The Molecular and Biochemical Basis of an Organism

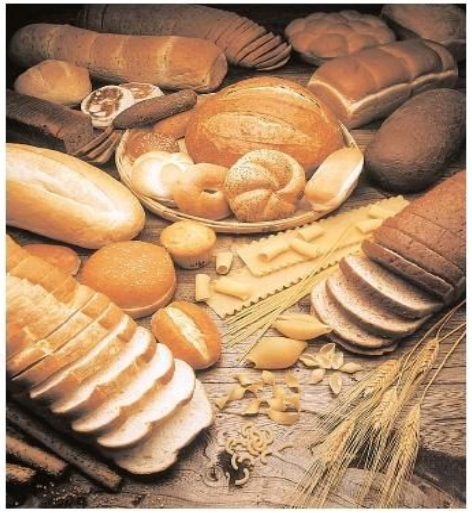
Organic Compounds

Carbon is essential to life!!

- All living things are composed mostly of **carbon.**
- All life on Earth is **carbon based.**
- There are four basic types of **organic (carbon based) molecules.**
  - **Carbohydrates**
  - **Lipids**
  - **Nucleic Acids**
  - **Proteins**

Carbohydrates

- Produced by plants during photosynthesis
- Provide **energy** for cells
- Carbohydrates include **sugars** and **starches**.
- Sugars - Monosaccharides, disaccharides, polysaccharides
- They supply carbon for the synthesis of cell
- components
- They serve as a form of stored chemical energy
- They form part of the structures of some cells and tissues



Classification of Carbohydrates

- Simple carbohydrates
  - Monosaccharide
  - Disaccharide
  - Perceived as sweeter than complex carbohydrates
  - Mixes with saliva and reacts with taste buds
- Oligosaccharides
- Complex carbohydrates
  - Polysaccharides

Absorption of Carbohydrates

Once digested to monosaccharides Absorbed

through the intestinal cell mucosa

Transported to the liver via the portal vein

Metabolic needs direct fate of the monosaccharides

Galactose and fructose

Used by the liver for energy

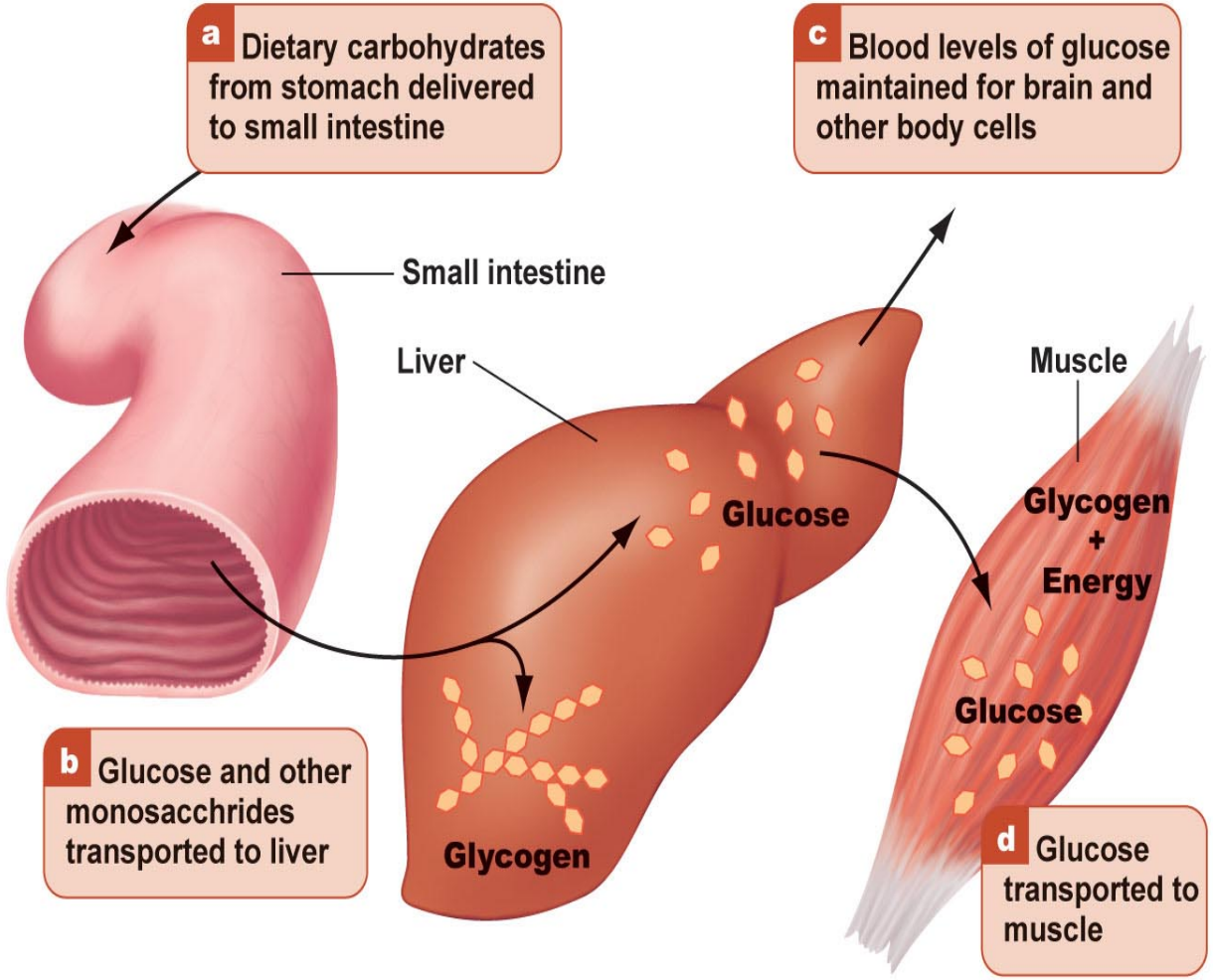
Converted to glucose

Glucose

Used for energy

Converted to glycogen through glycogenesis

Converted to glycerol and fatty acids for storage in adipocytes



Lipids

- Composed of C, H, O
- Lipids are insoluble in water.
- Lipids store energy.
- Building Blocks - Fatty acids, glycerol

Saturated Fat:

All C bonded to H

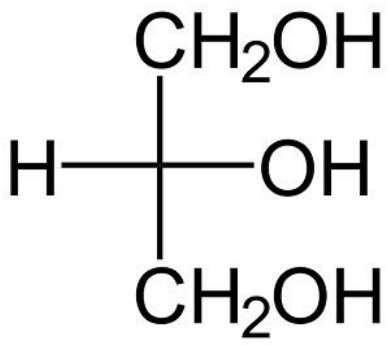
- No C=C double bonds
- long, straight chain
- most animal fats
- solid at room temp.
- contributes to cardiovascular disease

