WELCOME TO
Biochemistry II

(BI/CH 422 & BI/CH 622 & BI/CH 459)

Pre-requisites
- Biochemistry I (421/621/437)
  - Orgo 2

Registration

Transition to Biochemistry II
- A1
- A2

Websites

Syllabus

		Appropriate Pre-lab Discussion Section		
Lab Time	Lab Section	C3 (W)	C2 (R)	C1 (F)
R 5:30	B4	YES	OK	NO
F 12:20	B5	YES	YES	OK
F 5:30	B6	YES	YES	OK
M 12:20	B1	YES	YES	YES
M 5:30	B2	YES	YES	YES
W 2:30	B3	NO	YES	YES

WELCOME TO
Biochemistry II (BI/CH 422 & BI/CH 622)

This course is Dedicated to the memory
of Sir Hans Kornberg

January 14, 1928 ~ December 16, 2019

Review of 421

Goals of 422

Review of chemical principles
- Thermo
- C/O cycles
- Overview of Metabolism
- ATP cycles

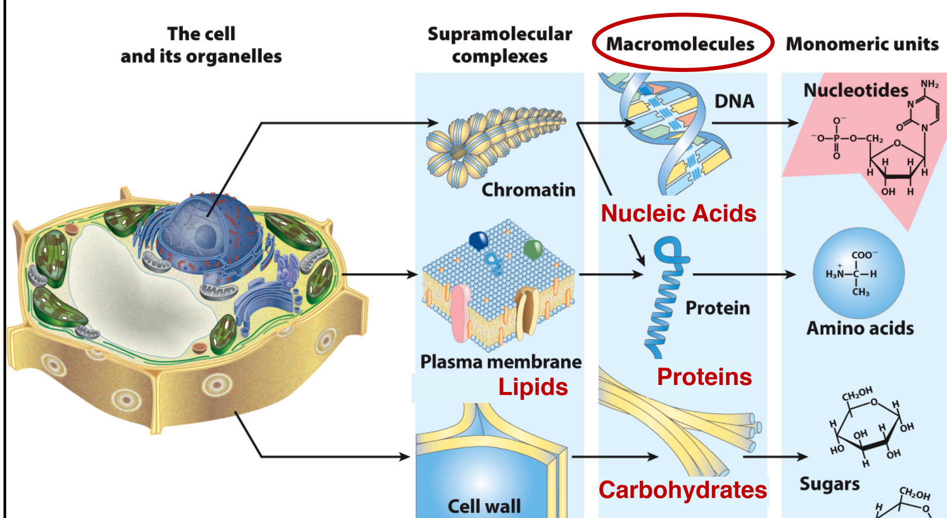
Energy Coupling

Chemical Reactivity

Bioenergetics

Dr. Kornberg: **Lecture 01.20.17 (35:58-42:12)**
(6 min)

Macromolecules are Key to Cellular Structures



Problem: A simple *E. coli* cell need only salts and a simple carbon source like acetic acid for growth. How is that possible?

Goals for Biochem II:

Problem: A simple *E. coli* cell need only salts and a simple carbon source like acetic acid for growth. How is that possible?

This semester we will answer this question, which relates all these macromolecular components:

- How are they interrelated?
- How are they synthesized from each other?
- What are the common chemical reactions and unique enzyme mechanisms?
- How is all this accomplished without breaking any of the rules of thermodynamics and organic chemistry?

All of these questions are answered, thus making LIFE possible, by what is termed INTERMEDIARY METABOLISM

FIRST, let's review some chemical principles and reactions…

Energetics of Life

The **laws of thermodynamics** apply to all matter and all energy transformations in the universe.

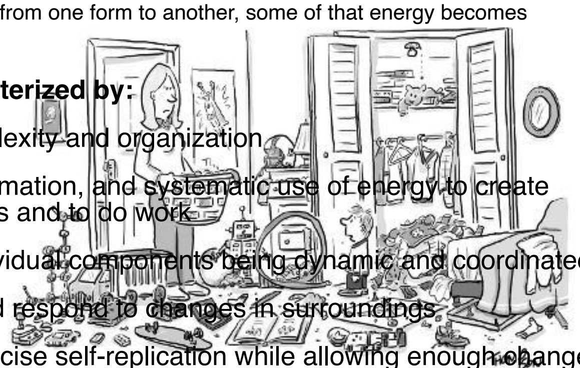
1st & 2nd Laws of Thermodynamics:

1) **Energy can never be created or destroyed, but can be interconverted.**
2) **The universe tends toward more disorder (randomness)**

   [When energy is converted from one form to another, some of that energy becomes unavailable to do work.]

