



Biological Physics

FYS4715 2021

Some questions

Write, 5 min, read aloud the parts you want, send as email to me, helpful for me

- Why did you choose to follow FYS4715?
- What do you expect to get out of the course?
- What have you learnt previously that is relevant for the course?
- What education background do you have?

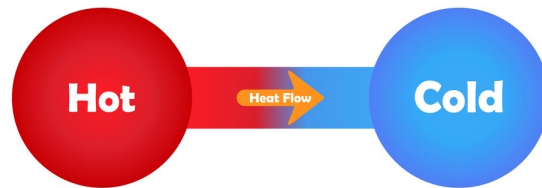
Themes this year

- General: Processes on cellular and molecular scale
 - 1nm – 100 um
 - from atomic to macroscopic: stat mech
 - small scale: atomic forces, velocities, charges
 - large scale: surface tension, stress-strain, diffusion, osmosis, electrochemistry
- Nelson ch 1-8, 12 + chosen topics
- Projects:
 - Passive and active swimmers
 - Cellular Potts model - morphogenesis & mechanobiology
 - [Mechanobiology](#), effects of ultrasound on cells
 - Nerve impulses

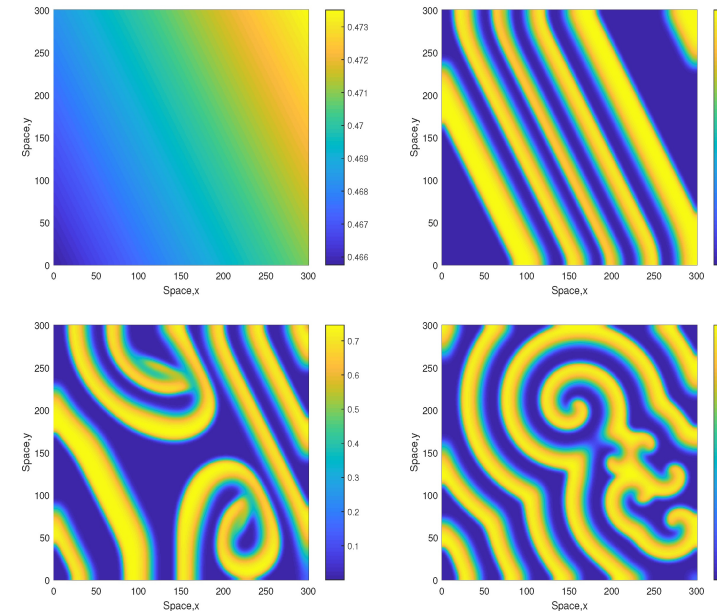
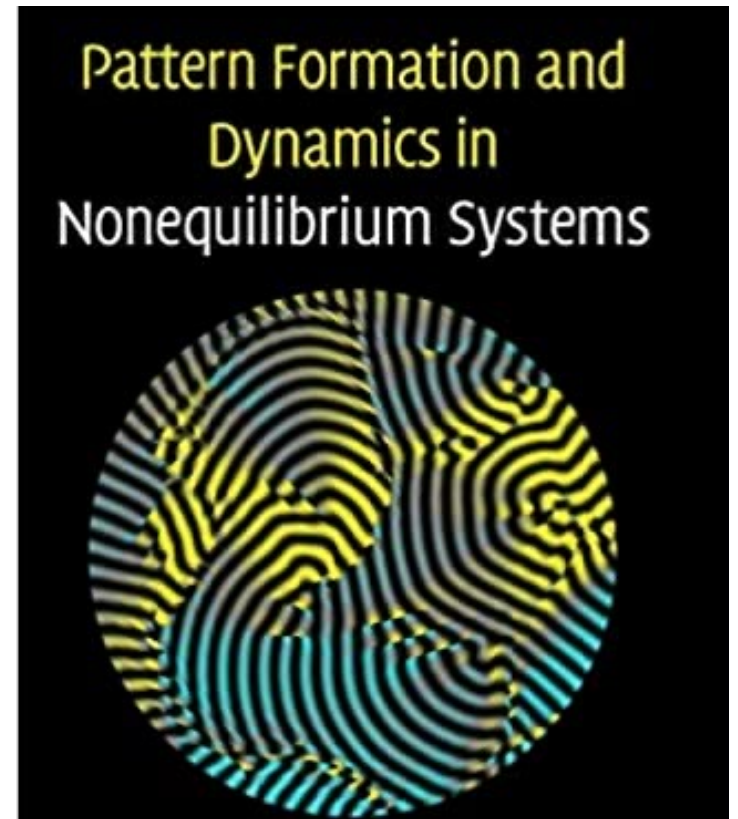
Course web pages (Vortex)

Law and order

- Second law of thermodynamics?

