

Chapter 5

Protein Structure and Function

Amino Acids and Primary Structure

- Amino acids

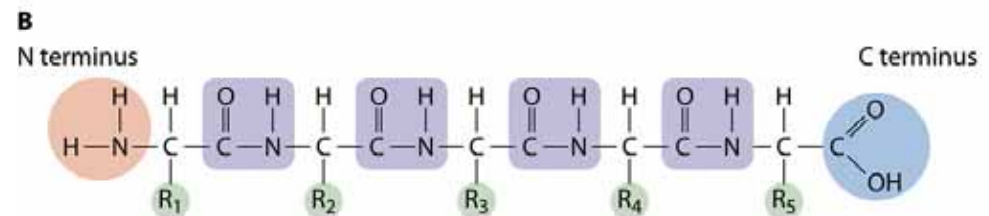
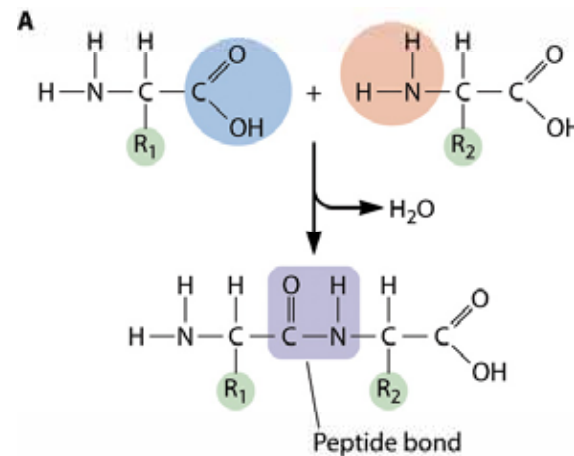
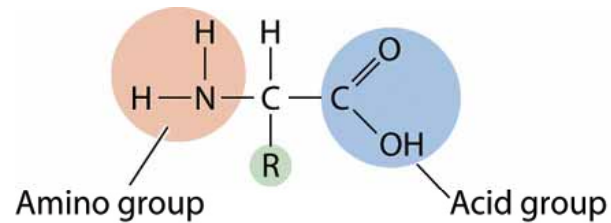
- ..
- ..
- ..

- Peptide bond

- Between ..

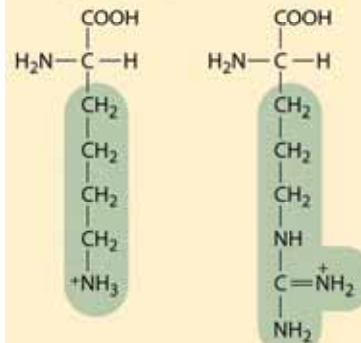
- Polypeptide

- A chain of amino acids
- N terminus and C terminus



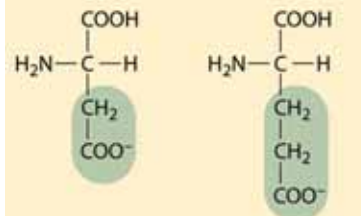
Amino Acids

Charged R groups



Lysine (Lys)

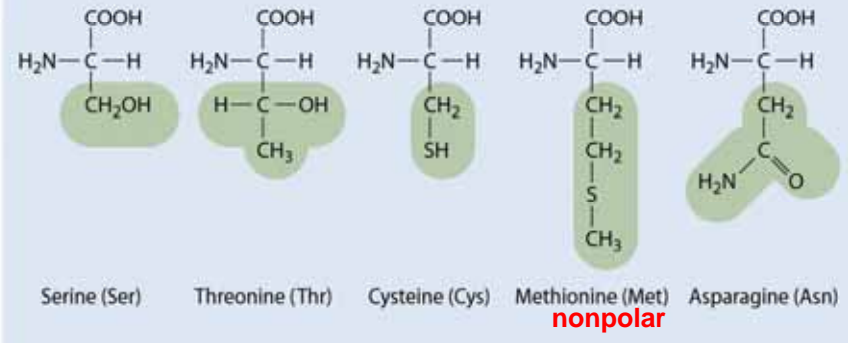
Arginine (Arg)



