Subject Area(s)
Biology

Associated Unit
None

Associated Lesson
None

Activity Title
Nanoscale

Header

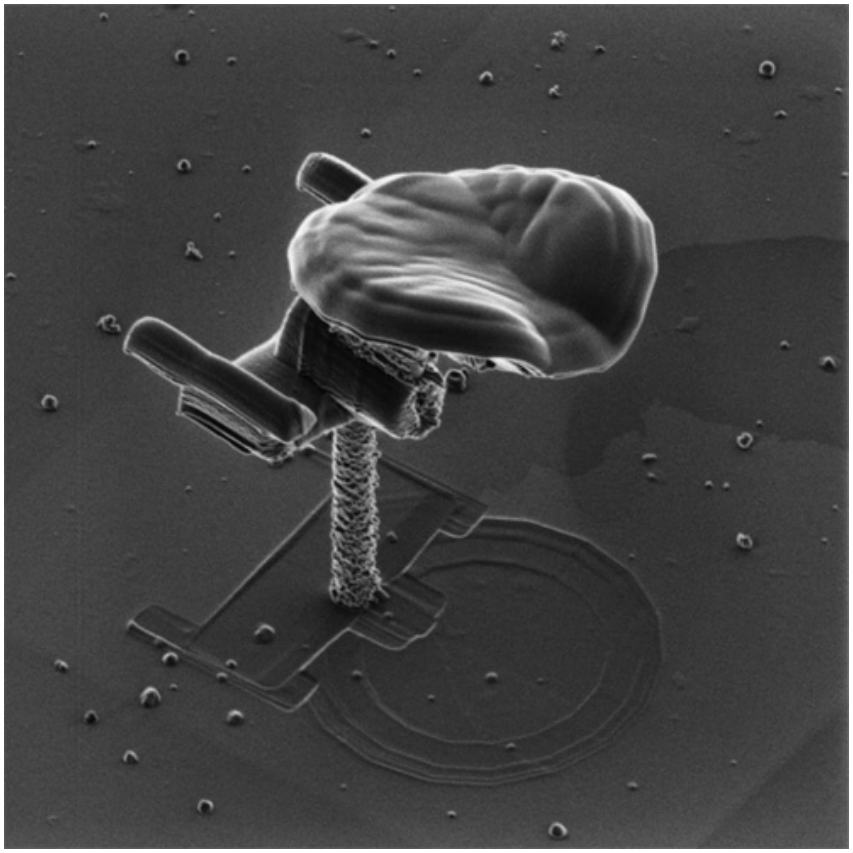

Image 1

ADA Description: Electron microscope image of a microstructure built in the shape of the starship Enterprise from the Star Trek TV series

Caption: Enterprise Nanoscale Starship

Image file: nanoscale-model-enterprise.jpg

Source/Rights: Copyright © Himeji Institute of Technology (http://www.zyvexlabs.com/EIPBNuG/2003MicroGraph.html)

Grade Level
9 (9-12)

Activity Dependency

None

Time Required

45 minutes

Group Size

N/A

Expendable Cost per Group US$ 0

Summary

Nanotechnology advancements have allowed people to design and manufacture devices that operate at smaller and smaller scales. The potential benefits of manipulating objects at scales close to the size of an atom are enormous. The wide range of nanotechnology applications include energy, optics, microelectronics, medical, engineering, etc. Of particular importance are the applications in the biology and medical fields where research at cellular and molecular level has resulted in great advancements. This activity is designed to introduce students enrolled in regular biology courses to the field of nanotechnology by analyzing bacteria growth with the use of a typical lab microscope at different magnifications and then by watching a short video clip explaining the basics of nanotechnology.

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 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. DNA sequencing, the development of gene therapy and new drugs, all depend on recent advancements in nanotechnology.

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, bacteria.

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.
- Know how to use the microscope.

