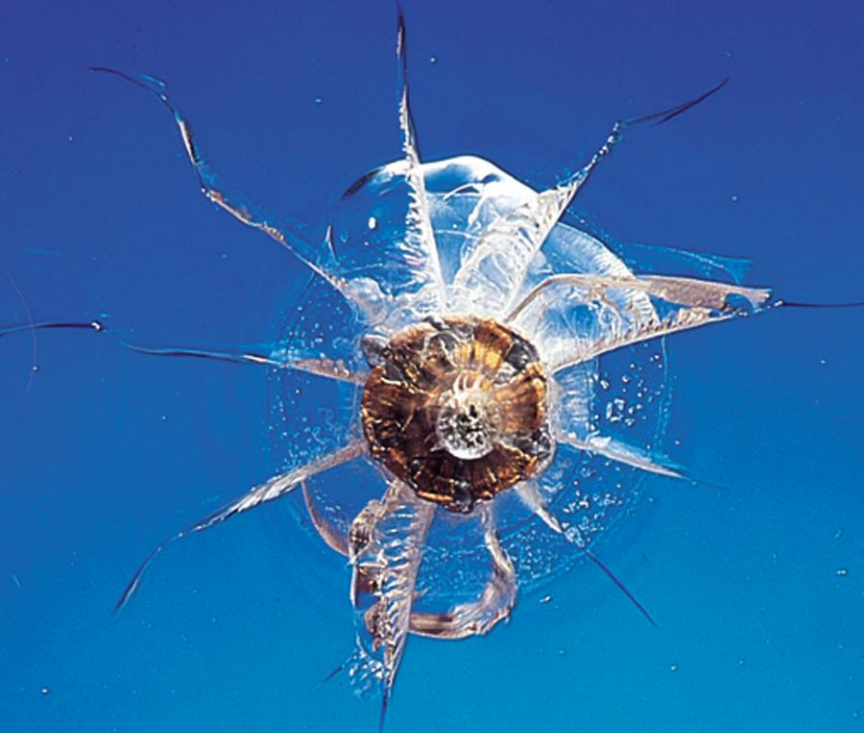
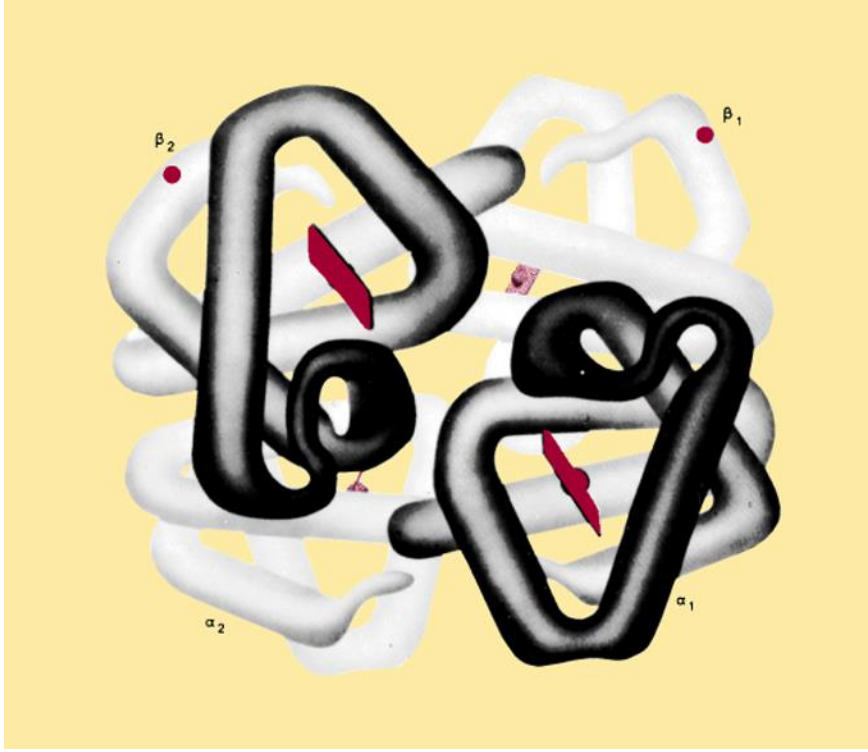




Synthetic and Natural Organic Polymer

Chapter 25

A ***polymer*** is a high molar mass molecular compound made up of many repeating chemical units.

Tyvek

<u>Naturally occurring polymers</u>

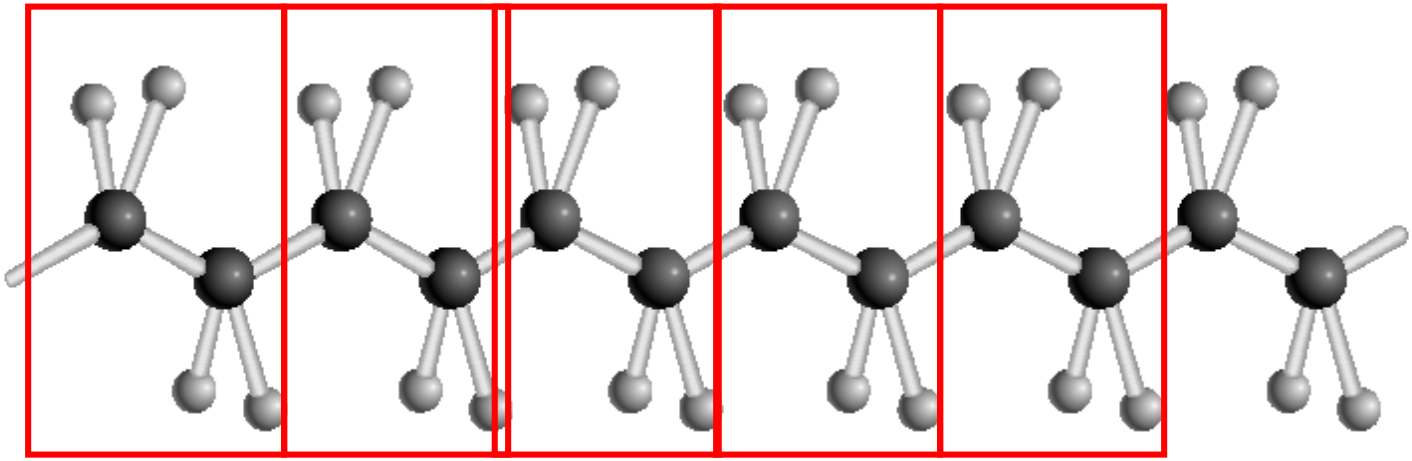
- Proteins
- Nucleic acids
- Cellulose
- Rubber

<u>Synthetic polymers</u>

- Nylon
- Dacron
- Lucite

Silverstone®: polytetrafluoroethylene

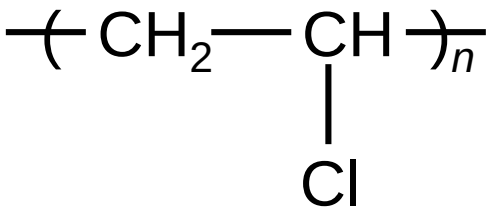
The simple repeating unit of a polymer is the ***monomer***.