Aspartate (Asp)

Glutamate (Glu)

Polar R groups



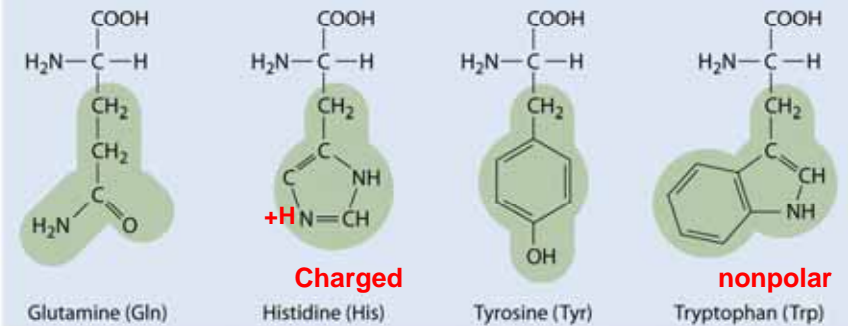
Serine (Ser)

Threonine (Thr)

Cysteine (Cys)

Methionine (Met)
nonpolar

Asparagine (Asn)



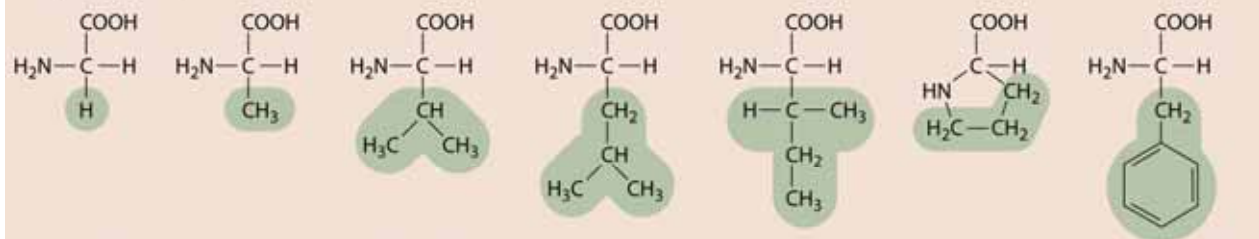
Glutamine (Gln)

Histidine (His)
Charged

Tyrosine (Tyr)

Tryptophan (Trp)
nonpolar

Nonpolar R groups



Glycine (Gly)

Alanine (Ala)

Valine (Val)

Leucine (Leu)

Isoleucine (Ile)

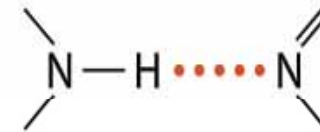
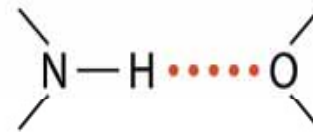
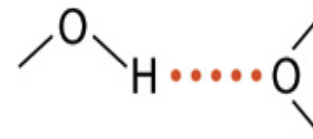
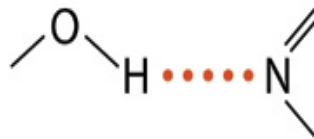
Proline (Pro)

Phenylalanine (Phe)

