Activity

Subject Area(s)
Biology

Associated Unit

None

Associated Lesson

None

Activity Title
Breaking News: Molecular Trucks Riding Inside Cells!

Header

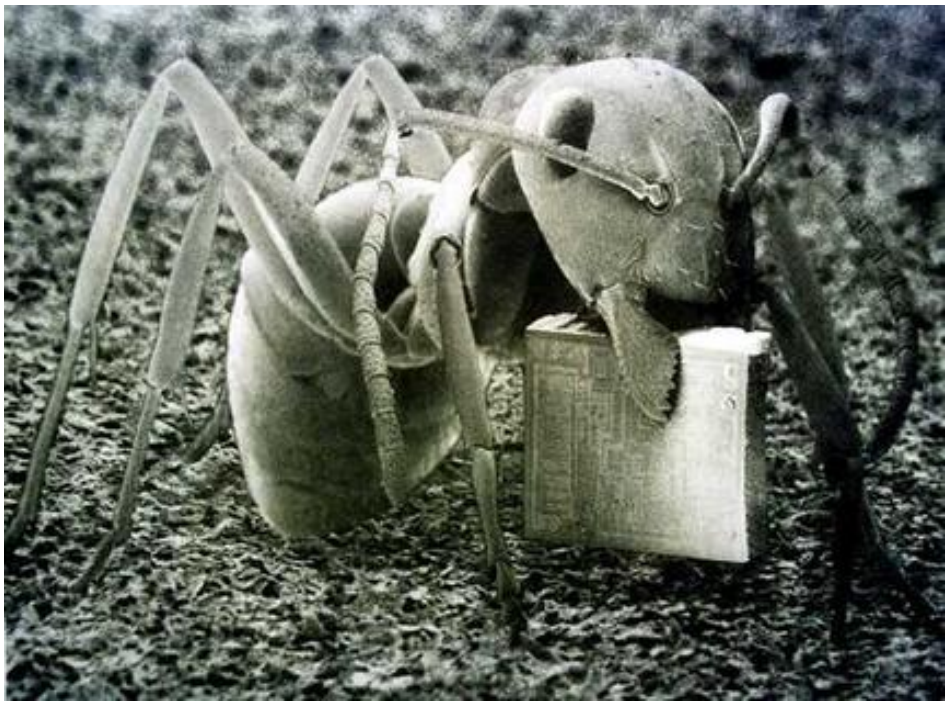

Image 1
ADA Description: An ant carries a 1 millimeter square micro chip.
Caption: Technology at the micro scale
Image file: ant_wideweb.jpg

(http://www.theage.com.au/articles/2004/12/08/1102182359368.html)

Grade Level 9 (9-12)

Activity Dependency

None

Time Required

30 minutes

Group Size

N/A

Expendable Cost per Group US$ 0

Summary

Nanotechnology has recently become a hot topic in science and technology as knowledge and technical advancements have allowed people to operate at smaller and smaller scales. This activity is designed to introduce students enrolled in biology courses to nanotechnology by the use of a typical lab microscope and with the aid of an on-line virtual scanning electron microscope. This activity also presents exciting results from cellular and molecular biology studies that employed latest nanotechnology advancements.

Engineering Connection

Molecular and cellular biologists and biomedical engineers have been one the first in the scientific field to make use of nanotechnology in their work. Analyzing and deciphering the inner works of Mother Nature at the small scales of cells and macromolecules. The technological advancements in the nanotechnology field have provided powerful tools to study and manipulate objects at almost atomic scales and design new devices with unlimited application potential.

Engineering Category = #3

Choose the category that best describes this activity's amount/depth of engineering content:

1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords

Nanotechnology, microscale, nanoscale, molecules, DNA, proteins.

Educational Standards

Biology: Texas Essential Knowledge and Skills (112.34. Biology, Beginning with School Year 2010--2011)

(c) (3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:

(D) evaluate the impact of scientific research on society and the environment;

(E) evaluate models according to their limitations in representing biological objects or events;

(c) (10) Science concepts. The student knows that biological systems are composed of multiple levels. The student is expected to:

(B) describe the interactions that occur among systems that perform the functions of transport, reproduction, and response in plants;

Pre-Requisite Knowledge
None.

Learning Objectives

After this activity, students should be able to:

- Know what nano means and describe or enumerate objects typical of the nanoscale.
- Give examples of biological events that take place at the nanoscale.
- Explain the properties (the magnification range, resolution) of the different visualization devices.
- Explain the function of motor proteins.
- Explain the function of kinesin and microtubules.

