

# **NANOTECHNOLOGY EXPERIMENTS FOR GENERAL CHEMISTRY LABORATORY CLASSES**

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**Web site: <http://www.chymist.com>**

- **Nanotechnology**
  - Major area of research and development
  - Only now being introduced into textbooks for general chemistry
  - Almost no inclusion in the student laboratory.
- **Lab procedures and kits developed at the Materials Research Science and Engineering Center (MRSEC) at the University of Wisconsin-Madison <http://mrsec.wisc.edu/Edetc/index.html>**  
(Go to video lab manual)

# **Courses**

**CHM 121IN, Chemistry and Society**

**CHM 125IN, Consumer Chemistry**

**Non-major courses**

**Taught as a hands-on learning courses**

**Experiments introduced in 2003**

**CHM 151-152IN, General Chemistry**

**ENG 110IN, Solid State Chemistry**

**LED and solar cell experiments included in  
laboratory**

# Mood Rings



**Dark blue:** Happy, romantic or passionate

**Blue:** Calm or relaxed

**Blue-green:** Somewhat relaxed

**Green:** Normal or average

**Amber:** A little nervous or anxious

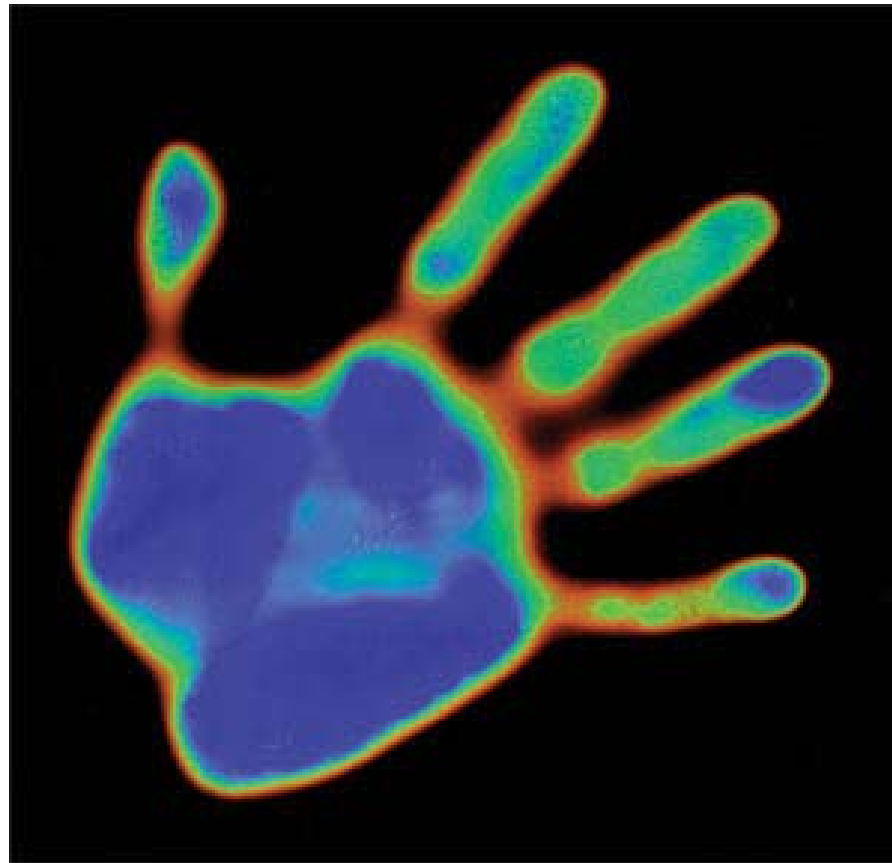
**Gray:** Very nervous or anxious

**Black:** Stressed, tense or feeling harried



# Liquid Crystals

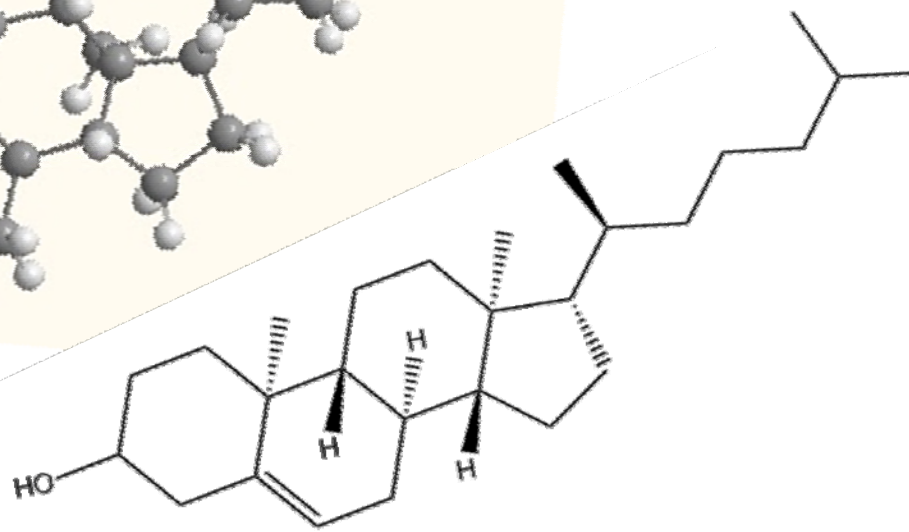
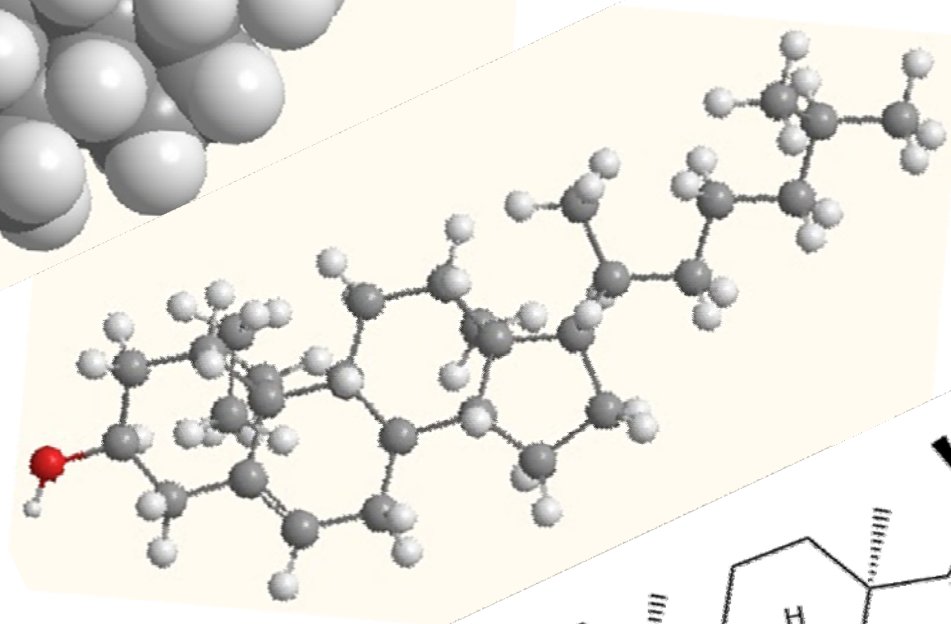
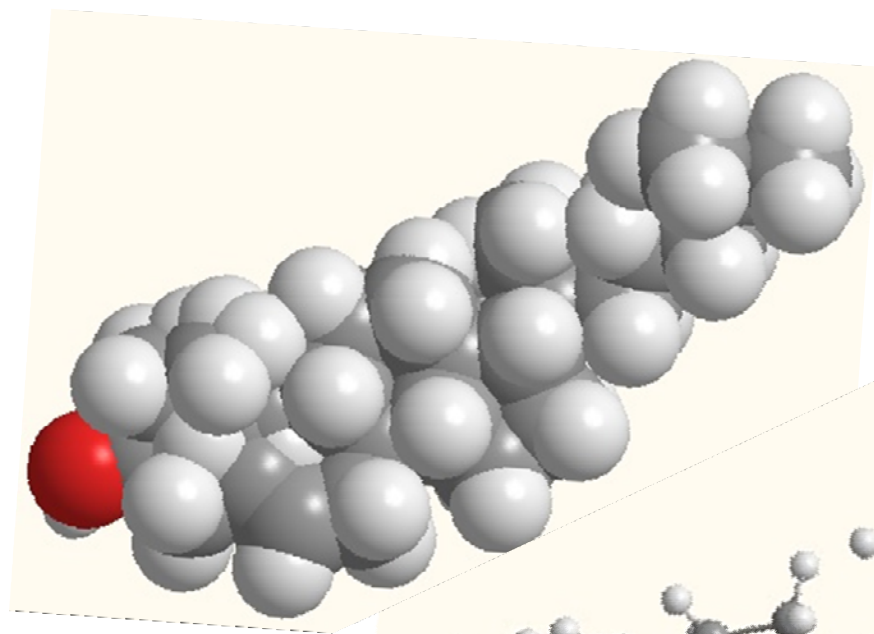
**Both pressure sensitive and temperature sensitive (thermochromic) mixtures are prepared**



