
Chemical
Properties of
Seawater

Water = only substance to exist naturally in all 3 states of matter!

- Solid (ice)
- Liquid (water)
- Gas (vapor)

Three States of Water

- Heating Water
  - H_2O molecules in constant motion

↑ TEMPERATURE = ↑ MOLECULAR MOVEMENT

  - Evaporation : molecules breaking hydrogen bonds and escaping liquid phase

Three States of Water

- 2. Cooling Water
  - Decrease in temperature = decrease in molecular speed

↓ TEMPERATURE = ↓ MOLECULAR MOVEMENT

  - Cooling = molecules moving slower & packing close together, increasing Density

$$D = \frac{\text{Mass}}{\text{Volume}}$$

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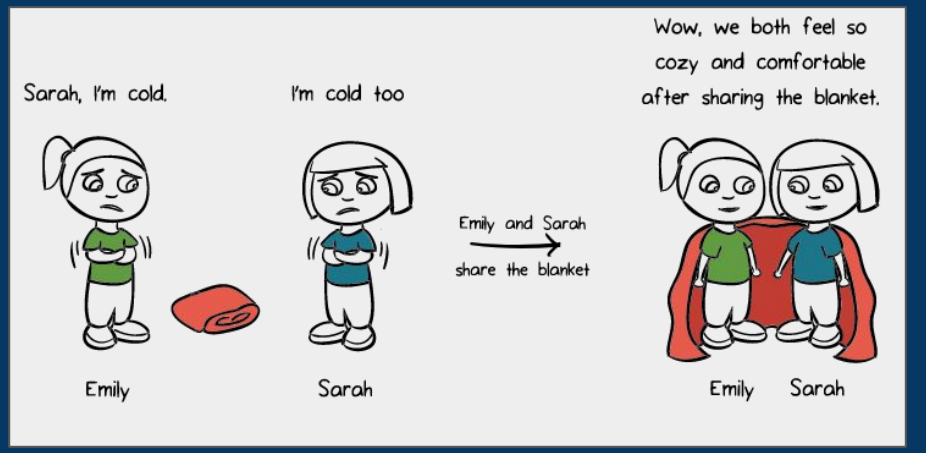
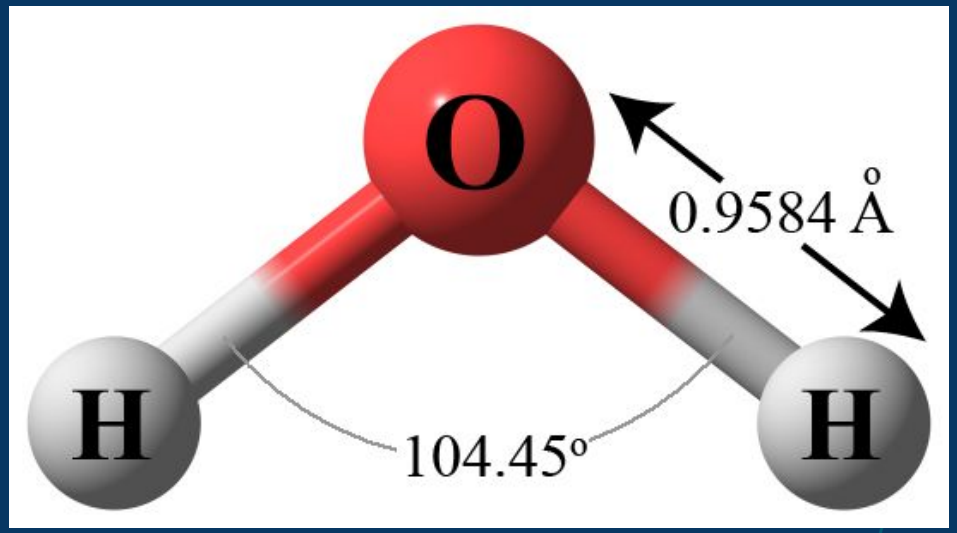
$$\text{Density} = \frac{1\text{g}}{2\text{ml}} = 0.5\text{g/ml} > \text{Density} = \frac{1\text{g}}{4\text{ml}} = 0.25\text{g/ml}$$

Bill Nye Water

Properties of Water

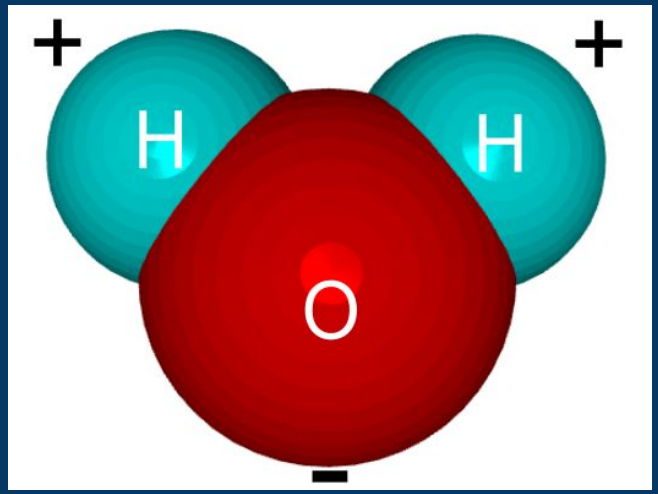
- Structure of Water Affects Properties!!
  - Oxygen covalently bonds to two Hydrogen atoms
  - bond angle of 104.5° between the two H atoms → shapes molecules as a "wide V"
  - this places two H's on one side of the molecule