Homopolymer is a polymer made up of only one type of monomer

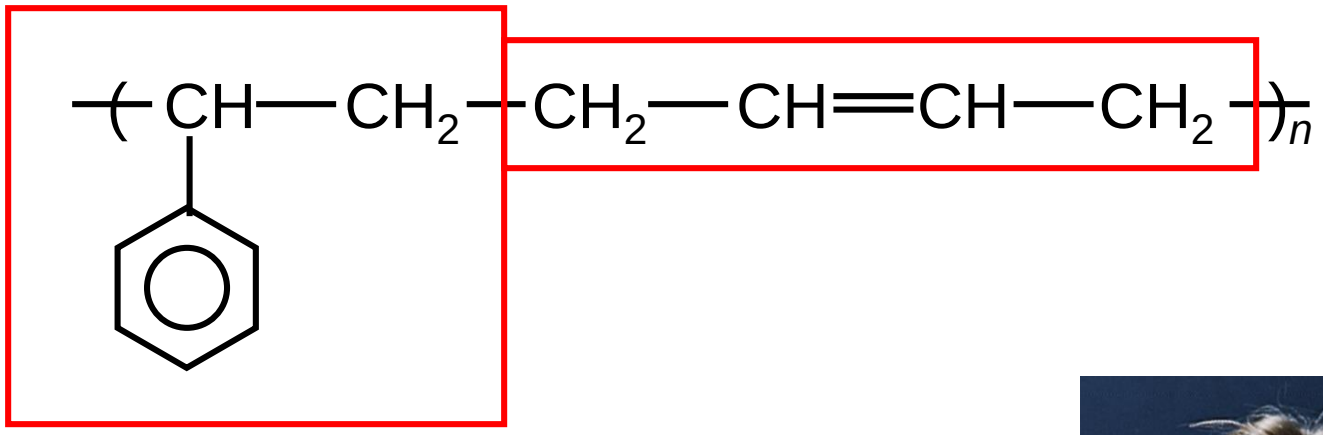
Teflon

Polyethylene



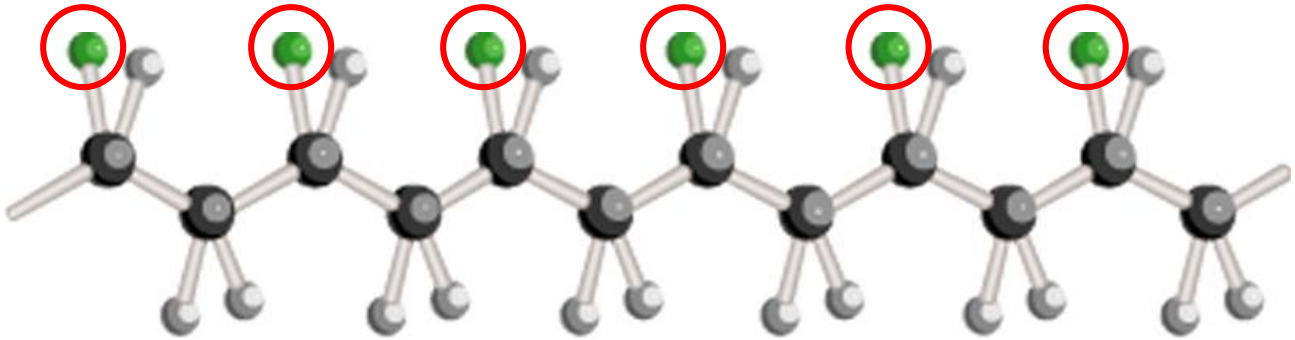
PVC

Copolymer is a polymer made up of two or more monomers



Styrene-butadiene rubber

Stereoisomers of Polymers



R groups on same side of chain

Isotactic

R groups alternate from side to side

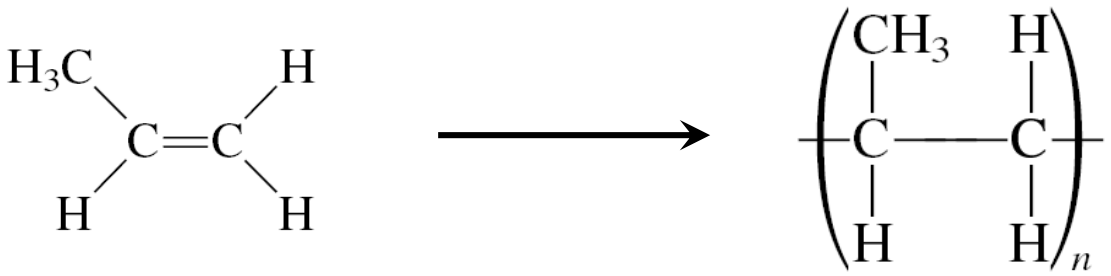
Syndiotactic

R groups disposed at random

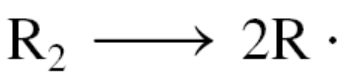
Atactic

Polymerization: Addition reactions

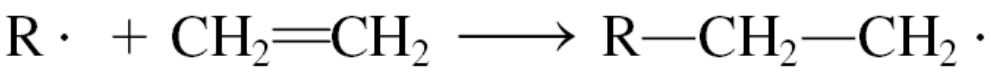
- Involve unsaturated compounds containing double or triple bonds
- Particularly C=C and C≡C
- Examples:
  - Hydrogenation
  - Reactions of hydrogen halides and halogens with alkenes and alkynes
  - Polymerization

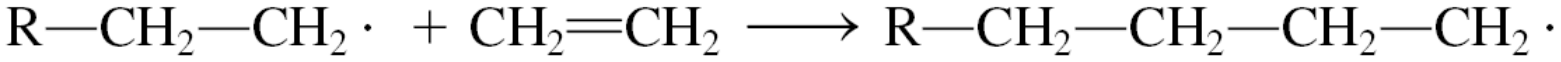


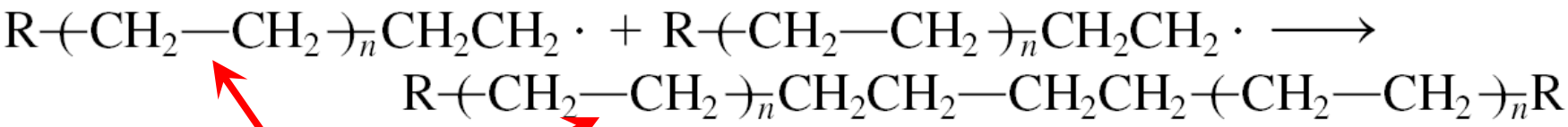
Mechanism of addition polymerization

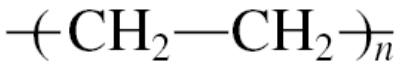


initiator



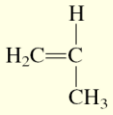
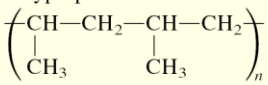
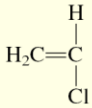
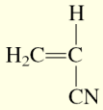
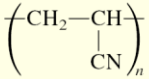
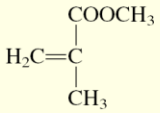
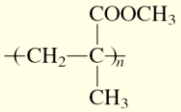
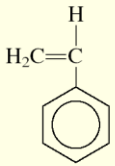
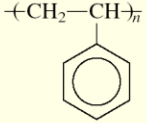
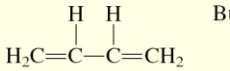
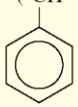




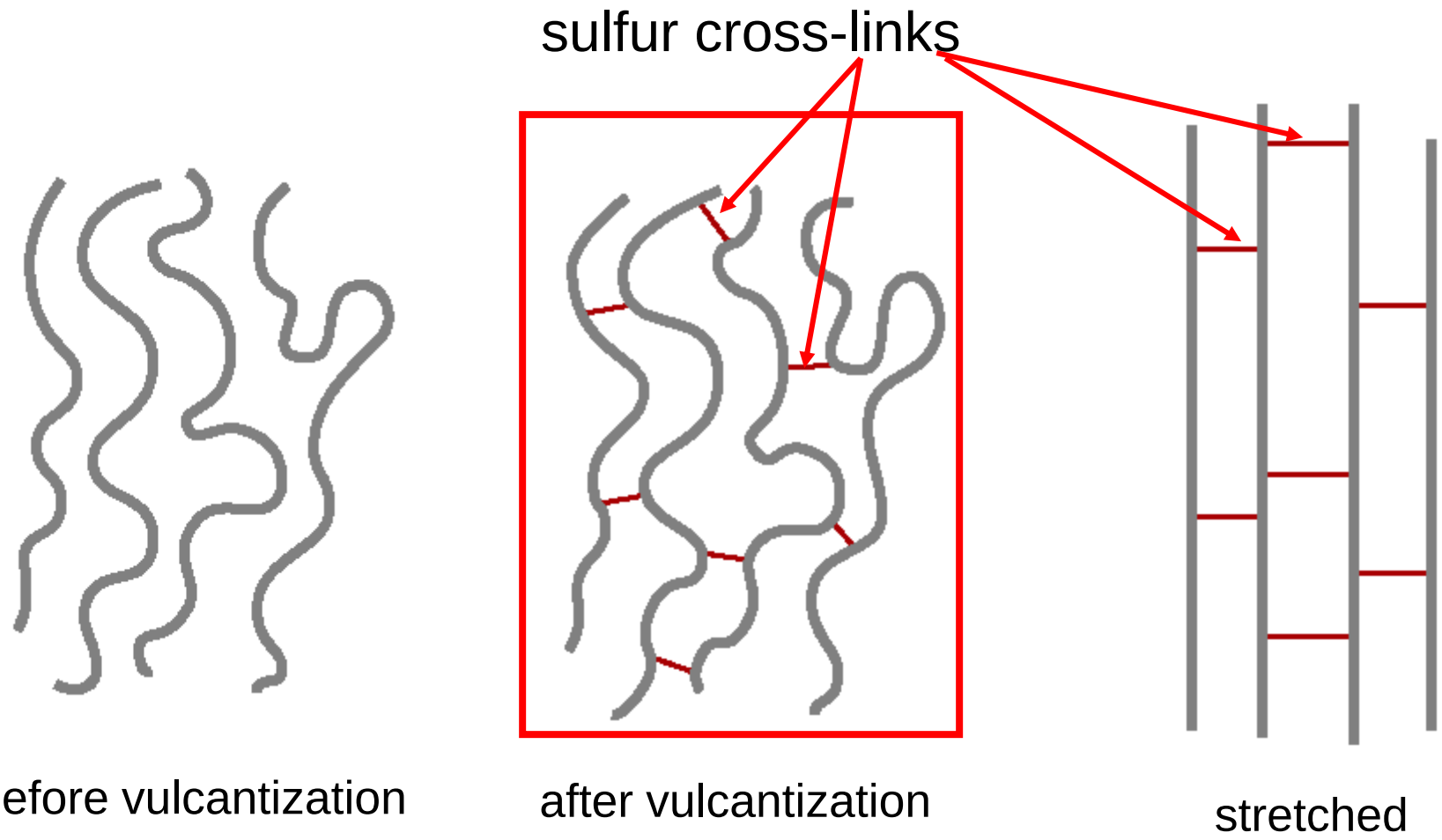


repeating unit (monomer)

