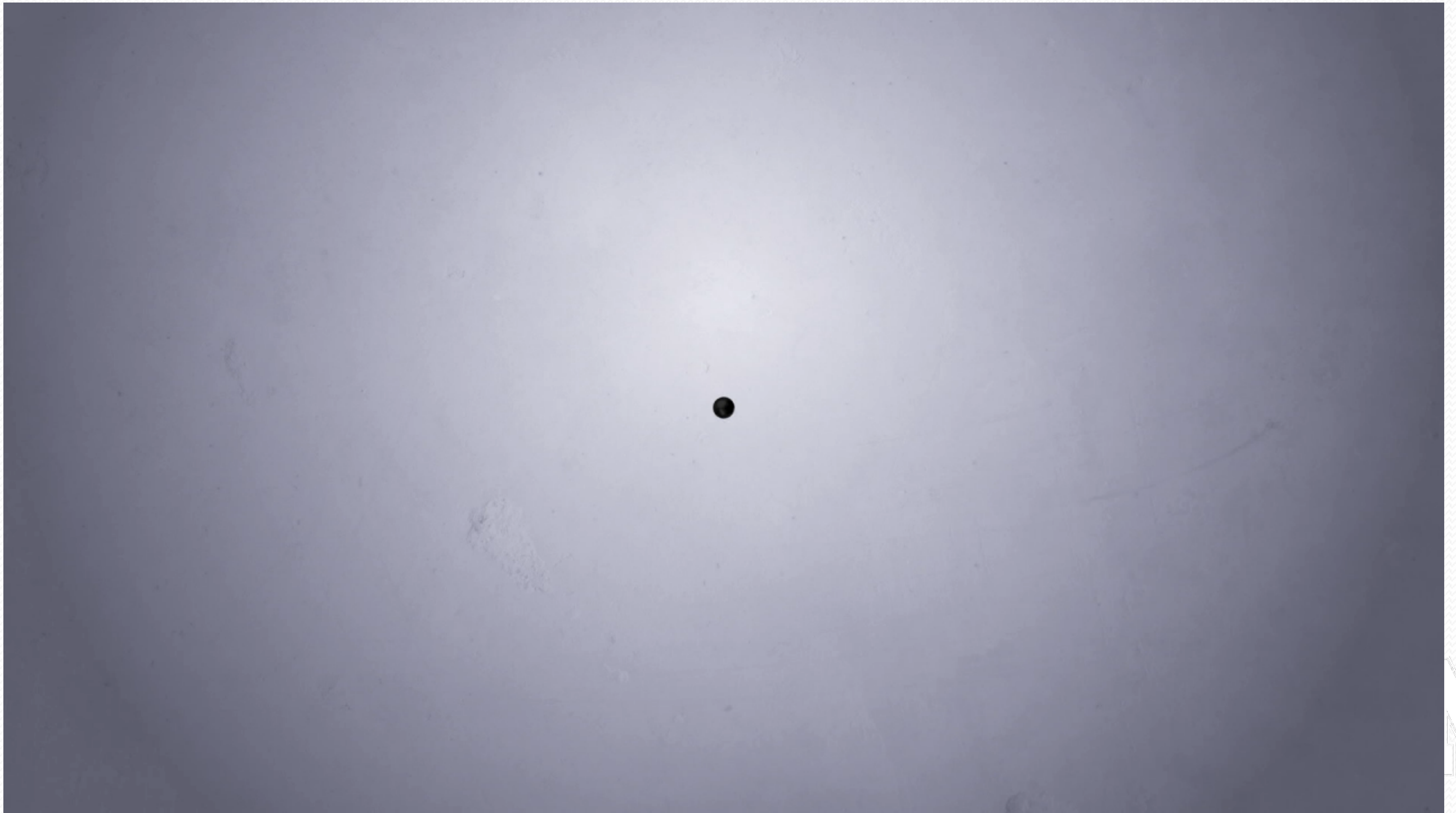
Nanotechnology and Exploring Electricity

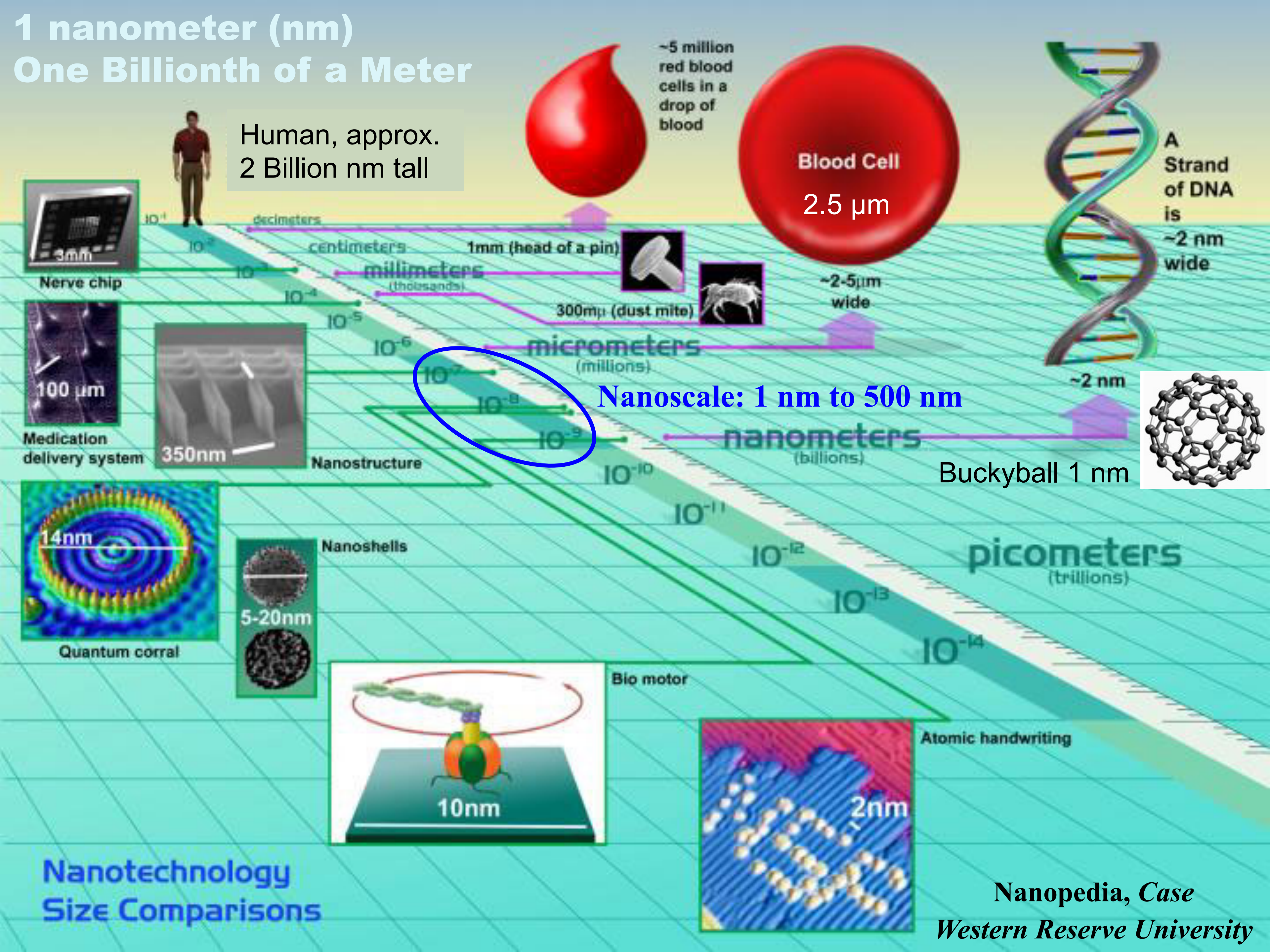
- *Presenters: Terese Janovec and Steve Wignall*
- Nebraska Center for Materials and Nanoscience

Intro to Nanotechnology



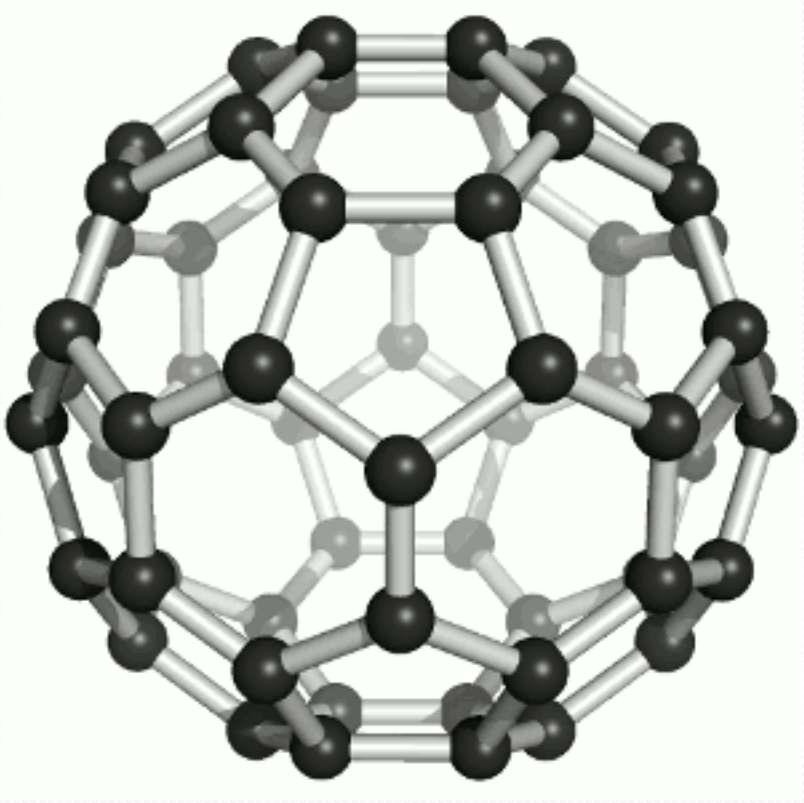
Materials and Nanoscience

The following concepts will be an introduction to Nanotechnology and examined through the activities and Nano-Kits.



