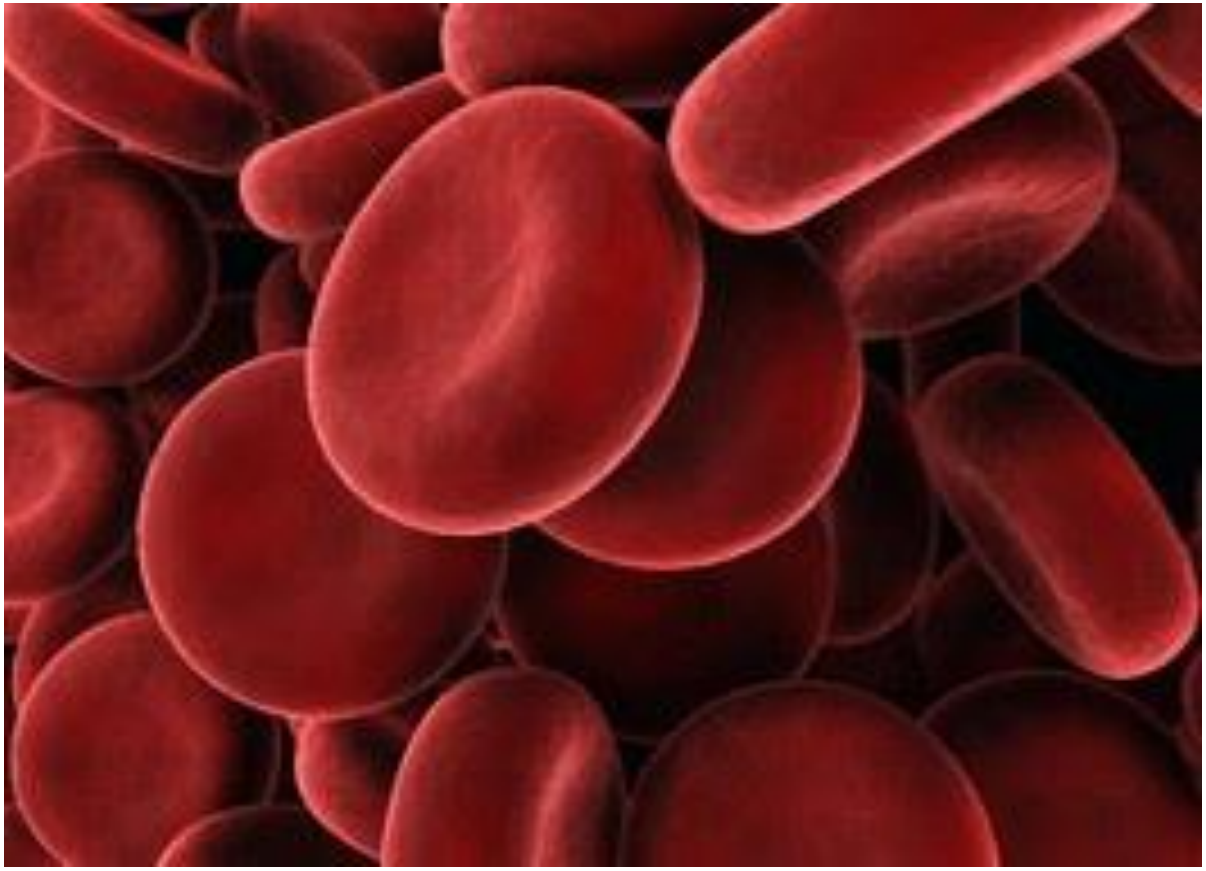
Welcome to BCH210
Convocation Hall T, R, F
10:00-11:00
Biochemistry I: Proteins, Lipids and Metabolism

- **Reinhart Reithmeier (Proteins)**
- **Roman Melnyk (Lipids & Membranes)**
- **Roula Andreopoulos (Enzymes)**
- **Sian Patterson (Metabolism)**

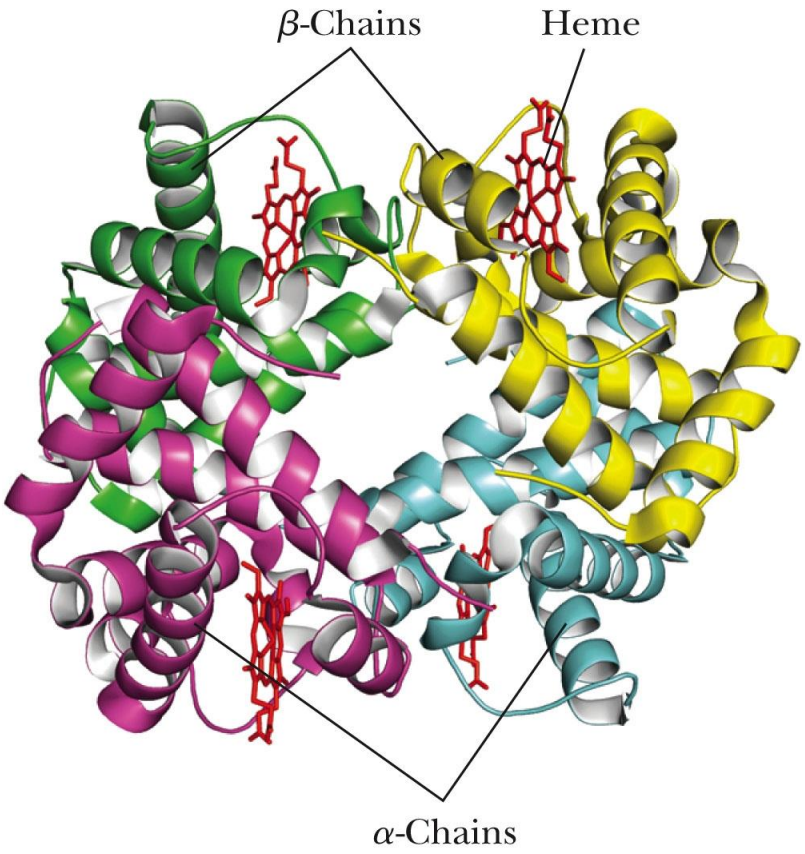
Lecture #1

- **Proteins and the molecules of life**
- **Complex molecules like proteins are built from simple building blocks like amino acids**
- **Biochemistry allows us to understand the molecular basis of life and disease**

Red Blood Cells

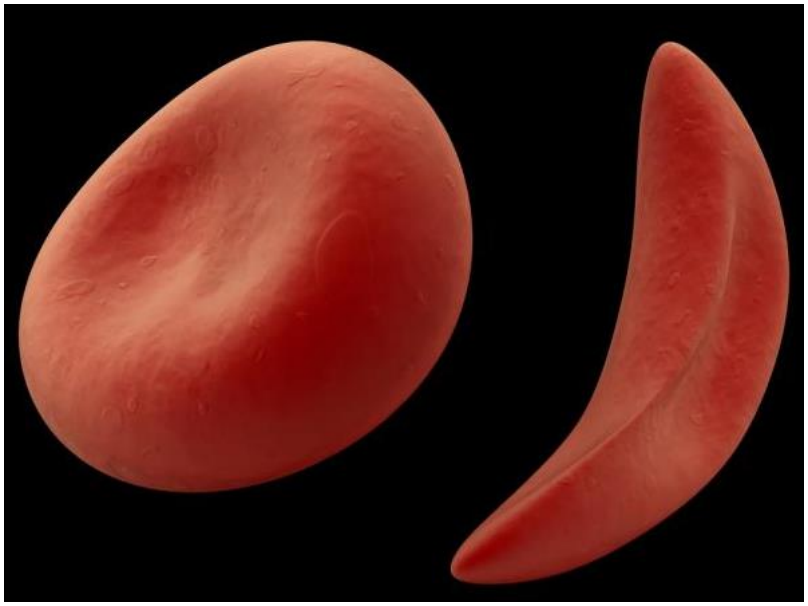


Hemoglobin is a protein



- **Hemoglobin is a tetramer of two α and two β polypeptide chains**
- **Contains heme**
- **Globin is a protein**

