STATES OF MATTER

"Be diligent to know the state of your flocks, *And* attend to your herds" Proverbs 27:23

Kinetic Theory of Matter

- atomic theory of matter: all matter is made up of extremely small particles called atoms; atoms combine to form molecules
- kinetic theory of matter: all molecules of matter are in constant motion; the warmer the object, the faster the molecules move; explains existence and states of solids, liquids, gases
- cohesion: attraction between atoms or molecules
- molecular movement limited in solids --> less limited in liquids --> practically unlimited in gases
- Brownian motion: random motion of microscopic particles; result of collisions between microscopic particles
- diffusion: process of mixing molecules of one substance with another by random motion
  ex: opening bottle of perfume
- always occurs from area of higher concentration to lower concentration until concentration of all substances is uniform
  ex: elevator; food coloring in water
- osmosis: semi-permeable membrane allows some substances to diffuse through in one direction only
  Ex: cellophane, skin, cell membranes

Solids

- Tight molecular arrangement
- Crystalline: solids whose molecules are arranged in a well-ordered pattern; have specific melting points
  Ex: sugar, salt, gemstones
- Amorphous: random arrangement of molecules; do not have specific melting points
- Deformation: change in shape when a force moves stationary molecule
- Elasticity: ability of a solid to recover its original shape after being deformed
  -resilience: how far a material can be deformed from its original shape before that deformation becomes permanent (rubber band)
  -rigidity: how strongly a material opposes deformation (metal bar)
- Plasticity: max amount of permanent deformation without breaking (bending plastic water bottles, paper clips); can be increased by heating
- Hardness: resistance of a material to certain types of small deformations
  -Mohs scale used by mineralogists; ranks materials by ability to be scratched/softest-hardest

-Brinell scale: measure how easily a material is dented by a hard ball

- Types of solid deformation: stretching, compression, bending, shearing, torsion
  -Stretching: molecules pulled apart; according to Hooke's Law:
  F = kx where F = force needed to produce a certain amount of stretch/k=constant/x=distance stretched
  -compression: forces pushing on a material, trying to squeeze atoms together; object becomes shorter; resisted by solids bc there are limits on how close molecules can be
  -bending: one side compressed, the other side stretched
  -shear: two forces in opposite directions are side by side
  -torsion: twisting; shear in a circular direction

<u>Liquids</u>

- liquids tend to adhere more strongly to matter than other types of matter
- cohesion: attraction to molecules of the same type
  adhesion: attraction to molecules of a different type
  ex: water droplet
- surface tension: tendency of cohesive forces to pull molecules at the surface back into the liquid, resulting in a film on the liquid's surface; stronger cohesion = greater surface tension
- droplets of liquid are round because of surface tension; a sphere is the shape with the smallest surface area
- surface tension allows objects too dense to float in water to rest upon the surface of the water
  ex: needles, paper, water strider insect can rest on the surface of water (also Jesus)
  detergent or agitation will impair surface tension
- meniscus formed because adhesion of water to sides of glass is greater than adhesion to other water molecules (p.39)
- capillarity/capillary action: water climbing the sides of container seem to raise the narrow column of water below it
  (also works in opposite way for mercury)
- pressure: force exerted per unit of area
  pressure = force / area or P = F/A
  unit of pressure = pascal (Pa), equal to one newton per square meter (N/m^2)
- Earth's atmospheric pressure at sea level = 101.3kPa or 14.7 psi (pounds per square inch)
- gravitational pressure: liquid exerts pressure with just its weight, caused by gravity pulling on the liquid
  -depth of liquid; Challenger Deep is deepest known point in ocean at 36,200 ft below sea level where water pressure is 16,100 psi
  -fluid density: denser liquids exert more pressure at a given depth bc they are heavier

- Pascal's principle: if pressure is applied to a fluid inside a closed container, the pressure increase will be distributed equally throughout the container
  ex: water balloon
  [Application p.40]
- Hydraulics: force applied to the small input causes a pressure increase to the output piston; multiplies force at the expense of distance; a small force over a long distance provides a larger force at a shorter distance
  Ex: barber's chair [illustration p.43]

<u>Gases</u>

- Molecules in a gas weakly attracted to each other; more space between gas molecules than in solid or liquid; gases affected by volume, pressure and temperature
- Compressibility: ability to be easily squeezed and compacted into smaller containers.
- Boyle's Law: relationship between volume and pressure in gases; if the temperature of a gas remains constant, the volume and pressure of the gas are inversely proportional:
  Pressure$_1$ x volume$_1$ = pressure$_2$ x volume$_2$ → $P_1V_1 = P_2V_2$
  [Application p.46]
  -change in volume changes frequency of collisions
  -increase in volume means decrease in pressure, increase in pressure means decrease in volume
- Charles's Law: if the pressure of a gas is constant, its volume and temperature are directly proportional:
  $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
- According to Charles's Law, there should be a temperature at which the volume of gas becomes zero → absolute zero=0 Kelvin
  -increased temperature means increase in volume, decrease in temperature means decrease in volume
- Amonton's Law: temperature and pressure are directly related when volume is held constant:
  $\frac{P_1}{T_1} = \frac{P_2}{T_2}$
  -increased temperature means increased pressure
- [Application p. 48]