

# Biochemistry I

Chemistry 662

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# Biochemistry

How would you define biochemistry walking into this class?

“Chemistry of Life”

Living Things are composed of lifeless molecules

Biochemistry- study of the structure, properties and changes of *biomatter*

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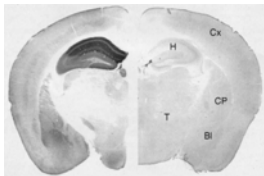
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# Special Considerations in Biochemistry

1. Complex and highly ordered
2. Everything has a function
3. Living things transform their environment (extract energy)
4. Self-replicating
5. Reactions occur at constant temperature, pressure and pH; in an aqueous environment



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## Biomolecules: Elements Essential to All Life-forms

C }  
H } 99% of mass of most cells  
O }  
N }  
P }  
S } "bulk" elements

Mg<sup>2+</sup>, Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Cl<sup>-</sup> }  
Fe, Zn, Mn, Co, Cu } "trace" elements

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## Biomolecules: Molecules/Macromolecules

1. Carbohydrates- made up mostly of 7 monosaccharides
2. Proteins -  $5 \times 10^6$ , made up of 20 amino acids
3. Nucleic Acids - 1,000, made up of 4 nucleotides
4. Lipids

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## Biochemistry is Based on Organic Chemistry

- Functional groups
  - aldehyde
  - carboxylic acid
  - amino group
  - ester (phosphoester)
- Forces of attraction between molecules
  - London forces (AKA van der Waals)
  - Dipole-dipole interactions
  - Hydrogen bonds

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## Review of Cell Structure

Prokaryote vs. Eukaryote

Plant vs. Animal

Course emphasis

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## Cell Membrane (AKA Plasma Membrane)



- Appears as 3 layers by EM
- 7.5-10 nm thick
- "Unit membrane"

These three things are explained on a molecular level as a *phospholipid bilayer*

Function: osmotic barrier

Present in all cells

Much further consideration in lipid material.

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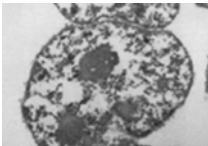
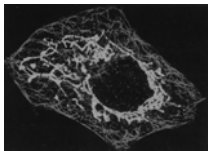
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## Nucleus



- Bounded by a porous nuclear membrane

Function: contain DNA

Present in all eukaryotic cells

1 per cell

- Often 1-4 *nucleoli*

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## Cell Wall

- No picture
  - thick, tough wall
- Function: rigidity  
Present in plant and prokaryotic cells

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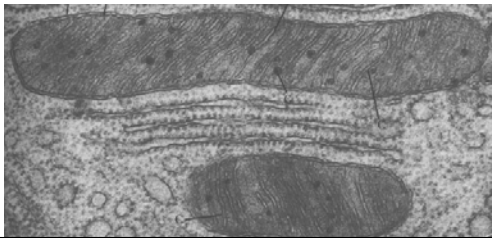
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## Mitochondria

- Shape varies, size varies
- 500-2,000 per cell



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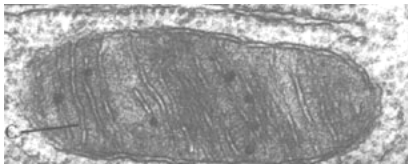
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## Mitochondria

Function: "powerhouse of the cell"  
Present in all eukaryotic cells  
Structure: compartments  
Further consideration in metabolism.



