Schedule for AFM Workshop

Introduction to scale and imaging (10 minutes)

- ask how many girls have used a microscope to look at small things (what things?)
- make chart on board of different scales in meters (ask girls what prefixes they have heard of and for examples of something this size; see “Scale Chart” on p. 2 for examples)
- explain that the smallest things you can see with an optical microscope are limited by the wavelength of light to about 0.2 microns (200 nanometers)
- ask if girls have idea of how to tell what something is without looking at it

AFM kit activity (30 minutes)

- help girls through real activity by describing/demonstrating (no manuals)
- allow parents/buddies to do activity with each other (not with girls)

Follow-up discussion: compare kit to real AFM with handout p. 3-6 (10 minutes)

- how AFMs work
- resolution (horizontal and vertical)
- real AFM images (biological images, carbon nanotubes)

Real AFM demonstration (10 minutes)

- go to Clark C3, where Vera/Markus will have AFM ready to image a nanotube

Scale Chart

(to be used as a guide while making a chart on a blackboard, not to be handed out)

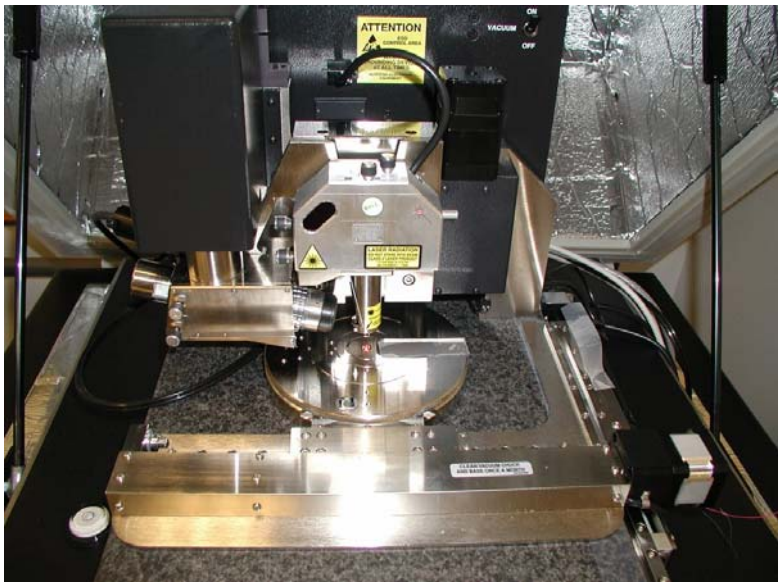
Power	Size	Name	Prefix	Symbol	Meters example
10^{18}	1,000,000,000,000,000,000	one quintillion	exa	E	Light takes 100 years to travel this distance, to the star Arcturus
10^{15}	1,000,000,000,000,000	one quadrillion	peta	P	Distance to the "cloud" of comets 10 times as far away as the outermost planet, Pluto
10^{12}	1,000,000,000,000	one trillion	tera	T	Distance to planet Jupiter
10^{9}	1,000,000,000	one billion	giga	G	The diameter of the Moon's orbit
10^{6}	1,000,000	one million	mega	M	Half-way across the USA
10^{3}	1,000	one thousand	kilo	k	A kilometre: a 15 minute walk
10^{2}	100	one hundred	hecto	h	The height of a giant sequoia tree and the Statue of Liberty
10^{1}	10	ten	deca		The height of a house
10^{0}	1	one			The length of an adult arm
10^{-1}	0.1	one tenth	deci	d	The length of your hand
10^{-2}	0.01	one hundredth	centi	c	The width of a finger
10^{-3}	0.001	one thousandth	milli	m	The width of a pin
10^{-6}	0.000 001	one millionth	micro	u	The size of a living cell
10^{-9}	0.000 000 001	one billionth	nano	n	The size of a water molecule
10^{-12}	0.000 000 000 001	one trillionth	pico	p	Only atoms are at this scale
10^{-15}	0.000 000 000 000 001	one quadrillionth	femto	f	The size of a proton
10^{-18}	0.000 000 000 000 000 001	one quintillionth	atto	a	? We know of nothing this small!

Atomic Force Microscopy

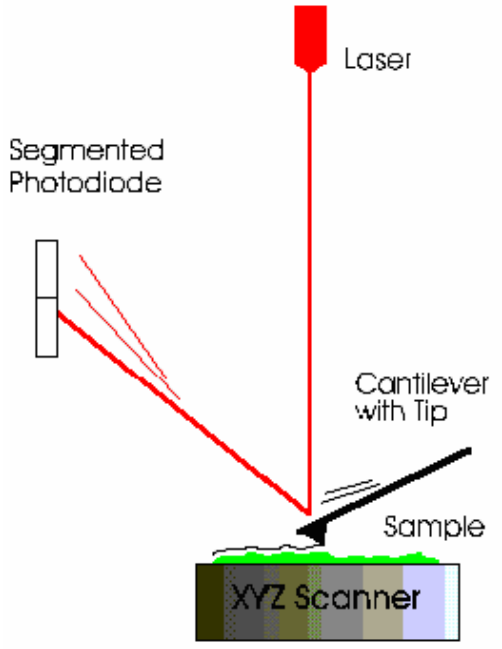
EYH Workshop – April 24, 2004

The technique you have used to image a Lego "molecule" is similar to the way an atomic force microscope (AFM) images a real molecule.

