

# TODAY'S GOALS

- Water quality
  - Chemistry of water
  - Water quality failure
- At the end of the lecture, we should be able to describe the properties of water and explain how those properties pertain to water quality.

# WATER QUALITY INTRODUCTION

- Water quality
  - The chemical, physical, and biological properties of water that are influenced by geology, climate, local environment, and people.
- The quality required depends on its intended use.
  - Quality: drinking > crop irrigation > industrial cooling

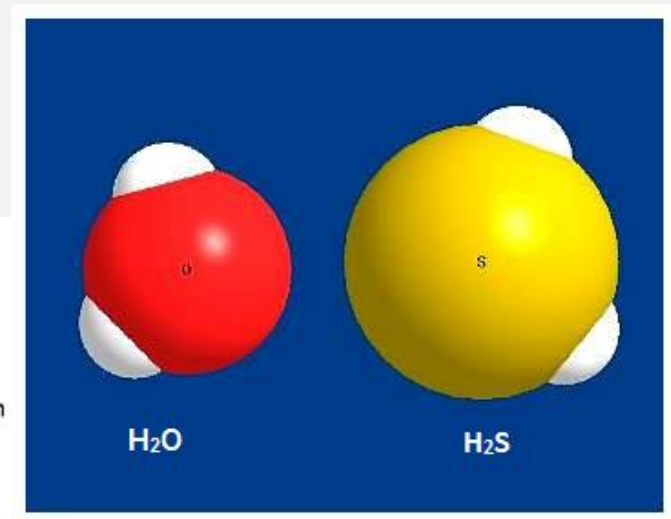
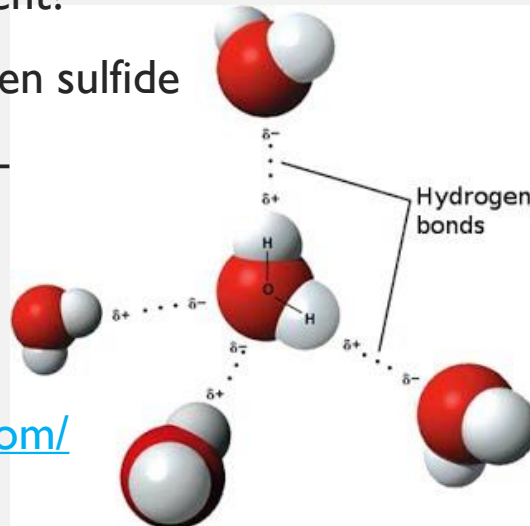
# THE CHEMISTRY OF WATER

- Exists as solid, liquid, and gas without extreme temperature changes – the only common, pure substance on Earth with this property
- Small molecular weight (the sum of the atomic weights of the atoms that form the molecule)

- Molecules with this small molecular weight are usually gases at room temperature.

Why is water different?

- Compare to hydrogen sulfide
- Hydrogen bonding – not a true bond



- <http://www.ptable.com/>

# THE CHEMISTRY OF WATER

- Physical-chemical properties of water
  - Universal solvent: many substances dissolve in it
    - **Hydrophobic** vs **hydrophilic**
      - Hydrophobic examples: fat, oils wax, plastic
      - Hydrophilic examples: alcohol, wood, cotton
  - Density – weight per unit of volume
    - Density of water = 1 gram per milliliter (or cubic centimeter) (1 g/mL)
    - What happens if you mix oil and water?
    - What about water and ice?
      - What if ice did not float?



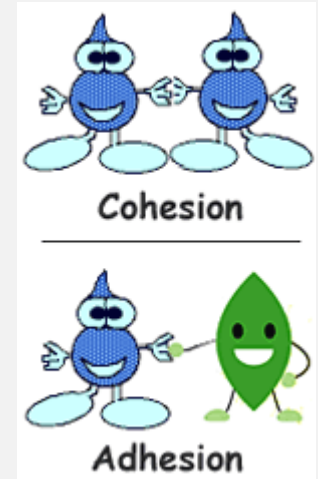
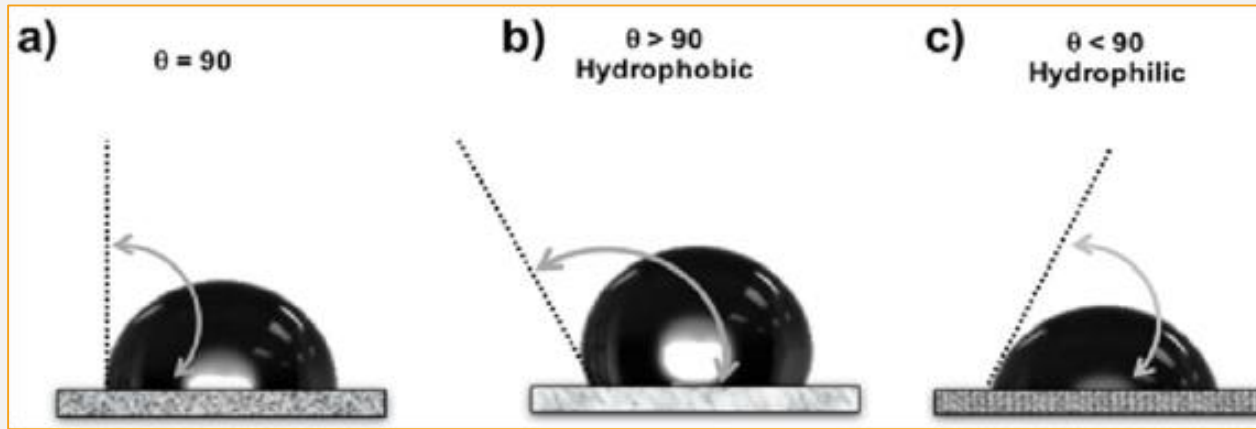
# THE CHEMISTRY OF WATER