Unsaturated Fat: C=C double bonds in the fatty acids

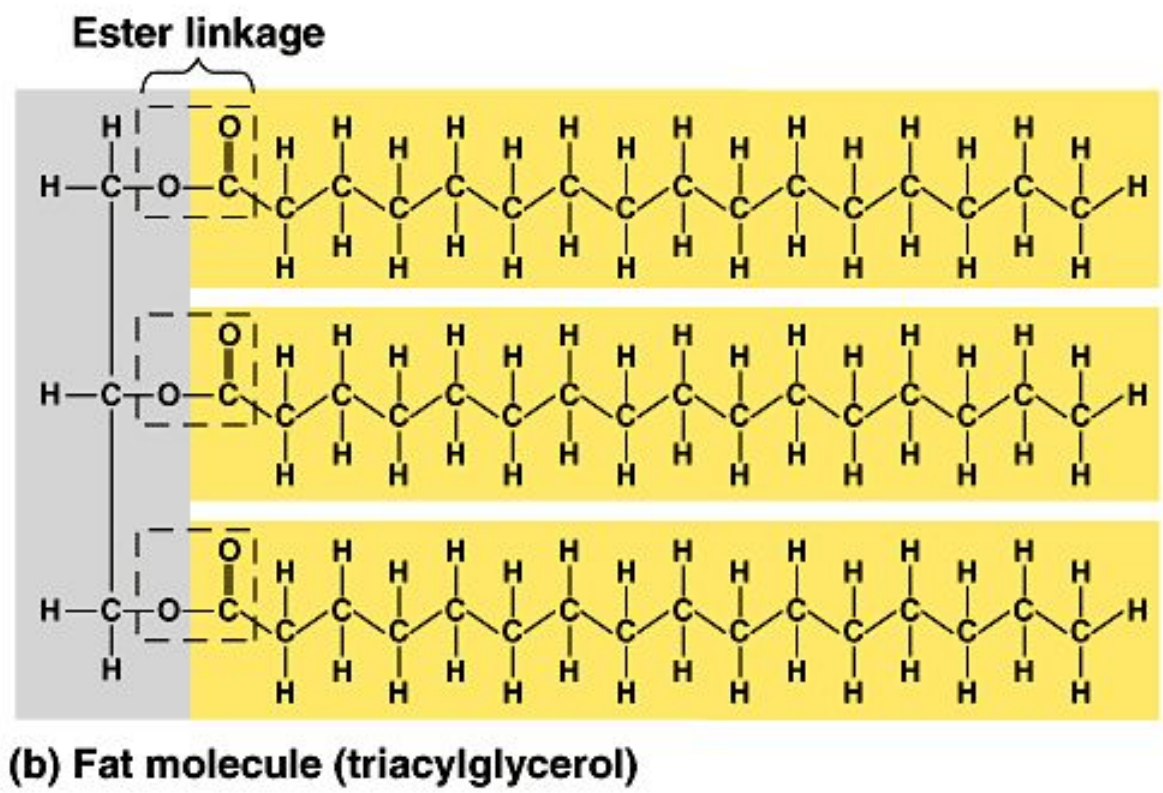
- plant & fish fats
- vegetable oils
- liquid at room temperature
- Liquid at room temperature

Building Fats

hydroxyl



carboxyl



(b) Fat molecule (triacylglycerol)

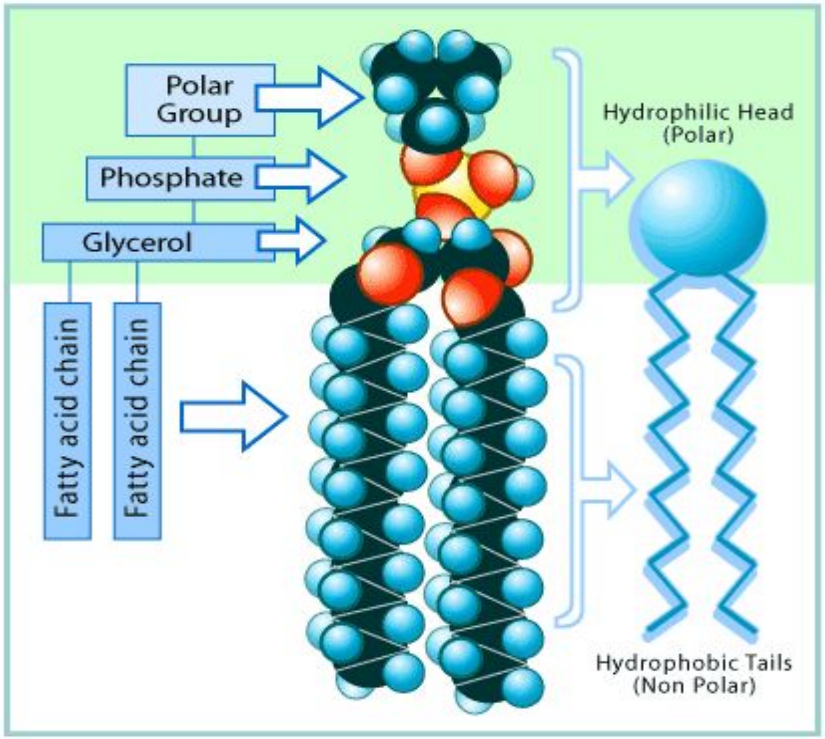
Triacylglycerol

3 fatty acids linked to glycerol

ester linkage = between OH & COOH

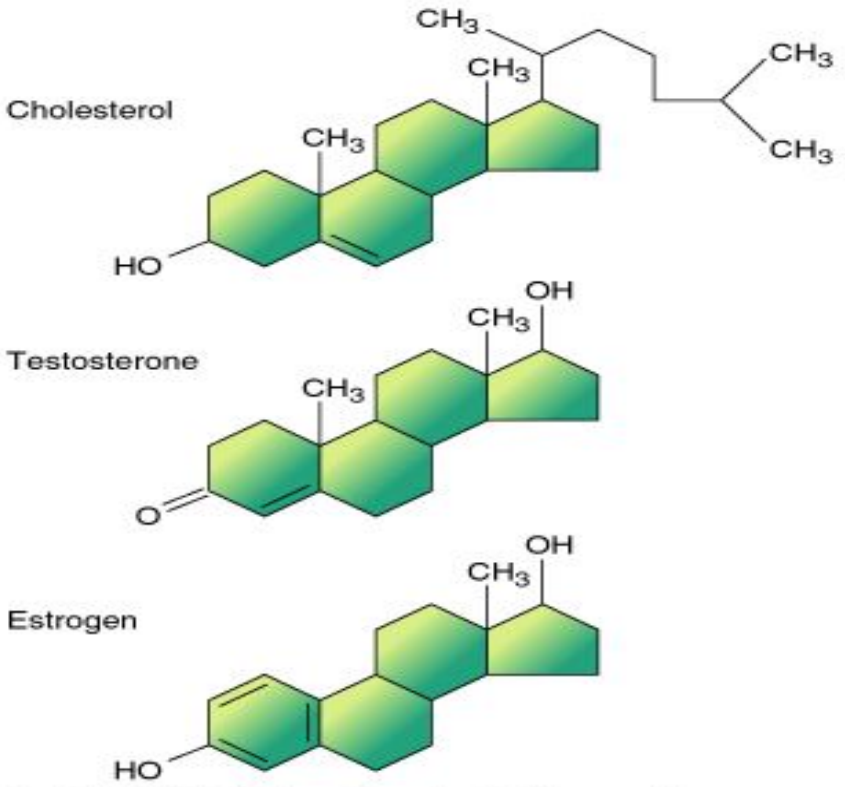
Phospholipids – similar to fat molecules, however, contains only two fatty acid chains. In the position of the third is a portion containing a phosphate group