Primary and Secondary Structure

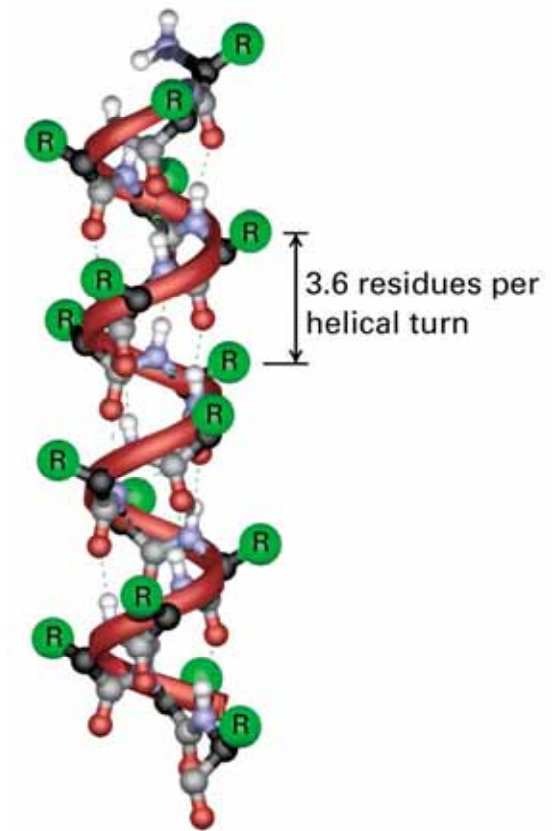
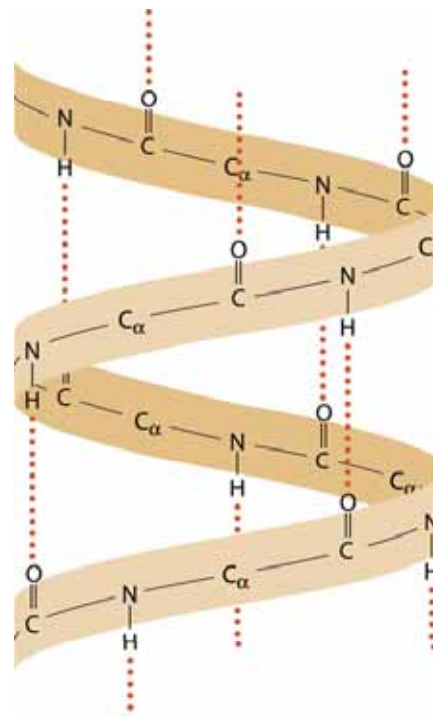
- Primary structure
 - Linear arrangement (sequence) of ..
- Secondary structure
 - Core elements of protein architecture
 - Neutralization of partial charges of the peptide backbone by ..
 - Local folding of polypeptide chain
 - ..
 - ..

Common Hydrogen Bonds in Biological Systems



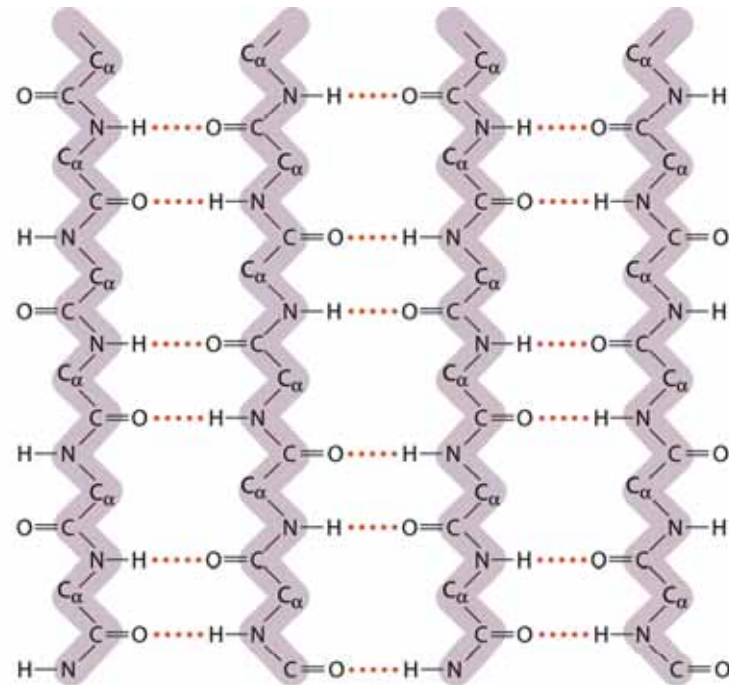
α -Helix

- Hydrogen bond between ..
- Directionality on the helix :
The same orientation of H bond donor
- Side chains point outward :
Determine ..