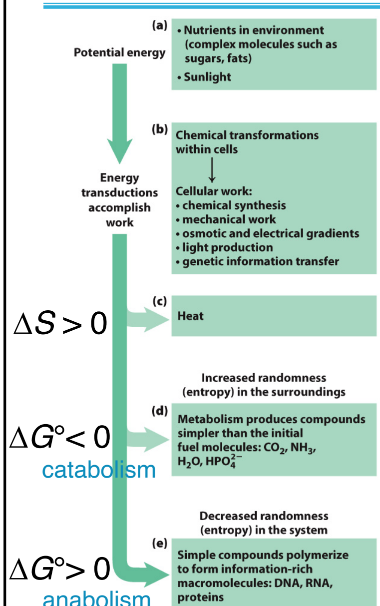
Living matter is characterized by:

- a high degree of complexity and organization
- the extraction, transformation, and systematic use of energy to create and maintain structures and to do work
- the interactions of individual components being dynamic and coordinated
- the ability to sense and respond to changes in surroundings
- a capacity for fairly precise self-replication while allowing enough change for evolution



"I blame entropy."

Organisms Use the First Law Big-Time (perform energy transformations) to Stay Alive



Favorable and Unfavorable Reactions

- The breakdown of some metabolites releases a significant amount of energy (**exergonic**).
  - Their cellular concentration is far higher than their equilibrium concentration.
  - Metabolites, such as ATP, NADH, NADPH, can be synthesized using the energy from sunlight and fuels…..
- Synthesis of complex molecules and many other metabolic reactions requires energy (**endergonic**).
  - A reaction might be thermodynamically unfavorable ($\Delta G°> 0$).
    - Creating order requires work and energy.
- Biochemistry **couples** exergonic with endergonic reactions to insure organisms continue to grow and divide.

Energetics of Life

- Living organisms cannot create energy from nothing.
- Living organisms cannot destroy energy into nothing.
- Living organism may transform energy from one form to another.
- In the process of transforming energy, living organisms must increase the entropy of the universe.
- In order to maintain organization within themselves, living systems must be able to extract useable energy from their surroundings and release useless energy (heat) back to their surroundings.

Overview of Metabolism

Metabolism

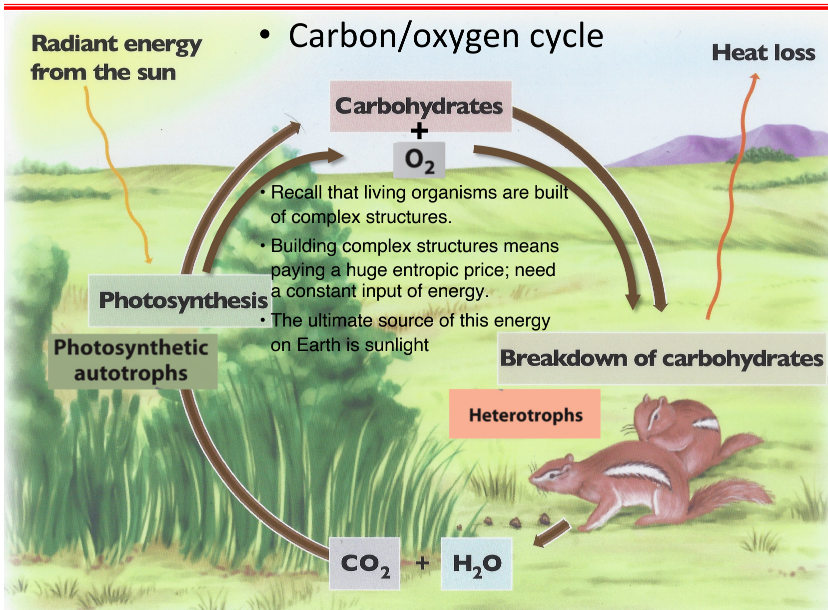
Issues:

- Thermodynamics and biochemistry; carbon/oxygen cycle & nitrogen cycle
- Common organic chemistry principles in biochemistry
- Some biomolecules are "high energy" with respect to their hydrolysis and group transfers.
- Energy stored in reduced organic compounds can be used to reduce cofactors such as NAD^+ and FAD, which serve as universal electron carriers and lead to ATP formation.

"Now, in the *second* law of thermodynamics . . . "

