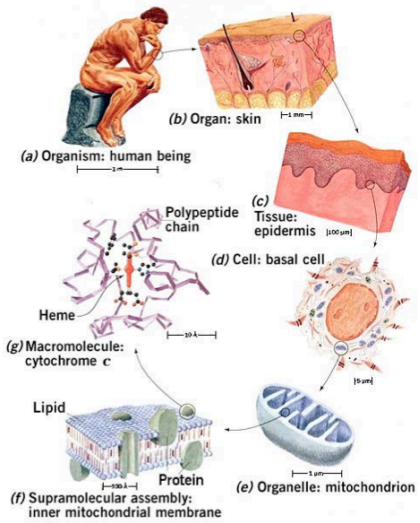
Introduction of Biomolecules (1)

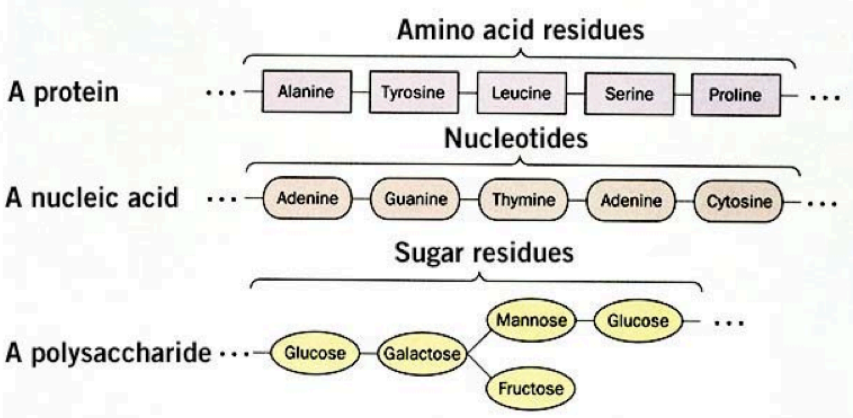
Date: 2011/12/06

Dr. Yi-Chung Tung

Biomolecules



Biomolecules



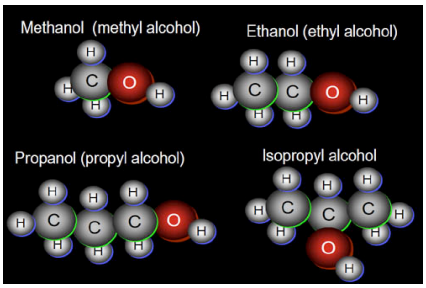
The Origin of Life

- The unique properties of carbon
  - The most abundant components of Earth's crust: O: 47%; Si: 28%, Al: 7.9%, Fe: 4.5%, and Ca: 3.5%.
- Elemental composition of the human body:

Element	Dry weight (%)	Elements present in trace amounts
C	61.7	B
N	11.0	F
O	9.3	Si
H	5.7	V
Ca	5.0	Cr
P	3.3	Mn
K	1.3	Fe
S	1.0	Co
Cl	0.7	Cu
Na	0.7	Zn
Mg	0.3	Se
		Mo
		Sn
		I

The Origin of Life

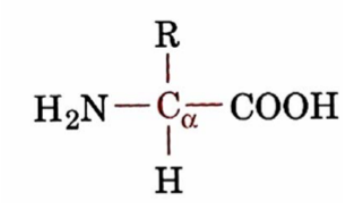
- Carbon has the unique ability to form a virtually infinite number of compounds as a result of its capacity to make as four highly stable covalent bonds (including single, double, and triple bounds) combined with ability to form covalently linked C-C chains of unlimited extent.
- About 13 million chemical compounds: 90% are organic (carbon-containing).



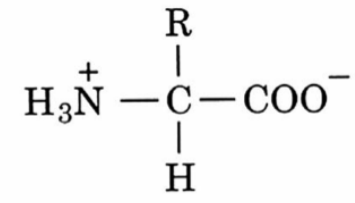
Amino Acids

- Amino acids are the monomeric units of proteins, energy, metabolites, and essential nutrients.

