Lab-2
Basic Concepts of Molecular biology (DNA, RNA & protein sequences)

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كلية المعلوماتية الطبية الحيوية

قسم الانظمة الطبية الذكية

Prokaryotic and Eukaryotic cells

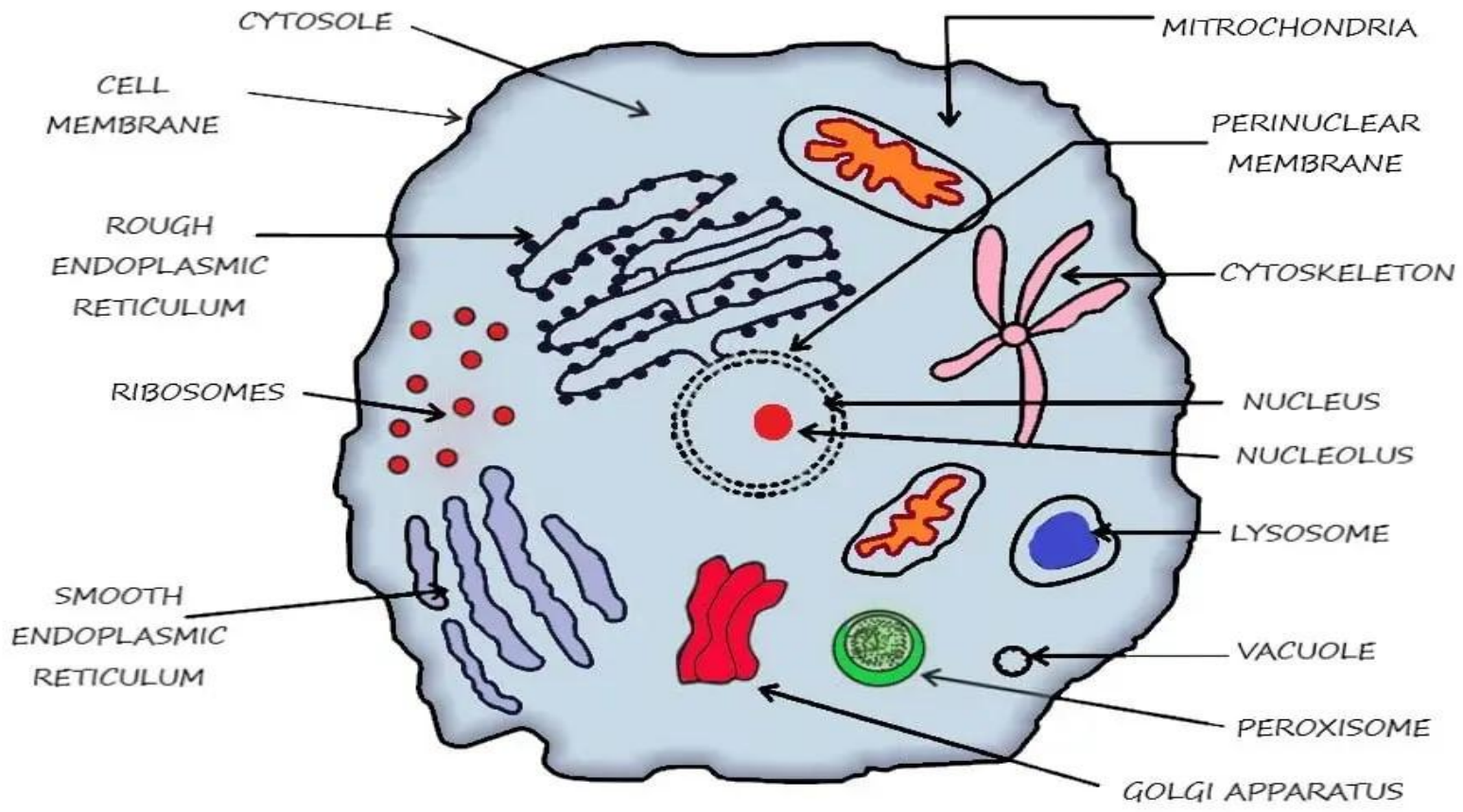
- Eukaryotes: Organisms whose cells contain compartments or organelles within the cell, such as mitochondria and nucleus
  - Animals, plants
- Prokaryotes: Whose cells do not have these organelles (e.g. bacteria)
  - Most prokaryotes have a smaller genome, typically contained in a single circular DNA molecule.
  - Additional genetic information may be contained in smaller satellite pieces of DNA called plasmids

What is Eukaryotic Cell?

