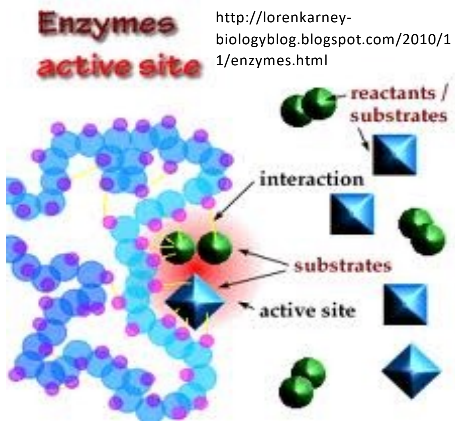
Lecture 4

Molecules of Life Proteins

LIF111

Proteins

- Of all the biological molecules proteins are the most diverse.
- Proteins are the workhorses in a cell.



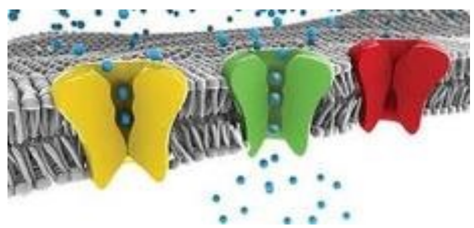
http://lorenkarney-biologyblog.blogspot.com/2010/11/enzymes.html

http://photographysammy.blogspot.com/2010/06/spider-web-i-hate-spiders-but-i-love.html

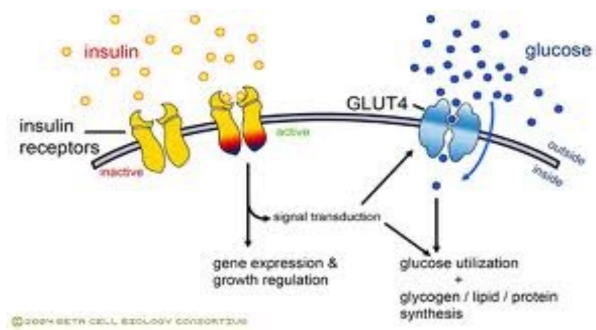
http://www.richard-seaman.com/Arthropods/Usa/Butterflies/Illinois/index.html

http://www.orthoandsportspt.com/article.php?aid=250

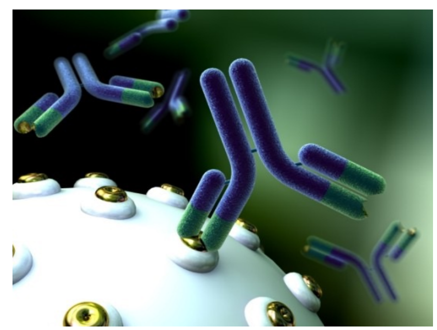
http://kids.mongabay.com/elementary/animals/scarlet_macaw.html



http://www.mc.vanderbilt.edu/lens/article/?id=177&pg=2



http://happyhealthybalance.blogspot.com/2010/05/insulin-sugar-fat.html



https://www.pharmatching.com/blog/category/monoclonals/

Some examples of what proteins can do:

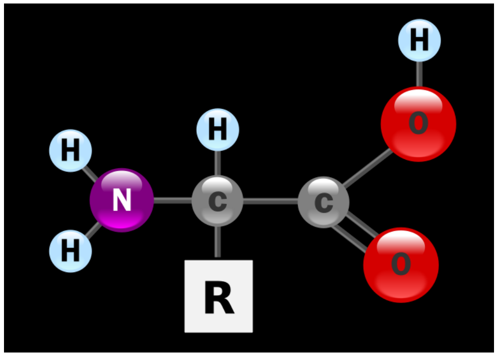
1) Protein enzymes drive the rates of metabolic reactions and make them faster.
2) Structural proteins perform diverse roles as constituents of spider webs, feathers, butterfly wings, cartilage and bone.
3) Transport proteins move ions across the cell membrane and carry molecules from one part of the body to another through body fluids like blood.
4) Protein hormones and other signaling molecules change cellular activities.
5) Proteins defend our bodies against disease causing bacteria.

Amino acids the building blocks of proteins

Cells build an enormous diversity of proteins from their pools of only twenty types of amino acids