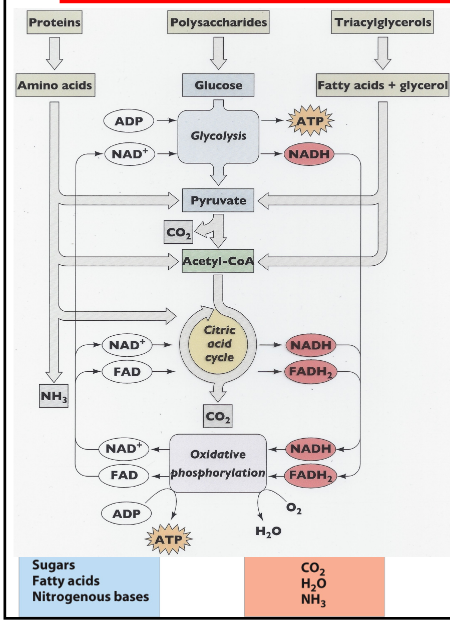
Metabolism

- Carbon/oxygen cycle

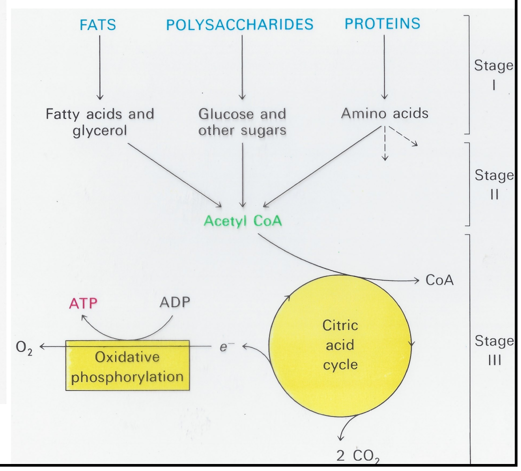


- Recall that living organisms are built of complex structures.
- Building complex structures means paying a huge entropic price; need a constant input of energy.
- The ultimate source of this energy on Earth is sunlight

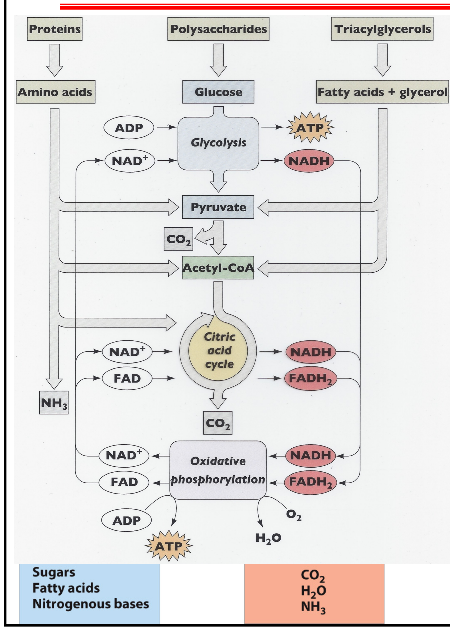
Metabolism



- In biochemistry, the oxidation of reduced fuels with O_2 is stepwise and controlled.
- Recall that being thermodynamically favorable is not the same as being kinetically rapid.



Metabolism



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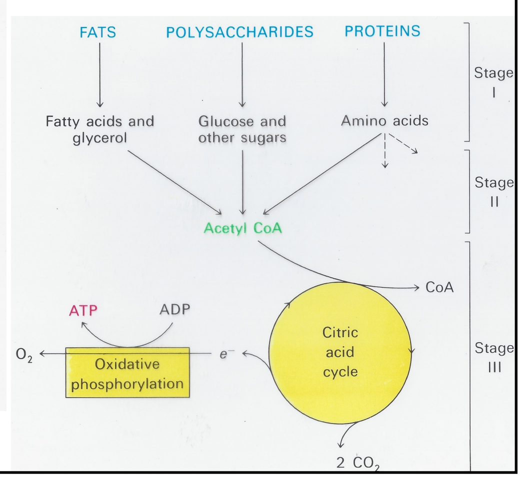


Metabolism

NAD and NADP Are Common Redox Cofactors

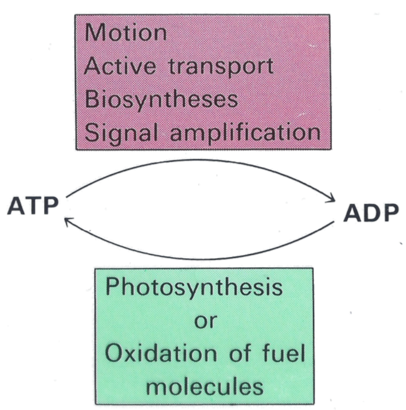
- These are commonly called pyridine nucleotides.
- They can dissociate from the enzyme after the reaction.
- In a typical biological oxidation reaction, hydride from an alcohol is transferred to NAD^+, giving NADH.

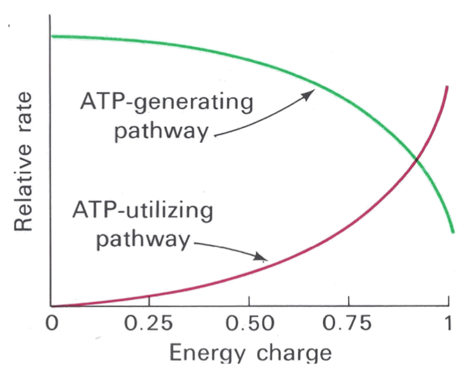
FAD and $FADH_2$ are another Common Redox Cofactor

- These are commonly called flavins.
- They are usually covalently bound at the active site of enzymes.
- They can undergo both 1-electron and 2-electron redox reactions.

Metabolism

THE ATP CYCLE





This "buffering" of energy in the cell keeps the [ATP] high enough to keep fighting the second law of thermodynamics.

$$\text{Energy Charge} = \frac{[ATP^{-4}] + \frac{1}{2}[ADP^{-3}]}{[ATP^{-4}] + [ADP^{-3}] + [AMP^{-2}]}$$