdish ($D = \ldots$ mm) and the number of coins to cross the diameter ($X = \ldots$).

   This is all the information you need to calculate the size of your coin. It is very simple. All you have to do is divide the diameter, $D$, by the number of coins, $X$, to find the size of the coin, $d = \ldots$ mm:

   $d = \frac{D}{X}$

   $d = \text{diameter of the coin}$

   $d = \ldots$ mm

   If you want to see how accurate your calculation is, use the micrometer to measure the actual size of the coin—how close were you? Try this same exercise with a couple different coins. Then move on to the next challenge: training with beans. This simple technique of drawing, estimating number, and calculating size can be used for any type of object you use with the microdish or encounter in the microcosmos!

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**MISSION IN PROGRESS**

**More Dimensions Using Beans**

Now that you feel comfortable measuring coins, continue your conquests over measurement with a more complicated object: the bean! Consult the drawings on page 7
as you explore the bean through the microdish. When you look at the bean through the microdish, you will notice right away that there are some problems—the bean has three dimensions! The bean has length, width, and a thickness! Because the bean is thick, it is hard to estimate exactly where the edges are. Do not worry, this is also what will happen when you see something through the Microprise. All you need to do is become comfortable with deciding where you think the edge is. Even though it is hard to decide on the edges at first, you will quickly get used to estimating the size of the bean in any direction you want.

The main idea here is to treat the bean just like a coin, but with two dimensions, length and width. Make a drawing like you did with the coins. You need to make sure the length and the width are in the proper relationship so that your drawing looks like the bean. It is very easy if you think of one dimension at a time (length, then width). You can then easily calculate the size of the bean first by length, then width. Make good drawings and record all your calculations just as you did in the coin exercise. Look at the diagrams on page 10 to see how to record all the needed information next to your drawing.

**Why Draw?**

One of the most important skills you can develop while traveling the microcosmos is an ability to make very beautiful drawings containing a lot of detail. Luckily, this important ability is also the most challenging and fun! The measurements and calculations you will make come very easily with a little practice (you can always go back to your notes to see how it is done). The worlds within the microcosmos are very interesting—they make great drawings and an attractive journal.

A drawing helps you remember not only what something looked like, but also how it compares to other things that you see and draw. Once the Microprise is gone, you will still be able to enter the microcosmos through the drawings you have made.

Remember that it is important to make good drawings that show what the relationship is between the microdish circle and the object at which you are looking. Your drawings will not be the same exact size as what you see inside the microdish or the microprise, so it is very important to make all parts of the drawing in proportion to one another. If you draw a microdish circle that holds ten pennies, be sure that the actual microdish does hold ten pennies!

If the drawings are good, you can look at them at any point in the future and still calculate the size of the object you saw. It is very likely that you will find critters inside the microcosmos that are one hundred times bigger than each other, but you still can’t see them with the naked eye!
MICRODISH MANIPULATIONS

B. THE BEAN EXERCISE

1. **Estimating Bean Length and Width**
   
   \[ D = \text{microdish diameter} = 50 \text{ mm.} \]
   
   \[ L = \text{bean length} \]
   
   \[ W = \text{bean width} \]

2. **Calculating Bean Length**
   
   \[ XL = \# \text{ of bean lengths to fill diameter} \]
   
   \[ XL = 4 \]
   
   \[ L = \text{bean length} \]
   
   \[ L = \frac{D}{XL} \]
   
   \[ L = 50 \text{ mm.} / 4 \text{ beans} = 12.5 \text{ mm}.! \]

3. **Calculating Bean Width**
   
   \[ XW = \# \text{ of bean widths to fill diameter} \]
   
   \[ XW = 7.5 \]
   
   \[ W = \text{bean width} \]
   
   \[ W = \frac{D}{XW} \]
   
   \[ 50 \text{ mm.} / 7.5 \text{ beans} = 6.7 \text{ mm}.! \]
LANDING AND DEBRIEFING

Entering the Unknown

After you have successfully completed the coin and bean exercises, apply your new skills to interesting objects of very irregular shapes, such as seashells, stones, pieces of wood, plants, and so on. Use the microdish and the same drawing procedure for making calculations. Almost anything you choose to draw is going to look just like something that can be found in the microcosmos—that is how diverse the microcosmos really is!

Good luck and Bon Voyage—see you in Part II, "... the Microbial World."
A SAMPLE JOURNAL ENTRY:
Drawing the Microdish with Calculations

X = 10

d = 10 mm.

Diameter of the Microdish
D = 100 mm.