1 nanometer (nm)
One Billionth of a Meter
Human, approx.
2 Billion nm tall
~5 million red blood cells in a drop of blood
Blood Cell
2.5 μm
A Strand of DNA is ~2 nm wide
~2 nm
3mm
Nerve chip
decimeters
centimeters
1mm (head of a pin)
millimeters
(thousands)
300mμ (dust mite)
~2-5μm wide
100 μm
Medication delivery system
350nm
Nanostructure
micrometers
(millions)
Nanoscale: 1 nm to 500 nm
nanometers
(billions)
Buckyball 1 nm
14nm
Quantum corral
Nanoshells
5-20nm
picometers
(trillions)
Bio motor
10nm
Atomic handwriting
2nm
Nanotechnology
Size Comparisons
Nanopedia, Case Western Reserve University

How Big is a Nanometer?



Carbon Nanoparticle about 1 nm across

Also Called:

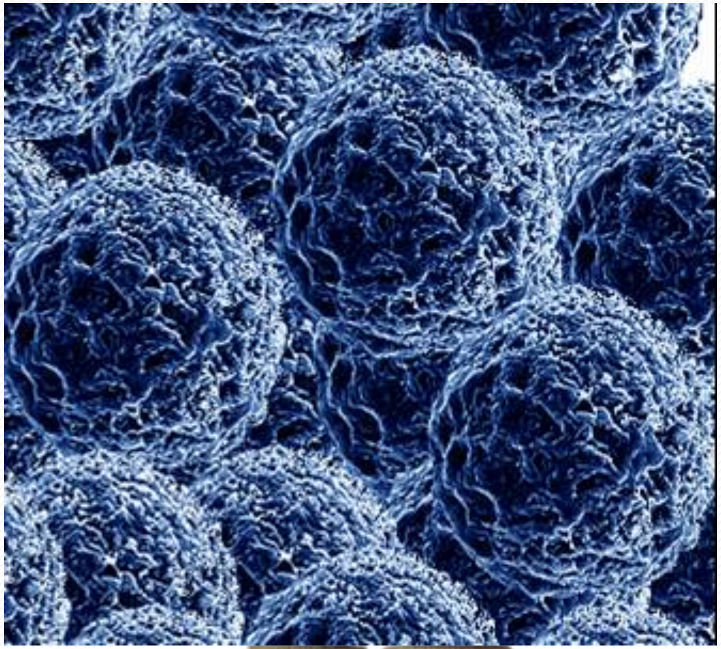
C-60, Fullerene, Buckyball

Intro to Nano

http://www.whatisnano.org

Nano Socks!

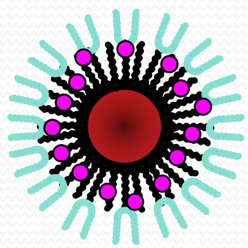
- Silver Nanoparticles 19 nm across have antimicrobial properties.



- They make ArcticShield™ Socks odor and fungus resistant

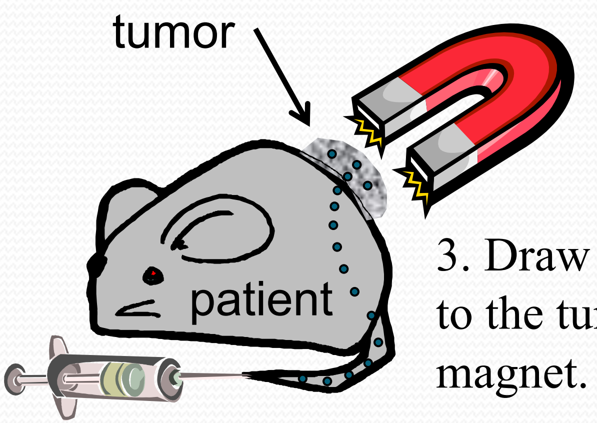
nanobits… Hyperthermal Therapy

1. Coat magnetic nanoparticles with biocompatible molecules.



4. Heat nanoparticles with radio waves.

5. Melt your tumor away.



3. Draw nanoparticles to the tumor with a magnet.

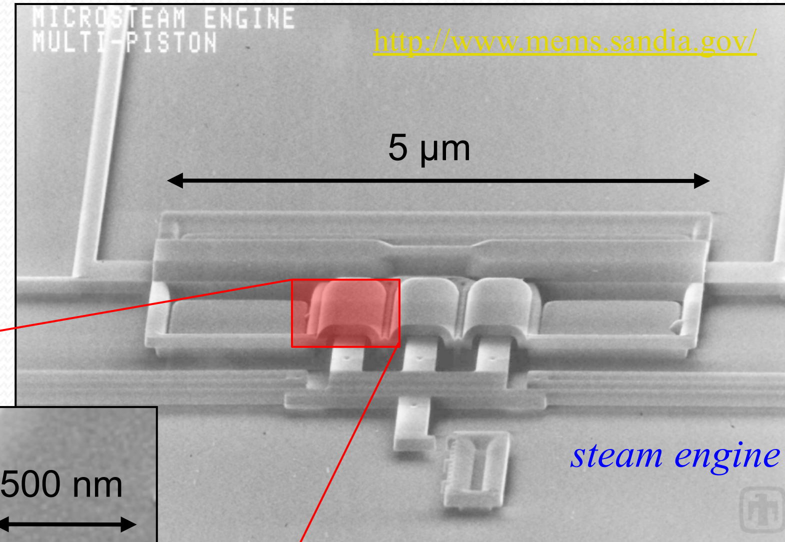
2. Inject nanoparticles into the patient.

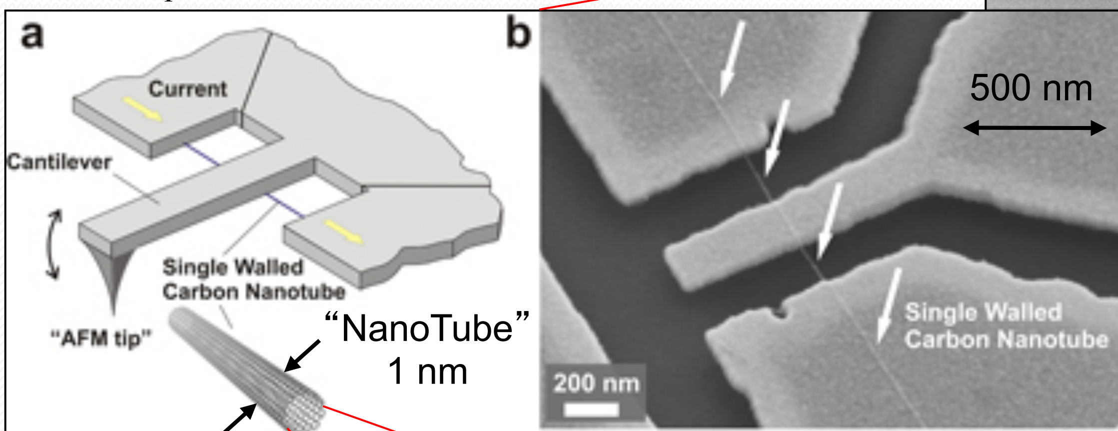
Prof. Diandra Leslie-Pelecky, ***UNL Department of Physics and Astronomy***

NanoTechnology

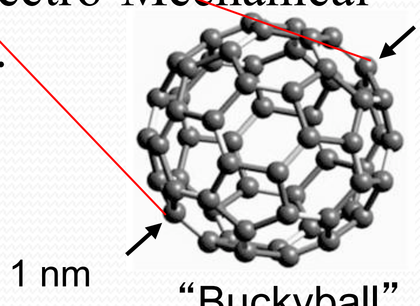
1959: Richard Feynman kicks off the nanotechnology era with his provocative lecture “There’s Room at the Bottom”, a scheme for building machines, which build smaller replicas of themselves, which build

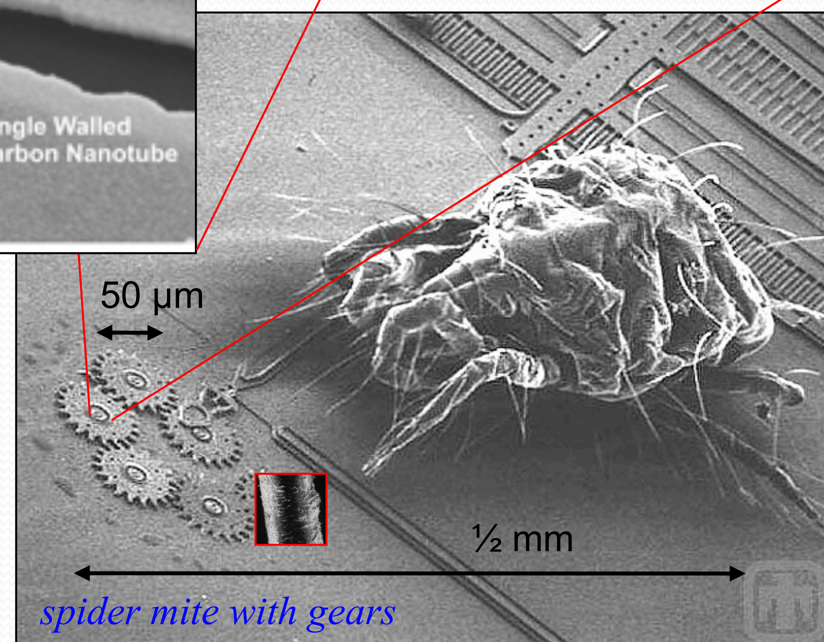
smaller replicas of themselves, which build





2000: Nano-Electro-Mechanical (NEMS) devices.



