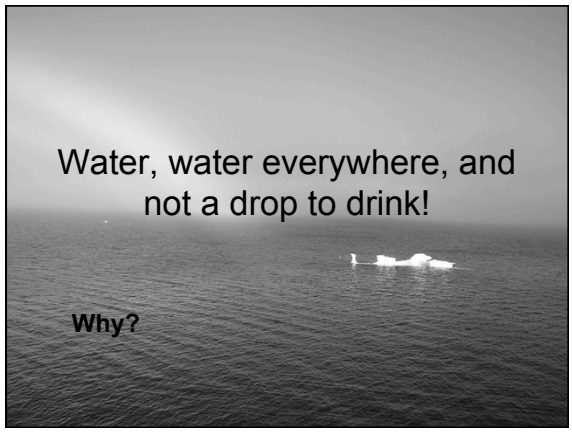
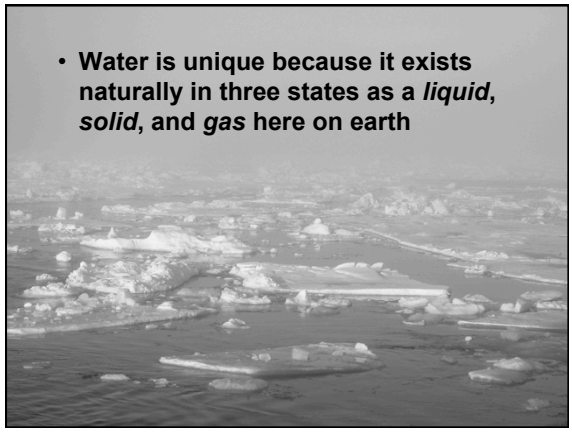
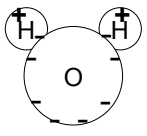




Water is the **Mickey Mouse molecule:**

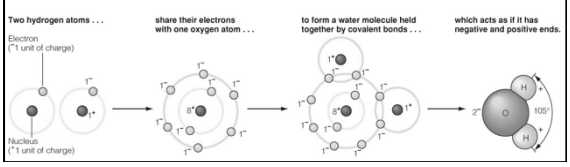


hydrogen has one proton(+) and one electron (-)

oxygen has 8 protons and 8 electrons (remember valence electrons?)

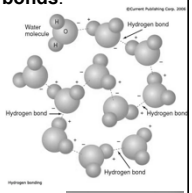
Sharing is caring!

Two hydrogen atoms and one oxygen atom share electrons: ***covalent bond***



Water is a *polar* molecule because it has *positive* and *negative* sides (poles).

The positive side is provided by the hydrogen atoms, so water molecules are held together by **hydrogen bonds**.



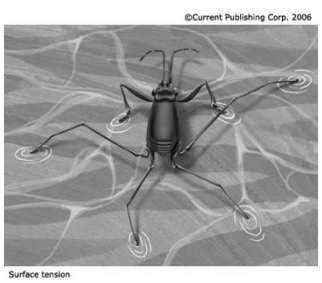
What are the effects of hydrogen bonding?

Cohesion: water sticks together

Adhesion: water sticks to other surfaces

Why is cohesion important to aquatic organisms?

Surface Tension: Cohesion makes water resistant to objects attempting to penetrate its surface (caused by hydrogen bonds holding the water molecules together and creating a skin-like surface)



Halobates sp., a marine insect that walks on water, also known as the "water strider"

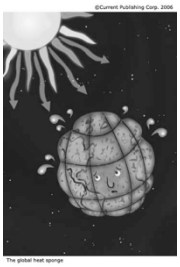
Another effect of hydrogen bonding…

Viscosity: the tendency for a fluid to resist flow; hydrogen bonds tend to make water more viscous, especially as it cools

Water can be a "sticky" place for tiny creatures

Physics of Water

What is the difference between heat and temperature?



Heat is energy produced by the random vibrations of atoms or molecules.

Temperature is an object's response to input or removal of heat.

Heat Capacity is a measure of the heat required to raise the temperature of 1g of a substance by 1°C.

Water has a very high heat capacity, which means it resists changing temperature when heat is added or removed.

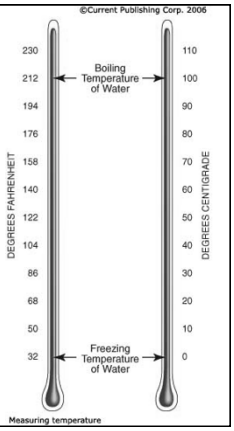
Thermal inertia and thermal equilibrium

- **Thermal inertia** is the tendency for water to resist temperature change.
- **Thermal equilibrium** means water cools at about the same rate as it heats.
- These two properties prevent large temperature changes on Earth (because it is the ocean planet).