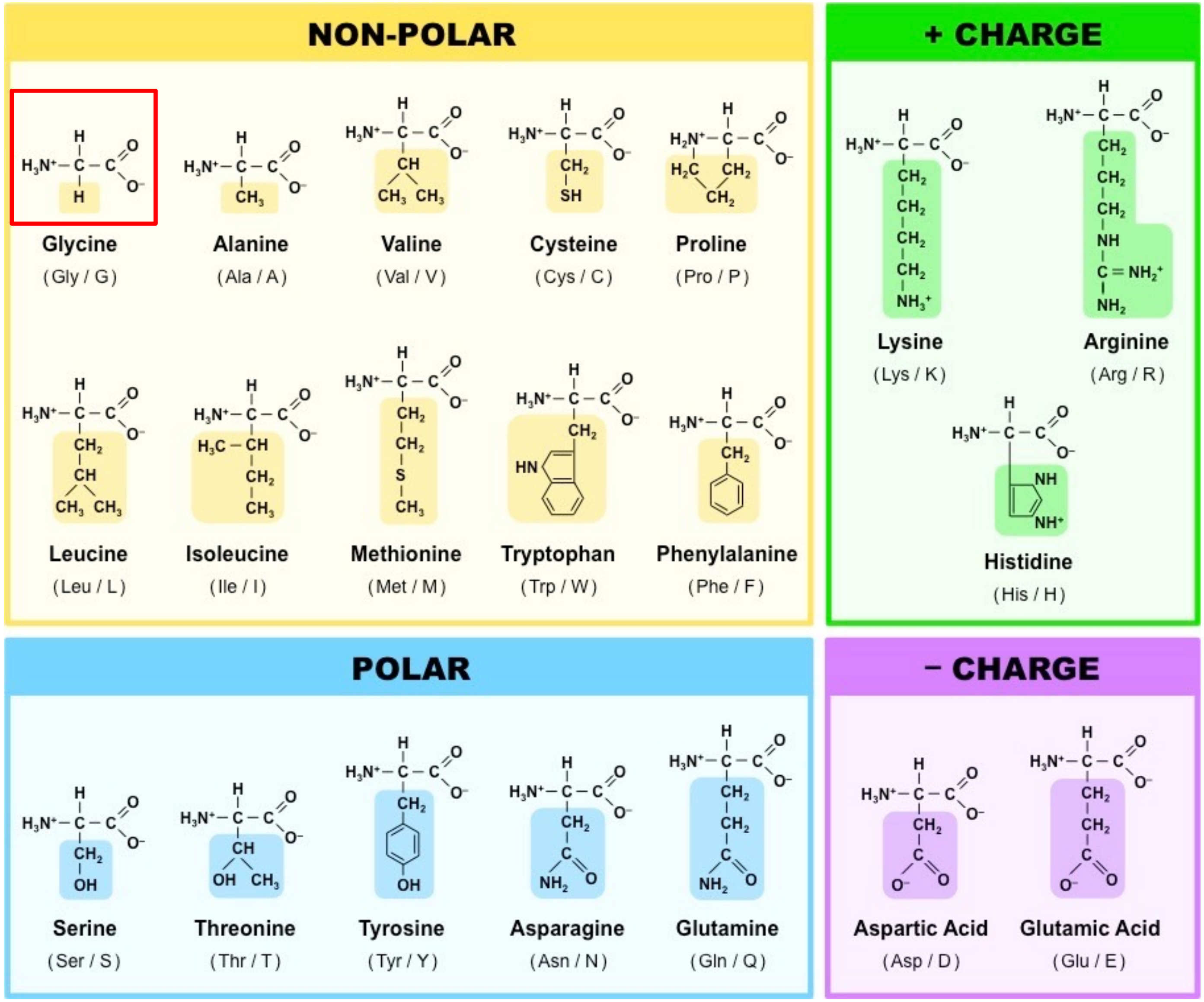
An amino acid comprises of a central carbon atom bonded to an amino group, a carboxyl group, a hydrogen atom and one or more atoms known as the "R" group.

Generalized structural formula for amino acids



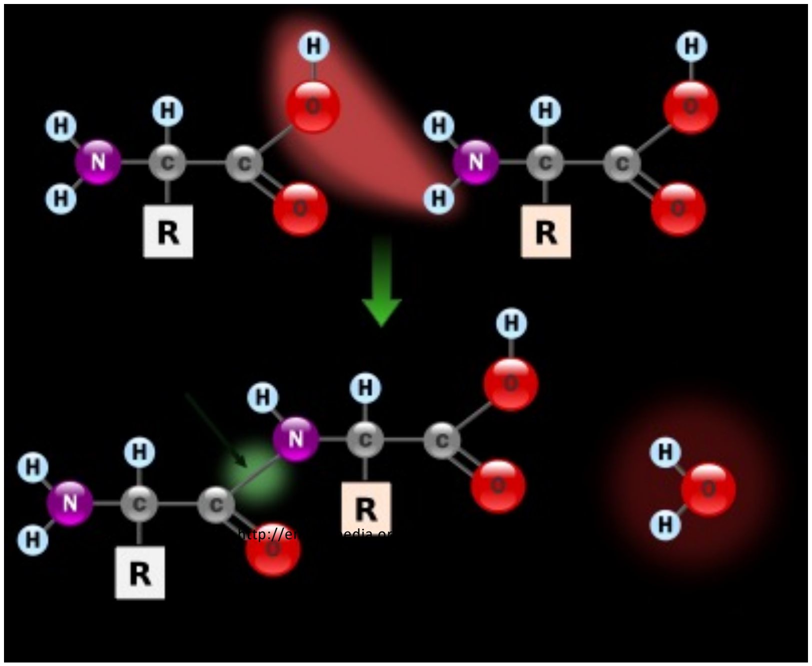
http://macrotomicro.blogspot.com/2011/04/amino-acids.html