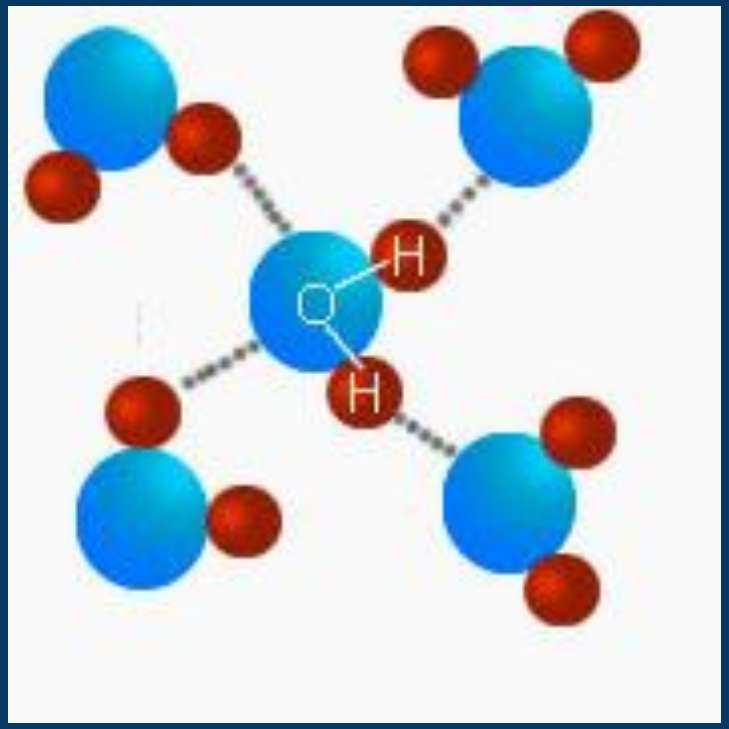
Properties of Water

- 1. **Polarity:**
  - electrons from H are not shared equally with O, due to the electronegative nature of oxygen
  - thus, electrons spend more time near to the O atom, rather than near the H atoms →



  - Oxygen becomes slightly (-) = δ-
  - Hydrogens become slightly (+) = δ+

Properties of Water



- 1. Polarity:
  - results in the formation of **hydrogen bonds** between H's of one molecule, and O's of another
  - the polar nature of water gives it emergent properties that allow life to flourish on Earth

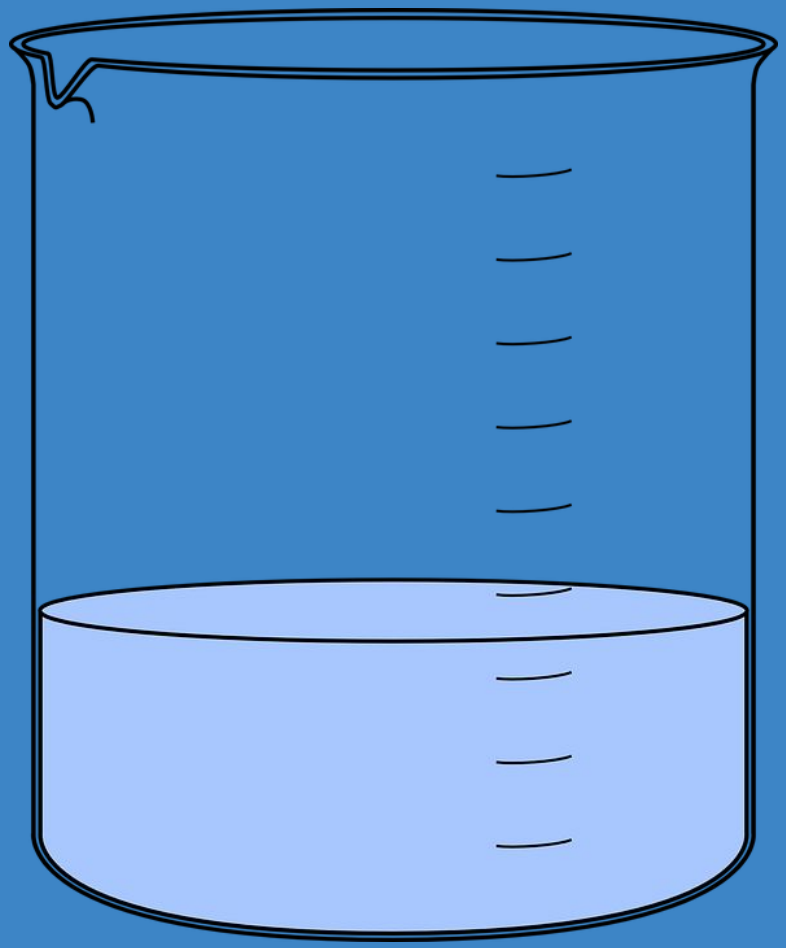
Properties of Water

- 2. Cohesion and Adhesion
  - hydrogen bonds (H-bonds) hold water molecules close together
    - → water attracts itself (cohesion)
    - → water attracts other things (adhesion)
    - this property is exploited by plants, allowing water to be transported (against gravity) up stems to leaves