Sickle Cell Anemia



- **A single amino acid change (Glu6Val) in the β-chain of hemoglobin causes sickle cell anemia**
- **Hb S forms long polymers that change the shape of the red blood cell**

Proteins

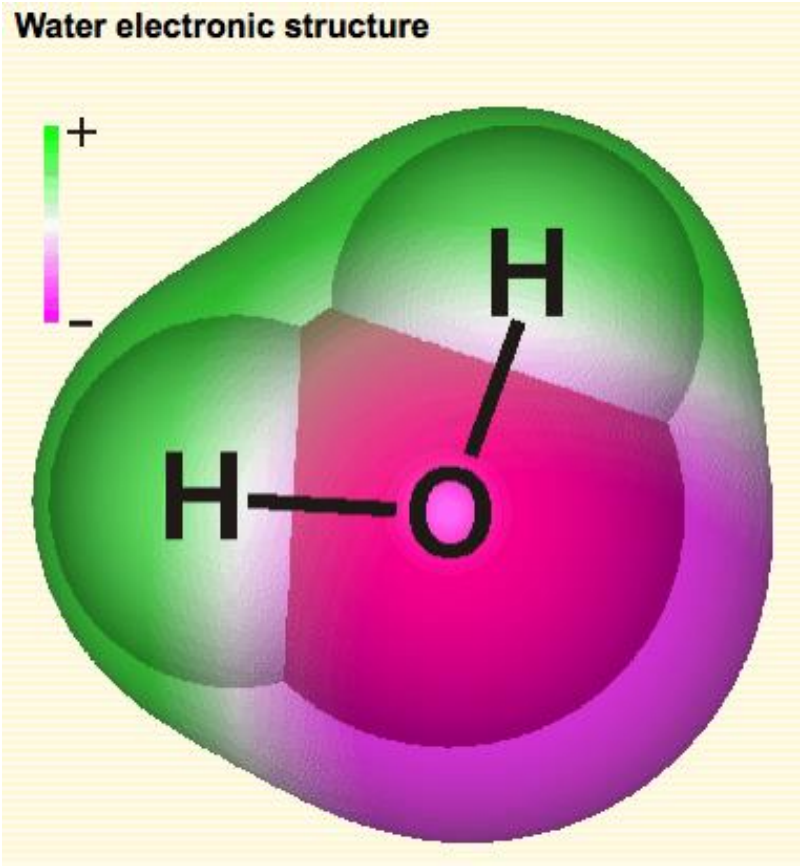
1. Proteins are polymers of amino acids linked in a linear series by peptide bonds
2. Proteins fold into specific 3-D structures
3. Proteins are the agents of biological function, often working as enzymes
4. Proteins are encoded by genes
5. Mutations in genes lead to defective proteins and inherited diseases

Molecules of Life

- **Proteins (hemoglobin, enzymes)**
- **DNA, RNA (genes, mRNA, tRNA)**
- **Lipids (fats, cholesterol, hormones)**
- **Sugars (energy = ATP)**
- **Small molecules (metabolites, vitamins)**
- **Ions (K^+, Na^+, Ca^{2+}, Cl^-)**
- **Water (H_2O)**

H_2O

- **Water is the most important molecule in biology and is essential for life**
- **Water plays a key role as a solvent and as a reactant**
- **Water is responsible for molecular structure**



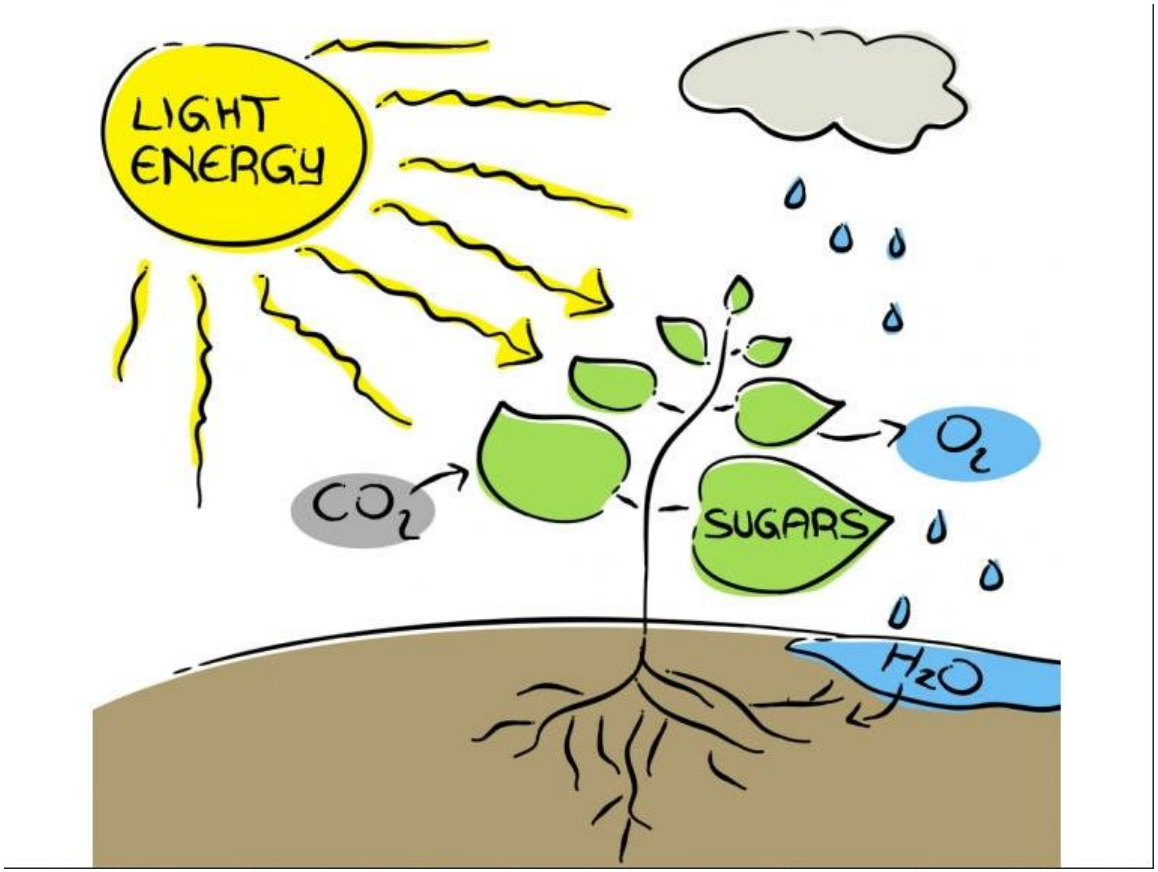
May the force be with you

- **Hydrophobic effect (avoid water)**
- **Ionic interactions (opposite charges)**
- **Hydrogen bonds (specific)**
- **Van der Waals (contact)**

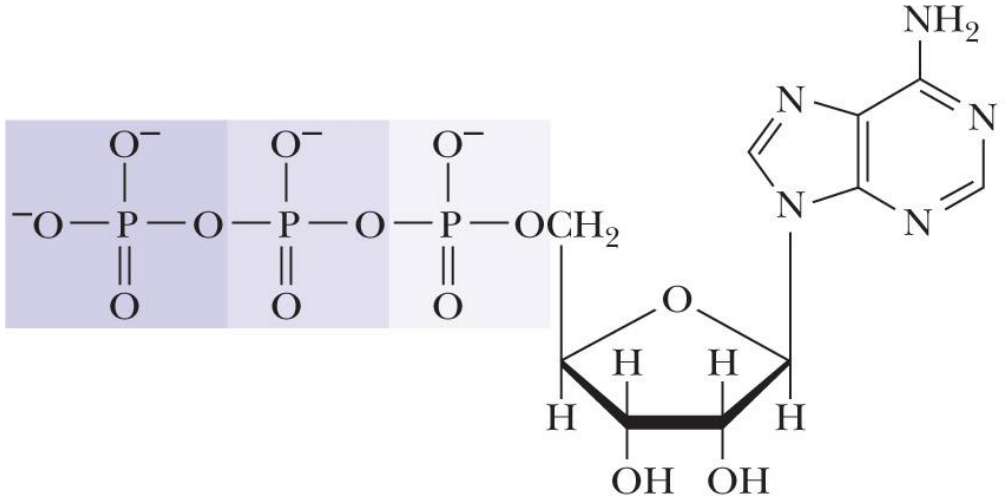
The hydrophobic effect

- **Hydrophobic amino acids usually occur in the non-polar interior of globular proteins**
- **Hydrophilic amino acids interact with the polar solvent on the protein surface**
- **The polar solvent is water**