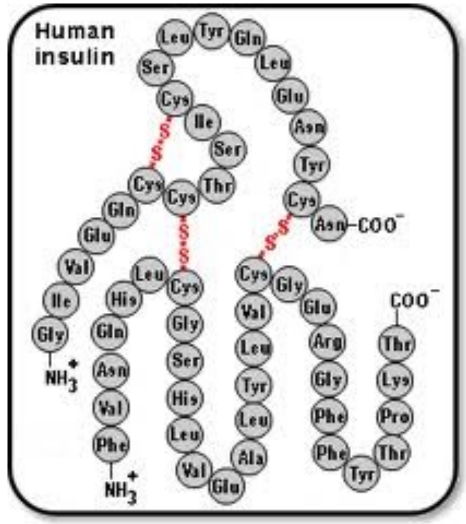
The only achiral amino acid



Primary structure of proteins

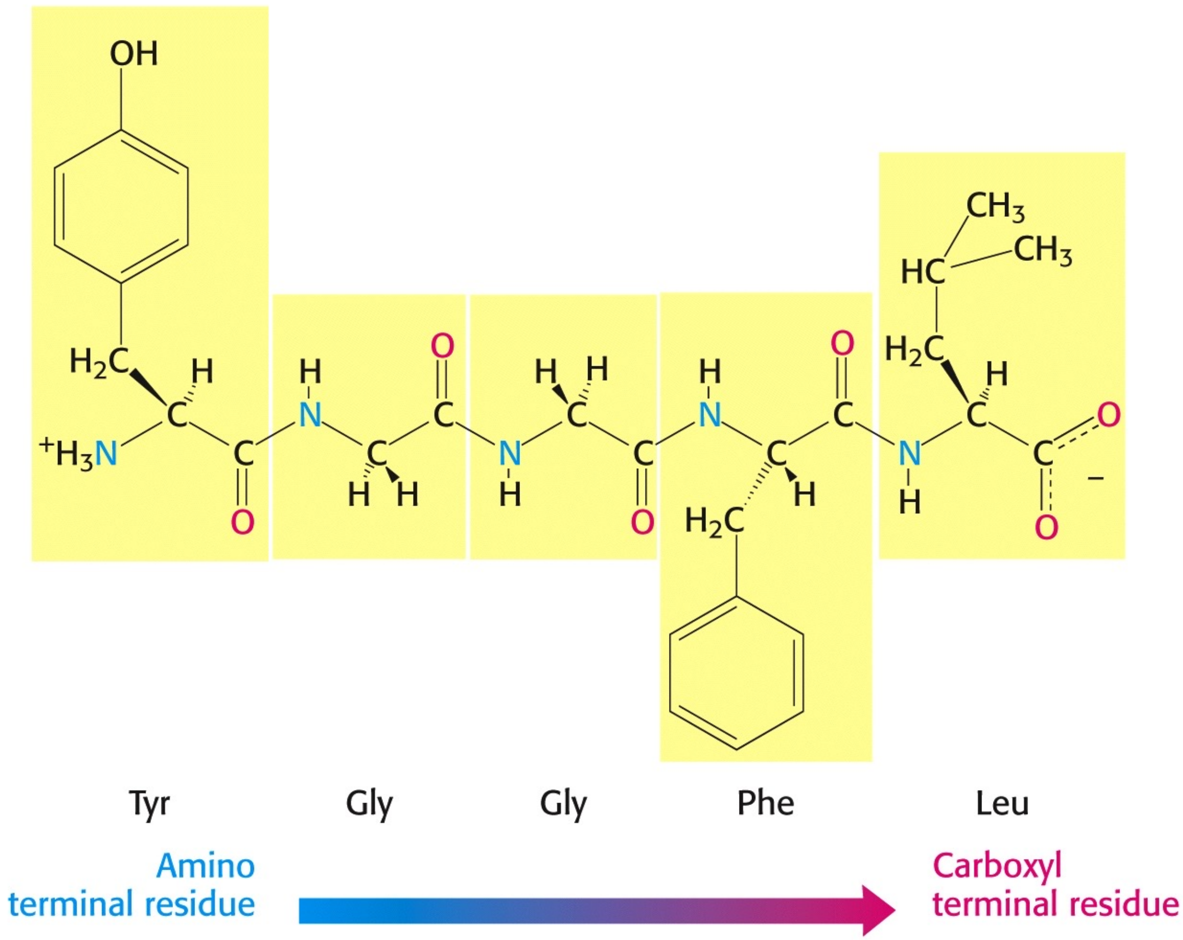
Amino acids are linked one after the other through peptide bonds to form proteins





http://www.physchem.co.za/OB12-mat/organic5.htm

When a peptide bond joins two amino acids we have a dipeptide. When there are three or more it is a polypeptide. The carbon backbone has a -N-C-C-N-C-C- structure. For each protein different amino acids are selected one at a time from the twenty available. This sequence of amino acids is unique for every protein and it is called the primary structure of the protein. The primary structure is prescribed by DNA.



YGGFL is a different polypeptide than LFGGY

Primary structure of proteins

Proteins can be broadly classified into two structural classes

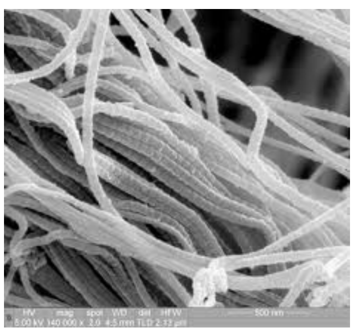
Fibrous proteins

Polypeptide chains are organized as strands or sheets. Collectively many such molecules contribute towards the shape and internal organization of the cell.