- The cell is the basic structural and functional unit of any living being. It is the fundamental building block, which when combined with similar cells forms a tissue and organs. A cell comprises several organelles:
- Cytoplasm
- Cytoskeleton
- Endoplasmic reticulum (ER)
- Golgi apparatus
- Lysosomes and peroxisomes
- Mitochondria
- Nucleus
- Plasma membrane
- Ribosomes

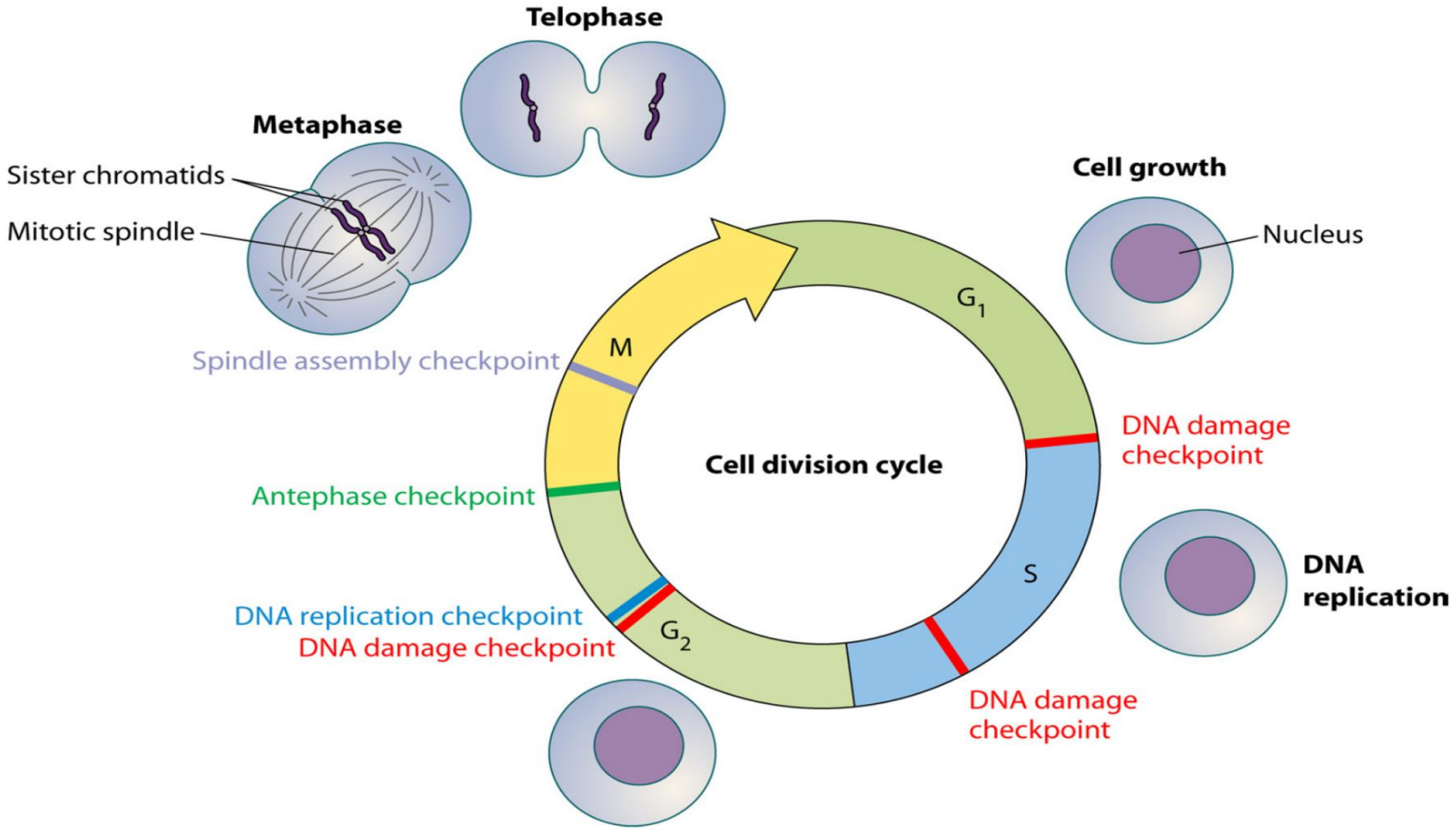
The Cell

- the **cell** is the basic structural and functional unit of all forms of life.