TABLE 25.1 Some Monomers and Their Common Synthetic Polymers

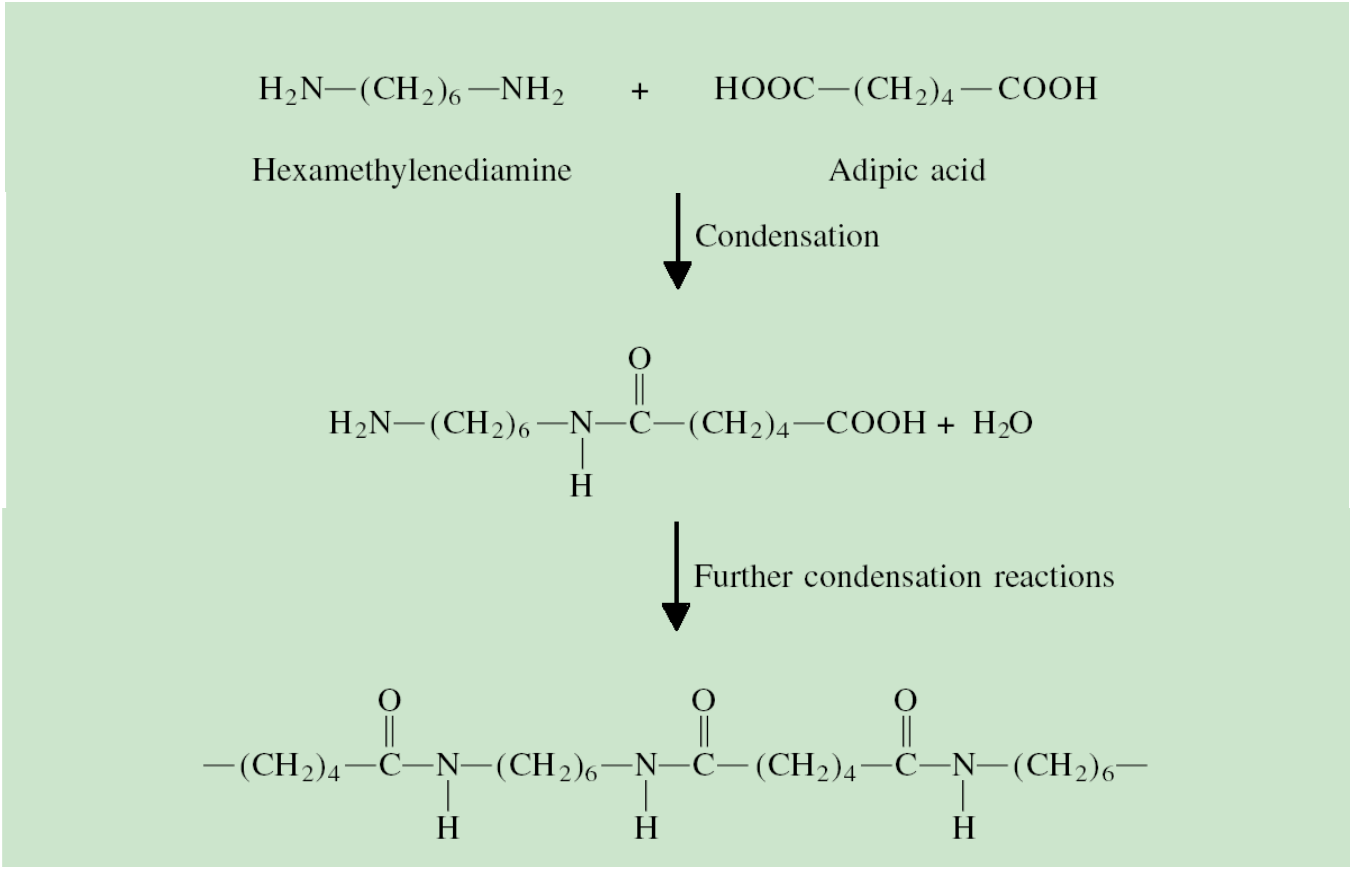
Monomer		Polymer	
Formula	**Name**	**Name and Formula**	**Uses**
$H_2C{=}CH_2$	Ethylene	Polyethylene $+CH_2{-}CH_2+_n$	Plastic piping, bottles, electrical insulation, toys
	Propene	Polypropene 	Packaging film, carpets, crates for soft-drink bottles, lab wares, toys
	Vinyl chloride	Poly(vinyl chloride) (PVC) 	Piping, siding, gutters, floor tile, clothing, toys
	Acrylonitrile	Polyacrylonitrile (PAN) 	Carpets, knitwear
$F_2C{=}CF_2$	Tetrafluoro-ethylene	Polytetrafluoroethylene (Teflon) $+CF_2{-}CF_2+_n$	Coating on cooking utensils, electrical insulation, bearings
	Methyl methacrylate	Poly(methyl methacrylate) (Plexiglas) 	Optical equipment, home furnishings
	Styrene	Polystyrene 	Containers, thermal insulation (ice buckets, water coolers), toys
	Butadiene	Polybutadiene $+CH_2CH{=}CHCH_2+_n$	Tire tread, coating resin
See above structures	Butadiene and styrene	Styrene-butadiene rubber (SBR) 	Synthetic rubber

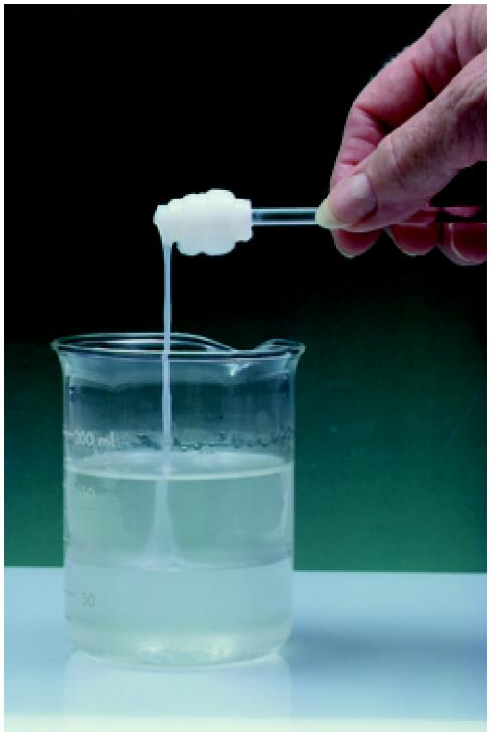
Vulcanization: Properties of rubber



relaxation after stretching

Polymerization: Condensation reactions

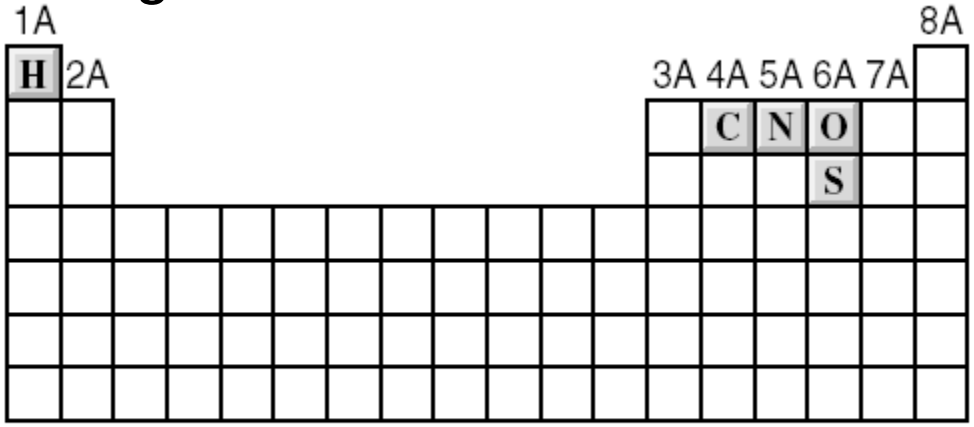




Proteins

Proteins are *polymers of amino acids*

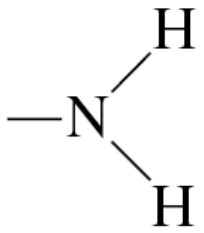
- Termed polypeptides
- Play a key role in nearly all biological processes
  - Enzymes, the catalysts of biochemical reactions
  - Transport of materials
  - Storage of vital substances
  - Coordinated motion
  - Mechanical support
  - Protection against diseases.



