CLS 232 - Lecture 1

An Introduction to Biochemistry

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What is Biochemistry ?

- Biochemistry is the application of chemistry to the study of biological processes at the cellular and molecular level.

- It emerged as a distinct discipline around the beginning of the 20th century when scientists combined chemistry, physiology and biology to investigate the chemistry of living systems by:

A. Studying the structure and behavior of the complex molecules found in biological material and

B. How these molecules interact to form cells, tissues and whole organism

What is Biochemistry ?

- Biochemistry = chemistry of life.
- Biochemists use physical and chemical principles to explain biology at the molecular level.
- Basic principles of biochemistry are common to all living organism
- Aim: to describe and explain, *in molecular terms*, all chemical processes of living cells
  - Structure-function
  - Metabolism and Regulation
  - How life began？

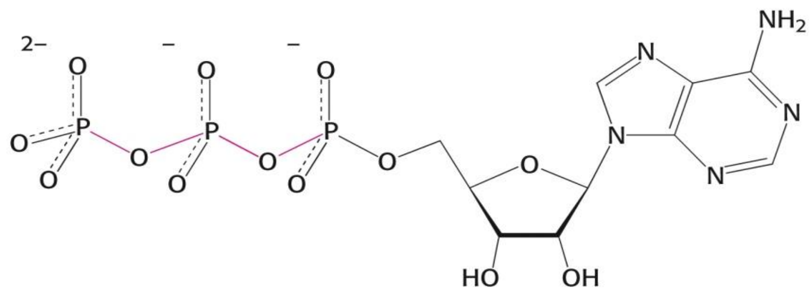
What is Biochemistry ?

- Significance: be essential to all life sciences as the common knowledge
  - Genetics; Cell biology; Molecular biology
  - Physiology and Immunology
  - Pharmacology and Pharmacy
  - Toxicology; Pathology; Microbiology
  - Zoology and Botany
  - Agriculture
  - Industrial applications
  - Environmental implications

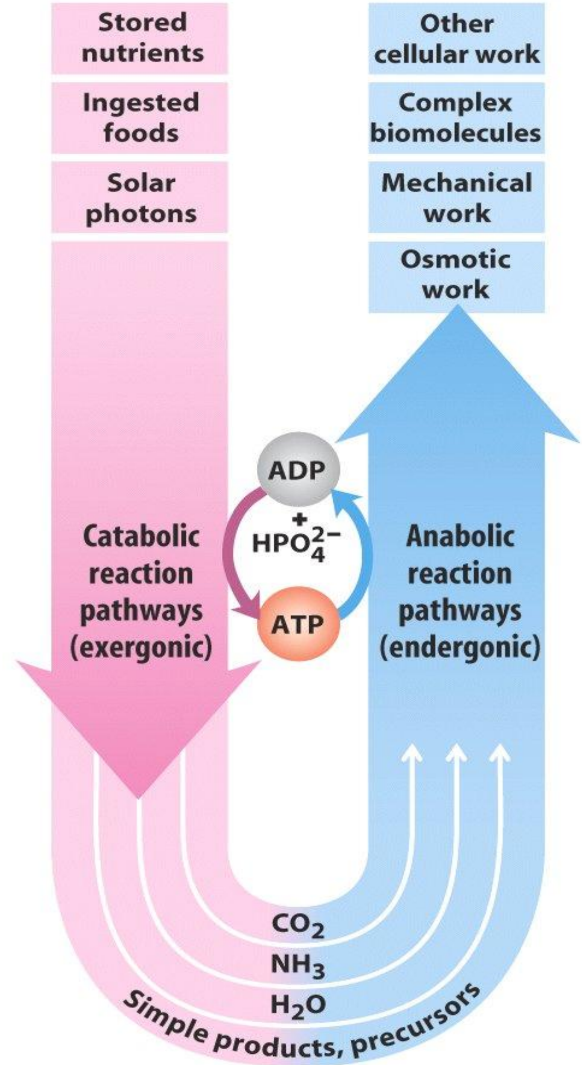
Life has 3 requirements:

(1)ENERGY: which it must know how to:

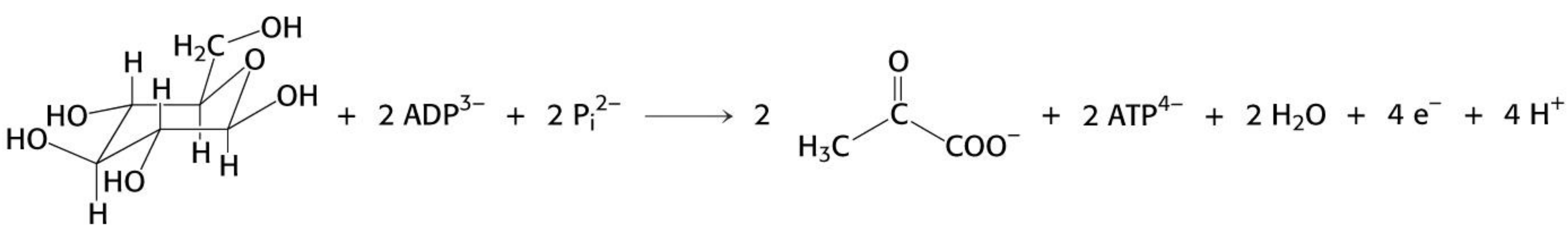
- Extract
- Transform
- Utilize



Adenosine triphosphate (ATP)



