جامعة المستقبل
كلية العلوم
علوم الكيمياء الحياتية

GENERAL BIOLOGY

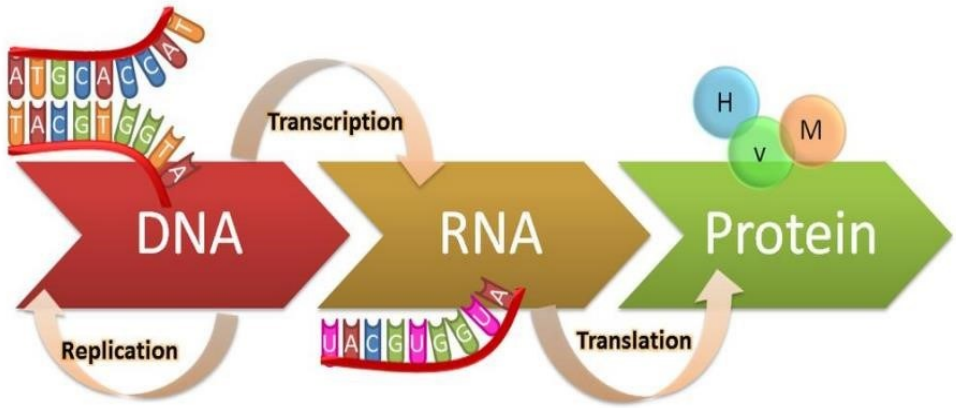
المرحلة الاولى

LECTURE : 2

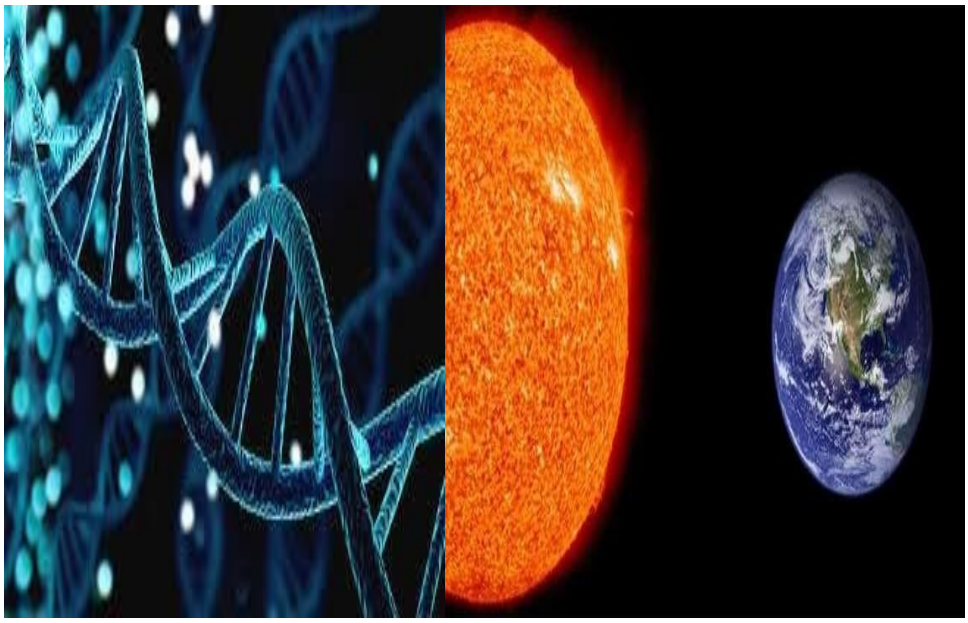
MOLECULAR BIOLOGY

أستاذ المادة: د. محمد زهير المرعب

Central Dogma of Molecular Biology



Which is the longest?
DNA strand over all cells or distance between sun and earth?