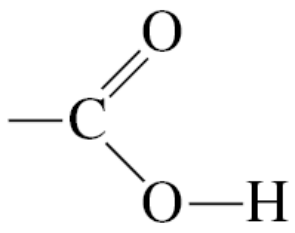
Elements in proteins.

Amino acids are the basic structural units of proteins.

- Contain at least one amino group (-NH_2)
- And at least one carboxyl group (-COOH)

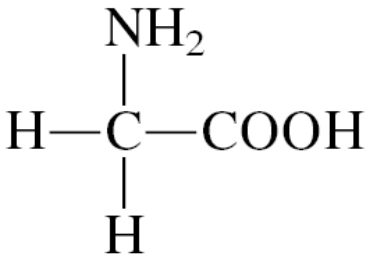


amino group

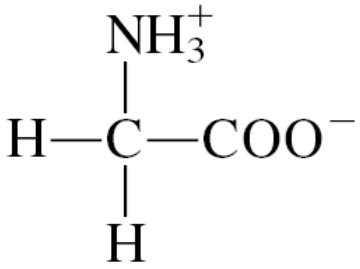


carboxyl group

- Existing form is pH dependent

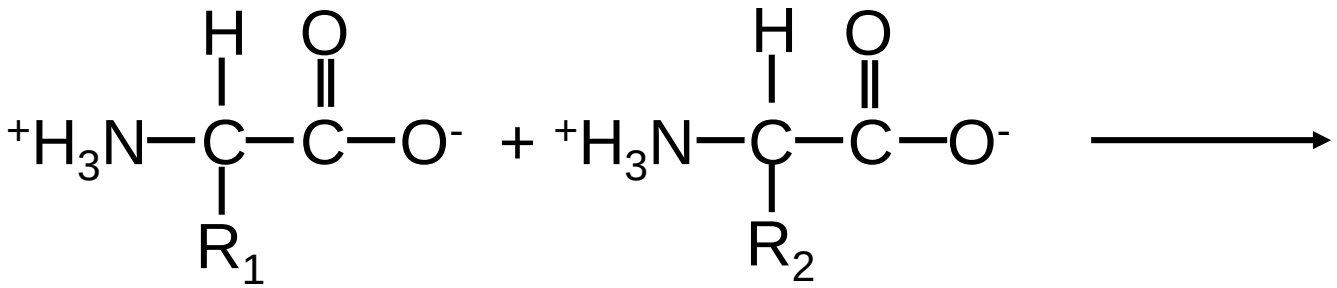


un-ionized form

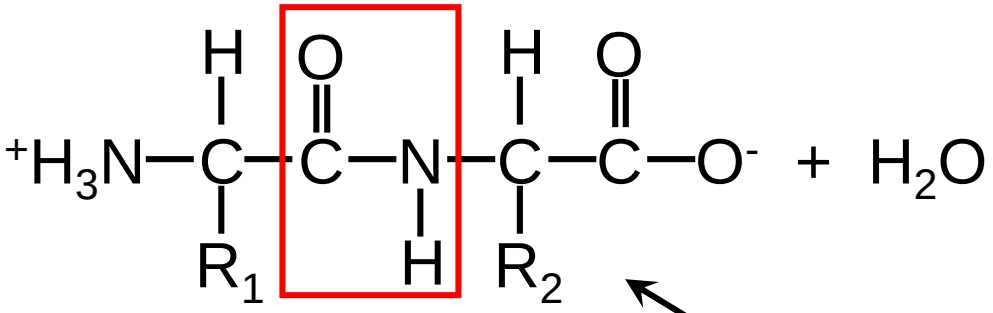


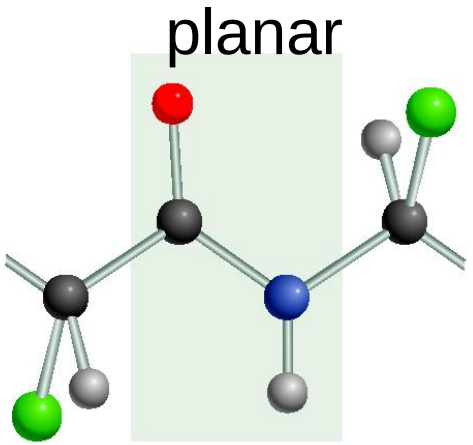
dipolar ion

Amino acids are joined in a protein by the formation of a peptide bond

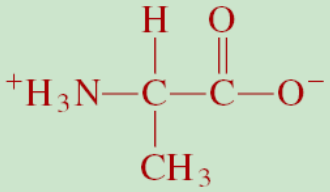


Peptide (amide) bond

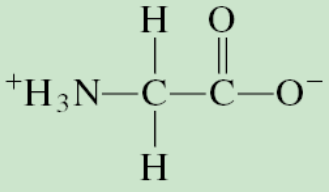




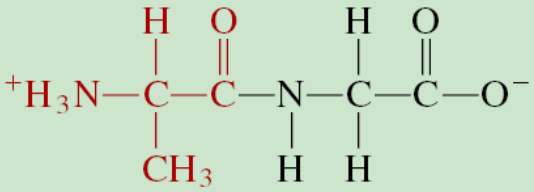
Dipeptide – contains two amino acid residues



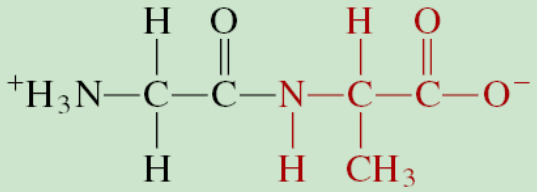
Alanine



Glycine



Alanylglycine



Glycylalanine

20 amino acids can form 20^2 or 400 dipeptides.

Protein with 50 amino acid residues can be arranged in 20^{50} or 10^{65} ways.

TABLE 25.2 The 20 Amino Acids Essential to Living Organisms*

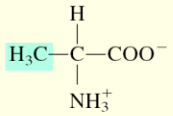
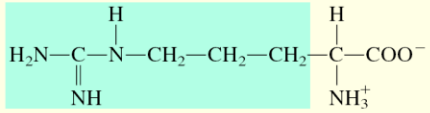
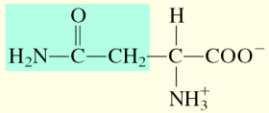
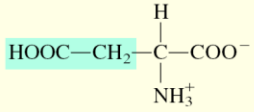
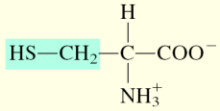
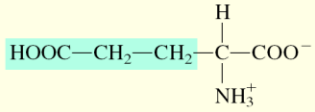
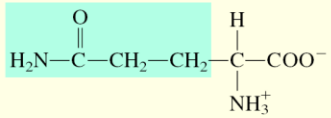
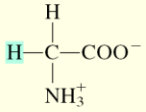
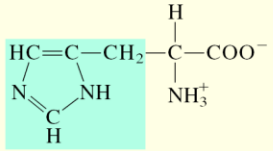
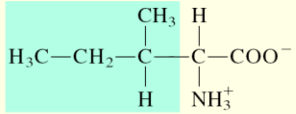
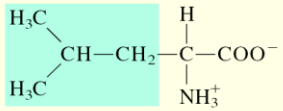
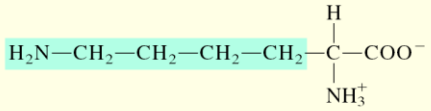
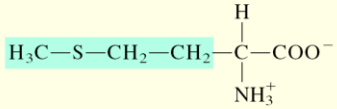
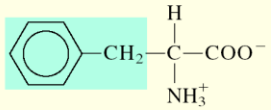
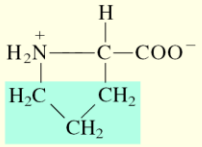
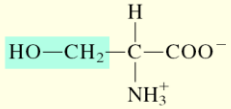
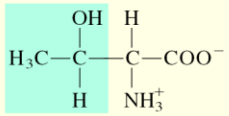
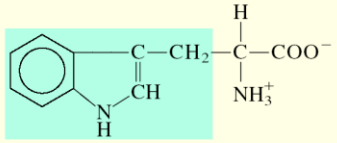
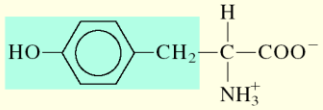
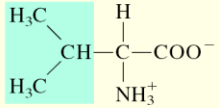
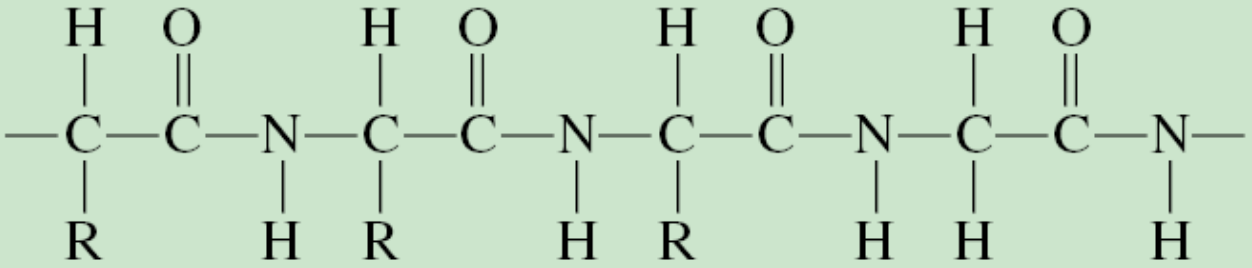
Name	Abbreviation	Structure
Alanine	Ala	
Arginine	Arg	
Asparagine	Asn	
Aspartic acid	Asp	
Cysteine	Cys	
Glutamic acid	Glu	
Glutamine	Gln	
Glycine	Gly	
Histidine	His	
Isoleucine	Ile	

