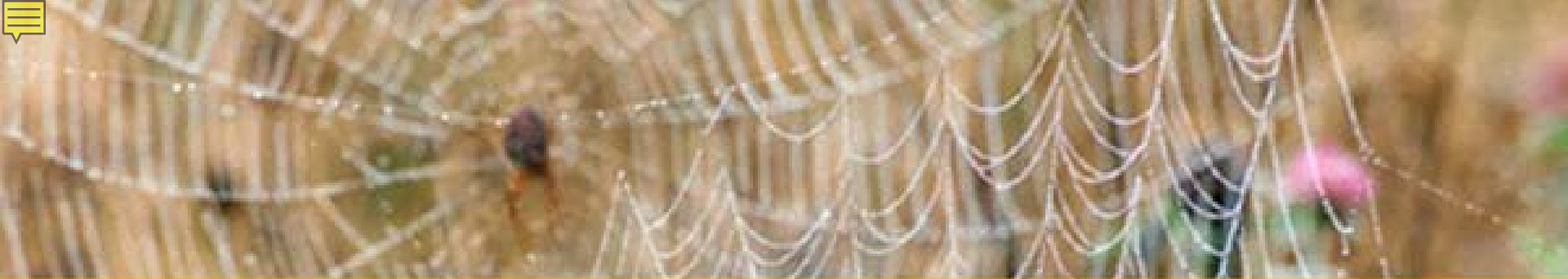


# GREEN CHEMISTRY

PREVENTING POLLUTION *and*  
SUSTAINING THE EARTH

**Serra High School  
2010 Earth Day Celebration  
Thursday, April 22, 2010**





“Chemistry has an important role to play in achieving a sustainable civilization on earth.”

— Dr. Terry Collins, Professor of Chemistry  
Carnegie Mellon University


WHAT IS A  
SUSTAINABLE  
CIVILIZATION?



# WE SHOULD CONSIDER THIS QUESTION FROM SEVERAL VIEWPOINTS:

- The environment and human health
- A stable economy that uses energy and resources efficiently
- Social and political systems that lead to a just society





TO UNDERSTAND THE ROLE  
OF CHEMISTRY IN  
SUSTAINABILITY,  
WE WILL LOOK AT THE  
FIRST TWO POINTS...

- The environment and human health
- A stable economy that uses energy and resources efficiently



# IN A SUSTAINABLE CIVILIZATION...

- Technologies used for production of needed goods are not harmful to the environment or to human health.
- Renewable resources (such as plant-based substances or solar energy) are used rather than those, like fossil fuels, that will eventually run out.



# IN A SUSTAINABLE CIVILIZATION...

- Materials are recycled at the end of their use if they are not biodegradable (easily broken down into harmless substances in the environment).



# IN A SUSTAINABLE CIVILIZATION...

- Manufacturing processes are either designed so as not to produce waste products,
  - OR -
- Waste products are recycled or biodegradable.



WHILE WE HAVE MADE SOME  
PROGRESS IN ACHIEVING  
THESE GOALS, WE STILL  
HAVE A LONG WAY TO GO...

- Mountains of solid waste are piling up—particularly in industrialized nations.
- Air and water pollution continue to be problems in many places.



BUT HOW CAN  
CHEMISTRY HELP US  
TO ACHIEVE  
A SUSTAINABLE  
CIVILIZATION?