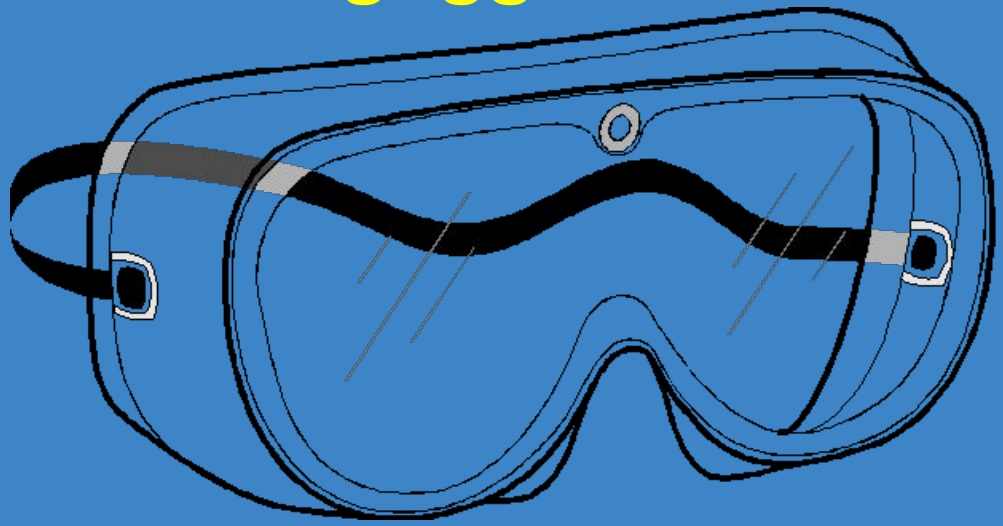
Properties of Water

- 2. Cohesion and Adhesion
  - Surface Tension
    - measure of how difficult it is to break the surface of a liquid
    - at surface, H_2O bonds to other nearby H_2O molecules, as well as to H_2O molecules below
    - creates a thick film at the surface

Surface Tension Demo

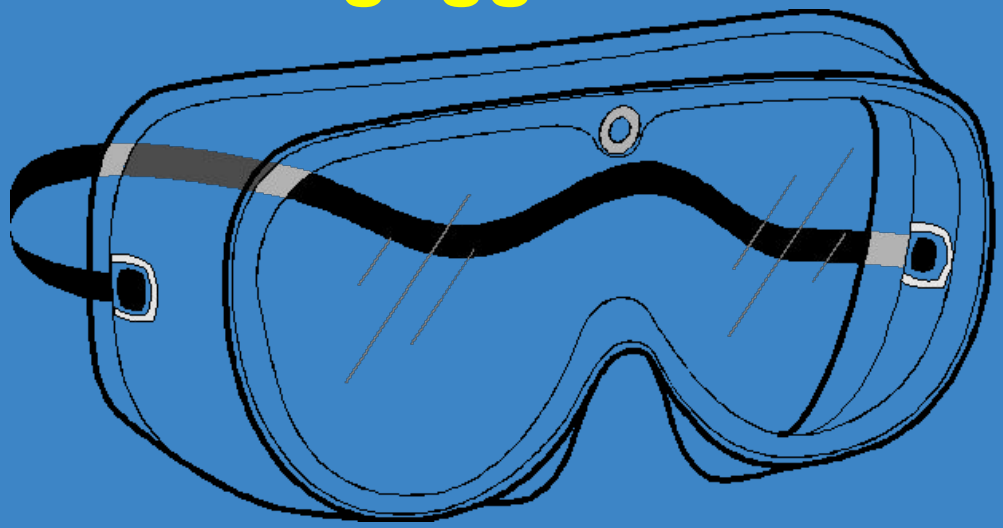


Put on your safety goggles!



Specific Heat Demo

Put on your safety goggles!



Properties of Water

- 3. Moderation of Temperature
  - Water has a High Specific Heat
    - Specific Heat
      - the amount of heat that must be absorbed or lost to change the temperature of 1g of a substance by 1°C

Water absorbs/loses heat slowly, thus it resists temperature change

Properties of Water

- 3. Moderation of Temperature
  - → increased heat, breaks more bonds
  - → decreased heat, forms more bonds
  - Big Picture: resists temp change, large bodies of water can modify local climate by absorbing/releasing heat