Number of coins to cross diameter
X = 10 coins

Diameter of Coin
d = D/X
d = 100 mm./10 coins
d = 10 mm.
Part II: “... the Microbial World”

Here’s the Microprise

COUNTDOWN

Consult the diagram in the appendix to this exploration, if you have any questions about parts of the Microprise microscope. This exercise explores the general use of the Microprise, but will not cover specific cleaning or handling techniques. It is recommended that students conducting this exercise be thoroughly introduced to the general principles of microscopy before proceeding. Microcosmos advises that how a microscope functions be a separate topic from having students simply know how to operate it. The former is not a priority and should not be done at the outset when introducing the microscope.

We also advise that four or five basic steps stated simply on an overhead be developed by the instructor for the microscope(s) appropriate to your classroom. Each step is revealed one at a time to the class as a whole. Once everyone in the room has accomplished the first step (e.g. “use the switch at the base to prepare for beaming down to the planet surface,” i.e. “turn on the light”), then the second step can be revealed and the students can proceed. While this may seem tedious and perfunctory to some students, it is essential to do, even for students who initially claim that they have operated microscopes before and know how to use them.

You will need the following equipment:

✓ “Microdish”
✓ “Micrometer”
✓ Scrap paper
✓ Slides, coverslips, droppers
✓ Pond water or any source of microorganisms
✓ Microscopes

TAKEOFF

Before we actually look at something through the Microprise, let’s explore how to control power and magnification. Microprise power level (P) is equal to the eyepiece lens power (10×) times the objective lens power (4×, 10×, 25×, 40×, 93×, or 100×). Check the “ship statistics” chart on page 16 for an easy display of how this works. Two parts of the chart have been left blank for you to fill in. You can calculate
the total power for the blank in the chart using the simple multiplication of the lens power times the objective power. You will calculate the diameter and complete the chart a little later.

The total power of the Microprise is controlled by changing the objective power (see the chart). Notice that the total power for the Microprise can be between 40X and 1000X, depending on the setting. Most scopes will have four objective lenses, and therefore four different power levels. See the Microprise picture in the appendix for the location of the objective lens. To set the total power you want, consult the chart, locate the power you want, and move the corresponding objective on the Microprise itself.

The next step is to see what happens to magnification as the power level changes.

**What Is Magnification?**

Let's conduct a simple demonstration to see what it is like to increase the power on the Microprise. Use the microdish (from Part I) to help you make drawings and calculate sizes. An object or drawing is posted in the room. Look at this object through the microdish from two different distances in the room—close to the board and far away from the board. Make drawings in the space on the next page illustrating what you can see through the microdish at both distances.

Start with the closest distance: How big is the object on the board compared to the circle of the microdish? Make a drawing that shows the object inside your microdish.

Now try the farthest distance. Notice the change in what you observe and draw. A new relationship exists between the microdish and the object. How big is the object inside the microdish circle now? Be sure to make drawings of what you see from both distances that show the change in size as a function of distance.

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**MISSION IN PROGRESS**

Things to Consider and Discuss . . .

- What is the difference between your two drawings?
- Has the object actually changed size?
- What does standing close or standing far away mean in terms of magnification?
- What does the Microprise microscope do that is similar to what you just did?
Drawing Space

Microdish Drawing I: Close to an Object

Microdish Drawing II: Far from an Object
Looking Inside

I. Microprise = Microdish

When you look through the Microprise, you will see a bright, circular area of light called the “microfield” (or field of vision). This microfield is measured in diameter (mili-meters) exactly like the microdish. You can think of the microfield as if it were the microdish. Both circles have a diameter that can be used for your calculations. If you know the diameter of the microfield on the Microprise, you can calculate the size of any object as if you were working with a dish sitting on the desk in front of you!

II. Diameter = Power

The diameter of the microfield changes as you change the Microprise power level (see the chart below). As you increase the power, what you are looking at gets bigger and bigger—just like walking closer to the blackboard! The microfield circle stays the same size, just as did the microdish you hold in your hand as you walk toward the board. Neither the microdish nor the microfield circle changes; what changes is the amount of an object you can see—or—how close you are. When you stand far away from the board, you can see a large portion of the blackboard. The diameter of the field you can see is several feet. As you walk closer to the board, the field that you can see becomes smaller, down to less than 1 foot! Thus, the diameter of your field of vision has decreased significantly. Remember that the microdish stays the same size during the moves; what it represents (your field of vision) is what gets smaller. Remember that the higher the power, the closer you are and the larger something appears to be.