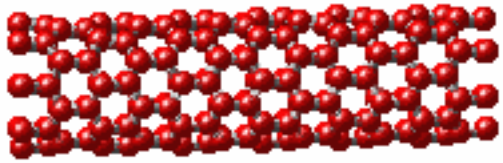


Nanoscience Research at the University of Nebraska

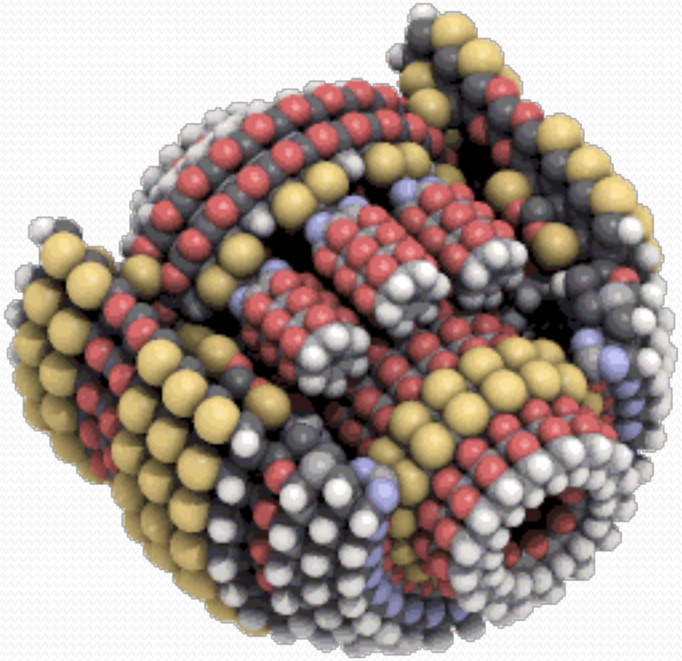
Voelte-Keegan Nanoscience Research Center

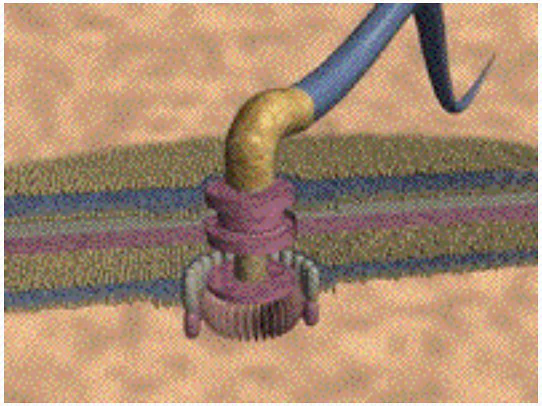
http://research.unl.edu/research_videos/