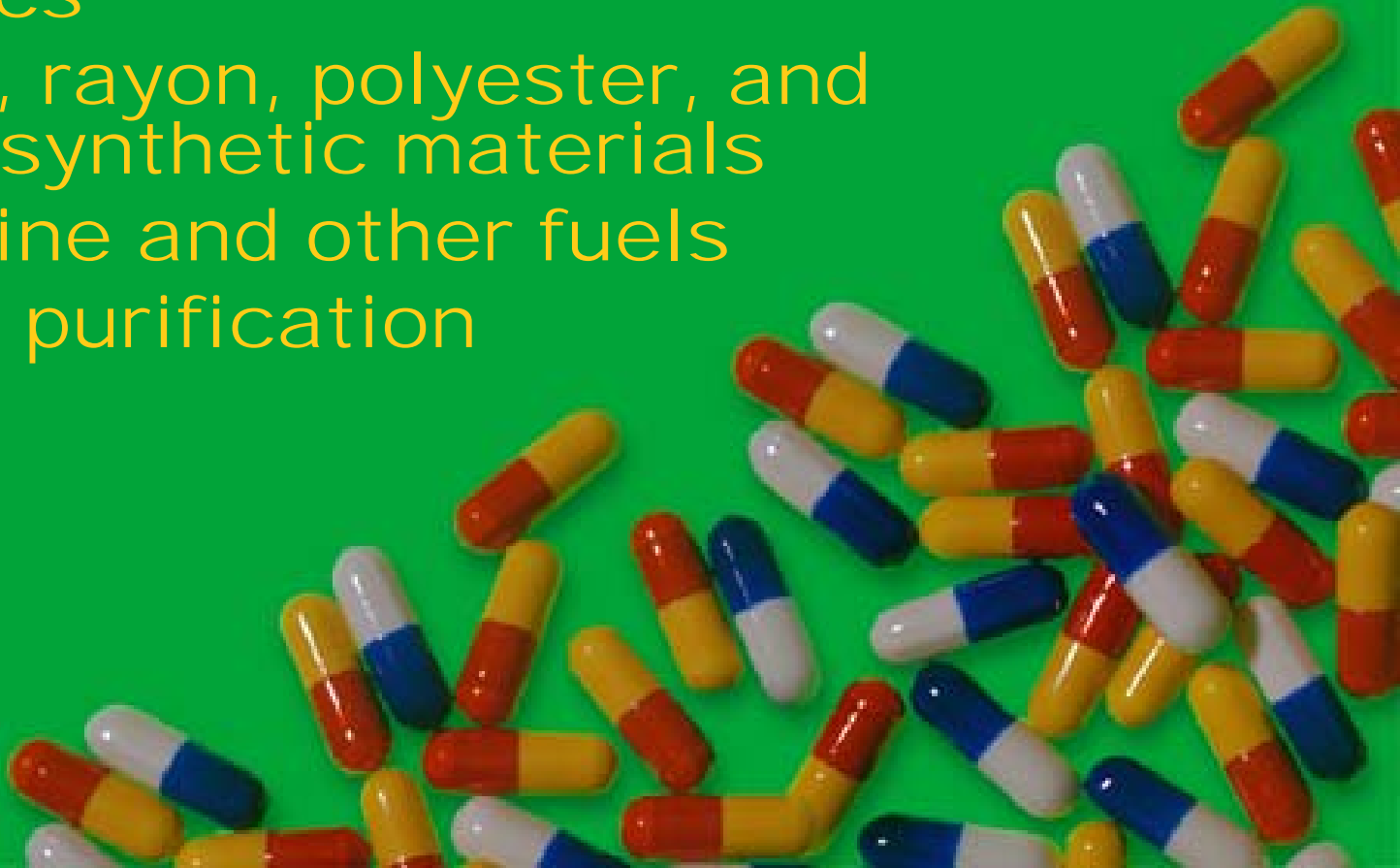


First, let's consider chemistry's benefits...

The chemical industry produces many products that improve our lives and upon which we depend.

# BENEFITS OF THE CHEMICAL INDUSTRY:

- Antibiotics and other medicines
- Fertilizers, pesticides
- Plastics
- Nylon, rayon, polyester, and other synthetic materials
- Gasoline and other fuels
- Water purification





Although the positive contributions of chemistry and the chemical industry are many, some pollution problems have also resulted.

Many of these problems can now be solved.

# SOME WELL-PUBLICIZED INCIDENTS FROM THE PAST FEW DECADES...


- The Cuyahoga River in Ohio became so polluted with chemicals it caught fire.
- A plant accident in Bhopal, India, released methyl isocyanate. Nearly 4,000 people died.



# SOME WELL-PUBLICIZED INCIDENTS FROM THE PAST FEW DECADES...

- An accidental release of chemicals, including dioxin, in Seveso, Italy in 1976 resulted in the deaths of farm animals and long-term health problems for many local residents.





MANY COUNTRIES HAVE  
ALREADY ENACTED LAWS AND  
SIGNED INTERNATIONAL  
TREATIES TO REDUCE POLLUTION  
LEVELS, INCLUDING:

- 
- Montreal Protocol to Protect the Ozone Layer
  - Global Treaty on Persistent Organic Pollutants
  - Rio Declaration on Environment and Development



Despite these efforts,  
large quantities of harmful  
substances are still being  
released into the environment.