(1) Unionized form.

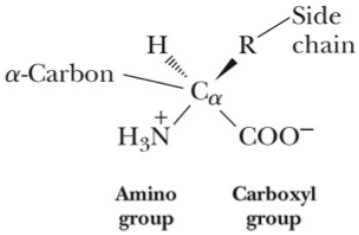


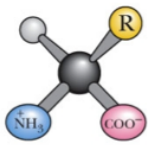
(2) Zwitterionic form.



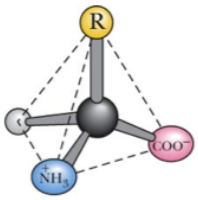
Amino Acids

- Anatomy of an amino acid. Amino acids commonly found in proteins possess this type of structure.





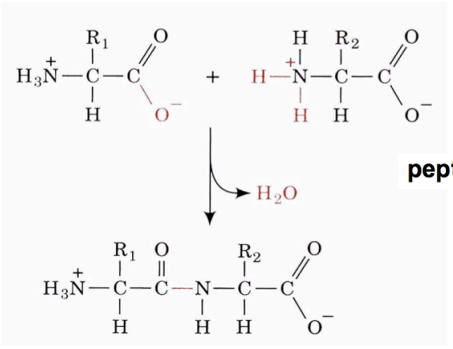
Ball-and-stick model



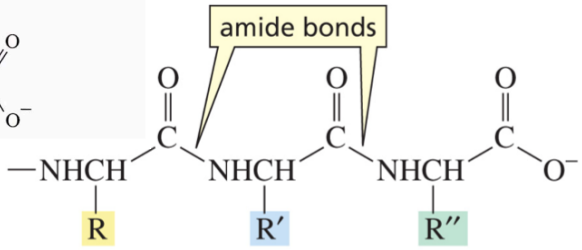
Amino acids are tetrahedral structures

Amino Acids

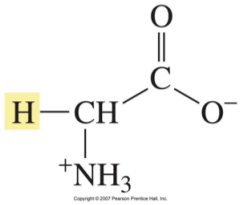
- Amino acids are linked together by **peptide bonds (amide bonds).**



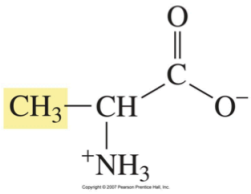
peptide ⟹ polypeptide ⟹ protein



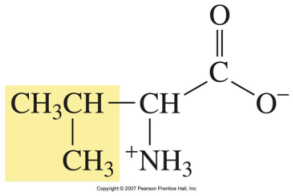
Amino Acids



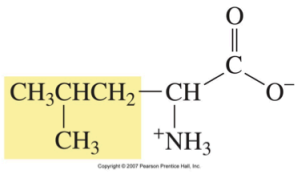
Glycine (Gly, G)



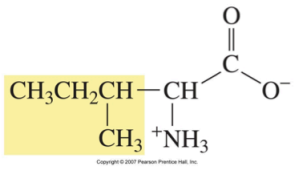
Alanine (Ala, A)



Valine (Val, V)*

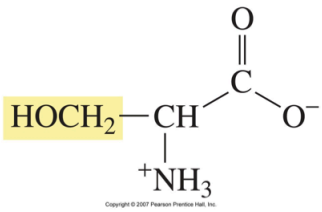


Leucine (Leu, L)*

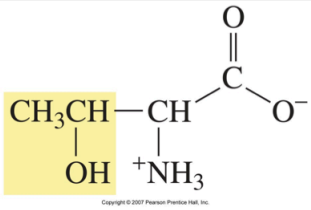


Isoleucine (Ile. I)*

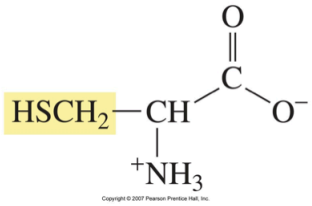
Amino Acids



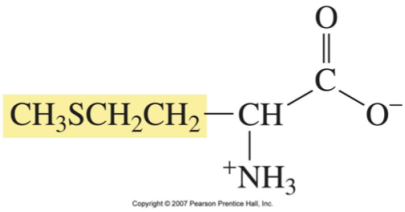
Serine (Ser, S)