Globular proteins

In the case of globular proteins one or more polypeptide chains are folded in compact rounded shapes. Most enzymes are globular proteins.

Collagen



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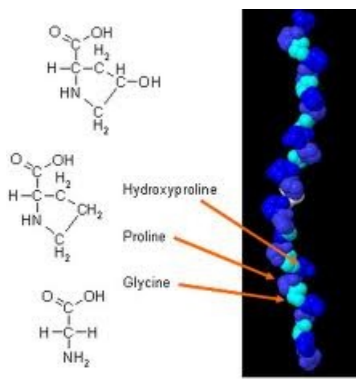
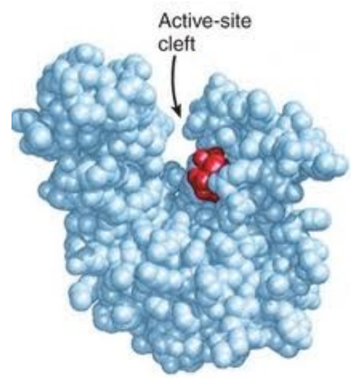
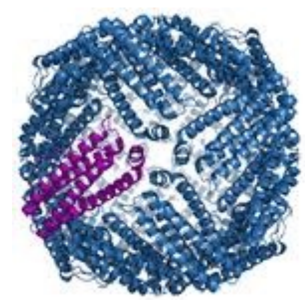


https://chempolymerproject.wikispaces.com/Collagen+-+B-+rgam



http://www.tumblr.com/tagged/tertiary+structure



http://www.physorg.com/news167574452.html

How does a protein's three-dimensional structure emerge?

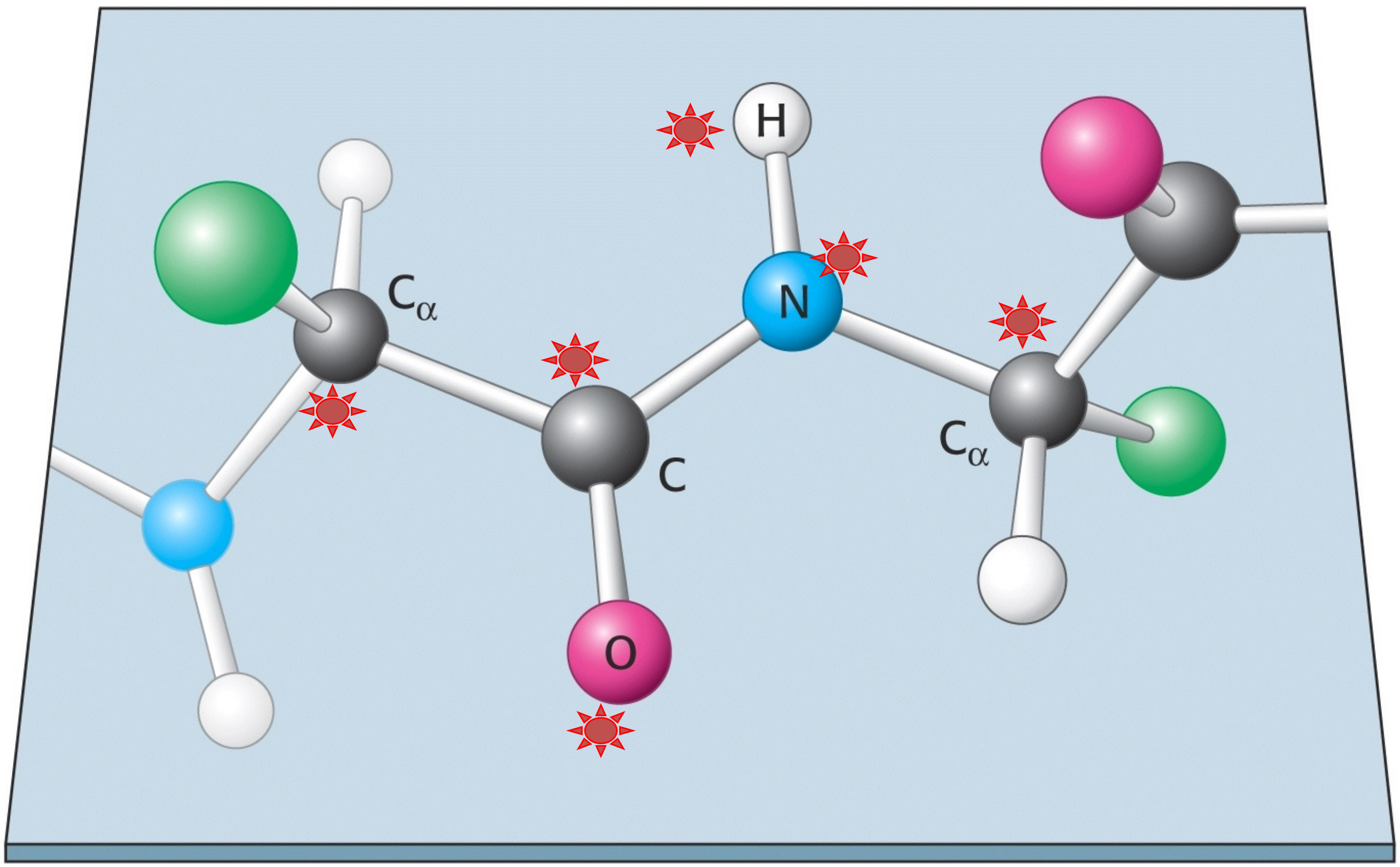
The primary structure of the protein gives rise to the protein's shape in the following ways:

1) It allows hydrogen bonds to form between the C=O and N-H groups of different amino acids along the length of the polypeptide chain.