# THE POLLUTION PREVENTION ACT OF 1990

- This is the U.S. environmental law stating that the first choice for preventing pollution is to design industrial processes that do not lead to waste production.
- This is the approach of green chemistry.

# GREEN CHEMISTRY WORKS TOWARD SUSTAINABILITY BY:

- Making chemical products that do not harm either our health or the environment,
- Using industrial processes that reduce or eliminate hazardous chemicals, and



# GREEN CHEMISTRY WORKS TOWARD SUSTAINABILITY BY:

- Designing more efficient processes that minimize the production of waste materials and decreases the amount of non-renewable energy used.





# GREEN CHEMISTRY MEANS...

- Preventing pollution before it happens rather than cleaning up the mess later.



# GREEN CHEMISTRY MEANS...

- Saving companies money by using less energy and fewer/safer chemicals, thus reducing the costs of pollution control and waste disposal.

# EXAMPLES OF GREEN CHEMISTRY

- Reducing lead pollution
- Putting out fires the green way
- Safer dry cleaning



# LEAD POLLUTION HAS BEEN DECREASED BY...

- Replacing lead in paint with safe alternatives, and
- Replacing tetraethyl lead with less toxic additives (e.g., "lead-free" gasoline).



# CHEMICAL FOAMS TO FIGHT FIRES

- Millions of tons of chemical fire-fighting foams used worldwide have discharged toxic substances into the environment, contaminating water supplies and depleting the ozone layer.

# PUTTING OUT FIRES THE GREEN WAY

- A new foam called Pyrocool FEF has now been invented to put out fires effectively without producing the toxic substances found in other fire-fighting materials.



# CHEMICALS FOR DRY CLEANING

- Perchloroethylene ("perc") is the solvent most widely used in dry cleaning clothing.
- Perc is suspected of causing cancer and its disposal can contaminate ground water.



# A SAFER METHOD OF DRY CLEANING

- Liquid CO<sub>2</sub> can be used as a safer solvent if a wetting agent is used with it to dissolve grease.
- This method is now being used commercially by some dry cleaners.



# IN SUMMARY, GREEN CHEMISTRY IS...

- Scientifically sound,
- Cost effective, and
- Leads toward a sustainable civilization.

*PowerPoint adapted from an original by  
The American Chemical Society*



# How **Green** is My **Orange**? Lab

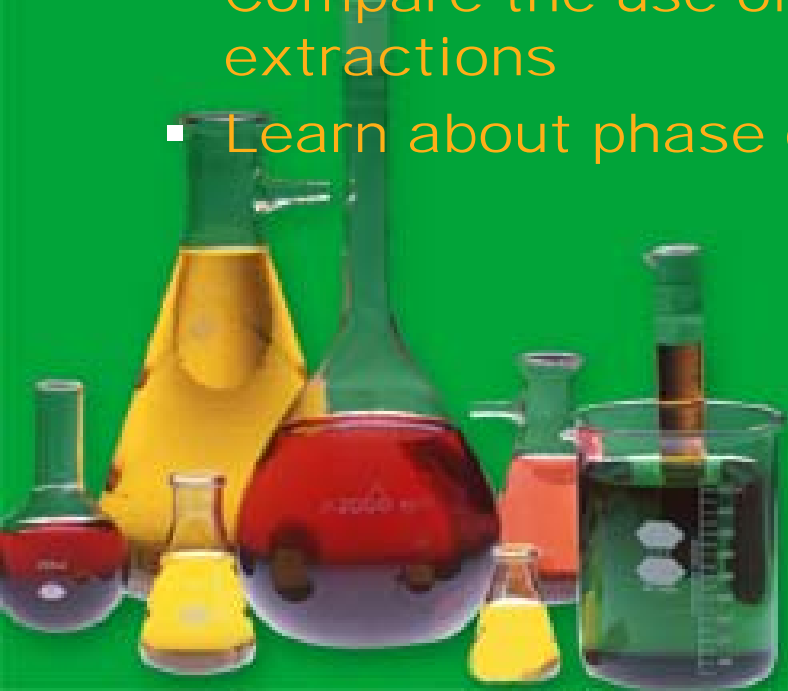
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# Student Objectives