Glycolysis is the preferred pathway for the formation of **ATP**



Glucose **Pyruvate**

(2) *SIMPLE MOLECULES,* which it must know how to:

- Convert
- Polymerize
- Degrade

(3) *CHEMICAL MECHANISMS,* to:

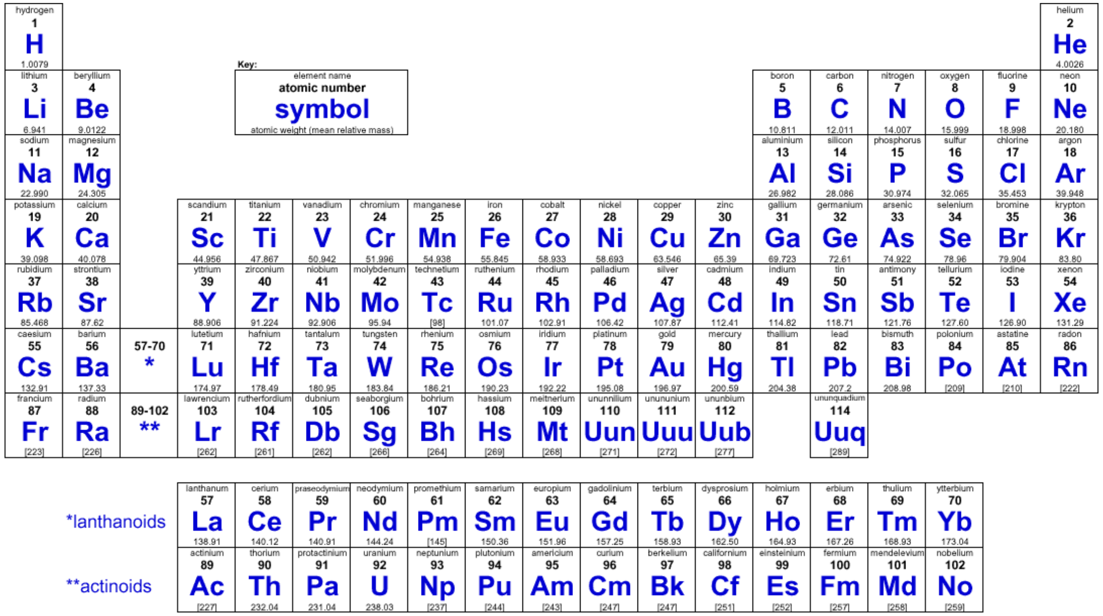
- Harness energy
- Drive sequential chemical reactions
- Synthesize & degrade macromolecules
- Maintain a dynamic steady state
- Self-assemble complex structures
- Replicate accurately & efficiently
- Maintain biochemical “order” vs outside

Organization of Life

- elements
- simple organic compounds (monomers)
- macromolecules (polymers)
- supramolecular structures
- organelles
- cells
- tissues
- organisms

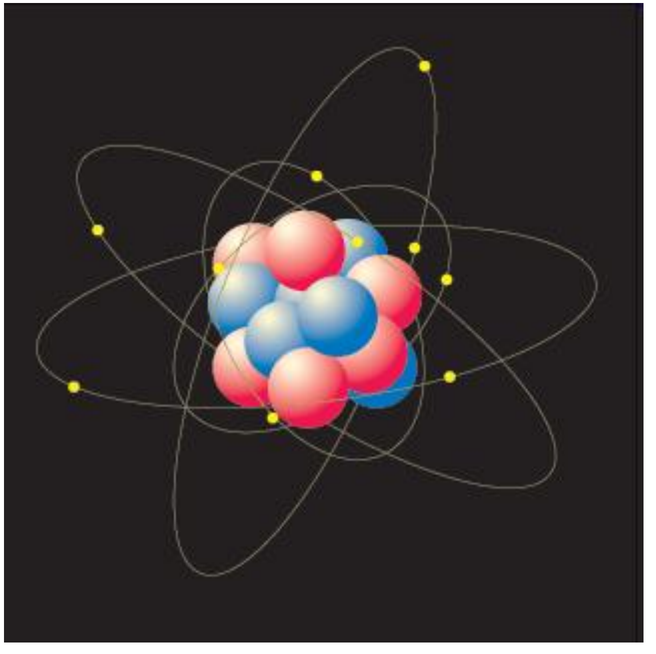
Elements

- Make up all matter.
- 92 occur in nature.
- Identified by names or chemical symbols (abbreviations of modern or Latin names).
- Identified by number (based on structure of subunits or atoms).
- Described and organized in periodic table.