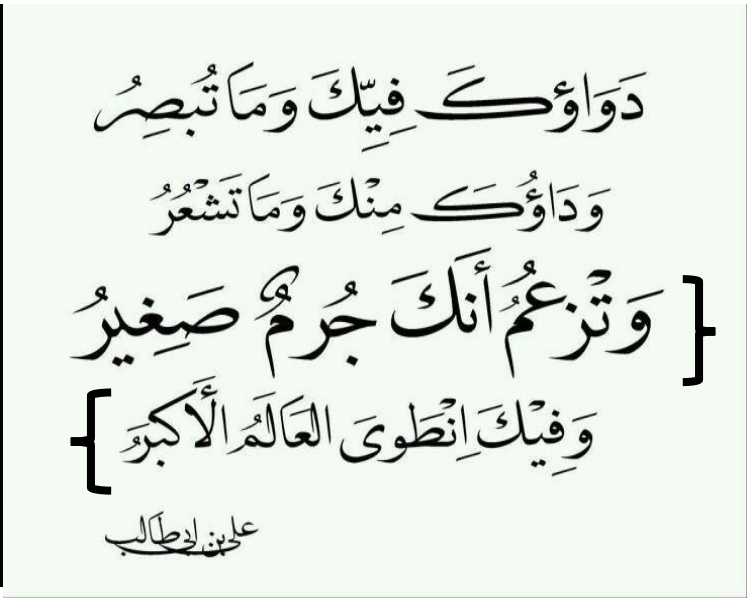
DNA packaging

- The length of DNA strand in the cell = 2 m
- Number of human cells = $7x10^{13}$ (70 trillion) cells
- Total length of DNA strand = 140 trillion meter = 140 billion Km

- The distance between earth and sun = 150,000,000 kilometers

- DNA strand of human body is taller than distance between sun and earth by 934 time = 467 time in two way

قال أمير المؤمنين (ع)



The nucleic acid

1- Nucleotides

2- DNA

3- RNA

1- NUCLEOTIDES

Importance of nucleotides

1- **Building units for <u>nucleic acids</u>** (DNA & RNA)

2- **<u>Other</u>** rules in metabolism & energy storage
(e.g. ATP is a nucleotide)

Structure of nucleotides

Nucleotides = nitrogenous base + sugar + phosphate group

Nucleoside = nitrogenous base + sugar

Nitrogenous base = Purine <u>OR</u> Pyrimidine

Sugar = Ribose <u>OR</u> Deoxyribose Purine = Adenine or Guanine

Pyrimidine = Thymine, Cytosine <u>OR</u> Uracil

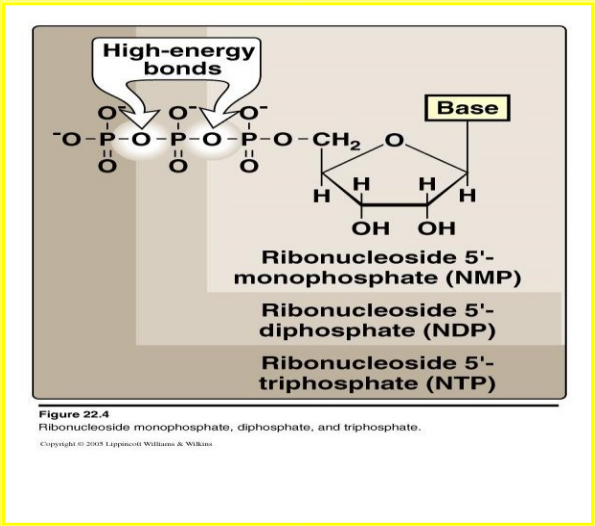
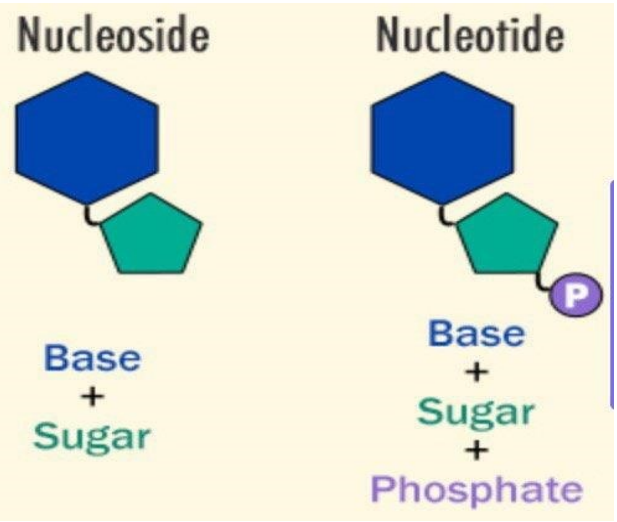


