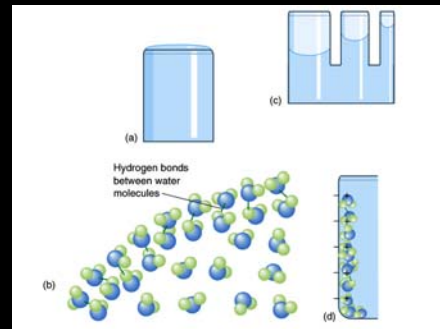
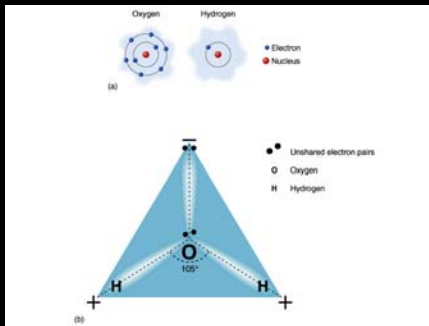


# Chapter 6- Water!

## Unique Properties of Water - *high surface tension*

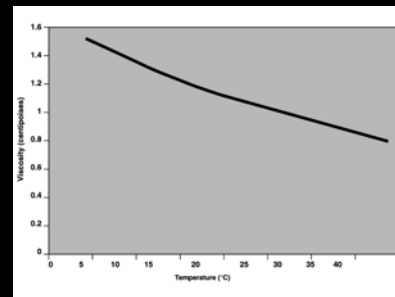


Water - A tetrahedral structure.  
But why is bond angle 105 instead of theoretical 109.5?

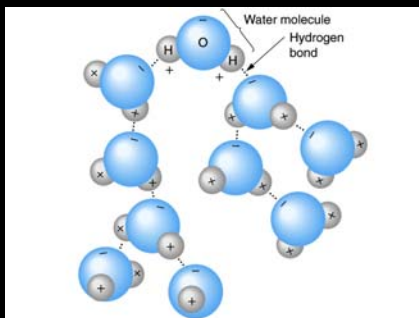


## Unique Properties of Water - *Viscosity*

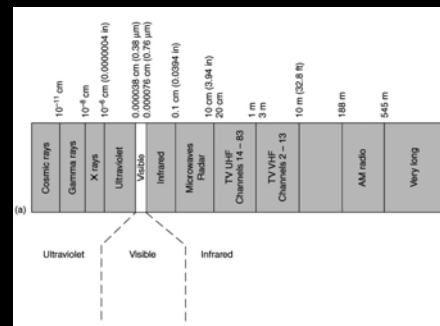
How does viscosity change with *T*, Salinity, and Pressure?



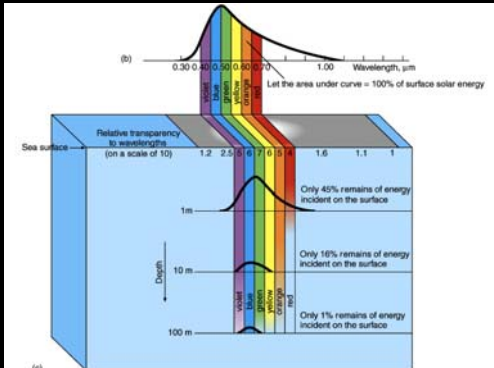
The secret behind some of water's unique properties is the  
"Charge Distribution --- Polarity"  
Leads to Hydrogen Bonding



## Unique Properties of Water - *Light Transmission*



**Unique Properties of Water -  
Light Transmission with Depth**



*There are two distinct types of SeaWiFS data,  
**LAC and GAC***

**GAC** (Global Area Coverage)  
data results from global measurements  
by satellite, obtained at 4 km resolution  
over most of the world's oceans

**LAC** (Local Area Coverage)  
data is at 1 km resolution,  
and is available for specific regions

**Unique Properties of Water -  
Measurement of Light Transmission with a Secchi Disk**



The concentration and predominant identity of substances and particles in the euphotic (lighted) zone of the upper ocean influences the apparent color of the ocean, which can range from deep blue to varying shades of green and ruddy brown.

1. **Living phytoplankton (which contain chlorophyll and associated photosynthetic pigments),**
  2. **inorganic sediments,**
  3. **detritus (particulate organic matter), and**
  4. **dissolved organic matter**
- all contribute to the color of the ocean.