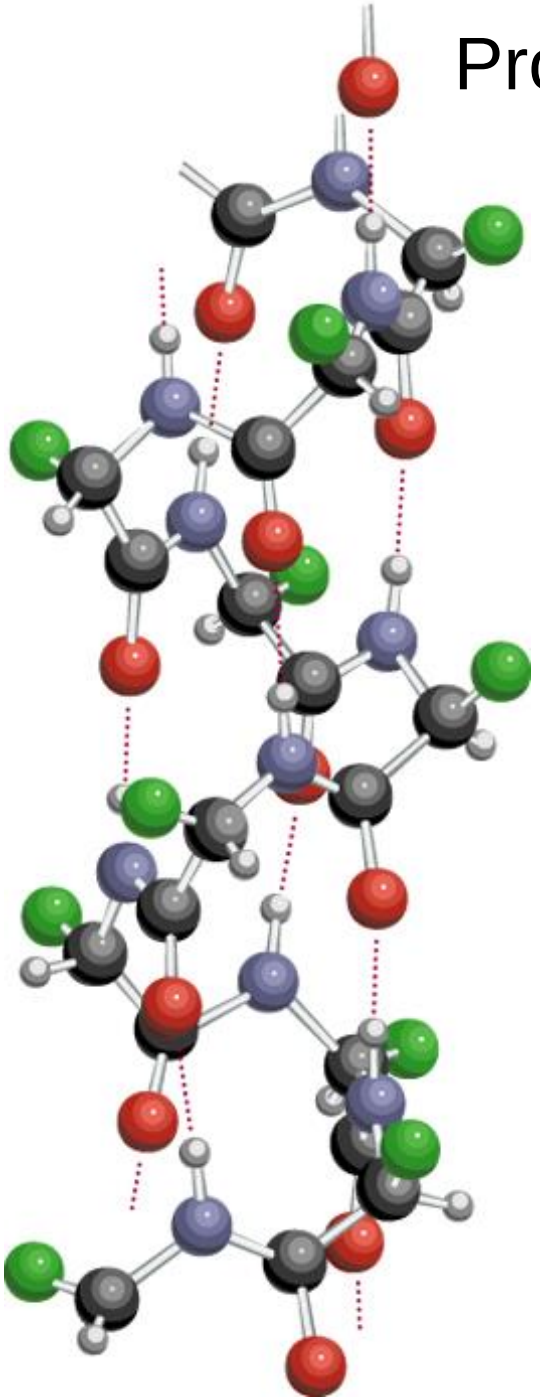
TABLE 25.2 The 20 Amino Acids Essential to Living Organisms—Cont.

Name	Abbreviation	Structure
Leucine	Leu	
Lysine	Lys	
Methionine	Met	
Phenylalanine	Phe	
Proline	Pro	
Serine	Ser	
Threonine	Thr	
Tryptophan	Trp	
Tyrosine	Tyr	
Valine	Val	

Polypeptide chain: repeating amide bonds



Protein Structure: α-helix



Carbon

Nitrogen

Oxygen

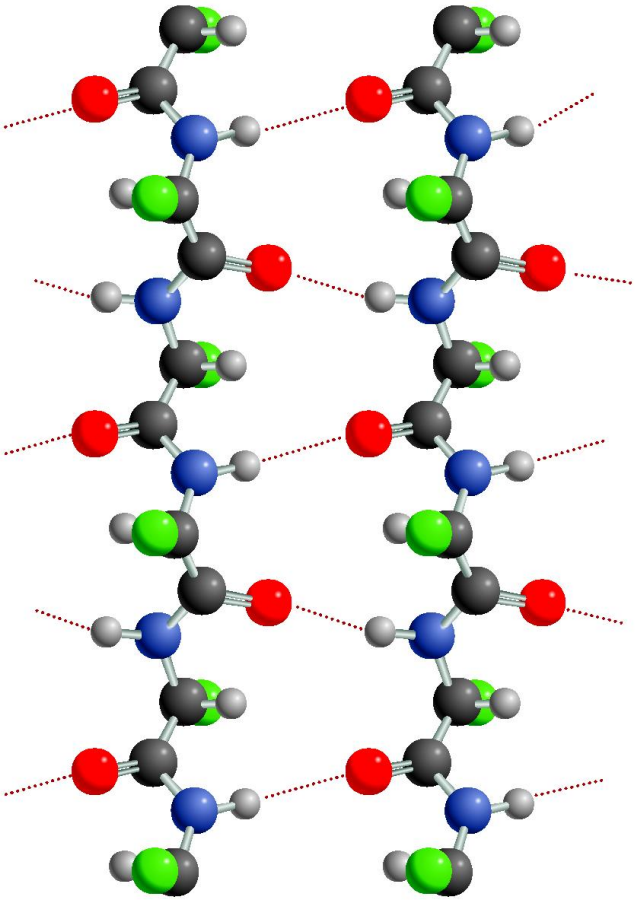
R group

Hydrogen

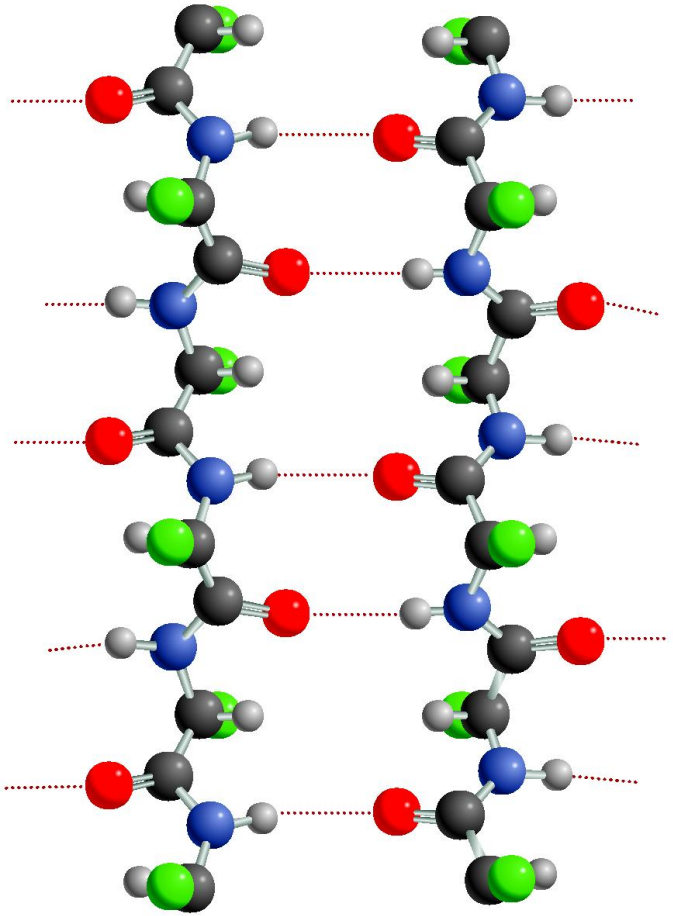
The structure is held in position by intramolecular hydrogen bonds (.....)