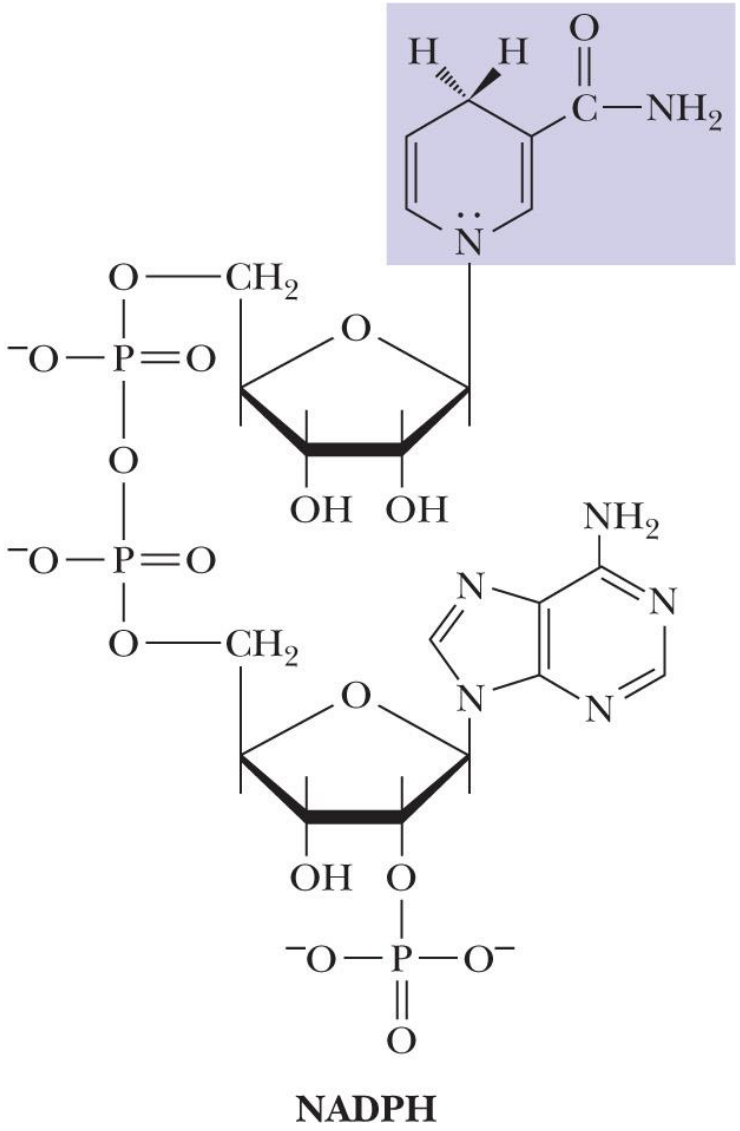
Source of energy is the sun



ATP and NADPH

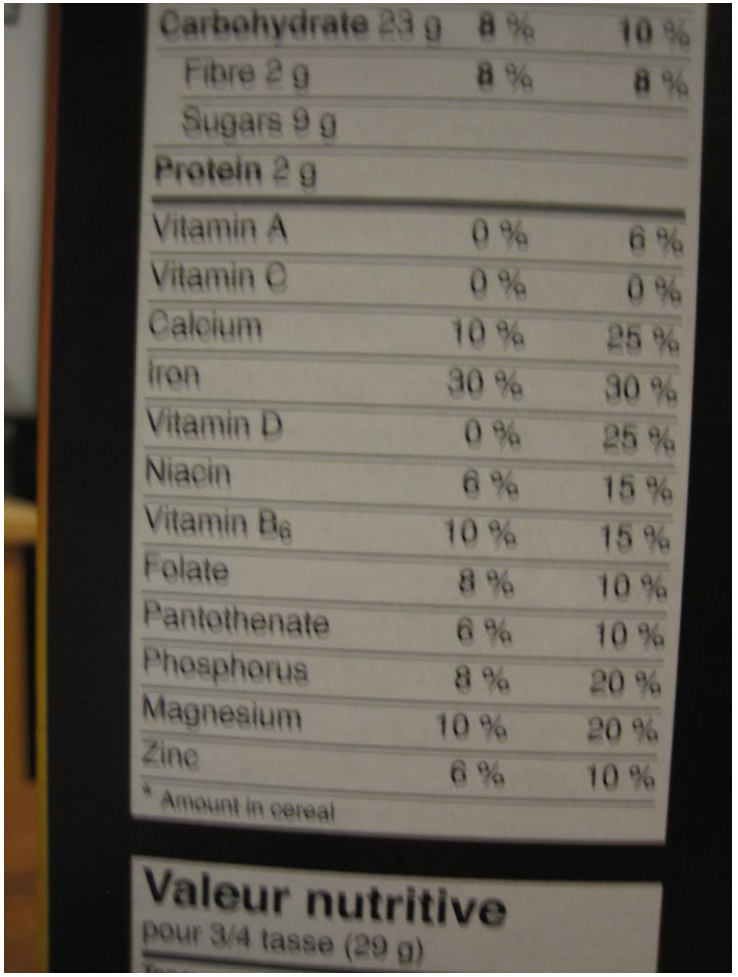


ATP

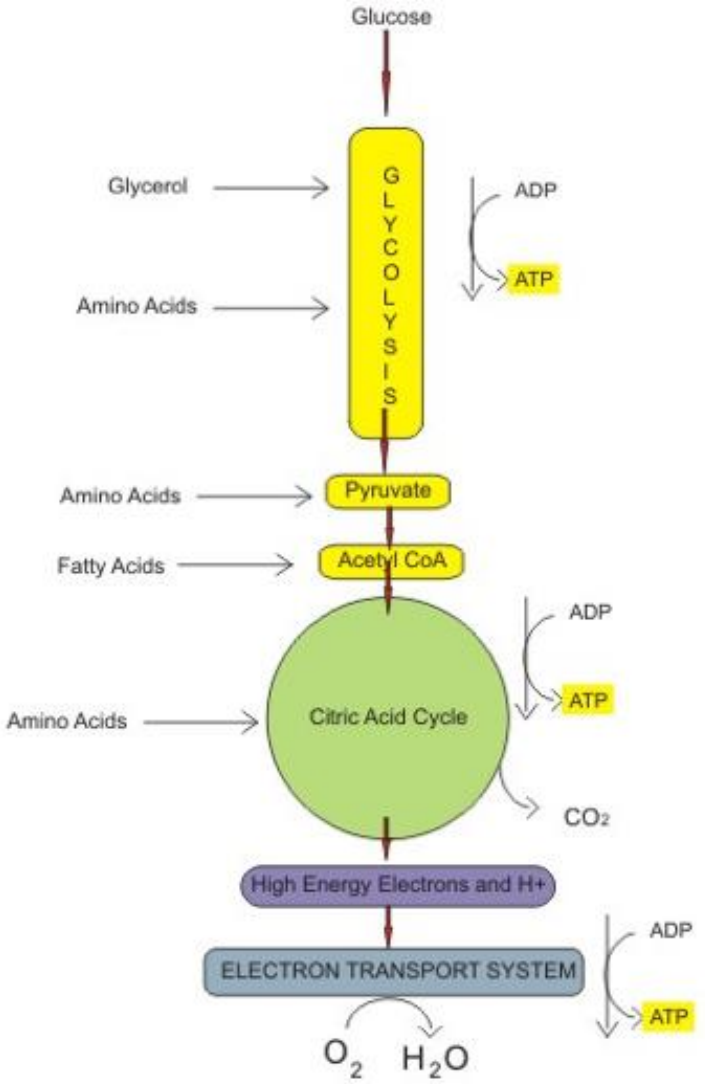


NADPH

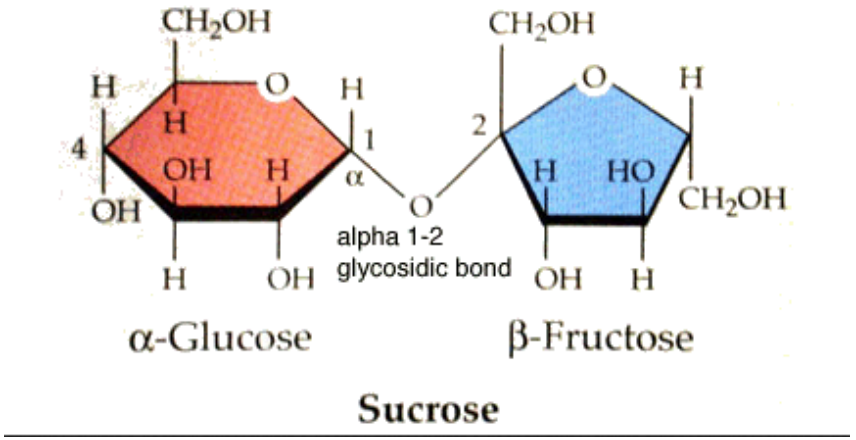
Eat your cereal



ATP production pathway



Sucrose is a disaccharide



Sucrose

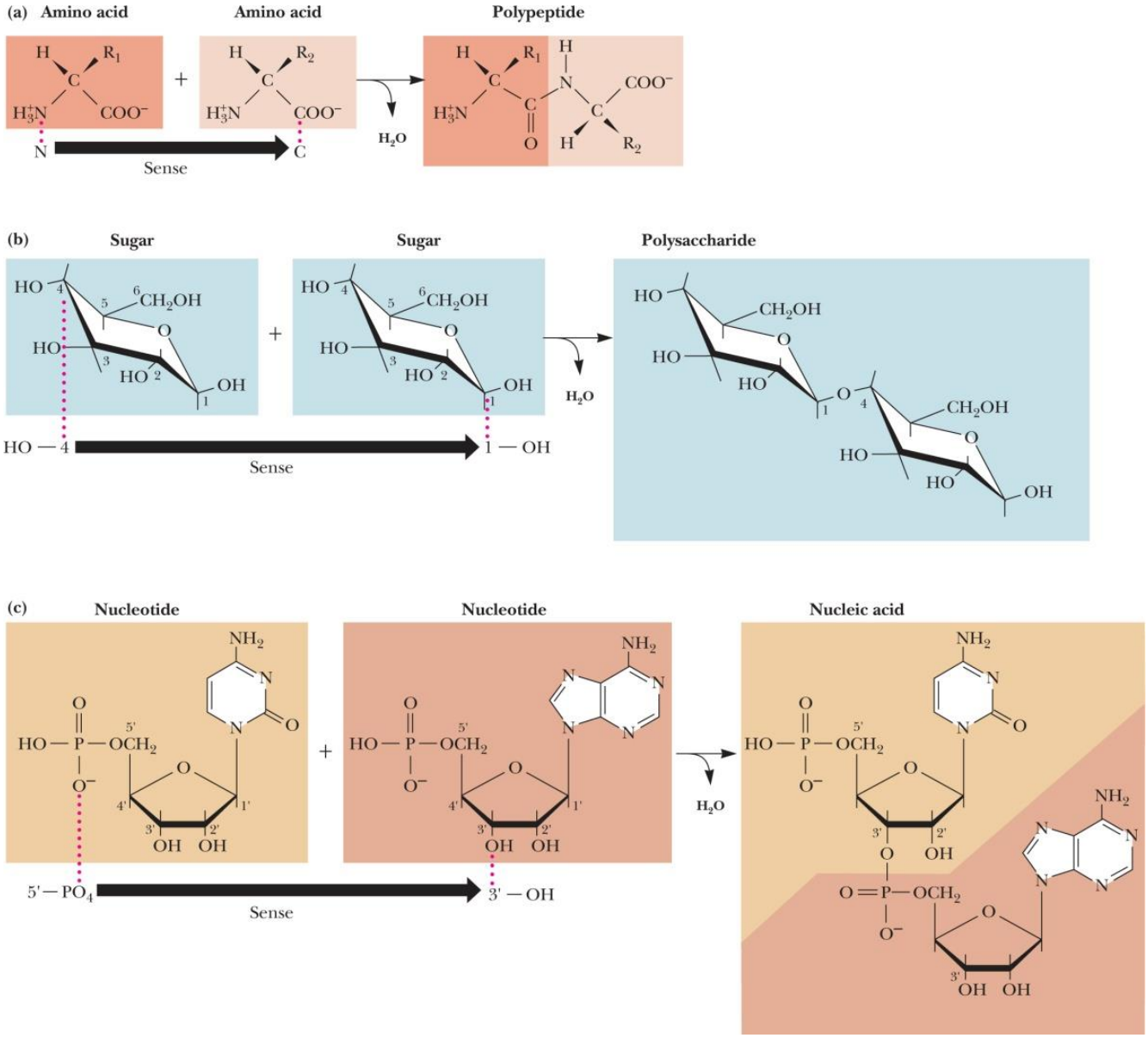
Ingredients you can actually pronounce?

- **Sugar**
- **Sucrose**
- **O-alpha-D-glucopyranosyl-(1-2)-beta-D- fructofuranoside**
- **(2R,3R,4R,5S)-2-(2S,3R,4R,5R)-3,4-dihydroxy-2,5-bis(hydroxymethyl) -tetrahydrofuran-2-yloxy)-6-(hydroxymethyl)-tetrahydro-2H-pyran-3,4,5-triol**