Atoms

- Subunits of elements.
- Smallest complete units of matter.
- Cannot be broken down or changed by ordinary chemical and physical means.



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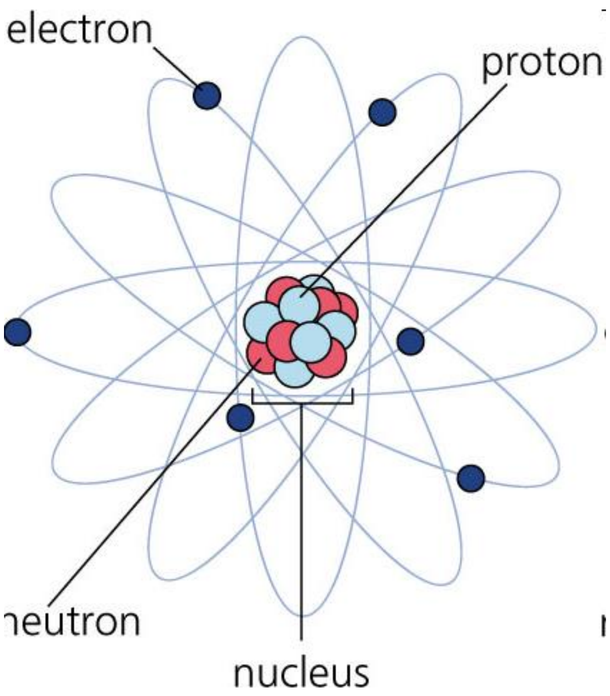
Atomic Structure

- **Nucleus**
  - Positively charged **protons.**
  - Neutrally charged **neutrons.**
  - Surrounded by negatively charged **electrons.**



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Molecules and Compounds

Molecules

- Formed when two or more atoms unite on the basis of their electron structures

- Can be made of like atoms or atoms of different elements

Compounds

- Composed of two or more elements

- Chemical bonds hold the atoms together in a molecule.

- There are 2 types of chemical bonds **IONIC** and **COVALENT**

Biomolecules as polymers

- Carbohydrates
- Proteins
- Lipids
- Nucleic acid

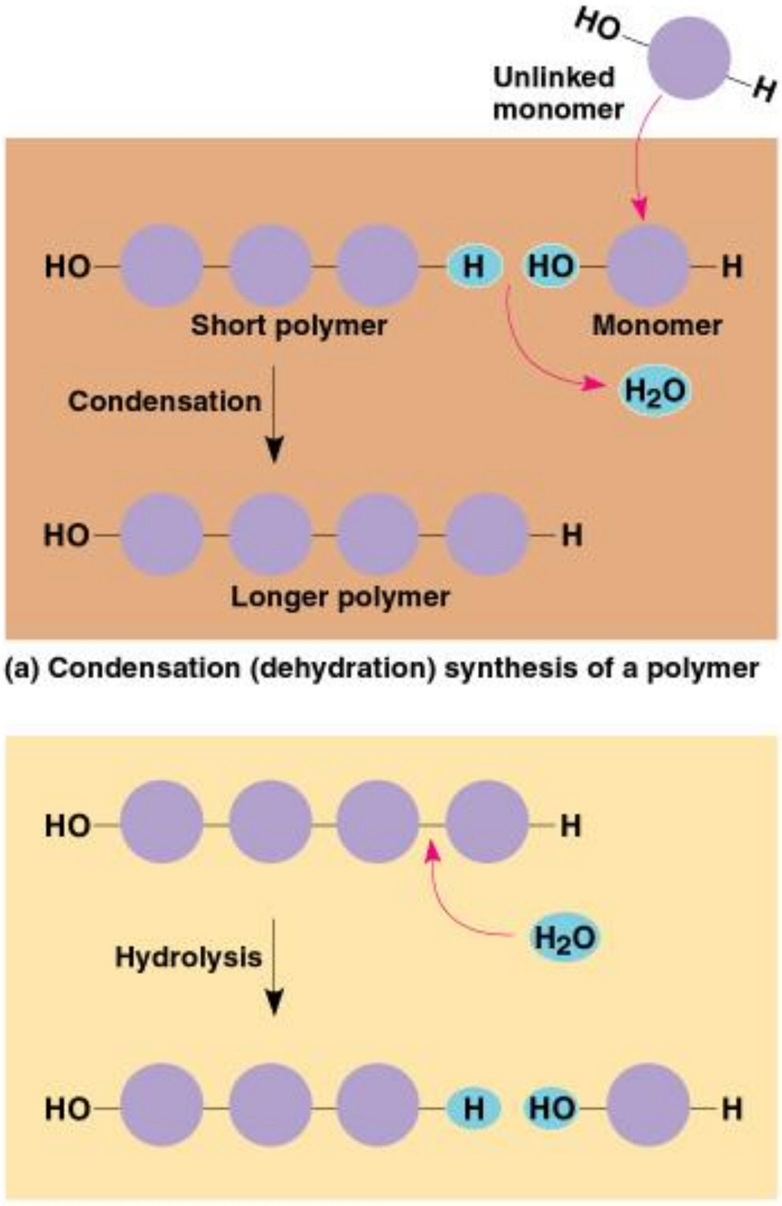
- Each of these types of molecules are **polymers** that are assembled from single units called **monomers**.