NanoMotors

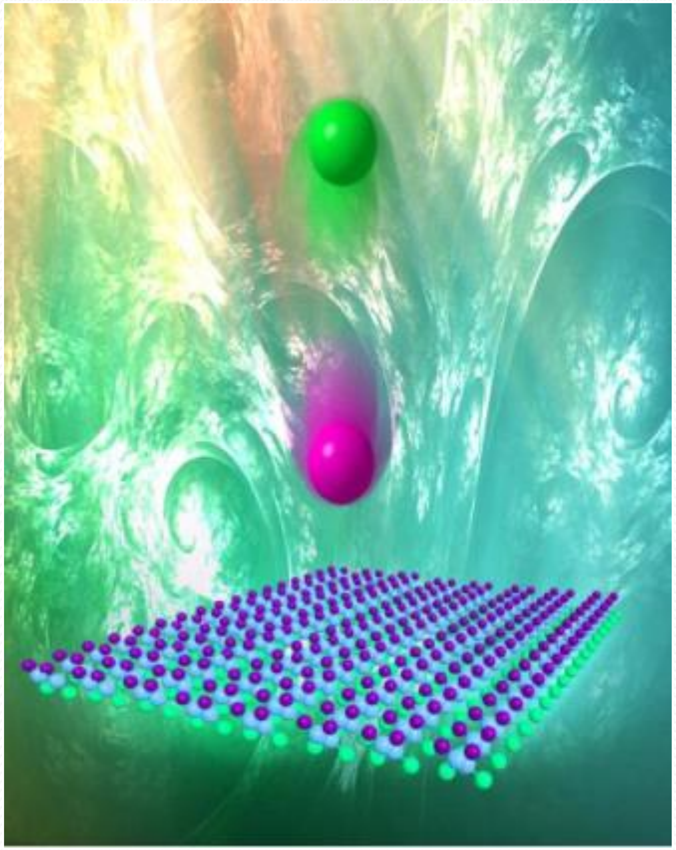


Carbon Nanotube about 1 nm across





Nanoscience Research at the University of Nebraska

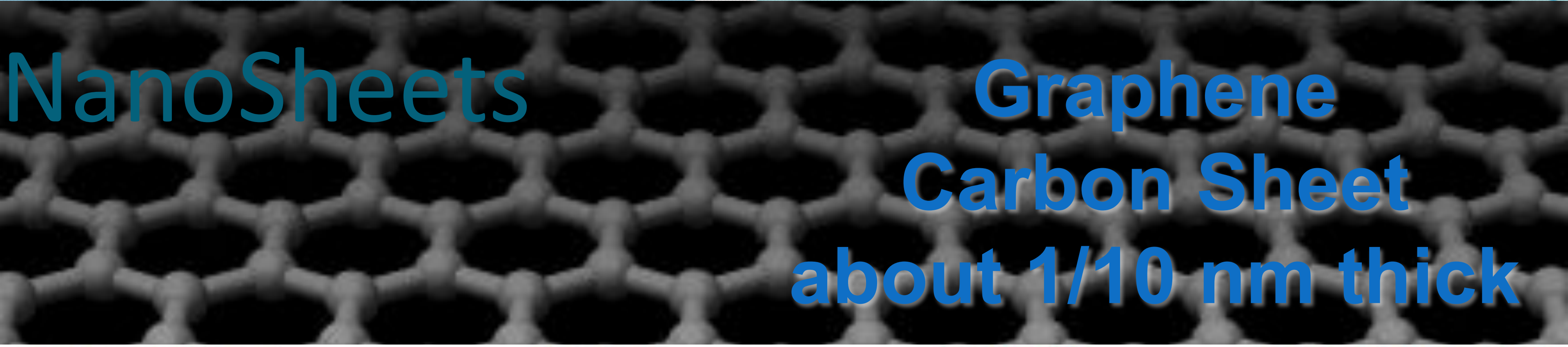


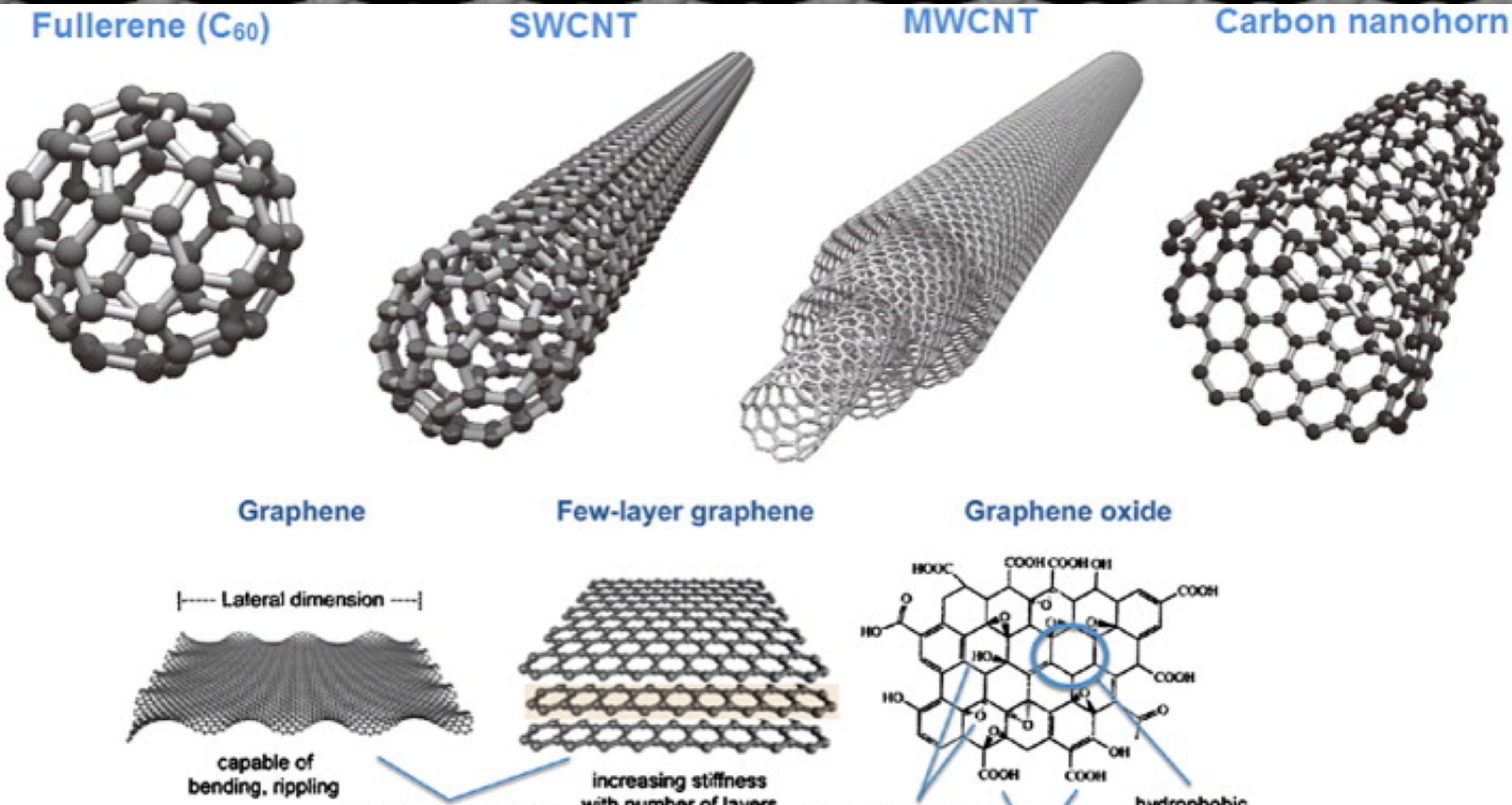
Polymer SolarCells

http://research.unl.edu/research_videos/

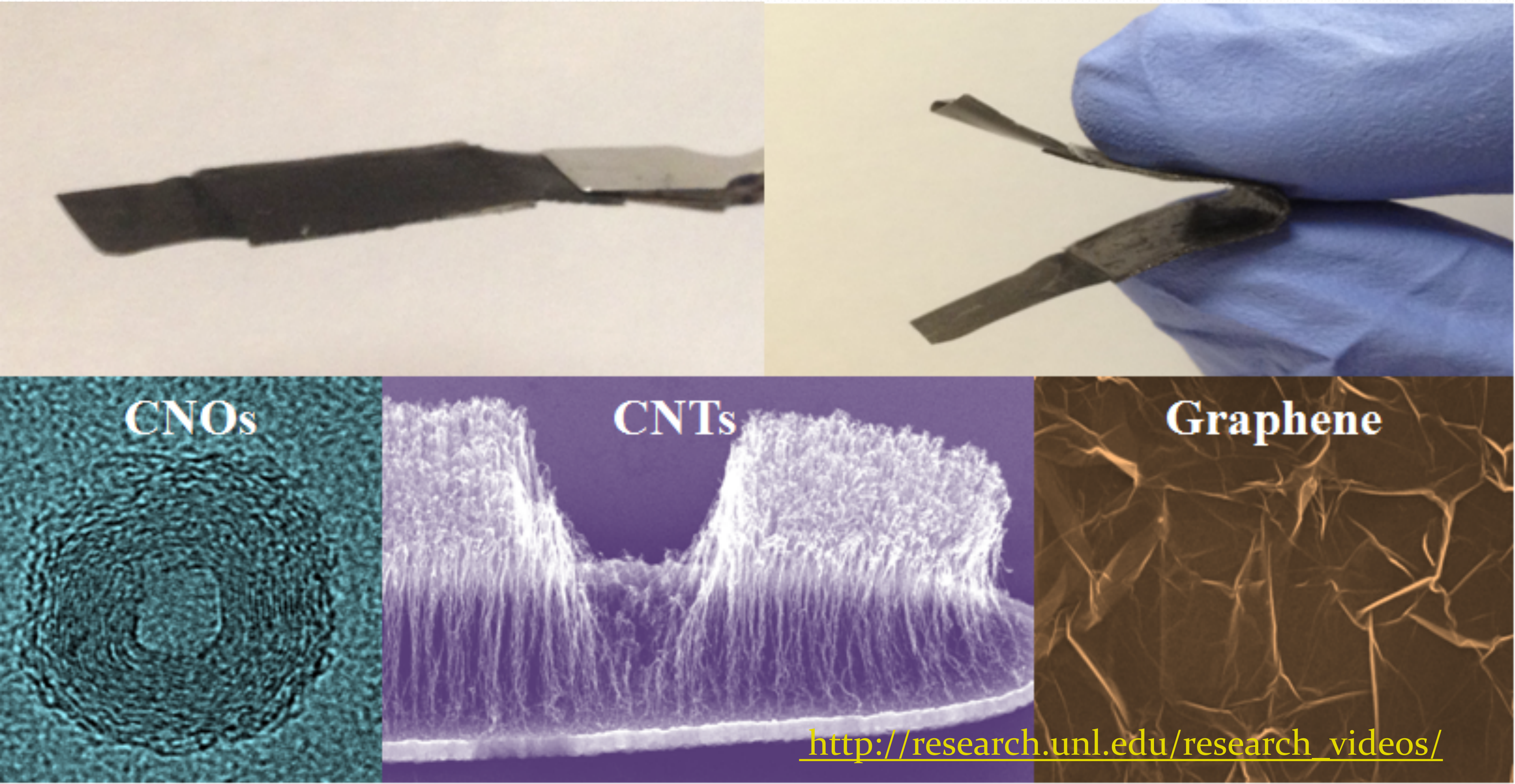
NanoSheets

Graphene
Carbon Sheet
about 1/10 nm thick



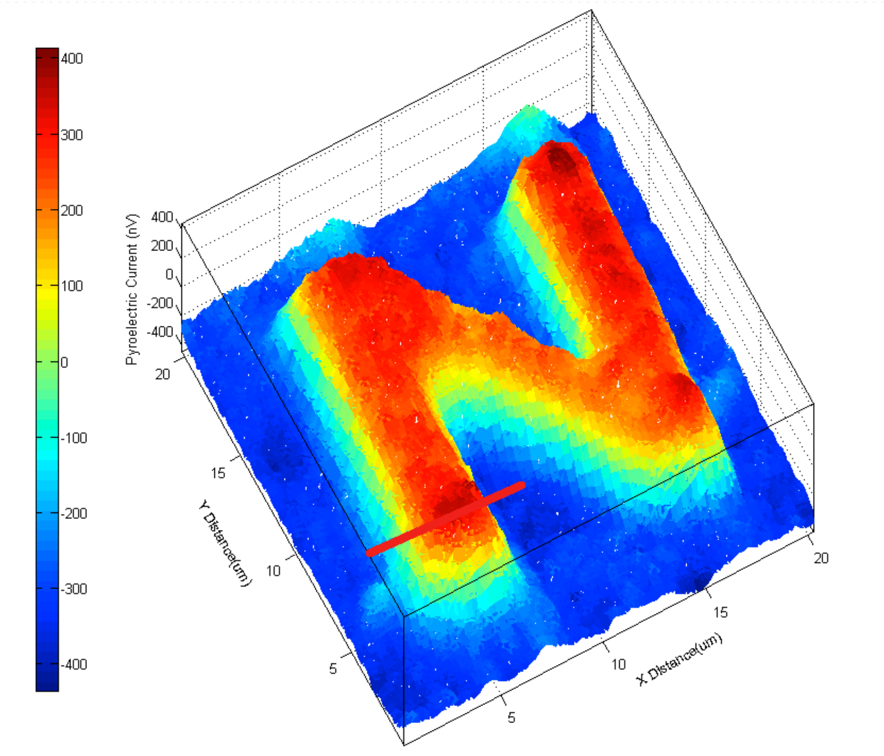


Nanoscience Research at the University of Nebraska



http://research.unl.edu/research_videos/

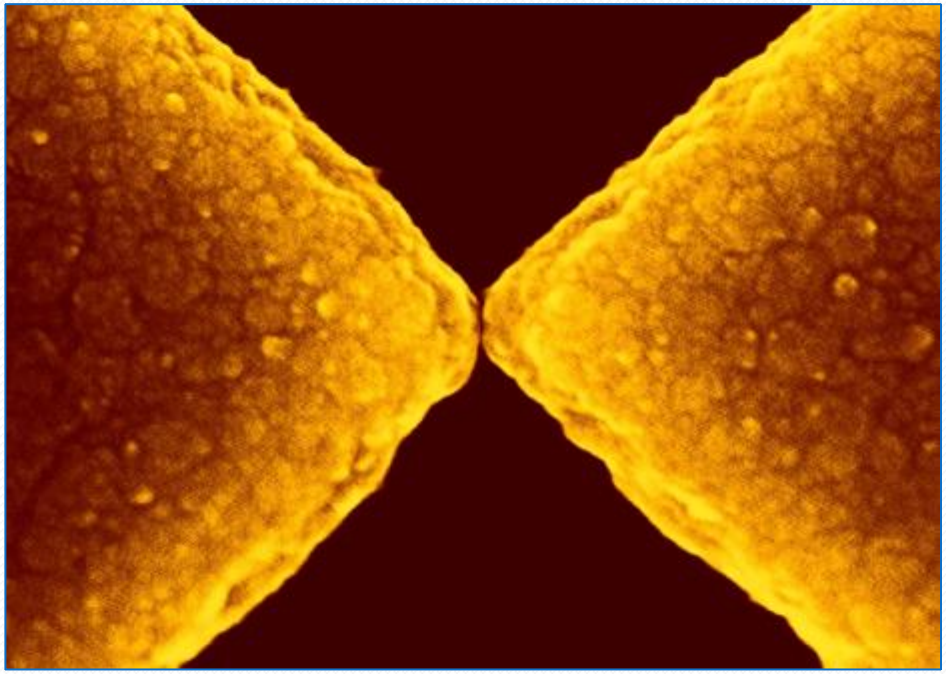
Nanoscience Research at the University of Nebraska



NanoPhysics Microscopes

http://research.unl.edu/research_videos/

Nanoscience Research at the University of Nebraska



Synthetic Bone Replacement

http://www.unl.edu/ncmn/videos.shtml

Rain Project

Remotely Accessible Instruments for Nanotechnology


RAIN Sites across the United States
Nano4me.org
NORTH SEATTLE COLLEGE
One of the Seattle Colleges
Salt Lake Community College
Northcentral TECHNICAL COLLEGE
Oakton Community College
IOWA
ERIE COMMUNITY COLLEGE
STATE UNIVERSITY of NEW YORK
CA BOCES
Stanford University
SUNY POLYTECHNIC INSTITUTE
PASADENA CITY COLLEGE
PennState
Arizona State University
COPPIN STATE UNIVERSITY
THE UNIVERSITY of NEW MEXICO
Georgia Tech
ForsythTech
University of Nebraska Lincoln
UTSA ROADRUNNERS
THE RESEARCH TRIANGLE PARK

X-ray fluorescence (XRF)

Remote Accessibility:

Nebraska Nanoscale Facility - (Rigaku Supermini200 X)

X-ray fluorescence (XRF) is the emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays. The phenomenon is widely used for elemental analysis and chemical analysis, particularly in the investigation of metals, glass, ceramics and building materials, and for research in geochemistry, forensic science, archaeology and art objects such as paintings and murals.

RAIN Outreach

Nebraska Nanoscale Facility and 4H Summer Partnership

Nebraska Nanoscale Facility (NNF), in partnership with the University of Nebraska Extension Office and 4-H program provided remote analysis services through RAIN to youth in Omaha this summer. Fourteen schools and various programs throughout Omaha participated in the Engineering with Nano Power experience. Students were introduced to how specialized nano equipment can be used to analyze environmental materials and new products being developed in our society. Using the XRF a variety of materials were examined and their compositions discussed in the classroom after utilizing the remote technical capabilities of the XRF. Youth were able to connect and relate with a real nanoscientist using the RAIN platform. A variety of questions helped students engage with the remote session such as: *Why is analyzing samples important? What can you do with the info? What does this analysis tell us and how do you become a nanoscientist*?

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Over 190 students, 4th-8th grade, were able to experience the RAIN sessions, about 45% were females and 70% from underrepresented groups. We believe the RAIN sessions with enthusiastic teachers and scientists working together can have a positive impact on STEM identity formation and career orientation for youth!