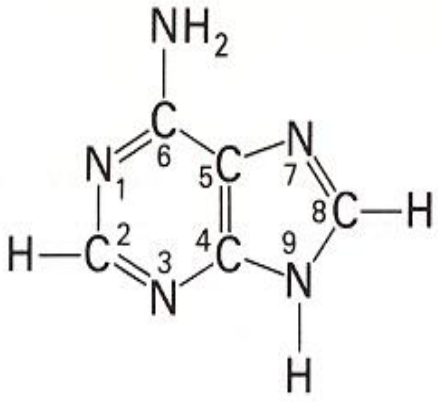
Building blocks

- **Proteins are polymers of amino acids linked in linear series by peptide bonds**
- **DNA are polymers of nucleotides linked in linear series of phosphodiester bonds**
- **Oligosaccharides are polymers of sugars (monosaccharides) linked in linear and branched series of glycosidic bonds**

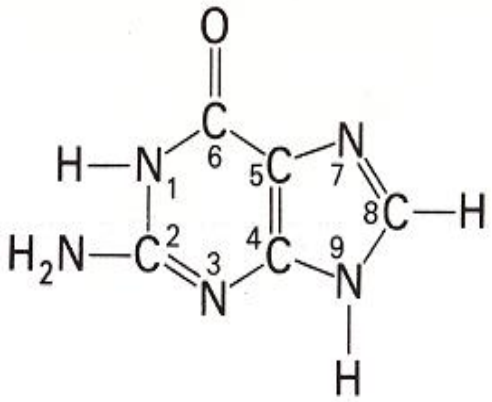
Polymerization processes



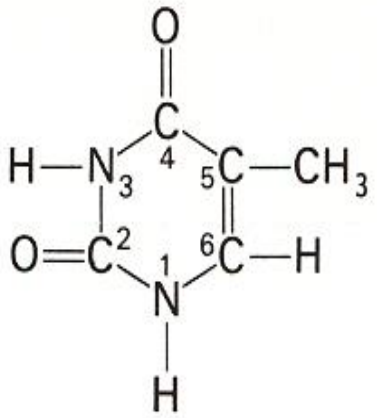
The four nucleotide bases



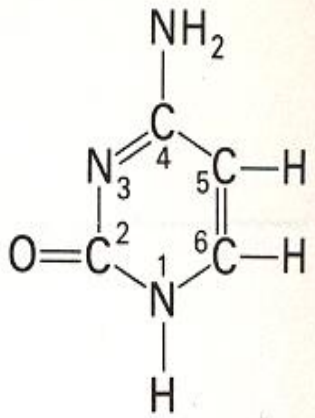
Adenine
(A)