This is what a real AFM looks like. To the right is the AFM at the Cornell Nanoscale Facility:







How does an AFM work?

A **sample** moves under the AFM **tip**, and the movement of the tip is measured by a **laser**.

What happens to the tip when a tall part of the sample passes beneath it?

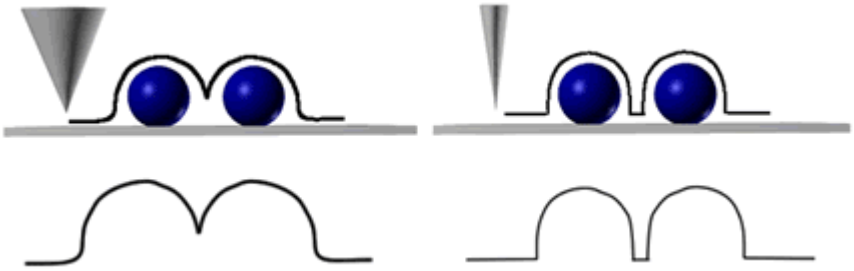
How will this change the reflected laser beam?

(UCSB, http://www.physics.ucsb.edu/%7Ehhansma/afm-acs_news.htm)

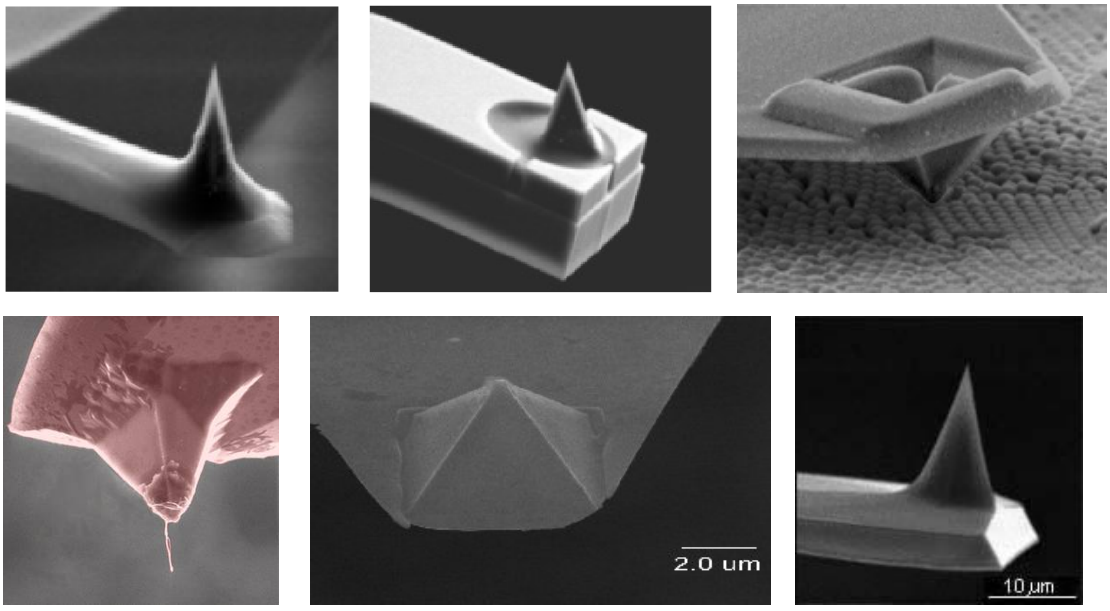
Resolution (What are the smallest features an AFM can measure?)

When you were imaging your Lego molecule, you probably found that you were not able to determine all the fine details of the molecule: this is due to limitations in the resolution of your model AFM. Did your Lego AFM have better resolution horizontally or vertically? (i.e., did you get a better measurement of the width or the height of your molecule?)