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"Exploring Electricity"

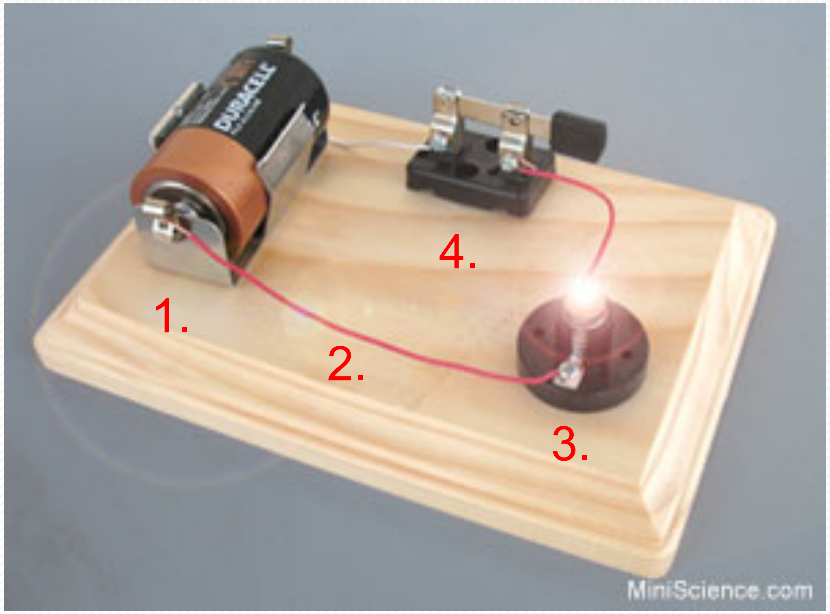
Squishy Circuits, and understanding Circuits

Agenda

- Basic Circuits
- LED's
- Squishy Circuits
- Tapetricity Card
- Speed Nano-Kits
- Conclusion

Basic Circuits

- What do you have to have for an Electrical Circuit?



1. Energy Source
2. Conducting path
3. Load (Resistance)
4. Switch (not needed, but usually present)

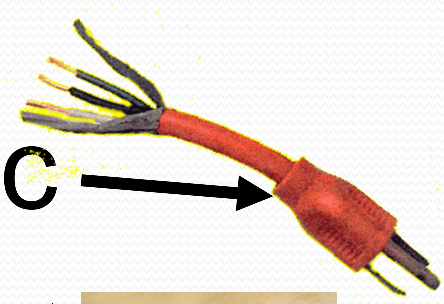
Conductors and Insulators

- Conductors – material through which electric current flows easily.
- Insulators – materials through which electric current does not move easily.

Insulator –

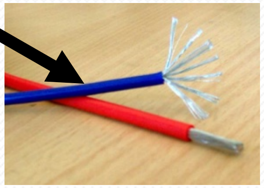
Any material that does not allow electric current to pass through it

- plastic



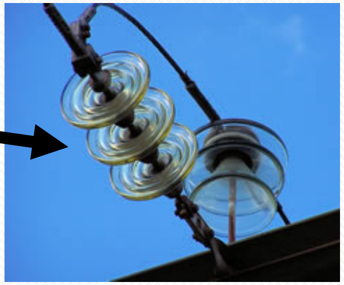
- cloth

- rubber



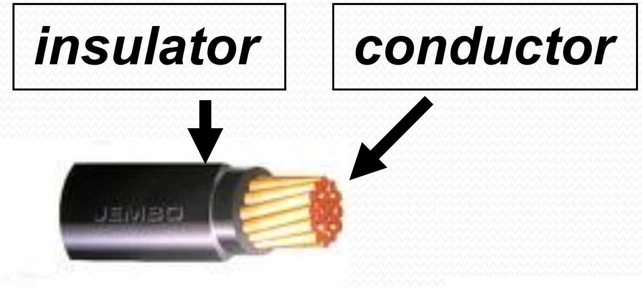
- wood

- glass



Conductor –

Any material that allows electric current to pass through it



- copper

- aluminum

- steel

- any metal

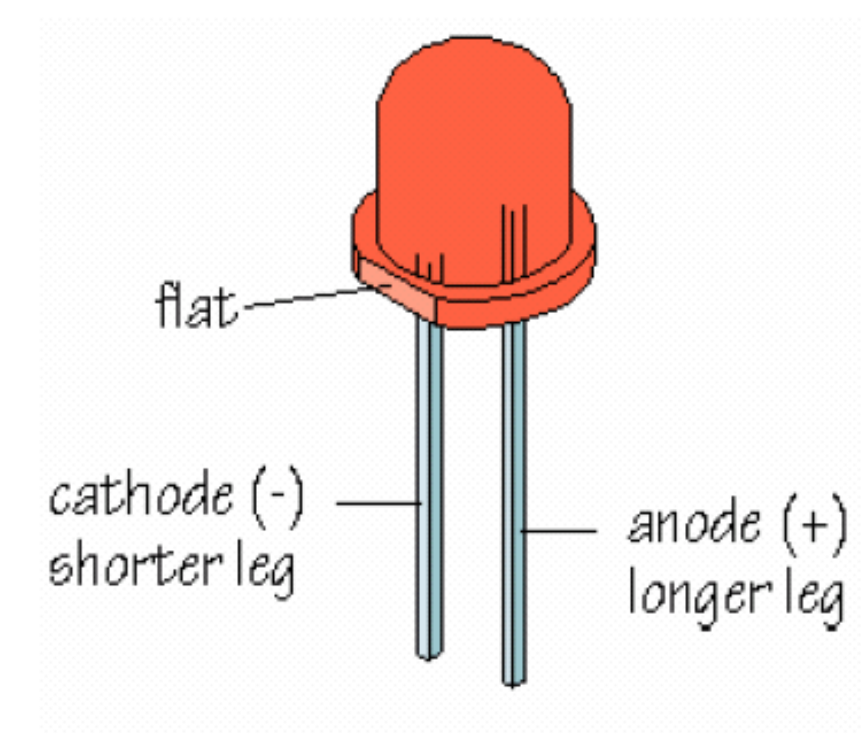
Semiconductors

- A semiconductor is a substance, usually a solid chemical element or compound, that can conduct electricity under some conditions but not others, making it a good medium for the control of electrical current.
- Can you think of an example of a semiconductor that we see every day?

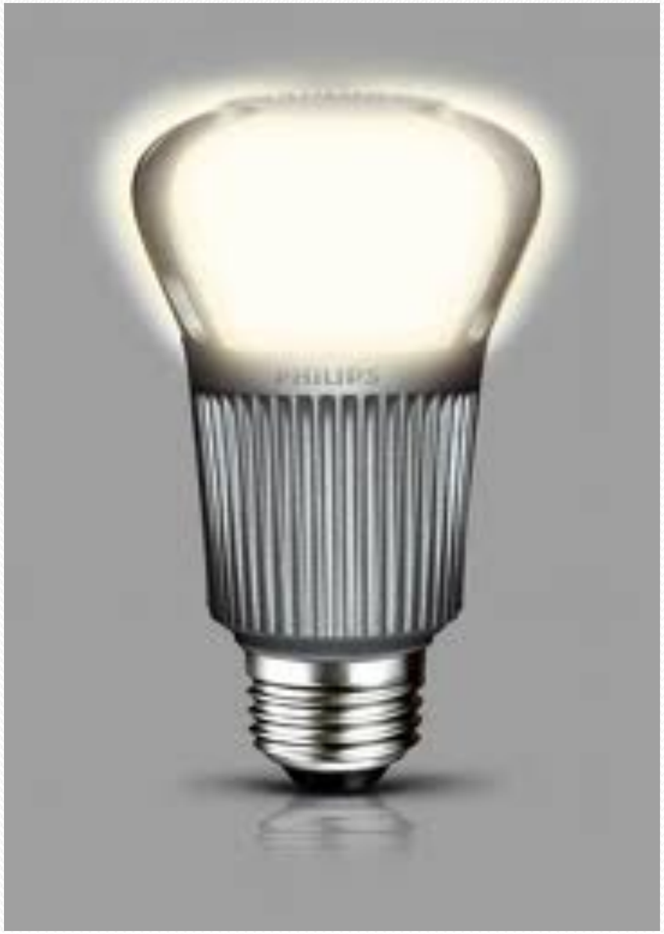
LEDS

What is an LED?

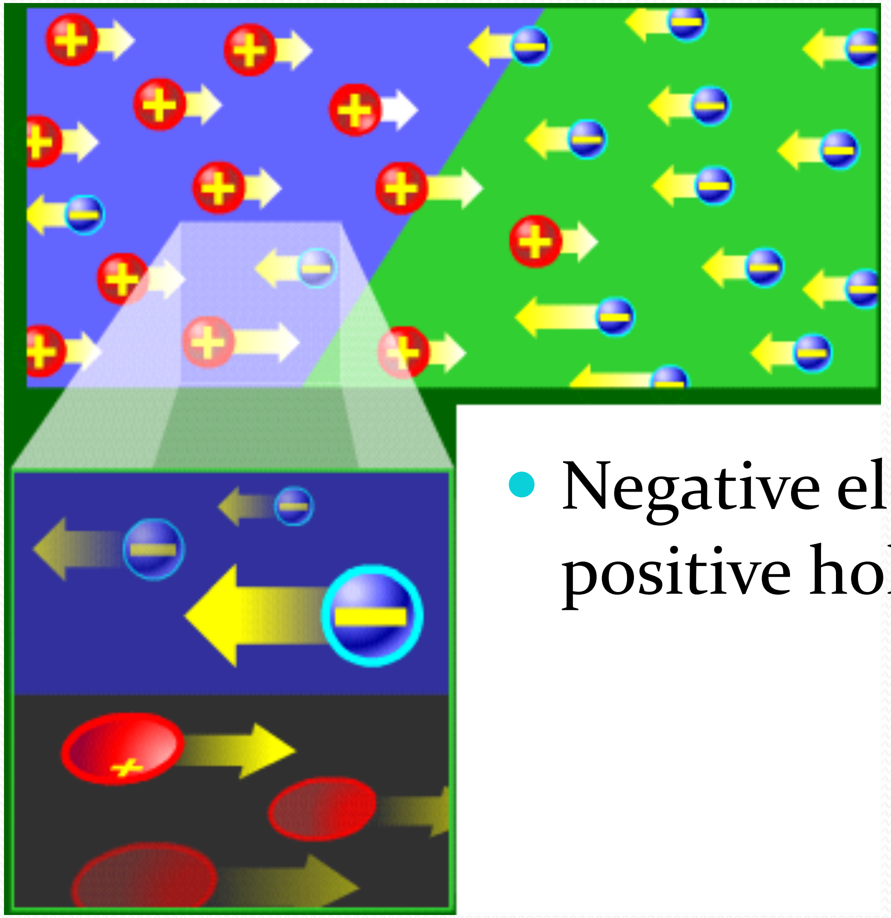
- Light-emitting diode
- Semiconductor
- Has polarity



