

University of Houston

BCHS 3304: General Biochemistry I - Fall 2009

Section 21734

Tuesday/Thursday 11:30 AM - 1:00 PM 102 SW

Instructor:

Dr. Glen B. Legge
Phone: 713-743-8380
Office: HSC 408
Email: glegge@uh.edu

Office hours:

Tuesday and Thursday (1:00-2:00 PM) or by appointment

Course web page:

<http://www.bchs.uh.edu/~glegge/teaching/>

The lecture notes and homework will be posted on the Web

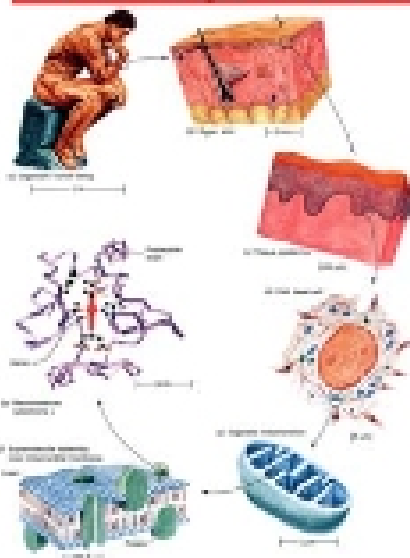
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These notes are not a substitute for class participation. These notes are posted on the web, although they may be altered before class. They are intended to make you pay attention in class, so take these notes with you. Don't just sit in class and just copy notes!!

Read the assigned material before the lecture

Collect Homework 1 and START IT!!!

Biochemistry: Life at the Molecular Level



Biochemistry is the study of biological processes at a chemical level

Foundations of Biochemistry

Chapter 1: Life

Biochemistry is the study of the chemistry of life. Biochemistry is an interdisciplinary science overlapping with chemistry, cell biology, genetics, immunology, microbiology, pharmacology, and physiology.

Main issues of Biochemistry

1. What are the chemical and three-dimensional structures of biological molecules?
2. How do biological molecules interact with each other?
3. How does the cell synthesize and degrade biological molecules?
4. How is energy conserved and used by the cell?
5. What are the mechanisms for organizing biological molecules and the coordinating of their activities?
6. How is genetic information stored, transmitted, and expressed?

Introduction to the Chemistry of Life

THE ORIGIN OF LIFE

- Universe is 15-20 billion years old - BIG BANG
- Initially H_2 was made then condensed to He
- Over the billions of years under the right conditions complex molecules formed.
- Complicated chemical reactions started occurring - intermolecular interactions and carbon based chemistry developed.

From this milieu sprang the property of

LIFE

Prebiotic World

Living matter consists of a small number of elements (see Table 1-1, p.3)

Elemental composition of the human body (98%)

- Carbon (C) - 61.7%; Nitrogen (N) - 11.0%; Oxygen (O) - 9.5%
- Hydrogen (H) - 5.7%; Calcium (Ca) - 5.0%; Phosphorus (P) - 3.3%
- Potassium (K) - 1.3%; Sulfur (S) - 1.0%; Chlorine (Cl) - 0.7%
- Sodium (Na) - 0.7%; Magnesium (Mg) - 0.3%
- Trace: B, F, Si, V, Cr, Mn, Fe, Co, Cu, Zn, Se, Mo, Sn, I

- Most organisms are ca. 70% water



- The earth is ca. 4.6 billion years old.



- Earliest known fossil is ca. 3.5 billion years old (filamentous bacterium).

The Physical Laws of Life

•Philosophers thought life contained a "vital force" or vitalism but this has been rejected by modern science.

- Haldane – simple organic compounds from H₂O, N₂ and CO₂
- Urey – chemical synthesis of urea

•Living organisms operate within the same physical laws that apply to physics and chemistry:

- Conservation of Mass, Energy
- Laws of Thermodynamics
- Laws of Chemical Kinetics
- Principles of Chemical Reactions

Molecular Logic of Life

These physical laws describe several axioms that make up the Molecular Logic of Life. These axioms define:

- Energy converted to work
- Catalytic chemical transformations
- Assembly of molecules with great complexity from simple subunits.
- Complex molecules combine to form supra molecular components, organelles and finally assemble into a cell.
- Store and pass on instructions for the assembly of all future generations from simple non-living precursors