**What is "Ocean Color Data"?**

**Sea-Viewing Wide Field of View Sensor  
(SeaWiFS)  
is an outer-spaced based  
spectroradiometer  
(measures radiance in specific bands  
of the visible light spectrum)**

Examples of the use of these data:  
Can study the relationship between ocean currents and biology

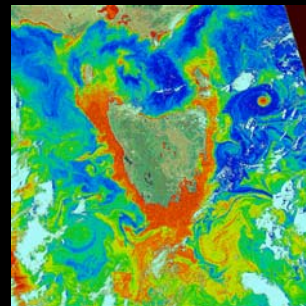
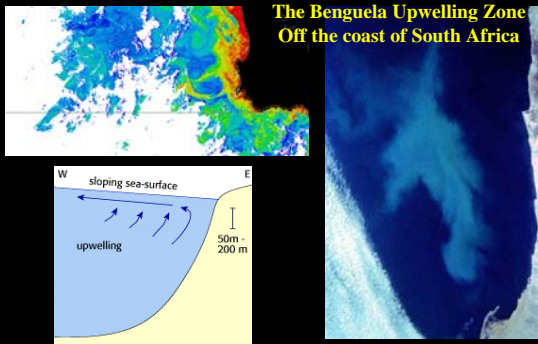


Image of  
Currents around the  
island of Tasmania.

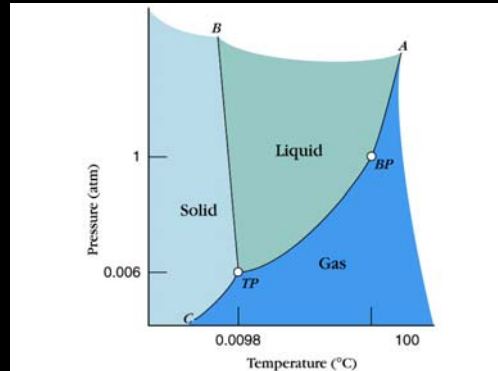
How does a land  
change a current?

Coastal zones are productive  
areas (phytoplankton rich)  
but currents move these  
productive masses elsewhere  
(both large and small scale)

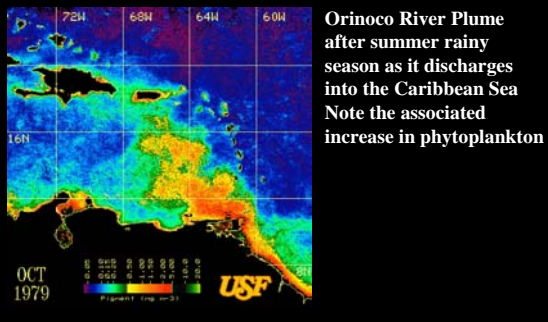
Examples of the use of these data:  
Locating "upwelling" areas



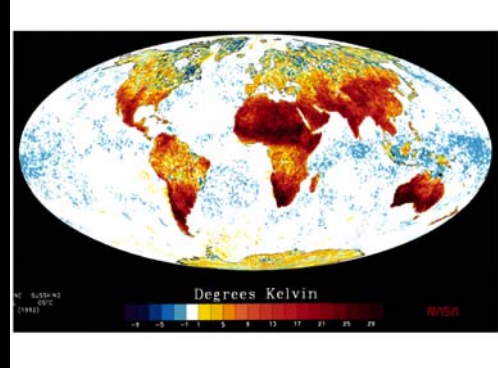
**Unique Properties of Water -  
Heat and Changes of State**