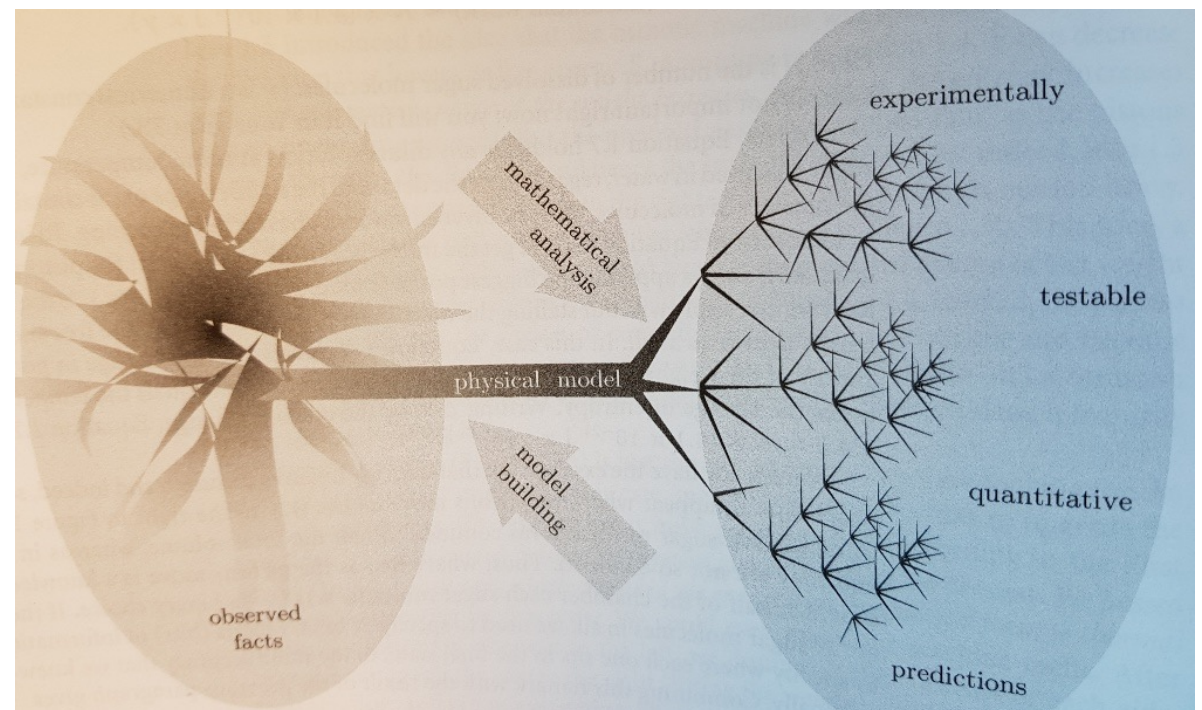
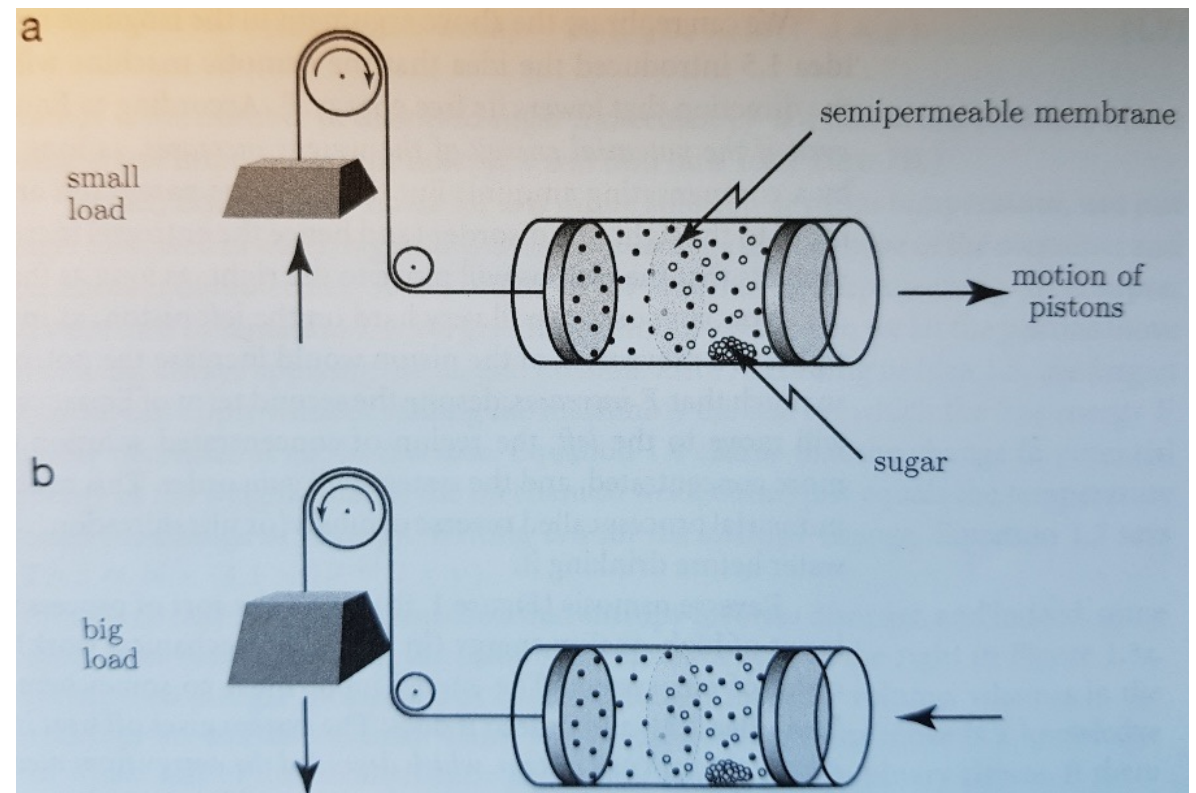