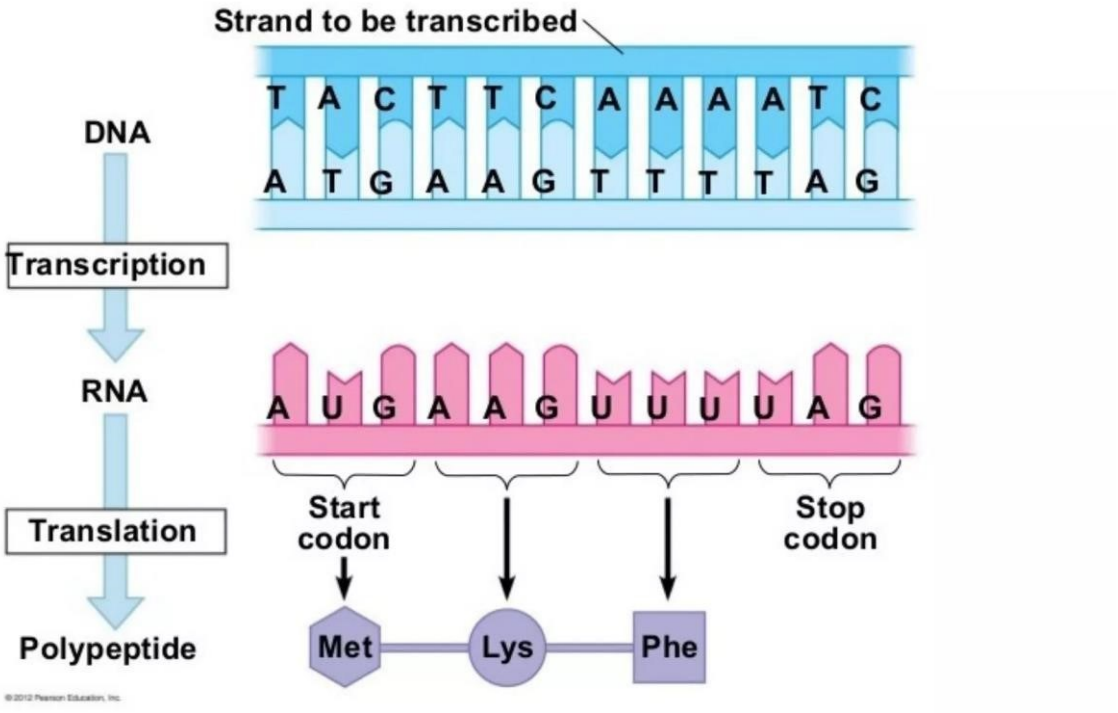
Figure 22.4
Ribonucleoside monophosphate, diphosphate, and triphosphate.



- **Purines** : **Adenine & Guanine**
- **Pyrimidines**: **Cytosine, Thymine & Uracil**

- **DNA** contains **Adenine & Guanine (purines)**
  Cytosine & Thymine (pyrimidines)

- **RNA** contains **Adenine & Guanine (purines)**
  Cytosine & Uracil (pyrimidines)



Metabolism of nucleotides

1- **Synthesis (anabolism)**
   i. sources of purine ring atoms
   ii. sources of pyrimidine ring atoms
2- **Degradation (catabolism)**
   i. end products of purine ring
   ii. end product of pyrimidine ring

Degradation (catabolism):

End products of purine ring degradation

- In human cells purine nucleotides is finally degraded to **URIC ACID**
- **Uric acid** is transported in blood to kidneys
- Finally, **Uric acid** is excreted in urine
- If uric acid is increased in blood, the case is called **HYPERURICEMIA**
- Hyperuricemia may lead to **GOUT**
- **GOUT** is a disease affects **joints** (arthritis) & **kidneys** (kidney stones) **caused by deposition of uric acid in these tissues**

DNA

1- **Importance of DNA**

2- **Structure of DNA molecule**

- **Structure of a single strand of DNA**
- **Structure of double stranded DNA**
- **Linear & circular DNA**

The history of DNA

- DNA as an acidic substance present in nucleus was first identified by ***Friedrich Meischer*** in 1868.
- He named it as 'Nuclein'.

The history of DNA

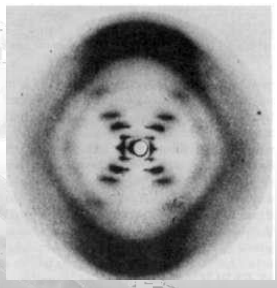
Rosalind Franklin 1952

- She worked in same laboratory as Maurice Wilkins.
- She study X -ray diffraction to study wet fibers of DNA.

X-ray diffraction of wet DNA fibers

The diffraction pattern is interpreted (using mathematical theory)

This can ultimately provide information concerning the structure of the molecule



X Ray Crystallography Rosalind Franklin's photo

The history of DNA

- She made marked advances in X-ray diffraction techniques with DNA
- The diffraction pattern she obtained suggested several structural features of DNA

- Helical
- More than one strand
- 10 base pairs per complete turn

The history of DNA

In 1953 , ***James Watson and Francis Crick***, described a very simple and famous ***Double Helix*** model for the structure of DNA.