- Specific heat capacity
  - A measure of how much heat a substance can store
  - Determined by measuring how much energy is required to raise the temperature of a substance by 1 °Celsius
  - Consider what oceans do for Earth's temperature
  - In other words... water is very skilled at storing energy

<b>MATERIAL</b>	<b>SPECIFIC HEAT</b> (Joules/gram • °C)
Liquid water	4.18
Solid water (ice)	2.11
Water vapor	2.00
Dry air	1.01
Basalt	0.84
Granite	0.79
Iron	0.45
Copper	0.38
Lead	0.13

# THE CHEMISTRY OF WATER

- Cohesion – water molecules are attracted to one another
- Adhesion – water molecules can stick to the surfaces of other things



- Dissolved oxygen
  - Oxygen that moves from the air and dissolves into water
  - Aquatic organisms rely on it for survival

# THE CHEMISTRY OF WATER

	pH Value	Examples
ACIDIC ↑	pH = 0	Battery acid
	pH = 1	Sulfuric acid
	pH = 2	Lemon juice, Vinegar
	pH = 3	Orange juice, Soda
	pH = 4	Acid rain (4.2-4.4) Acidic lake (4.5)
	pH = 5	Bananas (5.0-5.3) Clean rain (5.6)
NEUTRAL	pH = 6	Healthy lake (6.5)
	pH = 7	Milk (6.5-6.8) Pure water
	pH = 8	Sea water, Eggs
	pH = 9	Baking soda
	pH = 10	Milk of Magnesia
	pH = 11	Ammonia
	pH = 12	Soapy water
	pH = 13	Bleach
BASIC ↓	pH = 14	Liquid drain cleaner

- pH – a measure of the acidity or basicity of a substance

- Acid: pH < 7
- Base: pH > 7
- Neutral: pH = 7

- Temperature

- Cold water holds more dissolved oxygen
- Diurnal (daily) and seasonal fluctuations

- Turbidity – clarity of water

- Caused by sediments or phytoplankton



# WATER QUALITY FAILURE

- Human-caused events
  - All pollutions and contaminants – examples include trash (littering) and industrial waste
- Natural events
  - Landslides, floods, erosions, volcanoes
- Point source and non-point source pollution
  - Point sources of pollution are anything that can be identified coming from specific pipe
    - Examples: pipe coming from a factory, oil spill
  - Non-point sources of pollution originate over a larger geographic region
    - Examples: chemicals carried by a river from an unknown source



# WATER QUALITY FAILURE

## 6 Types of water pollutants (continued on the next two slides)

1. Nutrients – an element or compound that is consumed by an organism to grow, repair, or create energy (examples: carbon, nitrogen, phosphorus, oxygen)
  - Nitrogen and phosphorus are the primary nutrient of plants – too much or too little can cause plant death
  - Toxic algal blooms <https://www.youtube.com/watch?v=ojEMeUvao4A>
2. Sediments – matter that settles at the bottom of a body of water
  - Can be a physical blockade clogging drainage
  - Can contain chemicals
  - Blocks sunlight which affects photosynthesis

# WATER QUALITY FAILURE

## 6 Types of water pollutants (continued)

### 3. Chemical/toxic substances

- Pesticide – any substance intended for preventing, destroying, repelling, or lessening the damage of any pest
- Hydrocarbons – long chains of carbons and hydrogens
  - oils, petroleum products
- Heavy metals – any metallic chemical that has a high density and is toxic at low concentrations
  - Mercury, Cadmium, Arsenic, Chromium, Thallium, Lead
  - Tend to bioaccumulate (build up in biological organisms)
- Trace elements – naturally-occurring chemicals that organisms require but are harmful in larger doses
  - Copper, Zinc, Iron, Potassium

# WATER QUALITY FAILURE

## 6 Types of water pollutants (continued)

### 4. Microbiological pathogens – microbes capable of causing disease

- Most common source: fecal matter from improperly or incompletely treated wastewater, animal feedlots, wildlife, livestock, and leaky septic tanks
- Viruses (hepatitis A), Bacteria (cholera, typhoid), Protozoa (amoeba, giardia), and Worms

### 5. Oxygen-depleting organics – organic materials from natural vegetative decay, or from wastewater treatment plant discharge

- Rain washes these materials into lakes and rivers where microbes consume them (requires dissolved oxygen to break down the organic matter into simpler compounds, which reduces dissolved oxygen)

### 6. Heat

- Recall that cold water holds more dissolved oxygen
- Plants and animals have evolved to live within a certain temperature range