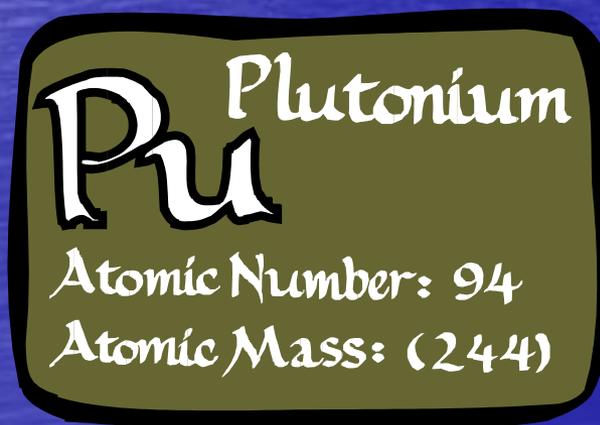
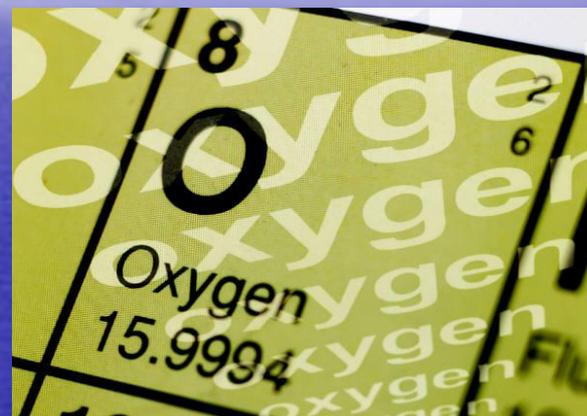


THE CHEMISTRY OF LIFE

Prof. Dr. Mohammed Qais
College of Science
University Of Anbar

ELEMENTS

- o An **element** is a substance that cannot be broken down into simpler chemical substances



C

Carbon

Atomic Number: 6
Atomic Mass: 12.01

H

Hydrogen

Atomic Number: 1
Atomic Mass: 1.00797

O

Oxygen

Atomic Number: 8
Atomic Mass: 16

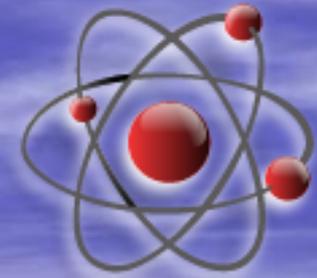
N

Nitrogen

Atomic Number: 7
Atomic Mass: 14.01

- The main components of a living cell are carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur
- CHNOPS

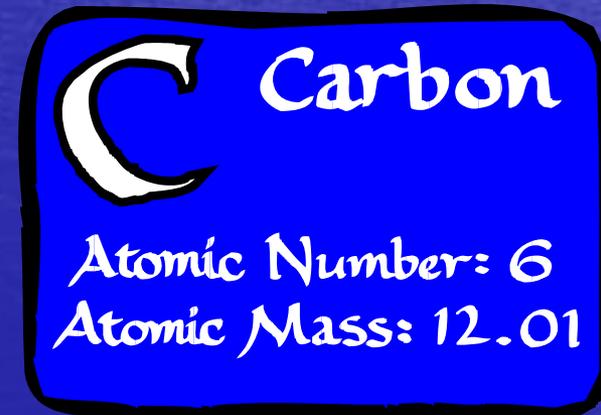
ATOM



- An **atom** is the smallest particle of an element that has the characteristics of that element
- Structure:
 - Nucleus – composed of **protons** (+) and **neutrons** (0)
 - Electron cloud – **electrons** (-)

ATOM

- Atomic number = # protons = # electrons
- Atomic mass = # protons + # neutrons
- To calculate # neutrons, subtract the # of protons from the mass number.



Example:

Carbon has atomic number 6, so it has 6 protons and 6 electrons. It has a mass number of 12 (round to the nearest whole number) so it has $12 - 6 = 6$ neutrons.

ISOTOPES

- **Isotopes** are atoms of the same element with different numbers of neutrons.

Example: carbon 12 and carbon 14

Carbon 12 has 6 neutrons while carbon 14 has 8 neutrons.

COMPOUND

- A **compound** is a substance that is composed of atoms of 2 or more different elements chemically combined.



CHEMICAL BONDS

- Covalent bonds – atoms **share electrons** to form a **molecule**. Ex: H_2O
- Ionic bonds – atoms form ions by **gaining or losing electrons**; ionic **compounds** are formed when ions of opposite charge bond together. Ex: NaCl

CHEMICAL REACTIONS IN AN ORGANISM

- **Metabolism** – all the chemical reactions that occur within an organism
- **Anabolism** – the reactions that build complex molecules from simpler ones
- **Catabolism** – the reactions that break down complex molecules into simpler ones

MIXTURES

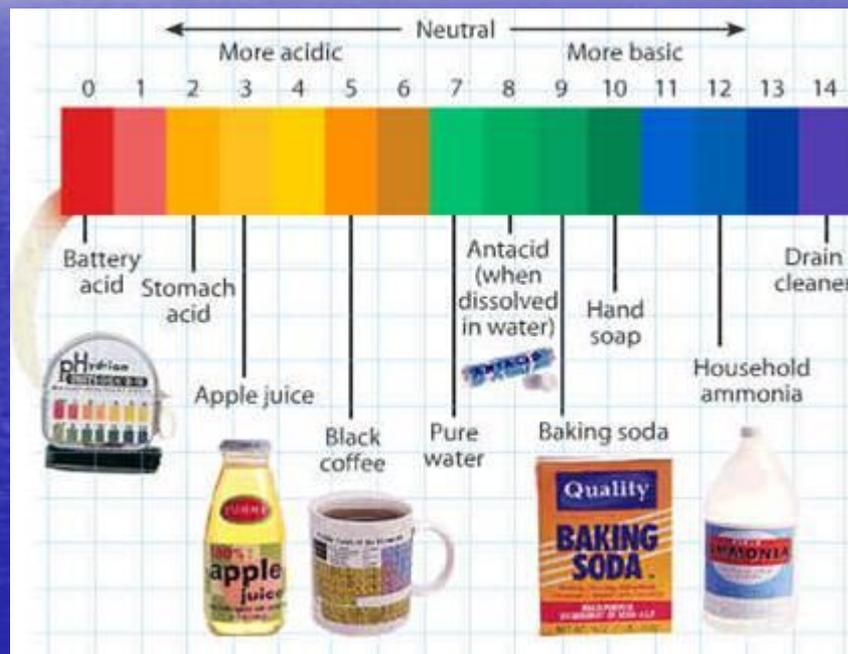
- A **mixture** is a combination of substances in which the individual components retain their own properties (physically combined, not chemically).
- A **solution** is a mixture in which one or more substances (solutes) are distributed evenly in another substance (solvent).
- A **suspension** is a mixture of nondissolved materials in water.

pH

- pH is a measure of how acidic or basic a substance is.
- The pH scale goes from 0 to 14.
- The pH of pure water is 7 or neutral.
- Substances added to water can lower or raise the pH.
- A pH below 7 is acidic.
- A pH above 7 is basic.

DEFINITIONS:

- **Acid** – any substance that form hydrogen ions (H^+) in water
- **Base** – any substance that form hydroxide ions (OH^-) in water



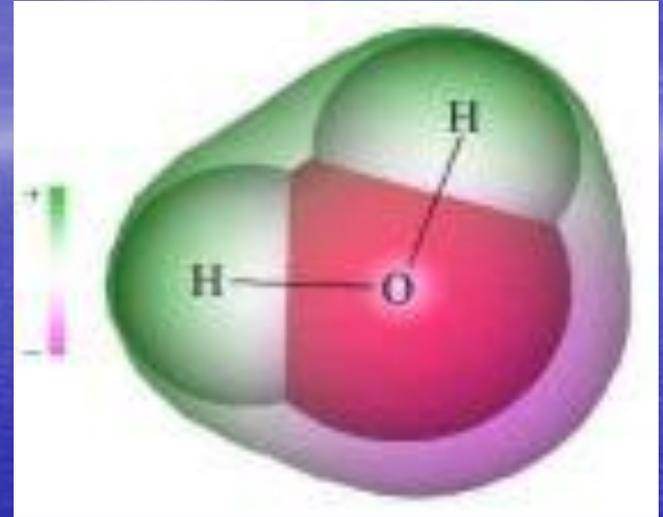
WATER

- Water makes up 70 to 95% of most organisms, therefore it is the most common compound found in most cells.



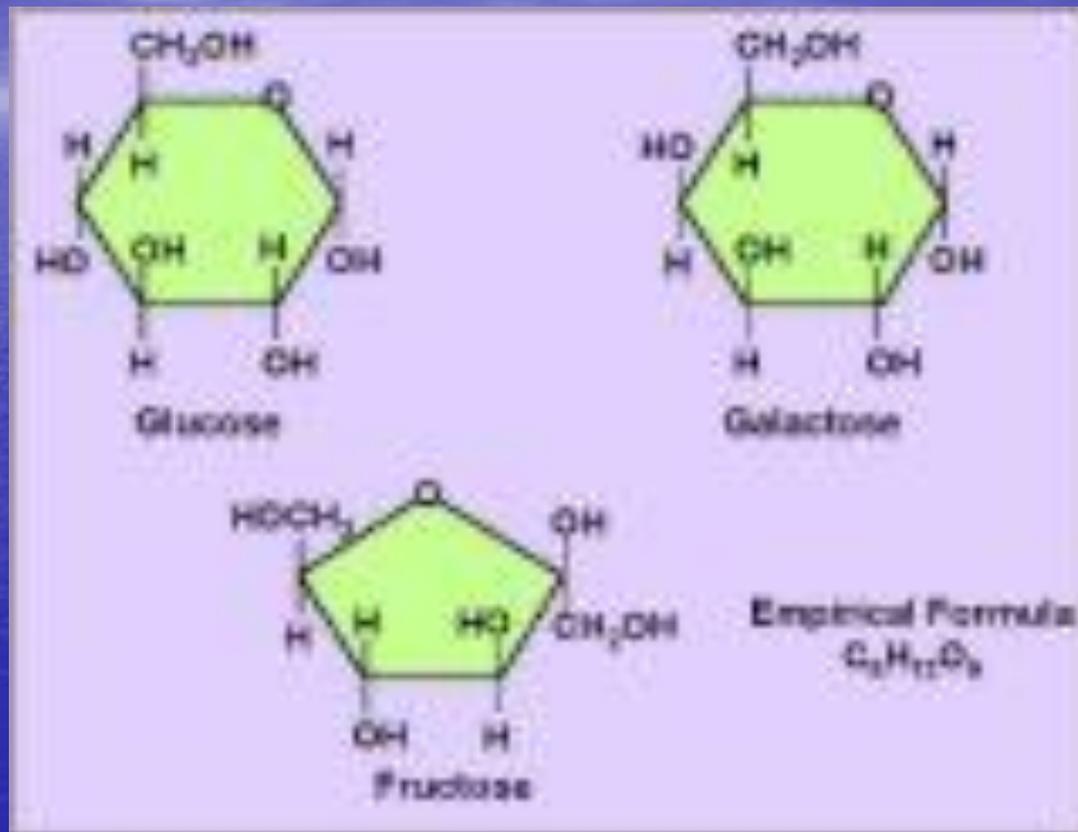
The water molecule is a polar molecule.

- A **polar molecule** has an uneven distribution of charge; it has a positive end and a negative end.
- Polar molecules form a weak bond when the positive end of one molecule is attracted to the negative end of another.
- This weak bond is called a **hydrogen bond**.



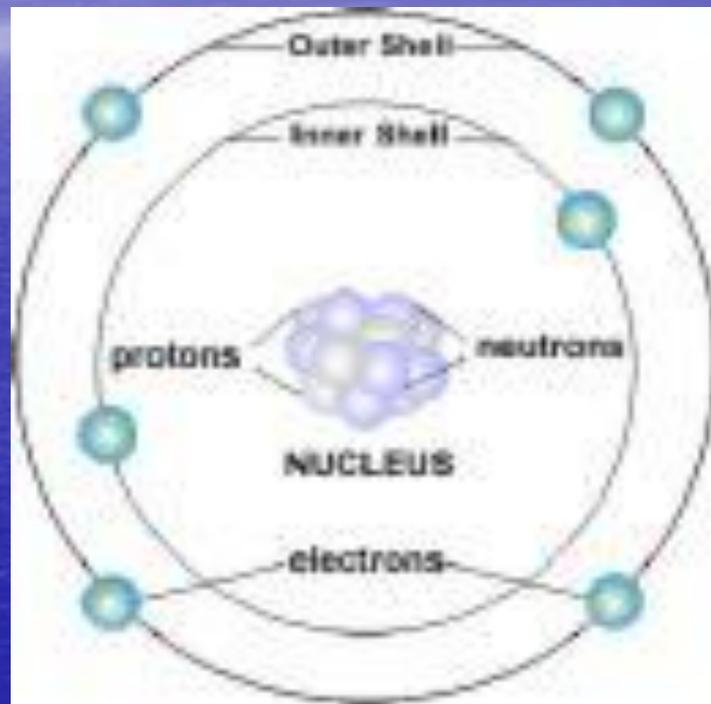
ORGANIC CHEMISTRY

- This is the study of organic compounds, those compounds containing carbon and made by living organisms.