Horizontal resolution is determined by the shape of your AFM tip:



(Pacific Nanotechnology, http://www.pacificnanotech.com/9_Article_A_13.html)



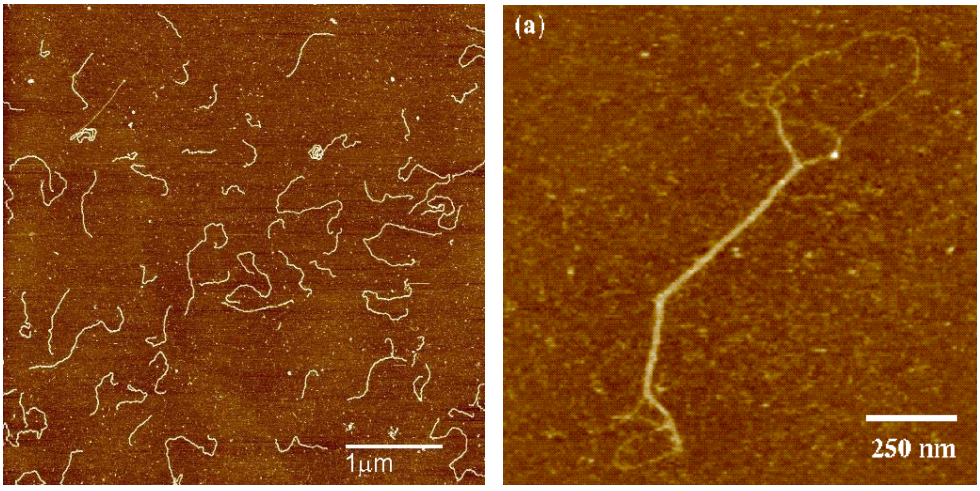
(Weizmann Institute, Micro Star Technologies, NIST, University of Bristol, and University of Toronto)

The *vertical resolution* of an AFM is much better than horizontal resolution and is limited by vibrations of the instrument.

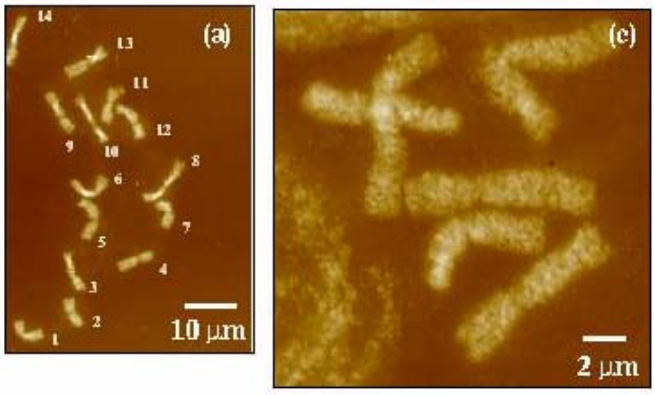
Biological AFM Images

(from the University of Bristol, http://spm.phy.bris.ac.uk/research/AFM/)