Protein Structure: β-Pleated Sheets

Hydrogen bonds in parallel and antiparallel β-pleated sheets

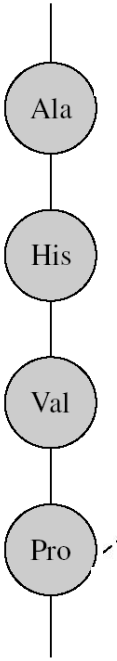


Parallel

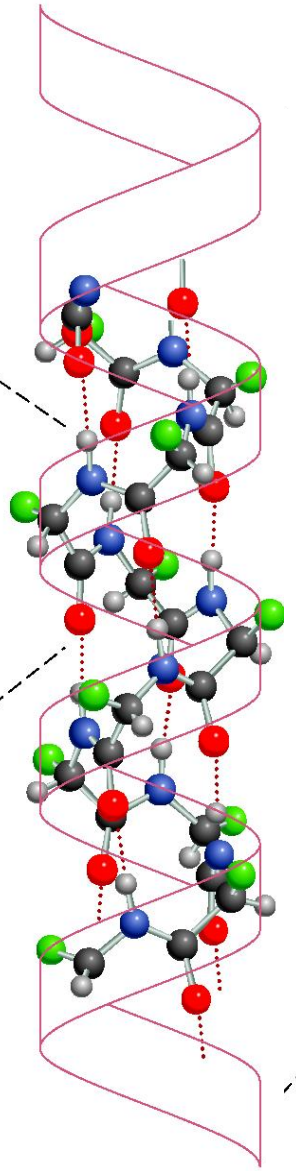


Antiparallel

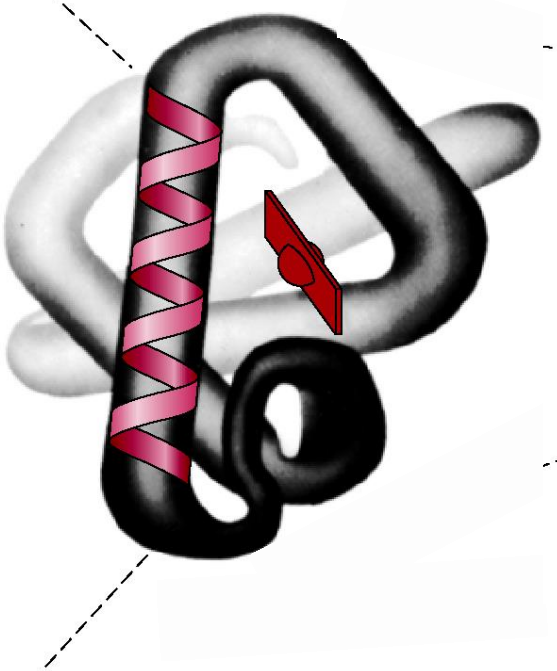
Protein Structure



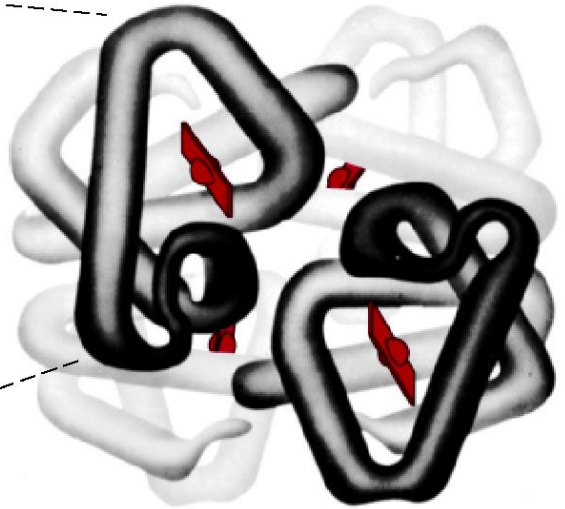
primary structure



secondary structure



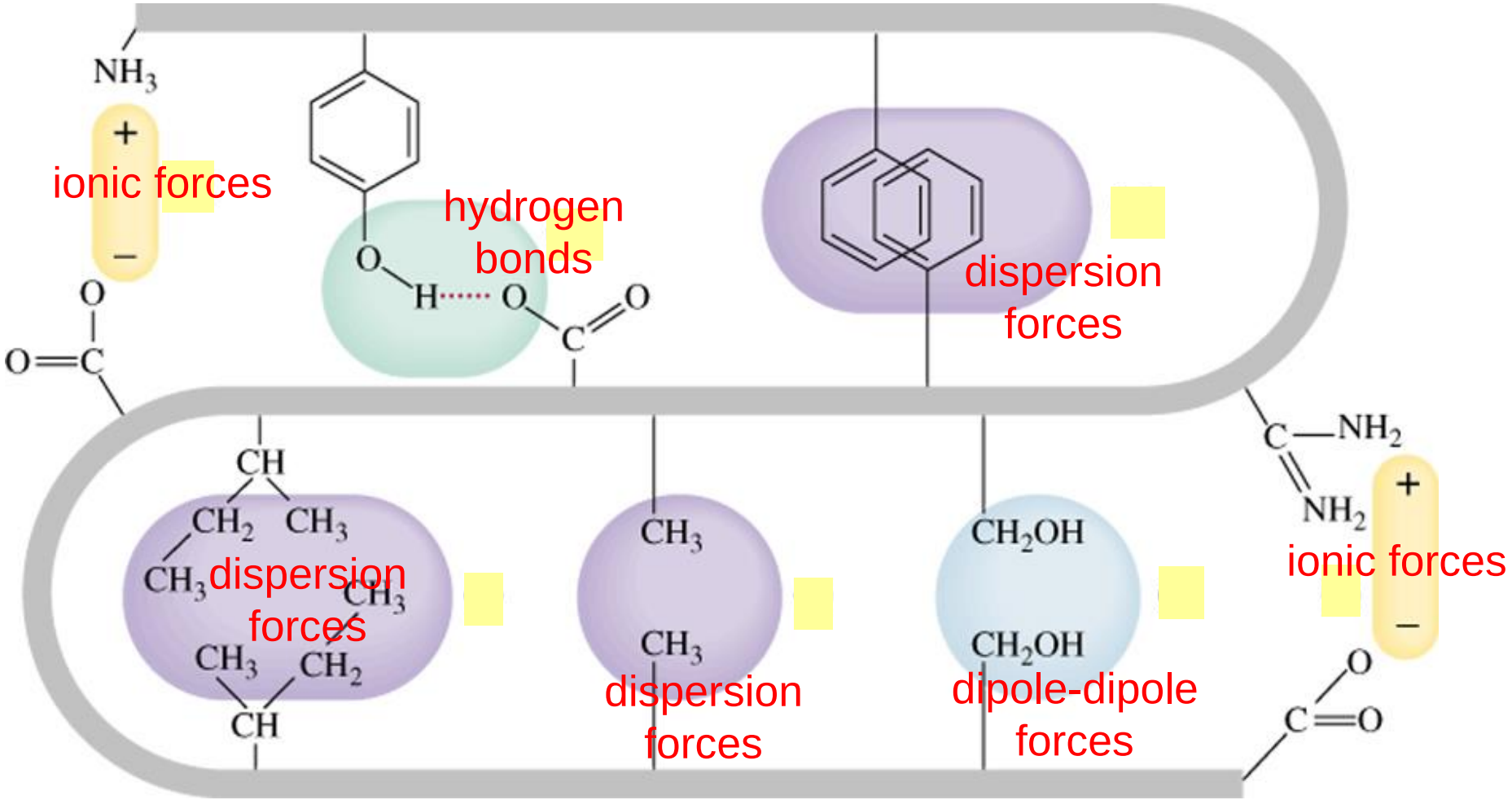
tertiary structure



quaternary structure