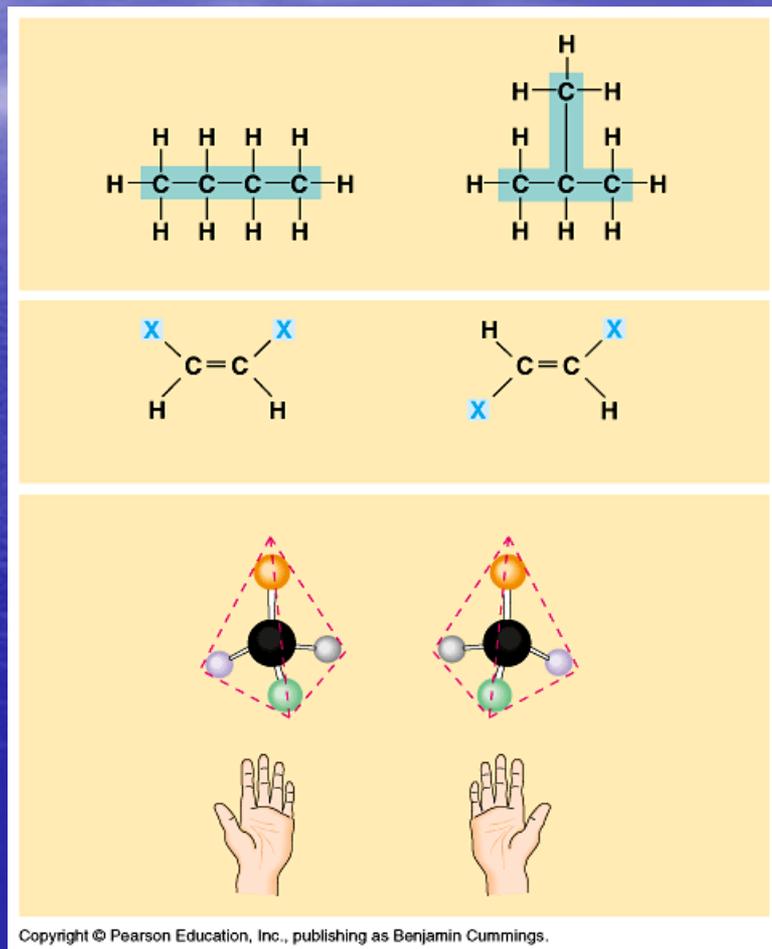
CARBON

- Has 4 electrons to share in its outer shell
- Can bond with up to 4 other atoms or compounds
- Can bond to other carbon atoms in chains and rings to form large complex molecules
- Can form single, double, or triple bonds (single bond – shares 1 electron, double – shares 2 electrons, etc.)



CARBON

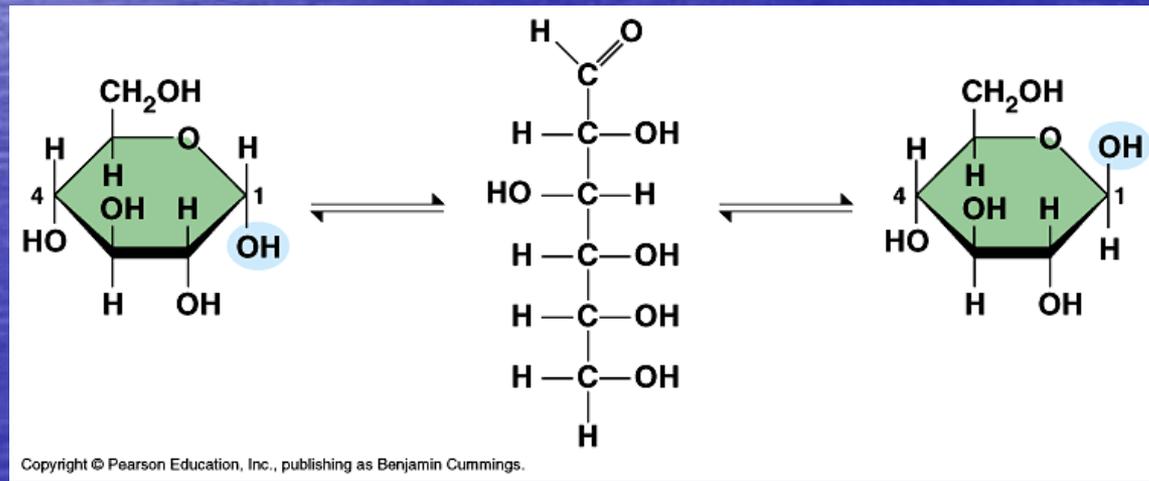
- Can form **isomers** — compounds with the same simple formula but different 3-D structures



- **Polymer** – a large molecule formed when many smaller molecules bond together. The smaller molecules are called **monomers**.
- **Polymerization** – process of building polymers
- **Condensation reaction** – reaction by which polymers are formed; also called **dehydration synthesis**
- **Hydrolysis** – reaction by which polymers are broken apart

The Macromolecules of life

- Cells can make a variety of **macromolecules** (large polymers) from a relatively small set of **monomers** (building blocks).



CARBOHYDRATES

- Used by cells to store and release **energy**
- Composed of C, H, and O with a ratio of 2H:1O
- Monomer (building block) is a **monosaccharide**, or simple sugar: examples are glucose and fructose
- A **disaccharide** is formed when two monosaccharides bond together; example sucrose = fructose + glucose

Carbs cont.

- The largest carbohydrates are the **polysaccharides** starch, glycogen, cellulose, and chitin
 - **Starch** – how plants store food they make
 - **Glycogen** – how animals store food reserves in the liver
 - **Cellulose** – structural material in plant cell walls; the fiber in the food you eat
 - **Chitin** – structural material in fungal cell walls; in the exoskeletons of arthropods

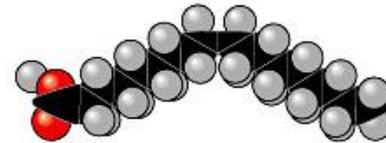
Lipids

- Commonly called **fats and oils**
- Are insoluble in water because the molecules are **nonpolar**
- Used for energy storage, insulation, and protective coverings; they are a major component in cell membranes
- Contain numerous C-H chains called fatty acids

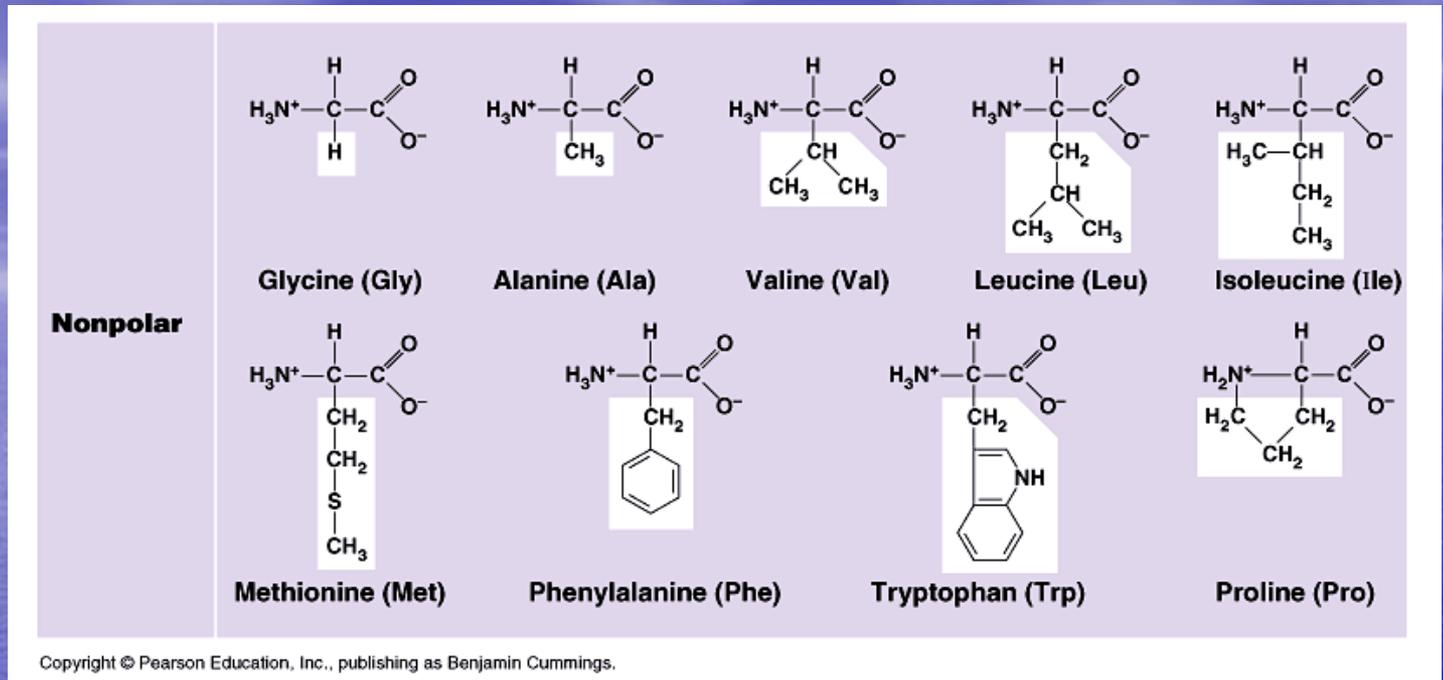


Lipids cont.

- **Saturated fats** contain only **single** bonds in the C-H chains; are solid at room temperature
- **Unsaturated fats** contain some **double** bonds in the C-H chains; are liquid at room temperature



Proteins

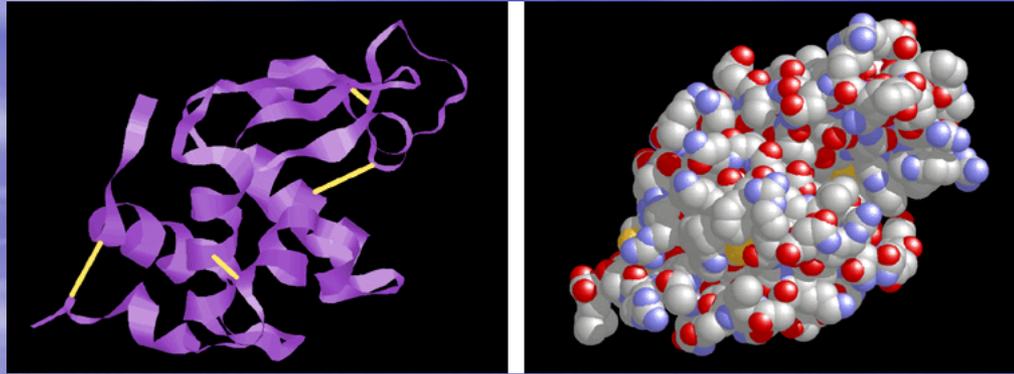


- Monomers are **amino acids**
- There are 20 amino acids composed of C, H, O, N, and S
- Proteins are formed by the bonding of amino acids; the bond is called a **peptide bond**

Functions of proteins:

- Structural – hair, nails
- Transport – hemoglobin
- Movement – muscle fibers and cytoskeletal elements
- Defense – antibodies
- Regulation of cell functions – hormones and enzymes



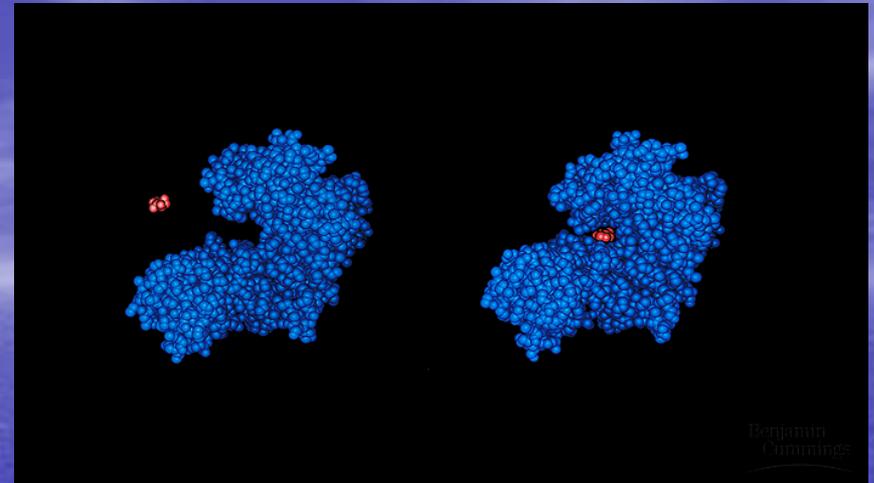


- A protein's function depends on its specific **conformation** (3-D structure); the sequence of amino acids and the shape of the chain are a consequence of attractions between the chain's parts.

Enzymes

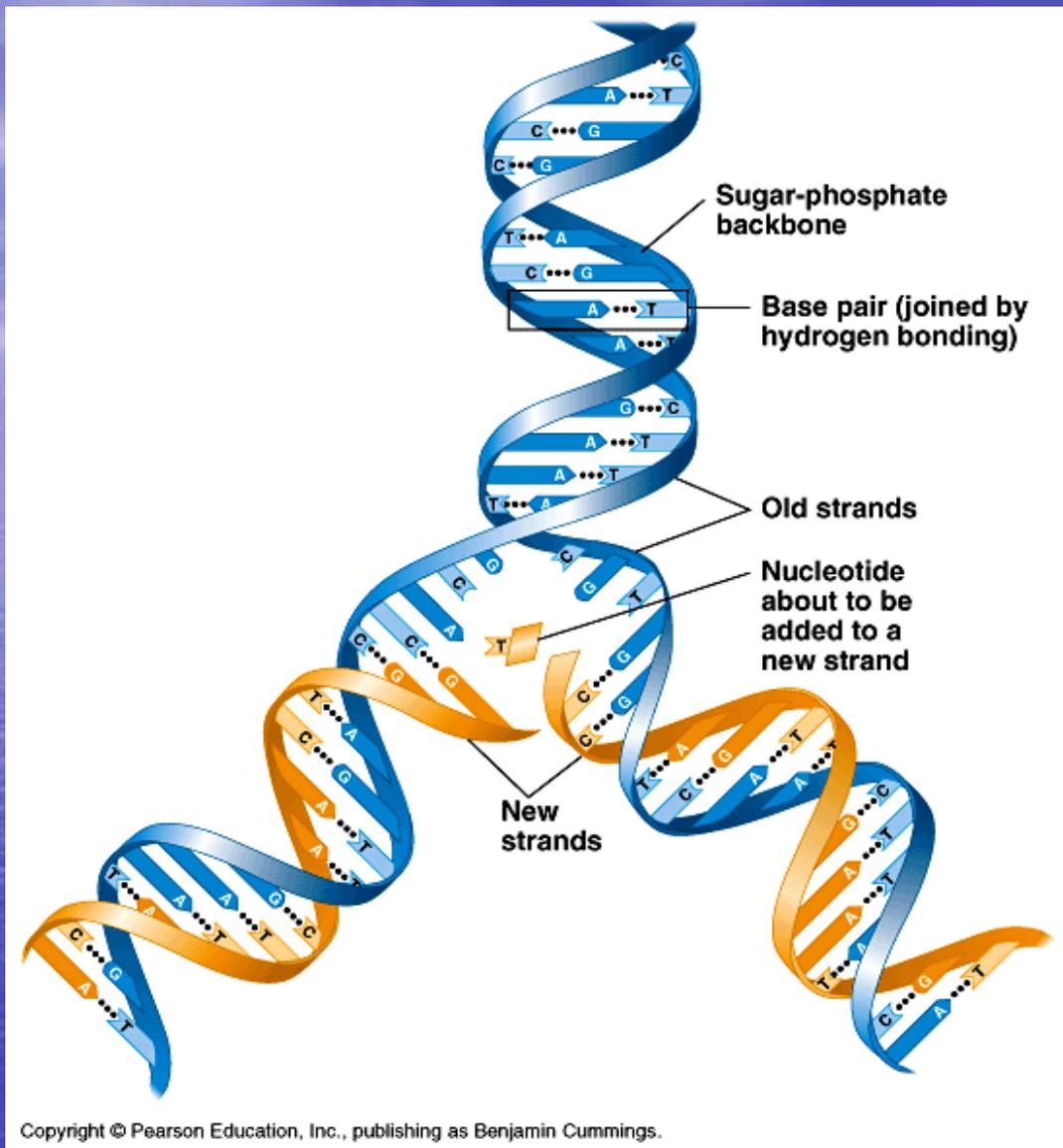
- Important **proteins**
- An enzyme is a **biological catalyst**
- It speeds up reactions by lowering **activation energy** needed to start the reaction
- The enzyme causes a chemical reaction to occur without being changed itself
- Each enzyme has a definite 3-D shape that allows it to recognize and bind with its **substrate** (substrate = reactant)