- "head" – phosphate portion(water soluble, hydrophilic)
- "tail" – fatty acid portion (hydrophobic)
- Important in cellular structures



Steroids – complex molecules that include four connected carbon rings

Ex: Cholesterol, estrogen, testosterone



STEROLS

Important part of:

1. Sex hormones – testosterone
2. Vitamin D
3. Bile (aids fat digestion)
4. Adrenal hormones - cortisol
5. Cholesterol – in foods and made by the liver; dietary sources include egg yolks, liver, meats, dairy products

WAX

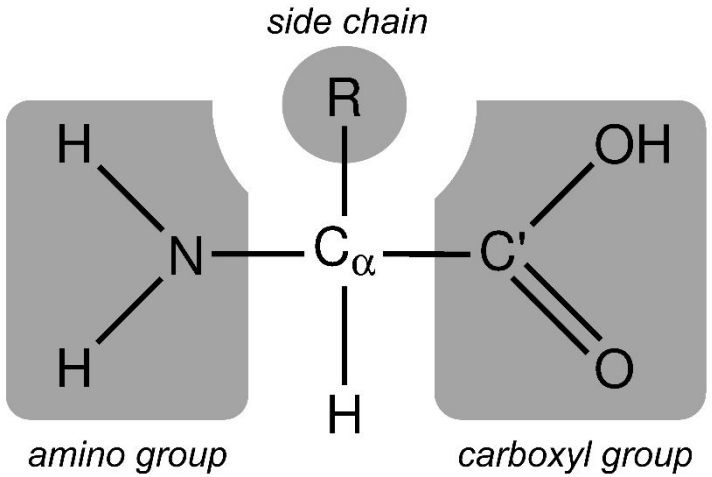
Waxes are lpids that consist of long alkyl chains. Natural waxes may contain unsaturated bonds and include various functional groups such as fatty acids, primary and secondary alcohols, ketones, aldehydes and fatty acid esters, and aromatic compounds.

Birds/insects - water repellant feathers/exoskeletons

Leaves/fruit - minimize water evaporation

Humans - to plug up ears

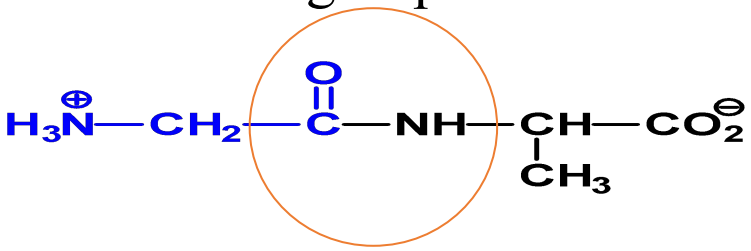
The Amino Acids



- Cα is at the heart of the amino acid
- Cα, C N and O are called backbone atoms
- R can be any of the 20 side chains