2) It puts "R" groups into positions that allow them to interact. Through their interactions the chain is forced to bend and twist.

The anatomy of the peptide backbone

The peptide bond is essentially planar



These atoms are on the same plane.

The peptide bond is essentially planar

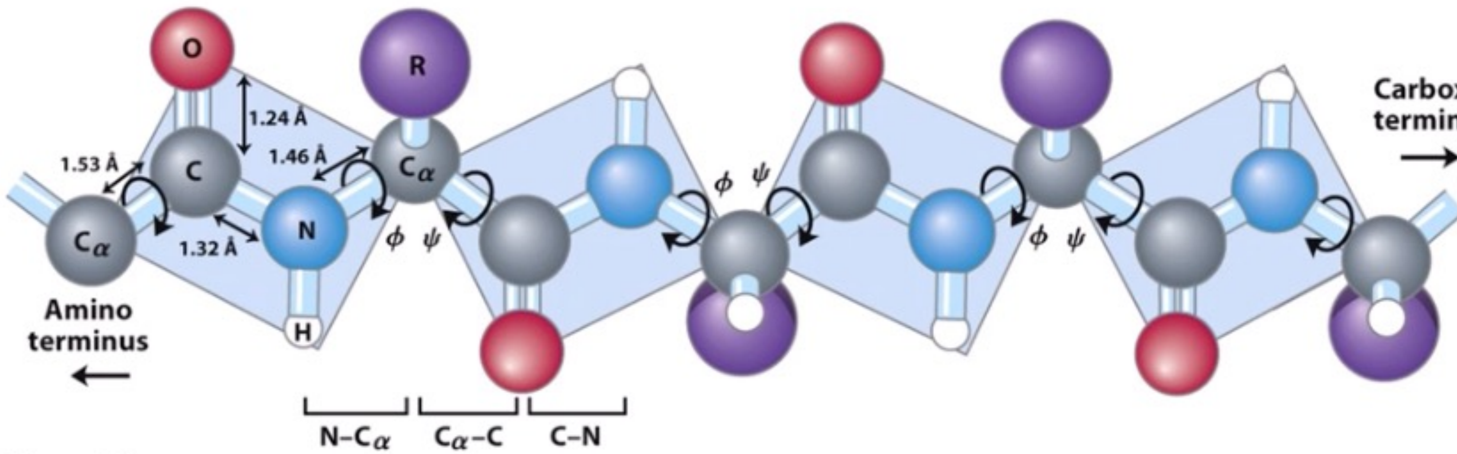


Figure 4-2b
Lehninger Principles of Biochemistry, Fifth Edition

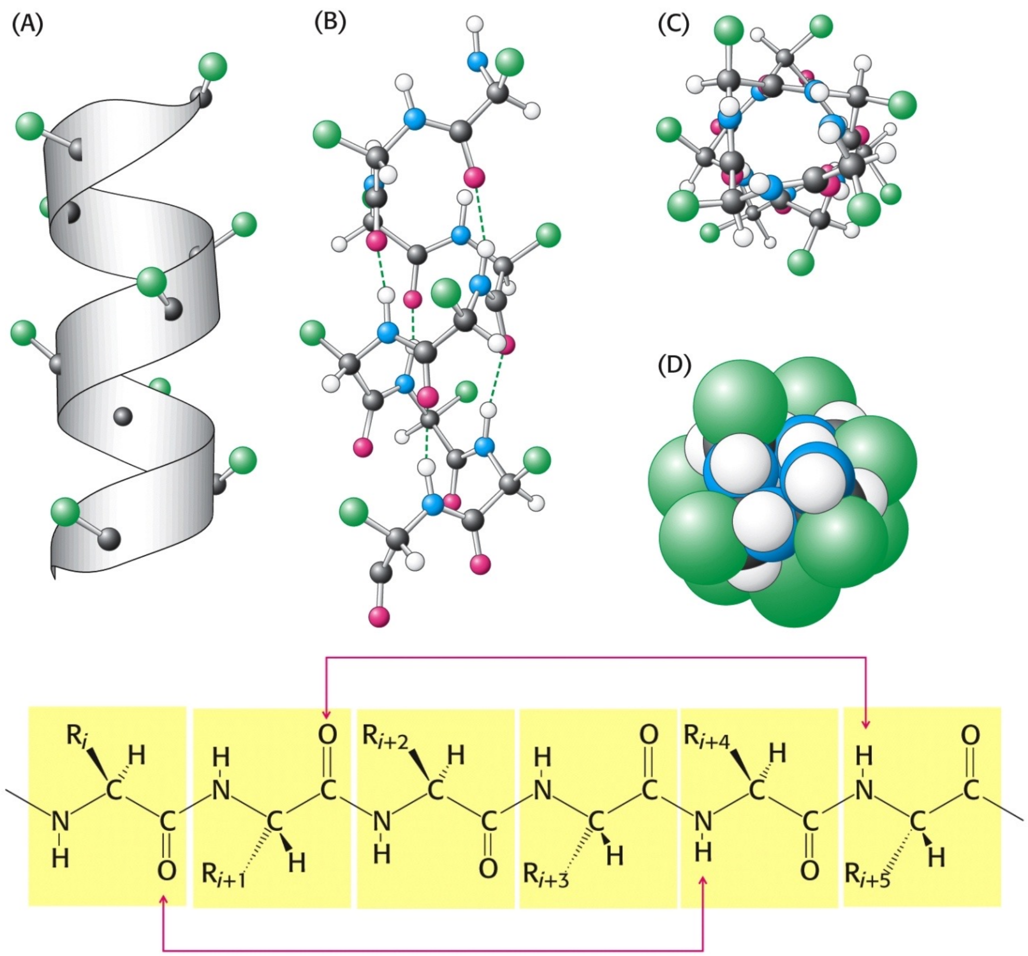
Think of the polypeptide chain as a set of rigid playing cards joined by links that can swivel a bit. Each card is a peptide group. Atoms on either side of it can rotate slightly around their covalent bonds and form bonds with neighboring atoms.

