LESSON — SIZE AND SHAPE

About This Lesson
This lesson is comprised of two linked activities that enable students to gain appreciation for the importance of relative size and morphology in identifying microscopic structures as viewed with the scanning electron microscope.

Activity 1 – SIZE AND SHAPE MATTERS

Students will sequence unlabeled electron micrographs of a sand, sugar, and yeast mixture. This sequence introduces students to morphology and scale in order to gain the perspective needed to make valid observations of scanning electron microscope (SEM) research images.

Activity 2 – SIZE AND SHAPE IMAGED

Students will view more SEM images of very small things to gain a perspective on the microscopic size range and morphologies of geology and microbiology samples. Students will then draw conclusions about three unlabeled images. These are the Mars meteorites that have prompted much discussion and research in astrobiology today.

Background
Virtually no organisms studied in microbiology and geo-microbiology can be seen with the naked eye, but require the use of optical or electron systems for magnification. The eye can only see to 1X (1 times normal vision). The most familiar microscope to secondary students is the compound light microscope. Its limit of resolution restricts its usefulness when studying very small objects such as viruses, bacteria and individual molecules as the highest magnification of the oil immersion compound light optical microscope is about 1000X (one thousand times).

To overcome the limitations of optical microscopes, a scanning electron microscope (SEM) is used. The range of magnification for the SEM is from 10X to 750,000X! The SEM gets its name from the pencil-like beam of electrons that scans back and forth across the surface of a specimen. Electrons bounce off the specimen and are picked up by detectors that provide information used by a computer to form an image of the specimen on a monitor. Rather than showing internal details of a specimen, the SEM shows detailed images of the sample surfaces. Scientists use the word *image* and not *photographs* or *pictures* because the process uses electrons and is not an optical system. Gradual magnification of images is accomplished by selecting a specific area of an image for further examination and then zeroing in on that portion of the specimen.

Use of the SEM at the secondary level is not a realistic expectation. However, the secondary student can make use of SEM technology by viewing electron micrographs and exploring on-line virtual SEM sites. Scientists use the SEM to study things like microorganisms and the characteristics of rocks. The scale bars on the micrographs supplied with this activity

establish how extremely small the specimens are. Some features are so small (10-100nm) that approximately a billion could fit on the head of a pin! (one nanometer is one millionth of a millimeter!).

Using the SEM, fossils of microorganisms have been found in terrestrial rocks. The scanning electron microscope is currently being used as an analytical tool in the study of meteorites. The results of these examinations determine chemistry, textures, and spatial relationships of geologic features, as well as identify features possibly produced by living organisms. Features found in the Mars meteorites ALH84001, Shergotty, and Nahkla are in the shapes and size range of terrestrial microorganisms (~one micrometer in length) although some are smaller and may be pieces of organisms that became fossilized. The ongoing research about these features reveals a wide and disparate range of interpretations. Some research points to a strong possibility of fossil evidence of microbial life in the samples. Interpretations of other experiments indicate that non-biological chemical processes might have made the features. This is real science in progress.

ACTIVITY 1 –

SIZE AND SHAPE MATTERS

About this Activity

Students will sequence a series of unlabeled electron micrographs of sand, sugar, and yeast. This will introduce students to morphology and scale so they can gain the perspective needed to make valid observations of scanning electron microscope (SEM) data

Objectives

The student will be able to:

- Gain appreciation for the size of objects viewed under microscopic magnification.
- Gain a perspective of morphology at various magnifications.

Vocabulary List

Compound light microscope, electron microscope, magnification, scale, scale bars, micron, nanometer

Materials

- Microscopes (1 per 4 students)
- Slides (1 per microscope)
- Cover slips (1 per slide)
- White granulated sugar (small bag)
- Sand (small bag available at pet, garden stores or home)
- Dry yeast (1 bottle or several packets)
- Beakers (1 per group)

- Student sheet (1 per student)
- Copies of images of sugar-sand-yeast mixture, cut for sequencing (1 set per group or one per student)
- Tape or glue stick (1 per group)

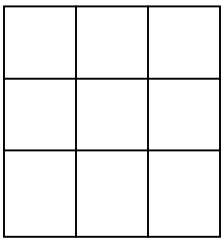
Procedure

Advanced Preparation

1. Print image pages from *Finger Prints of Life?* CD or from the NASA-JSC-ARES website http://ares.jsc.nasa.gov/Education/Websites/AstrobiologyEducation/index.html. NOTE: Images may be photocopied for multiple sets, but printer images are usually clearer.
2. Cut images and paper clip sets together in random order
3. Photocopy student sheets.
4. Prepare a sand-sugar-yeast mixture (equal parts of each) in beakers for passing as visual aids.
5. Set up several dry mounts of the mixture under optical microscopes for quick viewing by students.
6. Prepare for projection of PowerPoint slide show (make transparencies or set up projector).