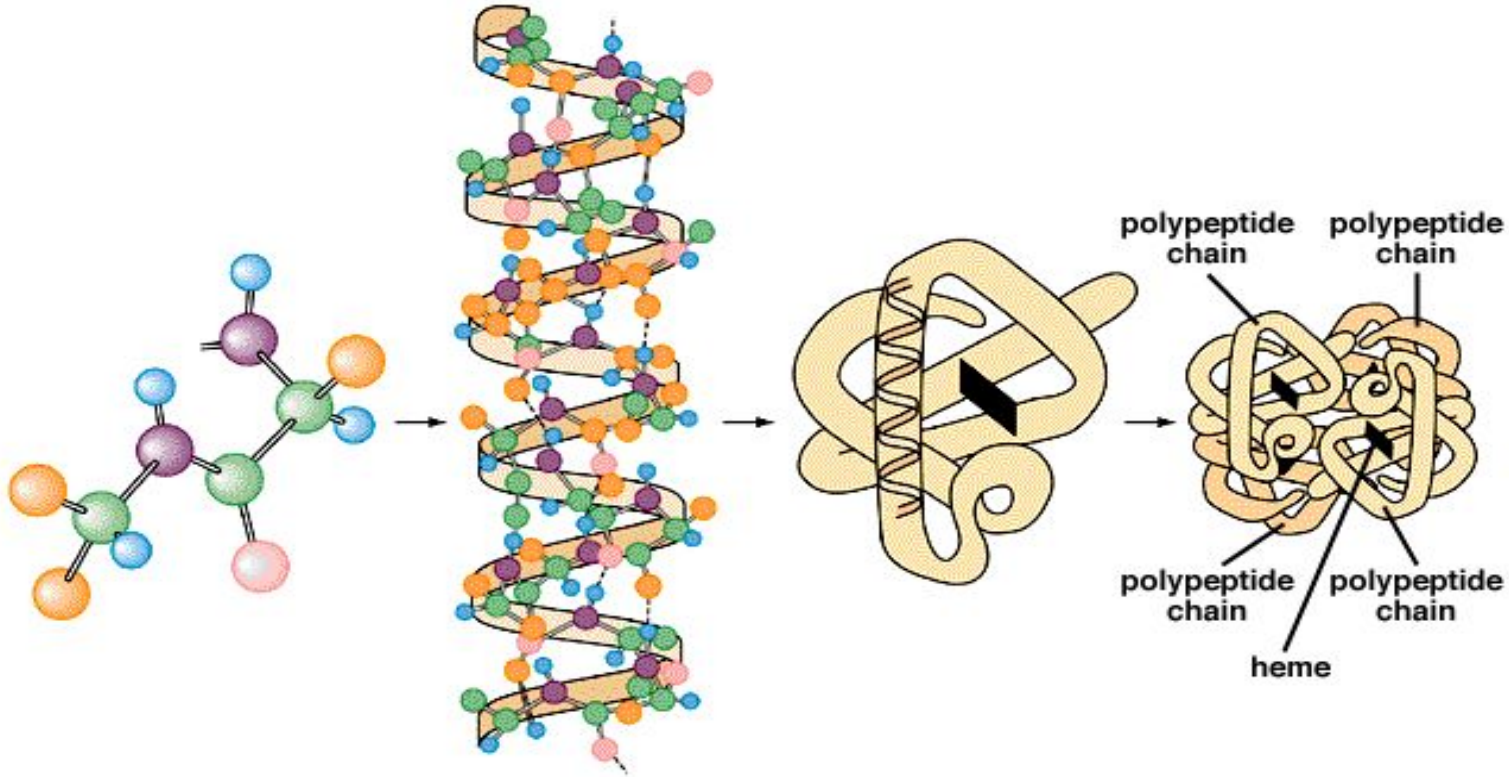
Polypeptides and Proteins

- In 1902, Emil Fischer proposed that proteins are long chains of amino acids joined by peptide bonds
- Peptide bond: The special name given to the amide bond between the α-carboxyl group of one amino acid and the α-amino group of another



- peptide: Peptides are amino acid polymers containing 2–50 individual units
- dipeptide: a molecule containing two amino acids joined by a peptide bond
- tripeptide: a molecule containing three amino acids joined by peptide bonds
- polypeptide: a macromolecule containing many amino acids joined by peptide bonds
- protein: Peptides with >50 units are called proteins

The Four Levels of Protein Structure



Summary of the four levels of protein structure, using hemoglobin as an example.

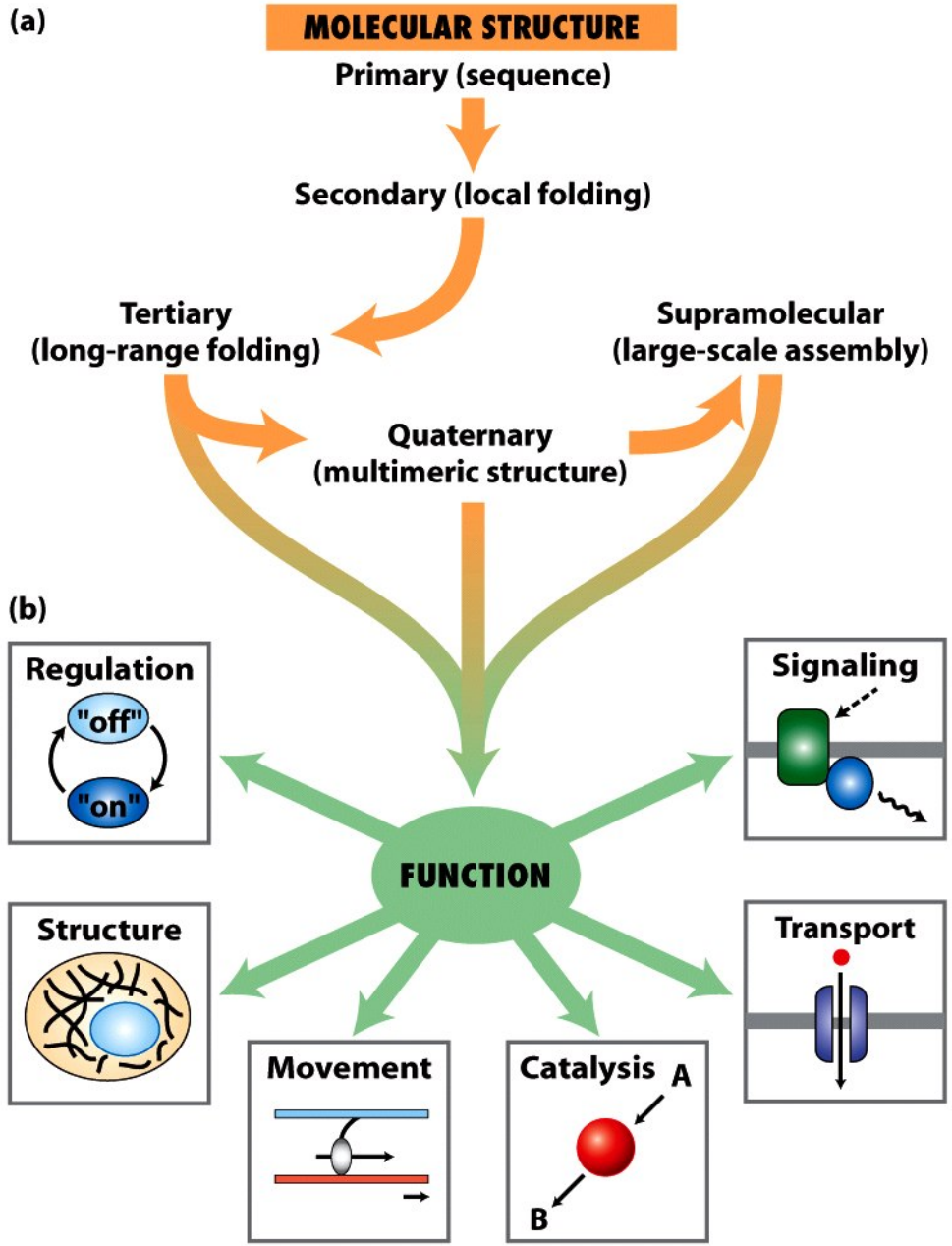


Figure 3-1
Molecular Cell Biology, Sixth Edition

Protein Function

- Catalysis – enzymes
- Structural – keratin
- Transport – hemoglobin
- Trans-membrane transport – Na+/K+ ATPases
- Toxins – rattle snake venom, ricin
- Contractile function – actin, myosin
- Hormones – insulin
- Storage Proteins – seeds and eggs
- Defensive proteins – antibodies

Nucleic Acids

- **Nucleic Acids – store information**

They contain the genetic instructions for all living things.