Guanine
(G)



Thymine
(T)

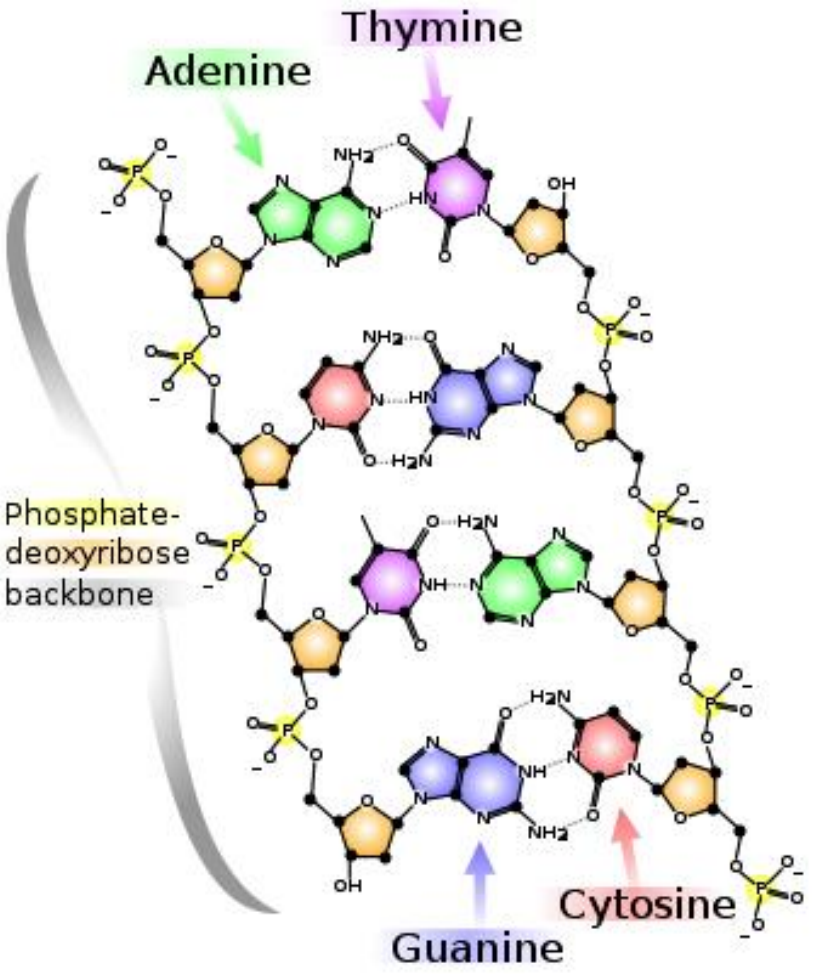


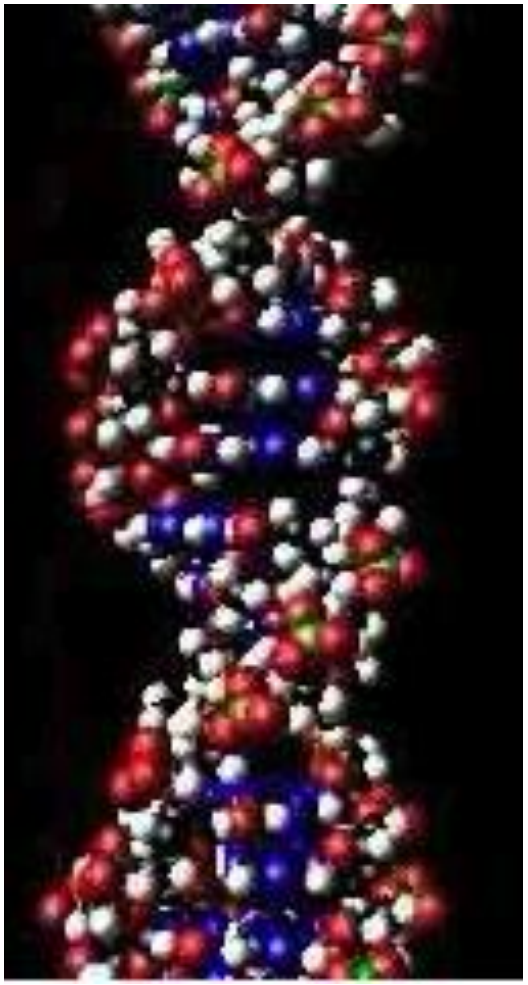
Cytosine
(C)

purines

pyrimidines

DNA double helix

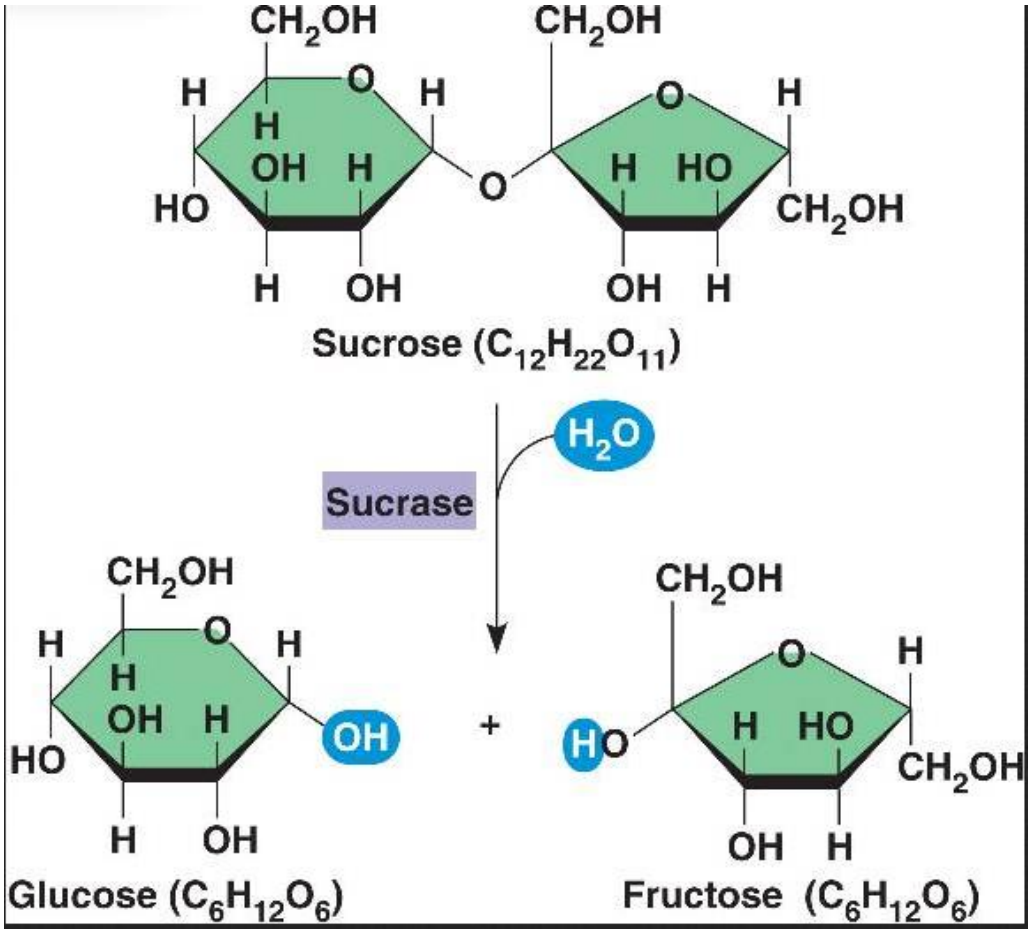




The genetic code

First position (5′ end)	*Second position*				*Third position (3′ end)*
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