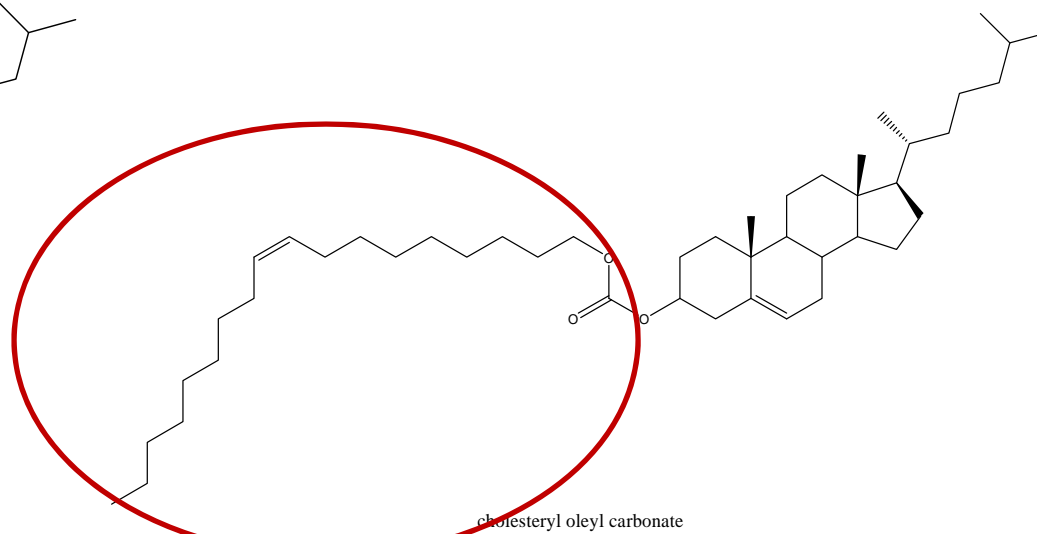
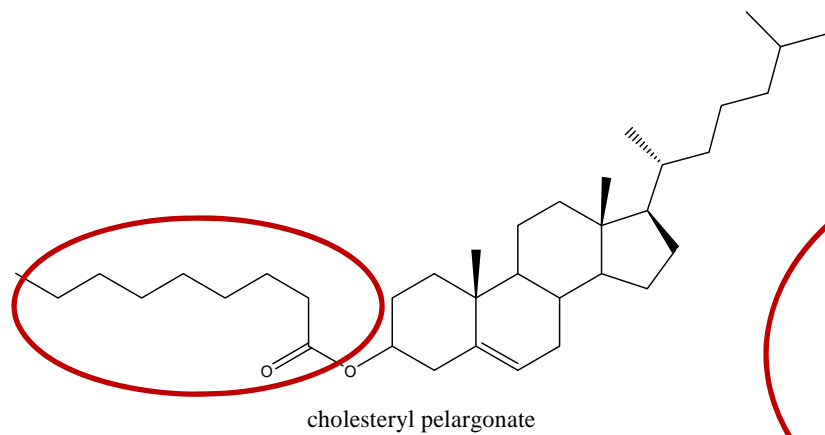
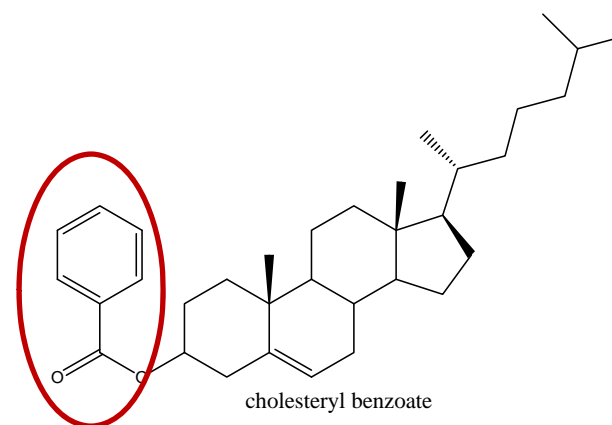
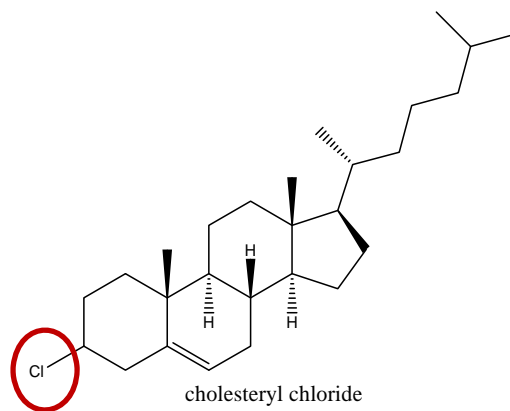
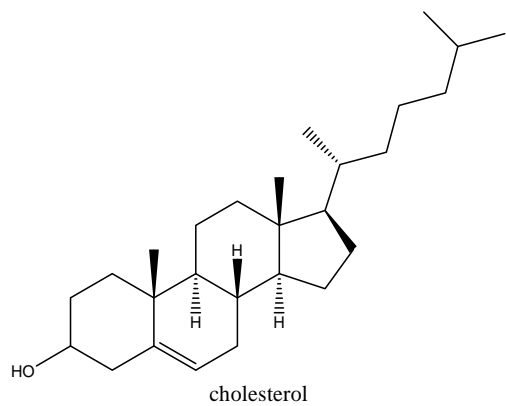
# Liquid Crystals

- **Organic compounds in a state between liquid and solid**
- **Viscous, jelly-like materials that resemble liquids in viscosity and crystals in lightscattering and reflection**
- **Highly anisotropic (having different optical properties in different directions) - usually long and narrow - and revert to an isotropic liquid (same optical properties in all directions) through thermal action (heat) or by the influence of a solvent.**

# Cholesterol



# Cholesteryl Ester Liquid Crystals





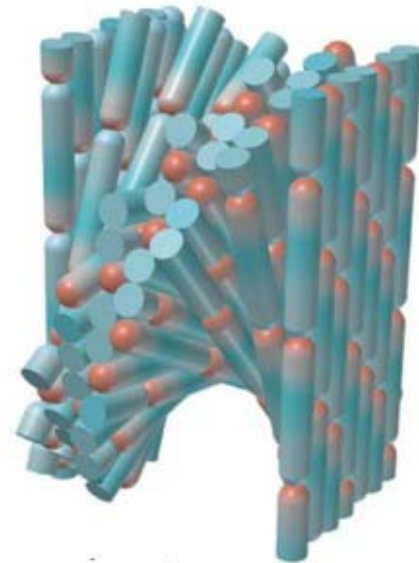
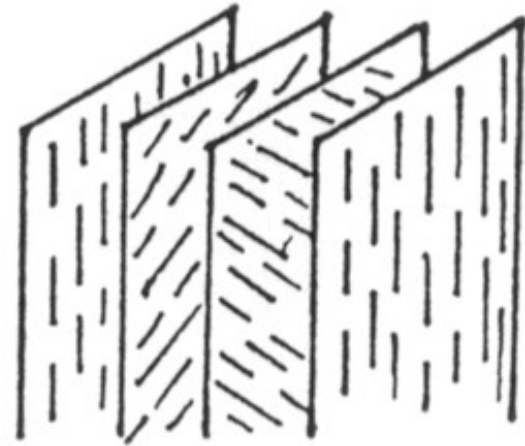
# Types of Cholesteryl Liquid Crystals

## **Lyotropic**

Molecules consist of a nonpolar hydrocarbon chain with a polar head group.

In a solvent, such as water, the water molecules are sandwiched between the polar heads of adjacent layers while the hydrocarbon tails lie in a nonpolar environment.

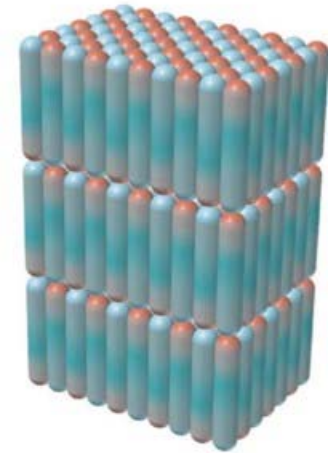
**These tend to be pressure and temperature sensitive**



# Types of Cholesteral Liquid Crystals

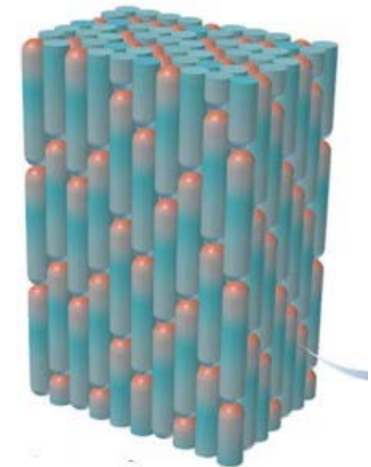
## Smectic

Molecules arranged in horizontal layers or strata and are standing on end either vertically or at a tilt.