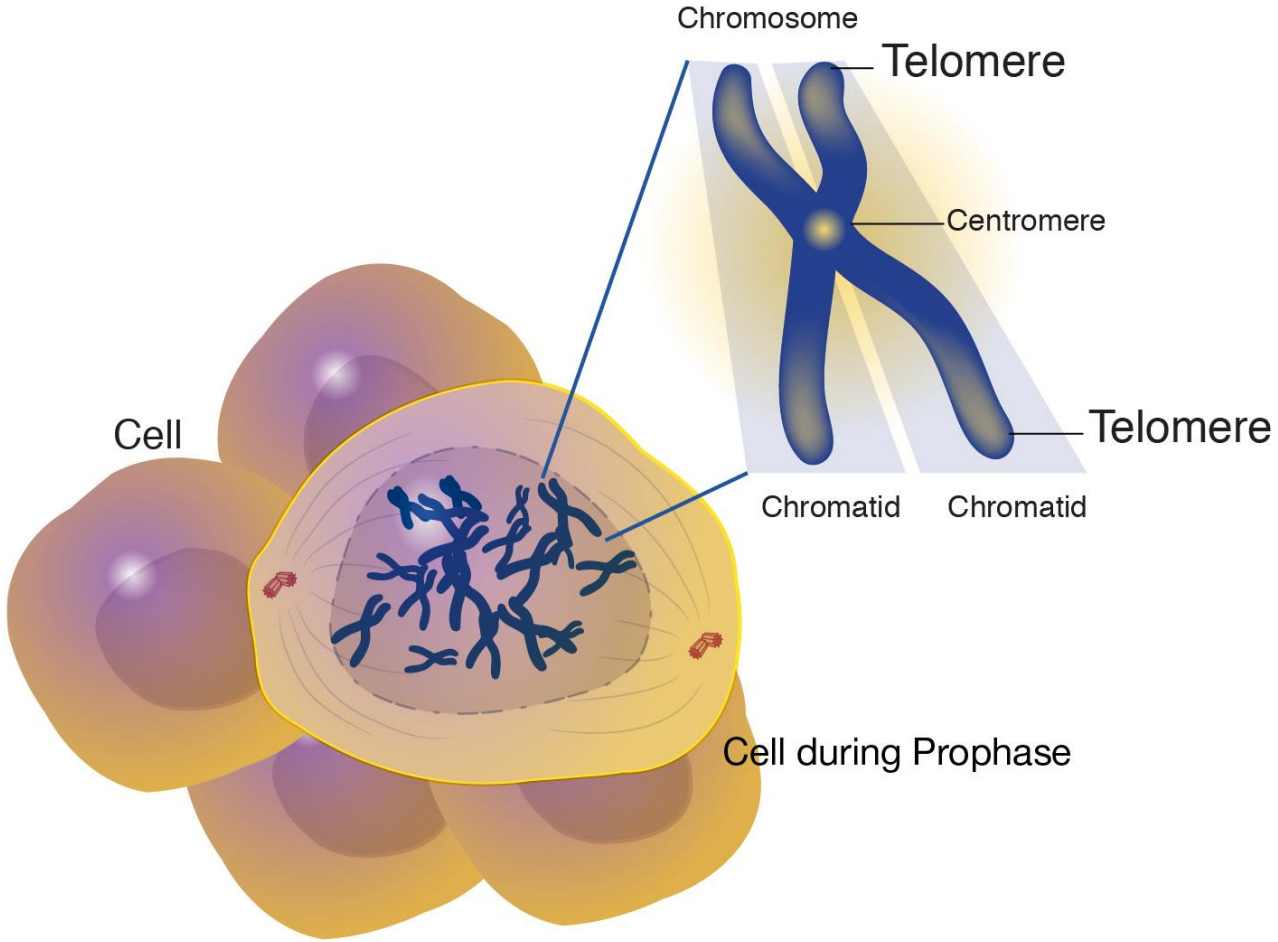
Cell cycle

“Cell cycle refers to the series of events that take place in a cell, resulting in the duplication of DNA and division of cytoplasm and organelles to produce two daughter cells.”