Importance of DNA

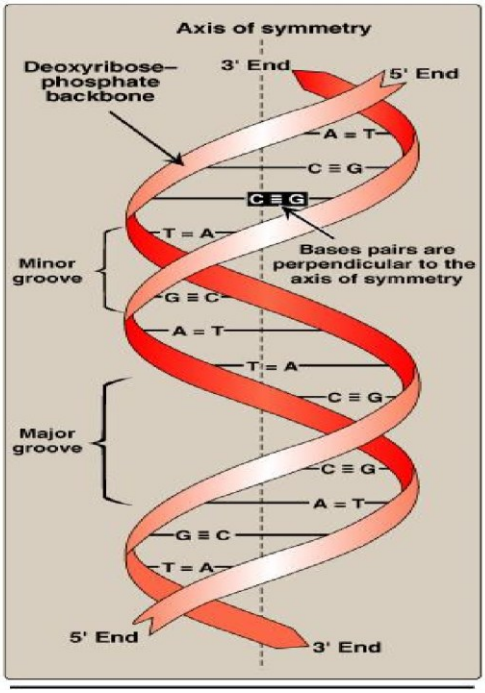
1- **Storage of genetic material & information (material of GENES)**

2- **Transformation of genetic information to new cells (template for REPLICATION) i.e. synthesis of new DNA for new cells**

3- **Transformation of information for protein synthesis in cytosol (template for TRANSCRIPTION) i.e. synthesis of mRNA in nucleus**

Structure of DNA molecule

- DNA molecule is formed of double helical strands.
- (Dounble helix)
- The two strands are held together by hydrogen bonds
- Each single strand is formed of polynucleotides
- Polyncleotides are mononucleotides bound to
- each other by phosphodiester bonds



Structure of *Single strand* of DNA

- **Building Units**: **Polynucleotide**
- **sugar**: deoxyribose
- **Base**: **Purine**: A or G OR **Pyrimidine**: T or C
- **Phosphoric acid**
- Mononucleotides are bound together by **phosphodiester bonds**
- In **linear** DNA Strand : **two ends** (**5`** = phosphate & **3`** = OH of deoxyribose)
- In **circular strand**: no ends

Structure of *double stranded* DNA

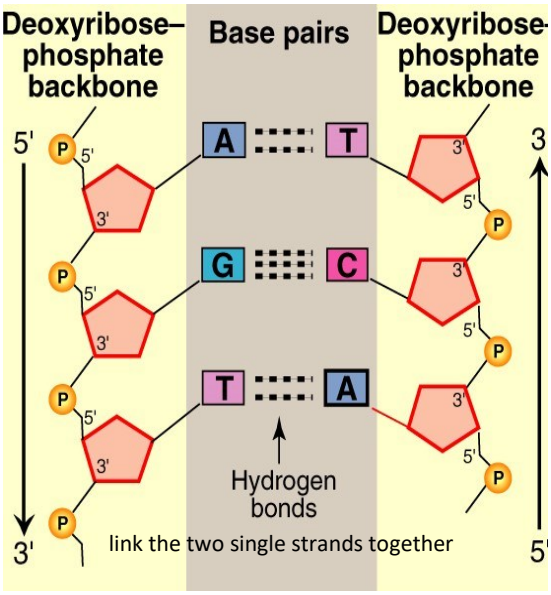
Two strands are anti-parallel (in opposite directions)

Hydrogen bonds between bases of opposite strands (A & T , C & G)

Denaturation

breakdown (loss) of hydrogen bonds between two strands leading to formation of two separate single strands)

Causes of denaturation : heating or change of pH of DNA



✞Structure of Double-helix

Property	B-DNA	A-DNA	Z-DNA
Strand	Antiparallel	Antiparallel	Antiparallel
Type of Helix	Right-handed	Right-handed	Left-handed
Overall shape	Long and narrow	Short and wide	Elongated and narrow
Base pair per turn	10	11	12
Major Groove	Wide & Deep	Narrow & Deep	No discrenible
Minor Groove	Narrow, shallow	Broad, Shallow	Narrow, Deep