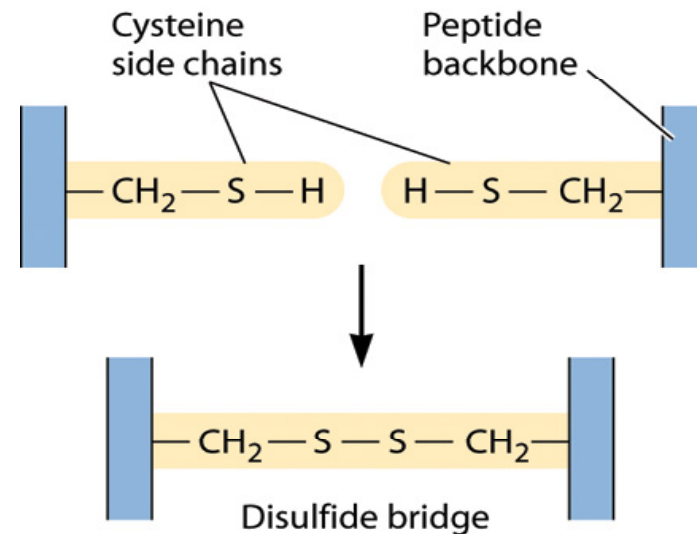
β -Sheet

- Hydrogen bonding between ..
→ ..
..
- Usually not flat, but ..



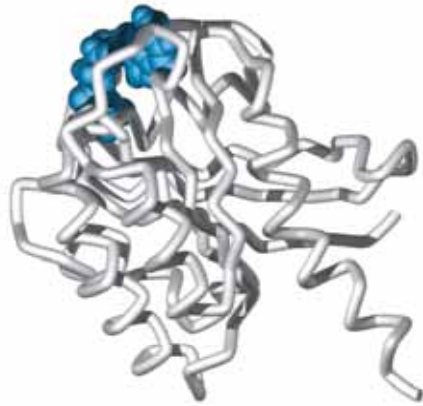
Tertiary Structure

- Overall folding of a polypeptide chain
- Stabilization
 - weak interaction
 - Hydrophobic interaction between ..
 - Hydrogen bond between polar side chains and peptide bonds
 - Disulfide bond formation

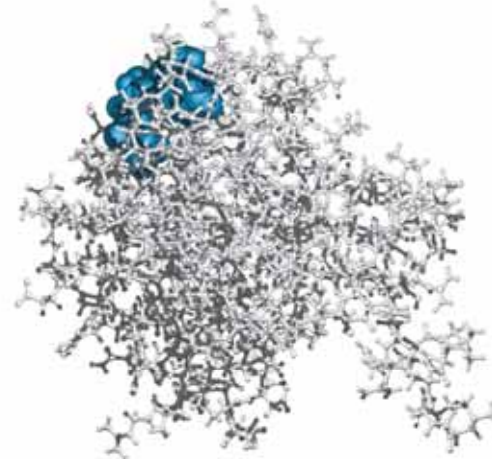


Graphical Representation of the Protein

(a) C_{α} backbone trace



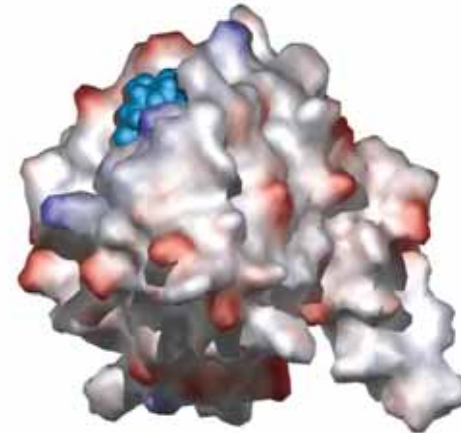
(b) Ball and stick



(c) Ribbons



(d) Solvent-accessible surface



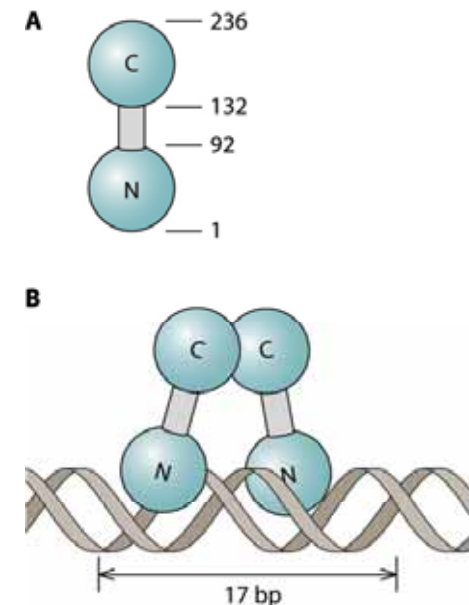
Higher Levels of Structure

■ Domains

- One stable, compact, three-dimensional shape
- Fundamental units of ..
 - DNA binding domain, transmembrane domain