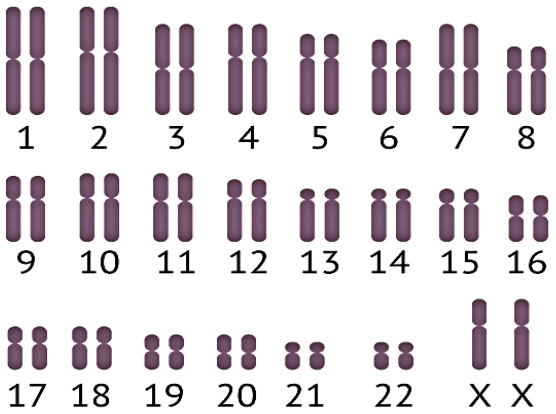
Cell and chromosome

- **chromosomes are the structures that hold genes.**

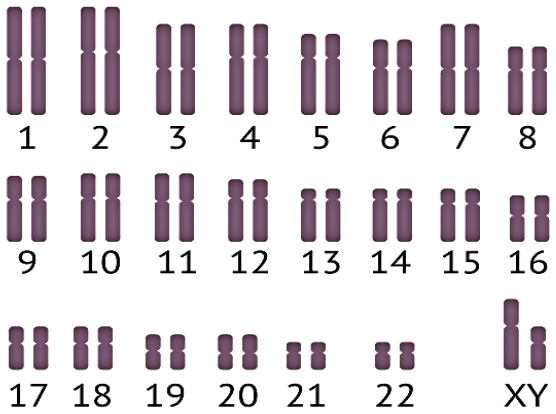


Cell and chromosome

- **the word chromosome was originally coined in german from the greek words chroma, meaning colour, and soma meaning body.**
- **chromosomes are the structures that hold genes.**
- **karyograms are images of real chromosomes**