- Non-equilibrium
 - -> equilibrium
 - -> heat death of universe
 - -> pattern formation
- Life is the ultimate order
 - non-equilibrium “systems”



Chapter 1

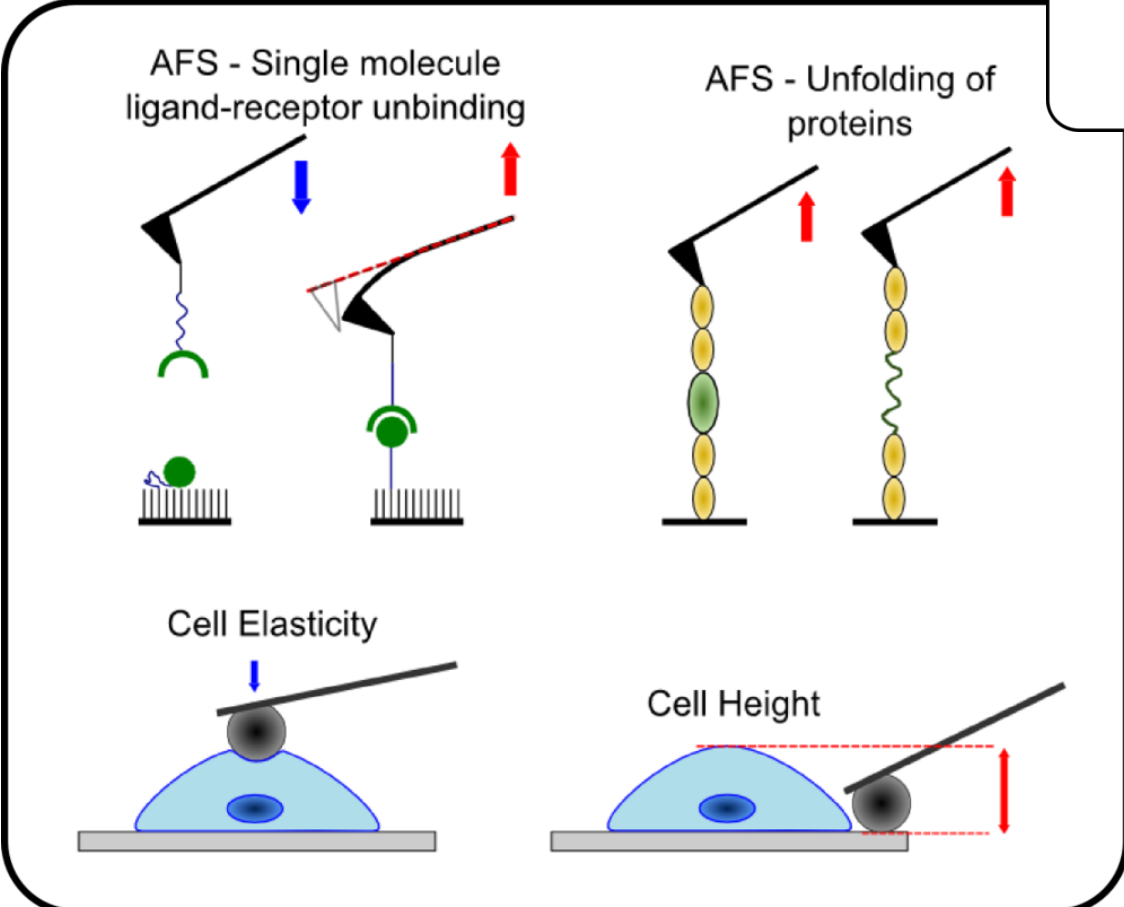
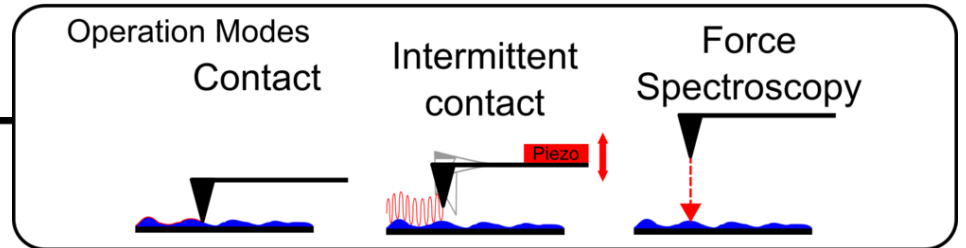
