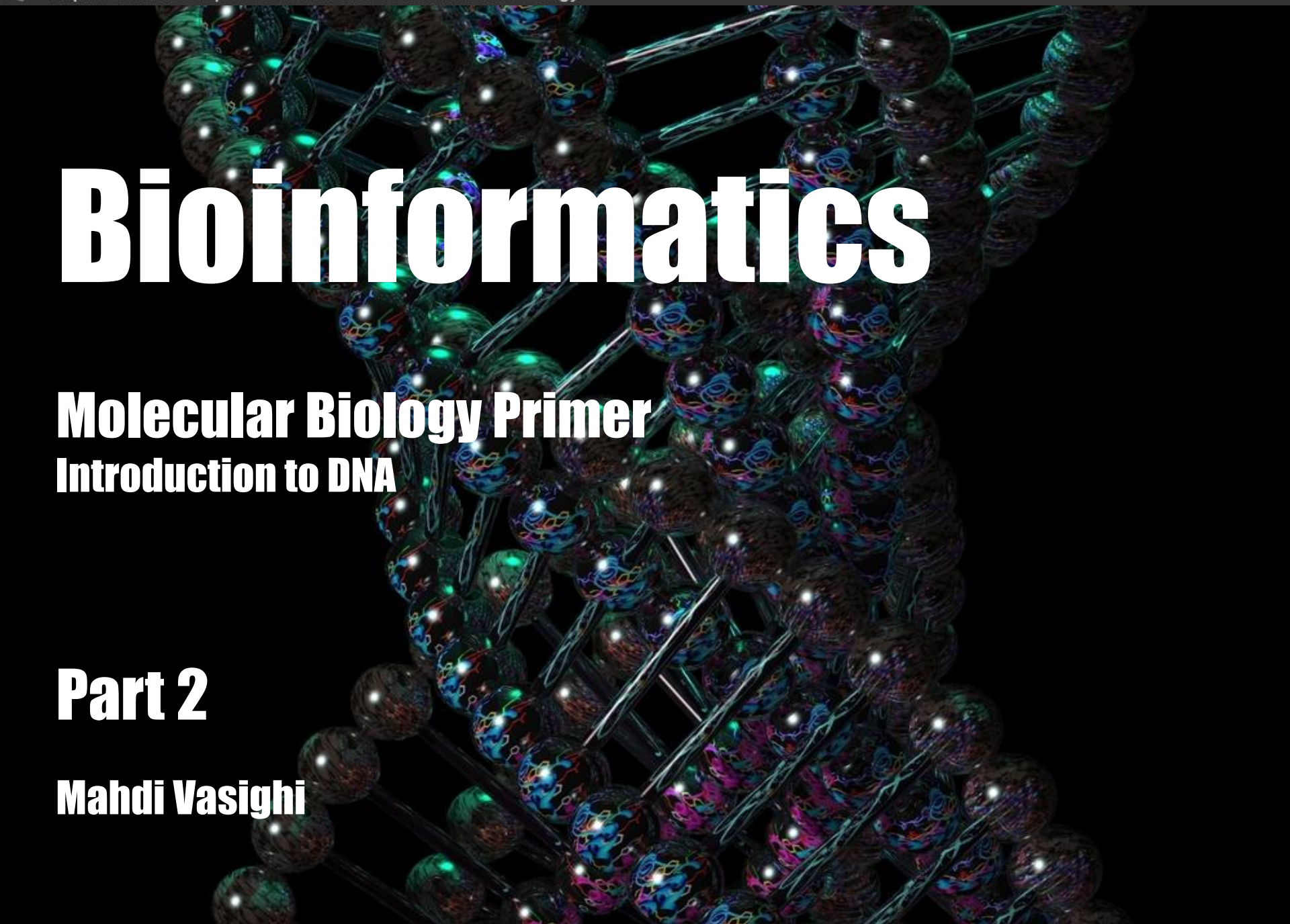


Bioinformatics

Molecular Biology Primer
Introduction to DNA

Part 2

Mahdi Vasighi

Molecular Biology: an Information Science

- the single most important scientific advance of the last century, it would likely be symbolized in the image of the double helix of DNA

- Its dual meaning is: “life propagates as pure information, which is encoded in physical molecules”

molecular biology is an information science as much as it is a physical science.

Molecular Biology: an Information Science

- Molecules are lifeless but molecules compose living things

- hydrogen (H), oxygen (O), carbon (C), and nitrogen (N) constitute >99% of human body

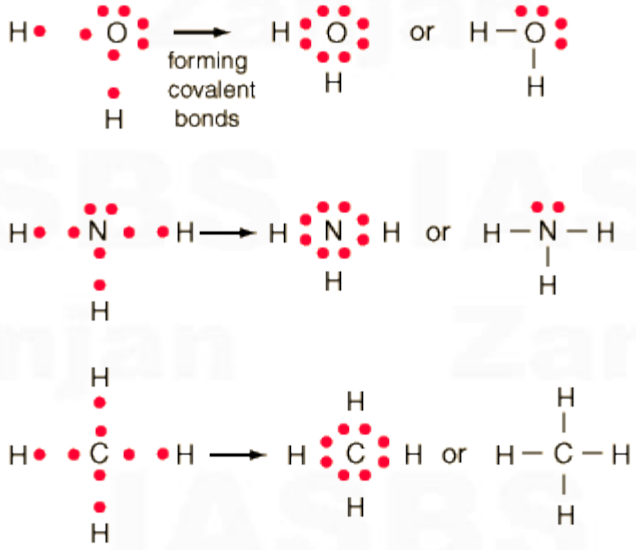
- Why are H, O, C, N so suitable to chemistry of life?
  - covalent bonds by electron-pair sharing!
  - the lightest elements of the periodic table capable of forming covalent bonds
- Two more elements appear in significant fractions: P (phosphorus) and S (sulfur)

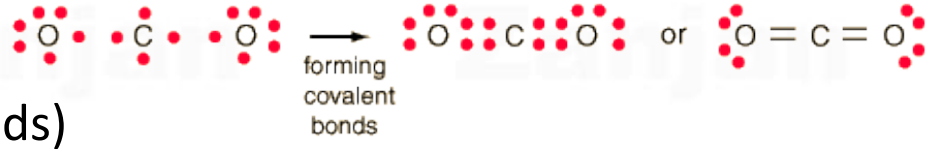
- Some other elements appear only in small traces: Cl (chlorine), Ca (calcium), Mg (magnesium), Cu (copper), Fe (iron), Mn (manganese), Zn(zinc), and Co (cobalt).