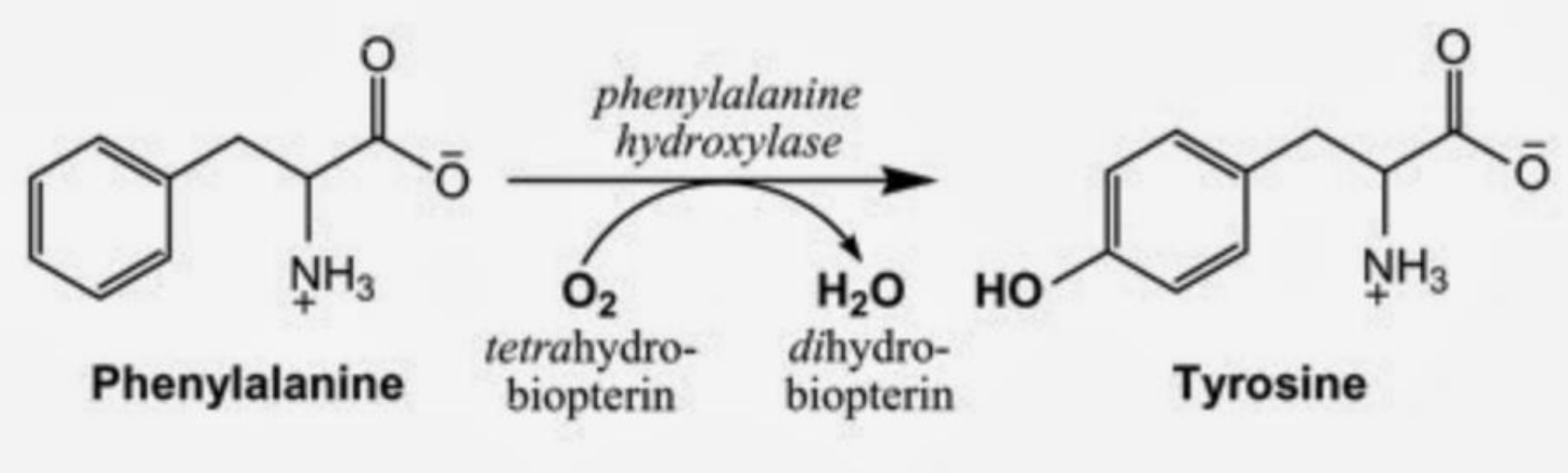
Proteins as enzymes



20 amino acids

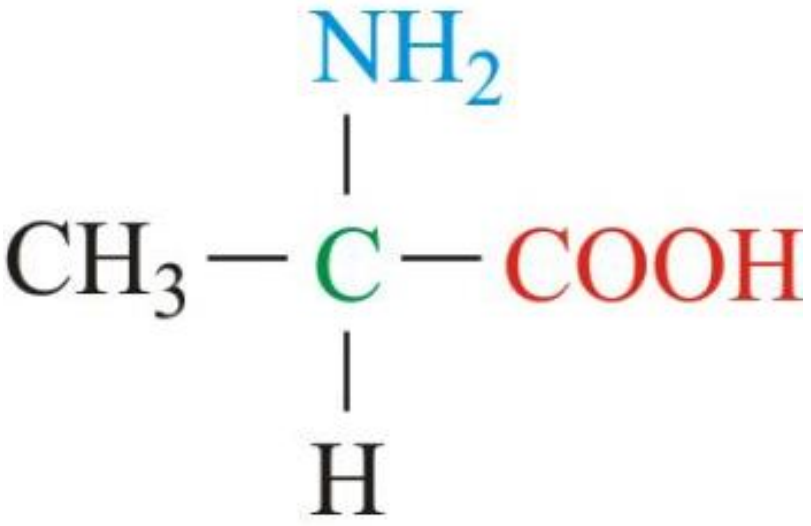
- **ACDEFGHIKLMNPQRSTVWY***
- **10 come from our diet**
- **“Zwitterionic”**
- **Joined through peptide bonds in proteins**

Phenylalanine Hydroxylase



The most boring amino acid

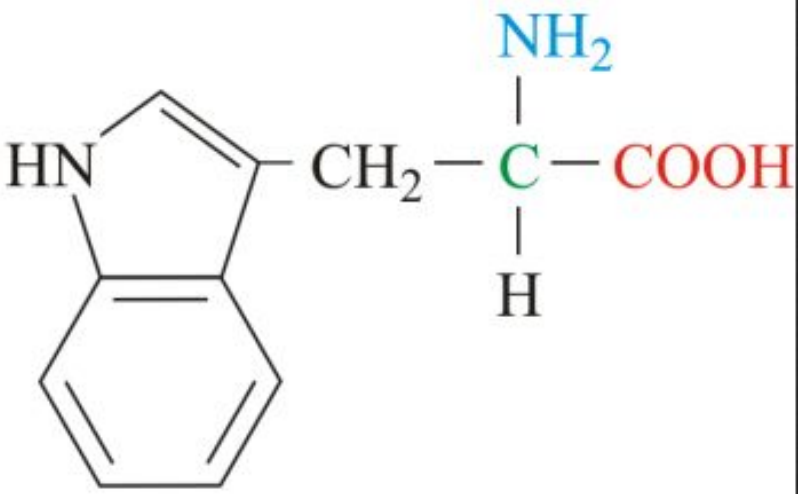
- **Alanine (Ala, A)**



- **Methyl side-chain**
- **Not too hydrophilic**
- **Not too hydrophobic**
- **Just right!**
- **Common for mutagenesis**

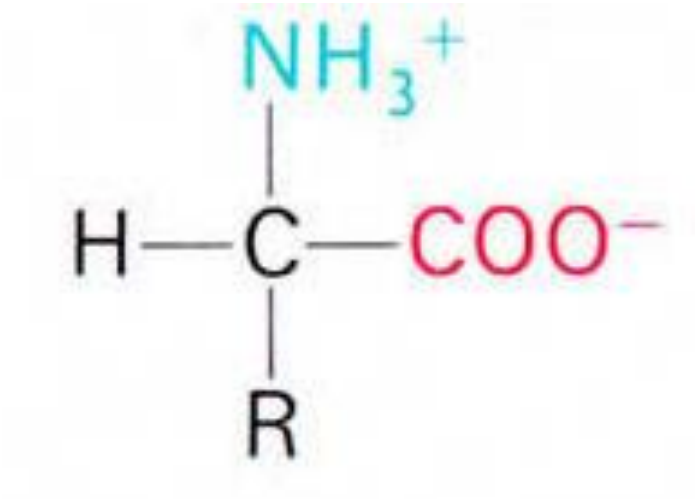
Biochemist's favourite amino acid

- **Tryptophan (Trp, W)**



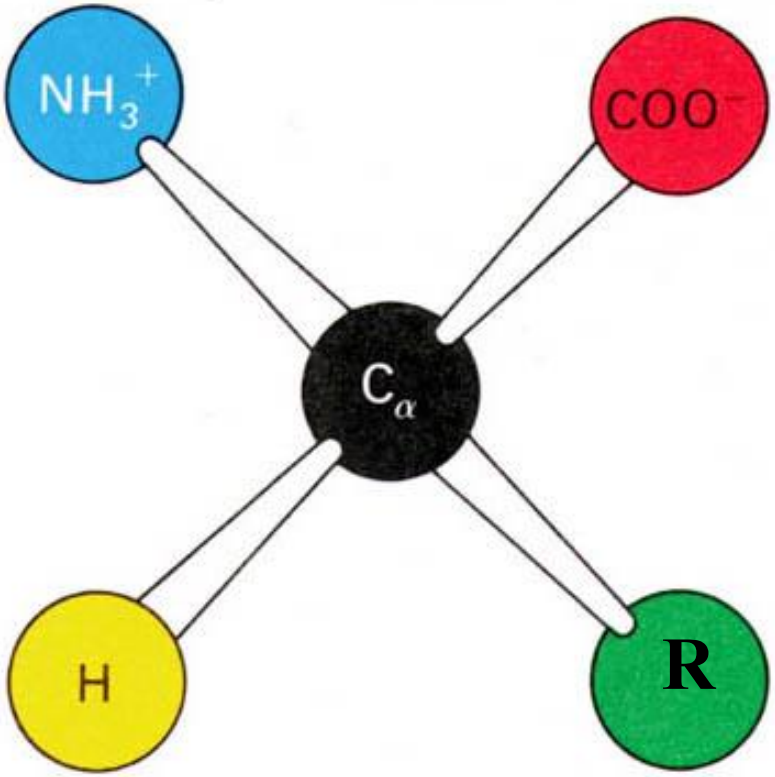
- **Fluorescent**
- **295/350 nm**
- **Sensitive to environment**
- **Monitor conformational changes**