## Nematic

Molecules possess a high degree of long-range order with their long axes approximately parallel, but without the distinct layers of the smectic crystals.



**These are temperature sensitive**

# Cholesteryl Ester Liquid Crystals



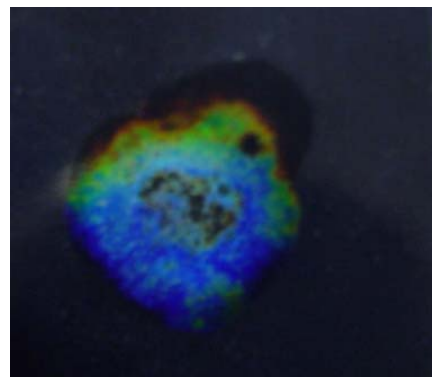
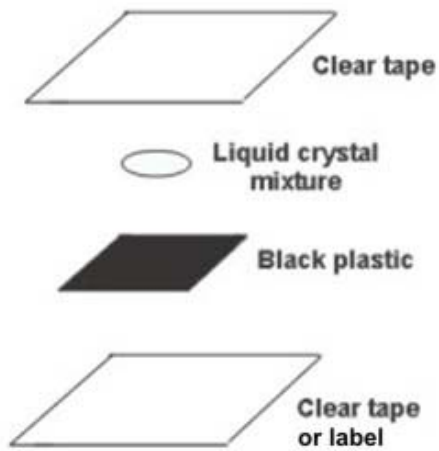
Mix liquid crystal materials



Melt the material



Allow to cool



# Temperature Transition of a Mood Ring (Coming soon)



**Dark blue:** Happy, romantic or passionate

**Blue:** Calm or relaxed

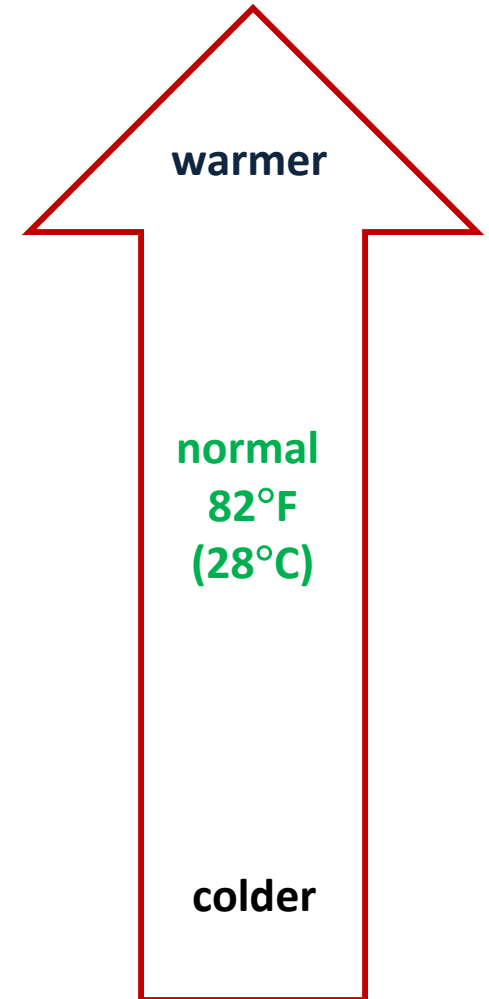
**Blue-green:** Somewhat relaxed

**Green:** Normal or average

**Amber:** A little nervous or anxious

**Gray:** Very nervous or anxious

**Black:** Stressed, tense or feeling harried



# Calibrate a Mood Ring

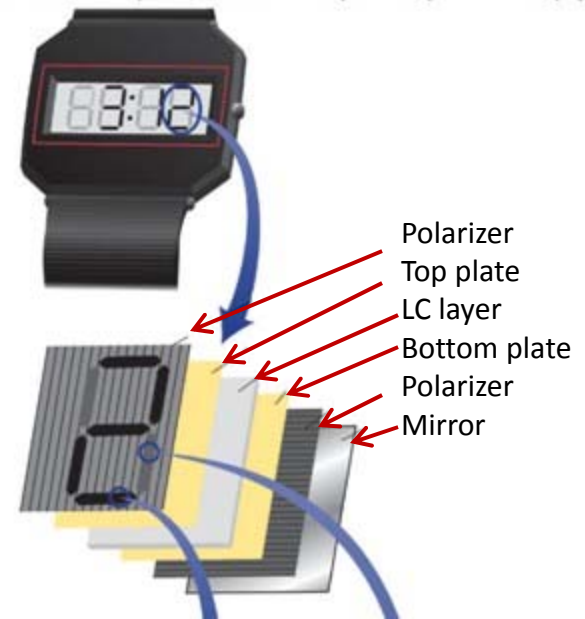
(under development)



Suspend a mood ring in a water bath with a magnetic stirrer and temperature probe.

Slowly heat the bath to determine transition colors.