Materials List

Each group needs:

- A lab microscope;
- Computer connected to the Internet.

To share with the entire class:

- Digital projector and computer with Internet access.

Introduction / Motivation

The term nanotechnology is encountered frequently today, but what does it mean? Let's look at the roots of the word. Does "nano" sound close to a familiar word for a number? The teacher should try and direct students toward the answer, nine. So if nano stands for nine then what is the link with technology? Explain that the nano, or nine, is referring to the dimension or the characteristic length scales of the objects or phenomena that the nanotechnology is studying. The number nine represents the negative power of ten, i.e., 10^{-9}, and the unit for the length scale is the meter so nanotechnology deals with phenomena at length scales of 10^{-9} meters. Ask students to give examples that fit into this very small length scale such as molecules, proteins, cell organelles, and cells. Try to steer the students to relate nanotechnology and biology.

Now, compare the nanoscale objects with other objects of larger dimensions. How everyday objects compare to the nanoscale? For example, the thickness of sheet of paper is about 10^{-4} meters, that is, 0.1 millimeters, or 100,000 nanometers. A human hair is, on average, 10,000 nanometers, about the size of the red blood cells. Thes objects can be seen with the naked eye or with the help of the conventional microscope. But what about the organelles inside the cells? And other smaller structures such as proteins or the DNA? For these structures approaching the nanoscale size, the conventional, optical microscope is unable to resolve the tiny length scales because of another phenomenon: the wavelength of light is much larger (between 400 and 750 nanometers) than the size of the objects at this very small scale. To overcome this obstacle, scientist have come with a few solutions: the so called electron emitting microscope, which emits electrons to the sample, and the scanning probe microscope

which consists of a fine probe tip that scans the sample (much like a blind person reading Braille with their fingers).

Biologists are interested in the way cells and their smaller parts such as organelles, proteins, and enzymes work. Recent results, making use of the latest microscopy technology, have been able to visualize the way small organelles such as the bacterial flagellar motor, or the kinesin and dynein proteins are performing their biological tasks as shown in Figure 1. The kinesin consists of two heads (Figure 1D) that move alternatively along the microtubule (which is part of the cytoskeleton of the cell together with the actin and intermediate filaments). These proteins (kinesin, dynein) are performing transportation tasks inside the cells while the microtubules are part of the cells' skeleton and provide structural integrity for cells. The bacterial flagellar motor (Figure 1B, artist's rendition) can be visualized by electron microscopy (Figure 1B, inset)

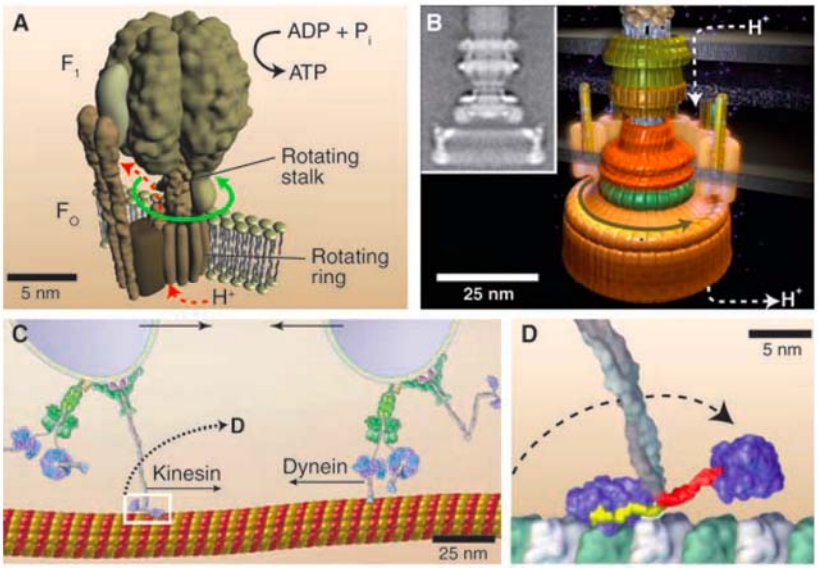

Figure 1

ADA Description: Four images showing protein motors inside cells (A, C, D) and a bacterial flagella motor (B)

Caption: Figure 1: Biological systems at the nanoscale

Image file: proteinpumps.jpg

Source/Rights: Copyright © 2007 American Association for the Advancement of Science

Vocabulary / Definitions

Word	Definition
Kinesin	Processive motor protein consisting of two heads that walk in alternate steps of 8 nm.
Microtubule	Polymers chains of 25 nm diameter that are part of the cellular cytoskeleton.
Nanometer	One billionth of a meter (10^{-9} meters).