Types of nucleic acids

- **RNA**
- **DNA**

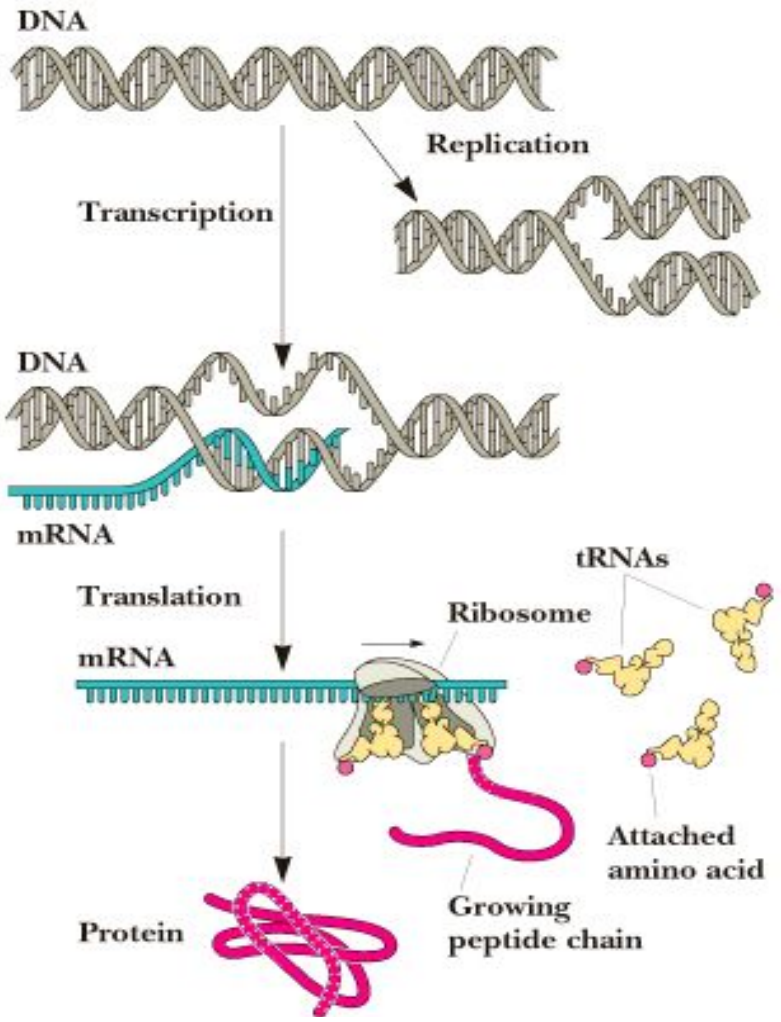
Information Transfer in Cells

Transcription:

Information encoded in a DNA molecule is transcribed via synthesis of an RNA molecule

Translation:

The sequence of the RNA molecule is "read" and is translated into the sequence of amino acids in a protein.



Replication
DNA replication yields two DNA molecules identical to the original one, ensuring transmission of genetic information to daughter cells with exceptional fidelity.

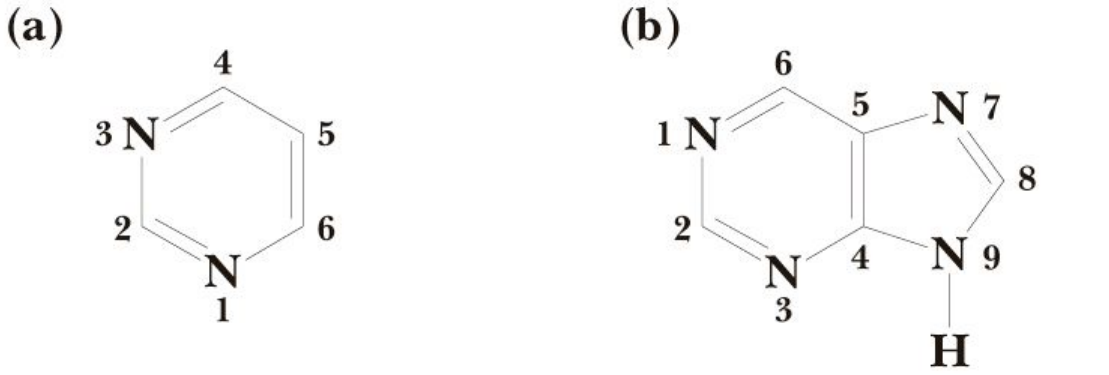
Transcription
The sequence of bases in DNA is recorded as a sequence of complementary bases in a single-stranded mRNA molecule.

Translation
Three-base codons on the mRNA corresponding to specific amino acids direct the sequence of building a protein. These codons are recognized by tRNAs (transfer RNAs) carrying the appropriate amino acids. Ribosomes are the "machinery" for protein synthesis.

Nitrogenous Bases

- Purines
  - Adenine (DNA, RNA)
  - Guanine (DNA, RNA)
- Pyrimidines
  - Cytosine (DNA, RNA)
  - Uracil (RNA)
  - Thymine (DNA)

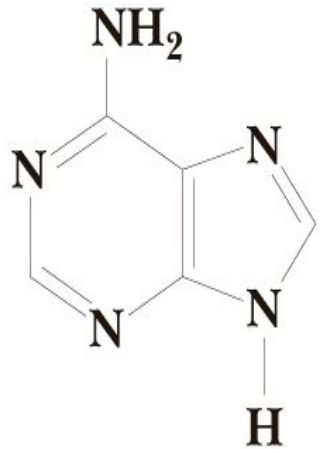
Garrett & Grisham: Biochemistry, 2/e
Figure 11.2



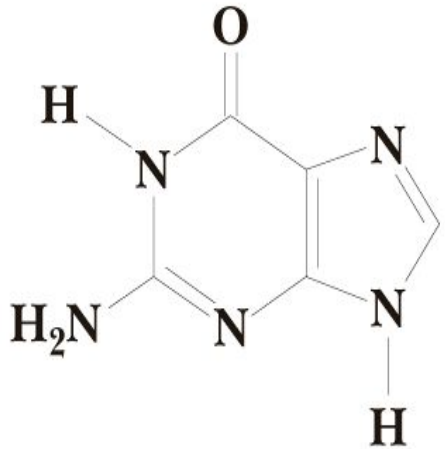
The pyrimidine ring

The purine ring system

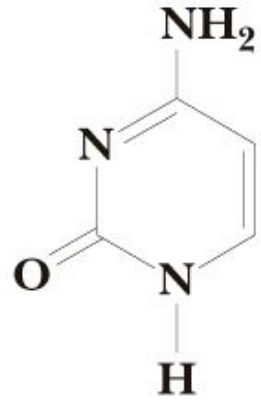
Saunders College Publishing



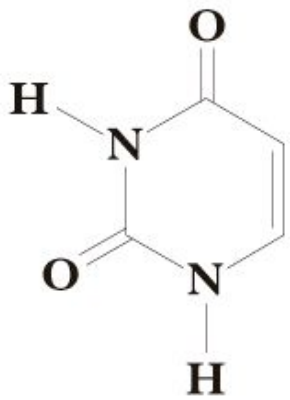
Adenine
(6-amino purine)



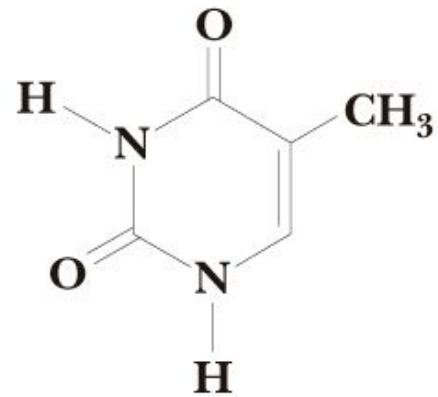
Guanine
(2-amino-6-oxy purine)