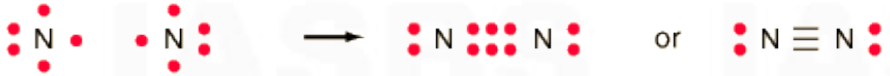
Molecular Biology: an Information Science

I	II	III	IV	V	VI	VII	0
H							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca	Ga	Ge	As	Se	Br	Kr
Rb	Sr	In	Sn	Sb	Te	I	Xe
Cs	Ba	Tl	Pb	Bi	Po	At	Rn

Metal Metalloid Nonmetal



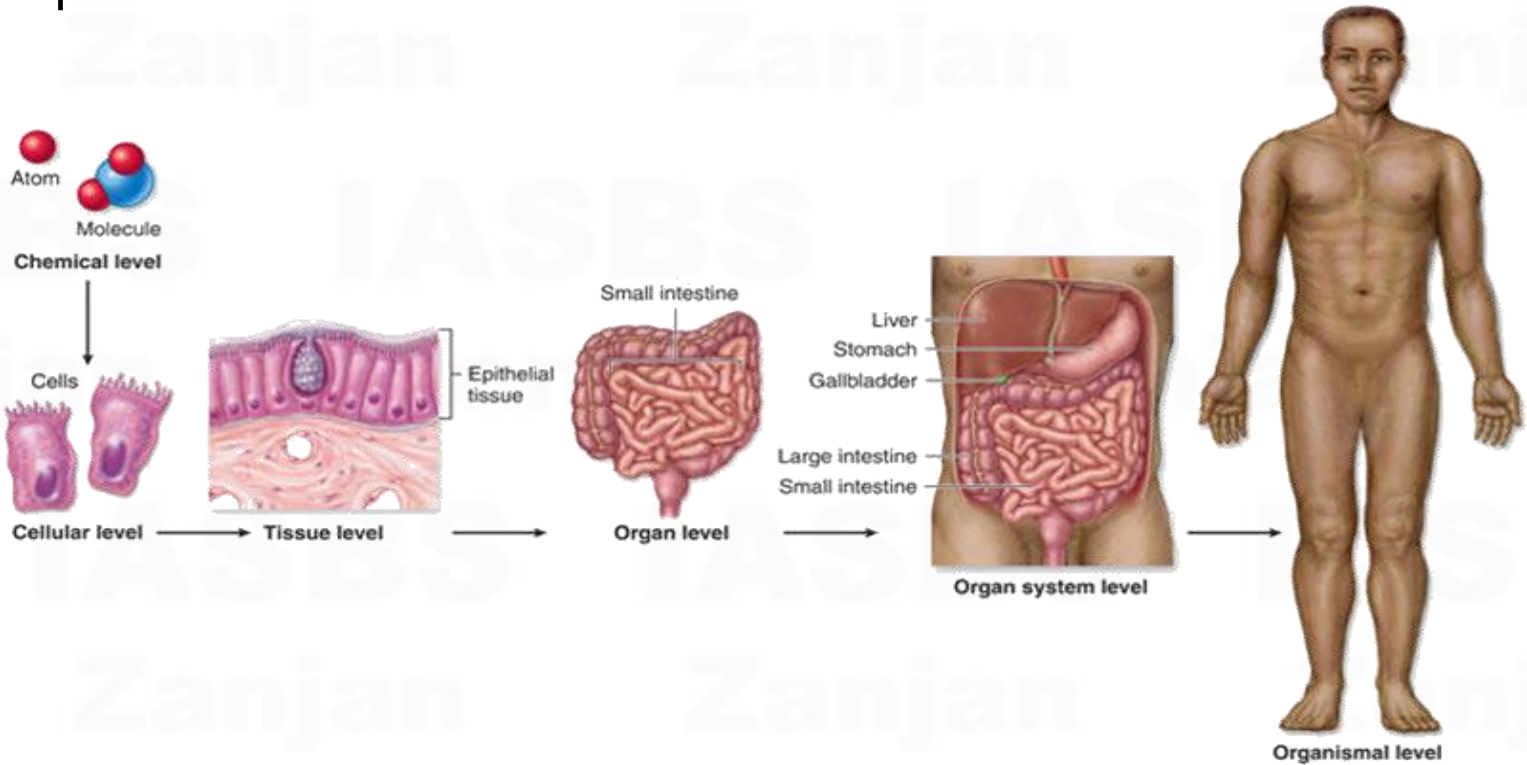




C can share 4 electrons (can form 4 bonds)
O has 2 unpaired electrons
N has 3 unpaired electrons
H has 1 unpaired electron

Basics of molecular Biology

- What makes living things distinct?
  - they can grow
  - they can replicate themselves
  - they can respond to stimuli
  - they can perform metabolism



What is a Cell?

Cells are the smallest structures capable of basic life processes, such as:

- growth
- metabolism (taking in nutrients and expelling waste)
- Stimulus response,
- Reproducing

Type of Cells

All living things fall into one of the two categories:

- **Prokaryotes**
- **Eukaryotes**

pro = means “prior to”
eu = means “true”
karyote = means “nucleus”

The distinction is based on whether or not a cell has a nucleus.

Prokaryotic cells do not have nuclei, while eukaryotic cells do. Also, eukaryotic cells have organelles.

Type of Cells

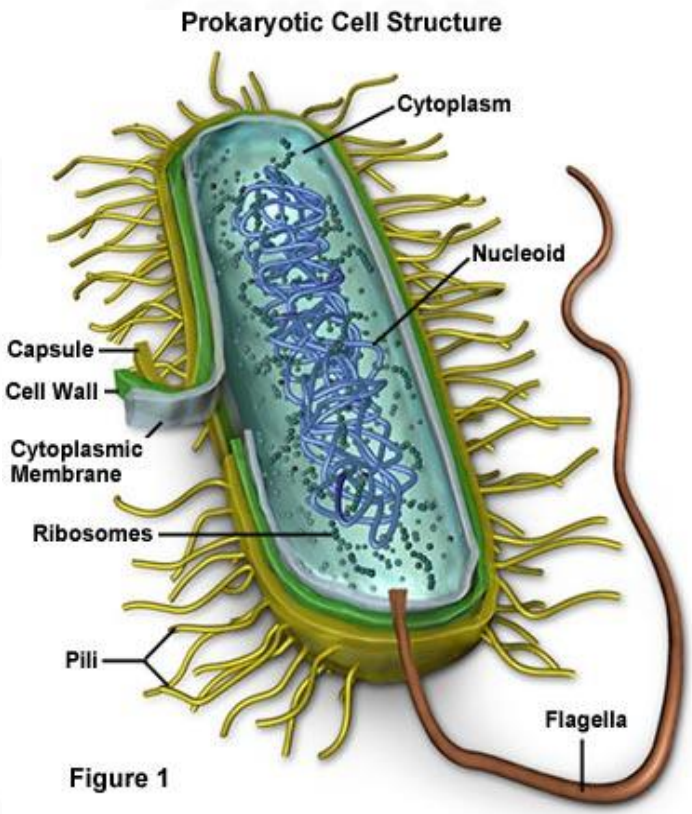
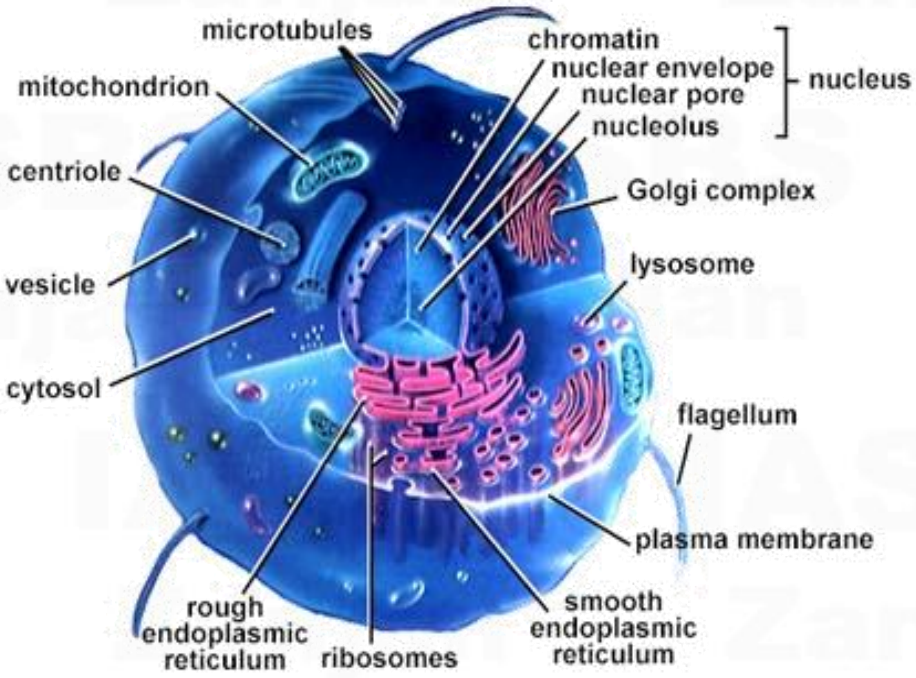