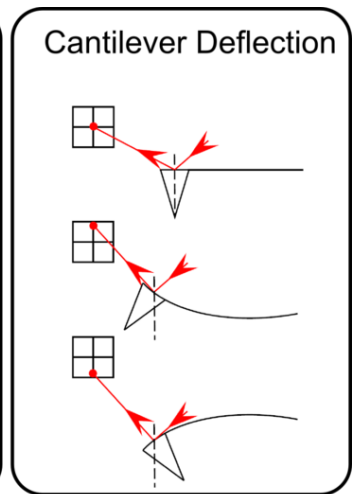
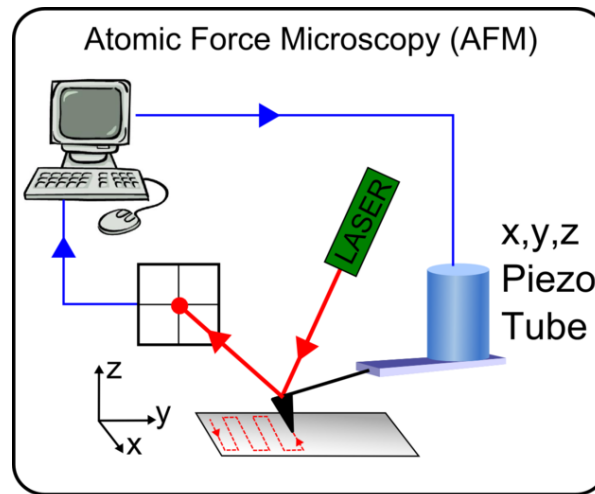
- What is heat?
- Entropy
- 2nd law vs. order
- Free energy
- Osmosis
- Physical models
 - For biologists:
<https://www.nature.com/articles/d41586-019-03960-z>