Look at the microfield diameters shown in the chart below. Notice that as you increase power, you decrease the diameter of the microfield. You can calculate how big the microfield diameter is by looking at the change in power. If the power increases ten times, then the diameter shrinks ten times! See if you can calculate the diameters missing in the chart (Hint: How many times greater is the power than 40×? Use the diameter from the 40× power level as your starting point.)

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<tr>
<td><strong>EYEPiece POWER</strong> (magnification)</td>
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<tr>
<td><strong>TOTAL POWER</strong> (magnification)</td>
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<tr>
<td><strong>MICROFIELD DIAMETER</strong> (millimeters)</td>
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</table>
Using Power

What does it look like to change the power level on the Microprise? Look at the diagrams on page 18. The power level increases from diagram A to diagram C. As the power level increases, notice that the size of the “L” increases. This is what you saw when you walked closer to the object seen through the microdish. The “L” takes up more room in the microfield—this means that the size of the microfield gets smaller. The real size of the “L” never actually changes; you just get closer and closer as you increase the power. Your drawing does change. This is why it is so important to write down all information next to your drawing. The microfield diameter (indicated next to the drawings) gets smaller from diagram A to diagram C.

Another interesting thing happens: The power level changes from 40X in diagram A to 400X in diagram C. The power has increased ten times. The size of the “L” in drawing has also increased ten times! You can actually measure this with your micrometer if you like. If you drew another circle as diagram D and labeled it as power 1000X (P = 1000X), what would the diameter of the circle be (D = _______ mm)? How big would your “L” be? Would the entire “L” fit on a piece of paper? How much of the “L” would actually be showing inside of the circle?

These and many more questions will come up as you look at microorganisms from pond water or any other source. Use the charts and the sample calculations in these exercises to help you navigate.

You can put Part I, “Sizing Up . . . ,” and Part II, “. . . the Microbial World,” together to form “Sizing Up the Microbial World”—a few simple steps for recording anything you see, and calculating how big it is compared to anything else. Take a look at the summary steps on page 19.
MICROPRISE POWER VERSUS MAGNIFICATION
"POWER DIAGRAMS"

A.  

\[ P = 40X \]
\[ D = 4.5 \text{ mm.} \]

B.  

\[ P = 100X \]
\[ D = 1.8 \text{ mm.} \]

C.  

\[ P = 400X \]
\[ D = 0.45 \text{ mm.} \]
LANDING AND DEBRIEFING

Summary Steps

1. Find your Microprise power level by using your objective power and the ship statistics on page 16.
   \[ P = \square \]

2. Use the ship statistics to find your microfield diameter at this power level.
   \[ D = \square \text{mm} \]

3. Estimate the number of objects it takes to cross the diameter, using one dimension at a time.
   \[ X = \square \]

4. Divide the diameter (D) by the number of objects (X) to calculate the size of the object (d).
   \[ d = \frac{D}{X} \]
   \[ d = \square \text{mm} \]

5. Enter this information, including your calculations, next to a good drawing of what the object looks like.
   Check the journal entry examples on page 21.

That's all there is to it!

You now have a way to navigate in the microcosmos and share your explorations with others through a permanent record of your drawings and calculations.

HAVE A GOOD TRIP!
BEYOND THE MISSION

Notes for Different Scopes

There are many types of microscopes and manufacturers, but the underlying principles are the same for any microscope. Most manufacturers will provide a chart of power level versus field of vision similar to the chart on page 16. If for some reason you are unable to get this information from the manufacturer, then you can start your own chart as follows:

All you need is one diameter measurement at one power level. Use your lowest power, and place a plastic metric ruler under the scope. Measure the diameter as best you can and use the power-versus-diameter relationship to fill in the chart for any other power levels you have. It is simple, actually. The only pitfall is that you can’t be very accurate with the increments on the ruler, but it is close enough. Check the chart to see that your values are coming out similar to the values shown, or at least in the same pattern. There is usually little difference between diameters on microscopes.
MICROPRISE MICROSCOPE JOURNAL ENTRY

*Lingbya* taken from a freshwater aquarium, Boston University  May 5, 1989

\[ D = 1.8 \text{ mm.} \]
\[ X = 5.5 \text{ to cross } D \]
\[ d = D/X \]
\[ d = 1.8 \text{ mm.}/5.5X \]
\[ = 0.33 \text{ mm. long} \]

\[ P = 100X \]
\[ D = 1.8 \text{ mm.} \]

Try your own drawing in the space below . . .
eyepiece/ocular

objectives

slide holders

stage

iris diaphragm

light source

light switch

arm/limb

coarse focus

fine focus

base