- The **active site** is the place where the substrate binds and the action occurs
- Most cells function best within a narrow range of temperature and pH; at very high temperature or extremes of pH, the 3-D structure of the protein changes and its function is altered



Nucleic Acids

- **DNA** and **RNA**
- Function – control cell activities by directing protein synthesis
- Monomers are **nucleotides** which are made up of a nitrogenous base, a sugar, and a phosphate group
- DNA – **deoxyribonucleic acid** is the master genetic code
- RNA – **ribonucleic acid** functions to make copies of DNA



DNA replicating, or the making of a new copy

The Human Body

Oxygen - 65%

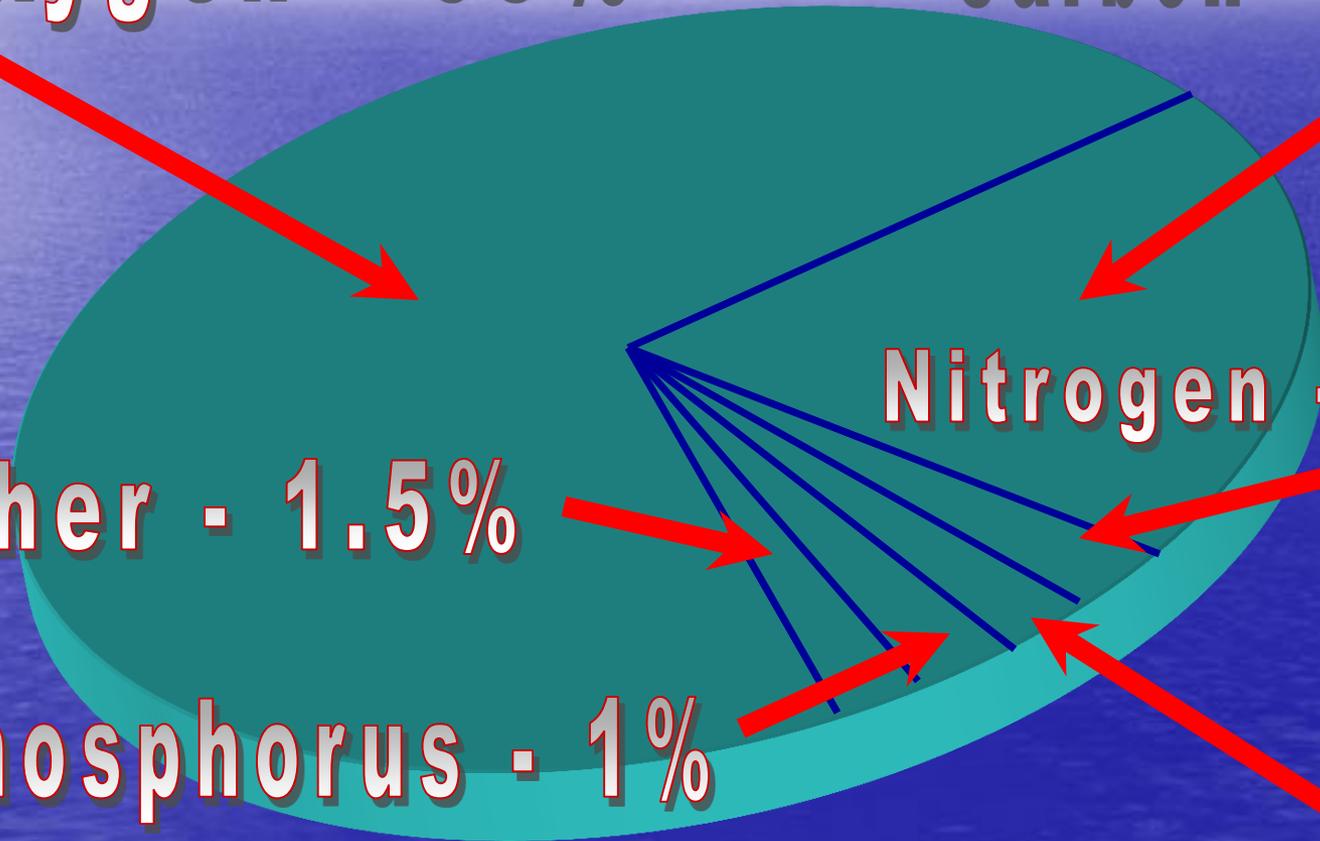
Carbon - 18.5

Other - 1.5%

Nitrogen - 3%

Phosphorus - 1%

Calcium - 1.5%



Nucleic Acids

- Store INFORMATION that controls CELL activities
- Made of a PHOSPHATE a SUGAR, and a BASE.

Examples of Nucleic Acids are:

- **DNA** :
 - Deoxyribonucleic Acid
- The master copy of an organisms information code.
- Instructions to form all of an organisms structural proteins

Examples of Nucleic Acids are:

- **RNA** :
 - Ribonucleic Acid
- This forms a copy of the DNA for use in making protein.

Two types of nucleic acid are found

- Deoxyribonucleic acid (DNA)
- Ribonucleic acid (RNA)

The distribution of nucleic acids in the eukaryotic cell

- DNA is found in the nucleus
with small amounts in mitochondria and chloroplasts
- RNA is found throughout the cell

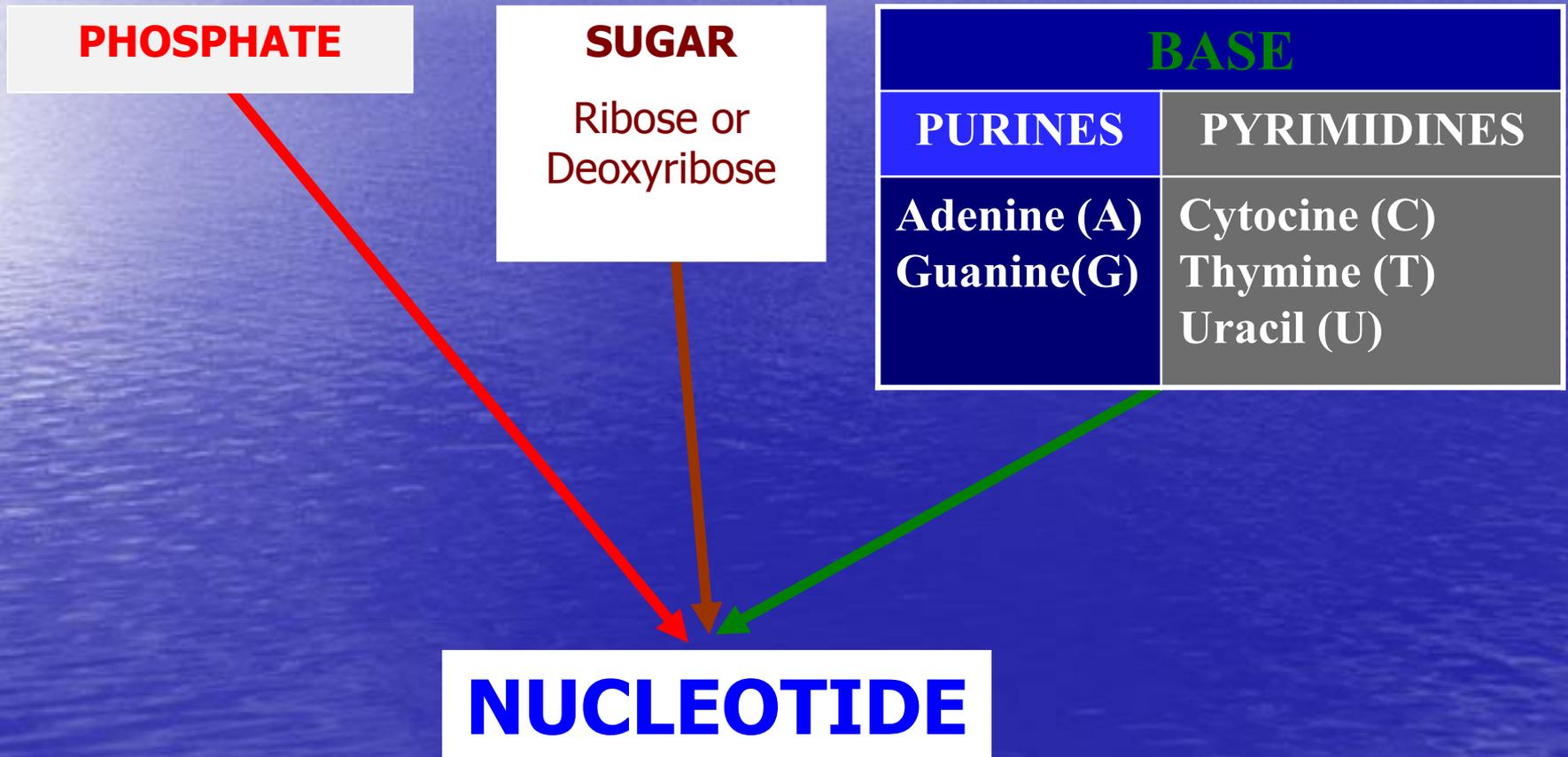
DNA as genetic material: The circumstantial evidence

1. Present in all cells and virtually restricted to the nucleus
2. The amount of DNA in somatic cells (body cells) of any given species is constant (like the number of chromosomes)
3. The DNA content of gametes (sex cells) is half that of somatic cells.
In cases of polyploidy (multiple sets of chromosomes) the DNA content increases by a proportional factor
4. The mutagenic effect of UV light peaks at 253.7nm.
The peak for the absorption of UV light by DNA

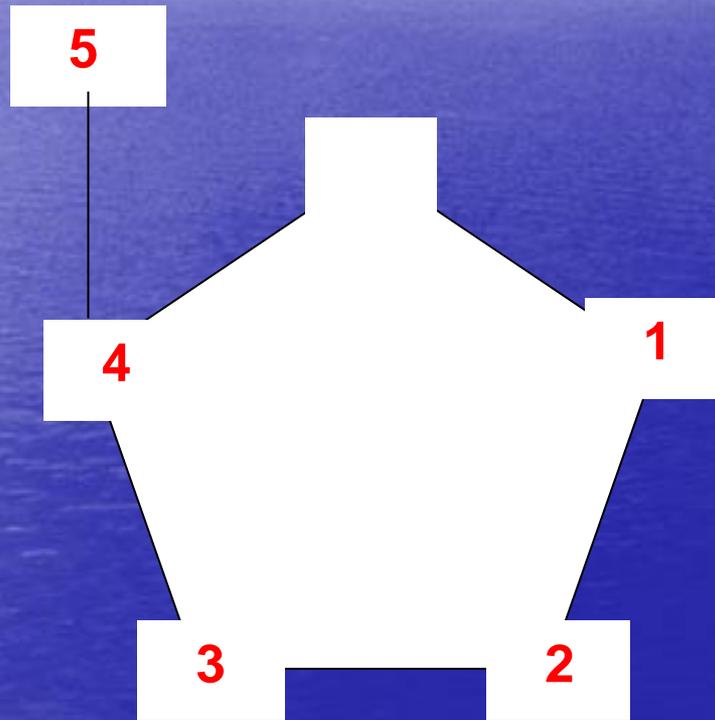
NUCLEIC ACID STRUCTURE

- Nucleic acids are **polynucleotides**
- Their building blocks are **nucleotides**