Biological Physics

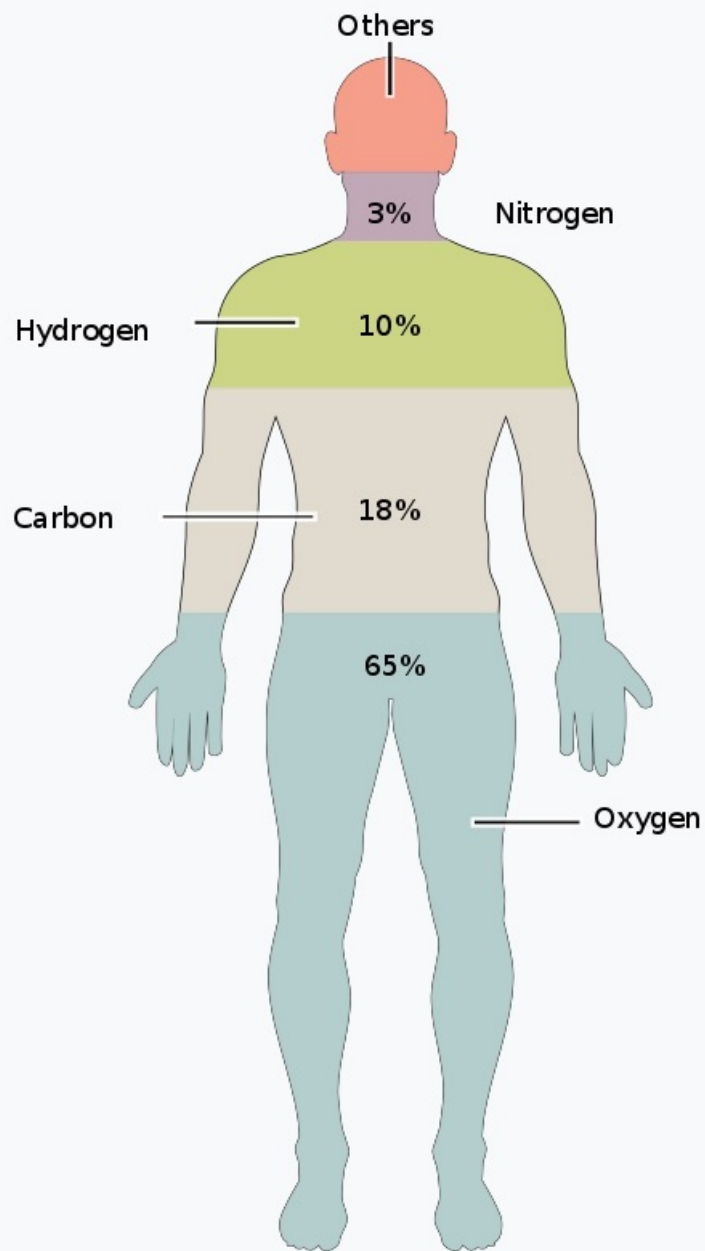
- In physics we make mathematical models and calculate stuff
- What is the volume of one molecule of water?
- Most famous model: ideal gas
 - equation of state: $PV = nk_B T$
 - What is PV ?
 - How much is $k_B T$?

pN forces
nm distances



Chapter 2: What's inside cells

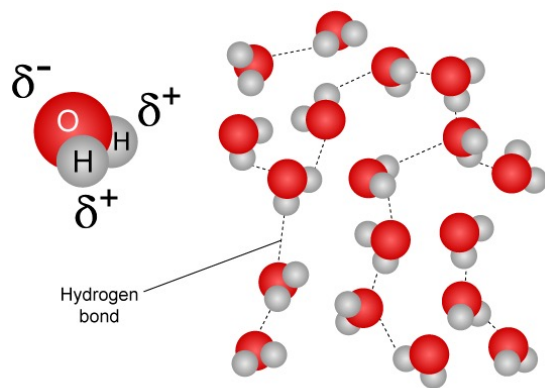
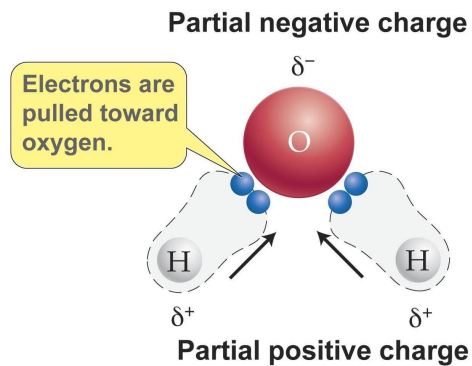
- Biological question: How do organisms organize all the chemical processes?
- Physical ideas
 - Compartmentalization
 - Active transport
 - Specific processes
 - Non-linearity -> switching in networks



Element	Symbol	% in body
Oxygen	O	65.0
Carbon	C	18.5
Hydrogen	H	9.5
Nitrogen	N	3.2
Calcium	Ca	1.5
Phosphorus	P	1.0
Potassium	K	0.4
Sulfur	S	0.3
Sodium	Na	0.2
Chlorine	Cl	0.2
Magnesium	Mg	0.2
Others		< 1.0

The main elements that compose the human body are shown from most abundant (by mass, not by fraction of atoms) to least abundant.