Linear & Circular DNA

1- Linear DNA

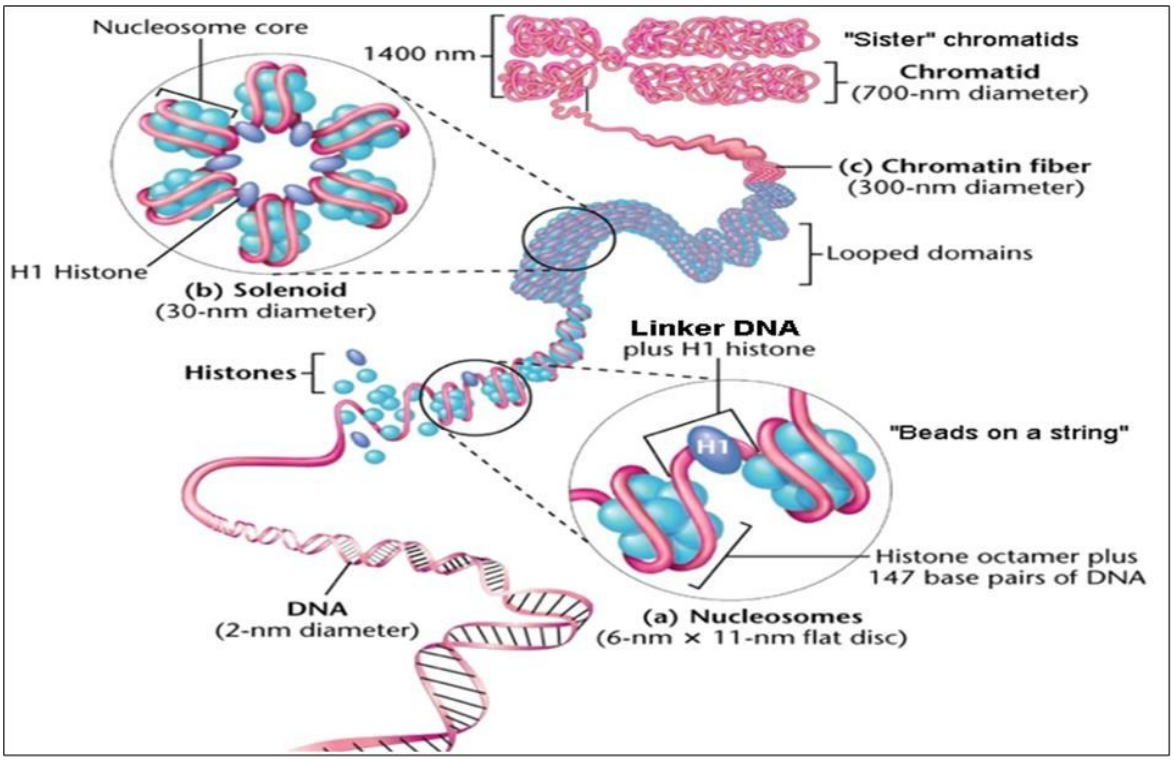
in nucleus of **eukaryotes** (including human cells) i.e. DNA of chromosomes

2- Circular DNA

i. in **eukaryotes**: mitochondria
ii. in **prokaryotic** chromosomes (nucleoid of bacteria)
iii. in **plasmids of bacteria** (extrachromosomal element)
iv. in **plant** chroroplasts

DNA packaging

- The pross of DNA compaction is supercoiling.
- In the first level of compaction, short stretches of the DNA double helix wrap around a core of eight molecules of histone proteins called a nucleosome, and DNA connecting the nucleosomes is called linker DNA.
- The second level of compaction occurs as the six nucleosomes and the linker DNA between them are coiled into a 30-nm call solenoid.
- In the third level of packing, a variety of fibrous proteins is used to pack the chromatin fiber
- The fourth level of packing is chromatids, the chromosomes have two sister chromatids both of them form chromosome the final level of packing.



DNA packaging

- There are three types of **Chromatin** (a complex of DNA and protein found in eukaryotic cells)
  1. **Euchromatin** is a lightly packed form of chromatin about 30 nm.
  2. **scaffold loop** is a medium packed form of chromatin about 300 nm.
  3. **Heterochromatin** is a tightly packed form of DNA or condensed DNA about 700 nm.

Table 1:The differences between Heterochromatin and Euchromatin

Heterochromatin	Euchromatin
More condensed	Less condensed
Diameter 700 nm	Diameter 30 nm
Gene poor (high AT content)	Gene rich (higher GC content)
Stains darker	Stains lighter

3- RNA

•Structure of RNA

- **Building units**: **Polynucleotides (bound together by PDE)**
- **Single strand**
- **Linear (but may fold into complex structure)**
- **with two ends**: **5`(phosphate) & 3`(-OH end)**
- **Sugar**: **Ribose**
- **Purine bases**: **Adenine & Guanine**
- **Pyrimidine bases**: **Cytosine & Uracil**

Difference between DNA and RNA are:

DNA	RNA
It is double stranded nucleic acid.	It is single stranded nucleic acid.
It contains deoxyribise sugar.	It contains ribose sugar.
It contains Thymine (T) as a nitrogenous base.	It contains Uracil (U) instead of Thymine.
It is the genetic and hereditary material of the cells.	It is involved in synthesis of proteins.
It is present in the nucleus of the cells.	It is present in both nucleus and cytoplasm.