Properties of Water

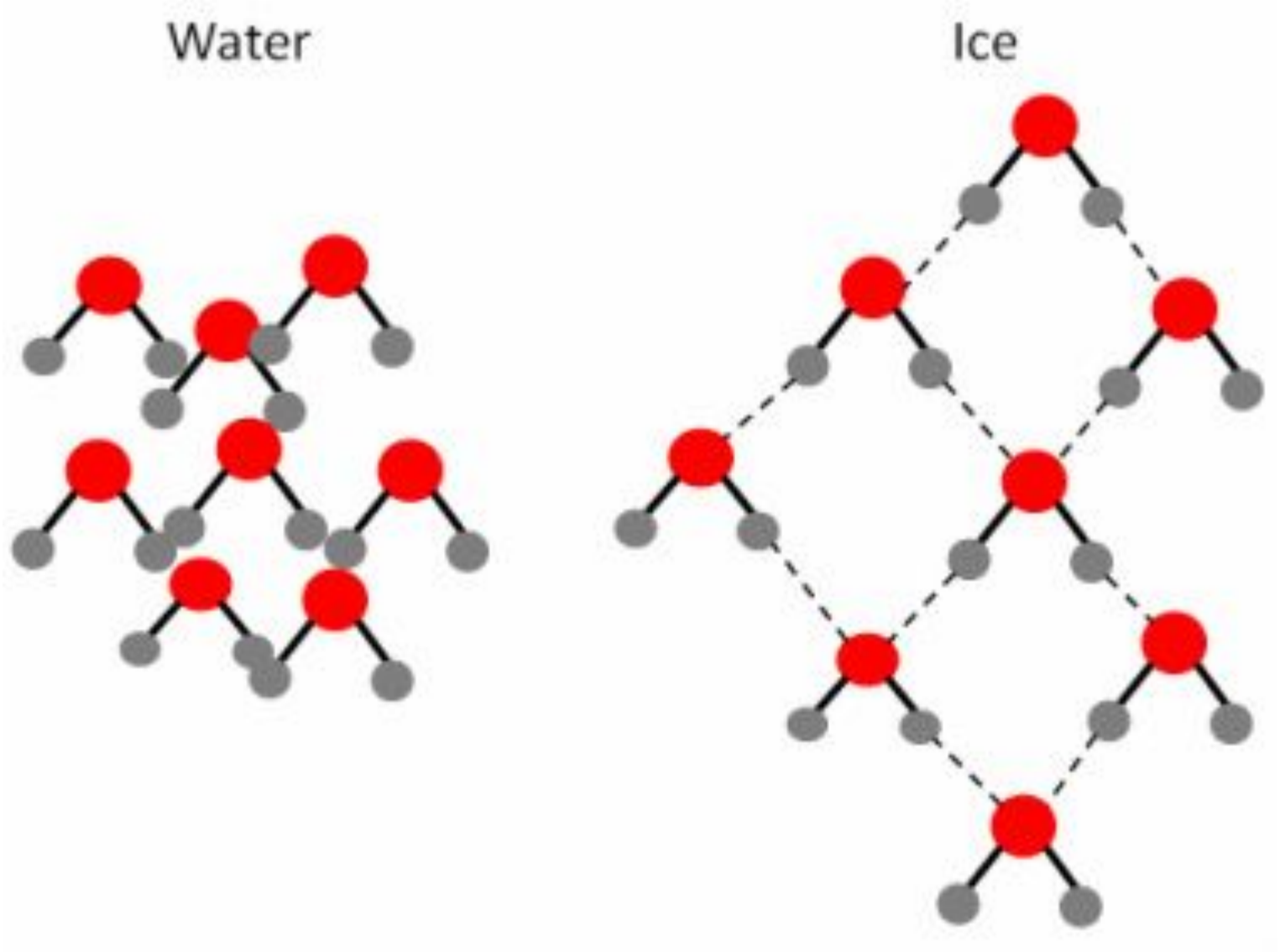
- 4. Expansion upon freezing
  - as water cools, molecular motion slows, resulting in increased H-bonding.
    - at 4°C, water reaches its maximum density – water molecules are as close to each other as they are going to get
    - from 3.9°C - 0°C, H_2O begins to form a hexagonal crystalline lattice (H-bonds become stable, lose flexibility)
    - spacing between H_2O molecules increases → lower density compared to density at 4°C (approx. 10% less dense)
    - thus, solid water (ice) floats in liquid water
    - ice acts as an insulator, preventing the total solidification of large bodies of water

How does aquatic life survive in extremely cold conditions?

When the temperature of atmosphere falls below 0°C, the water at the surface gradually freezes to ice, but the water under the ice layer remains at 4°C.

ICE WITH LONGER HYDROGEN BONDS

Ice formation



Properties of Water

- 5. Water is a universal solvent
  - "like dissolves like"
    - polar substances dissolve polar substances
    - non-polar substances dissolve non-polar substances
    - Polar substances will NOT dissolve non-polar substances

Check Your Understanding:

1. What are the five properties of water that are affected by the structure of a water molecule?

2. Why is it important to aquatic organisms that water has a high specific heat?

1. Start Unit 3 Vocab

OR

2. Make up your Unit 2 Test from Friday if you were absent

Buoyant Boats Lab

- Pages 31-32 in NB
- Pre- Lab
- Copy Data Table in notebook
- Answer Conclusion questions in complete sentences

Water Relationships #1

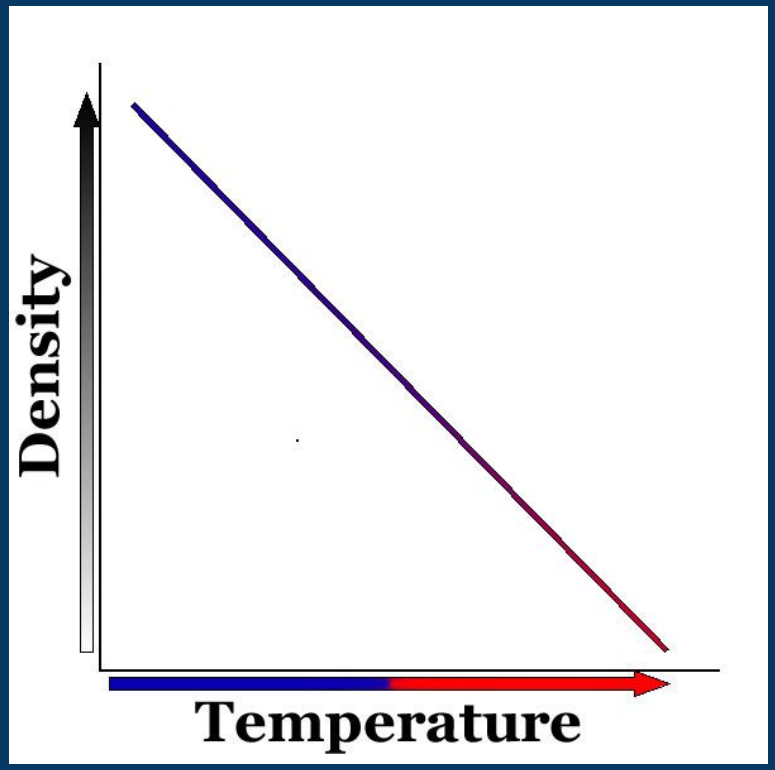
1. Density & Salinity: **DIRECTLY PROPORTIONAL**
   - Increasing salinity increases density
   - Why? *Increasing the amount of dissolved material increases mass, but volume stays same*

Density

Salinity

Pure water has a density of 1.0 g/ml. Average density of ocean water at the surface is 1.025 g/ml.