Examples of the use of these data:  
Look at sediment discharges from rivers

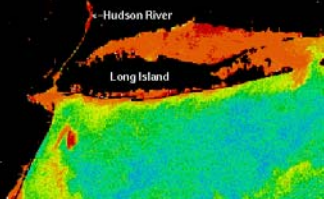


**Unique Properties of Water -  
Very High Heat Capacity**

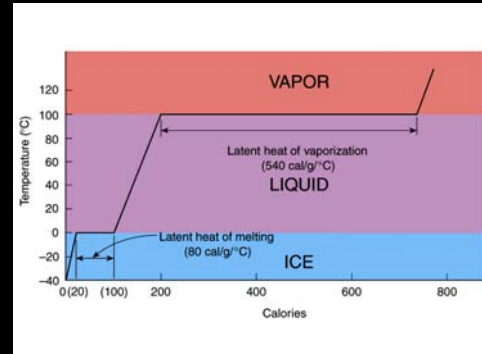


Examples of the use of these data:  
Ocean Pollution

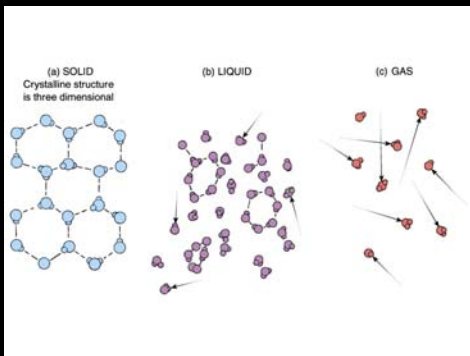
Discharge of wastes (nutrients) can be spotted off the coast of NJ (hook - shaped zone)



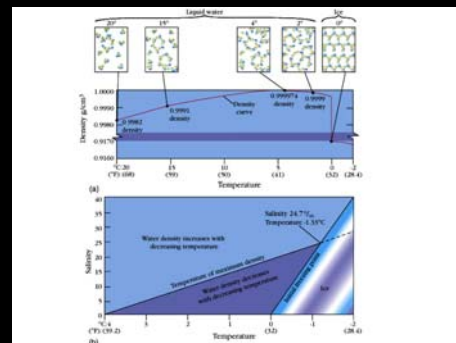
**Unique Properties of Water -  
Latent Heats of Melting and Vaporization**



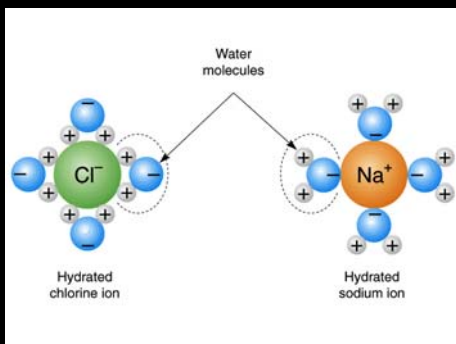
### Unique Properties of Water - Ice Floats (Thank Goodness)



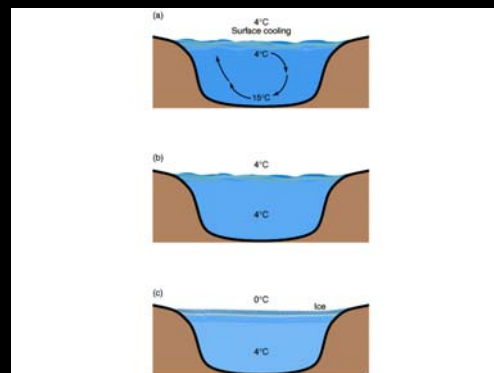
### Water Density and Temperature



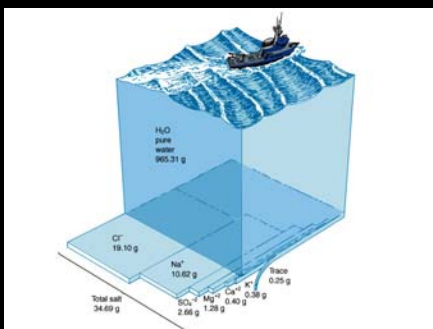
### The Dissolving Power of Water: Hydration Spheres