NUCLEOTIDE STRUCTURE

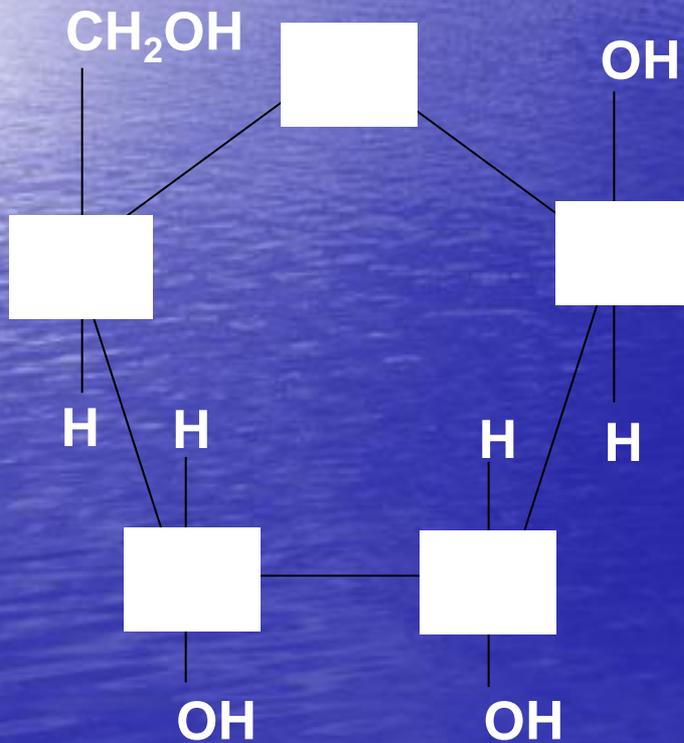


Ribose is a pentose

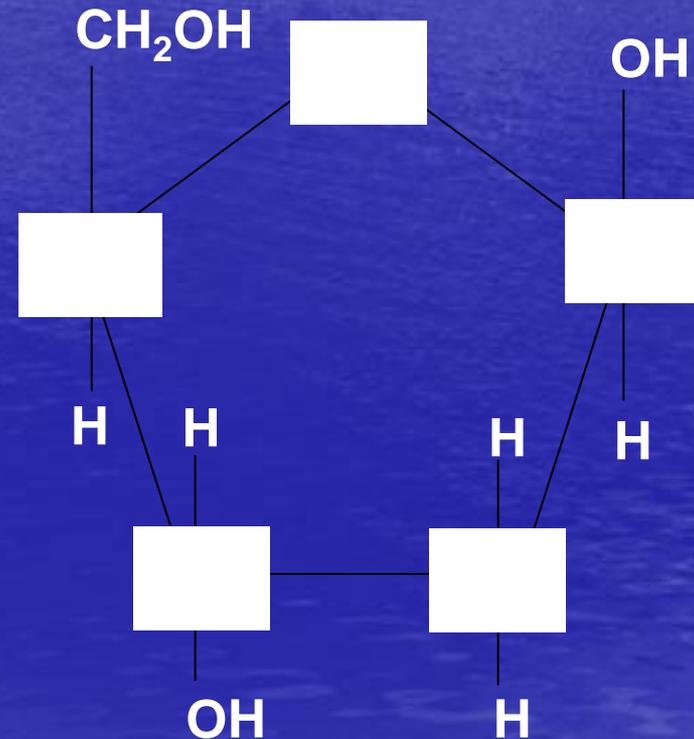


Spot the difference

RIBOSE

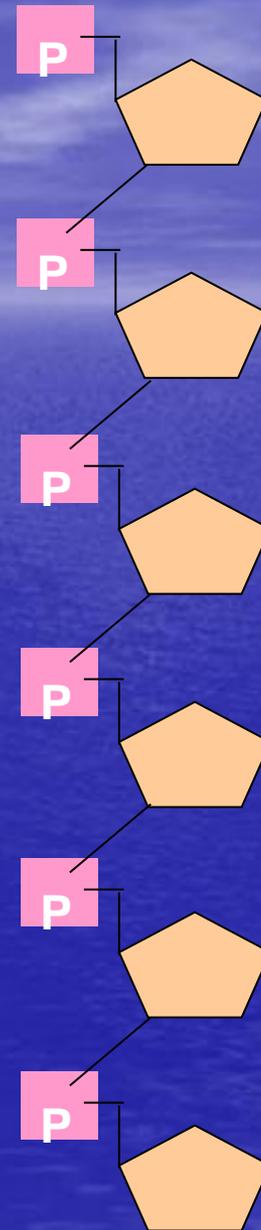


DEOXYRIBOSE



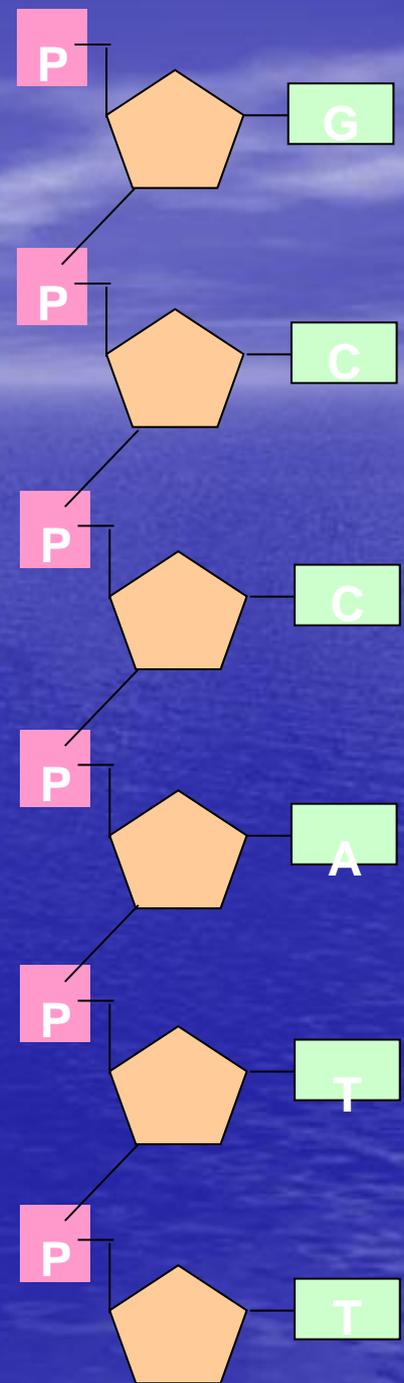
THE SUGAR-PHOSPHATE BACKBONE

- The nucleotides are all orientated in the same direction
- The phosphate group joins the 3rd Carbon of one sugar to the 5th Carbon of the next in line.

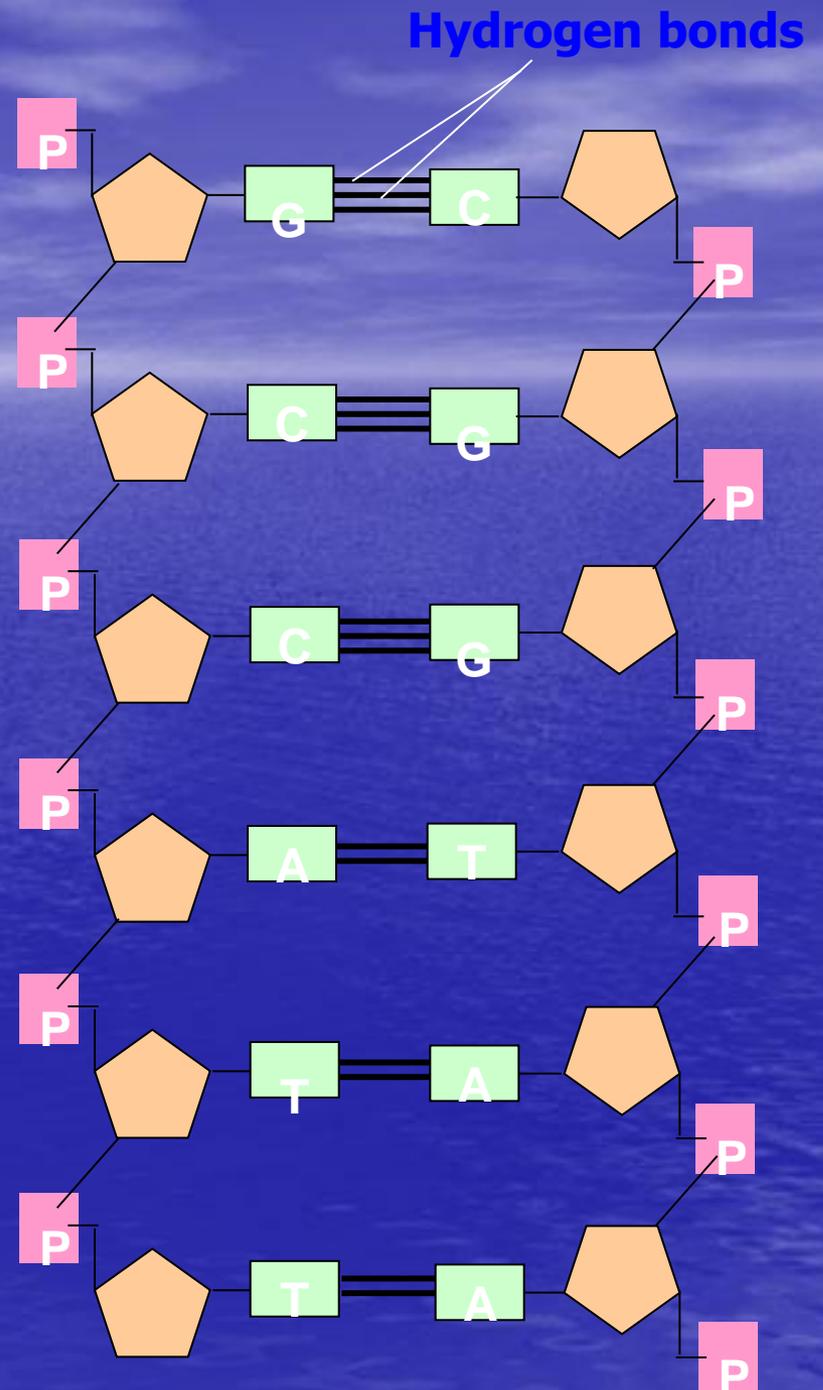


ADDING IN THE BASES

- The bases are attached to the 1st Carbon
- Their order is important
It determines the genetic information of the molecule



DNA IS MADE OF TWO STRANDS OF POLYNUCLEOTIDE



DNA IS MADE OF TWO STRANDS OF POLYNUCLEOTIDE

- The sister strands of the DNA molecule run in opposite directions (**antiparallel**)
- They are joined by the bases
- Each base is paired with a specific partner:

A is always paired with **T**

G is always paired with **C**

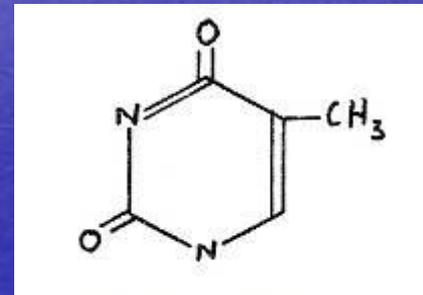
Purine with Pyrimidine

- Thus the sister strands are **complementary** but **not** identical
- The bases are joined by **hydrogen bonds**, individually weak but collectively strong.

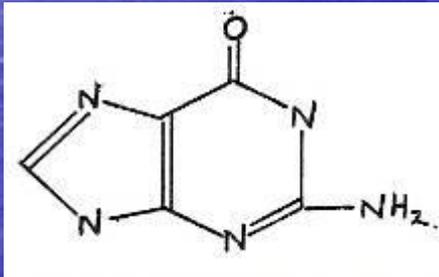
Purines & Pyrimidines



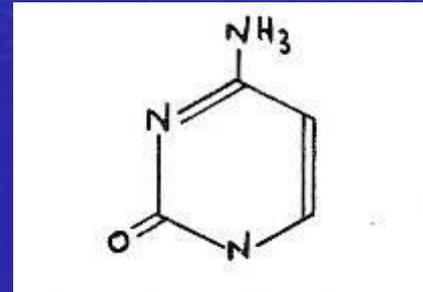
Adenine



Thymine

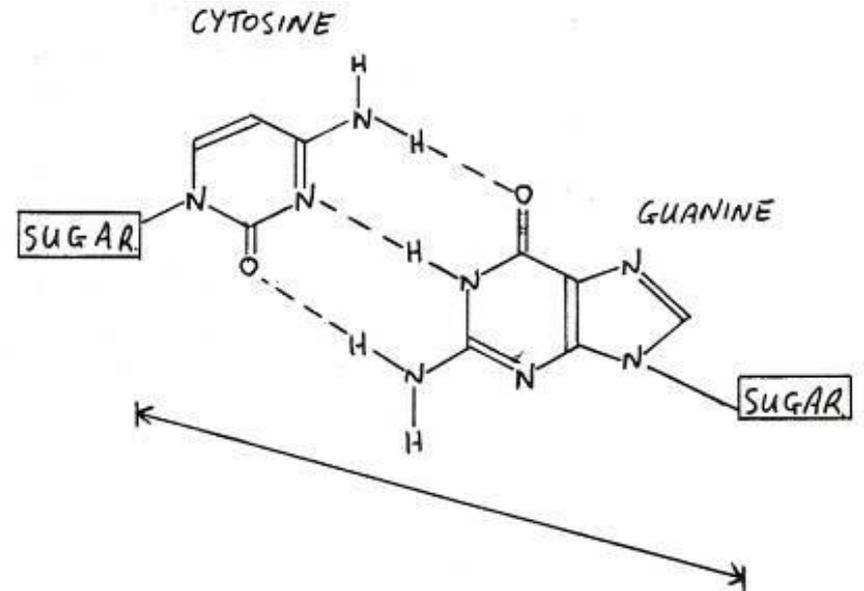
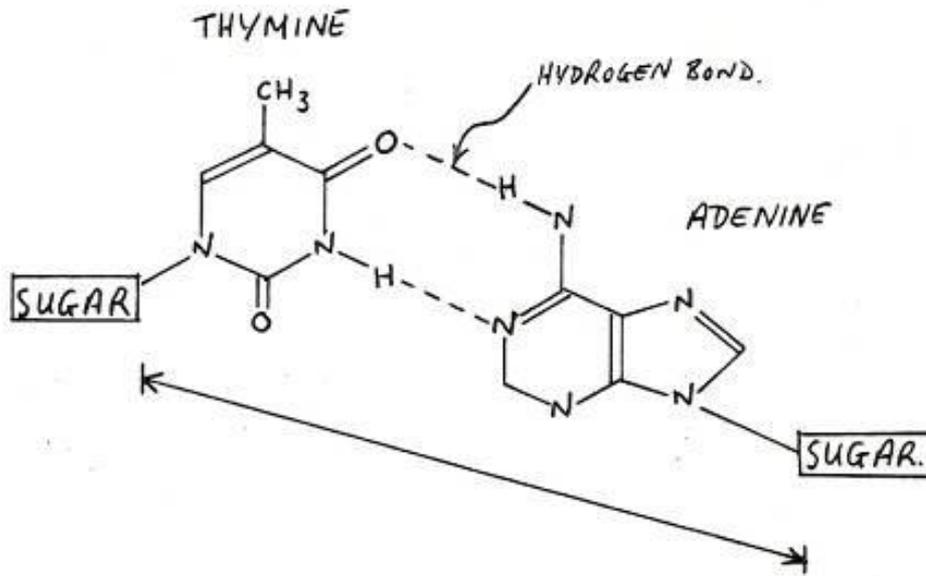