Polar – hydrophilic – water soluble

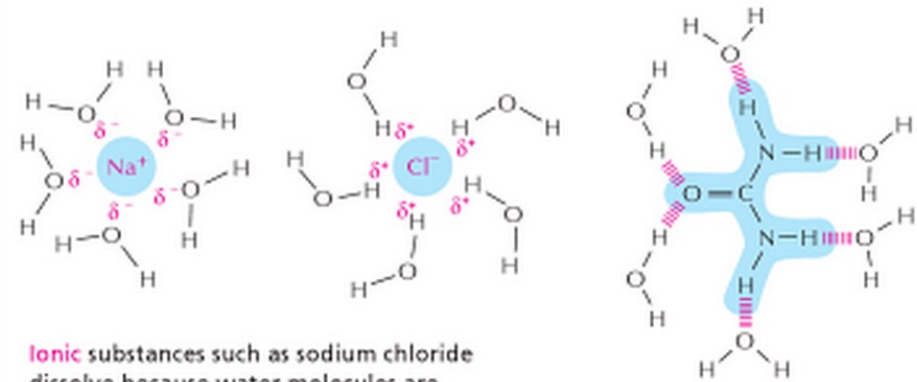


(length appears different for perspective (3D))

Dept. Biol. Penn State ©2002

HYDROPHILIC MOLECULES

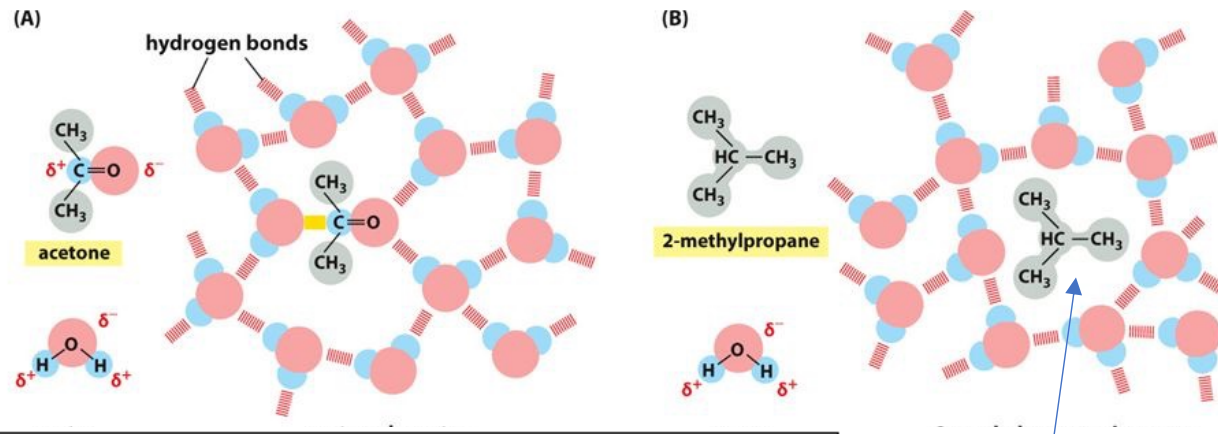
Substances that dissolve readily in water are termed **hydrophilic**. They include ions and polar molecules that attract water molecules through electrical charge effects. Water molecules surround each ion or polar molecule and carry it into solution.



Ionic substances such as sodium chloride dissolve because water molecules are attracted to the positive (Na^+) or negative (Cl^-) charge of each ion.