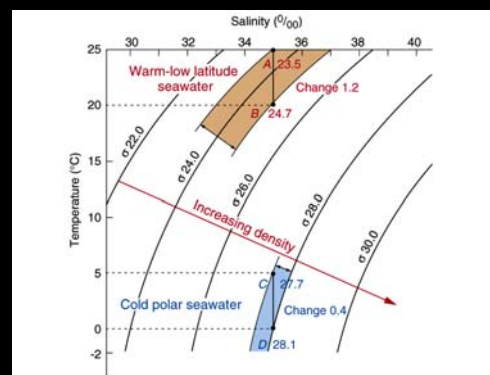
### Thermal Stratification in Lakes



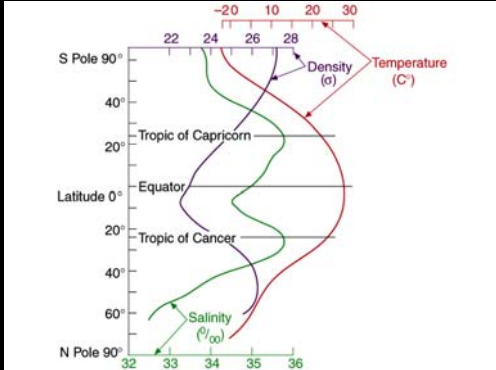
### Salinity: The amount of dissolved solids in seawater



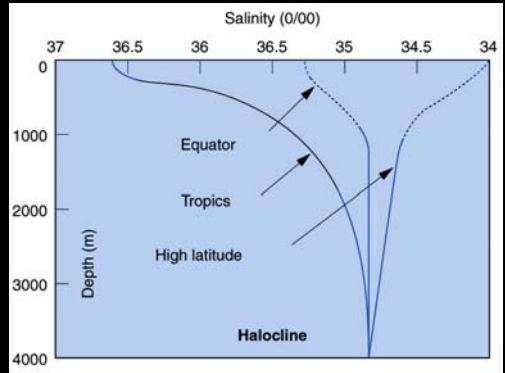
### SW Density Variations with Temp and Salinity



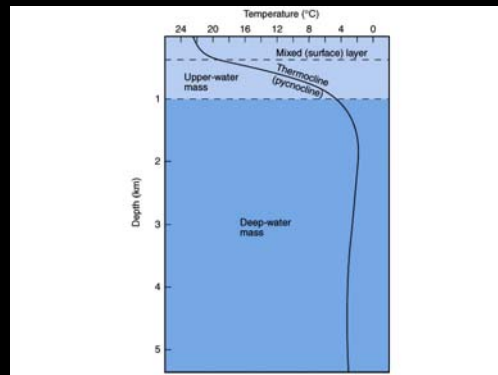
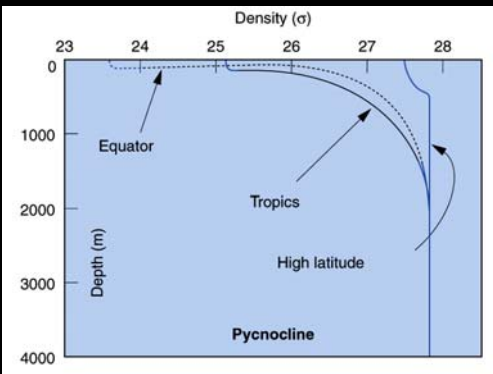
**T, S, and Density of Surface Seawater by Latitude**



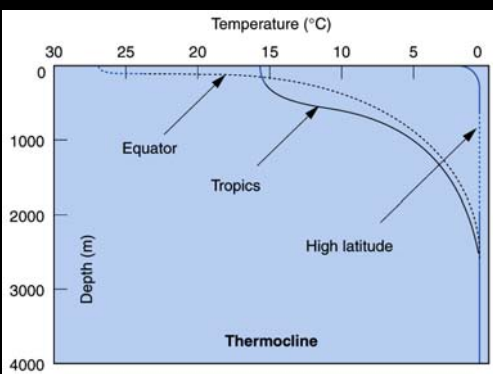
**SW Salinity Variations with Depth at Different Latitudes**



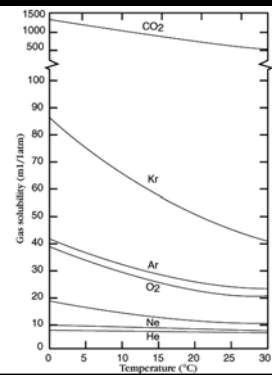
**SW Density Variations with Depth at Different Latitudes**