Second level of protein structure

Hydrogen bonds form at short intervals along the new polypeptide chain and they give rise to a coiled or extended pattern known as the secondary structure of the protein.

- **Alpha helix**
- **Beta Sheets**

Alpha helix (α helix)



Features:

1. It is a rod like structure.

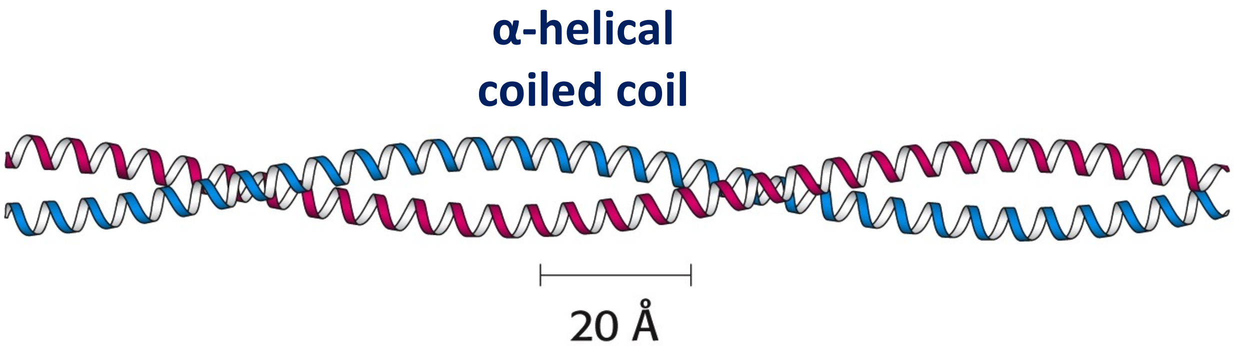
2. Backbone is inside while side chains are on the outside.

3. Hydrogen bonding between CO and NH groups of the main chain stabilizes the structure.

4. CO group of residue R hydrogen bonds with the NH group of residue R+4.

5. Rise per residue is 1.5Å and rotation per residue is 100 degrees, residues per turn is 3.6.

6. Most α-helices observed naturally are right-handed helices.



The helical content of a protein may vary anywhere between 0% to 100%.

75% of AAs in Ferritin, an iron storage protein is in alpha-helices.

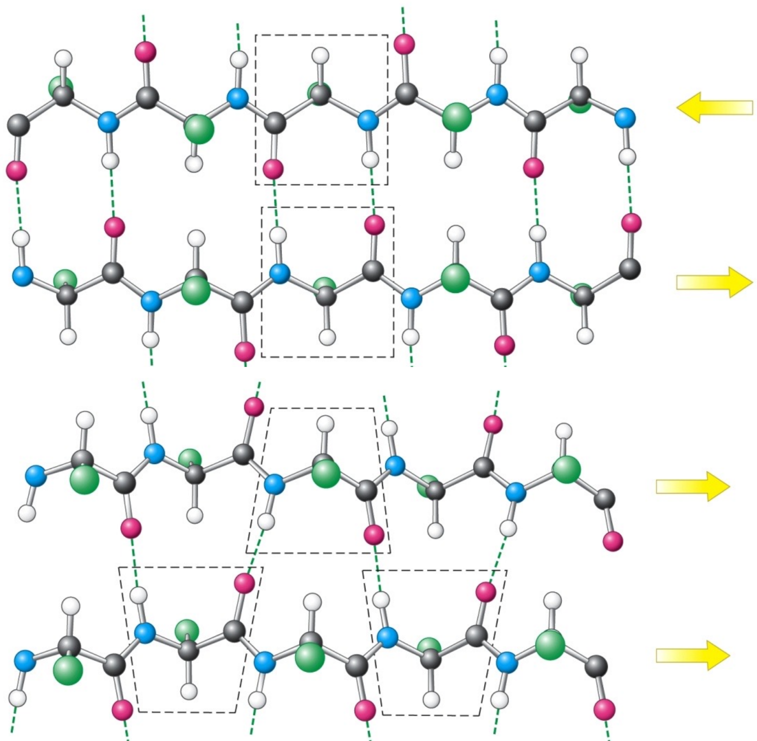
α-helices are usually less than 45Å long. However, two or more α-helices can entwine to form a very stable structure, which can have a length of 1000Å or more.