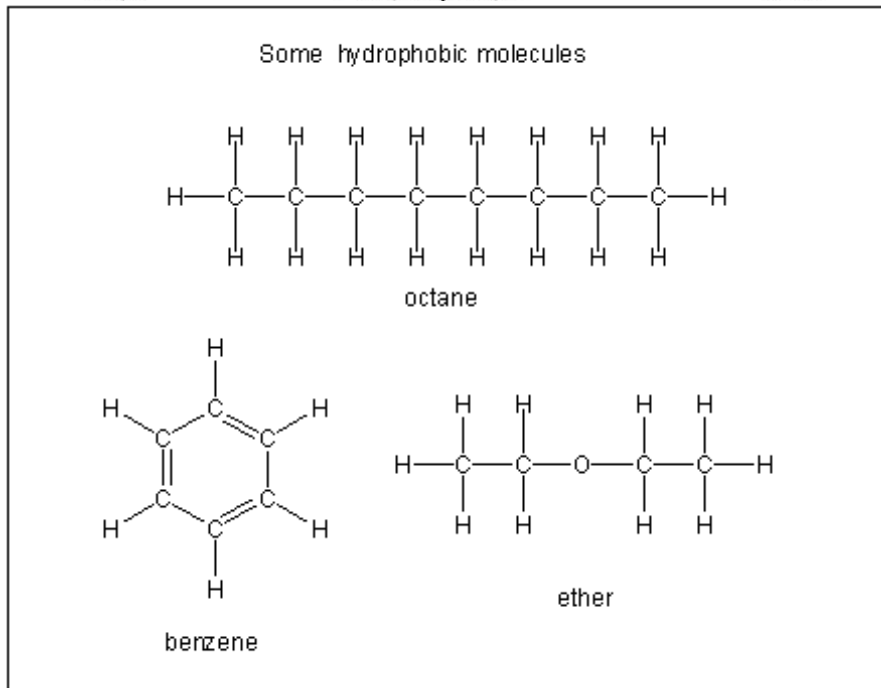
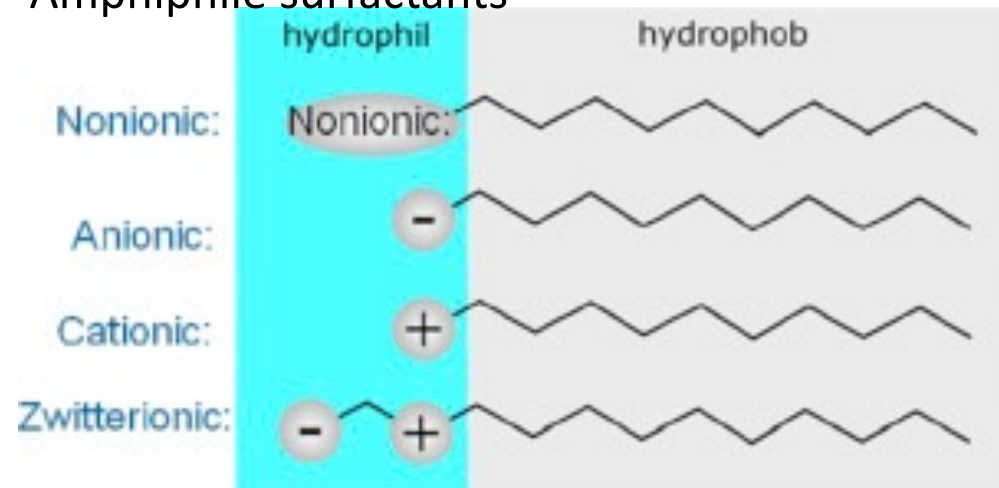
Polar substances such as urea dissolve because their molecules form hydrogen bonds with the surrounding water molecules.