- Each type of macromolecule is an assemblage of a different type of monomer

Common theme:

Monomers form polymers through condensations

Polymers are broken down through hydrolysis.

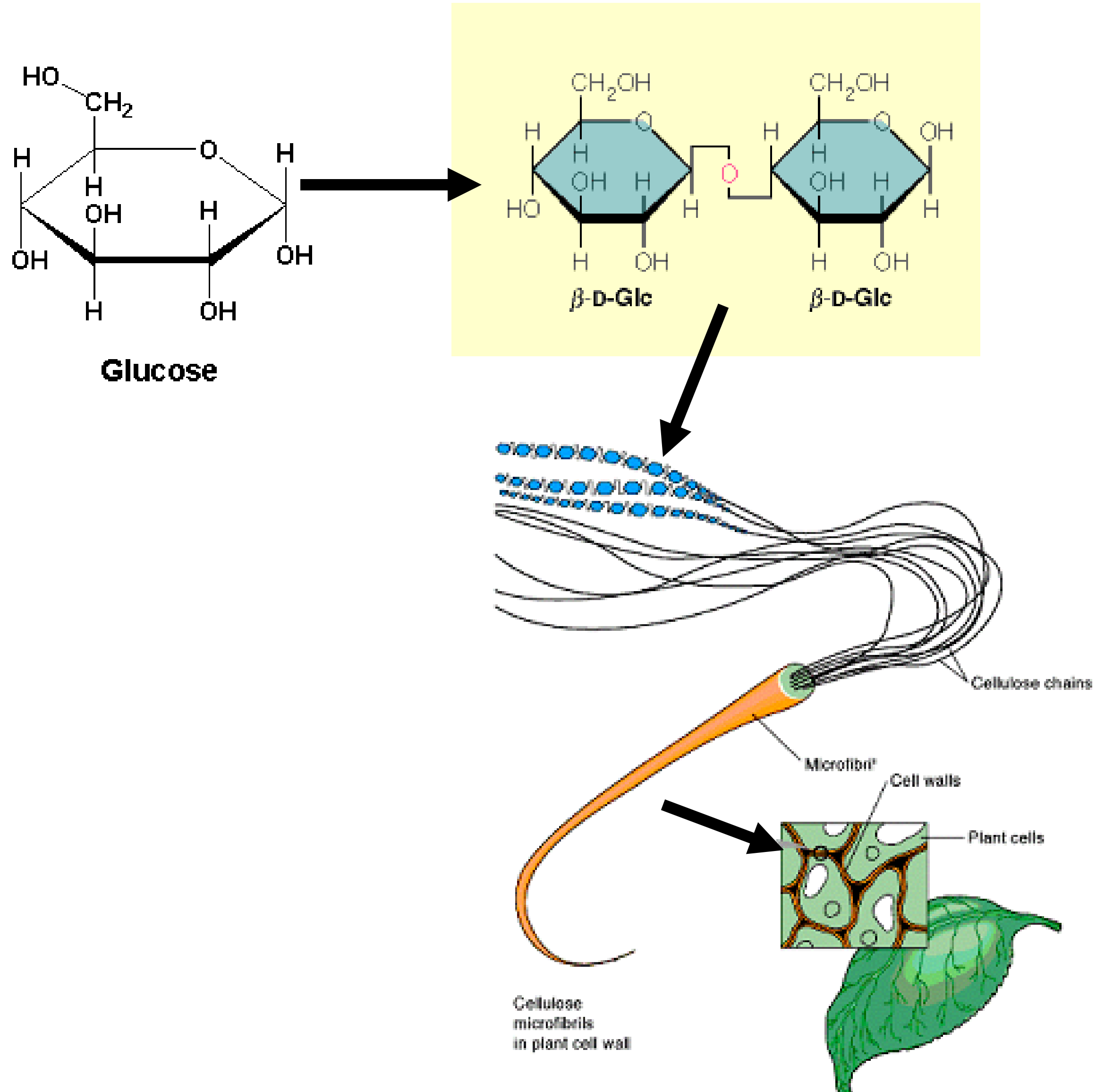


(a) Condensation (dehydration) synthesis of a polymer