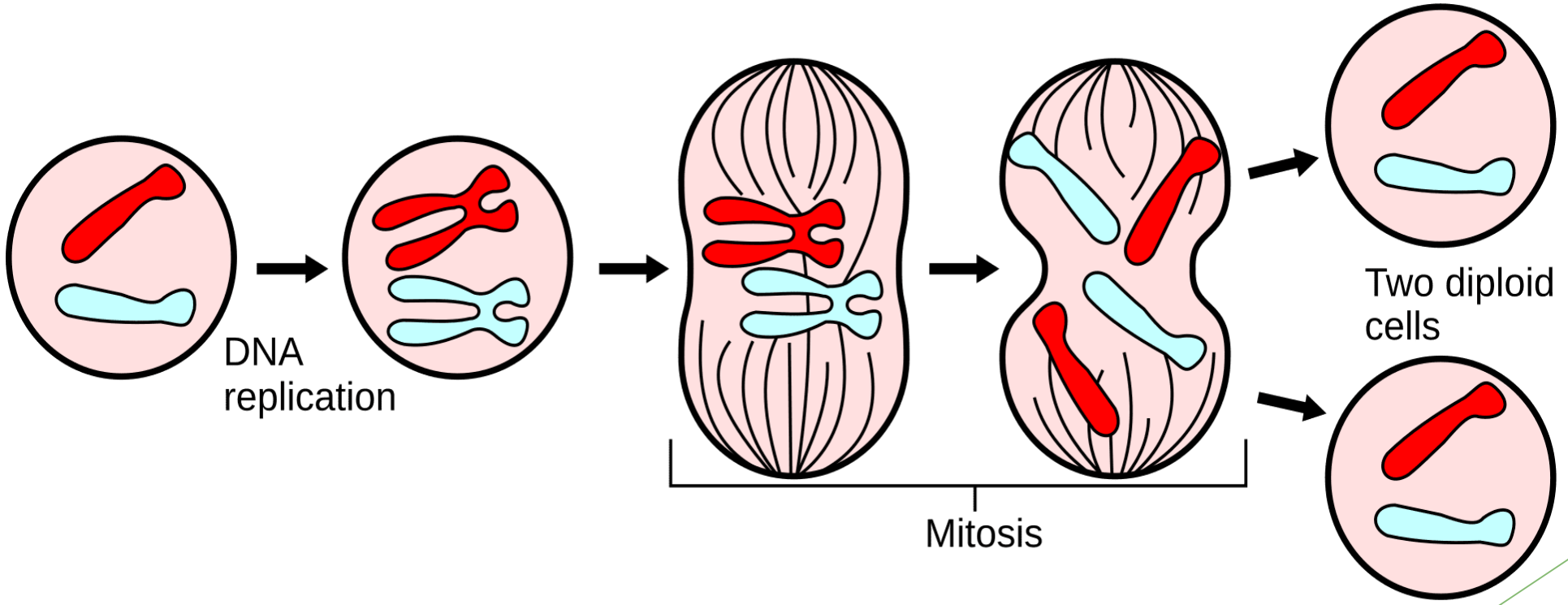
Female karyotype



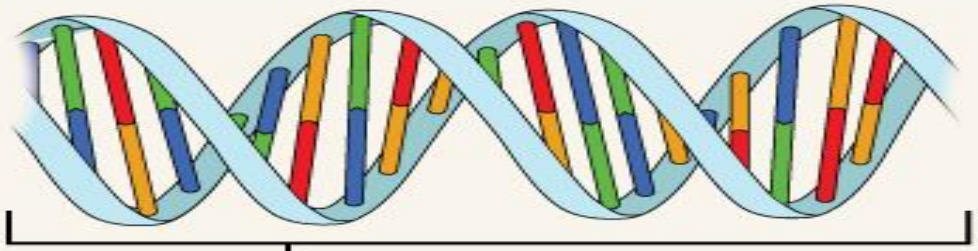
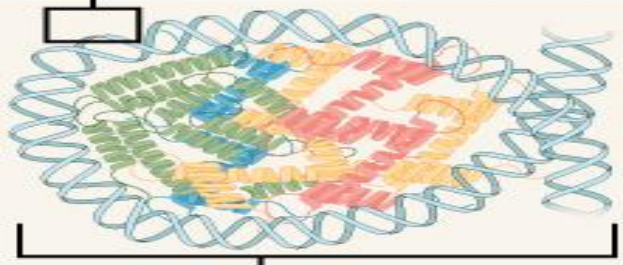
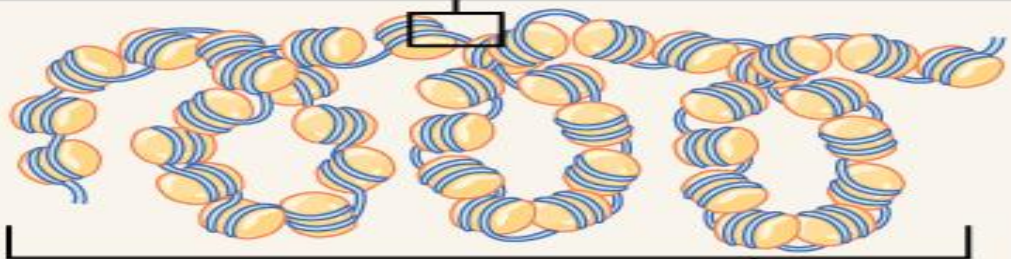
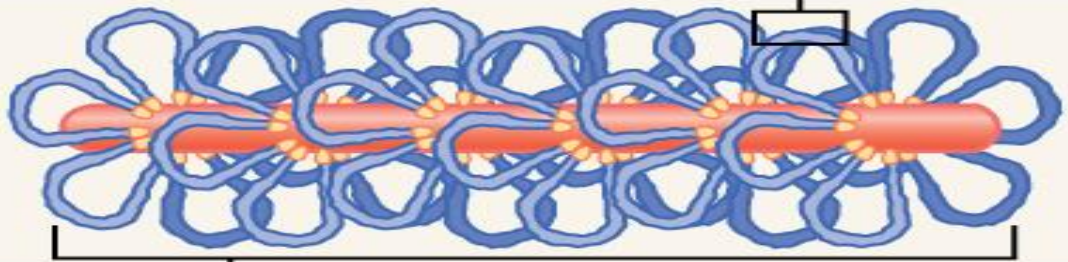
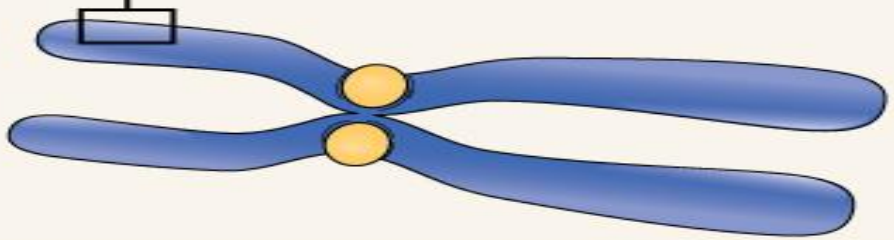
Male karyotype

MITOSIS

the process by which a cell replicates its chromosomes and then segregates them, producing two identical nuclei in preparation for cell division.