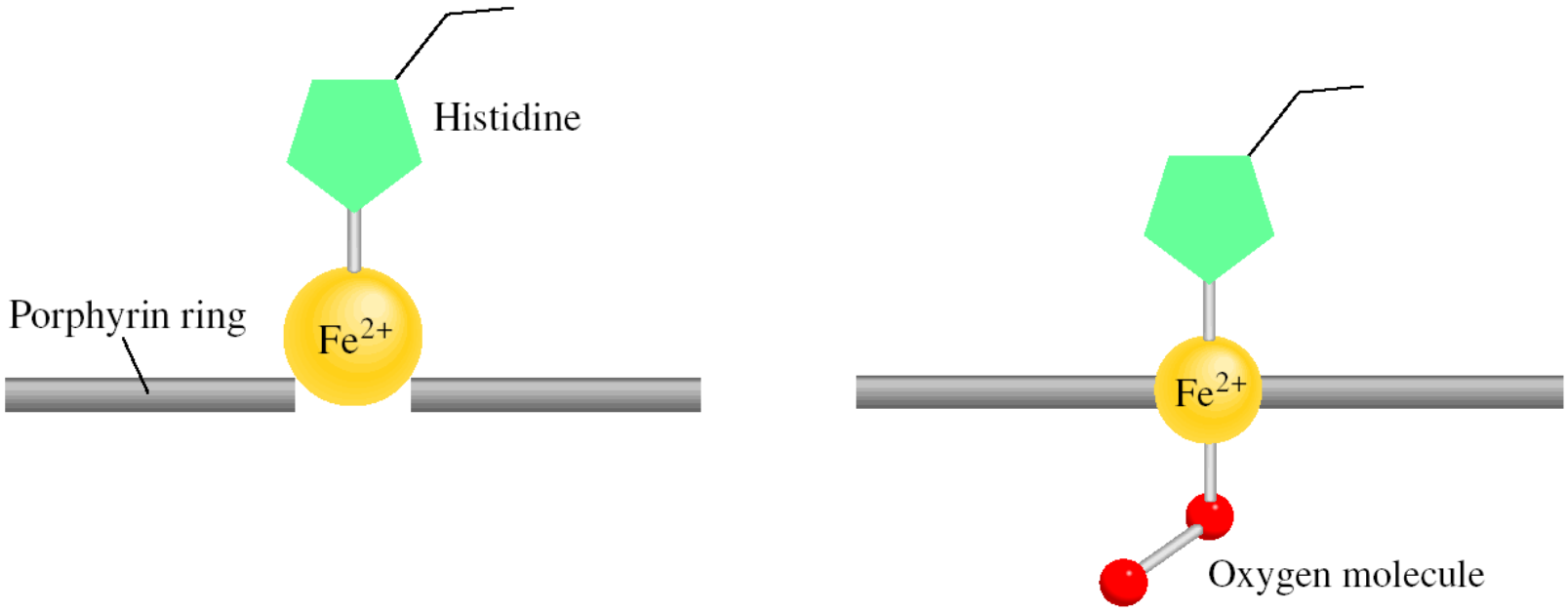
Protein Structure

Intermolecular Forces in a Protein Molecule



Protein Structure

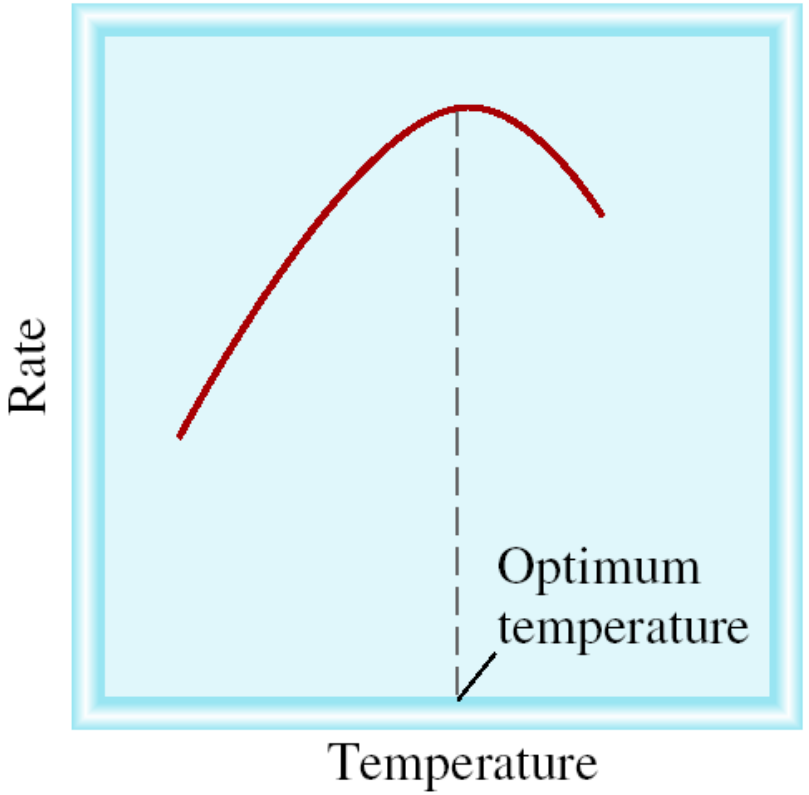
The structural changes that occur when oxygen binds to the heme group in hemoglobin.



Denatured proteins: no longer exhibit normal biological activities.

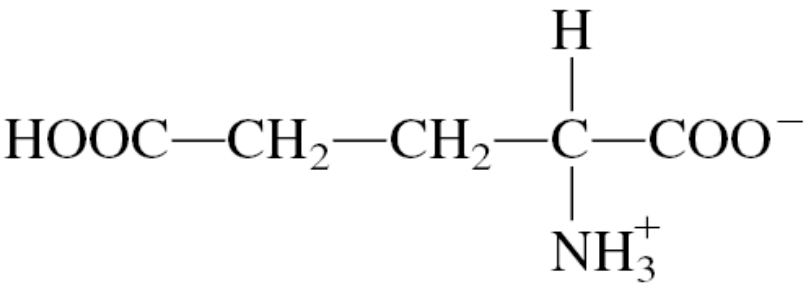
Denaturation can be caused by pH, denaturants (special reagents) or temperature