(b) Hydrolysis of a polymer

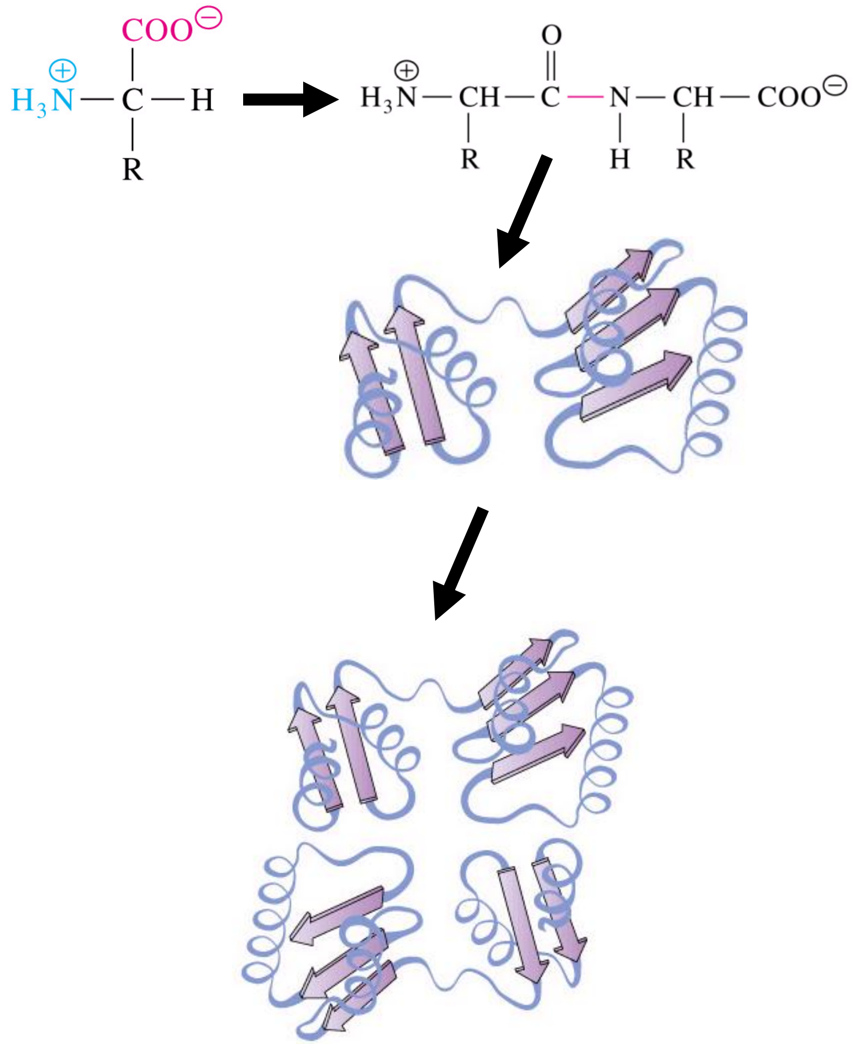
Carbohydrates

monomer	glucose
polymer	cellulose
supramolecular structure	cell wall



Proteins

monomer	amino acid
polymer	protein subunit
supramolecular structure	Enzyme complex