Threonine (Thr, T)*

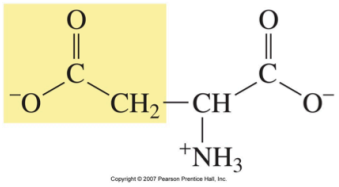


Cysteine (Cys, C)

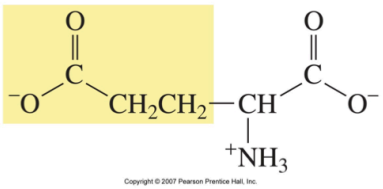


Methionine (Met, M)*

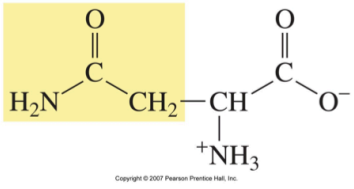
Amino Acids



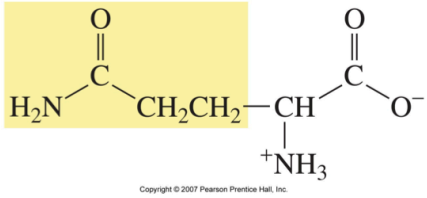
Aspartate (Asp, D)



Glutamate (Glu, E)

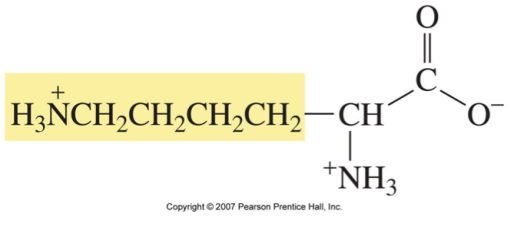


Asparagine (Asn, N)

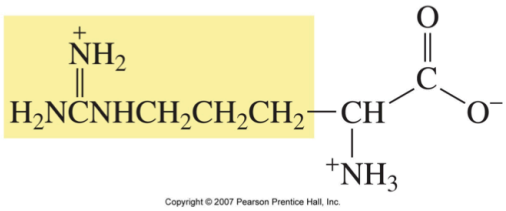


Glutamine (Gln, Q)

Amino Acids

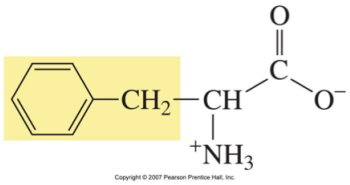


Lysine (Lys, K)*

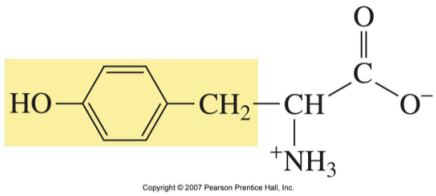


Arginine (Arg, R)*

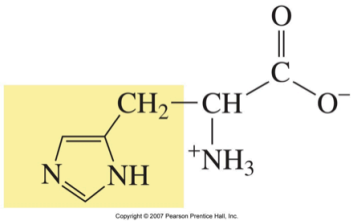
Amino Acids



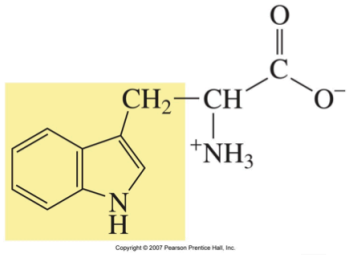
Phenylalanine (Phe, F)*



Tyrosine (Tyr, Y)