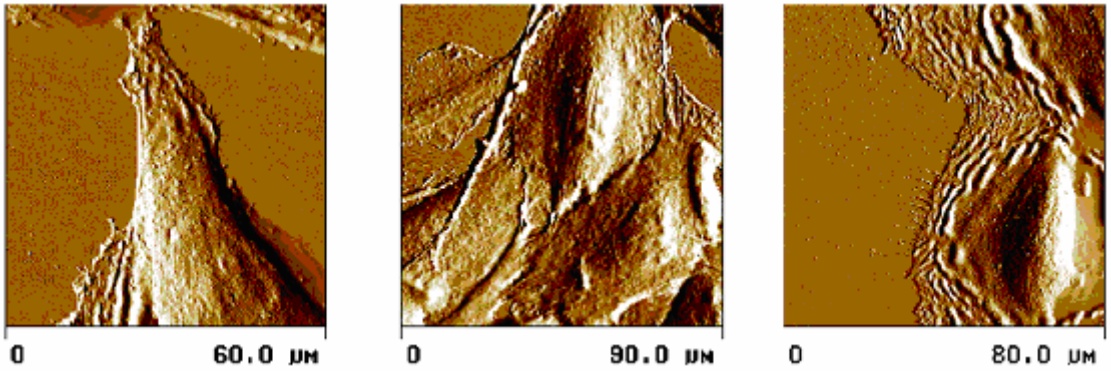
DNA



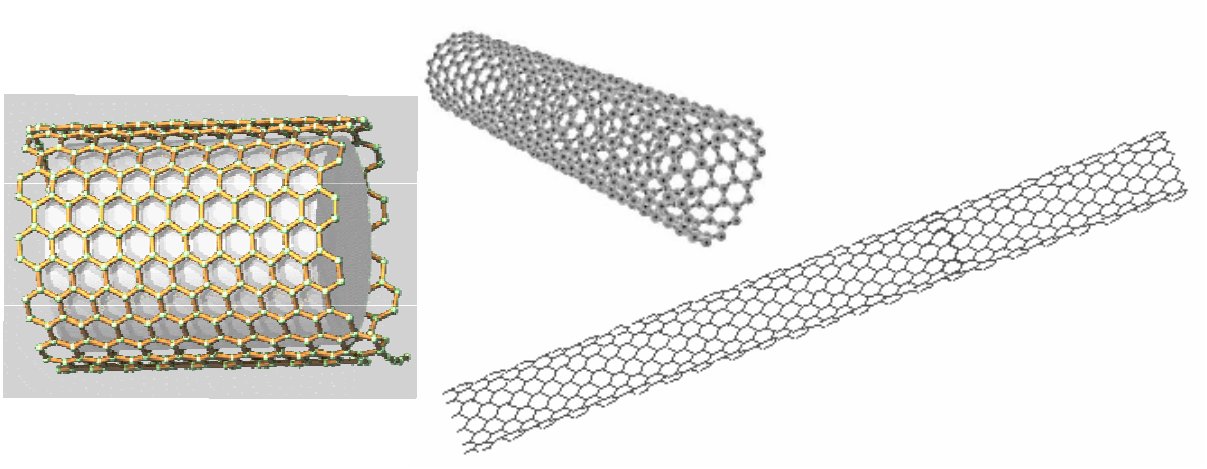
Chromosomes (from wheat)

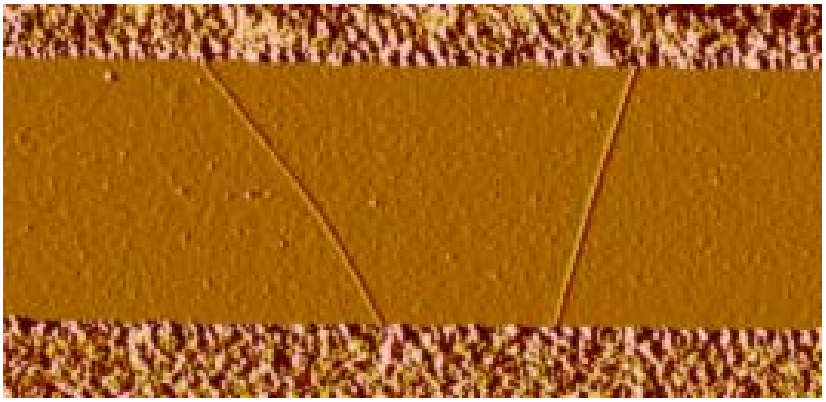


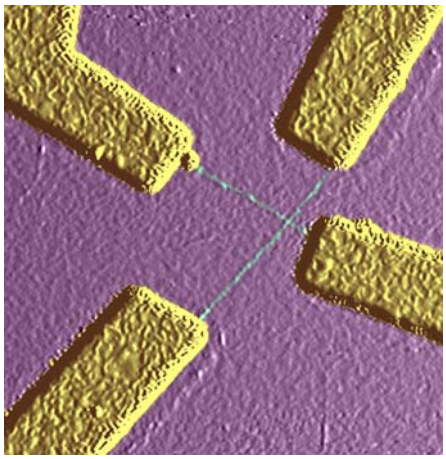
Cells (from rat kidneys)

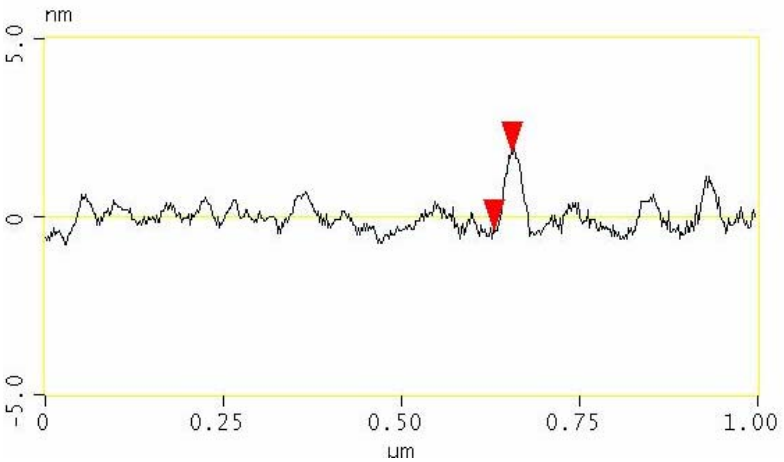


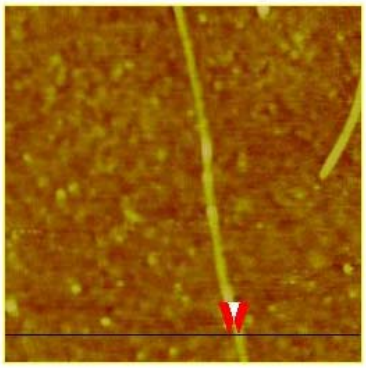
Carbon Nanotubes











Horiz distance(L) 25.391 nm
Vert distance 2.159 nm