Microscopy Imaging at the Macro and Nano Scale

Ms. Janet Hudson, RET Fellow
Dr. Anna Shaw Middle School: A NASA Explorer School
Drexel Faculty Mentors: Dr. Bradley Layton, Dr. Calin Belta
Cellular Mechanics and MicroRobotics Laboratory

Objectives

- Compare Microscopic Imaging at the Macroscale and Nanoscale
- Introduce students to microscopes used in Nanotechnology
- Connect Nanotechnology with different fields of science

Background

Microscopes can be used to view objects at the Macro and Nano scale. Students in grades K-12 are exposed to microscopes that magnify objects at the macro scale using visible light to create a magnified image. During my RET experience at Drexel this summer, I had the opportunity to learn about and use microscopes that image materials and substances at the atomic level (nanoscale). In consultation with my mentor, Dr Layton, Joyce (my teacher partner), and I chose the project of building a model of an Atomic Force Microscope. This required researching the characteristics of an AFM, understanding how it images (mechanical function), making a parts list, testing sensors, selecting a computer program to process information, assembling the microscope and testing it. In addition, I learned how Transmission Electro and Scanning Electron Microscopes are used. I operated both the Atomic Force Microscope and Scanning Electron Microscope. It was an amazing experience to view samples at the molecular level using state of the art Nanotechnology equipment.

Transmission Electron Microscope

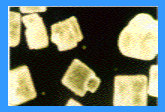
Nanoscale

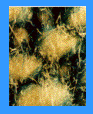
- Uses electrons to “illuminate” an object
- Sample must be cut very thin
- Electron beam is directed onto the object to be magnified
- Looks at a large area of sample at once
- Wavelength of electrons used is usually half an angstrom (50 trillionths of a meter
- Has an electron gun that emits electrons
- Magnetic fields are used to create “lenses”
- Interior is sealed at a very high vacuum
- Has a system that record and display images produced by electrons

Monocular Microscope

Macroscale

- Uses visible light to create a magnified image of an object
- Double convex lens
- Short focal length
- Can magnify objects up to 15 times





Binocular Microscope

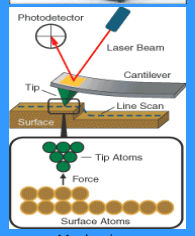
Macroscale

- Uses visible light
- Two lenses: Objective lens and Ocular Lens
- Mounted at opposite ends of closed tube
- Greater magnification compared to single lens
- Magnifies objects 40x-1000x

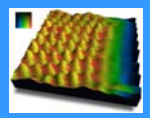
Microscopes using visible Light can only resolve Structures that are larger than the height of waves reflecting off them.

Atomic Force Microscope

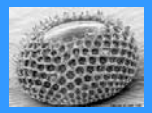
Nanoscale



Mechanics
How the AFM works



Topography of Image



Butterfly Egg

Ant

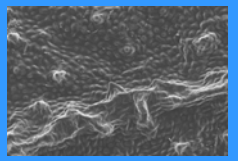
- Does not use lenses
- Sample does not need to conduct electricity
- Uses a probe to scan the surface of a sample
- Provides three dimensional image of atoms or molecules on surface of object
- Works by measuring a local property : height, optical absorption, or magnetism with a probe tip
- Small probe allows measurement to be taken over a small area
- Electrons on probe are repelled by electrons in the atom of sample
- Height of probe is adjusted to keep force on it constant
- Sensing mechanism records the up and down movements of the probe and feeds data in computer
- Computer program processes data and creates a three-dimensional image of the surface of sample

Ms. Hudson using an AFM to view collagen

Scanning Electron Microscope

Nanoscale

- Uses electrons to “illuminate” an object
- Sample do not need to be thinly sliced
- Samples need to be dehydrated
- Can Magnify Objects 100,000 times or more
- Can produce 3D images of the surface of object



Ms. Hudson using the Scanning Electron Microscope to image leaf vein sample to the left

COMPARING MAGNIFICATIONS

Magnification Scales	Monocular	Binocular Microscope	Transmission Electron Scanning Microscope	Scanning Electron Microscope	Atomic Force Microscope
Nanoscale			Can magnify objects 1,000,000 times its size	Can magnify objects 100,000 times Or more its size	Can magnify objects 1,000,000 times its size
Macroscale	Magnifies up to 15 times its size	Can magnify objects 2000 times its size			

In relation, middle and high school students have used monocular and binocular (light microscopes) to view structures and surfaces at the macroscale (large). However, few if any, are aware that those structures and surfaces can be viewed at the nanoscale (atomic) using electron microscopes. Light microscopes can only resolve structures and surfaces that are larger than the length of waves reflecting off them. On the other hand, electron microscopes can obtain a higher power magnification. Today, many applications in life science, material science, and physical science, and industries use microscopes that are able to image at the nanoscale. It is imperative that students interested in the fields of Science, Technology, Engineering, Mathematics, and Geography, get exposed to the state of the art Microscopy Imaging Equipment.

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