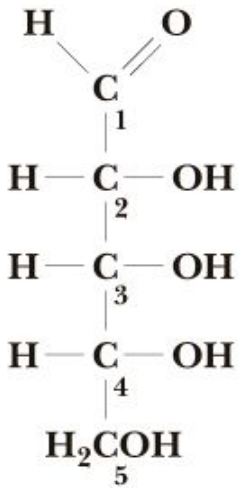
Cytosine
(2-oxy-4-amino
pyrimidine)



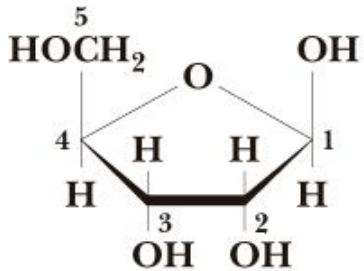
Uracil
(2-oxy-4-oxy
pyrimidine)



Thymine
(2-oxy-4-oxy
5-methyl pyrimidine)

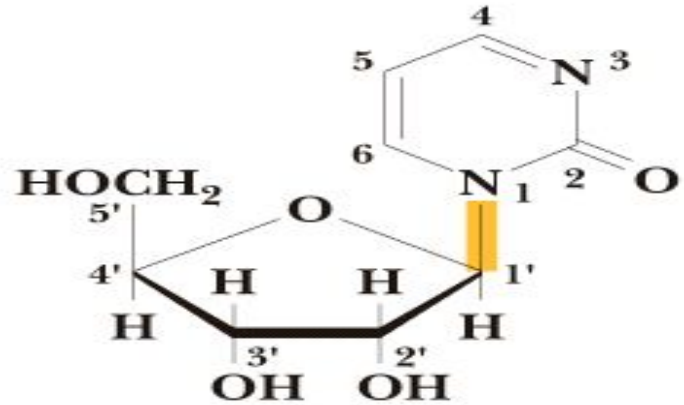


D-Ribose

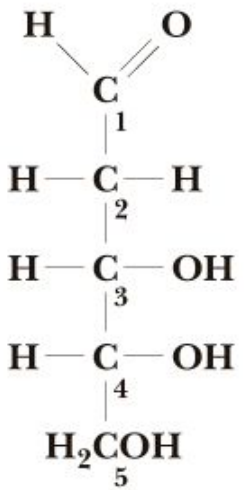


Furanose form of D-Ribose

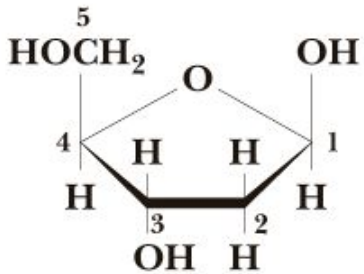
β-D-Ribofuranose



β-N_1-glycosidic bond in pyrimidine ribonucleosides

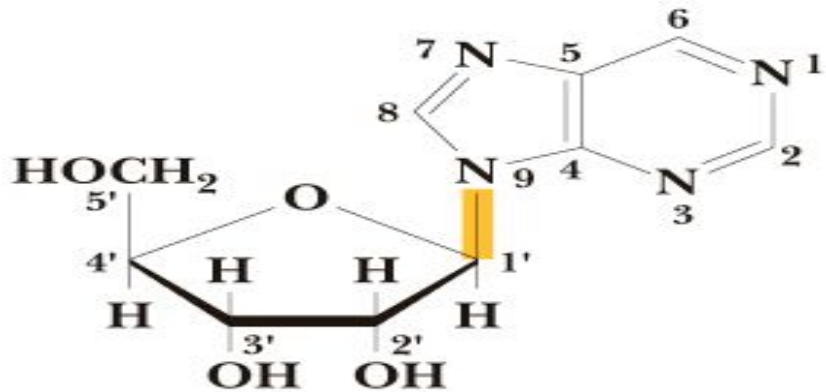


D-2-Deoxyribose



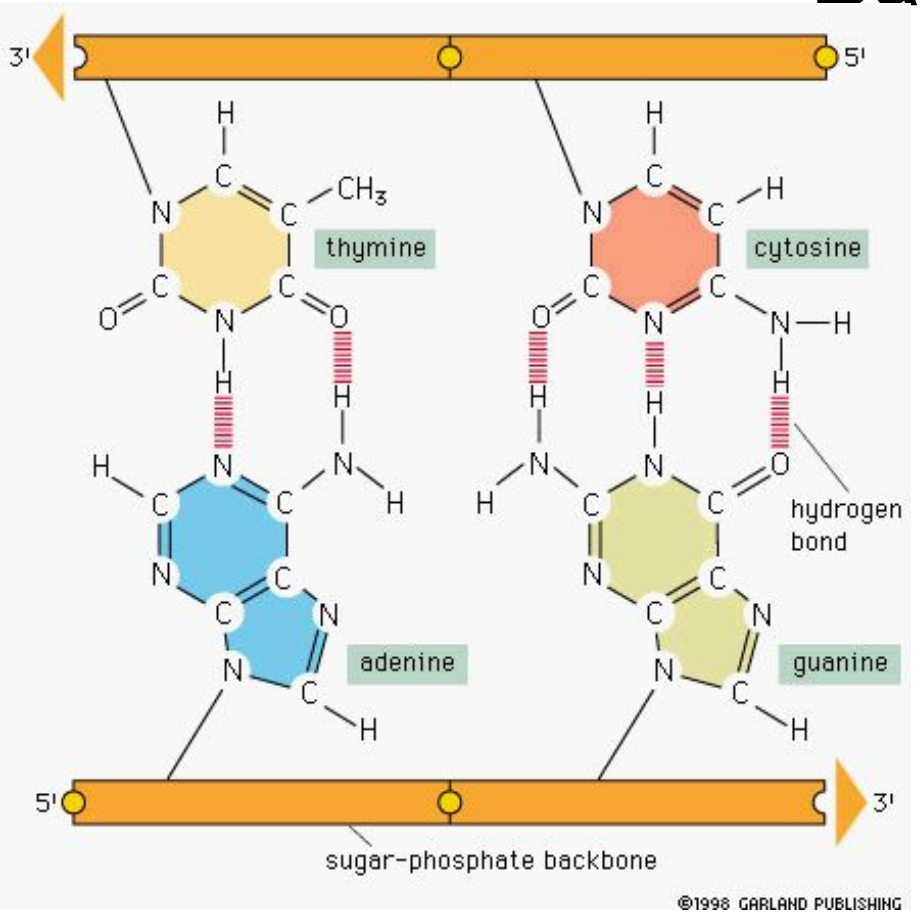
Furanose form of D-2-Deoxyribose

β-D-2-Deoxyribofuranose



β-N_9-glycosidic bond in purine ribonucleosides

Nucleic Acid Structure
"Base Pairing"