Classroom Procedure (for guided discussion)

1. Pass out Student Sheet.
2. Show beaker with mixture of sand, sugar, and yeast.
3. Lead students through questions 1 and 2.
4. Pass out the image sets of the mixture.
5. Show the conglomerate image of sand, sugar, and yeast from the slide show. Allow time to look at the image on screen and find it in their sets.
6. Tell students that the remaining nine pictures are low, medium and high magnifications of a sand grain, a sugar crystal, and a yeast colony in the conglomerate image.



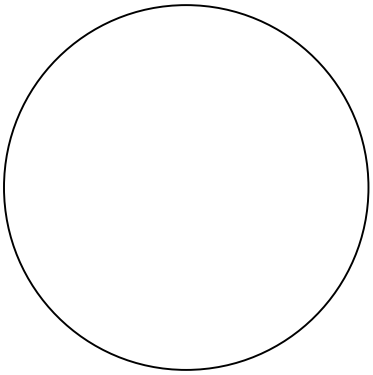
7. Emphasize that the student should concentrate on the center of an object and imagine what it would look like magnified 10X (ten times).
8. Have students sort and sequence the nine images from low to high magnification putting the images in a grid formation on their desks.
9. Have students answer Questions 3 and 4 on the Student Sheet.
10. Walk around to check their work before proceeding through the slide show. The teacher may encourage peer tutoring by groups who have the correct sequence quickly.
11. Show the correct sequence by quickly working through the remaining slides explaining what can be seen in each view. Emphasize magnification, scale, and morphology.
12. Point out that sand looks like a rock (irregular); sugar makes a geometric crystaline shape; yeast makes colonies.
13. Have students answer Questions 5-7.
14. Discuss students' answers. Questions 6 and 7 are a lead-in to Activity 2.

STUDENT SHEET

SIZE AND SHAPE MATTERS

1. How might you separate the sand grains, sugar crystals, and yeast from one another?

2. Draw the microscope view of the sand-sugar-yeast mixture and record your observations.



3. What criteria did you use to sort the pictures?

4. Was it easier to sort by substance or by magnification? Explain.

STUDENT SHEET – PAGE 2

SIZE AND SHAPE MATTERS

5. Sketch the conglomerate image and label at least one sand, sugar, and yeast.

6. What kinds of things do you think scientists view with an electron microscope?

7. Are you able to determine whether something in these images is ALIVE?

STUDENT SHEET - KEY

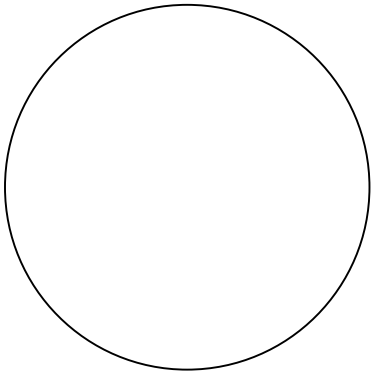
SIZE AND SHAPE MATTERS

1. How might you separate the sand grains, sugar crystals, and yeast from one another?

-Student answers will vary, but should be reasonable.

2. Draw the microscope view of the sand-sugar-yeast mixture and record your observations.

-Student answers will vary, but should be reasonable.



3. What criteria did you use to sort the pictures?

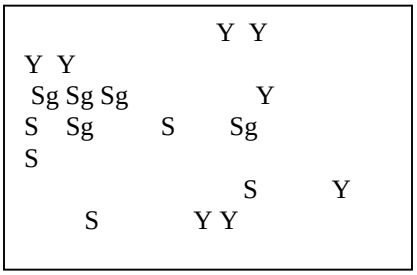
-Student answers will vary, but should be reasonable.

4. Was it easier to sort by substance or by magnification? Explain.

-Student answers will vary, but should be reasonable.

5. Sketch the conglomerate image and label at least one sand, sugar, and yeast.

approximate



6. What kinds of things do you think scientists view with an electron microscope?

- Bacteria, viruses, atoms, molecules, minerals, cells, fungi, protozoa . . . – small things!