# Investigation of an LCD watch display



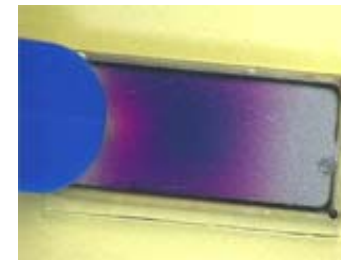
Take watch apart



View with polarizer



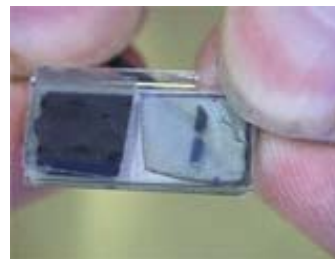
Remove electronics  
and display



Display is touch  
sensitive



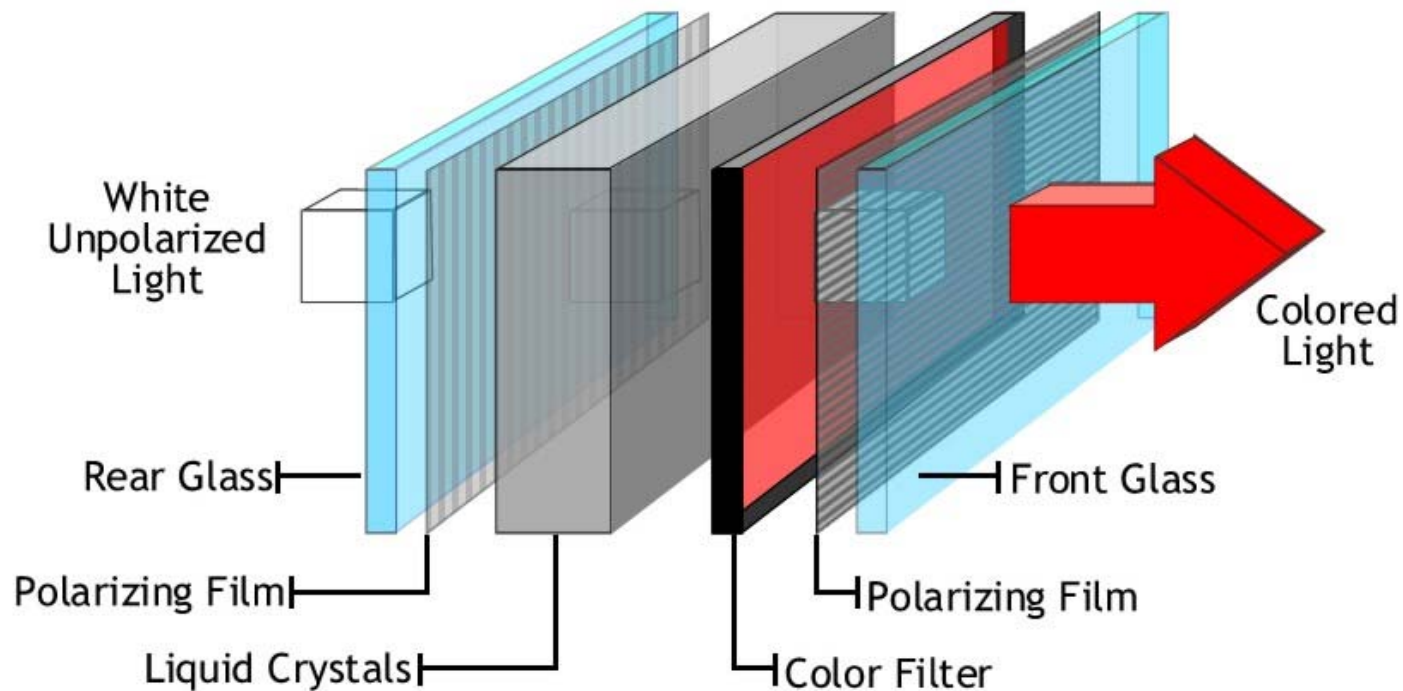
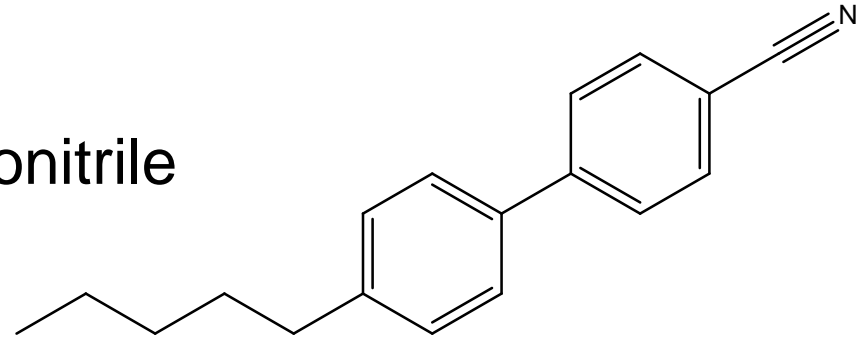
Determine transition  
temperature



Cut and rotate part  
of top polarizer

# Liquid Crystal "Pixel"

Uses 4'-pentyl-4-biphenyl-carbonitrile

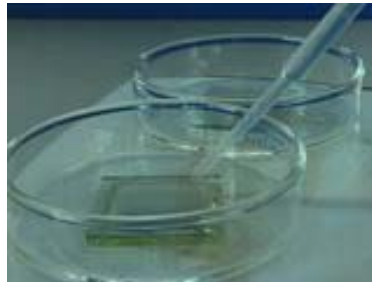




# Liquid Crystal "Pixel"



Prepare polyvinylalcohol solution



Coat conductive glass



Wipe surface



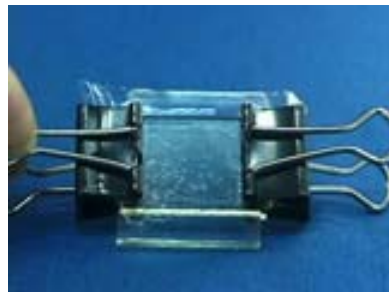
Clean edge



Prepared glass plate



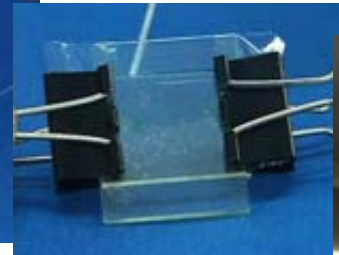
Plastic film spacers



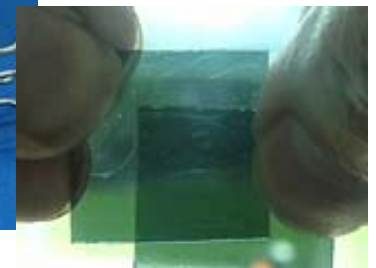
Clamp together



4'-pentyl-4-biphenyl-carbonitrile



Add to "pixel"