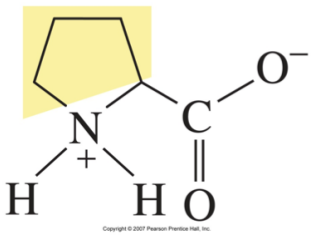


Histidine (His, H)*



Tryptophan (Trp, W)*

Amino Acids



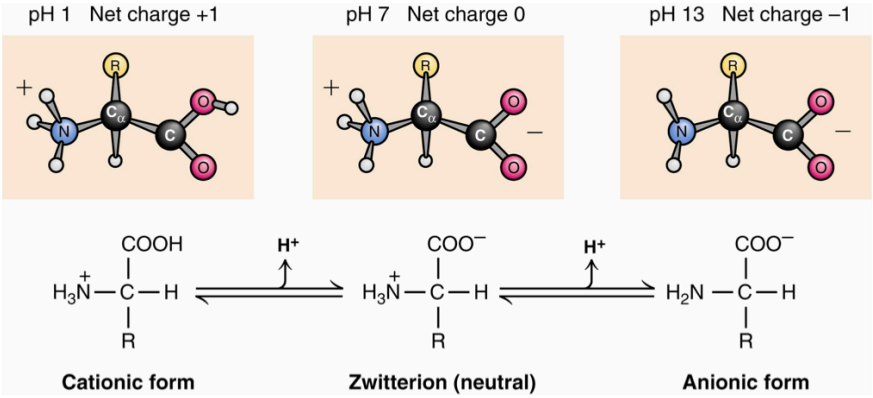
Proline (Pro, P)

Amino Acids

- Hydrophobic:
  - A, G, I, L, F, V, P
- Hydrophilic:
  - D, E, R, S, T, C, N, Q, H
- Amphipathic:
  - K, M, W, Y
- Essential amino acids:
  - V, L, I, T, M, K, R, F, H, W

Amino Acids

- The ionic forms of the amino acids, shown without consideration of any ionizations on the side chain.

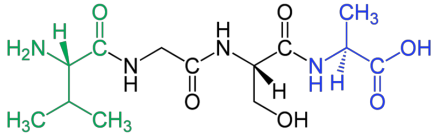


Peptide

- **Peptides** are short polymers of amino acid monomers linked by peptide bonds. They are distinguished from proteins on the basis of size, typically containing less than 50 monomer units.
- The shortest peptides are dipeptides, consisting of two amino acids joined by a single peptide bond. There are also tripeptides, tetrapeptides, etc.
- A **polypeptide** is a long, continuous, and unbranched peptide.
- Amino acids which have been incorporated into a peptide are termed “residues”; every peptide has a **N-terminus** and **C-terminus** residue on the ends of the peptide.

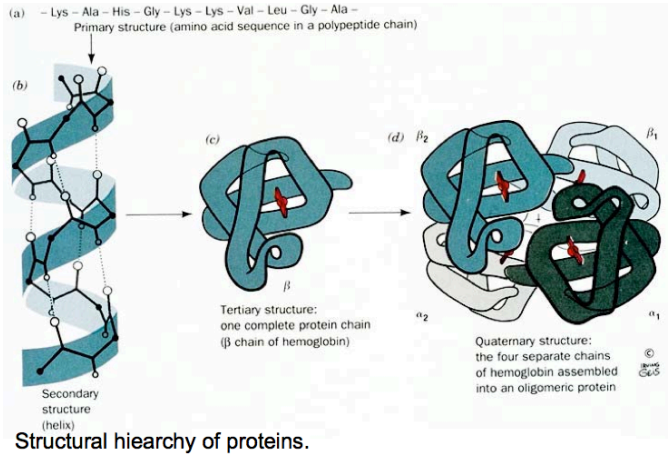
Peptide

- The **N-terminus** (also known as the **amino-terminus**, **NH_2-terminus**, **N-terminal end** or **amine-terminus**) refers to the start of an amino acid chain (protein or polypeptide) terminated by an amino acid with a free amine group (-NH_2).
- The **C-terminus** (also known as the **carboxyl-terminus**, **carboxy-terminus**, **C-terminal tail**, **C-terminal end**, or **COOH-terminus**) is the end of an amino acid terminated by a free carboxyl group (-COOH).
- When the protein is translated from messenger RNA, it is created from N-terminus to C-terminus.
- Val-Gly-Ser-Ala:



Protein

Proteins consist of one or more polypeptides arranged in a biologically functional way and are often bound to cofactors, or other proteins.