Purine always pairs with Pyrimidine

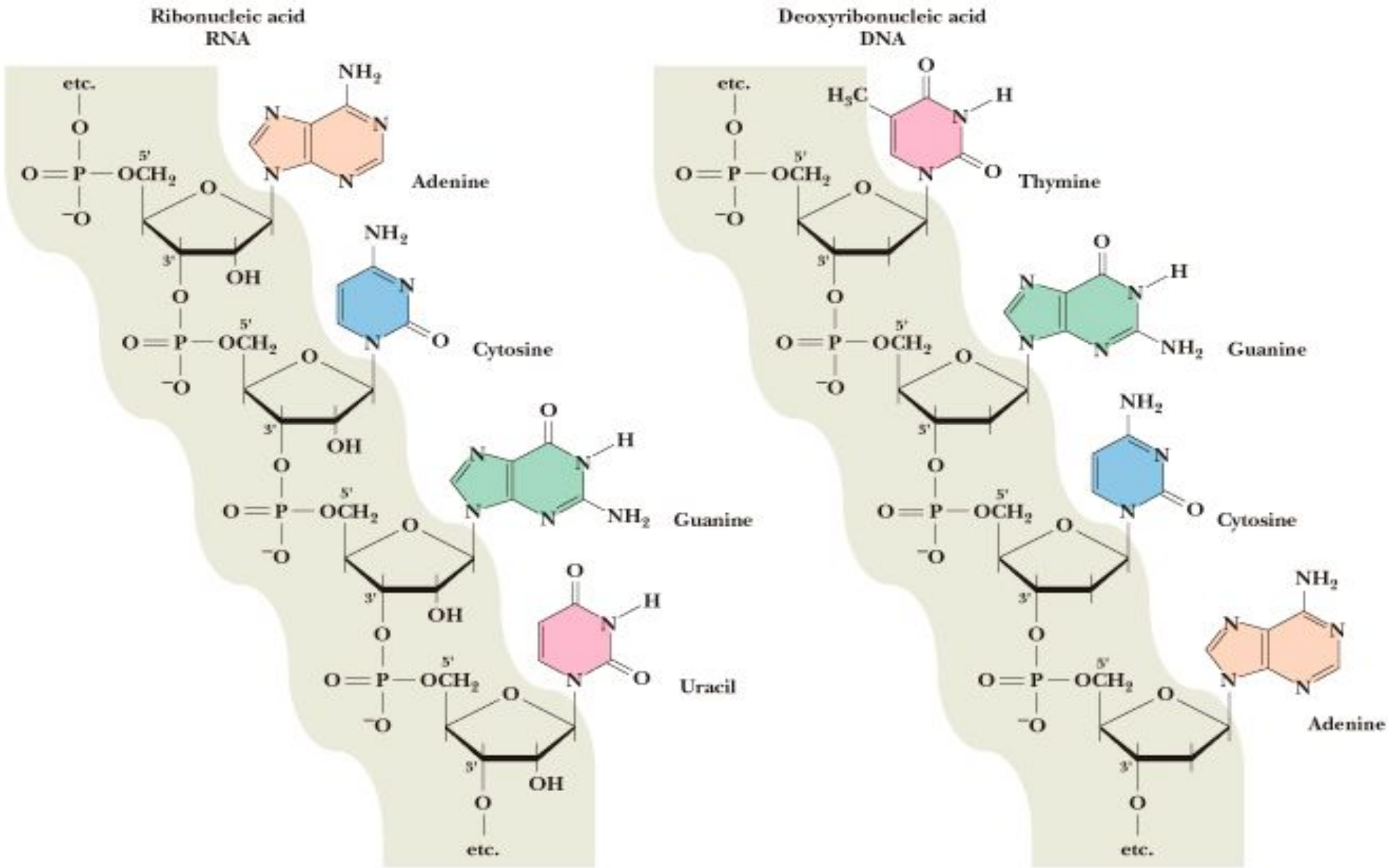
In a DNA

A is always paired with **T**

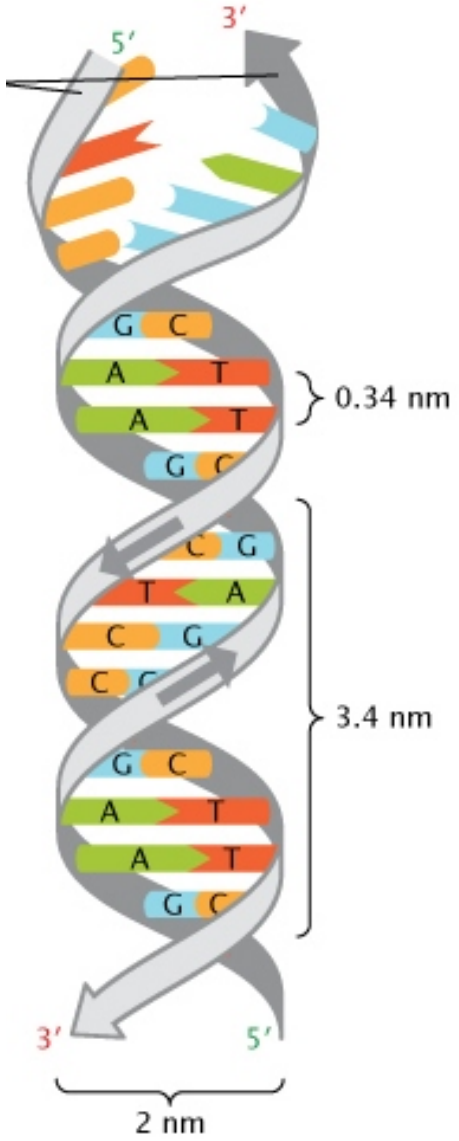
G is always paired with **C**

In an **RNA A** is paired with **U**

- The bases are joined by **hydrogen bonds**, individually weak but collectively strong.