Such α-helical coiled coils are found in many structural proteins e.g. myosin, tropomyosin in muscle, Fibrin in blood, Keratin in hair etc.

Beta sheet (β sheet)

Anti-parallel β sheet

Parallel β sheet

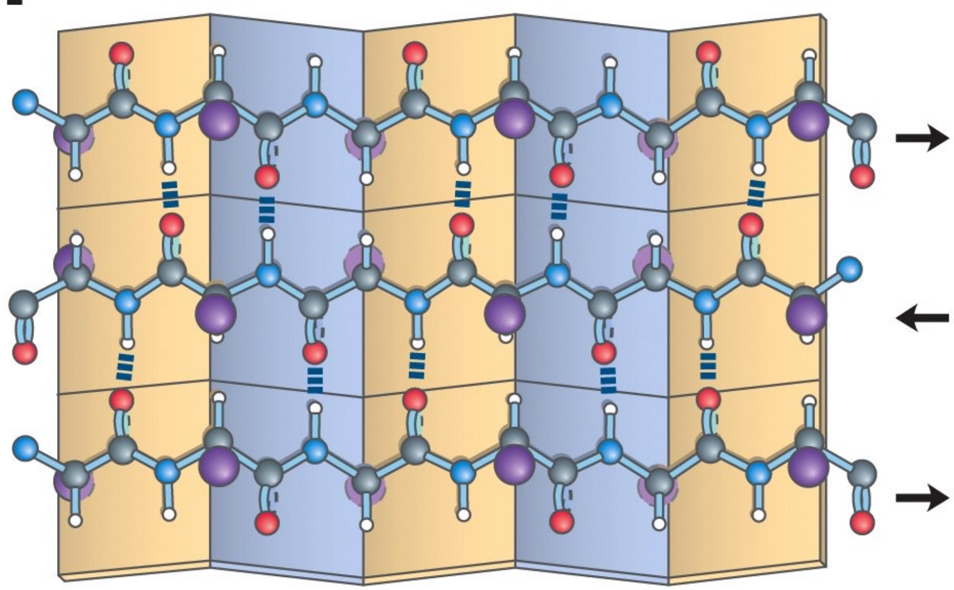


Features:

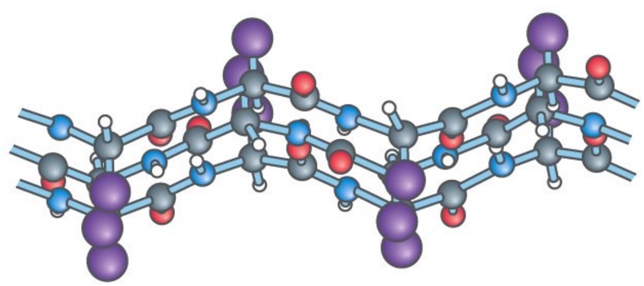
1. Distance between two successive amino acids is 3.5Å.
2. The side chains are at 180° to each other.
3. Adjacent β-strands are linked by hydrogen bonds.
4. In anti-parallel β-sheets the hydrogen bonds between the CO and NH of adjacent strands form between groups that are diametrically opposite to each other.
5. In parallel β-sheets hydrogen bonds between CO group of one amino acids forms with the NH group of two amino acids downstream in the other strand.
6. β-strands are depicted by arrows schematically.