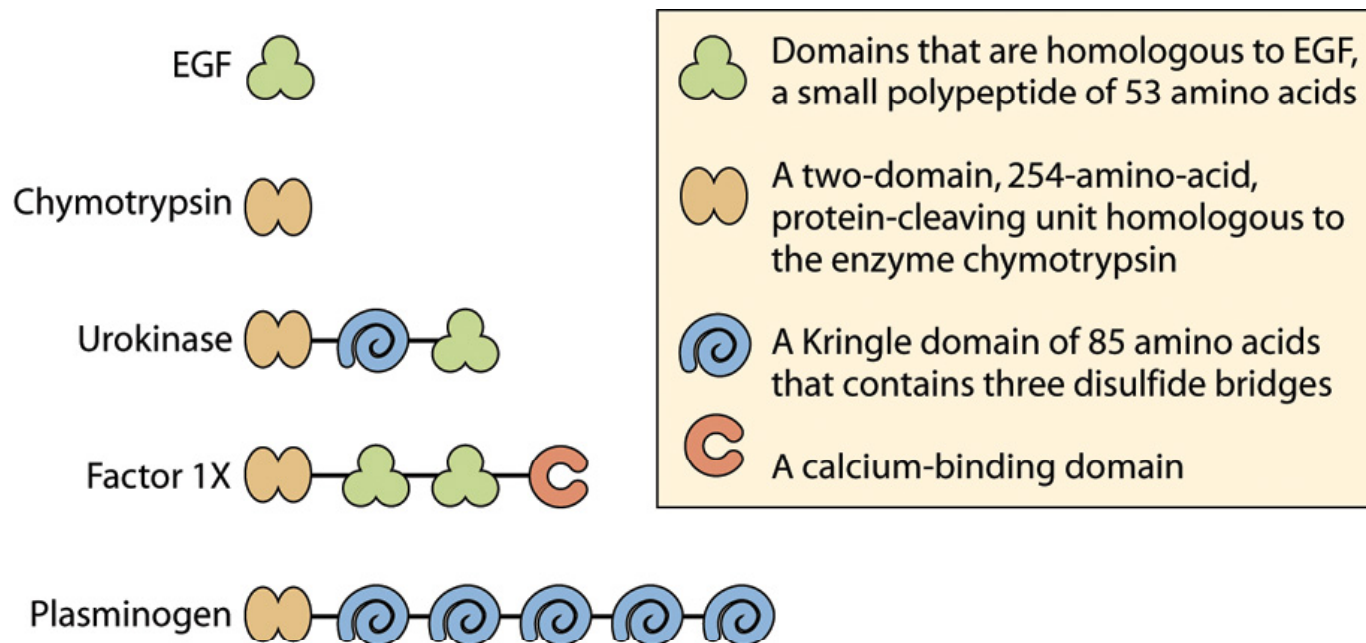
- e.g. lambda repressor (236 aa)

- N terminal domain : DNA binding
- C terminal domain :
Interaction with C terminal domain
of another molecule (dimerization)