Can be reversible or irreversible

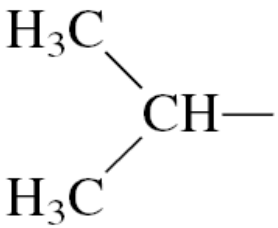


Chemistry in Action

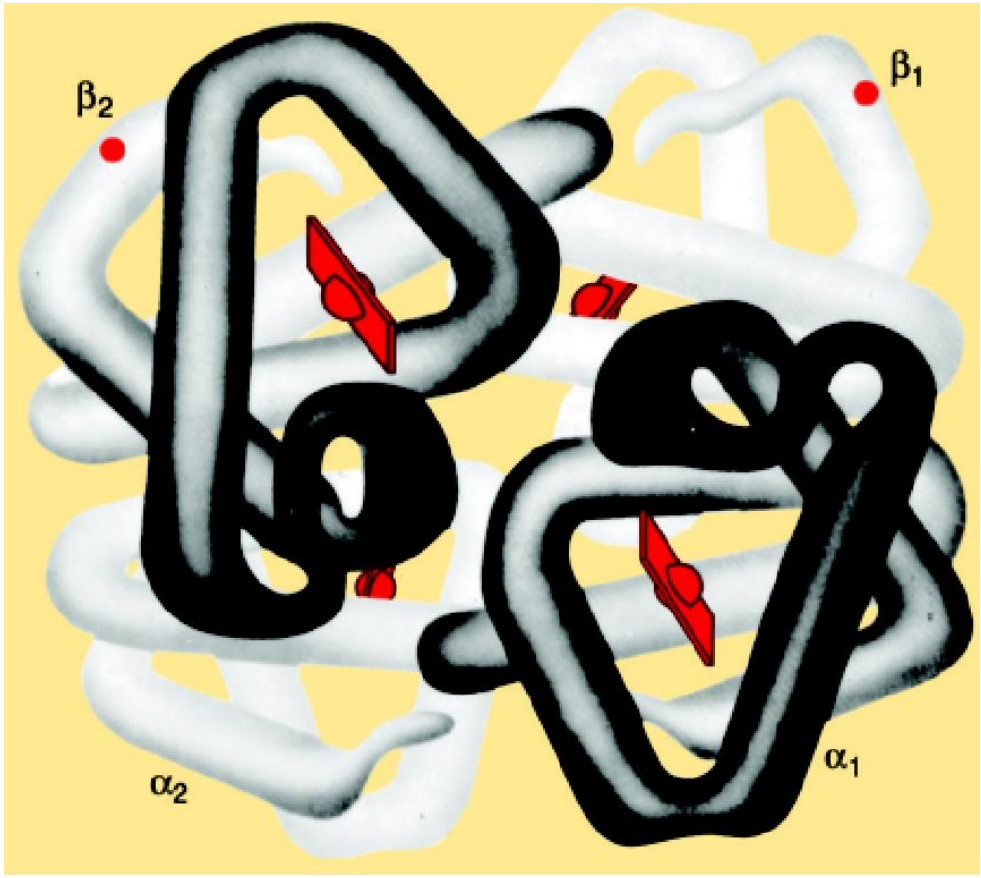
Sickle Cell Anemia: A Molecular Disease



glutamic acid



nonpolar portion of valine

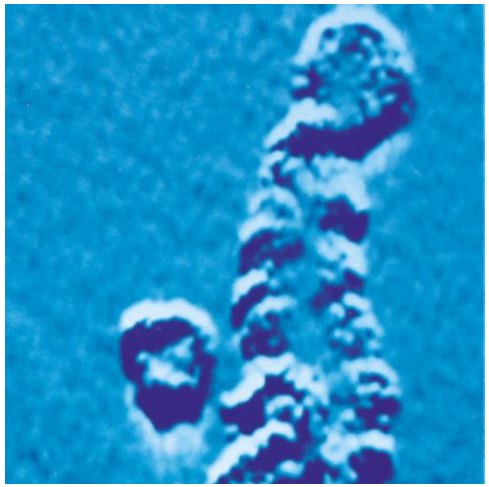


Nucleic Acids

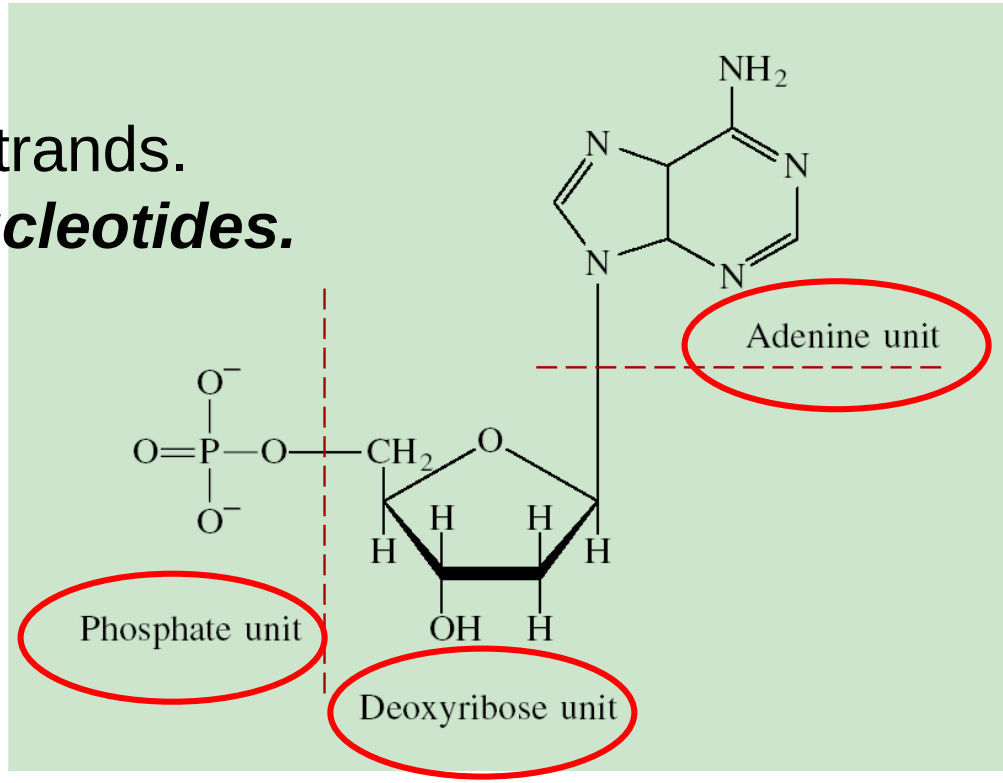
Nucleic acids are high molar mass polymers that play an essential role in protein synthesis.

1. ***Deoxyribonucleic acid (DNA)***
2. ***Ribonucleic acid (RNA)***

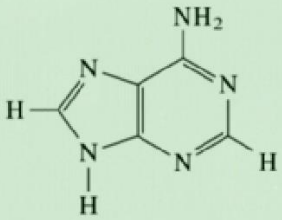
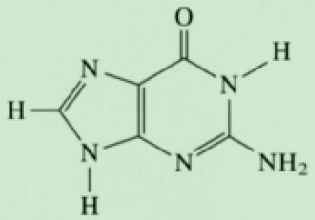
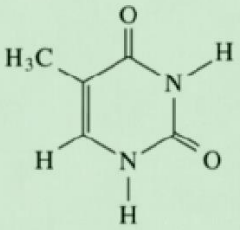
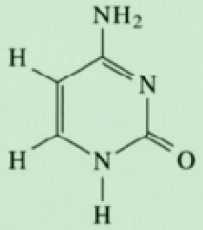
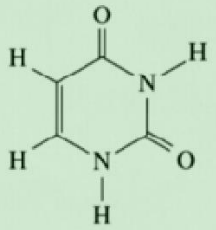
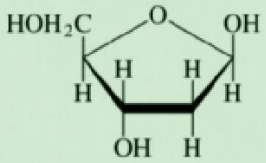
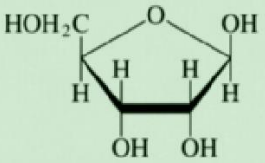
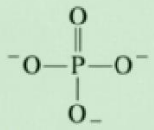
DNA molecule has 2 helical strands.
Each strand is made up of ***nucleotides.***



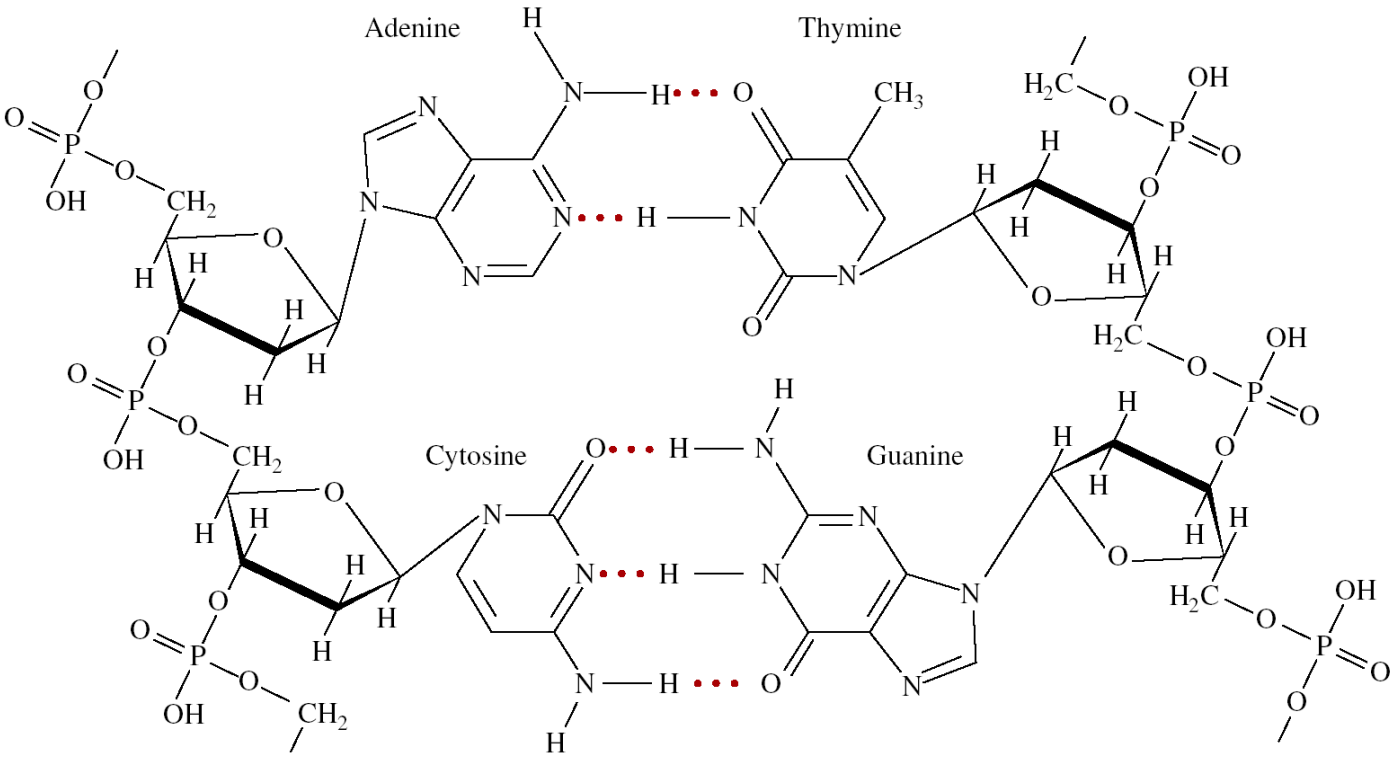
Electronmicrograph of DNA

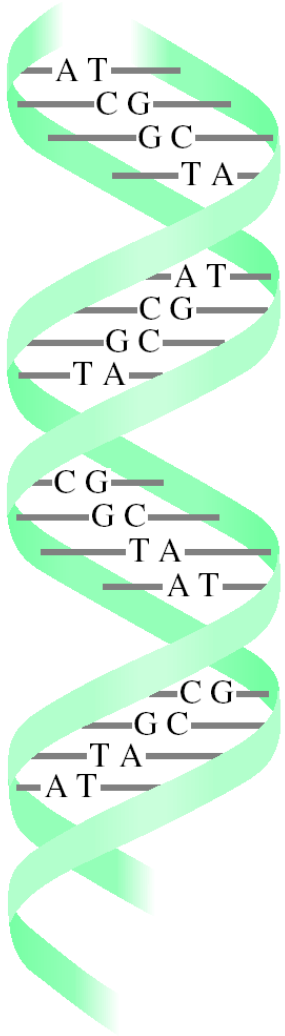


The Components of the Nucleic Acids DNA and RNA

	Found only in DNA	Found in both DNA and RNA	Found only in RNA
Purines		 Adenine  Guanine	
Pyrimidines	 Thymine	 Cytosine	 Uracil
Sugars	 Deoxyribose		 Ribose
Phosphate		 Phosphate	

Base-Pair Formation by Adenine and Thymine and by Cytosine and Guanine





Chemistry In Action: DNA Fingerprinting