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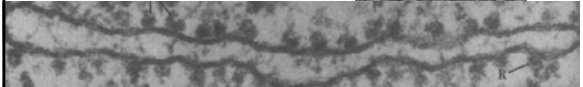
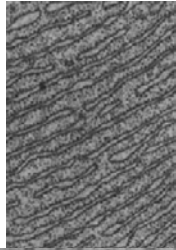
## Endoplasmic Reticulum Rough and Smooth

Phospholipid bilayer surrounding a lumen,  $\pm$  ribosomes

Function: protein synthesis (RER)  
lipid synthesis (SER)

RER-Surface looks rough because of the presence of ribosomes, another organelle (present in all cells)

Present in all eukaryotic cells (lots)



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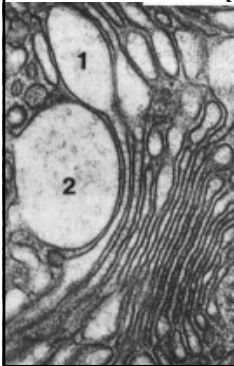
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## Golgi Apparatus



Historically cis, medial and trans: trans-golgi network

Function: protein processing and secretion

Present in all eukaryotic cells (lots)

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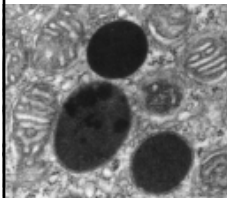
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## Lysosomes



- About as big as a mitochondrion
- not much to see

Function: degradation of proteins

Present in animal cells, plant cells have similar organelle called *peroxisome*

Number per cell varies enormously

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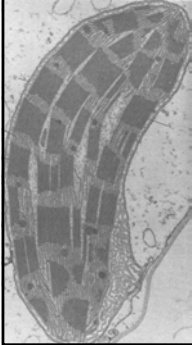
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## Chloroplasts



- Stacks of “grana”
  - grana composed of thylakoid disks
- Function: photosynthesis  
Present in photosynthetic cells  
50-200 per cell

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## Cytoplasm

Aqueous, solute-containing contents within the plasma membrane  
Contains soluble proteins, salts, organelles  
Cytosol- is the supernate of a centrifugation process

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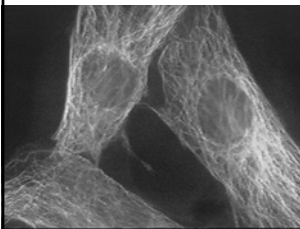
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## Microtubules



- Polymer of a protein called *actin*
- Gives shape to cell, also functions in transport around the cell

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## Water

- ~70% of most organisms
- Structure and polarity
  - favors solubility
  - directionality holds macromolecules in given conformations
- hydrogen bond
  - half-life < 1/1,000,000 sec
  - holds water together without being viscous
- high specific heat
- colligative properties
- weakly ionizable

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## Equilibrium Constants



- But: Keq' is used in biochemistry

$$K_{eq} = \frac{k_1}{k_{-1}} = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

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## Buffers

Buffer- a compound that does not allow the pH to change even if acid or base is added to the system.

Good buffers are often *amphiprotic* compounds.

Amphiprotic compound- a compound that can act as a proton donor or as a proton acceptor.

Important physiological buffers include  $\text{HCO}_3^-$ ,  $\text{HPO}_4^{2-}$ , and protein

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## Henderson-Hasselbalch Equation

$$\text{pH} = \text{pK}_a' + \log \frac{[\text{salt}]}{[\text{acid}]}$$

or

$$\text{pH} = \text{pK}_a' + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

$\text{pH} = \text{pK}_a' + \log \frac{[\text{A}^-]}{[\text{HA}]}$

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## pH Problems

- What would the pH be if 0.1 mL of 6.0 M HCl was added to 100. mL H<sub>2</sub>O?
- What would the pH be if 0.1 mL of 6.0 M HCl was added to 100. mL of 1.0 M MOPS, initially at pH 7.2?
- What would the pH be if 0.1 mL of 6.0 M HCl was added to 100. mL of 50. mM MOPS, initially at pH 7.2?

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## Buffer Questions

- How do you determine the pK of an acid?
- What makes a good buffer?
- What is the pH of a lactic acid sol'n that contains 60% lactate and 40% lactic acid?
- What is the ratio of lactate to lactic acid in a sol'n at pH 5.0?
- Lehninger Ch.4 problems to work through: 2, 3, 5, 6, 7, 10

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