Modular Proteins

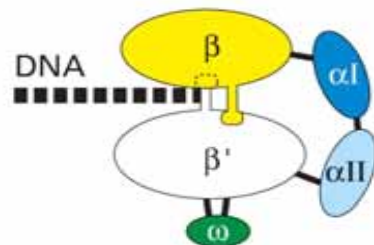
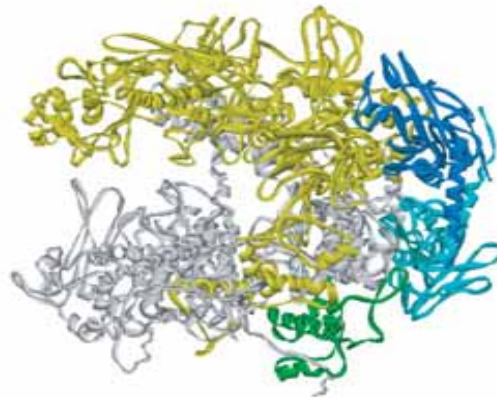
- New proteins by combination of functional domains
- Biotechnological application using recombinant DNA technology



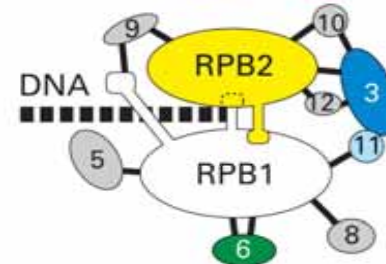
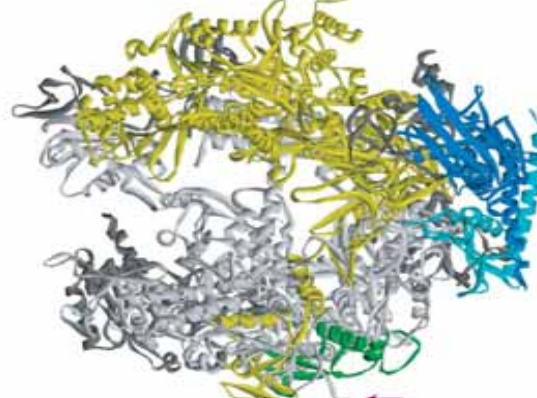
Quaternary Structure

- Association of multiple polypeptide chains
 - Lambda repressor : dimer
 - *E. coli* RNA polymerase : Five polypeptide chains

(a) Bacterial RNA polymerase



(b) Yeast RNA polymerase II



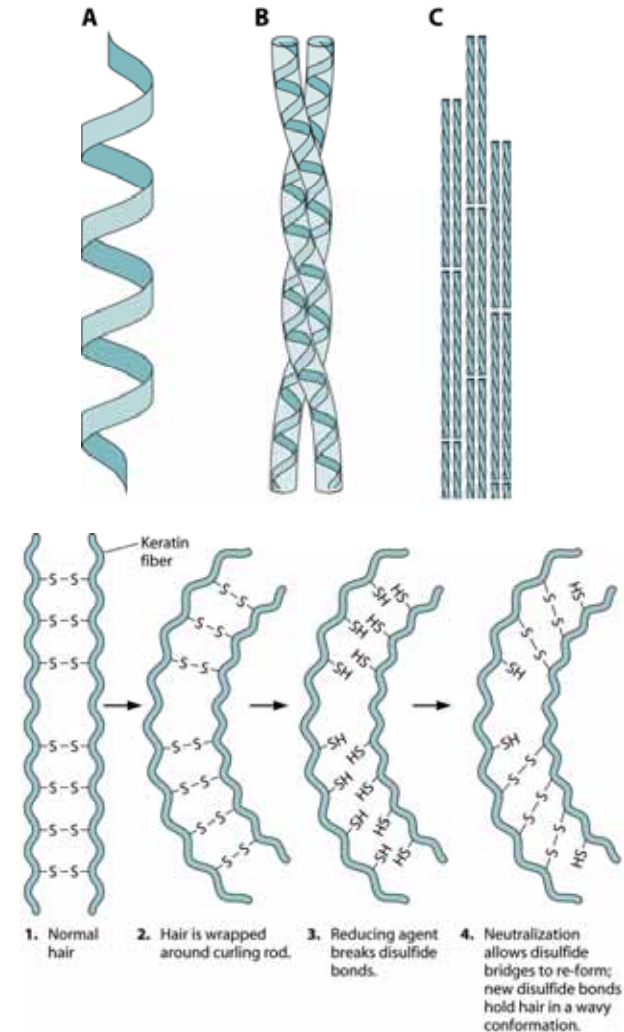
Disruption of Protein Structure

- Factors disrupting protein structure
 - ..
- Denaturation
 - Complete unfolding of ..
 - Sometimes irreversible : e.g. boiled egg
 - Melting temperature (T_m)
 - .. temperature for a given protein
 - Depending on protein structure
 - Proteins from organisms living at high temperatures