Figure 1

Prokaryotic Cell

- **Cell wall:** a rigid framework of polysaccharide cross-linked by short peptide chains;
- **Cell membrane:** bilayer; highly selective and controls the entry of most substances into the cell;
- **Nucleoid** (DNA): repository of the cell's genetic information; contains a single tightly coiled DNA
- **Ribosomes:** sites where proteins are synthesized; a bacterial cell has about 15,000 ribosomes
- **Storage granules:** granules where polymerized metabolites are stored (e.g. sugars)
- **cytosol** or cytoplasmic matrix: the site of intermediary metabolism

Type of Cells



Eukaryotic Cell

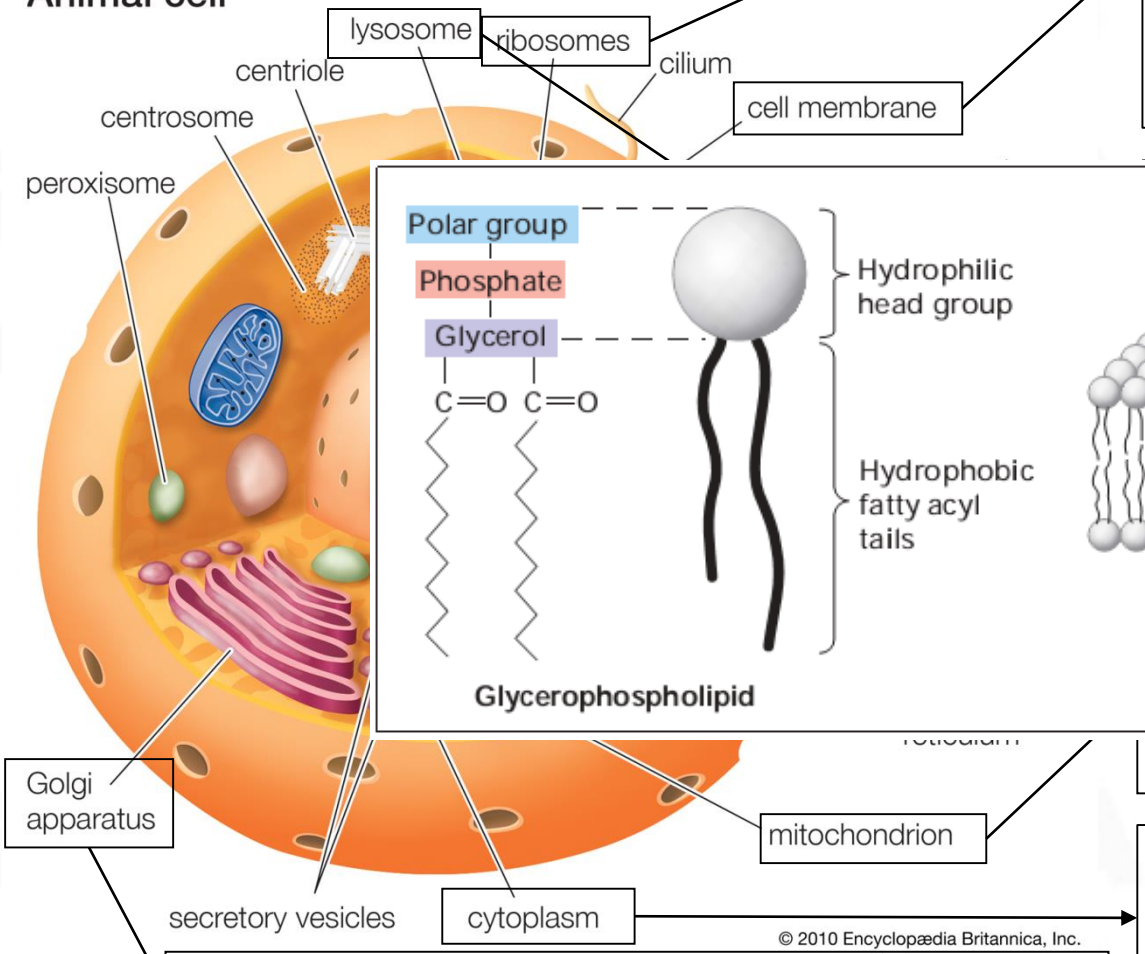
- much larger in size (1,000 to 10,000 times larger than prokaryotic cells)
- much more complex metabolic processes are organized into compartments, with each compartment dedicated to a particular function (enabled by a system of membranes)
- possess a nucleus, the repository of cell's genetic material which is distributed among a few or many chromosomes

Cell Organelles

Ribosome assembles proteins

Membranes are the boundaries between the cell and the outside world. All present day cells have a phospholipids cell membrane. Phospholipids are lipids (oils or fats) with a phosphate group attached.

Animal cell



that powers the cell.

Cytoplasm is the name for the gel-like collection of substances inside the cell.