Water Relationships #2



Proportional relationship true until water becomes ice

2. Density and Temperature: **INDIRECTLY PROPORTIONAL**

- Temperature greatly affects the density of water
- *Review: Decrease in temperature = decrease in molecular speed*
- *Cooling down causes molecules to pack closer together, reducing volume, and thus, increasing density*

Water Relationships

Review: temperature affects density of water
Review: salinity affects density of water

- Temperature in open ocean varies between 28° to 86°F

At what temperature does pure water freeze?

Salt lowers the freezing point of water!!!!

How can ocean water be 28° and still liquid??

Water Relationships #3

3. Density and Buoyancy
   - **Buoyancy:** upward force exerted by a fluid that opposes the weight of an immersed object
   - The more dense the liquid, the more force it exerts upward

Example: The Dead Sea or Great Salt Lake
Dead Sea Float

Bowling Ball

Recap:

- Describe the shape of water:
- Water's shape contributes to its properties:
  - 1. Polarity
  - 2. Adhesion/Cohesion
  - 3. Moderation of temperature
  - 4. Expansion upon freezing
  - 5. Universal solvent

Check Your Understanding

The density of water is related to its characteristics.

- If you _____ salinity, you _____ density.
- If you_____ temperature, you _____ density.
- If you _____density, you _____ buoyancy.

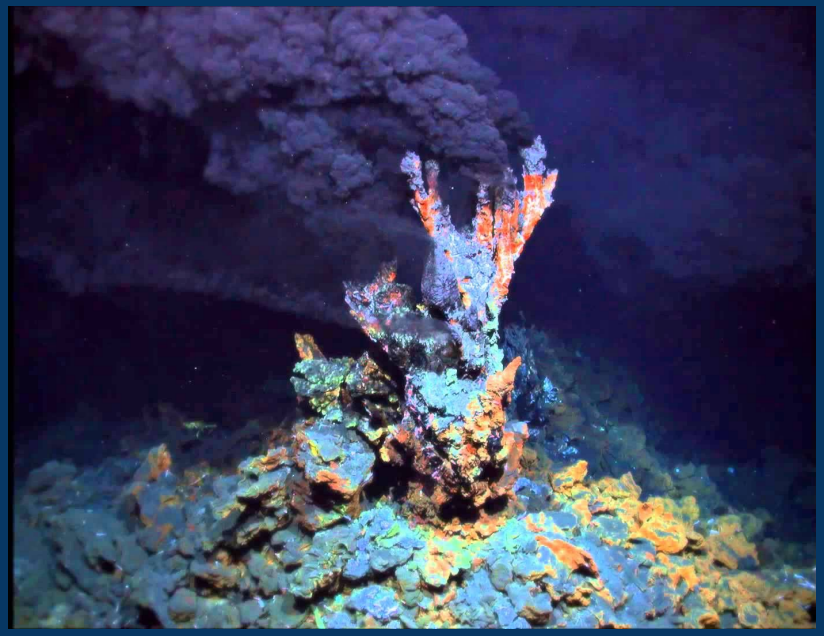
Seawater

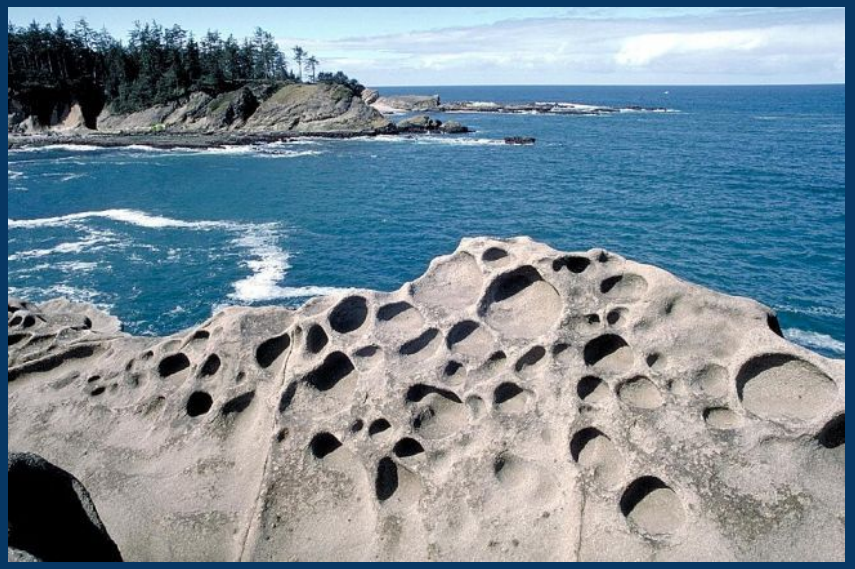
- Six ions make up the 99% of dissolved solids in seawater
  - Sodium Na^{+}
  - Magnesium Mg^{+}
  - Calcium Ca^{2+}
  - Potassium K^{+}
  - Chloride Cl^{-}
  - Sulfate SO_4^{2-}

Cations – positive charges
Anions – negative charges

Seawater

- Na^+ and Cl^- make up 85% of dissolved solids
- Solids dissolved in seawater present due to…
- Weathering
- Release of minerals at hydrothermal vents