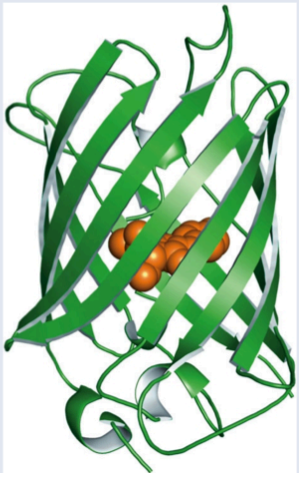


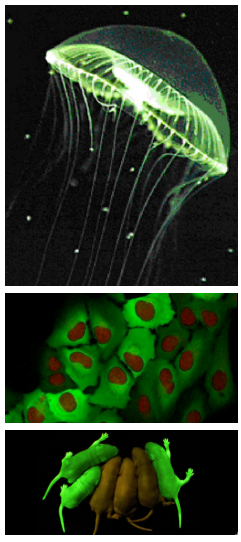
Structural hiearchy of proteins.

Protein

Green fluorescent protein (GFP) is a bioluminescent polypeptide consisting of 238 residues.

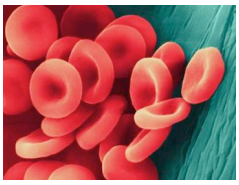
A jellyfish (Aequorea victoria) native to the northwest Pacific Ocean contains a **green fluorescent protein**. GFP is a naturally fluorescent protein. Genetic engineering techniques can be used to "tag" virtually any protein, structure, or organelle in a cell. The GFP chromophore lies in the center of a β-barrel protein structure.

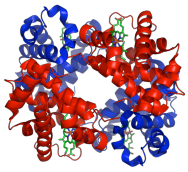




Protein

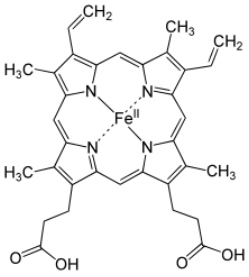
- **Hemoglobin** (**Hb** or **Hgb**) is the iron-containing oxygen-transport metalloprotein in the red blood cells of all vertebrates.
- Hemoglobin in the blood carries oxygen from the respiratory organs (lungs or gills) to the rest of the body (i.e., the tissues) where it releases the oxygen to burn nutrients to provide energy to power the functions of the organism, and collects the resultant carbon dioxide to bring it back to the respiratory organs to be dispensed from the organism.

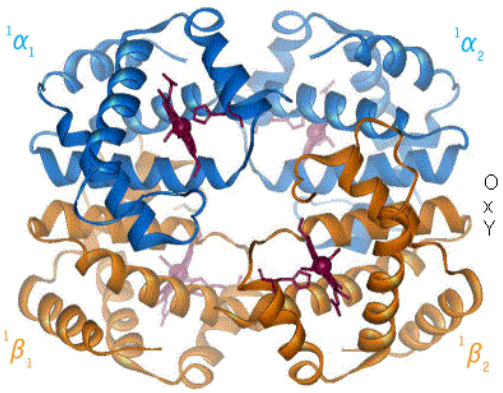




Protein

- **Hemoglobin – Heme b Group**





Protein

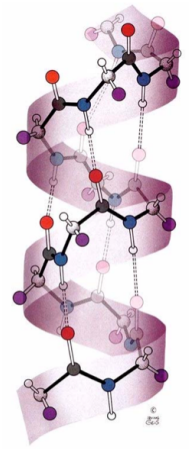
- When oxygen binds to the iron complex, it causes the iron atom to move back toward the center of the plane of the porphyrin ring.
- At the same time, the imidazole side-chain of the histidine residue interacting at the other pole of the iron is pulled toward the porphyrin ring. This interaction forces the plane of the ring sideways toward the outside of the tetramer, and also induces a strain in the protein helix containing the histidine as it moves nearer to the iron atom.
- This strain is transmitted to the remaining three monomers in the tetramer, where it induces a similar conformational change in the other heme sites such that binding of oxygen to these sites becomes easier.