Materials List

Each group needs:

- A lab microscope;
- Microscope slides of plant or animal cells and bacteria.
- Paper, pencils.
- Computers connected to the Internet for the electron microscope demonstration.

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. These 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 micro- and nano-scale 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).

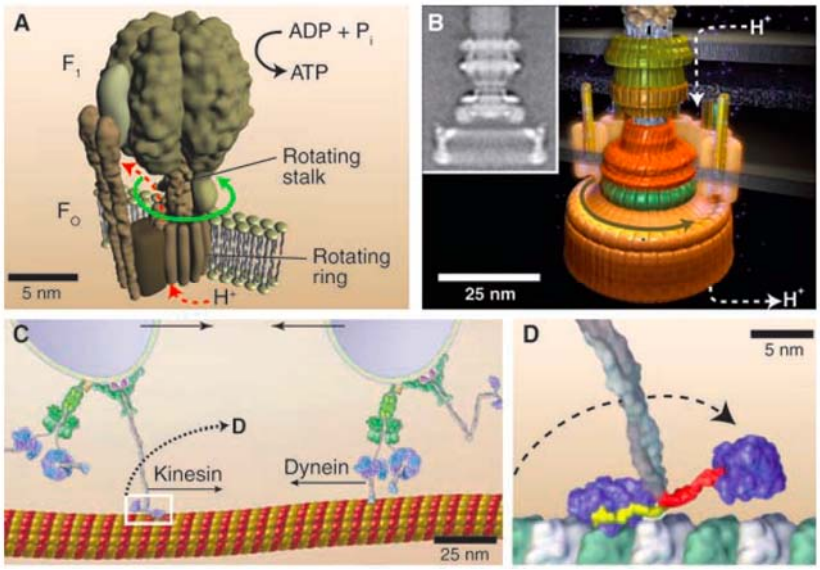

Figure 1

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

Vocabulary / Definitions

Word	Definition
Nanometer	One billionth of a meter (10^{-9} meters).
Resolution	Capability of making distinguishable the individual parts of an object.

Procedure

Background

The different microscope magnifications can give students some idea about the different scales encountered in nature. Details of cells and organelles vary as the objective magnification changes. By observing the changes in the details seen through the microscope, students should realize that may biological phenomena take place at very small scales and that nanotechnology provided many breakthroughs in molecular biology, especially genetics, and medicine. The short video presentation introduces students to the basics of nanotechnology and the small scales. For this activity the students will use a conventional optical microscope to visualize cells and bacteria at different microscope magnifications.

With the Students

Lab microscope activity:

1. Ask students to use the objective (or lens) of the microscope with the least amount of magnification (4X). Have the students visualize a cell (either plant or animal) sample prepared for microscope. Have the students draw on a piece o paper the image they are seeing through the microscope. Also students should try identifying parts of the cells.
2. Next, ask students to use the objective with a higher magnification (10X) and draw again the image seen through the microscope.
3. The last step involves students looking at the cells through the highest magnifying objective (usually 40X). Have them draw the image from the microscope while identifying large cell parts (membrane, nucleus).
4. Have students analyze a bacteria culture under the microscope at the highest magnification. Again, students should draw what they see through the lens.
5. The last part of the activity consists of viewing a short video clip (26 minutes) about nanotechnology: http://www.youtube.com/watch?v=p6peZ7gh0Lo&feature=related
6. Have the students take short notes about facts and things they think are interesting while watching the video.
7. The scientist from the video is using powerful electron microscopes to look at the small scale structures. Discuss with students the difference in the magnification of the electron microscope and that of the conventional microscope.

Attachments
worksheet_nano.pdf

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://cordis.europa.eu/nanotechnology/src/pe_leaflets_brochures.htm
http://www.youtube.com/watch?v=p6peZ7gh0Lo&feature=related

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

Other

Redirect URL

Contributors
Mircea Ionescu, Myla Van Duyn

Supporting Program
University of Houston GK12 Program under the National Science Foundation Grant (DGE--0840889).