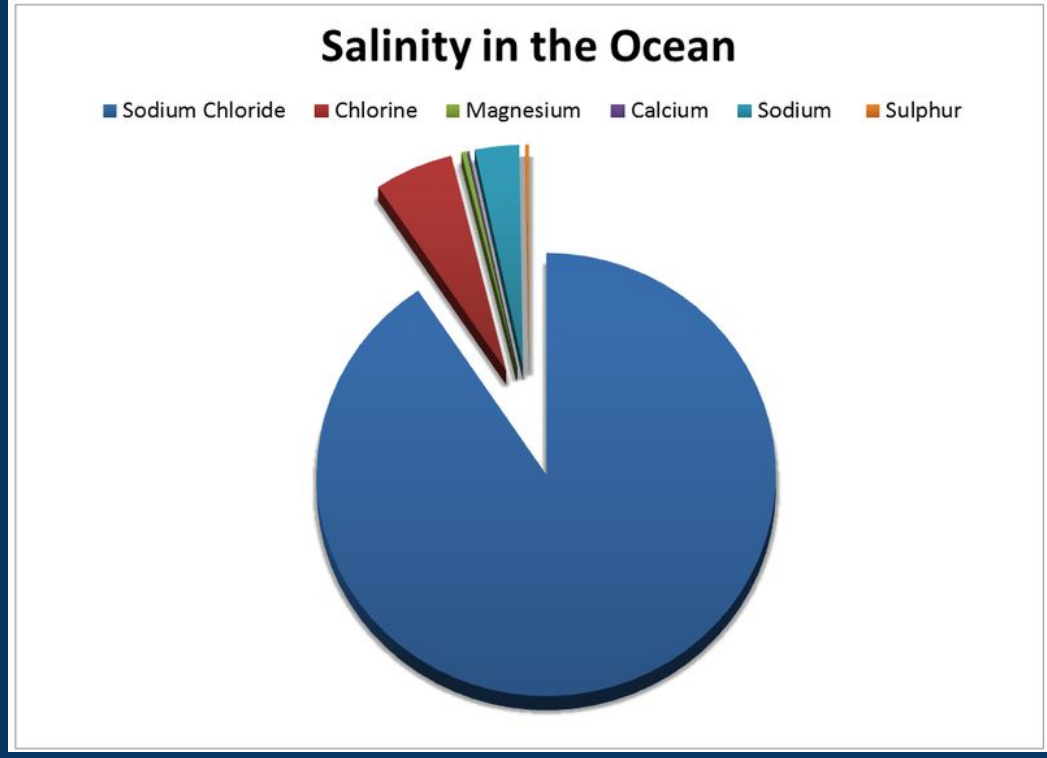


Seawater

Salts enter the ocean through:

- rivers
- chemical reactions in seawater
- volcanic gases
- mid-ocean ridges
- Estimated that salinity of ocean has been same for 1.5 billion years

Seawater



- Thus, salts must be removed at the same rate they are added
  - Rule of constant proportions: the proportions of salts in the ocean remains constant.

Removal of salt

- Sea spray deposits salts on shore
- Land deposits (ocean evaporates)
- Form mineral deposits that sink to bottom

Seawater

- Salinity:
  - total amount of salt dissolved in seawater
  - expressed in PSU (practical salinity units) → same as ‰ (parts per thousand … 1/1000)

- Practice Problem: If we evaporated 1,000 grams of seawater and were left with 35 grams of salt, our seawater's salinity in PSU or parts per thousand would be _____.

35 ‰

Check Your Understanding

1. How does salt enter the oceans?

2. How is salt removed from the oceans?

Dissolved Gases

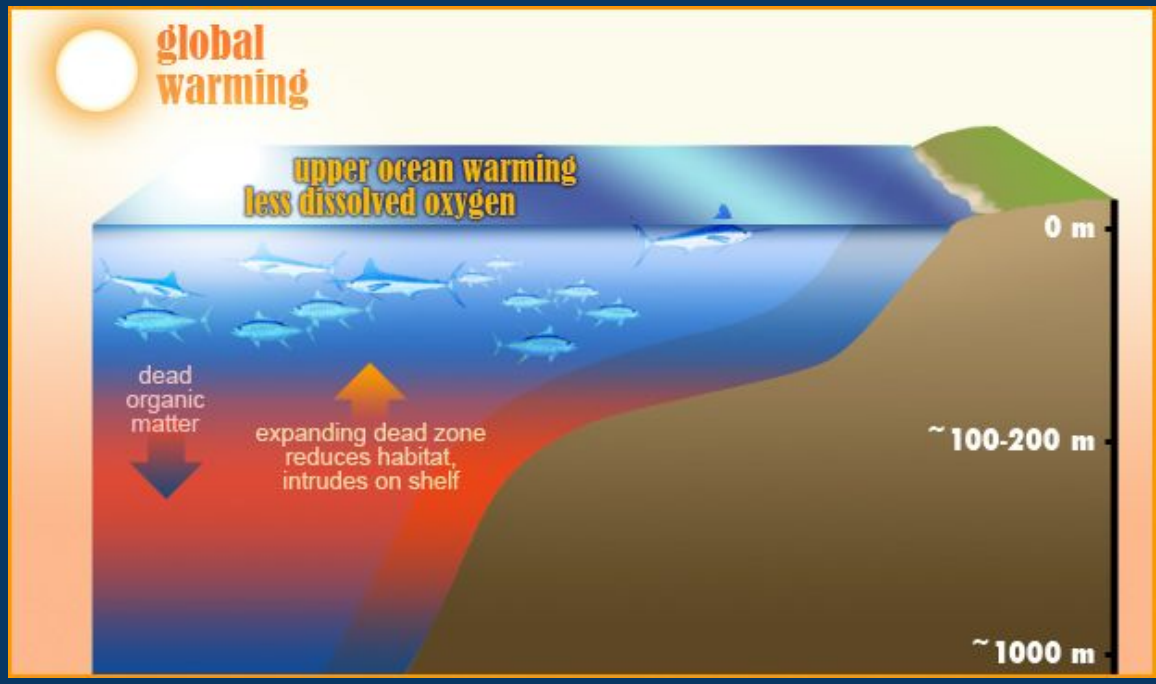
- Saturation Value – amount of any gas that can be held in solution without causing the solution to gain or lose gas
  - Depends on:
    - Temperature
      - Cold water holds more gas than warm water
      - Thus, colder water is more oxygenated than warm water
        - Oxygen can only be added to the ocean at the surface
        - CO_2 enters at surface as well as through respiration and decomposition
    - Salinity
    - Pressure