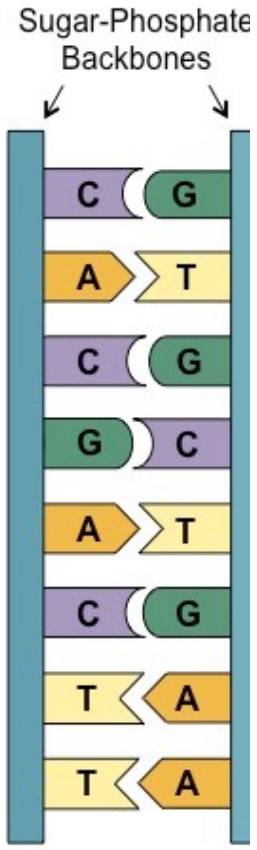

Ribonucleic acid
RNA
Adenine
Cytosine
Guanine
Uracil
Deoxyribonucleic acid
DNA
Thymine
Guanine
Cytosine
Adenine

Double heical structure of DNA



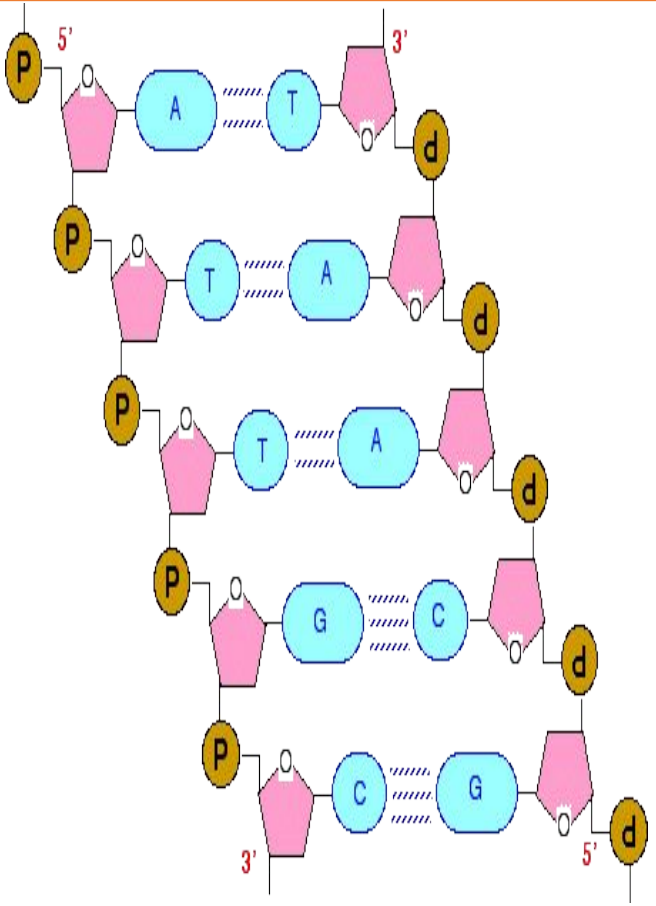
- The width(or diameter) of a double helix is 20 A ˚(2nm).
- Each turn (pitch)of the helix is 34A˚(3.4nm) with 10 pairs of nucleotides, each pair placed at a distance of about 3.4 A ˚ (0.34nm).

Salent features of double helical structure of DNA



DNA Ladder

- The two strands are antiparallel i.e., one strand runs in the 5’ to 3’direction while the other in 3’ to 5’ direction.
- The two polynucleotide chains are not identical but complementary to each other due to base pairing.
- Each strand of DNA has a hydrophillic deoxyribose phosphate backbone on the outside(periphery) The two strands are held together by hydrogen bonds formed by complementary base pairs. The A-T pair has 2 hydrogen bonds while the C-G pair has 3 hydrogen bonds. The G-C is stronger by about 50% than A-T.
- The hydrogen bonds are formed between a purine and pyrimidine only. The only base arrangement possible in DNA structure is A-T, T-A , G-C, C-G.
- The genetic information resides on one of the two strands known as template strand or sense strand. The opposite strand is antisense strand.

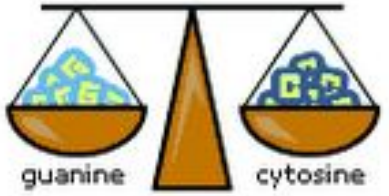


CHARGAFF'S RULE

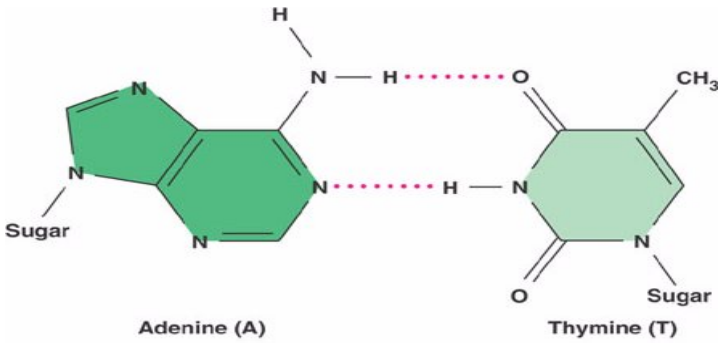
- Chargaff studied percentages of nitrogenous bases (1950)
- Percentage of guanine and cytosine are almost equal
- Percentages of adenine and thymine are almost equal
- Chargaff's Rule supports idea that Adenine (A) bonds to Thymine (T) and Cytosine (C) bonds to Guanine (G)

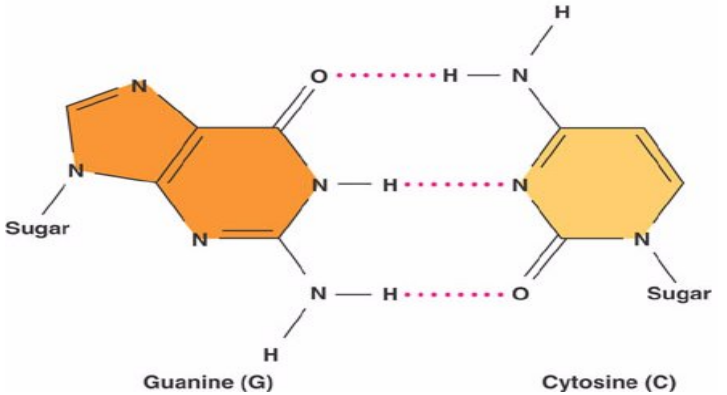
(%A + %T) + (%G + %C) = 100%

Adenine = Thymine



Guanine = Cytocine





DNA vs RNA

DNA

- Deoxy-Ribose sugar
- A = T
- More Stable
- Exists mostly as Double stranded
- Located in Nucleus, Mitochondria and Chloroplast

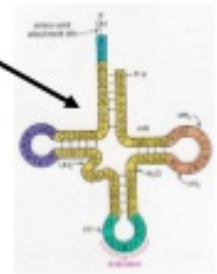
RNA

- Ribose Sugar
- A=U
- Less stable
- Exists Mostly as Single stranded
- Located throughout the cell

Types of RNA

mRNA	tRNA	rRNA
"messenger"	"transfer"	"ribosomal"
made using DNA	<u>transfers</u> an amino acid to the growing protein	makes up the bulk of ribosomes
carries genetic info from the nucleus to the ribosome	cloverleaf shape	
every 3 bases (codon) specifies an amino acid	3 complimentary bases (anticodon) binds to the mRNA codon	

Messenger RNA
Carries instructions for polypeptide synthesis from nucleus to ribosomes in the cytoplasm.



Ribosome

Ribosomal RNA
Forms an important part of both subunits of the ribosome.

Thank You