Structure of the zwitterionic form of an amino acid

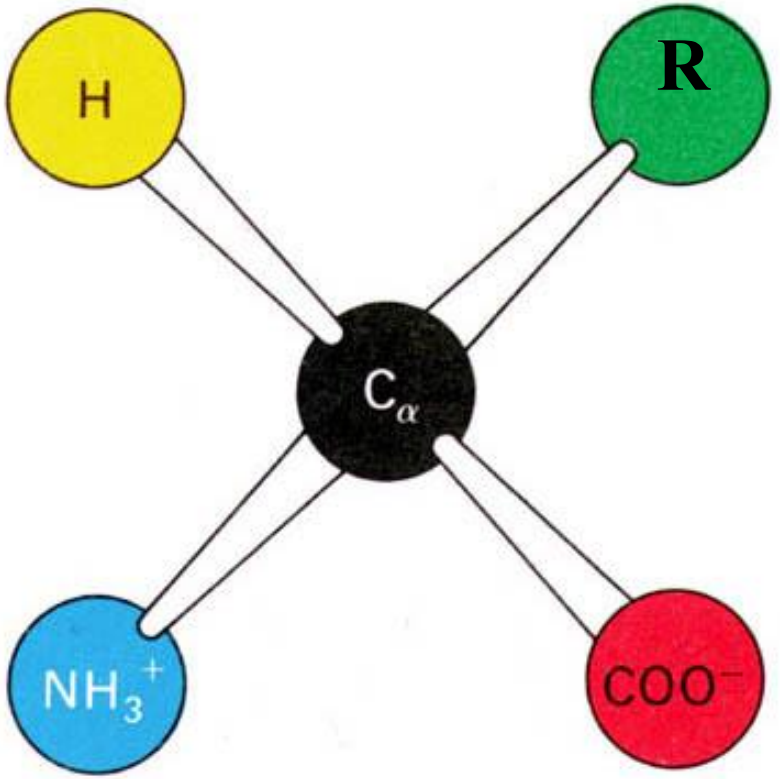


Zwitterion at neutral pH

The α - carbon of an amino acid is an asymmetric center

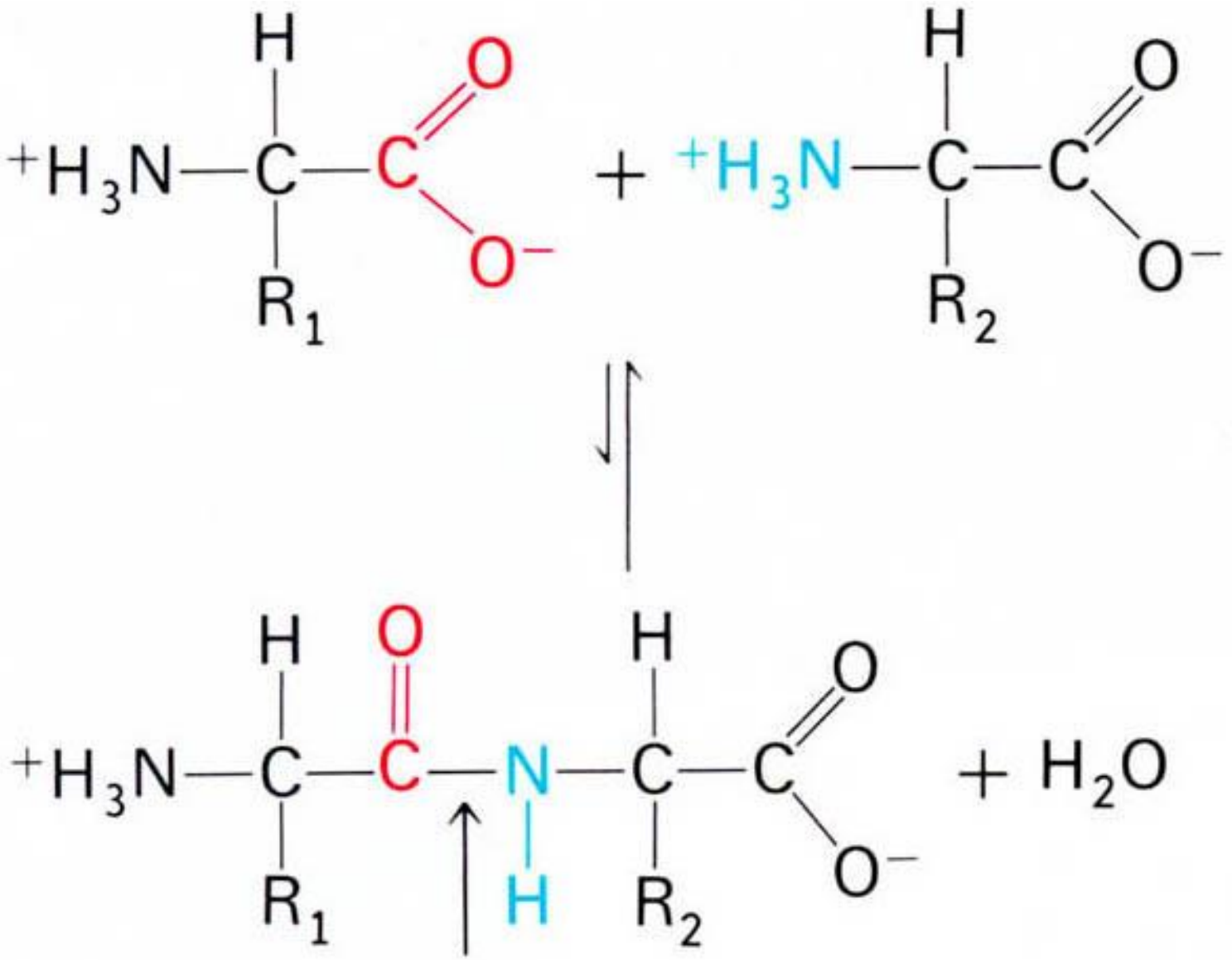


L - isomer



D - isomer

Formation of a peptide bond

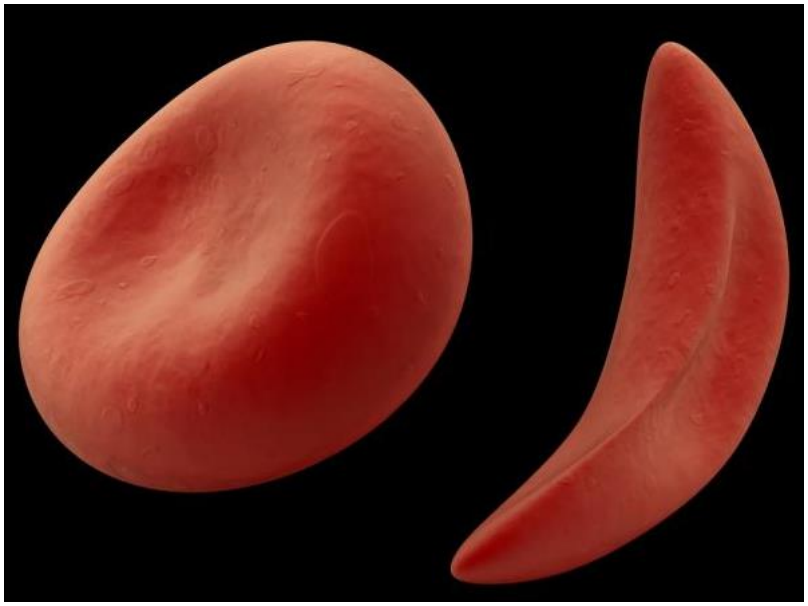


Properties of amino acid side chains

- **Side chains (R-groups) categorized as:**

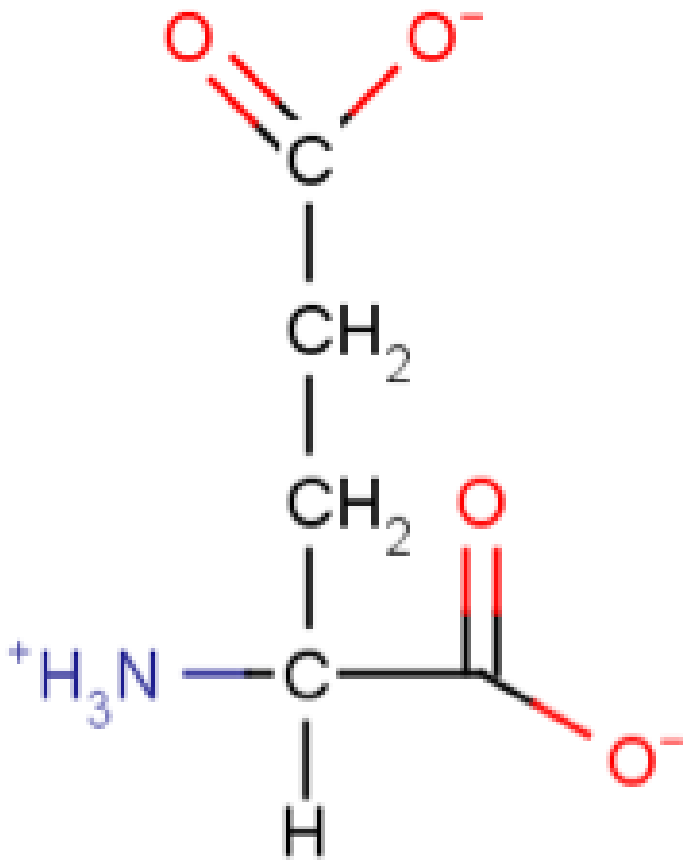
  - **Hydrophobic (non-polar)**
  - **Hydrophilic (polar, charged)**

Sickle Cell Anemia

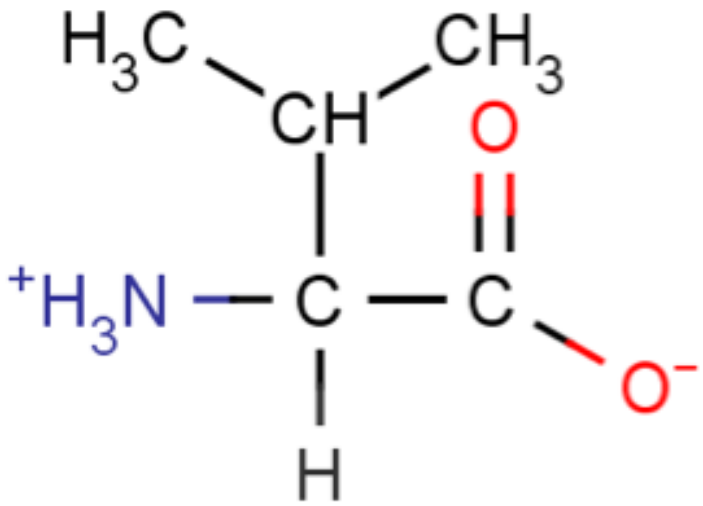