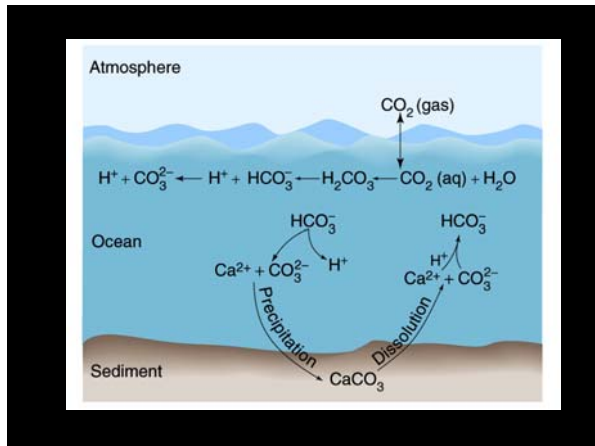


**SW Temperature Variations with Depth at Different Latitudes**



**Solubility of Gases in SW with Temperature**

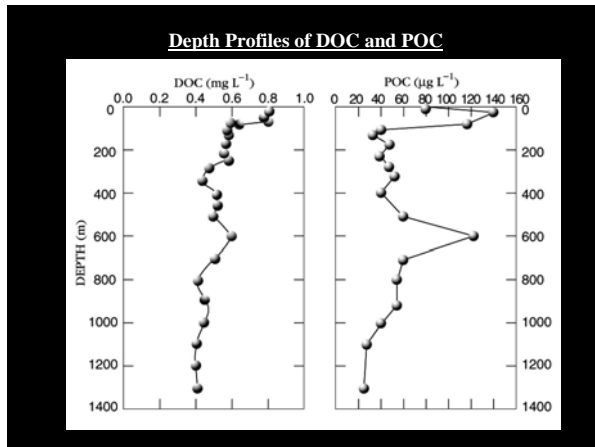




**TABLE 7-2** Composition of average rain and river water.

Ion	Rain (mg/L)	Rivers (mg/L)
Na <sup>+</sup>	0.2 – 1	5.2
Mg <sup>2+</sup>	0.05 – 0.5	3.4
Ca <sup>2+</sup>	0.1 – 3.0	13.4
K <sup>+</sup>	0.1 – 0.3	1.3
Cl <sup>-</sup>	0.2 – 2	5.8
SO <sub>4</sub> <sup>2-</sup>	1 – 3	5.3
HCO <sub>3</sub> <sup>-</sup>	trace	52.0
SiO <sub>2</sub> (aq)	trace	10.4
<b>Total</b>	<b>1.7–9.8</b>	<b>99.6</b>

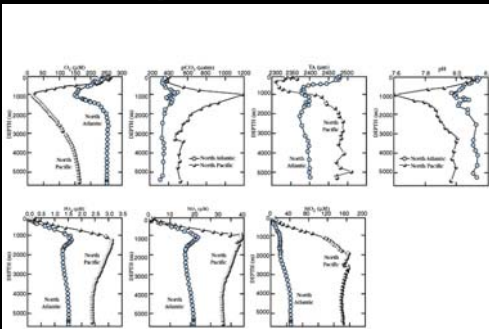
(from Berner and Berner, 1996, *Global Environment: Water, Air and Geochemical Cycles*. Upper Saddle River: Prentice Hall, Inc.)



**TABLE 7-1** Composition of seawater.

Ion	% (by weight)	g/1000 g seawater (%)
Na <sup>+</sup>	30.66	10.77
Mg <sup>2+</sup>	3.65	1.29
Ca <sup>2+</sup>	1.17	0.41
K <sup>+</sup>	1.13	0.40
Sr <sup>2+</sup>	0.023	0.008
Cl <sup>-</sup>	55.02	19.35
SO <sub>4</sub> <sup>2-</sup>	7.71	2.71
HCO <sub>3</sub> <sup>-</sup>	0.30	0.12
Br <sup>-</sup>	0.19	0.067
CO <sub>3</sub> <sup>2-</sup>	0.046	0.016
B(OH) <sub>4</sub> <sup>-</sup>	0.023	0.008
F <sup>-</sup>	0.004	0.0014
OH <sup>-</sup>	0.0004	0.0001
B(OH) <sub>3</sub>	0.055	0.019
Trace components	0.02	0.007
<b>Total</b>	<b>100</b>	<b>35.0</b>