Add polarizing filter



Attach 9-V battery.  
Finished "pixel"



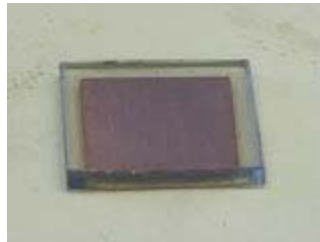
# Titanium Dioxide Raspberry Solar Cell



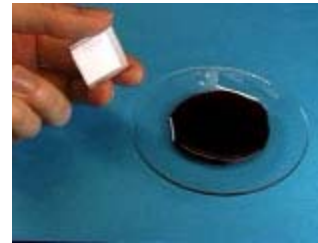
Grind  
nanocrystalline  
 $\text{TiO}_2$  with dilute  
acetic acid



Coat surface  
conducting glass



Bake coating on  
hot plate



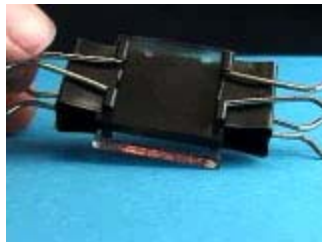
Dip into berry juice



Rinse



Coat 2<sup>nd</sup> piece of  
glass with carbon



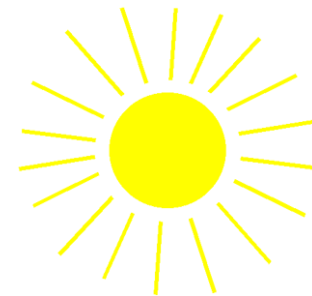
Clamp together



Dope with  $\text{KI}_3$   
solution



Measure voltage



# Aqueous Ferrofluid

- Colloidal suspensions of magnetic nanoparticles.
- Responds to an external magnetic field
- $\text{Fe}_2\text{O}_3$  magnetite nanoparticles can be produced by mixing Fe(II) and Fe(III) salts together in a basic solution.
- Surfactants are used to prevent the nanoparticles from approaching one another too closely.
- Ferrofluids exhibit “spikes” when placed in the proximity of a strong magnet.



# Aqueous Ferrofluid



Mix  $\text{FeCl}_2$  and  $\text{FeCl}_3$



React with aqueous  $\text{NH}_3$



Allow to settle



Decant liquid and transfer solid to a weighing boat



Rinse with water and tetramethylammonium hydroxide



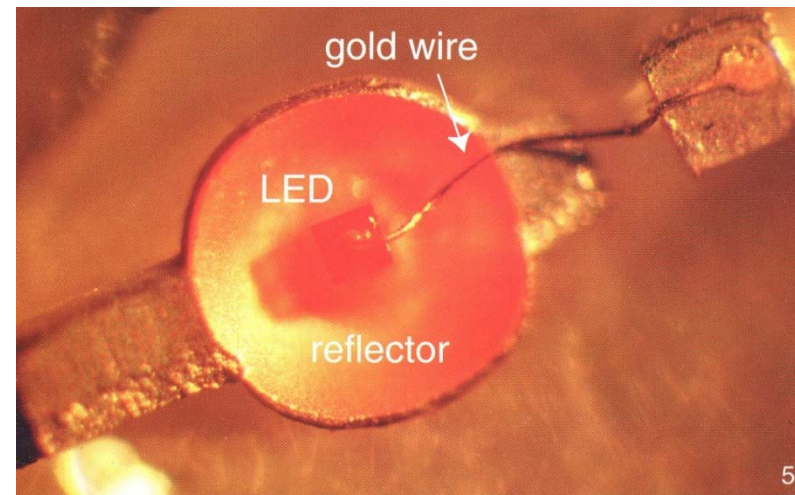
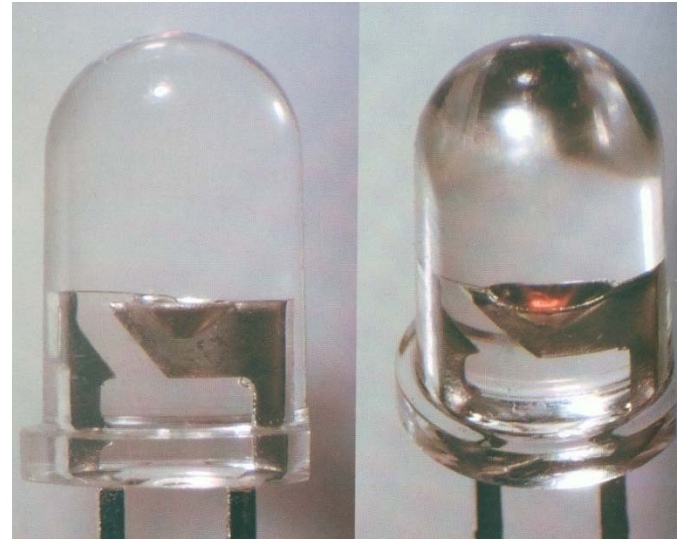
Place a magnet under the ferrofluid.