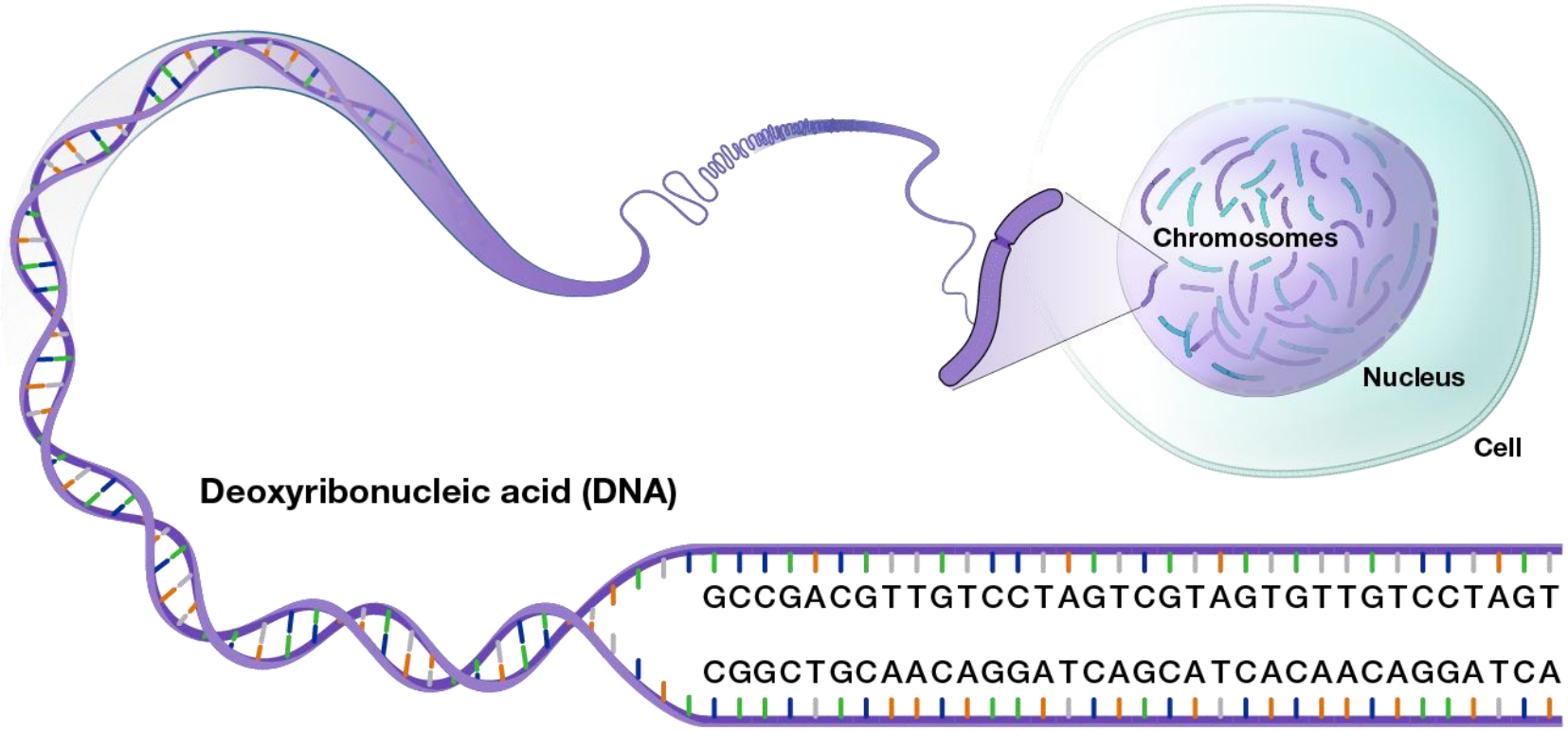


Organization of Eukaryotic Chromosomes

DNA double helix	
DNA wrapped around histone	
Nucleosomes coiled into a chromatin fiber	
Further condensation of chromatin	
Duplicated chromosome	

What is gene?

Genes are made of DNA sequence (deoxyribonucleic acid)



Structure of DNA

- Made up of 4 different building blocks (so called nucleotide bases), each an almost planar nitrogenic organic compound
  - Adenine (A)
  - Thymine (T)
  - Guanine (G)
  - Cytosine (C)
  - Base pairs (A -- T, C -- G)

NUCLEIC ACIDS

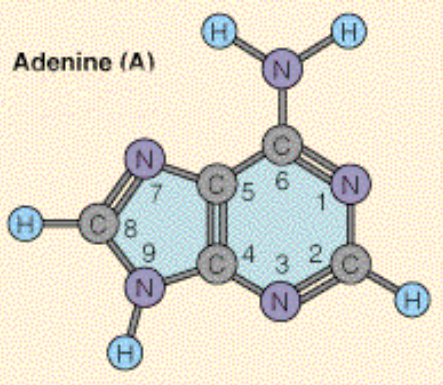
- Nucleic acids are polymers
- Monomer---nucleotides
  - Nitrogenous bases
    - **Purines**
    - **Pyrimidines**
  - Sugar
    - **Ribose**
    - **Deoxyribose**