A day at the beach: hot feet - cool feet!

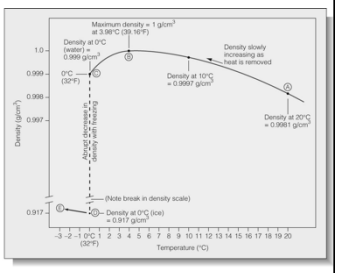
Measuring temperature

– The two most common temperature systems are **Fahrenheit** and **Celsius**. **Celsius is most used in science** because it is based on water's physical properties.



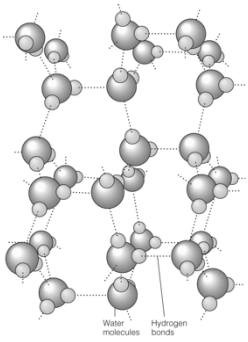
Water's Temperature Affects Its Density

Water is most dense at ca. 4ºC, and becomes less dense as temperature increases above 4ºC or decreases below 4ºC



Note that points C and D both represent 0°C (32°F) but different densities and thus different states of water. Ice floats because the density of ice is lower than the density of liquid water.

Water Becomes Less Dense When It Freezes



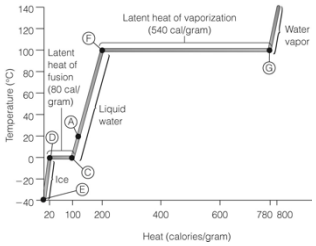
The lattice structure of an ice crystal, showing its hexagonal arrangement at the molecular level.

The space taken by 24 water molecules in the solid lattice could be occupied by 27 water molecules in liquid state, so water expands about 9% as the crystal forms.

Because molecules of liquid water are packed less efficiently, ice is less dense than liquid water and floats.

Temperature versus heat

For water to evaporate, heat must be added to water in the liquid state. After water reaches 100°C, an input of 540 cal/gram is required to break the hydrogen bonds and allow evaporation.



The amount of energy required to break the bonds is termed the **latent heat of vaporization.**

What other property of seawater affects density?

What is Salinity?

Total dissolved salts (ions)

About 3.5% of most ocean water consists of dissolved salts; salinity is measured as parts per thousand, abbreviated ‰ (e.g.,35‰).

Water is called the *Universal* ***Solvent***

Why?

Polar characteristics of water “pull apart” other molecules such as NaCl into charged ions

Na^+

Cl^-

Note that sodium chloride is a **solute**

Effects of dissolved salt in water?

Less heat required to raise temperature

Decreased freezing temperature

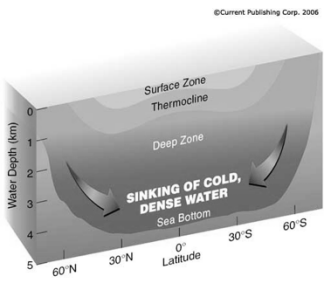
Electrical conductivity

More salt=greater density

Gravity forces water of different densities to form layers

Density layers. Temperature and salinity affect water density causing **stratification**.

Three common layers.
Surface Zone
Thermocline
Deep Zone



The Ocean Is Stratified into Three Density Zones by Temperature and Salinity

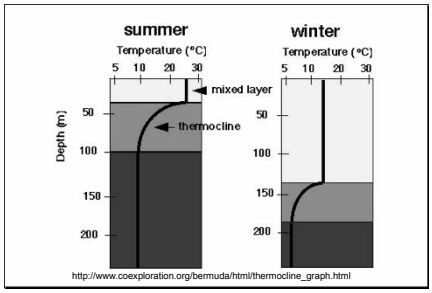
- The ocean is divided into three density zones
- **Surface zone** – the upper layer of the ocean, containing the least dense water. The surface zone is only about 2% of total ocean volume.
- **Pycnocline** – a zone in which density increases with depth, containing about 18% of all ocean water
- **Deep zone** – contains about 80% of all ocean water. There is little change in density throughout this layer.

Stratification (layering)

A **pycnocline** caused by temperature change is a **thermocline**

A pycnocline caused by a salinity change is a **halocline**

Thermocline - a transition between a colder, deep water layer and a warmer upper layer of water.