Store in 70% 2-propanol

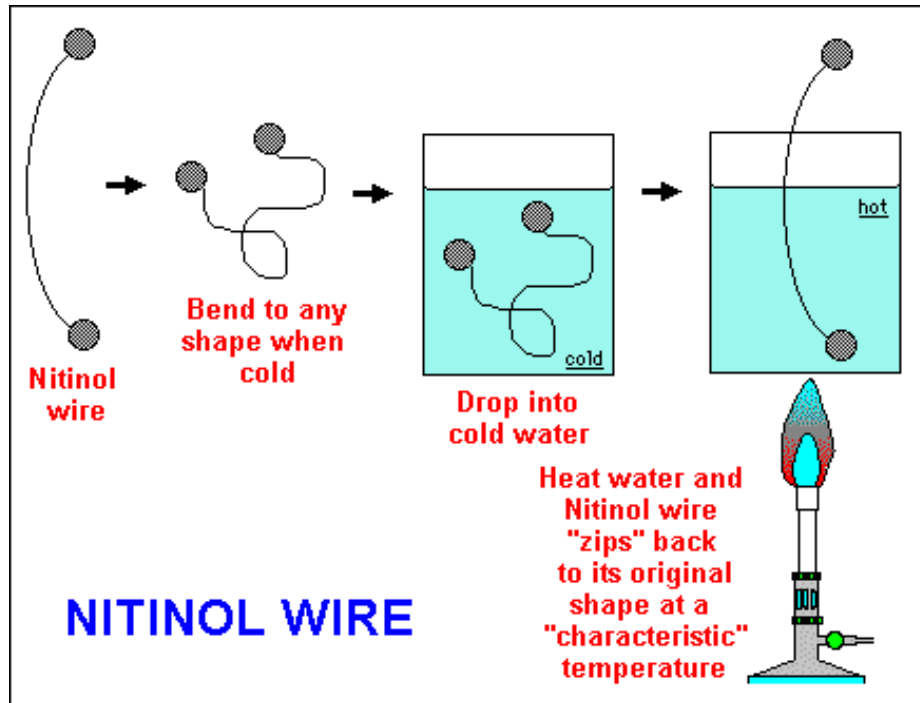
# LED's

## Experiments:

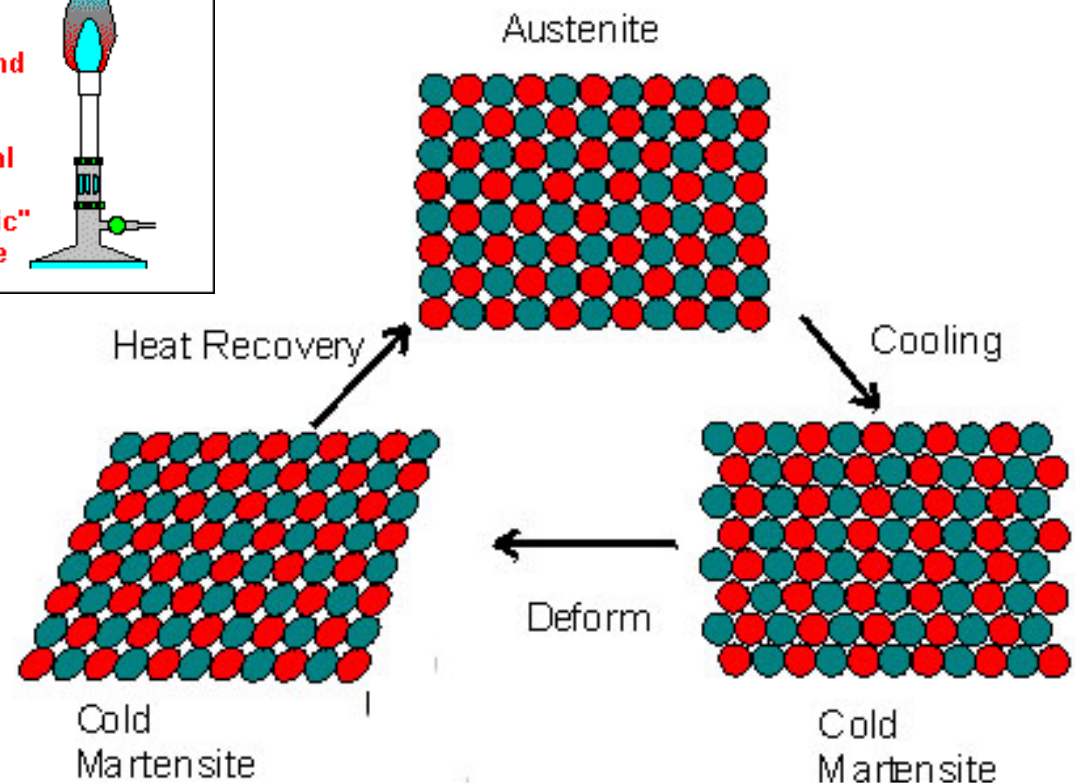
- Observe diode behavior
- Determine relative wavelength of light
- Determine relative energies of different colored LED's
- Measure voltages
- Control light path with an optical fiber
- Apply LED light to a luminescent material