Hydrophobe & amphiphile



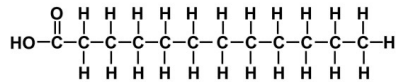
higher energy cost

Amphiphile surfactants

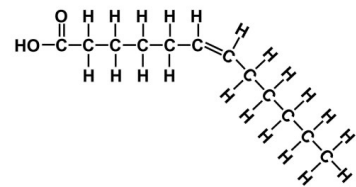


fatty acids -> phospholipid -> membranes

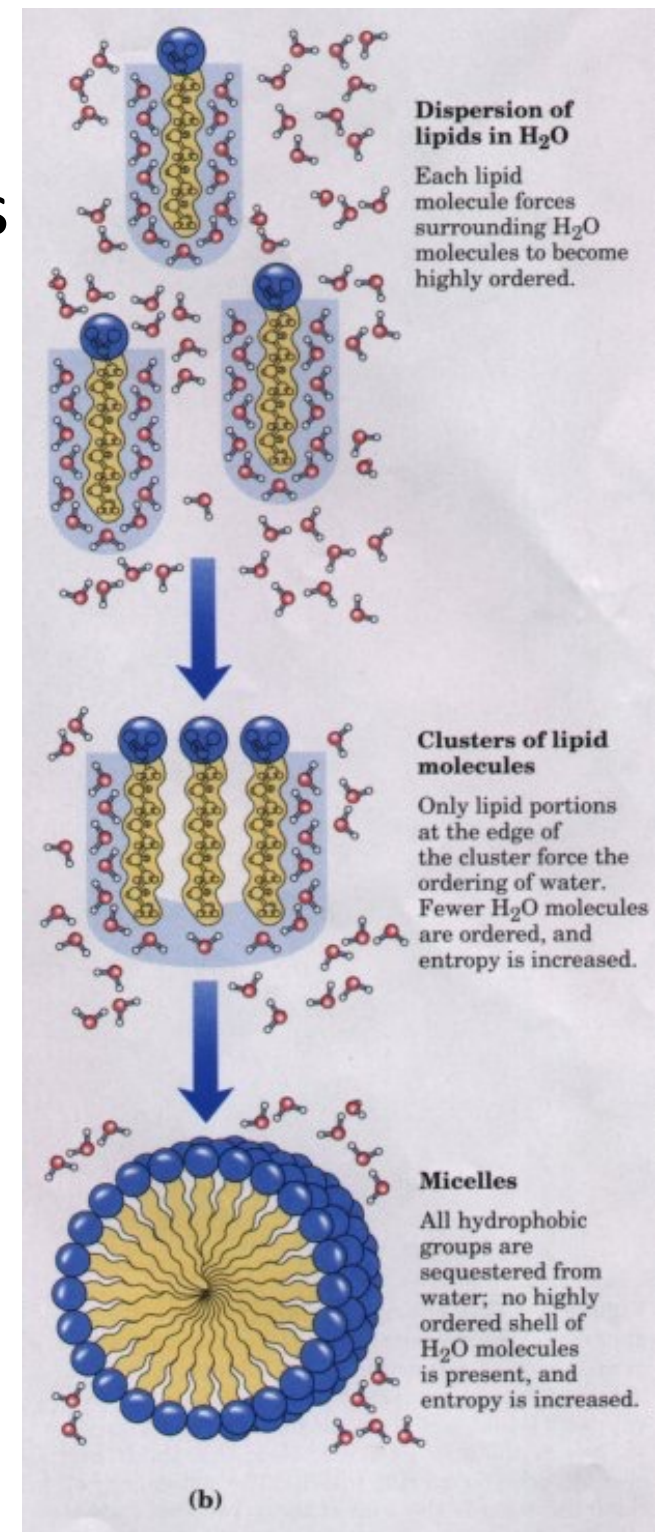
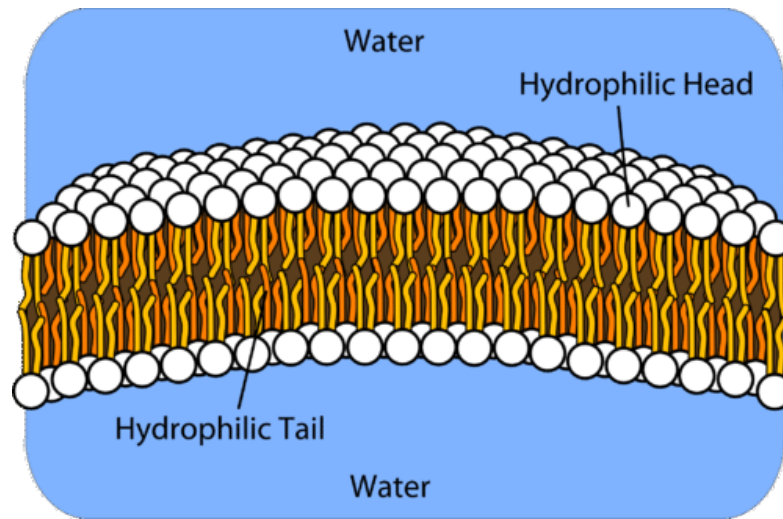
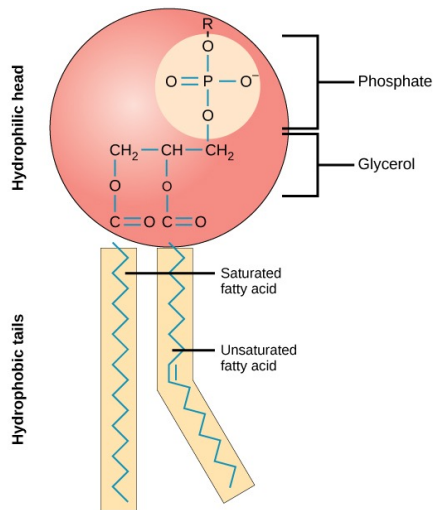
Saturated Fatty Acid



Unsaturated Fatty Acid



lipid:
macromolecule that is
soluble in nonpolar solvents



energy and entropy