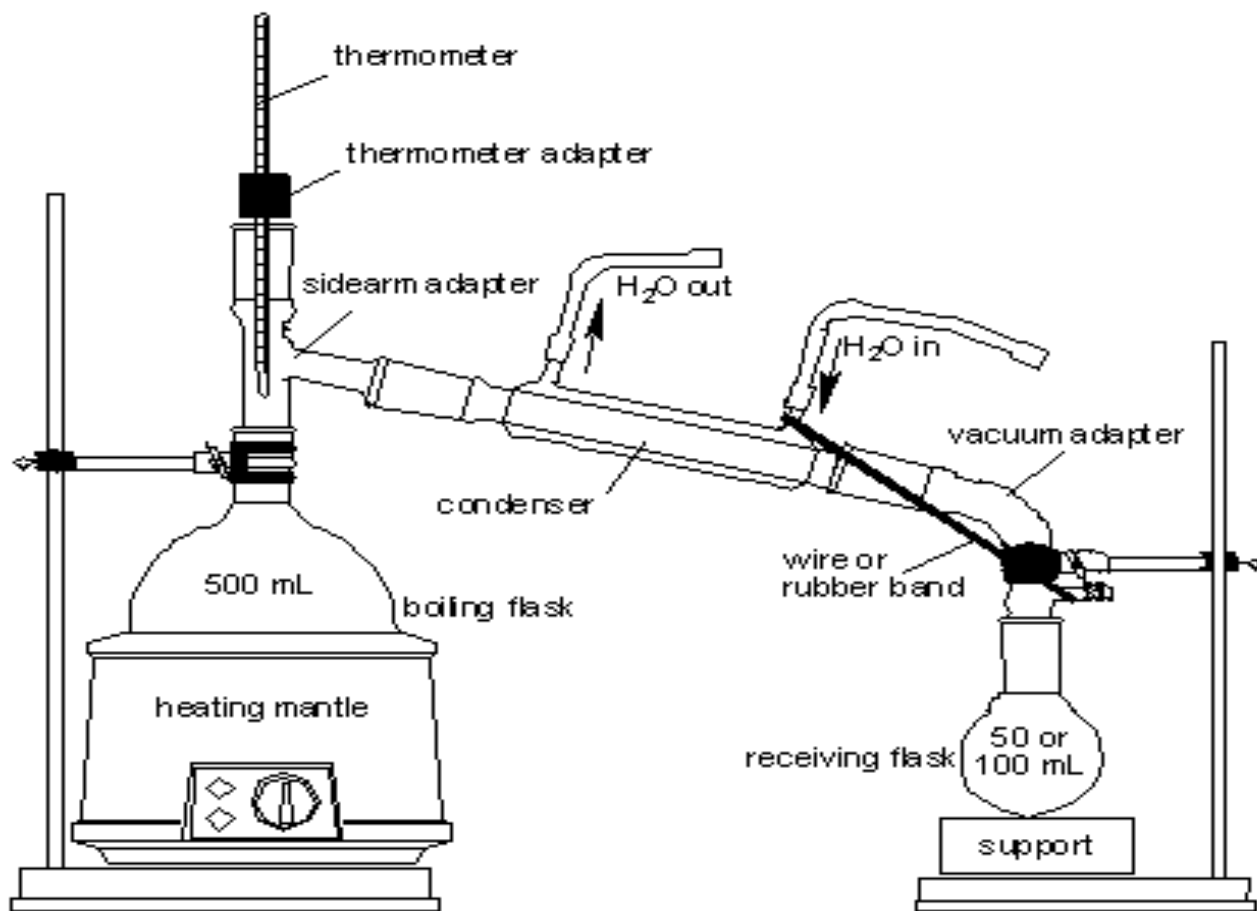
## Students will ...

- Evaluate the process of extracting essential oils from oranges using steam distillation
- Extract essential oils from oranges using supercritical CO<sub>2</sub>
- Compute the use of energy in both extractions
- Compare the use of energy in both extractions
- Compare the use of hazardous chemicals in both extractions
- Learn about phase changes of CO<sub>2</sub>



# STEAM DISTILLATION

Steam distillation is a technique used to isolate or extract compounds at temperatures below their boiling points.



Evaporated compounds are in their gaseous phase when heated, but condense back into their liquid phase when they come in contact with a cold surface (such as a condenser with cold water surrounding it). The compound in liquid form is then collected into a receiving flask.

# SUPERCRITICAL CO<sub>2</sub> EXTRACTION