Resolution	Capability of making distinguishable the individual parts of an object.

Procedure

Background

For this activity the students will use a conventional optical microscope to visualize different objects and then they will use a computer to access the Internet web tool developed by the Florida State University which shows different biological systems imaged with electron microscopy.

With the Students

1. Ask students to use the objective (or lens) of the microscope with the least amount of magnification. Have the students visualize a sample prepared for microscope visualization, preferable ragweed pollen for comparison with the later steps of this procedure (bacteria or a small sample of biological tissue (plant or animal) can also be used). Ask the students to take noted and describe in words what they see.
2. Next, ask the students to use the next largest magnification objective and take notes. They should see the tissue and maybe some cells in greater detail.
3. If the microscope has a third objective (with the highest magnification), ask the students to use it and describe again what they are seeing.
4. Now ask the students to go on the Internet and in the address bar to type this address: http://micro.magnet.fsu.edu/primer/java/electronmicroscopy/magnify1/index.html
5. The students should now have on their computer screens the interactive Java tool called Virtual Scanning Electron Microscopy of the Florida State University.
6. Ask the students to select the ragweed pollen from the dropdown menu just beneath the main picture and tell students to play with the adjustments control that vary the magnification, the image contrast, brightness, and focus.
7. Notice the rich detail of the ragweed pollen that can be visualized with electron microscopy.
8. Encourage students to look at other specimens that are available from the dropdown menu under the main image.

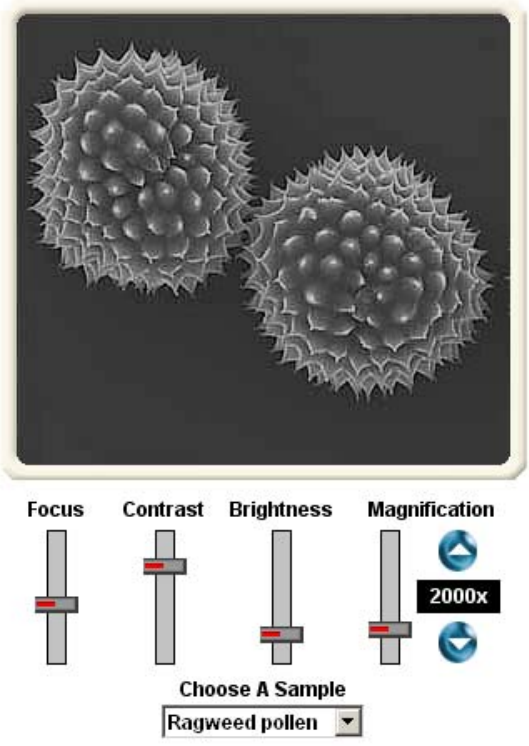

Figure 2

ADA Description: Image showing the ragweed pollen particles as visualized by electron microscopy

Caption: Figure 2: Ragweed pollen visualized using the Virtual Scanning Electron Microscopy of the Florida State University.

Image file: ragweed.jpg

Attachments

None

Safety Issues

- None

Troubleshooting Tips

None

Investigating Questions

None

Assessment

Post-Activity Assessment

Descriptive Title: Nanoscale Assessment

Activity Extensions

None

Activity Scaling

- For lower grades,
- For upper grades,

Additional Multimedia Support

http://micro.magnet.fsu.edu/primer/index.html

References

van den Heuvel, M. G. L. and Dekker, C. "Motor Proteins at Work for Nanotechnology" Science. July 20, 2007: 317.

http://micro.magnet.fsu.edu/primer/virtual/virtual.html

Other

Redirect URL

Contributors

Mircea Ionescu, Myla van Duyn

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Supporting Program

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Name:_____ Date:_____ Period:_____

Nanoscale Assessment

1. What is the typical length scale that nanotechnology is concerned with?

2. Enumerate a few biological systems whose size are typical of nanoscale?

3. Can conventional optical microscopy be used to visualize proteins and enzymes?

4. What new visualization technology is required to image an object about 100 nanometers in length?