Chemical Time	Reaction	Biological Time of Event
10 ⁻¹⁵ s	H ₂ → 2H	10 ⁻¹⁵ s - 10 ⁻¹⁴ s
10 ⁻¹⁴ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻¹⁴ s - 10 ⁻¹³ s
10 ⁻¹³ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻¹³ s - 10 ⁻¹² s
10 ⁻¹² s	H ₂ + O ₂ → 2H ₂ O	10 ⁻¹² s - 10 ⁻¹¹ s
10 ⁻¹¹ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻¹¹ s - 10 ⁻¹⁰ s
10 ⁻¹⁰ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻¹⁰ s - 10 ⁻⁹ s
10 ⁻⁹ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻⁹ s - 10 ⁻⁸ s
10 ⁻⁸ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻⁸ s - 10 ⁻⁷ s
10 ⁻⁷ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻⁷ s - 10 ⁻⁶ s
10 ⁻⁶ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻⁶ s - 10 ⁻⁵ s
10 ⁻⁵ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻⁵ s - 10 ⁻⁴ s
10 ⁻⁴ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻⁴ s - 10 ⁻³ s
10 ⁻³ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻³ s - 10 ⁻² s
10 ⁻² s	H ₂ + O ₂ → 2H ₂ O	10 ⁻² s - 10 ⁻¹ s
10 ⁻¹ s	H ₂ + O ₂ → 2H ₂ O	10 ⁻¹ s - 10 ⁰ s
10 ⁰ s	H ₂ + O ₂ → 2H ₂ O	10 ⁰ s - 10 ¹ s
10 ¹ s	H ₂ + O ₂ → 2H ₂ O	10 ¹ s - 10 ² s
10 ² s	H ₂ + O ₂ → 2H ₂ O	10 ² s - 10 ³ s
10 ³ s	H ₂ + O ₂ → 2H ₂ O	10 ³ s - 10 ⁴ s
10 ⁴ s	H ₂ + O ₂ → 2H ₂ O	10 ⁴ s - 10 ⁵ s
10 ⁵ s	H ₂ + O ₂ → 2H ₂ O	10 ⁵ s - 10 ⁶ s
10 ⁶ s	H ₂ + O ₂ → 2H ₂ O	10 ⁶ s - 10 ⁷ s
10 ⁷ s	H ₂ + O ₂ → 2H ₂ O	10 ⁷ s - 10 ⁸ s
10 ⁸ s	H ₂ + O ₂ → 2H ₂ O	10 ⁸ s - 10 ⁹ s
10 ⁹ s	H ₂ + O ₂ → 2H ₂ O	10 ⁹ s - 10 ¹⁰ s

Life is in constant flux

Enzyme catalyzed reactions- Substrates ⇌ Products 10⁻¹ sec - milli sec
Unwinding of DNA 10⁻⁶ sec - micro sec

10⁻¹⁵ s 10⁻¹² s 10⁻⁹ s 10⁻⁶ s 10⁻³ s 10 s 10³ s
femto pico nano micro milli sec

- femto fs excitation of chlorophyll
- pico ps charge separation in photosynthesis
- nano ns hinge protein action
- 10⁻⁸ - 10 ns fluorescence lifetime
- micro μs DNA unwind
- milli ms enzymatic reactions
- 10⁰ generation of bacteria
- 2.5 x 10⁸ sec average human life span

What distinguishes living organisms?

- 1) Structurally complicated and highly organized
 - a. intricate internal structures
 - b. many kinds of complicated molecules

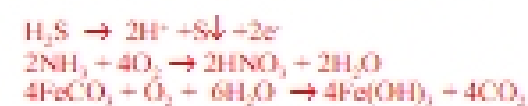
proteins, DNA, RNA, starches, and lipids etc. (inanimate objects sand clay are mixtures of simple compounds)

- 2) Living organisms:

- a. extract
 - b. transform
 - c. store
 - d. use
- ENERGY

Living things can extract energy from the environment

Chemical: Chemoautotrophs or lithoautotrophs



or

Sunlight: Photoautotrophs
 $n\text{CO}_2 + n\text{H}_2\text{O} + h\nu \rightarrow (\text{CH}_2\text{O}) + n\text{O}_2$

Energy is needed to build and maintain structures

- a) mechanical energy - muscles
- b) chemical energy - electric eel
- c) osmotic energy - plant turgor
- d) light energy - bioluminescence

3) Most characteristic attribute of living things is self-replication and self assembly

it is the quintessence of the living state

1 single bacteria → 10⁹ in 24 hr

With near-perfect fidelity during replication!

A crystal at equilibrium grows but life at equilibrium is death!

Life is a set of relationships characterizing the nature, function and interaction of biomolecules.

The Essential Role of Water

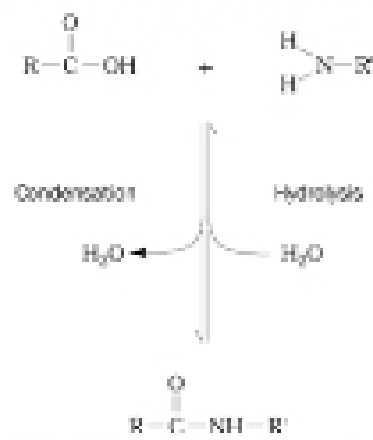
•H₂O is the key to understanding the behavior of macromolecules. It is the solvent of life and all living transformations occur in an aqueous media-

Life is thought to have arisen from the sea

•Even water-insoluble compounds such as lipid membranes derive their nature and function by their interactions with H₂O.

Condensation reactions

◀Chemical Evolution, simple molecules condense to form more complex forms (polymers)



Reaction of a carboxylic acid with an amine

Replication through complementarity

- Specific pairing of functional groups gives rise to complementarity
- More complex molecules increases chemical versatility
- Complementarity makes it possible for macromolecules to replicate
- Over time natural selection favored molecules that made accurate copies of themselves