Applications of LEDs

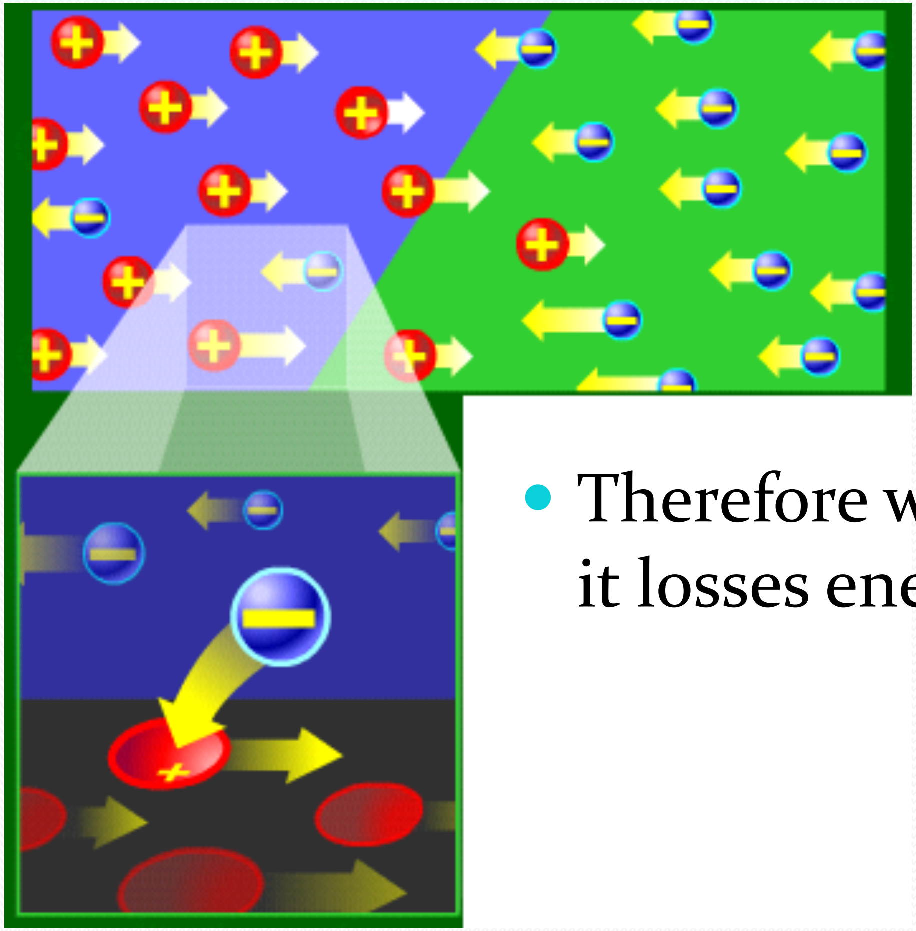


LED: How It Works



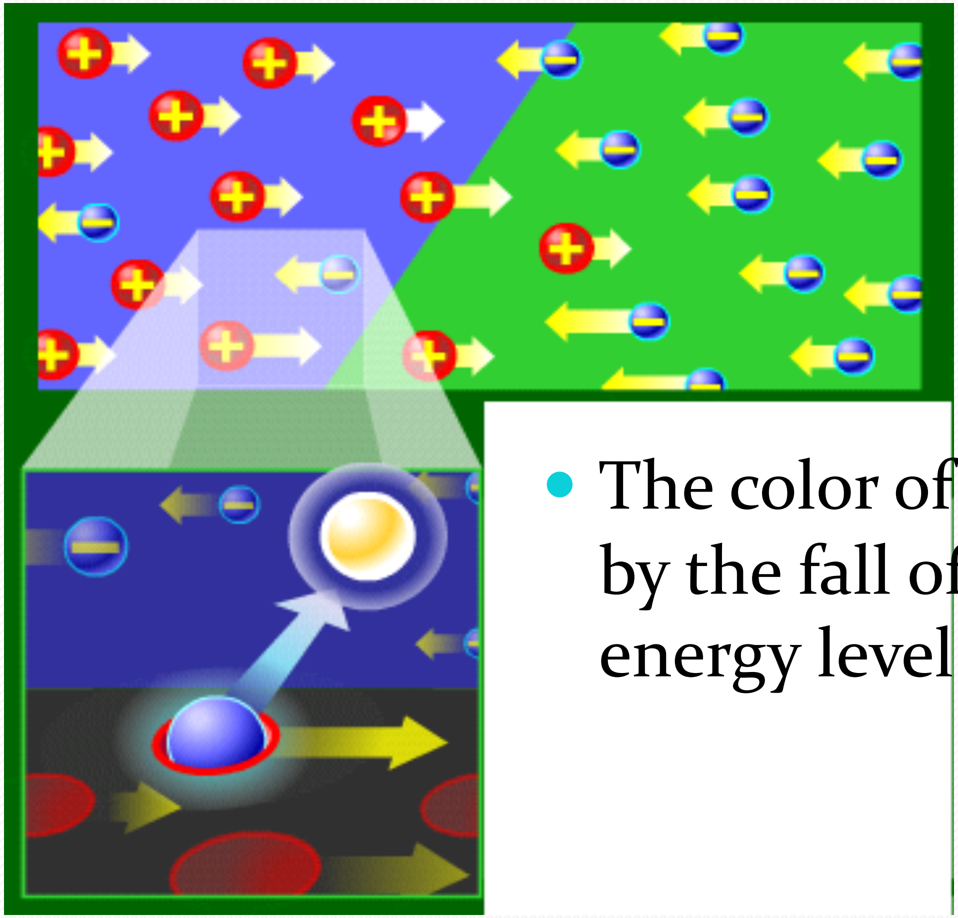
- When current flows across a diode
- Negative electrons move one way and positive holes move the other way

LED: How It Works



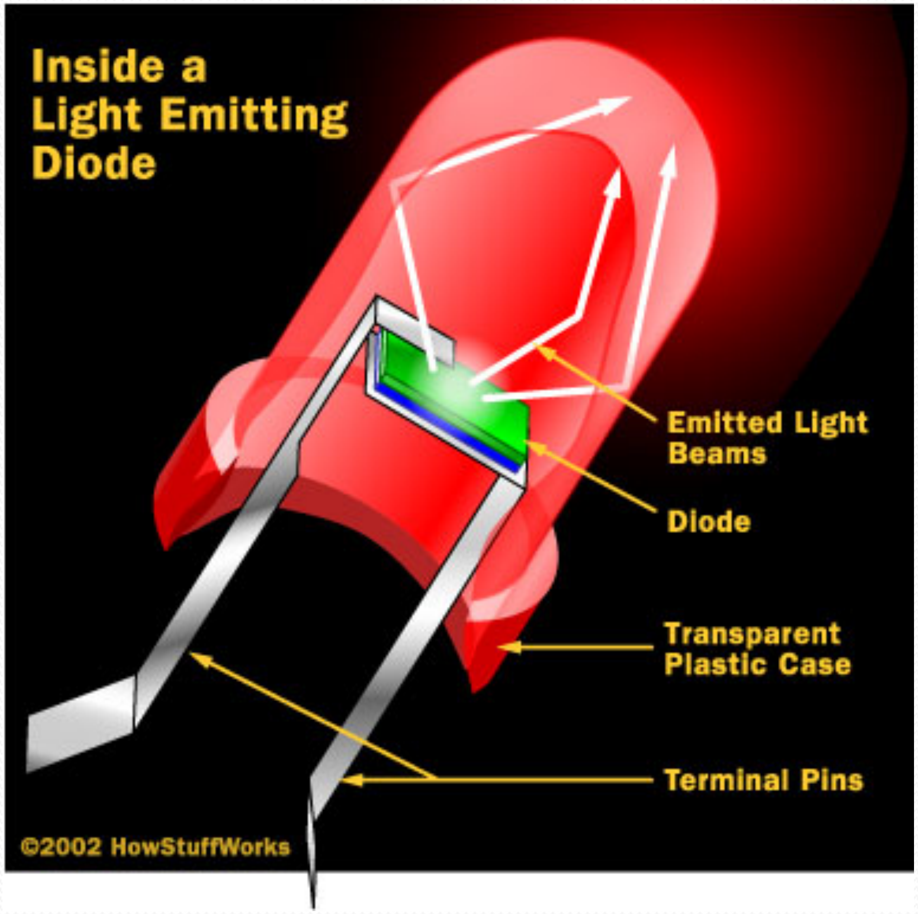
- The holes exist at a lower energy level than the free electrons
- Therefore when a free electrons falls it losses energy

LED: How It Works



- This energy is emitted in a form of a photon, which causes light
- The color of the light is determined by the fall of the electron and hence energy level of the photon

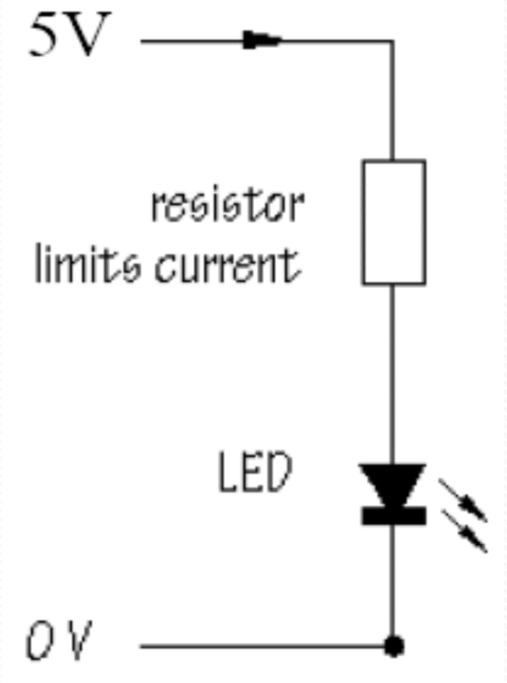
Inside a Light Emitting Diode



1. Transparent Plastic Case
2. Terminal Pins
3. Diode

How to Connect a LED:

- Requires 1.5~2.5V and 10 mA
- To prevent overloading, use resistor 470 Ω



Let’s make circuits

Squishy Circuits

Squishy Circuits are a great way to introduce electronics education into your curriculum by using two different doughs as circuit building materials. Because of the playful nature of the dough, this activity is suitible for children of all ages. The doughs are made with readily available ingredients such as flour and salt.