Dissolved Gases

- Three most important:
  1. O_2
  2. CO_2 (80%)
  3. N_2
- **Oxygen minimum layer**: 1600 ft. deep layer of ocean where levels are virtually zero.

O_2 concentration depends on: photosynthesis and respiration

But life still survives!!!!!!!!!!



Dead Zone Videos

- NOAA Dead Zone
- CBS News Dead Zone

Dead Zone Case Study

- What is a “case study?”
  - Qualitative story focused on research of a specific subject
  - These are used in college sciences a lot!
  - Collaborative
-
- Read and answer the questions about the Dead Zone of the Gulf on pages 81-82 in COMPLETE SENTENCES (!)

Water Clarity

- Clarity- property of water that affects organisms' ability to photosynthesize

Red is absorbed quickly

Blue scatters, reflects

Temperature and Density Lab

- Ice Water and Hot Water are on my front lab station- only need to send one person up

- Write in COMPLETE SENTENCES to answer the questions.

Water Pressure

- On land, we live in 1 atm, or 14.7 psi
- Pressure increases 1 atm with every 10 meters in depth. (an extra 14.7psi with every 33 ft)
- Gases expand and contract with pressure changes

Pressure videos

- Myth Busters Diver Video
- James Cameron
- Free dive

Water Pressure Problems

1. **A cliff diver in Acapulco dives from a 200 ft cliff into the ocean. He is moving so fast that his body plunges to a depth where the pressure on his body is just over 44 psi.**

How far underwater is he?

How many atmospheres are pressing on him?

Water Pressure Problems

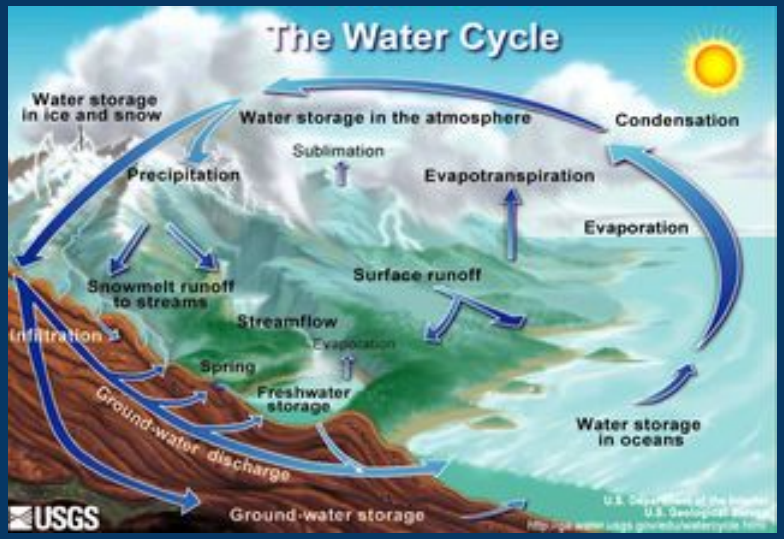
2. **A submarine is planning to make a test dive to a depth of 2,425 feet.**

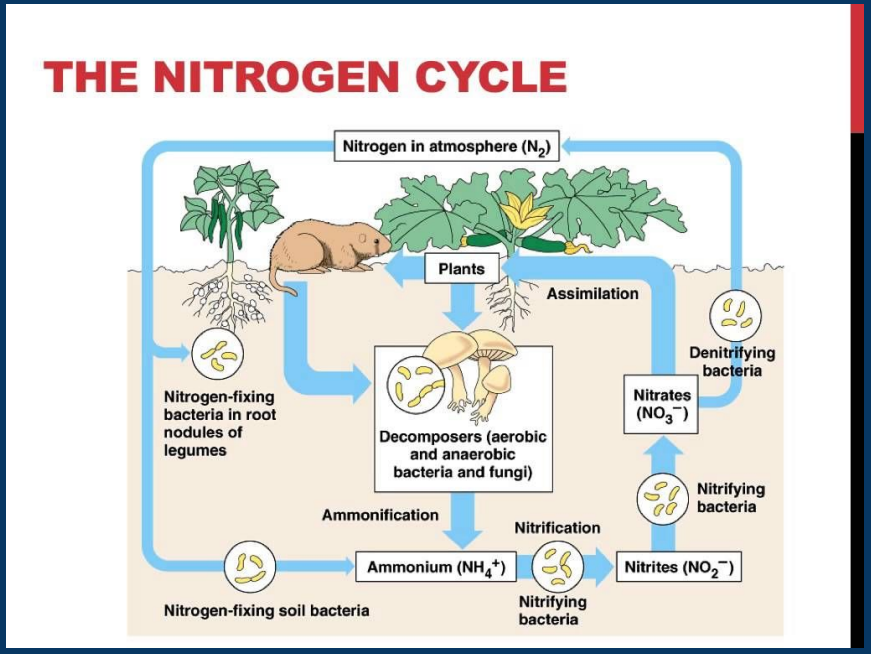
How many atm is that?