# Nitinol



- Explore properties.
- Train wire into spiral shape





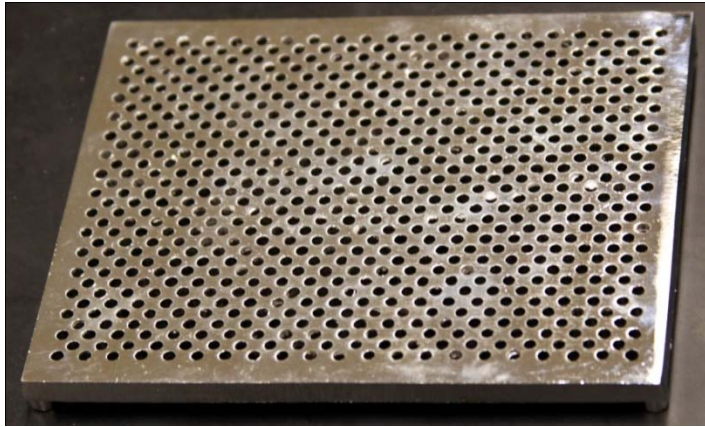
# Nitinol

The  
Thermobile,  
a nitinol motor



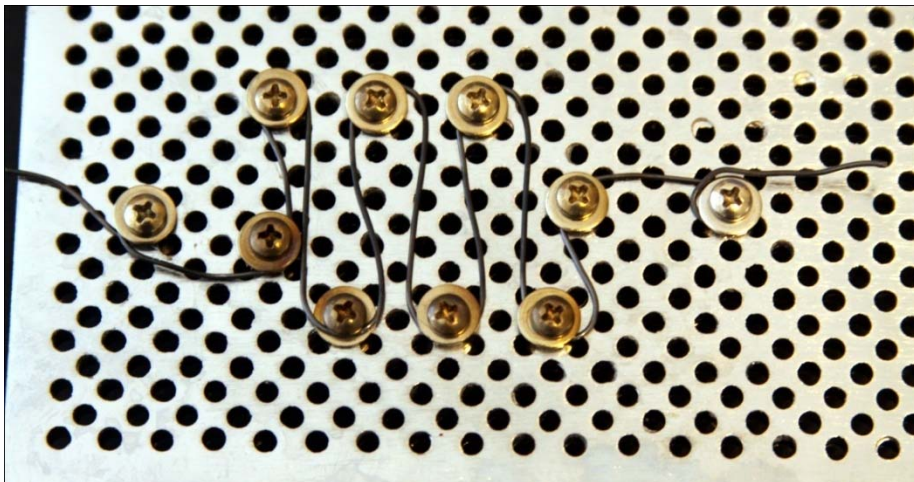
A Nitinol butterfly

# Training Nitinol Wire



Obtain a wire bending plate  
This is a Beadalon Thing-a-ma-Jig

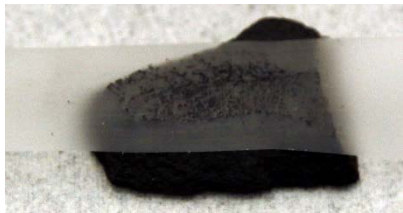
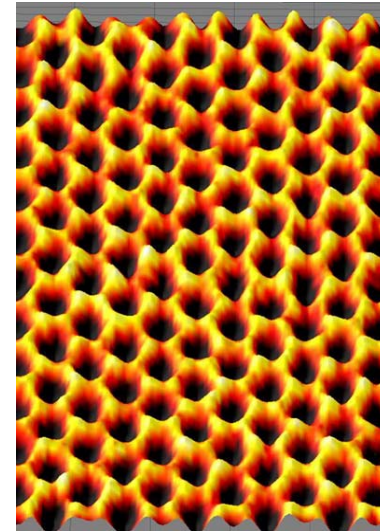
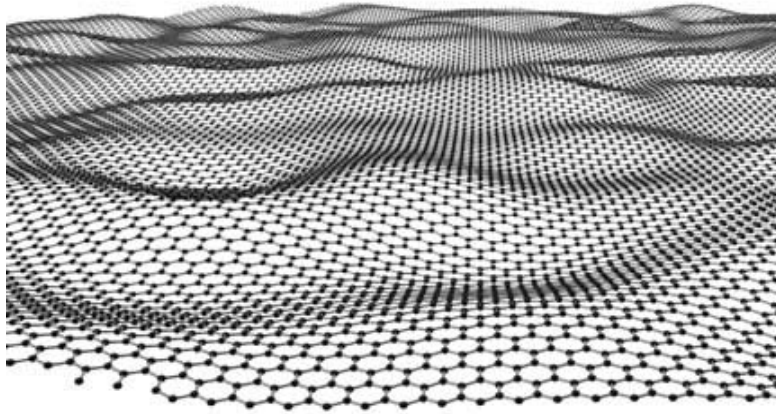
Fasten Nitinol wire in place  
with stainless steel screws  
and washers



Heat with a  
mini blow  
torch or use a  
small furnace  
at 500°C



# Graphene



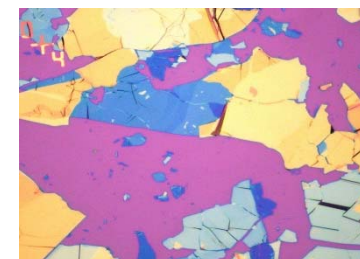
Transfer graphite to Scotch tape



Peel layers apart



Transfer to a silicon wafer

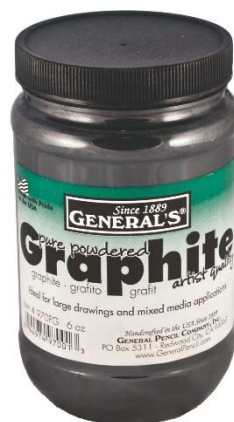


View under a microscope  
(lots of debris)



# Graphene in a Blender

(coming soon)



# Sources

Cholesteryl liquid crystals: Sigma-Aldrich Chemical Co.

Nanocrystalline titanium dioxide solar cell kit: ICE – Univ. of Wisconsin (get one kit only)

Aqueous Ferrofluid: Flinn Scientific and Sigma-Aldrich

LED Color Strip Kit: ICE-Univ. of Wisconsin (get one kit only – additional materials from an electronics store)

Nitinol wire: Images Scientific Instruments

Nitinol Butterfly: Images Scientific Instruments

Beadalon wire bending plate: Craft store or Amazon.com

Mini-torch: Harbor Freight Tools

## Web sites:

<http://www.chymist.com>

Click on Laboratory Experiments on left-hand menu.

**Materials Research Science and Engineering  
Center (MRSEC) at the University of  
Wisconsin-Madison**

<http://mrsec.wisc.edu/Edetc/index.html>

Go to video lab manual

**Note: See The Nano Song**

<http://www.youtube.com/watch?v=LFoC-uxRqCg>