This teacher's guide contains the dough recipes, basic instructions, helpful hints and sample worksheets. All of this material is free and open-source, courtesy of the University of St. Thomas.

If any questions, comments, or concerns arise, we urge you to contact us via our website:
www.StThomas.edu/SquishyCircuits
We also have how-to videos and other support materials located there.

Classroom Guide,
http://courseweb.stthomas.edu/apthomas/SquishyCircuits/PDFs/Squishy%20Circuits%20Classroom%20Guide.pdf

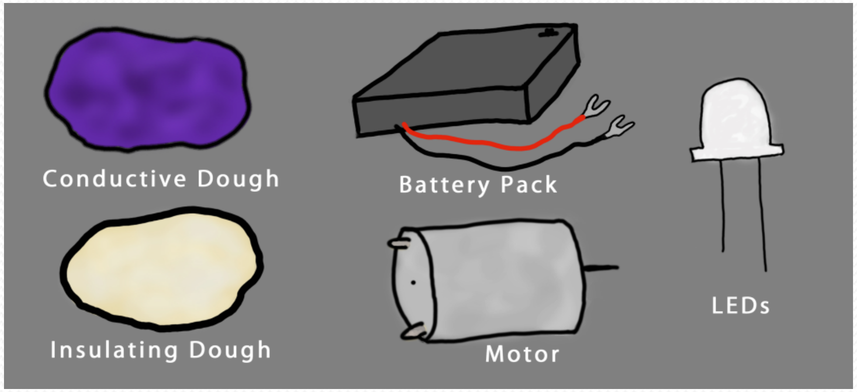
Squishy Circuits

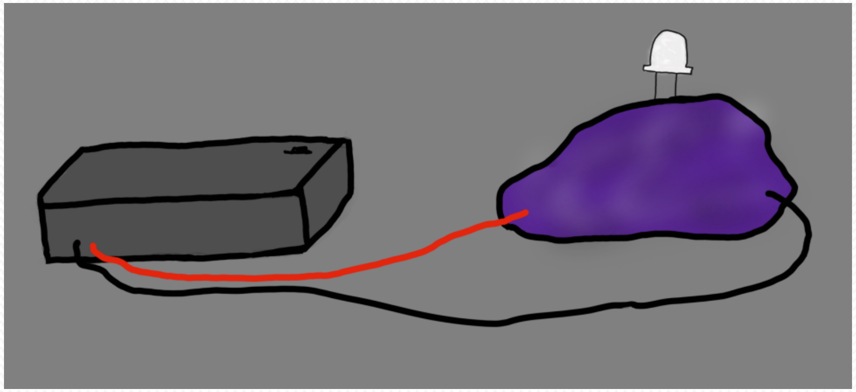
Make the Clay

Half make conductive, with color.

Half make insulating, no color. Share with another group.

Complete the introduction





Challenge

1. Brainstorm.
Use conductive and insulating dough to make battery-powered creatures that light up and/ or buzz. Ask each group to brainstorm possible creature designs. What do they want the creature to do? (have glowing eyes, make a noise when pressed)

2. Sketch and build. Groups will draw sketches and then agree on one design to build.

Draw here!

3. Test. Start small, like trying to get one eye to light up, then once you have accomplished this, move on to a more complicated task, such as getting two eyes to light.

4. Share. When everyone is done, have groups demonstrate their creations and discuss.

Pointer: Dough does not conduct as well as metal. You may find it helpful to use short thick chunks of the dough (to reduce resistance) or to increase the surface area of the electrical contacts.

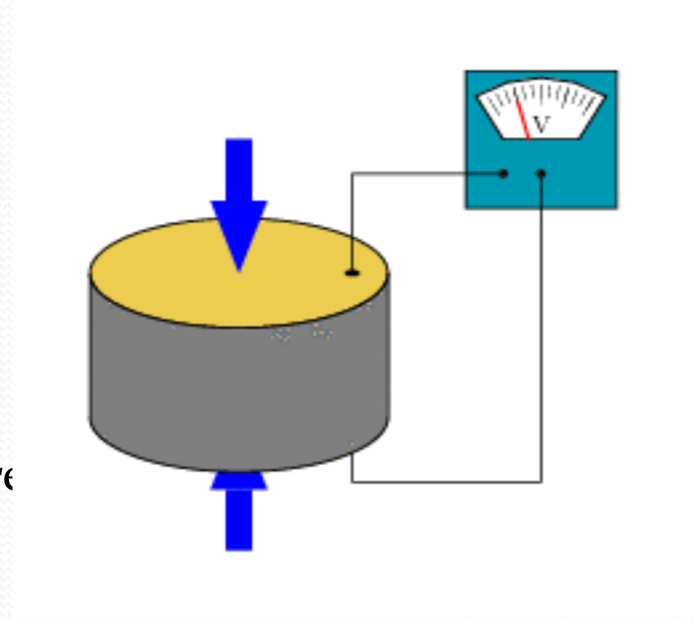
Piezoelectricity

What is Piezo Electricity?

What is Piezoelectricity?

Piezoelectric materials are produce an electric voltage when deformed mechanically—such as by squeezing or tapping.

The reverse effect is also true.
If we apply a voltage to the material, it deforms.



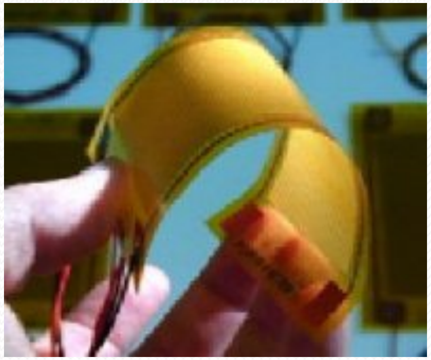
One early application of piezoelectric materials was for sonar in WWI.

Other applications include: sensors, actuators, artificial muscles, light-up shoes, and many more

Piezoelectrics and Energy Harvesting

Imagine charging your phone as you walk, thanks to a paper-thin generator embedded in the sole of your shoe.

One of the most exciting advancements in the field of materials science is using piezoelectric materials to harvest energy from everyday occurrences, like walking, climbing stairs, opening and closing doors—any sort of movement.



This can be done by placing piezoelectric materials where they experience a great number of mechanical deformations.

Then, the electric potential created is stored in batteries for later use.

Energy Harvesting Applications

Piezoelectric Sidewalks and Highways

- In France, piezo sidewalks power a town's street lights as people walk over the piezo elements and deform them.

- In Israel, the same principle has been scaled up to a stretch of highway that converts the energy from cars driving over the piezo elements in the road to collect power for a nearby small town.

Energy Harvesting Applications

Piezo-Clothing

- Georgia Tech researchers created tiny flexible piezoelectric generators that can be embedded in fabric.
- As you move throughout the day, clothes made with this fabric could generate enough power for small electronic devices such as calculators and phones.

Piezo-Cars

- A Jaguar concept car has a thin coating of piezoelectric materials on the outside of the body.
- When the car moves down a road, the air moving past it deforms the piezoelectric materials, generating electricity to recharge the car battery.
- This design has the potential to develop into electric cars with unlimited range!

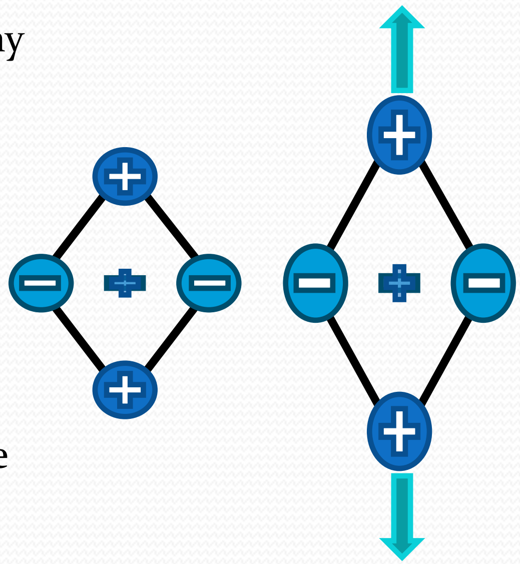
Why are only some materials piezoelectric?

To answer this question, let's look at the materials on the atomic level.

The crystal structure of a material—how the atoms and charges are arranged—determine if it is piezoelectric.

First, lets look at non-piezoelectric materials:

- These materials have symmetric atomic structures. If we flip them in any direction, the positive and negative charges are in the same locations.
- If we average the locations of the positive and negative charges, to find what are called the centers of charge, we notice that these locations overlap.
- This overlapping causes the charges to cancel out and no electricity is generated.
- When we deform the material by stretching it, the positive and negative centers of charge do not change, and still no electricity is generated. Thus, the material is non-piezoelectric.

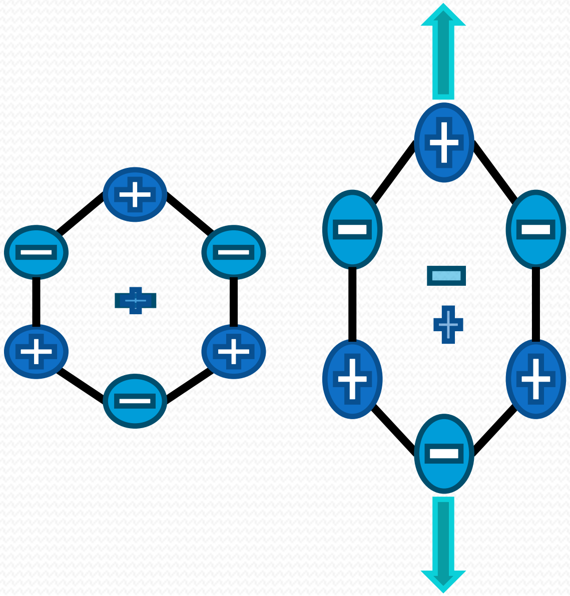


Why are only some materials piezoelectric?

If symmetric materials are non-piezoelectric,
that means that non-symmetric materials are piezoelectric.

Lets look at the structure of a piezoelectric material:

- At first glance, the structure appears to be symmetric. If we flip it around, the shape may look the same, but the positions of the positive and negative charges may change. Thus, it is not symmetric. ➔
- Again, when we find the centers of charge for this material, they overlap and no electricity is generated.
- However, when we deform the material by stretching it, the positive and negative centers of charge no longer overlap.
- Since these centers of charge do not overlap and cancel each other out, some electricity is generated! **This material is piezoelectric.** ➚



Is energy really Created?