What do you think will happen to the sub if its construction can't take the pressure?

Biogeochemical Cycling

- Photosynthesis, Respiration, and Nitrogen cycles provide important substances for life to thrive





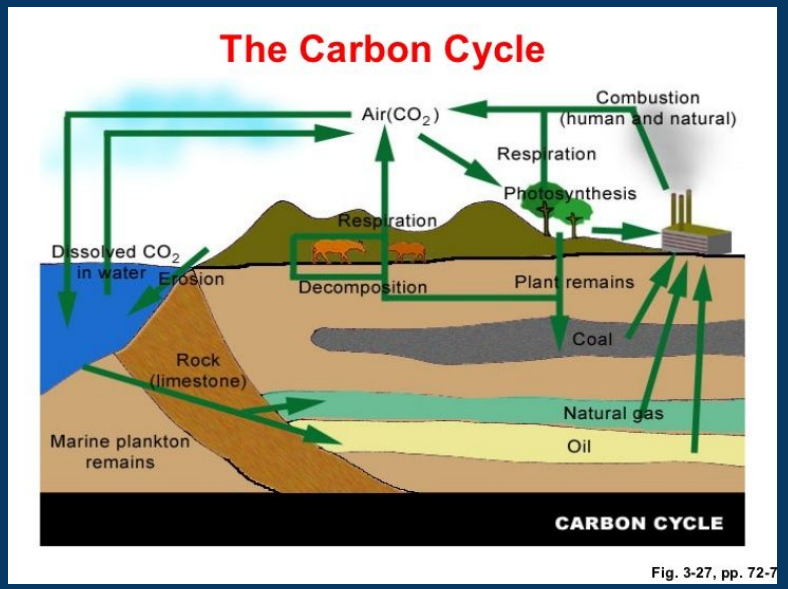


Fig. 3-27, pp. 72-7

TO DO:

1. Update TOC
2. Get Notebook in order
3. Complete Chemical Properties of Water Vocab (finished by end of class)

Chapter Resources/Extra Slides

Review Questions – on a half sheet

- 1. How does the Coriolis effect direct surface currents?
- 2. Describe Ekman transport in relation to the surface winds above the ocean.
- 3. How does the transport of energy by surface currents affect the distribution of life in the world ocean?
- 4. Why are there tides? Does the moon really revolve around the earth?
- 5. How does the position of the sun affect tidal range?
- 6. Describe the differences between semidiurnal, mixed semidiurnal, and diurnal tides.

Wave Investigation

- Design and carry out an experiment that examines the effects water depth and sample length have on wave speed
- Write a set of steps you follow to do so
- Use:
  - Stopwatches
  - 2 sizes of water containers
  - An object that can make a smooth wave

Salinity and Density Lab

- Each group needs:
  - One 25ml graduated cylinder
  - Lab sheet [DO NOT WRITE ON]
  - Calculator
  - Separate paper for recording data, conclusion answers

- Each group will need to:
  - Construct a data table
  - answer Conclusion questions 1-6 (use your textbook)
  - create a bar graph of their data.
  - Answer 2 additional questions:
    - How is salinity measured today?
    - In what units do scientists express ocean salinity?

Salinity/Density Lab

- Copy the mass and volume data table on next slide
- Calculate density to complete the table D=m/v
- Answer the conclusion questions on your own.
- Take about 30 minutes of class time and do this now.

Exit Questions

- Under what conditions might salinity change in the ocean?
- Describe the motion of the water particles in waves
- How does the position of the sun affect tidal range?

Homework – due Friday

http://science.nasa.gov/earth-science/oceanography/physical-ocean/salinity/

1. How does salinity affect movement of ocean currents?
2. Is it true that the ocean stores more heat in its upper meter than the entire atmosphere stores? Why or why not?
3. How can ocean salinity be measured?
4. What factors can affect salinity readings?
5. Where is the saltiest area in the open ocean? Why is it so salty?

Lab 9/18 Salinity and Density

- The purpose of this lab to answer the following questions:
  - How does salinity affect water density?
  - How does salinity affect water movement?
- To answer these questions, you will be calculating the density of saltwater solutions of various concentrations

Tidal Curve Extensions

- What days of the month do you see a quarter moon? Full moon? New Moon?
- Calculate the tidal ranges on these days.
- Do these tidal ranges confirm your estimates?
- What causes tidal bulges on New Moon and Full Moon days?

Label Current Maps ~10 minutes

- Use your textbook pg. 54 to label cool and warm currents (*color code cool vs. warm*)
- Use these terms:
  - Kuroshio
  - North Equatorial (more than once)
  - South Equatorial (more than once)
  - California Current
  - Anarctic Circumpolar Current
  - Peru Current

Oceanography Current Events

- Whale "graveyard" in Chile

Graveyard

Oceanography Current Events

Activity: Model Coriolis Effect

- Lab Sheets
- Droppers with colored water
- Paper plates
- Scissors
- 25 minutes to complete

Wind Patterns

- Hot air from equator rises
- **Nearby air rushes in to replace it = trade winds**
- Examples of other wind zones:
  1. Polar easterlies
  2. Westerlies

Help drive ocean movement

On your Earth maps…

- Label the 5 major gyres
  - North Atlantic
  - South Atlantic
  - North Pacific
  - South Pacific
  - Indian
- Use your textbook pg. 54 to color-code cool and warm portions

Decompression sickness

water animation