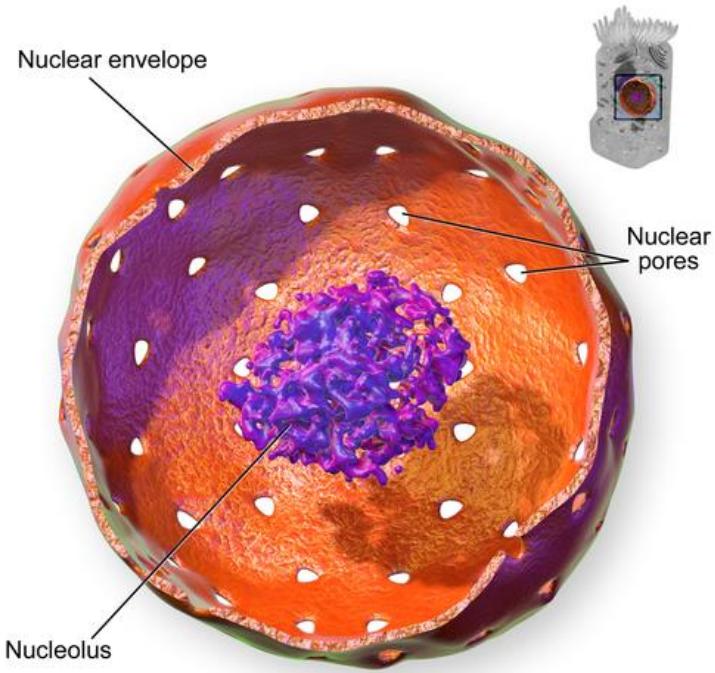
Golgi Apparatus is the delivery system for the cell

Nucleus

The nucleus of eukaryotic cells is composed primarily of protein and **deoxyribonucleic acid** or **DNA**.

- Spherical shape
- Denser than surrounding cytoplasm

The DNA is organized into linear units called **chromosomes**, also known as **chromatin** when the linear units are not obvious.

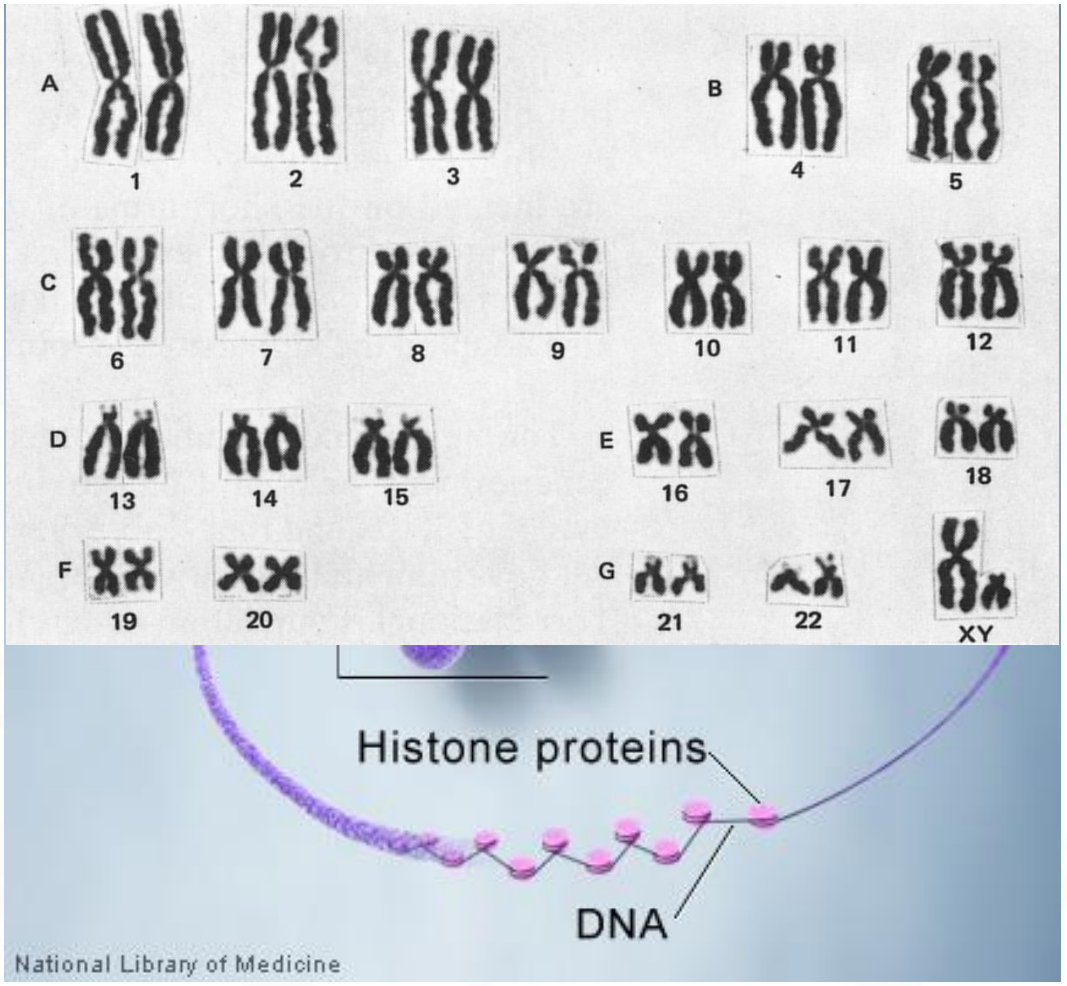


Nucleus

Chromosome

A chromosome is an organized structure of DNA and protein found in cells.

It is a single piece of coiled DNA containing many genes and regulatory elements.