While devices using piezoelectric materials are called generators, no energy is actually created!

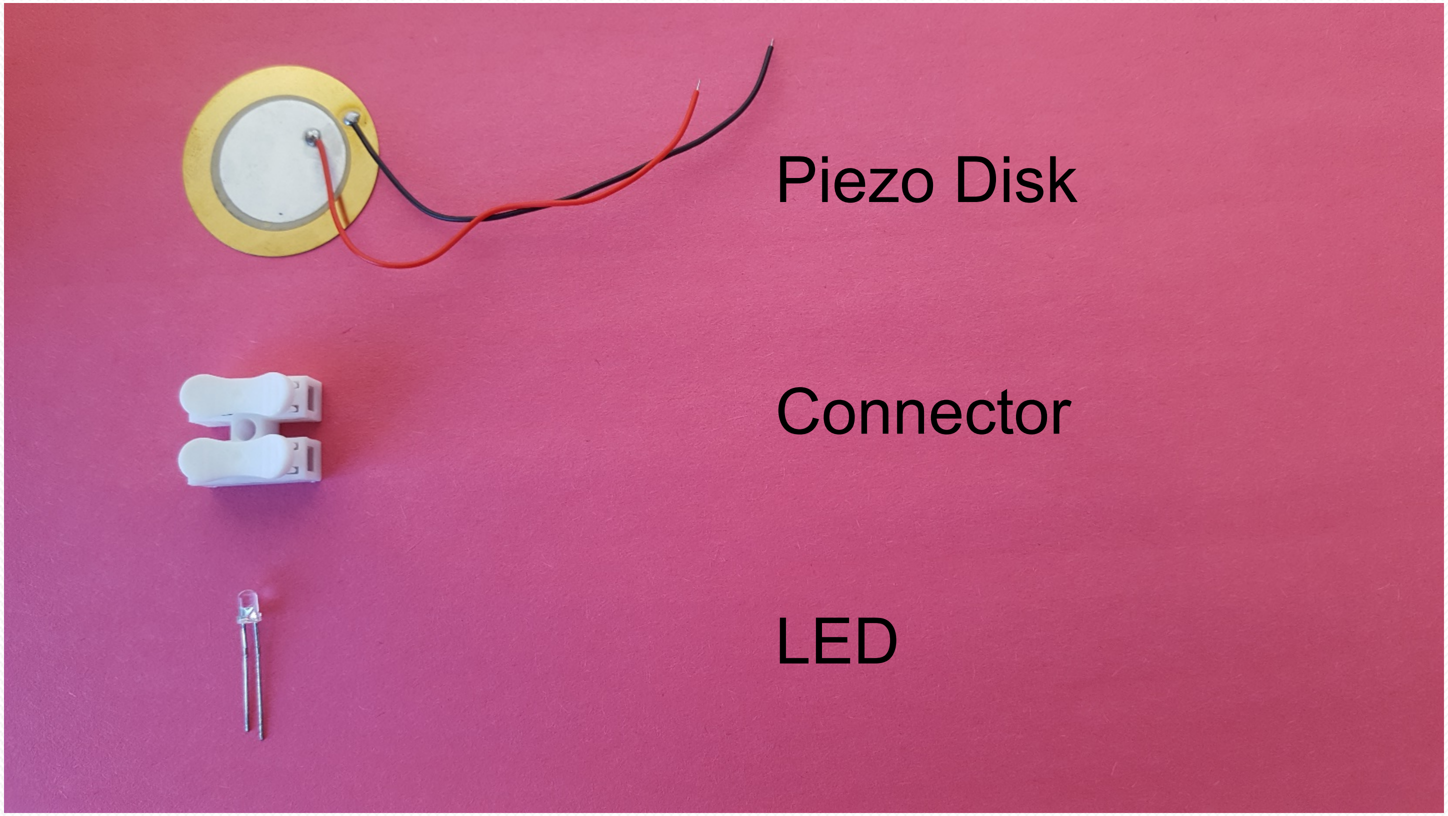
In fact nowhere in the entire universe is energy ever created! This is one of the fundamental laws of physics.

If this is true, then from where is this electricity or energy coming?

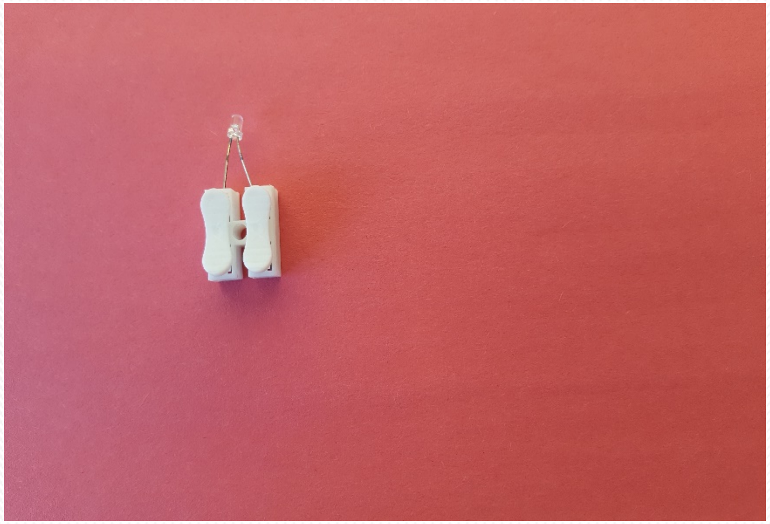
- Even though energy cannot be created, it can be converted from one type to another. In the case of piezoelectric materials, mechanical energy, from applying some force to deform the material, is converted into electrical energy.
- The reverse effect enables piezoelectric materials to convert electrical energy back into mechanical energy, making them very useful materials.

Lets make a Piezo Generator

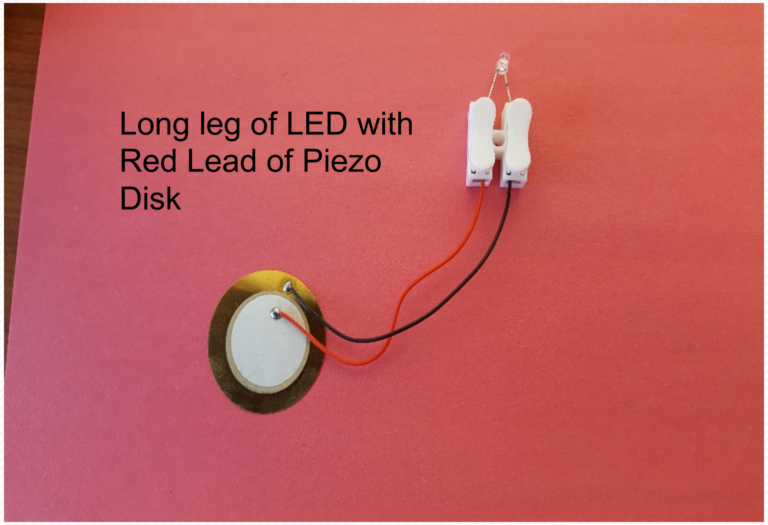
- Parts needed.



Assembly

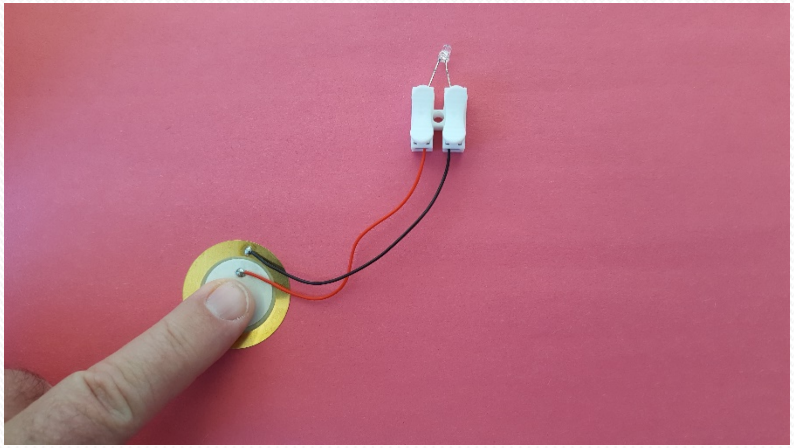


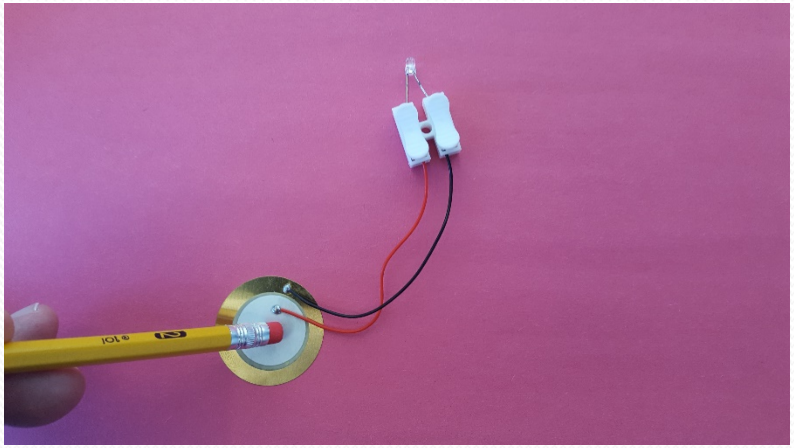
Push down connectors on one side insert LED.



Push down connectors on other side, insert leads to Piezo Disk.

Test your Piezo Generator





Tap white part with your Finger or Pencil eraser, and watch the LED. What do you see happening?

Let’s Look at some Nano-Kits!

Kits for Purchase

Ordering: Visit http://ncmn.unl.edu/kit-order-form to purchase one or more kits for your school (non-profit required for order). We will invoice and ship kits within a few weeks.

Exploring Materials—Thin Films

Exploring Materials—Graphene

Exploring Products—Nano Sand (State Standards)

Exploring Products—Liquid Crystal Displays (State Standards)

Exploring Properties—Invisibility (State Standards)

Exploring Materials—Memory Metal (State Standards)

Exploring Materials—Ferrofluid (State Standards)

Exploring Materials—Oobleck

Exploring Size—Measure Yourself

Thank you.

Any Questions??