(a) Antiparallel

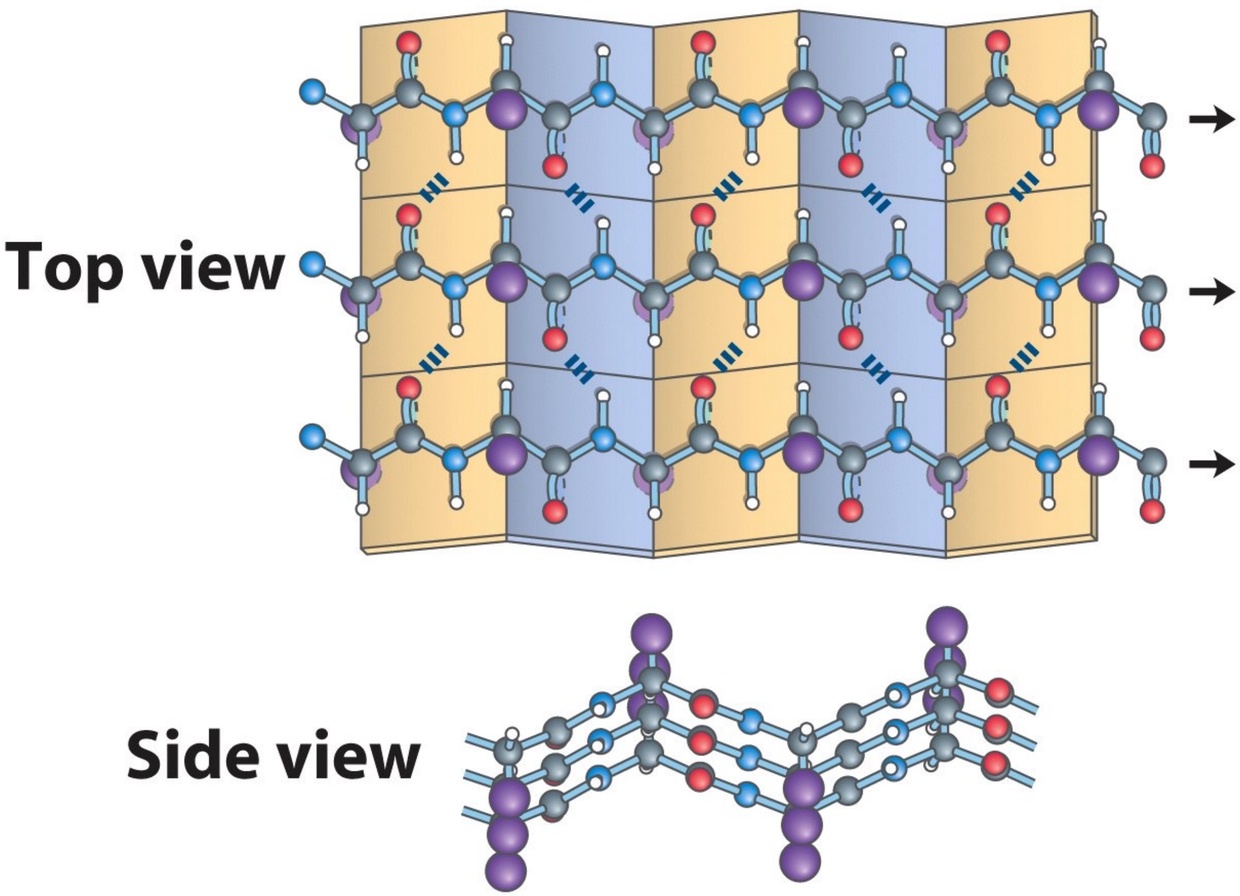
Top view



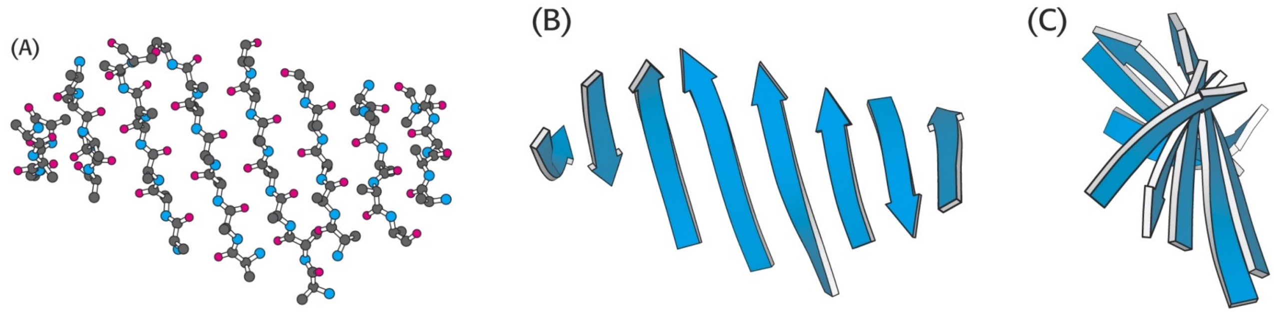
Side view



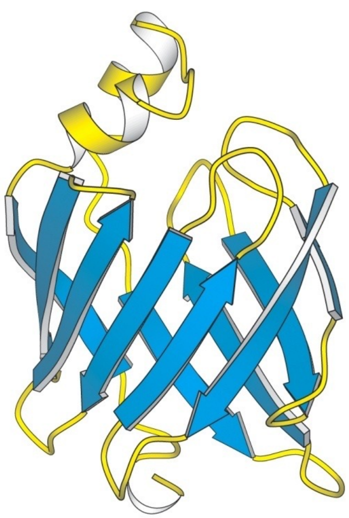
(b) Parallel



Many β-strands (4-10 or more) may come together in a protein. These β-strands may be all parallel to each other or anti-parallel or mixed.



A and B are ball and stick and ribbon model of the same polypeptide, respectively. β-strands may have twists. Side view of the schematic in B demonstrates the twists.



A protein rich in β-sheets, a fatty acid binding protein.

Questions

1. A denatured protein has lost its _________.
   A. hydrogen bonds
   B. Function
   C. Shape
   D. all of the above

2. Which of the following is responsible for specifying the 3D shape of a protein?
   A. The peptide bond
   B. The amino acid sequence
   C. Interaction with other polypeptides
   D. All of the above

3. What is a bond between amino acids called?
   A. Ionic bond
   B. Acidic bond
   C. Peptide bond
   D. Hydrogen bond