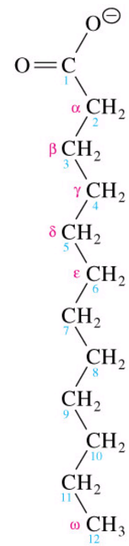


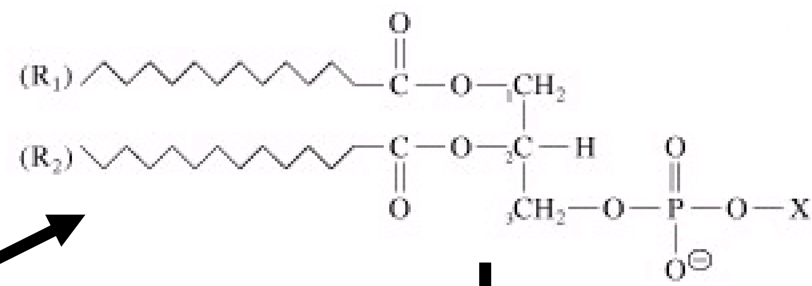
Lipids

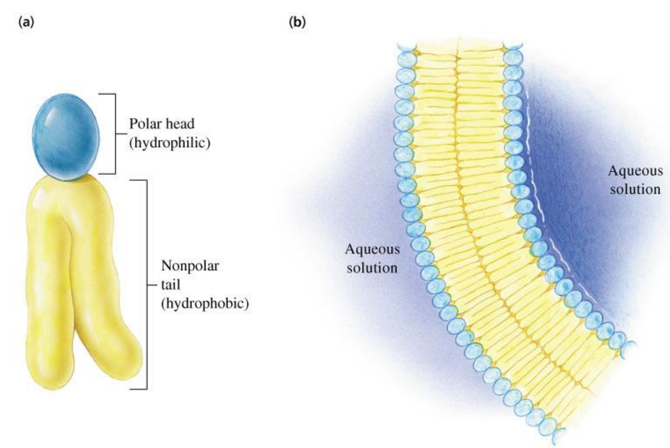
monomer — fatty acid

polymer — phospholipid

supramolecular structure — membrane





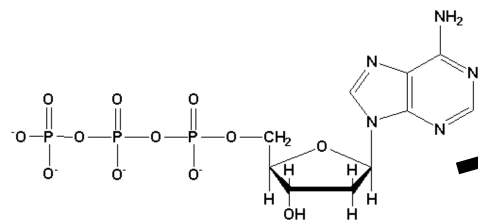


Nucleic Acids

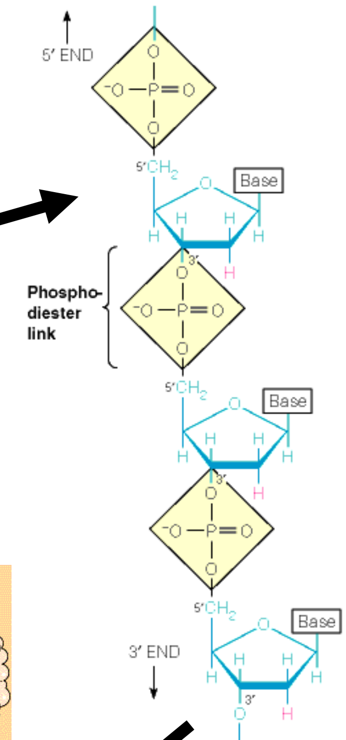
monomer — nucleotide

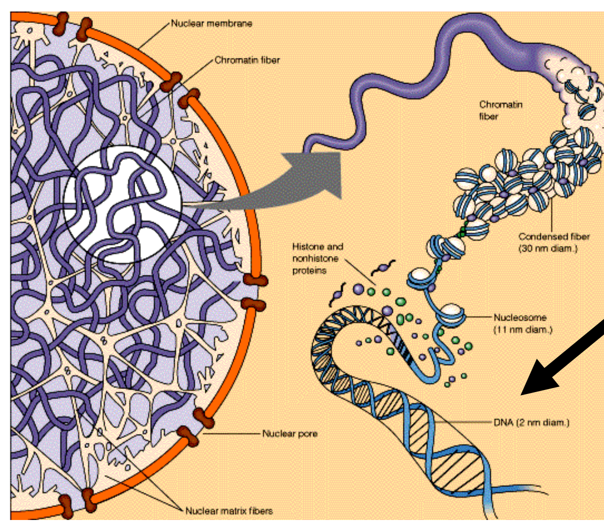
polymer — DNA

supramolecular structure — chromatin



Deoxyadenosine Triphosphate (dATP)





Many Important Biomolecules are Polymers

	Carbs	Proteins	Lipids	Nucleic Acids
monomer	glucose	amino acid	fatty acid	nucleotide
polymer	cellulose	protein subunit	phospholipid	DNA
supramolecular structure	cell wall	protein complex	membrane	chromosome

History and development of Biochemistry

1903, Neuberg (German): "Biochemistry"

"Chemistry of Life"

Two notable breakthroughs

(1) Discovery of the role of **enzymes** as catalysts

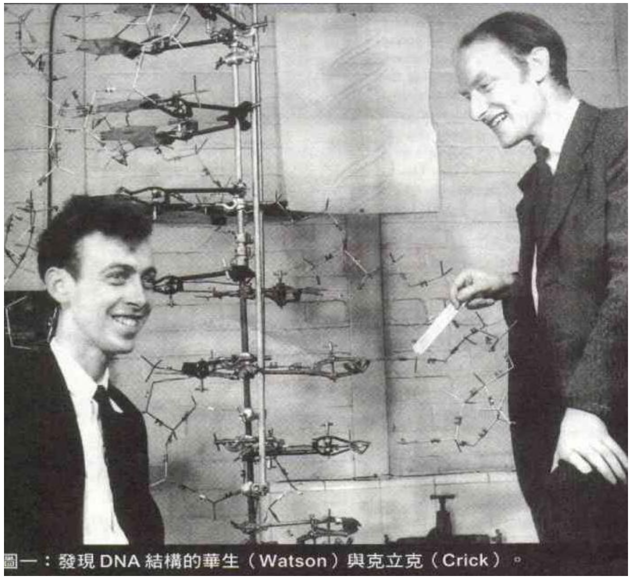
(2) Identification of **nucleic acids** as information molecules