7. Are you able to determine whether something in these images is ALIVE?

- No. One can only suspect that a structure with the correct size and shape could be evidence of life. Further investigation is necessary, observation alone is often not enough.

ACTIVITY 2 –

SIZE AND SHAPE IMAGED

About this Lesson

Students will view SEM images of very small things to gain a perspective of the microscopic size range and morphologies of geology and microbiology samples. Students will then draw conclusions about using images of Mars meteorites. These are the images that have prompted much discussion and research recently in the scientific community.

Objectives:

The student will

- Gain appreciation for the size of objects viewed at the microscopic scale
- Gain a perspective of the shape of common microscopic specimen
- Observe the relative sizes and shapes of typical microbes and minerals
- Observe that evidence of life may exist in meteorites from Mars
- Apply new perspectives to speculate about the origin of some features

Vocabulary List

Scanning electron microscope, magnification, scale, scale bars, microbe, fungi, bacteria, coccus, bacillus, spirochete, strep-, staph-, ebola, meteorite, abiotic, biotic, crystals, micron, nanometer

Materials/Equipment

- Slideshow and script for the *Size and Shape Imaged* PowerPoint presentation from *Finger Prints of Life?* CD or from the NASA-JSC-ARES website http://ares.jsc.nasa.gov/Education/Websites/AstrobiologyEducation/index.html
- Projection system for PowerPoint
- Student Sheet (one per student)
- Alternative – Copy of PowerPoint presentation of micrographs

Procedure

Advanced Preparation

1. Copy Student Sheet
2. Prepare for projection of PowerPoint slide show
3. Optional -- Photocopy PowerPoint lecture notes (3 slides per page) for students – for use after they have viewed the presentation – not before.

Classroom Procedure (for guided discussion)

1. Introduce the presentation with the question “What kinds of things are viewed with an electron microscope?” (Question 1 on the Student Sheet)
2. Present the slideshow reading the script. Encourge the students to look at the images as the script is read. Encourge discussion about size scale and shapes.

3. Leave the last slide projected. Pass out the Student Sheet and have the students complete Questions 1-4.
4. For discussion, review and revise ideas about Question 1 and 2. Lead the discussion to the idea that observations are not sufficient to make interpretations, but that they can help focus further scientific research such as chemical investigations.
5. Have the students complete Question 5 on the Student Sheet. Direct them to investigate the answers to their questions as homework. See *Resources* on the *Finger Prints of Life?* CD or from the NASA-JSC-ARES website. http://ares.jsc.nasa.gov/Education/Websites/AstrobiologyEducation/index.html.

STUDENT SHEET

SIZE AND SHAPE IMAGED

1. What kinds of things are viewed with an electron microscope?

2. Are you able to determine whether or not something in these images is ALIVE? Explain your answer.

3. Draw the structure you see in these samples.

   a. ALH84001 _____

   b. Nahkla _____

   c. Shergotty _____

4. What is your reaction to learning the identity and source of the "unknowns"?

5. What question(s) do you have now?

STUDENT SHEET - KEY

SIZE AND SHAPE IMAGED

1. What kinds of things are viewed with an electron microscope?

   - Bacteria, viruses, atoms, molecules, minerals, cells, fungi, protozoa . . . – small things!

2. Are you able to determine whether or not something in these images is ALIVE?

   - No. One can only suspect that a structure with the correct size and shape could be evidence of life. Further investigation is necessary.

3. Draw the structures you see in these samples.

   a. ALH84001

   b. Nahkla

   c. Shergotty

4. What is your reaction to learning the identity and source of the "unknowns"?

   *- Individual answer will vary, but surprise and awe at "seeing" a <u>possible</u> extraterrestrial "face-to-face" is expected. (*Educators, please stress to the students that scientists do not have confirmed documentation of fossils in Mars meteorites, but they are still looking and testing.)

5. What question(s) do you have now?

   Individual answer will vary, but commonly asked questions are:
   (1) How do you know the meteorites are from Mars?
   (2) How did a piece of Mars get to Earth?
   (3) How could you tell if "it" (meaning the possible extraterrestrial microbe) was alive?

   Look at *Resources* on the *Finger Prints of Life?* CD or from the NASA-JSC-ARES website
   <u>http://ares.jsc.nasa.gov/Education/Websites/AstrobiologyEducation/index.html</u>