Guanine

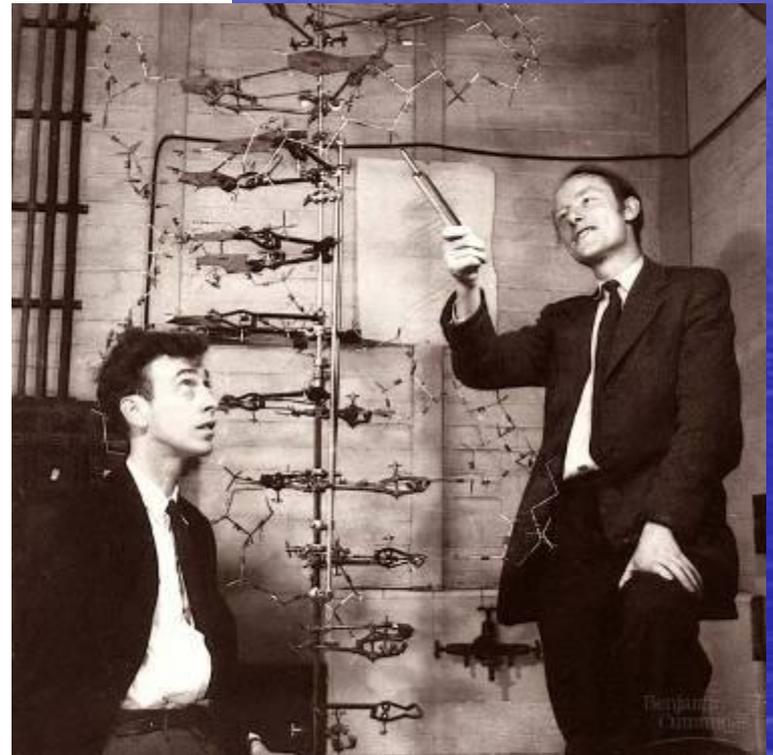
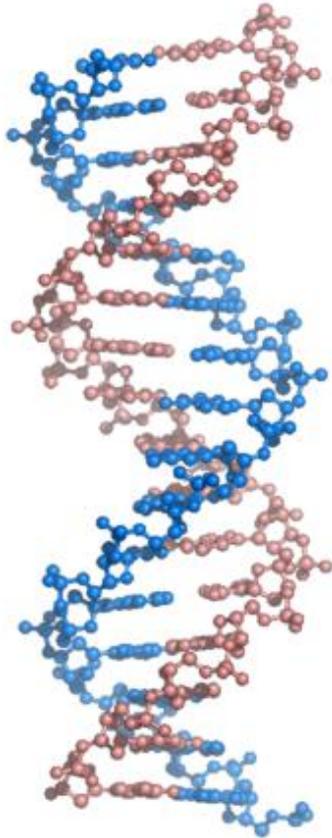


Cytosine

Watson & Crick Base pairing



The Double Helix (1953)



10.1 Discovery of DNA

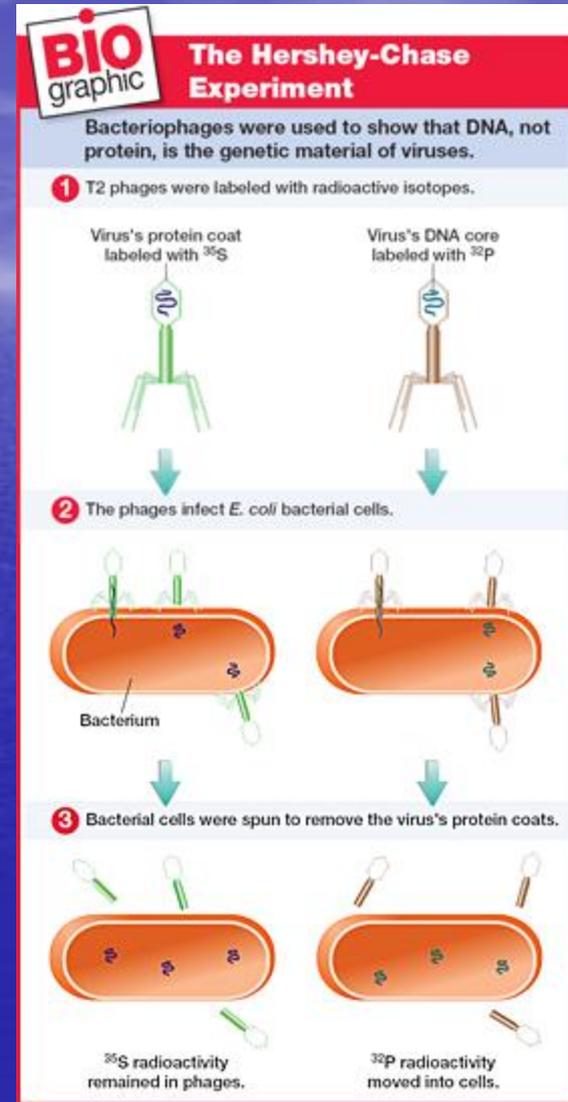
- Griffith's Experiments (1928)
- Griffith's experiments showed that hereditary material can pass from one bacterial cell to another.
- The transfer of genetic material to one cell from another cell or from one organism to another organism is called transformation.

Avery's Experiments (1940's)

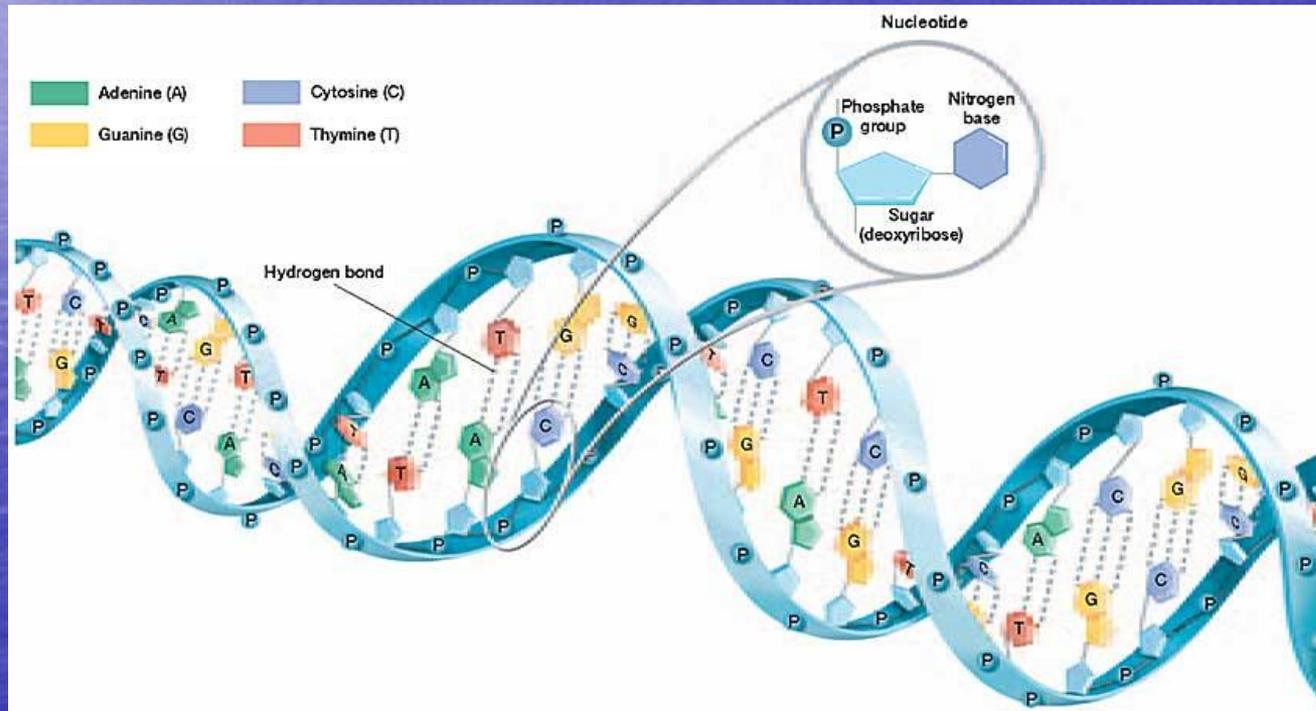
- Avery's work showed that DNA was the heredity material that transfers information between bacterial cells.

Hershey-Chase Experiment

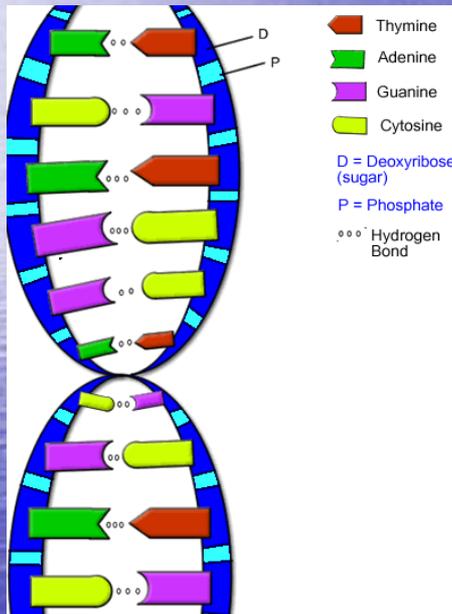
- Hershey and Chase confirmed that DNA, and not protein, is the hereditary material.



Structure of DNA



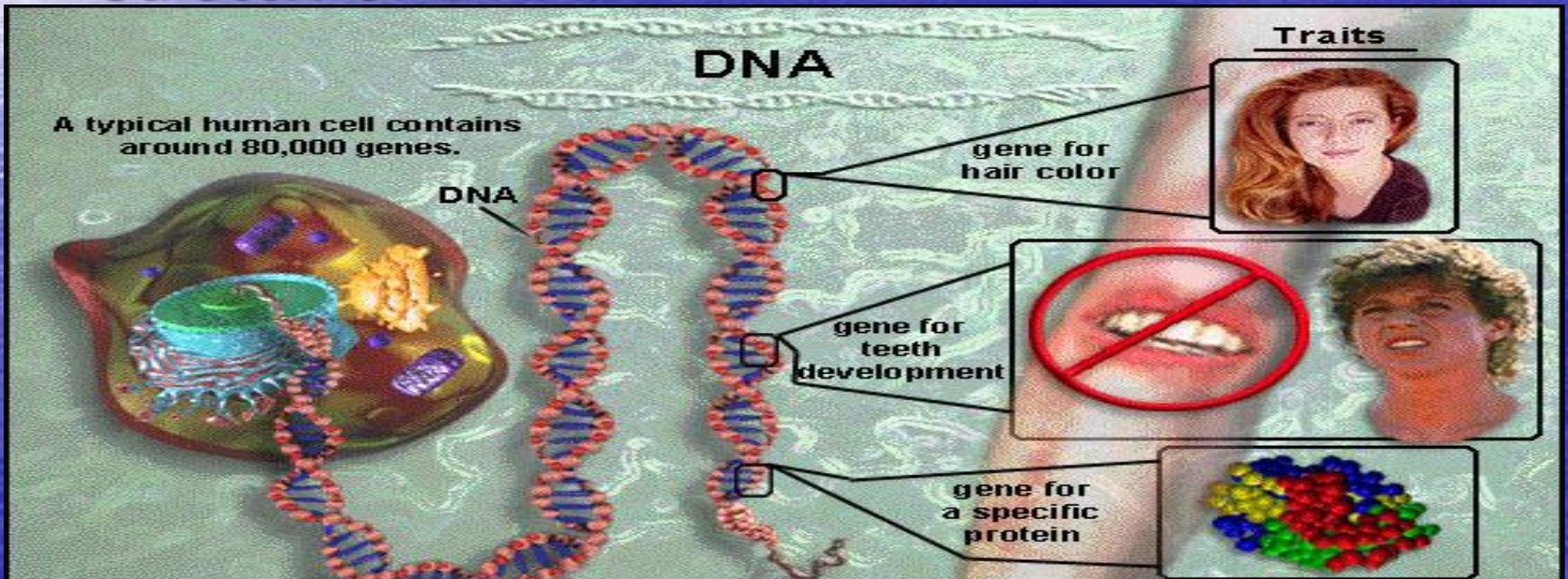
DNA – The Blueprint of Life



- Established by James Watson and Francis Crick (1950's)
- DNA contains the instructions for making proteins within the cell.
- Shape of a double helix
- Made up of repeating sub-units called nucleotides

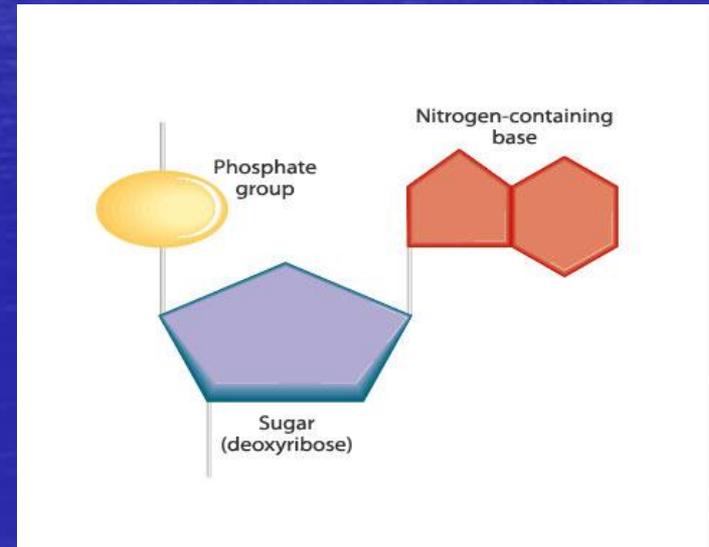
DNA codes for genes

- Gene - A segment of DNA that codes for a protein, which in turn codes for a trait (skin tone, eye color...etc.), a gene is a stretch of DNA.