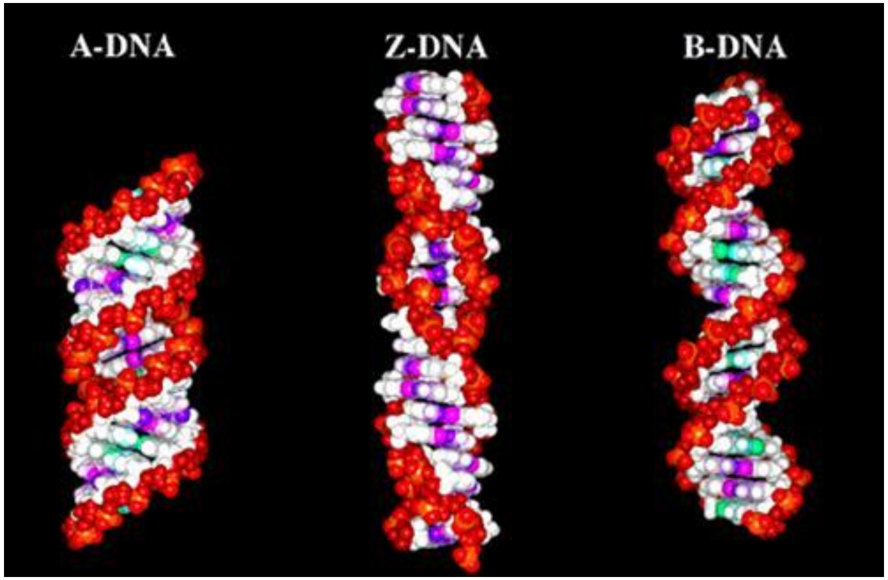
Flow of information: from nucleic acids to proteins

DNA → RNA → Protein

- **1937**: *Krebs* won the Nobel Prize in Physiology or Medicine in 1953 for the discovery of the Citric Acid Cycle

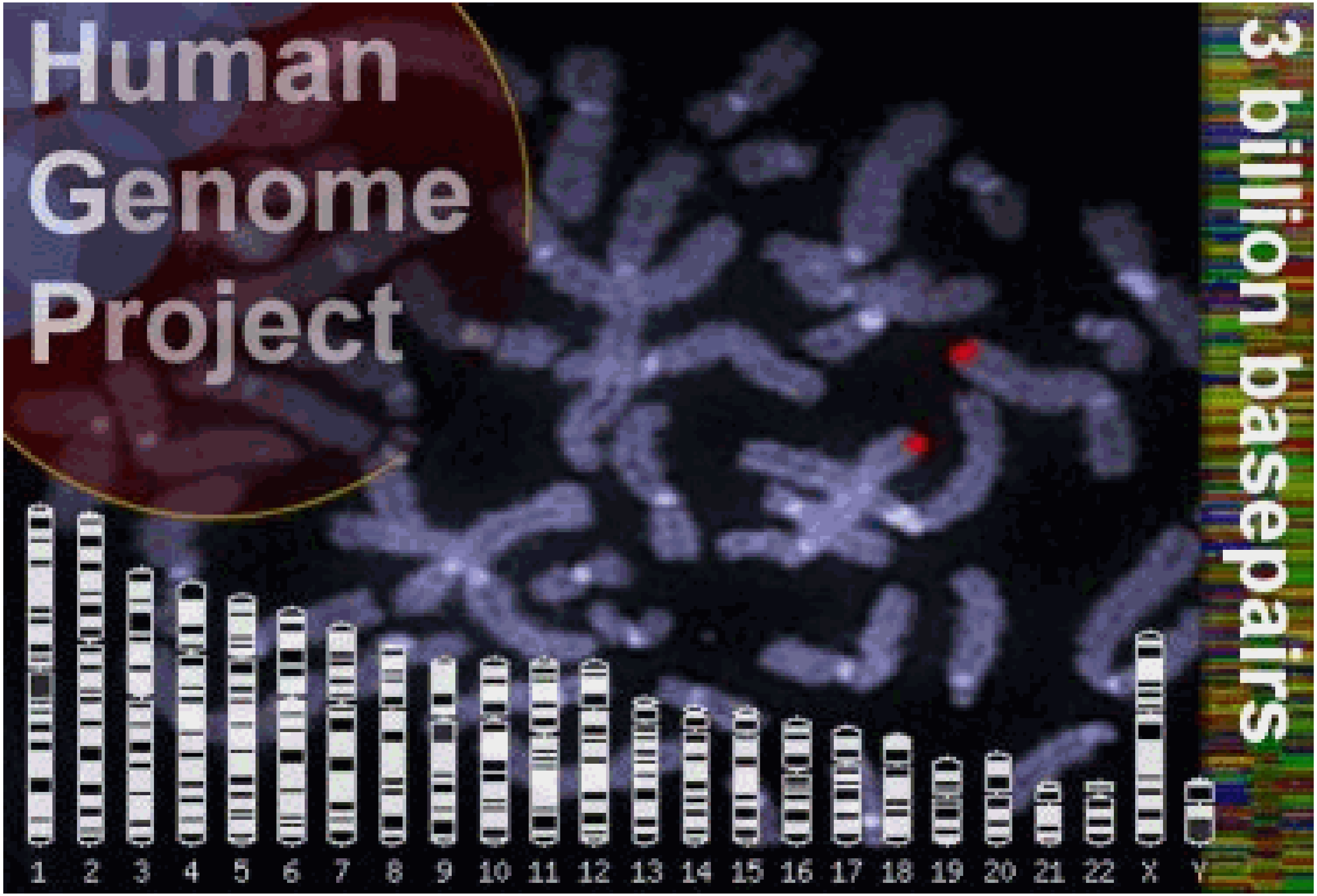
- **1953**: *Watson & Crick* won the Nobel Prize in Physiology or Medicine in 1962 for the discovery of the DNA Double Helix