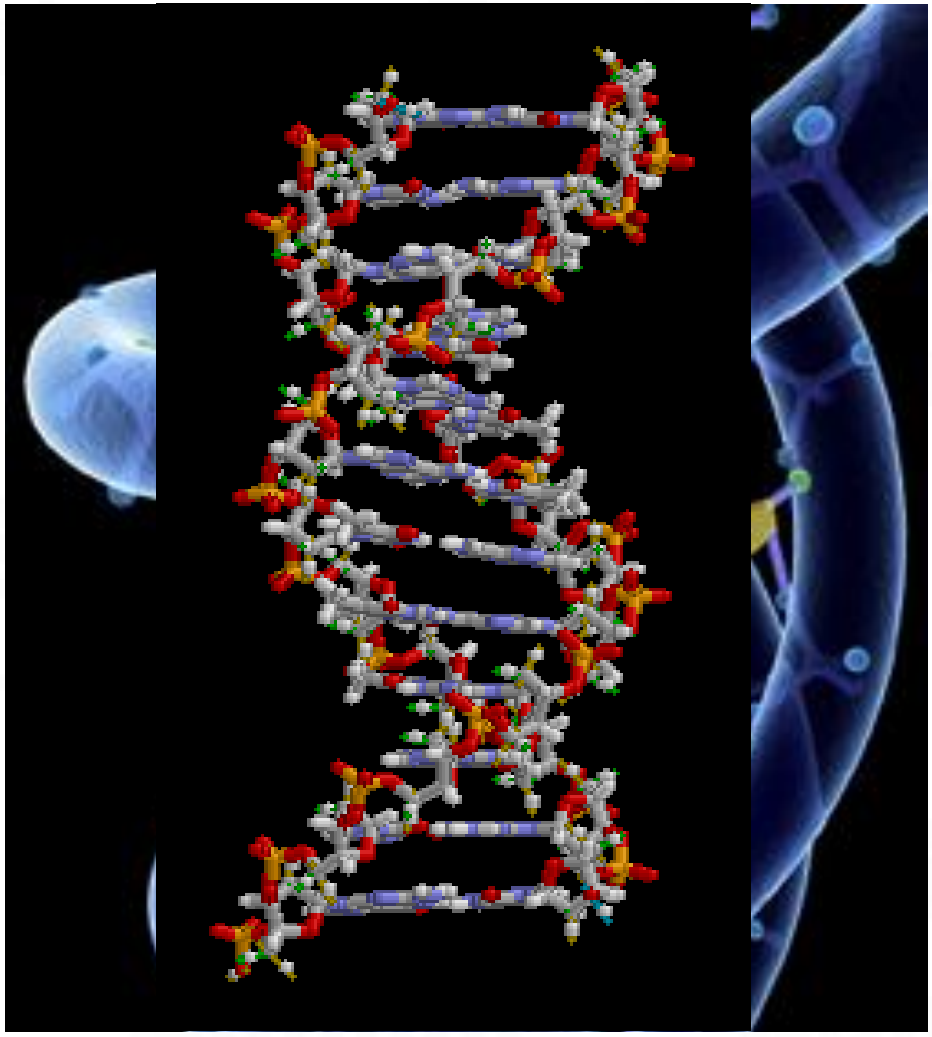


Deoxyribonucleic Acid : DNA

All the information directing every cell function is stored in large **DNA** molecules found in the nucleus.

The DNA segments that carry genetic information are called **genes**.

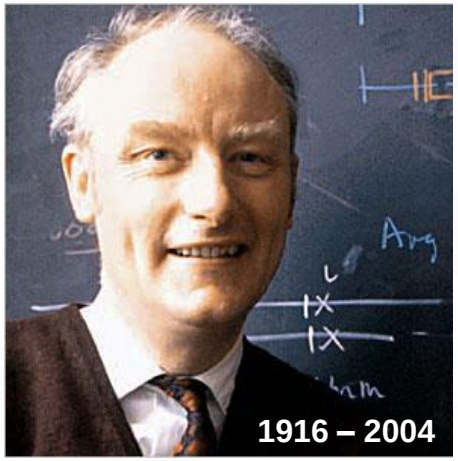
DNA consists of two long polymers of simple units called **nucleotides**.



Deoxyribonucleic Acid : DNA

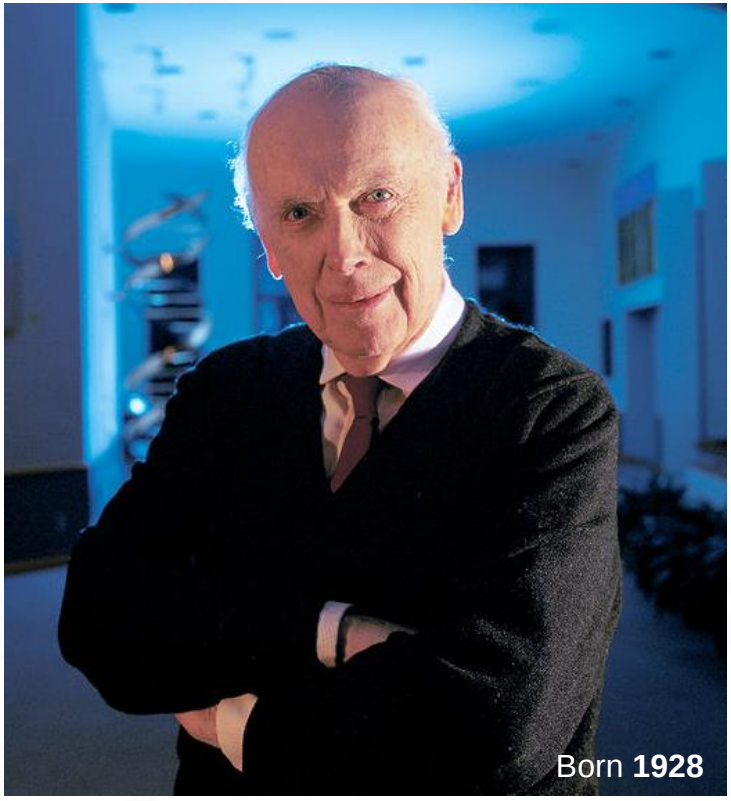

1920 –1958

The double helix model was supported by the work of **Rosalind Franklin** and **Maurice Wilkins**


1916 – 2004


1916 – 2004

The structure of DNA was discovered in 1953 by **Francis Crick** and **James Watson**


Born **1928**

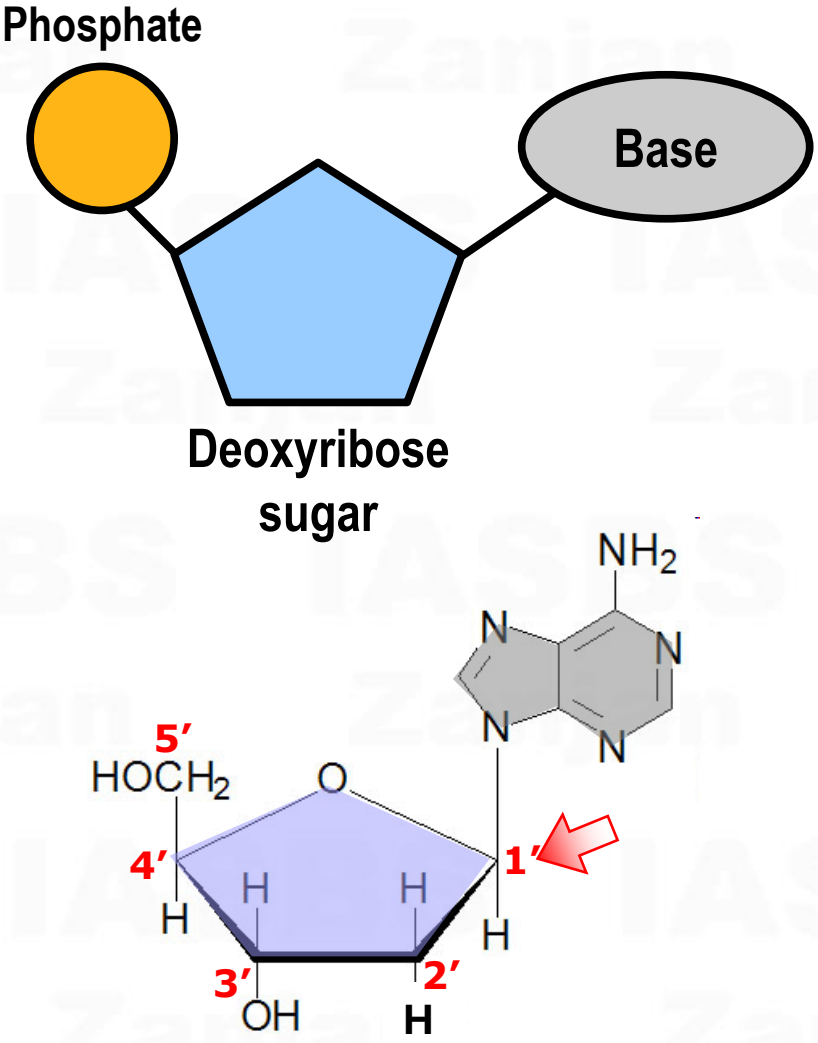
Deoxyribonucleic Acid : DNA

A nucleotide is composed of:

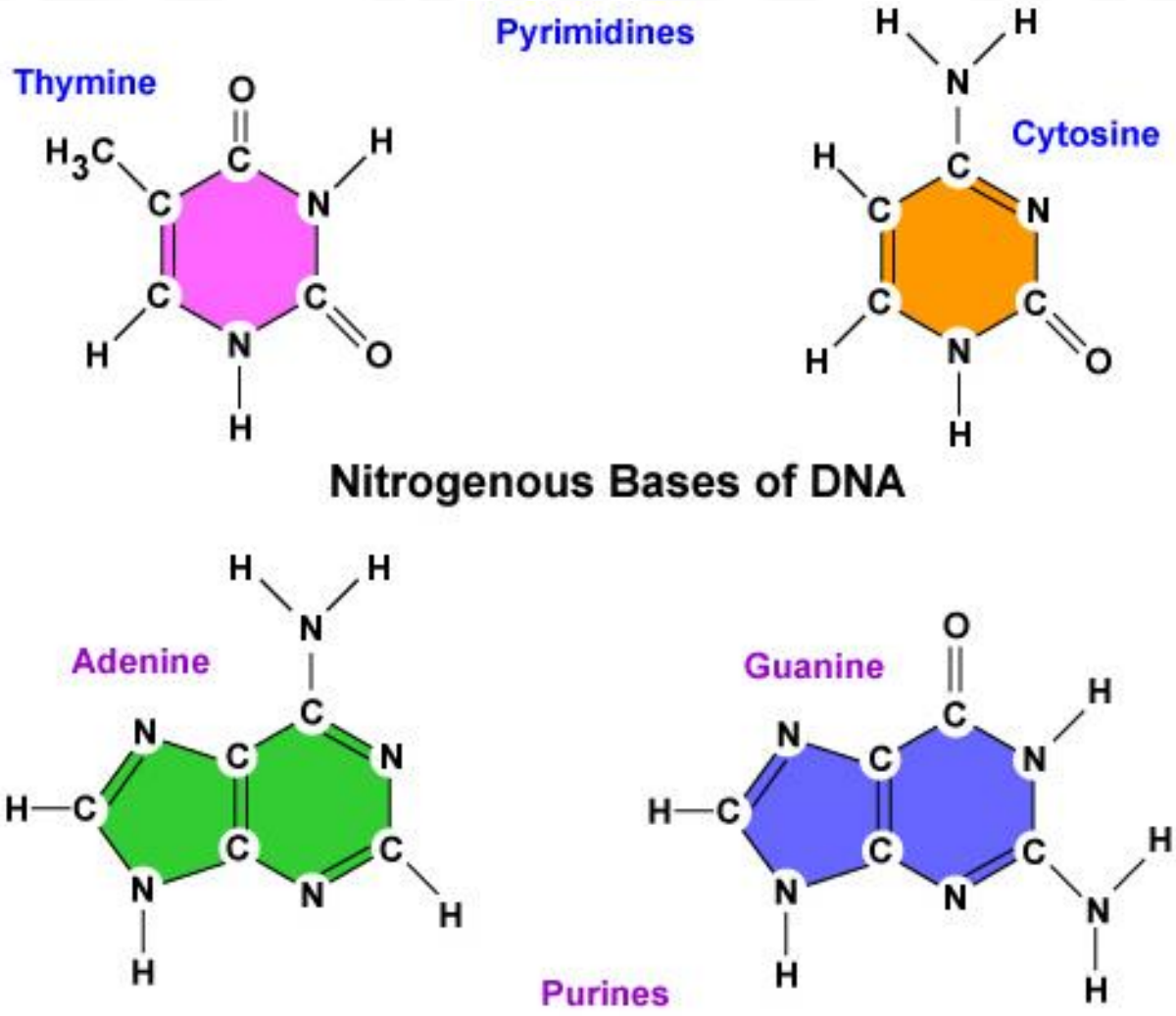
- a nitrogenous base
- a five-carbon sugar
- a phosphate groups

Sugar + Base = ***Nucleoside***

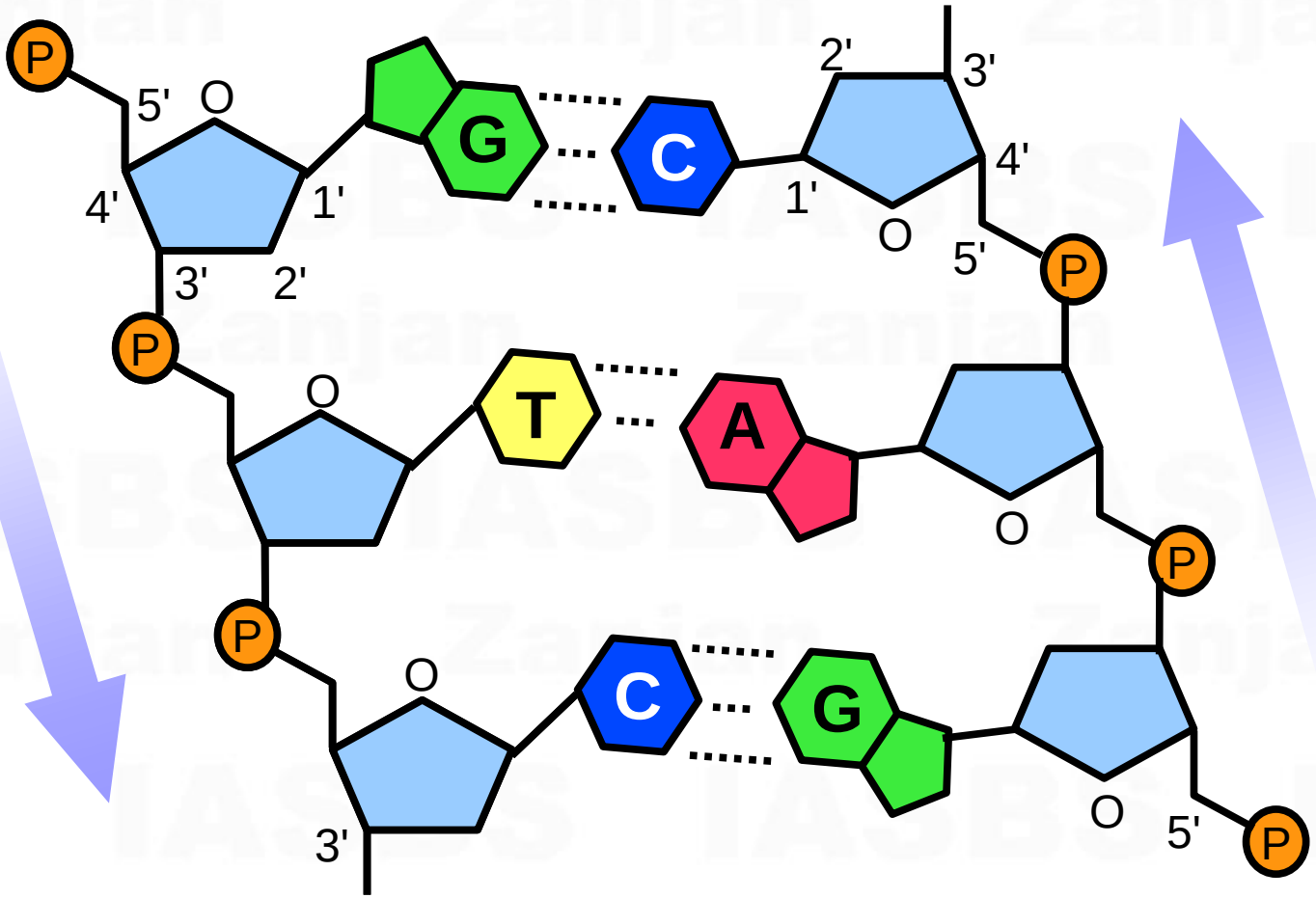
a phosphoric acid residue to the 5’ carbon of a nucleoside to make a ***Nucleotide***.