Examples of Protein Structure and Function

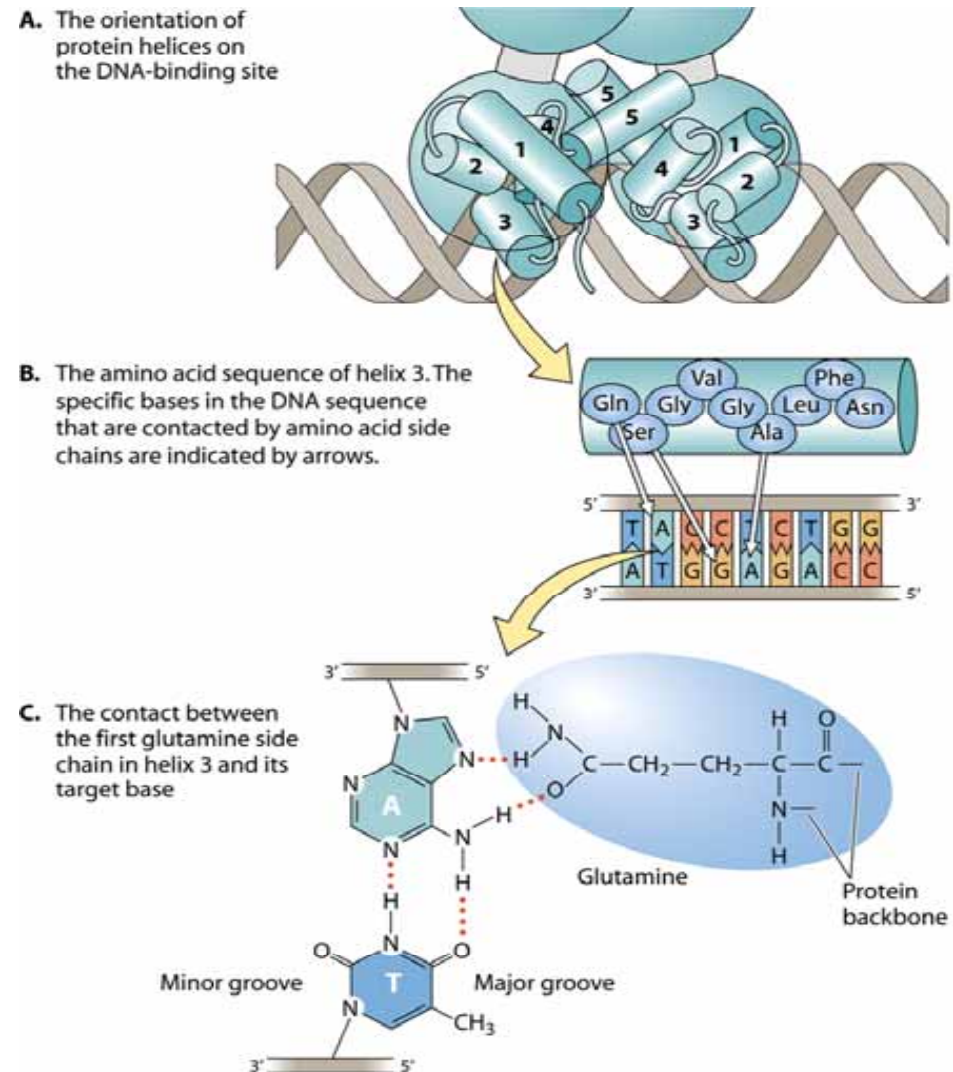
■ Keratin

- Structural protein for hair, wool, feathers, nails, scales, hooves, horns, skin
- Very strong and water insoluble
 - Hydrophobic alpha helices
 - Long α -helix with hydrophobic amino acids
 - Forming fibers by hydrophobic interactions
 - Disulfide bonds
 - The more S-S bonds the harder the structure
 - Permanent hair wave
 - » Reducing of disulfide bond \rightarrow Generation of new disulfide bond