- In **1955**， *Sanger* for the determination of insulin sequence- won the Nobel Prize in Physiology or Medicine in 1956
- In **1980**， *Sanger & Gilbert* for first sequencing DNA- won the Nobel Prize in Chemistry in 1980
- In **1993**, *Kary B. Mullis* for the invention of the PCR method -won the Nobel Prize in Chemistry in 1993

HGP from 1990, completed in 2003



Principle areas of Biochemistry

- Structure and function of cellular components
  (i.e.) proteins, carbohydrates, lipids, nucleic acids and other biomolecules

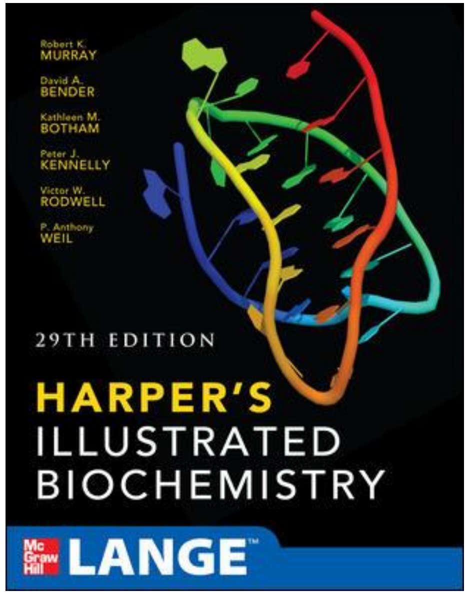
- Metabolism (catabolic and anabolic processes) and its regulation

- Molecular Genetics:
  - Gene expression and modulation
  - Regulation of protein synthesis
  - How life is replicated

DNA $\longrightarrow$ **RNA** $\longrightarrow$ **Protein**

Topics of this course

1. Acids, Bases, pH scale and buffers
2. Chemical bonds
3. Amino acids: structure and properties
4. Peptide bonds, proteins: types, structure, function
5. Enzymes
6. Vitamins and coenzymes
7. Carbohydrates: structure and properties
8. Nucleotides and nucleic acids
9. Fatty acids and lipids
10. Hormones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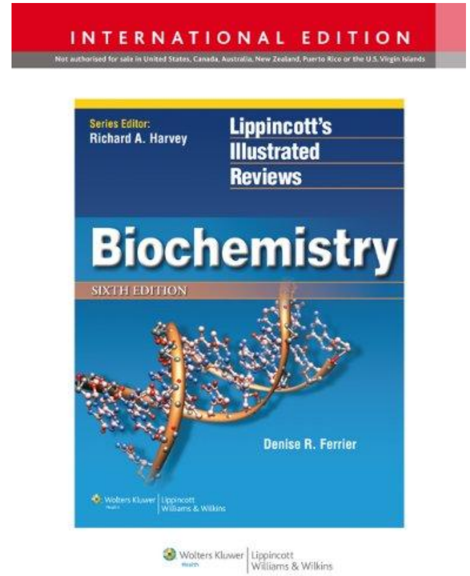
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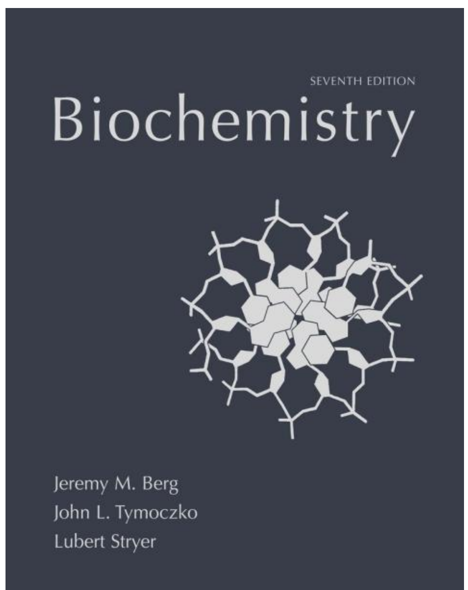
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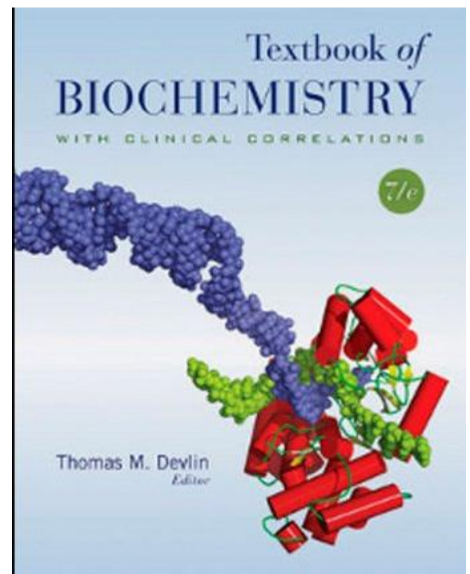
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