Nitrogenous Bases

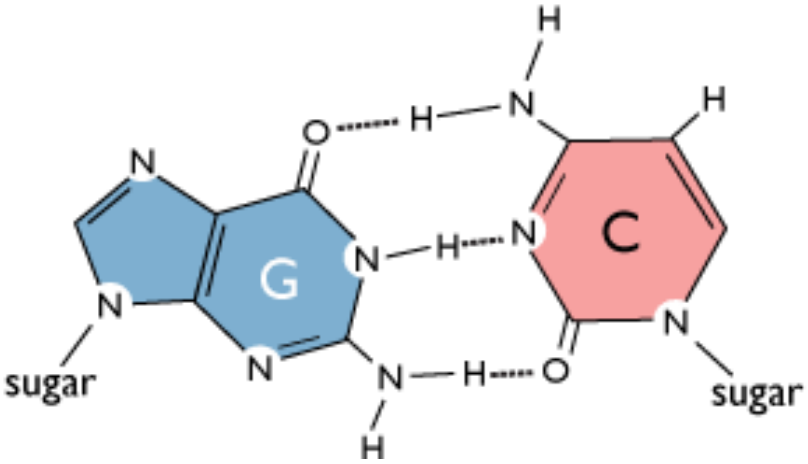


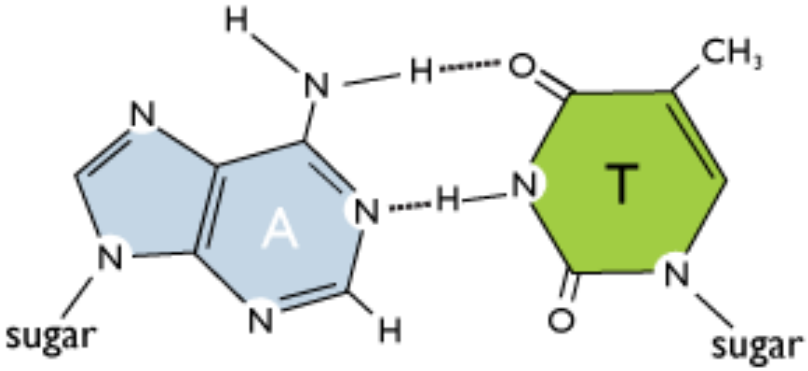
Nitrogenous Bases



The orientation of the two strands is antiparallel

Nitrogenous Bases





Guanine must pair with **Cytosine**

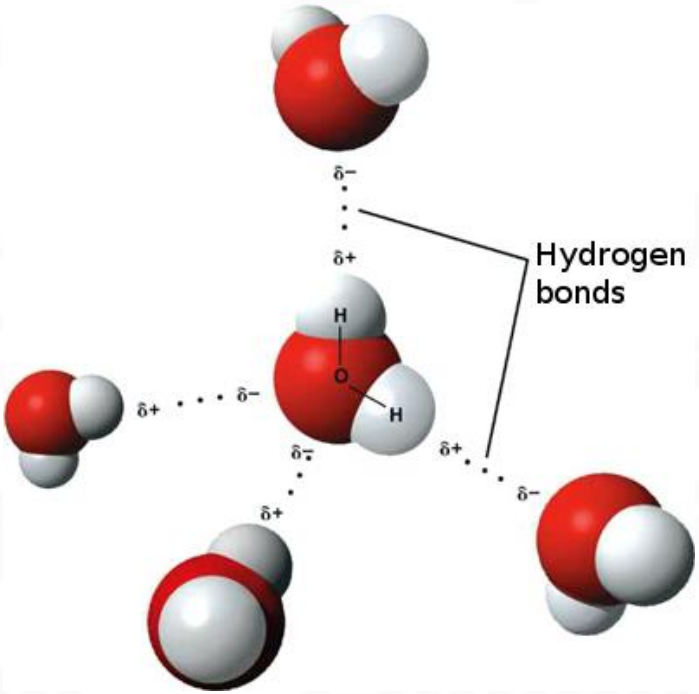
Adenine must pair with **Thymine**

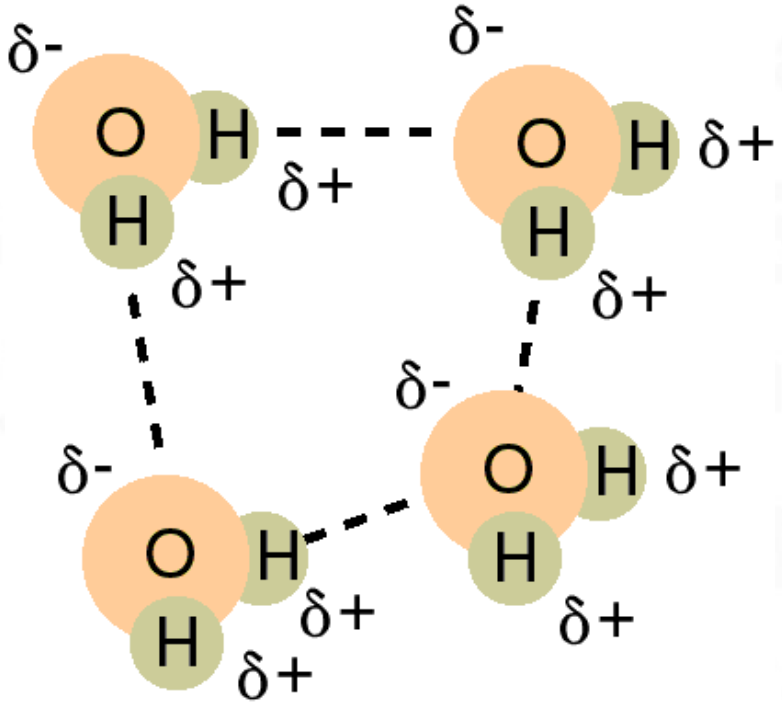
Specificity comes from **hydrogen bonding**