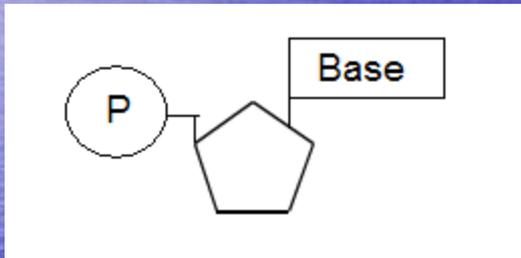


Deoxyribonucleic acid - DNA

- Monomer:
nucleotides
- Each nucleotides
has:
 1. Deoxyribose sugar
 2. Phosphate group
 3. (1 of 4) nitrogen
containing base



The 4 Bases in DNA are:



Thymine (T)

Cytosine (C)

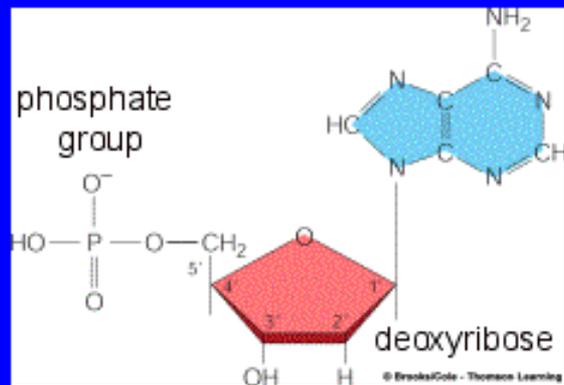
Guanine (G)

Adenine (A)

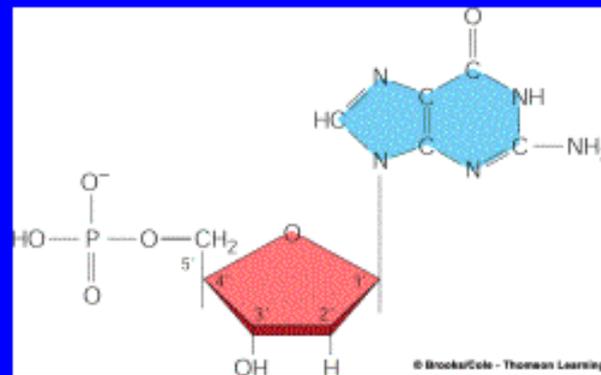
Nitrogen Rings

- **Purines** have double rings of carbon-nitrogen (G, A)
- **Pyrimidines** have single carbon-nitrogen rings (C, T)

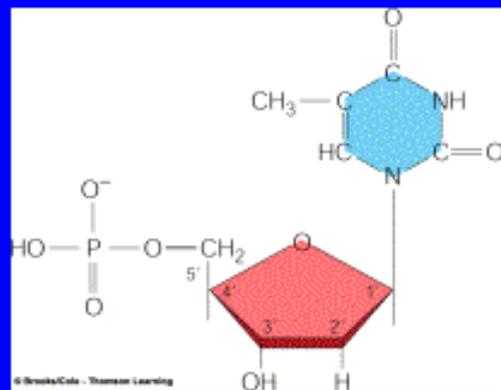
Nucleotide Bases



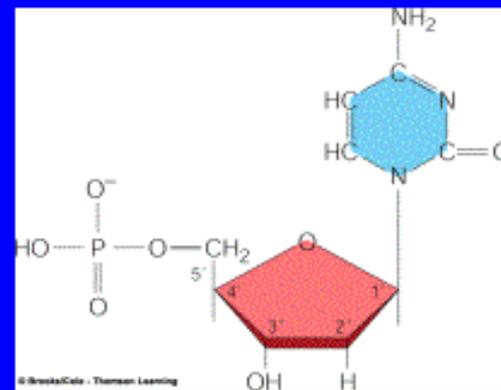
**ADENINE
(A)**



**GUANINE
(G)**



**THYMINE
(T)**

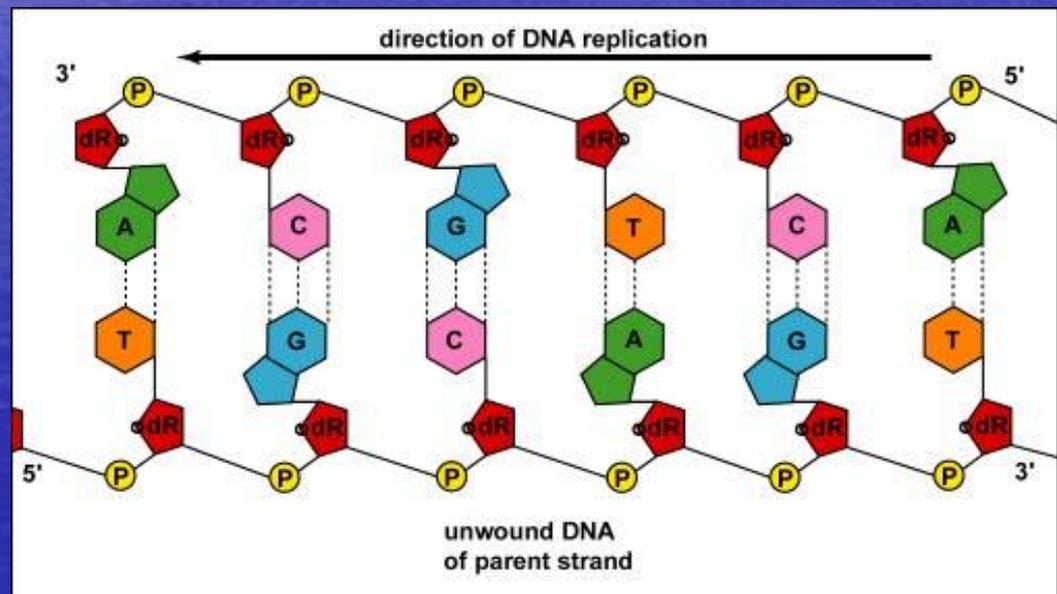


**CYTOSINE
(C)**

Complementary Base Pairing

- Base Pairing Rules

1. C and G
2. T and A

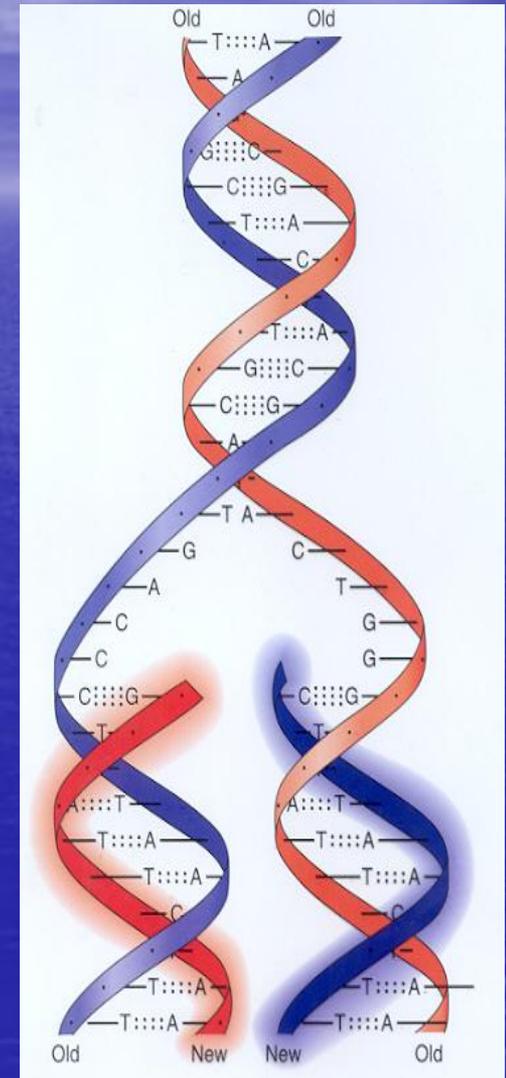


Hydrogen Bonds

- How do the nitrogenous bases stick together?
- Hydrogen bonds
- 3 H bonds hold G & C together
- 2 H bonds hold T & A together

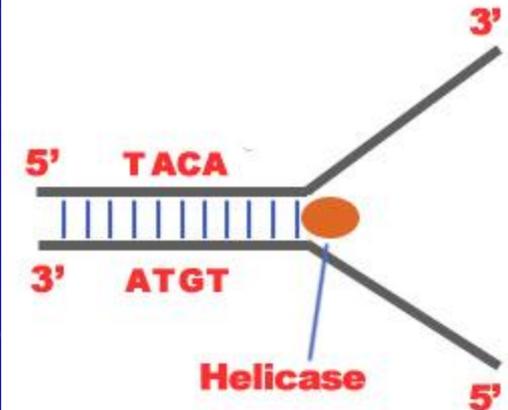
DNA Replication

- Occurs when chromosomes duplicate before mitosis & meiosis
- Makes an exact copy of the DNA
- H bonds between bases break and enzymes “unzip” the molecule

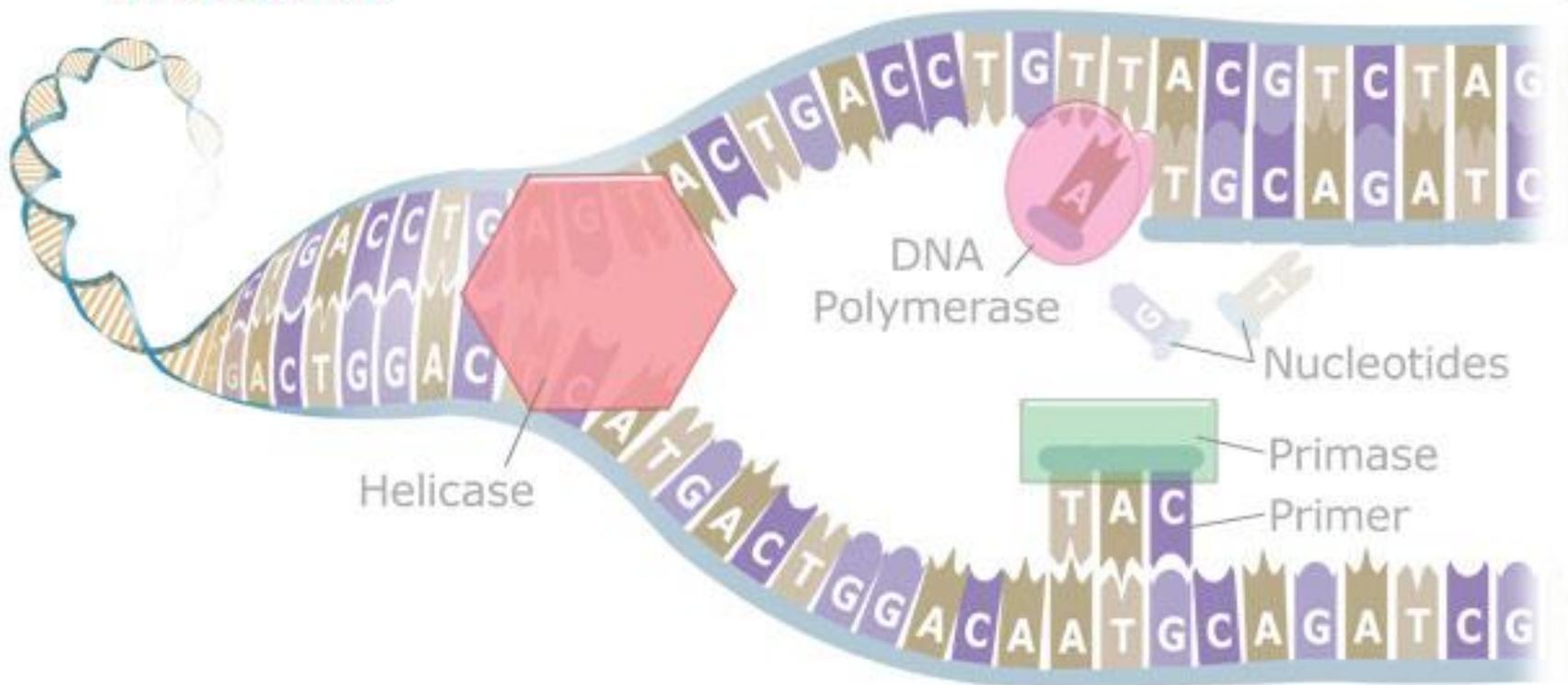


Steps of DNA Replication (pg. 201)

- 1) Enzymes called **helicases** separate the DNA strand breaking the H bonds at the **replication fork**
- 2) Enzymes called **DNA polymerase** add complementary nucleotides
- 3) DNA polymerase falls off when done replicating and the result is identical strand of DNA

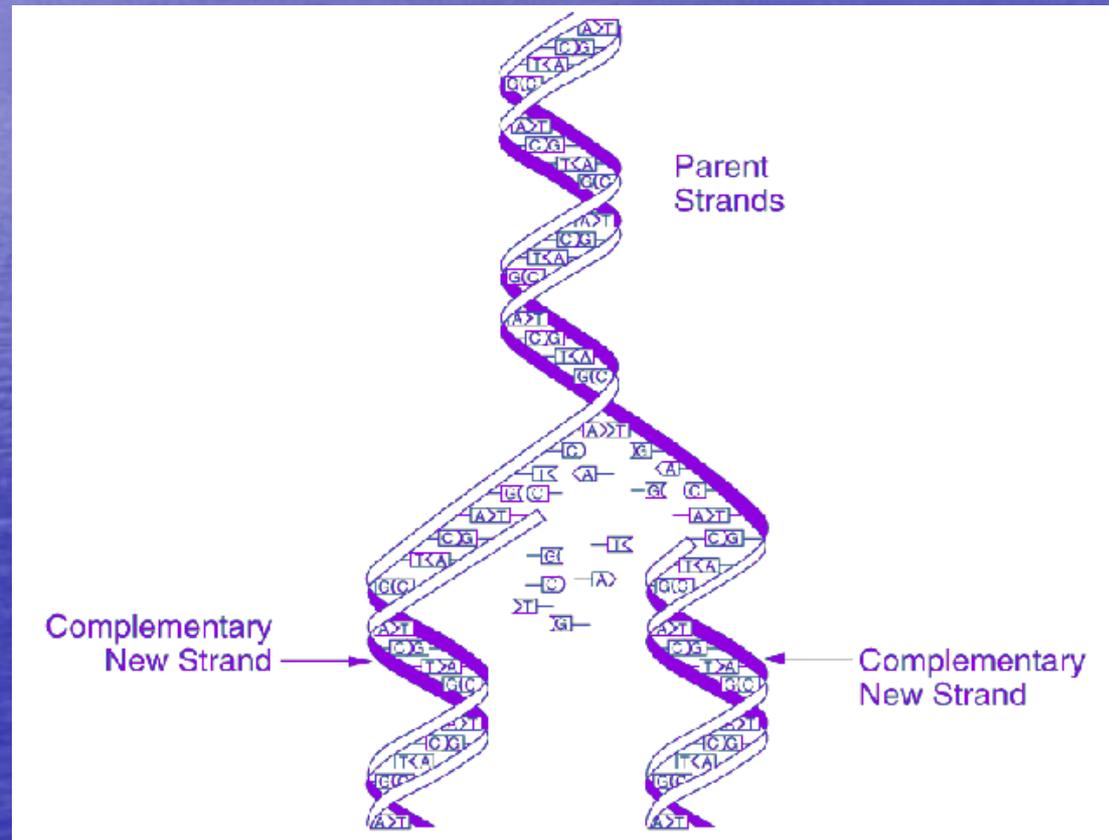


DNA Replication



Semi-conservative replication-

Each old strand of nucleotides serves as a template for each new strand.