- **A single amino acid change (Glu6Val) in the β-chain of hemoglobin causes sickle cell anemia**
- **Hb S forms long polymers that change the shape of the red blood cell**

Glutamate vs Valine

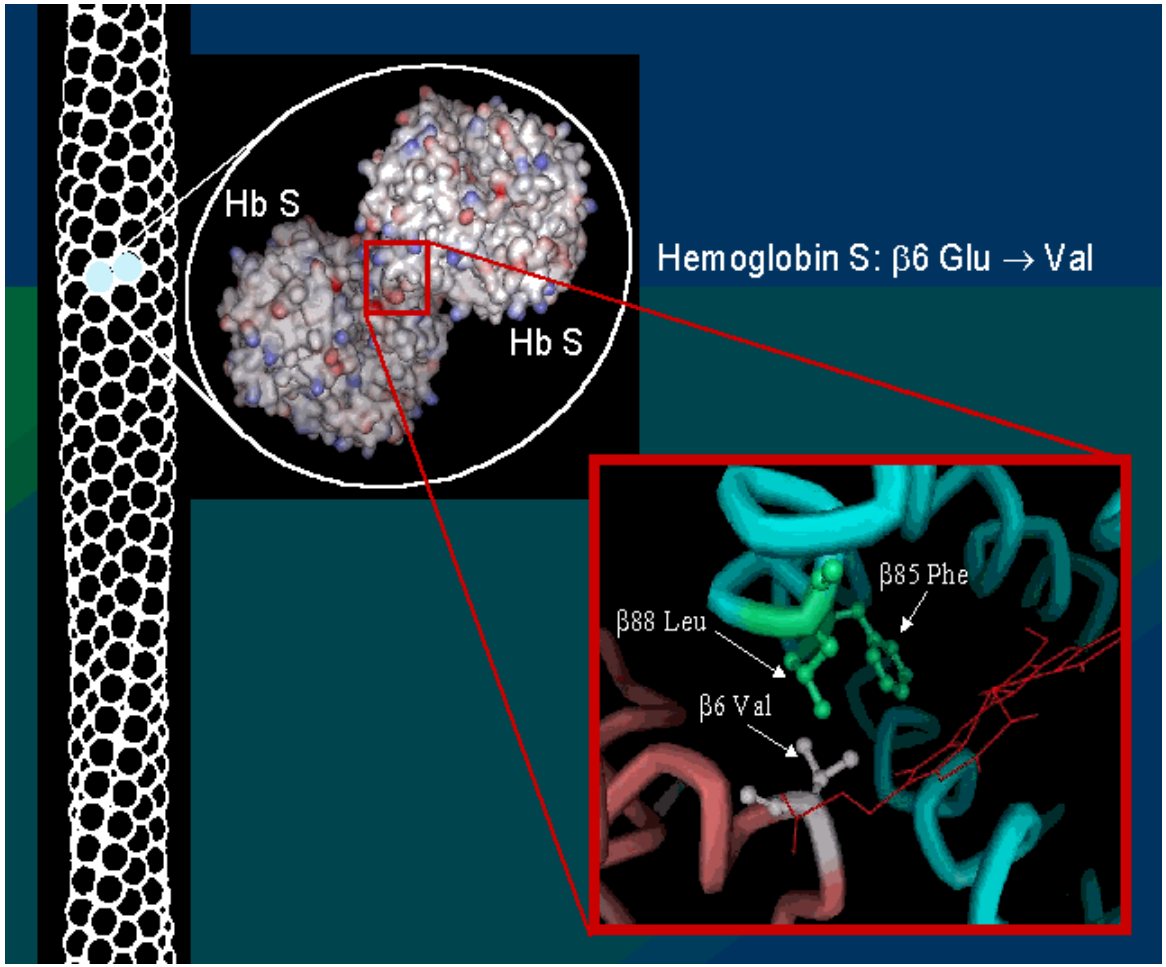


Glutamate



Valine

Sickle Cell Anemia



Summary

- **Biochemistry explains the molecular basis of disease**
- **Mutations in genes can change the amino acid at specific positions**
- **Complex structures are built from simple building blocks**

Question: What important roles does water play in biochemistry?