The first clue for the base pairing came by Erwin Chargaff

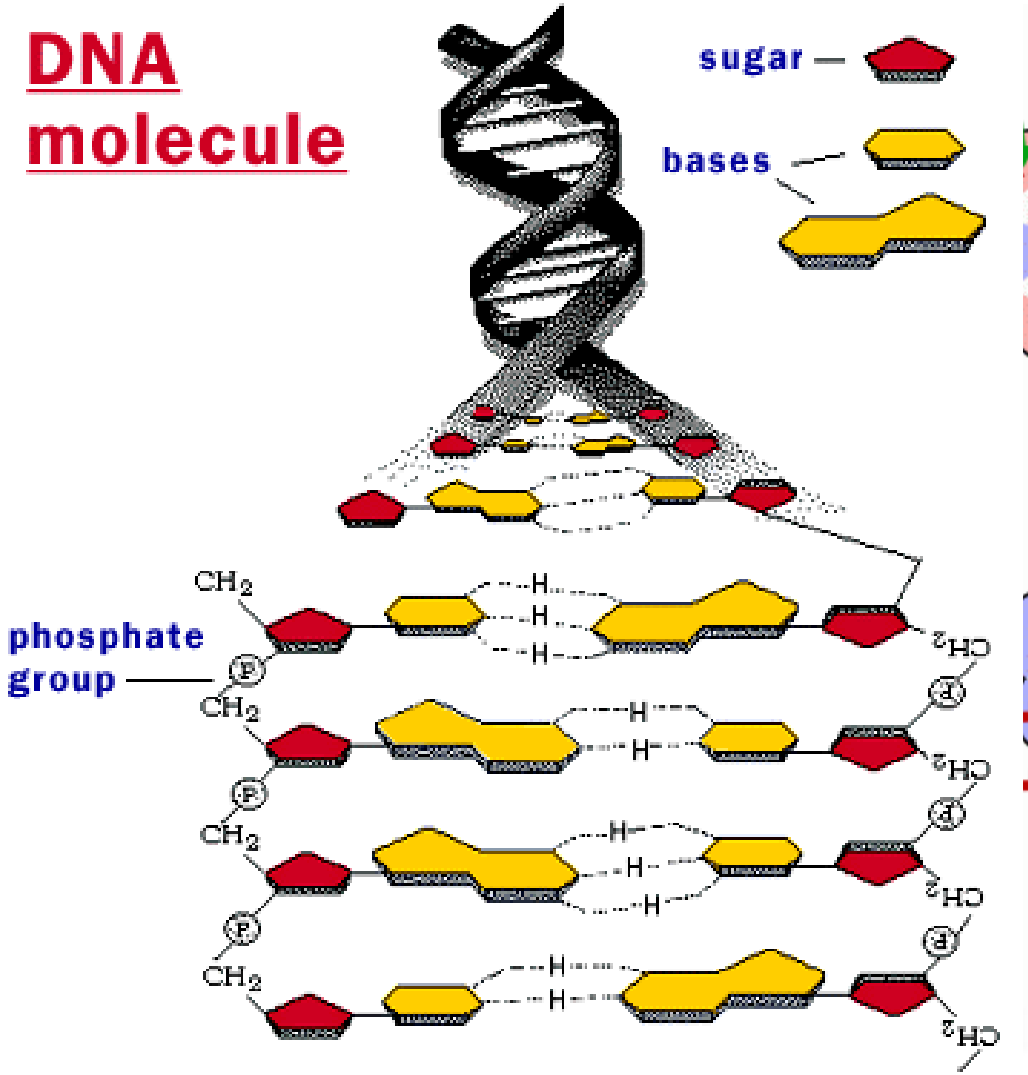
Nitrogenous Bases

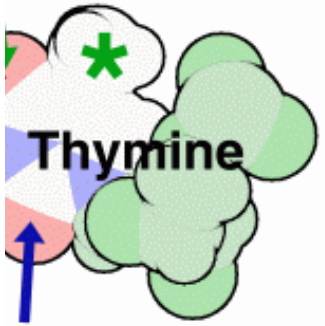
A hydrogen bond is the electromagnetic attractive interaction between polar molecules in which hydrogen (H) is bound to a highly electronegative atom, such as nitrogen (N), oxygen (O) or fluorine (F).

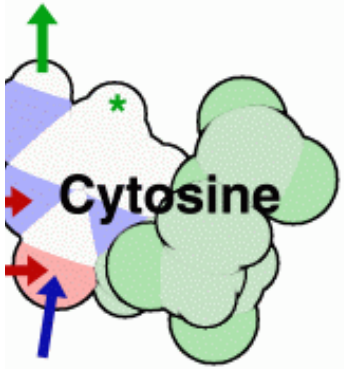




Nitrogenous Bases







Overview of DNA

- a thread-like molecule (twisted ladder-like)
- the DNA isolated from different cells consists of two polynucleotide strands wound together to form a long, slender, helical molecule, the DNA double helix.
- each DNA strand consists of four types of nucleotides: adenine (A), cytosine (C), guanine (G), and thymine (T)
- the strands run in the opposite directions, that is, they are antiparallel
- the strands are held together in the double helical structure through inter-chain hydrogen bonds
- the H-bonds pair the bases of nucleotides in one chain to complementary bases in the other (so-called base pairing)

Virus

Sub microscopic entity consisting of a single nucleic acid surrounded by a protein coat and capable of replication only within the living cells of bacteria, animals or plants.

When it comes into contact with a host cell, a virus can insert its genetic material into its host, literally taking over the host's functions.

Virus

Influenza A virus (A/Ahvaz/106899/2015(H1N1))

```
   1 atgaaggcaa tactagtagt tctgctatat acatttgcaa ccgcaaatgc agacacatta
  61 tgtataggtt atcatgcgaa caattcaaca gacactgtag acacagtact agaaaagaat
 121 gtaacagtaa cacactctgt taaccttcta gaagacaagc ataacgggaa actatgcaaa
 181 ctaagagggg tagccccatt gcatttgggt aaatgtaaca ttgctggctg gatcctggga
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 301 agttca
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 421 cccaat
 481 ttctac
 541 tcctac
 601 actact
 661 tcaaga
 721 gaaggg
 781 gcaact
 841 ggtatt
 901 ggtgct
 961 ccaaag
1021 attcaa
1081 atggta
1141 gacctg
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1261 atagag
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