Protein Synthesis

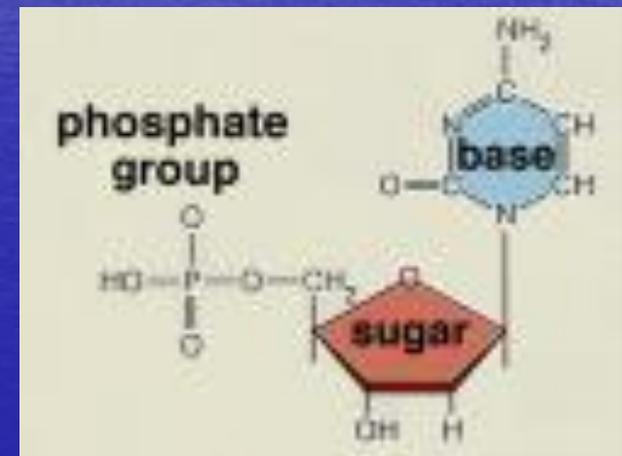
The Central Dogma: the flow of genetic information from DNA to RNA to Protein

Protein Synthesis

- 2 Parts
 1. **Transcription** – makes a RNA molecule complementary to a portion of DNA.
 2. **Translation** – occurs when the sequences of bases of mRNA directs the sequence of amino acids in a polypeptide.

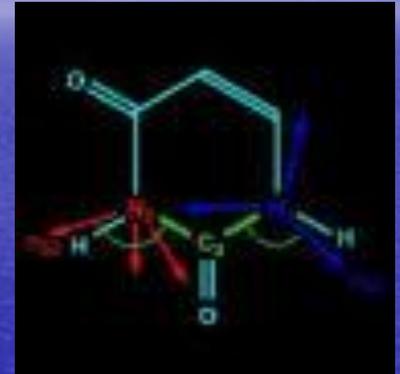
RNA

- Ribonucleic Acid
- 2nd type of nucleic acid
- Monomer = nucleotide
 1. Ribose sugar
 2. 1 of 4 N bases
 3. Phosphate group



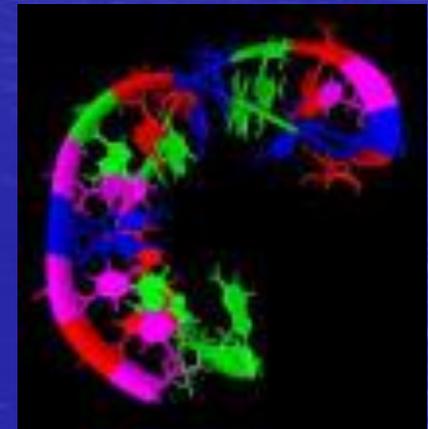
N-bases:

- A, G, C, & U
 - Uracil replaces Thymine
- Base pairing rules: A-U, G-C
- **Purpose:** to transfer genetic material from DNA (inside the nucleus) to the site of protein synthesis (in the cytoplasm)



How does RNA differ from DNA?

1. Different sugars (deoxyribose vs. ribose)
2. Different N-bases (thymine vs. uracil)
3. Different shapes (double helix vs. single strand)



Types of RNA:

1. Messenger RNA (mRNA):

- Carries genetic info from the nucleus to the cytoplasm

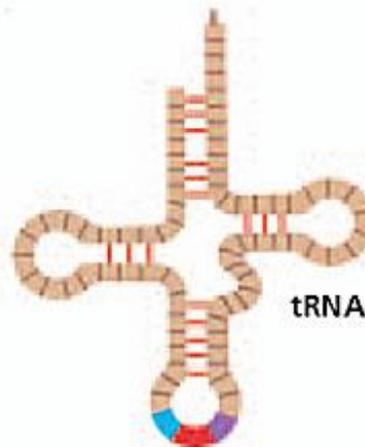
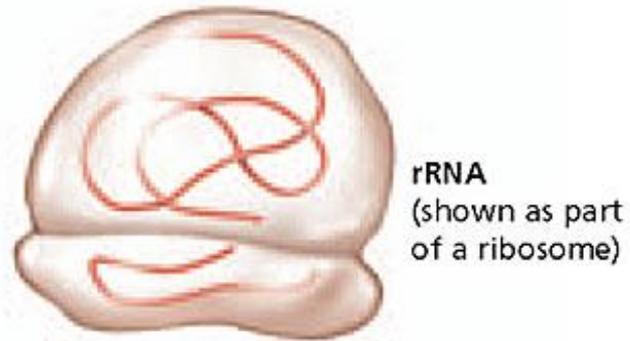
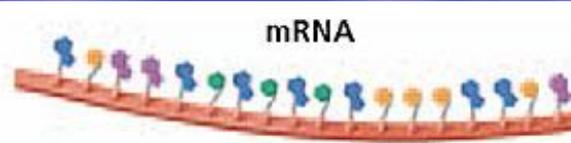
2. Transfer RNA (tRNA):

- Carries specific amino acids to the ribosome to build the protein

3. Ribosomal RNA (rRNA):

- Major component of the ribosome organelle
- Site of protein synthesis
- Most abundant type of RNA

3 Types of RNA



How is RNA made?

- **Transcription**

- The process by which RNA is copied from DNA in the nucleus

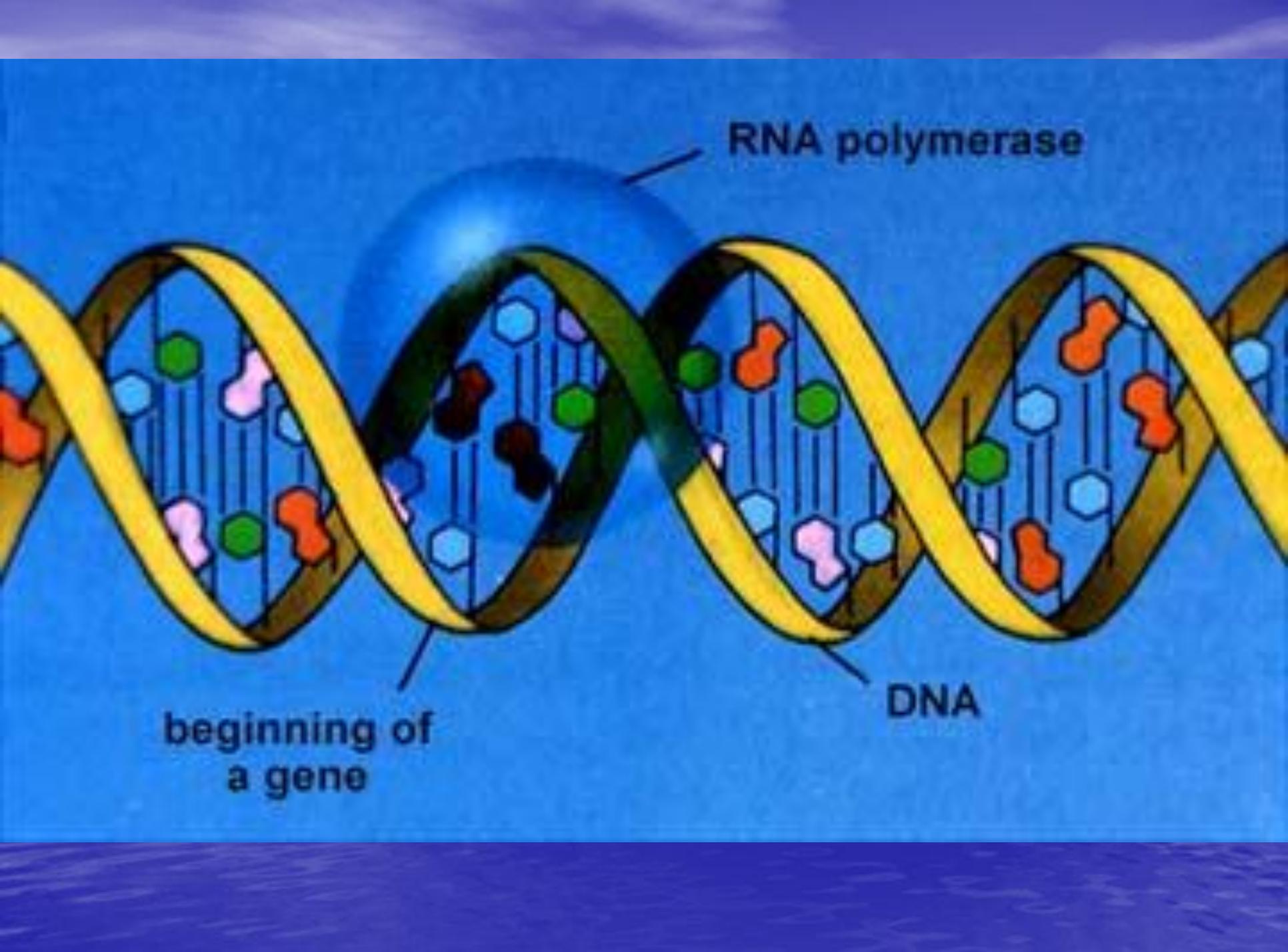


Steps of Transcription:

1. RNA polymerase binds to the promoter section of DNA
2. DNA unwinds and separates
3. RNA polymerase adds nucleotides complimentary to the DNA template strand
4. Process ends once RNA polymerase reaches the termination signal on the DNA

Definitions:

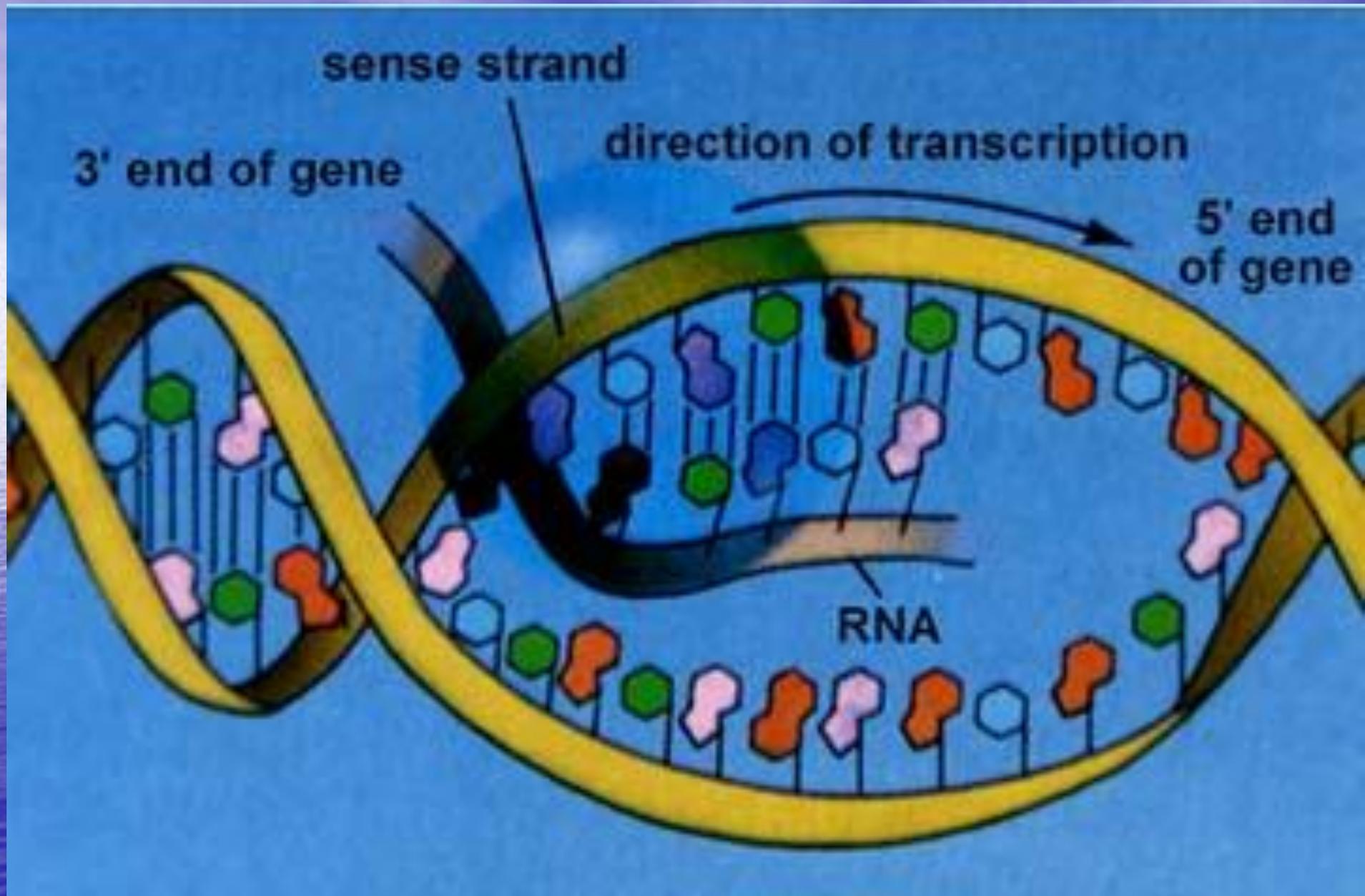
- **RNA polymerase:** enzyme use to make an RNA polymer from DNA
- **Promoter:** Starting point on DNA
- **DNA template:** Strand of DNA that RNA is complementary to (create from)
- **Termination signal:** Ending point on DNA