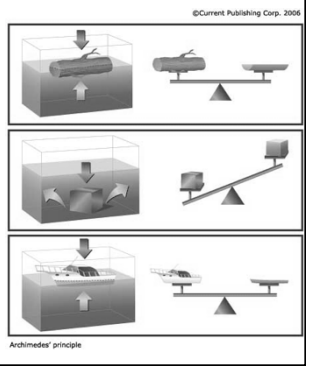


Density and Buoyancy

The greater the density of a fluid, the greater the buoyant force it exerts on an object immersed in the fluid.

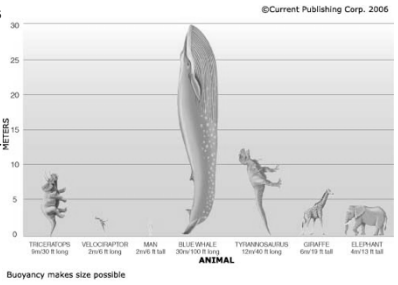
Buoyancy

- An object immersed in a gas or liquid (any fluid) is buoyed up by a force equal to the weight of the gas or liquid displaced. This is known as *Archimedes Principle.*



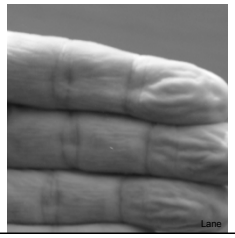
Buoyancy

Buoyancy makes size possible. Larger animals can live in the sea than on land because the buoyancy of water reduces the effect of their weight (counteracting gravitational pull).

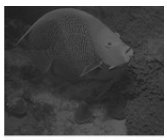


Buoyancy of Small Organisms?

- Small organisms (e.g., plankton) sink very slowly, especially through a **pycnocline**.
- Why might this be an important concept?

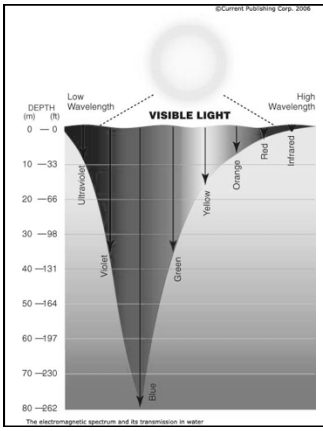


Light and Sound in the Ocean



Refraction Can Bend the Paths of Light and Sound through Water

- Sound and light both travel in waves:
  - **Refraction** is the bending of waves, which occurs when waves travel from one medium to another.
- Scattering and absorption weaken light:
  - Scattering - light is bounced between air and water molecules, dust and other objects.
  - Absorption – light energy is converted to heat in the molecules of seawater.



Green blood on the reef?

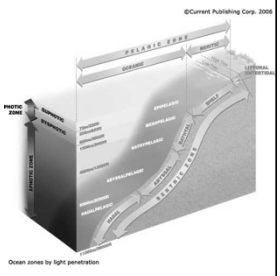
Water absorbs low energy reds faster than high energy blues.

Ocean Zones by Light Penetration

Euphotic zone: "good light" – near-surface zone where photosynthesis occurs

Dysphotic zone: "weak light"

Aphotic zone: no light, total darkness



Sound

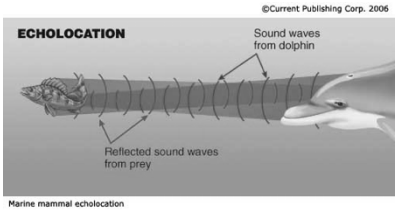
Male humpback whales “sing” during mating season

Marty Snyderman

Singing humpback whales

Does sound travel faster underwater than through air?

- About 5 times faster



Marine mammal echolocation

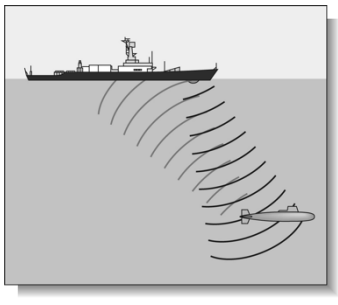
Sonar Systems Use Sound to Detect Underwater Objects

The principle of active sonar.

Pulses of high-frequency sound are radiated from the sonar array of the sending vessel.

Some of the energy of this ping reflects from the submerged submarine and returns to the sending vessel.

The echo is analyzed to plot the position of the submarine.



Sonar Systems Use Sound to Detect Underwater Objects

Side-scan sonar in action. Sound pulses leave the submerged towed array.