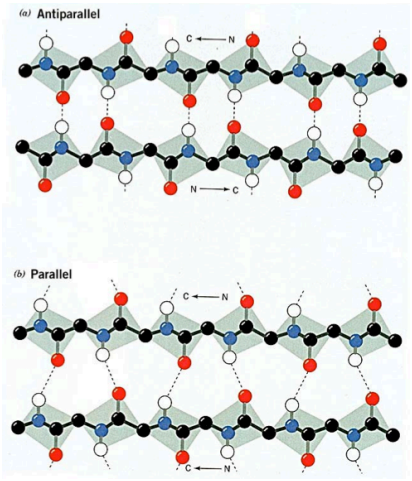
Protein

- The binding of oxygen is affected by molecules such as carbon monoxide (CO).
- CO competes with oxygen at the heme binding site. Hemoglobin binding affinity for CO is 250 times greater than its affinity for oxygen, meaning that small amounts of CO dramatically reduce hemoglobin's ability to transport oxygen.
- Even though carbon dioxide is carried by hemoglobin, it does not compete with oxygen for the iron-binding positions, but is actually bound to the protein chains of the structure.

Protein

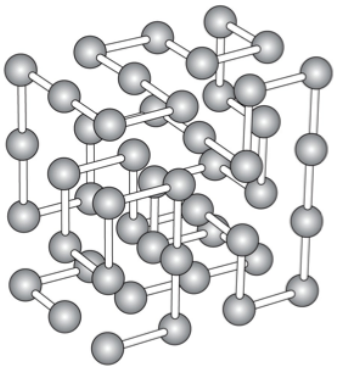
- The right hand α helix and β sheet.

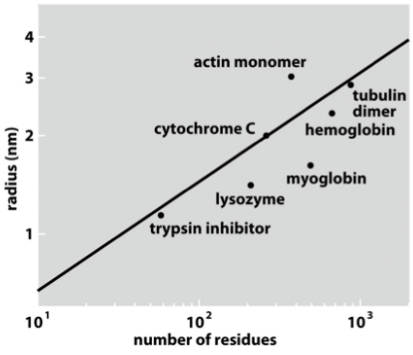




Protein

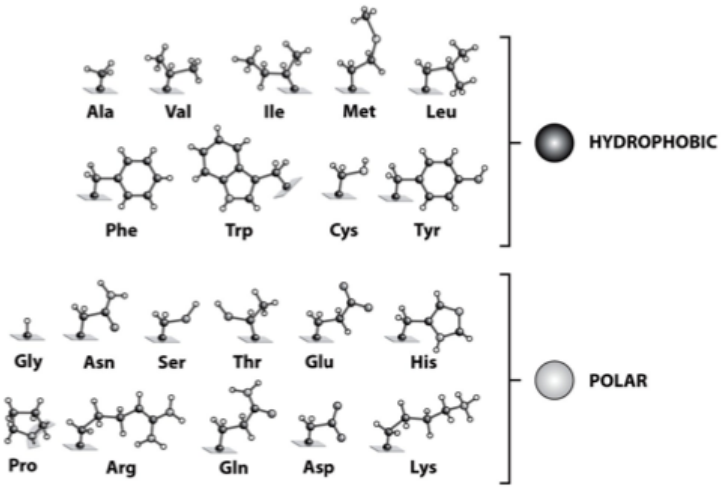
- Structural Biology: protein function follows its structure.





Protein

- HP Model: Hydrophobic (H), Polar (P).



Protein

- HP Model: Hydrophobic (H), Polar (P).