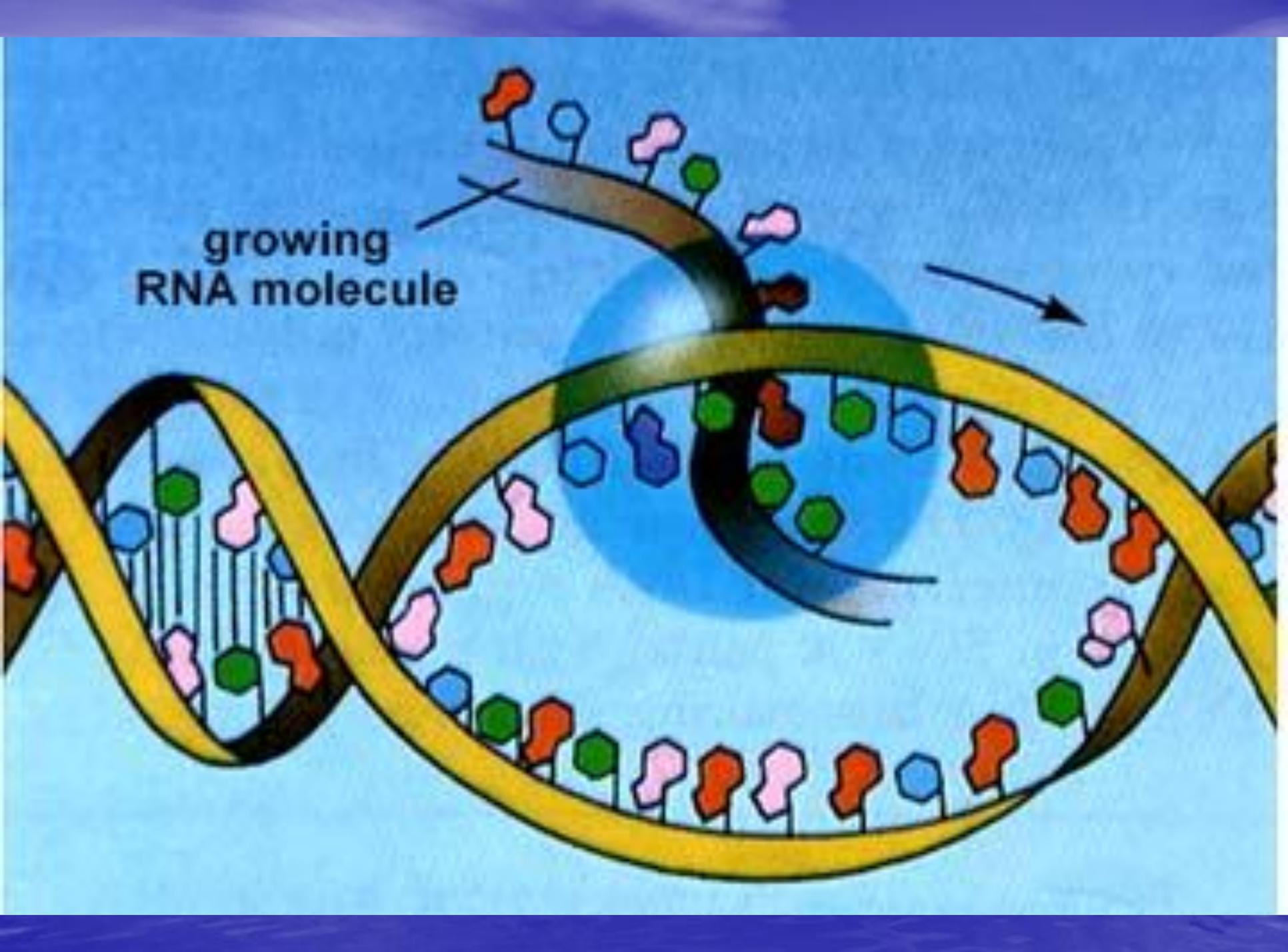


RNA polymerase

beginning of
a gene

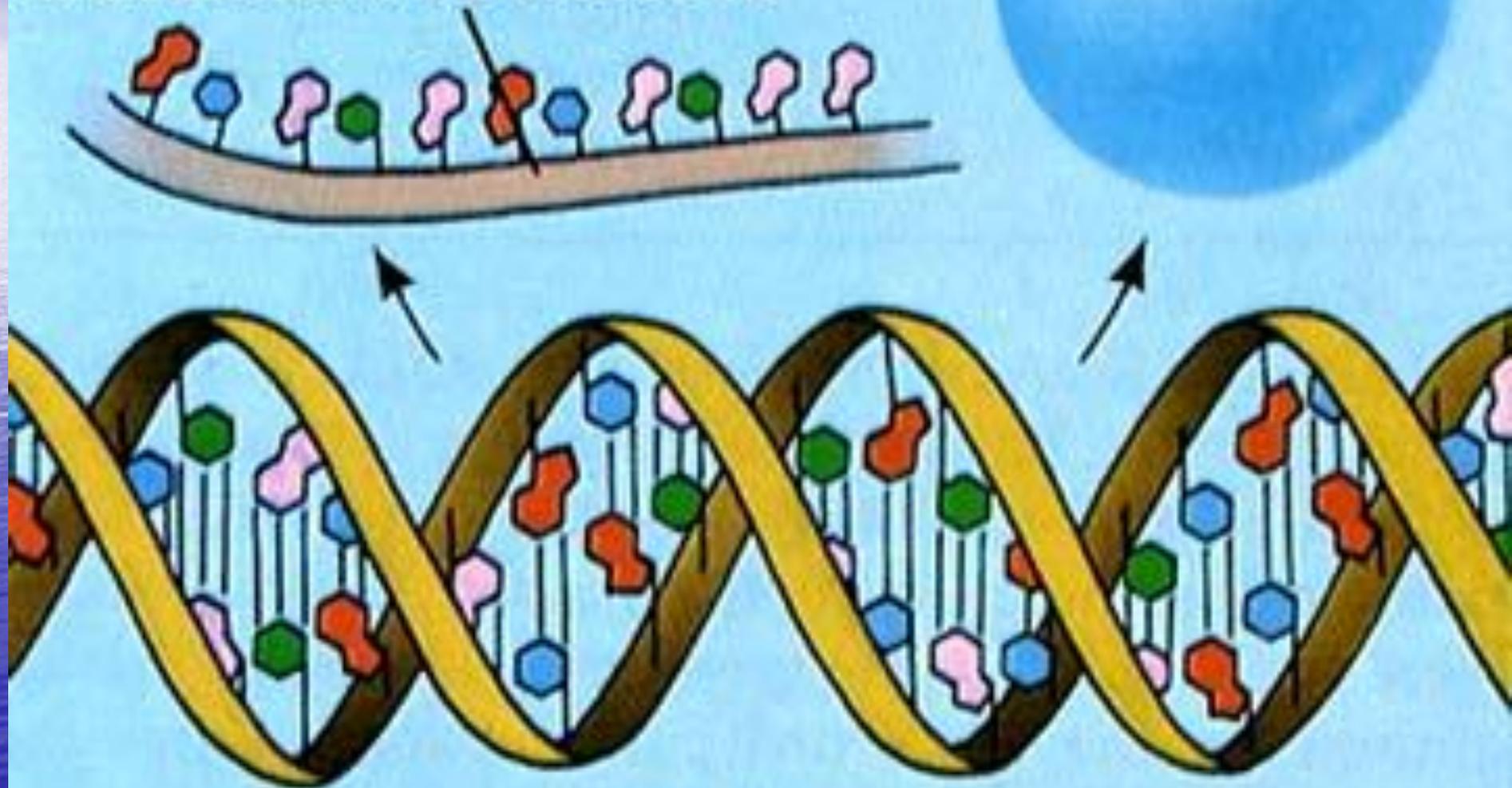
DNA





RNA polymerase
leaves DNA

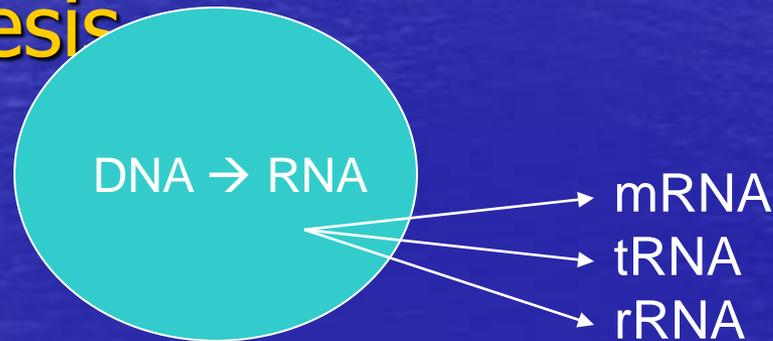
RNA molecules released



DNA rewinds

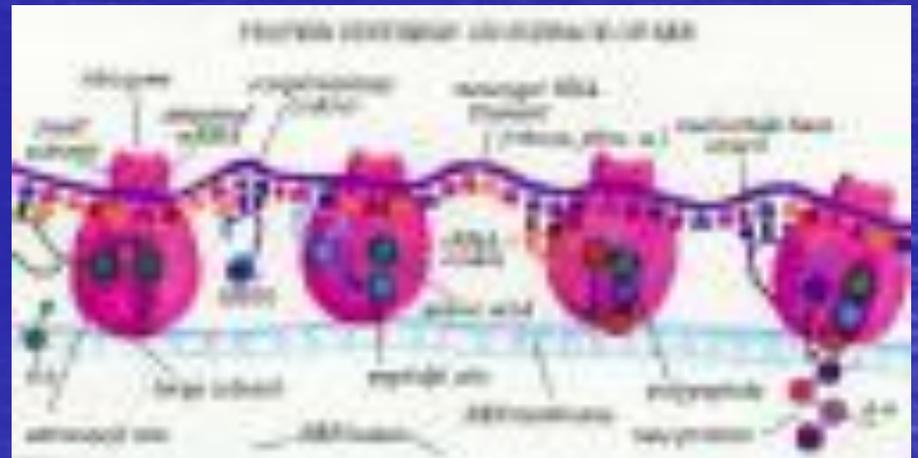
Products of Transcription:

- mRNA, tRNA, & rRNA
- All products move out of the nucleus and go into the cytoplasm to be used in protein synthesis

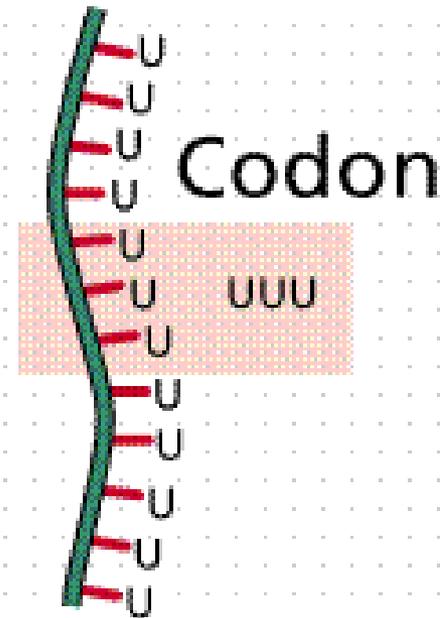


Protein Synthesis:

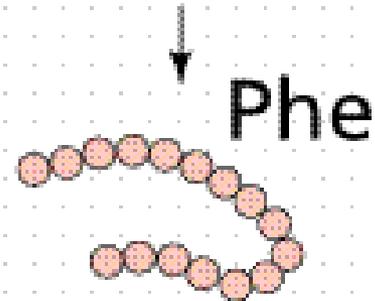
- The making of proteins at the ribosome
- The amount and kind of proteins produced in a cell determine its structure & function
 - Proteins carry out the genetic instruction in DNA



Poly U



Translation



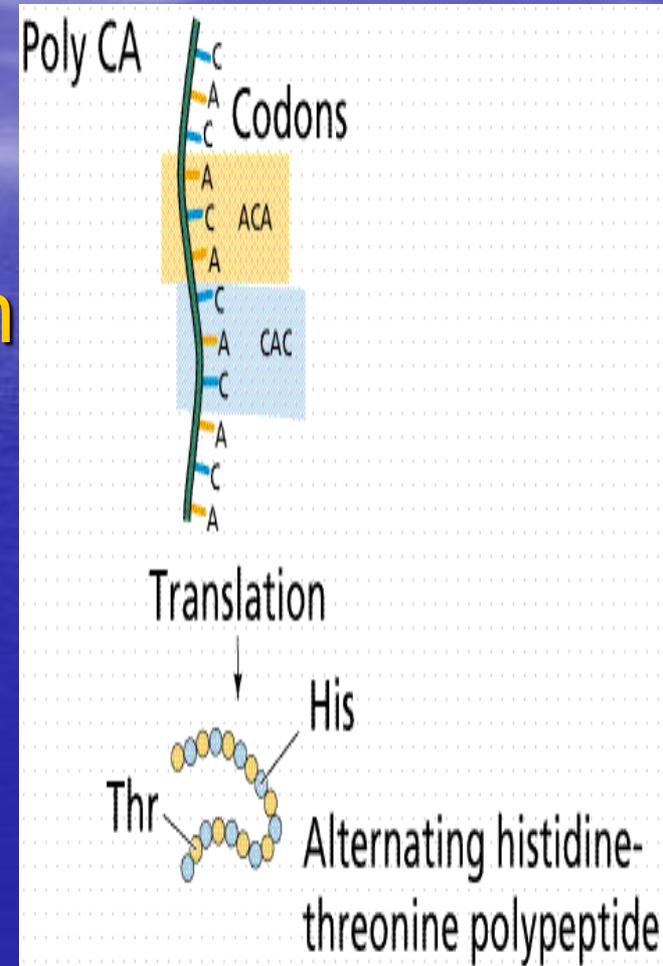
Polyphenylalanine

Types of codons:

- 64 codons code for 20 amino acids
 - Thus more than one codon codes for an AA
- Start codon: (AUG) starts the process of translation
- Stop codons: (UAA, UAG, UGA) ends the process of translation

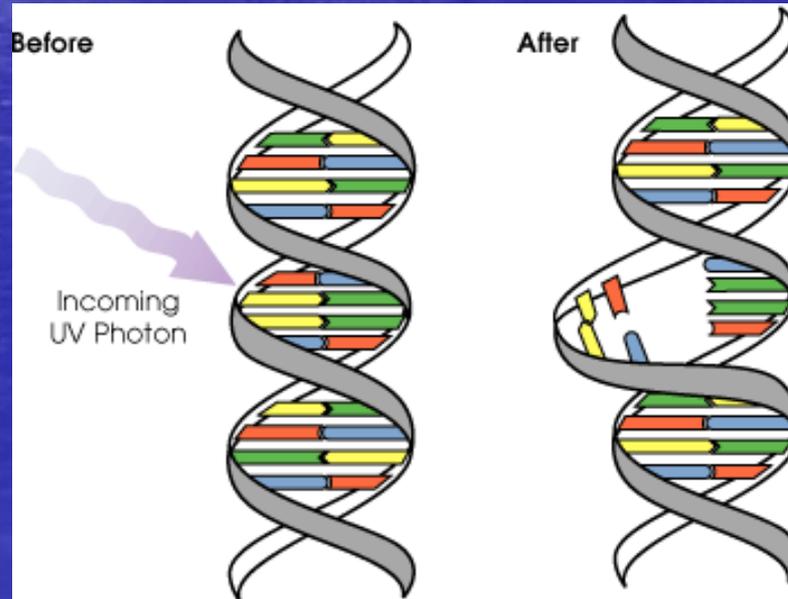
Translation:

- The process of assembling polypeptides (proteins) from nucleotide sequence in mRNA
- “Translating” from one language (nucleotides) into another language (amino acids)



Mutation

- A change in the nucleotide sequence of a DNA molecule.
- DNA proofreading and repair prevent many replication errors.
- Unrepaired mutations that affect genes that control cell division can cause diseases such as cancer.



Thank U

- With Best Wishes