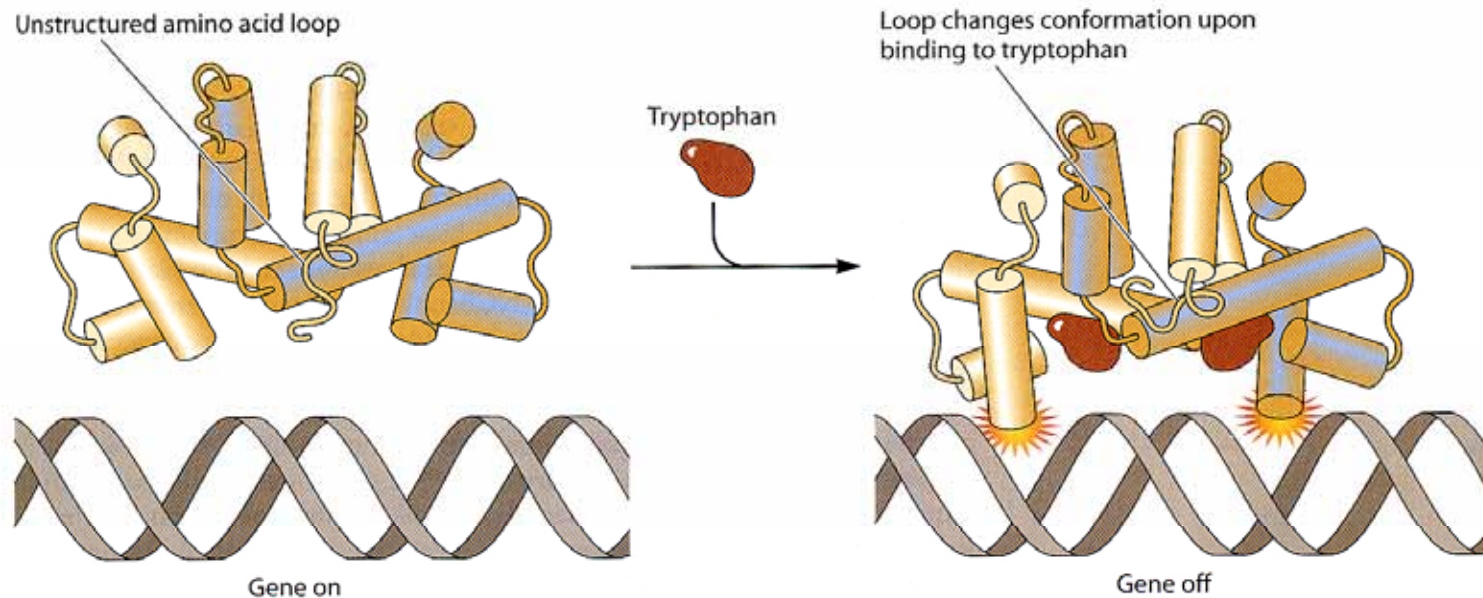
Lambda Repressor

- Binding of N-terminal domain helix 3 to specific bases within the DNA sequence



Trp Repressor

- If plenty of Trp in the cytosol
- Binding of Trp into Trp Repressor and change the conformation
- Trp repressor binds to DNA and represses the expression of genes involved in Trp synthesis



Predicting Protein Structure

- It is difficult to predict three dimensional structure from the amino acid sequence
- Compare to other proteins with known function or structure
 - Easy access of information through public database
 - NCBI (National center for Biotechnology Information) run by National Institutes of Health (NIH)
 - <http://www.ncbi.nlm.nih.gov>
 - Testing structure-function prediction
 - Using molecular biological tools

Protein Engineering

- Manipulation of ..
- Chemical manufacturing
 - Develop enzymes more suitable for industrial applications
 - Increasing enzyme stability
 - e.g. bacteriophage lysozyme: introduce S-S bond to increase heat resistance
 - Proteases in detergent