**Depth Profiles of DO, CO<sub>2</sub>, pH, Alkalinity, Phosphate, Nitrate and Silicate**



**TABLE 7-3** Common weathering reactions and hydrothermal reactions on the sea floor.

Weathering Reactions
$2\text{H}_2\text{CO}_3 + 9\text{H}_2\text{O} + \text{NaAlSi}_3\text{O}_8 \Rightarrow \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + 2\text{Na}^+ + 2\text{HCO}_3^- + 3\text{H}_4\text{SiO}_4$
carbonic acid + water + albite feldspar $\Rightarrow$ kaolinite clay + dissolved sodium + bicarbonate + silicic acid
$\text{H}_2\text{CO}_3 + \text{CaCO}_3 \Rightarrow \text{Ca}^{2+} + 2\text{HCO}_3^-$
Carbonic acid + calcite $\Rightarrow$ dissolved calcium + bicarbonate
Hydrothermal Reactions
$\text{CaAl}_2\text{Si}_2\text{O}_8 + 2\text{H}^+ + 4\text{SiO}_2 \Rightarrow 2\text{NaAlSi}_3\text{O}_8 + \text{Ca}^{2+}$
Anorthite Feldspar + dissolved sodium + dissolved silica $\Rightarrow$ albite feldspar + dissolved calcium
$3\text{Mg}^{2+} + 2\text{CaAl}_2\text{Si}_2\text{O}_8 + 2\text{H}_2\text{O} \Rightarrow \text{Mg}_3\text{Si}_2\text{O}_7(\text{OH})_4 + 2\text{Al}_2\text{O}_3 + 2\text{Ca}^{2+} + 2\text{H}^+$
dissolved magnesium + anorthite feldspar + water $\Rightarrow$ talc + aluminum oxide + dissolved calcium + acid
$2\text{Mg}^{2+} + 2\text{SO}_4^{2-} + 11\text{Fe}_2\text{SiO}_4 + 2\text{H}_2\text{O} \Rightarrow \text{Mg}_2\text{Si}_2\text{O}_7(\text{OH})_2 + \text{Fe}_5\text{S}_4 + 8\text{SiO}_2 + 7\text{Fe}_2\text{O}_3$
dissolved magnesium + dissolved sulfate + olivine + water $\Rightarrow$ serpentine + pyrite + dissolved silica + hematite

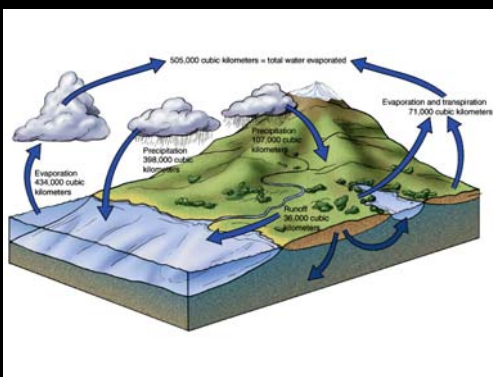
# The Water Cycle (a quick review/overview)

**TABLE 6-2** Annual fluxes between reservoirs

Pathway	Volume ( $10^3 \text{ km}^3 \text{ yr}^{-1}$ )
Atmosphere to ocean	398
Atmosphere to continent	107
Continent to atmosphere	71
Ocean to atmosphere	434
Continent to ocean	36

(Berner and Berner, 1987, 1996; Drever, 1988)

**The Hydrologic Cycle**



**TABLE 6-3** Residence times of water in reservoirs

Reservoir	Residence time (years)
Oceans and sea ice	
Shallow	100's
Deep	1000-2000
Glaciers and land ice	10-1000's
Groundwater	
Extractable	0.003-1000
Deep	10,000's
Lakes	1-3
Rivers	0.03
Soil moisture	0.04-1
Atmosphere	0.0307

(Berner and Berner, 1987, 1996; Drever, 1988)

**TABLE 6-1** Reservoirs of the hydrosphere

Reservoir	Volume ( $10^6 \text{ km}^3$ )	Percent of total
Oceans and sea ice	1400	95.96
Glaciers and land ice	43.4	2.97
Surface waters		
Lakes	0.125	0.009
Rivers	0.0017	0.0001
Subsurface waters		
Groundwater	15.3	1.05
Soil Moisture	0.065	0.0045
Atmosphere	0.0155	0.001
Biosphere	0.002	0.0001
<b>Total</b>	<b>1459</b>	<b>100</b>

(Berner and Berner, 1987, 1996; Drever, 1988)