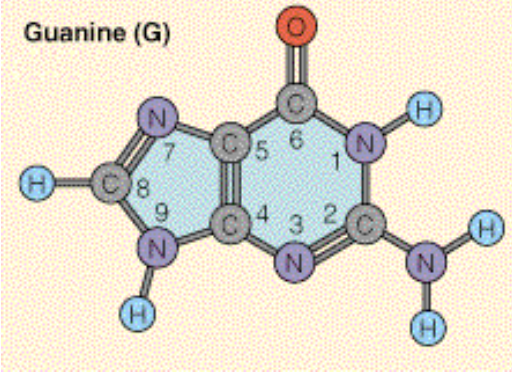
} Nucleosides

  - Phosphates
    - +nucleoside=nucleotide

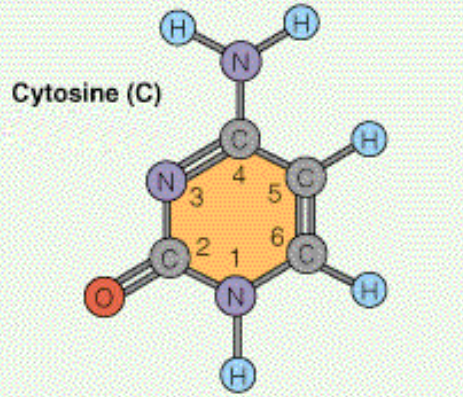
Bases of DNA (and RNA)

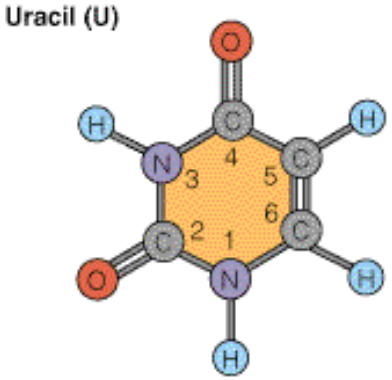
Purines:



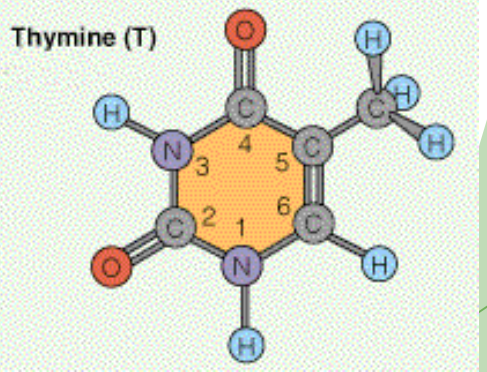


Pyrimidines:



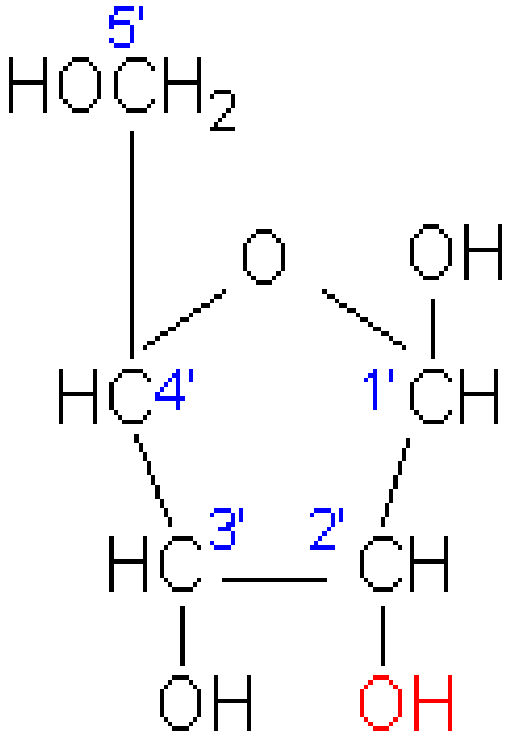


RNA only

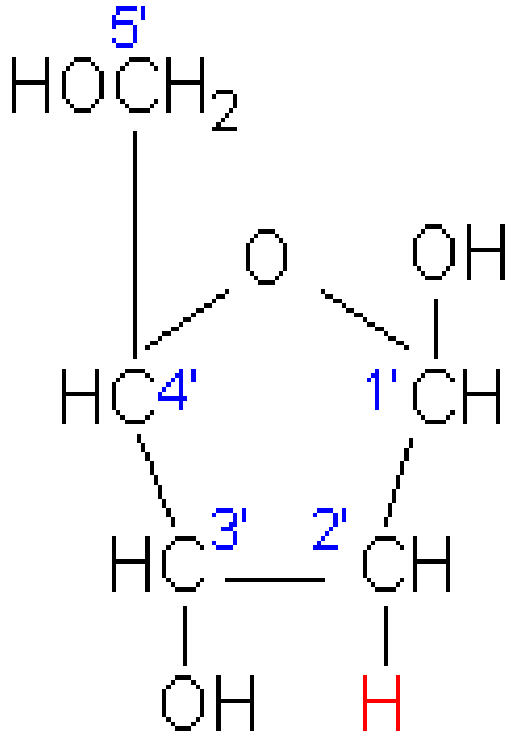


DNA only

The Sugars



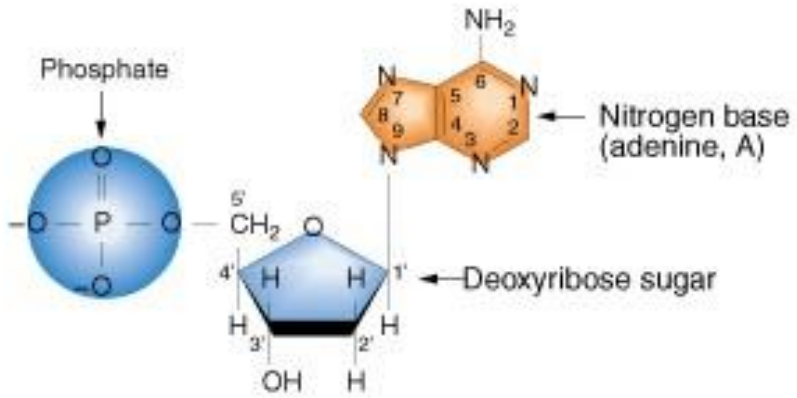
Ribose
(in RNA)



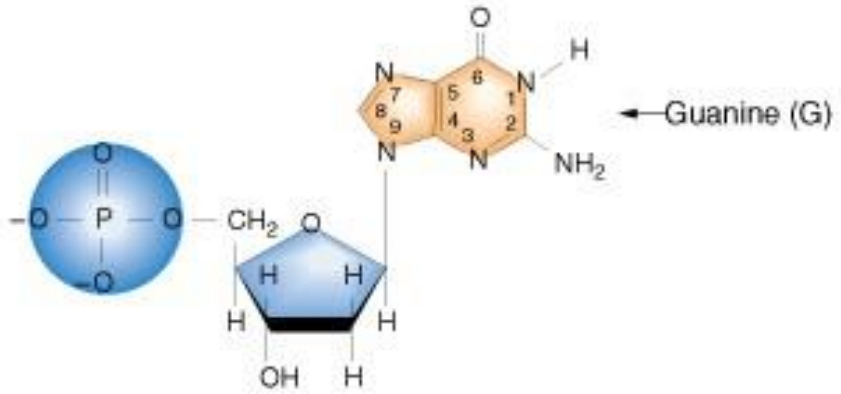
2'-Deoxyribose
(in DNA)

Nucleotides and Nucleosides

Purine nucleotides

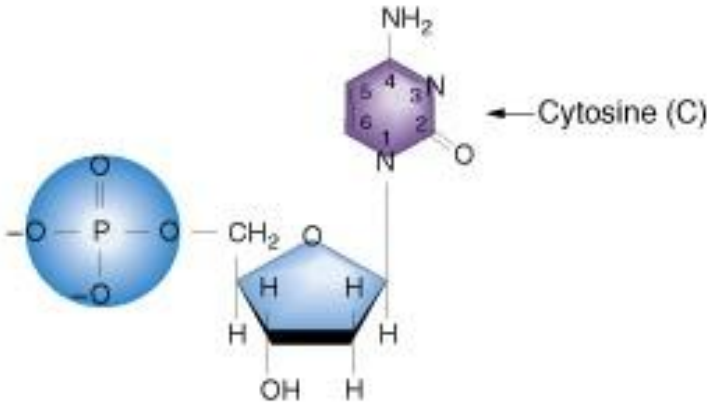


Deoxyadenosine 5'-phosphate (dAMP)

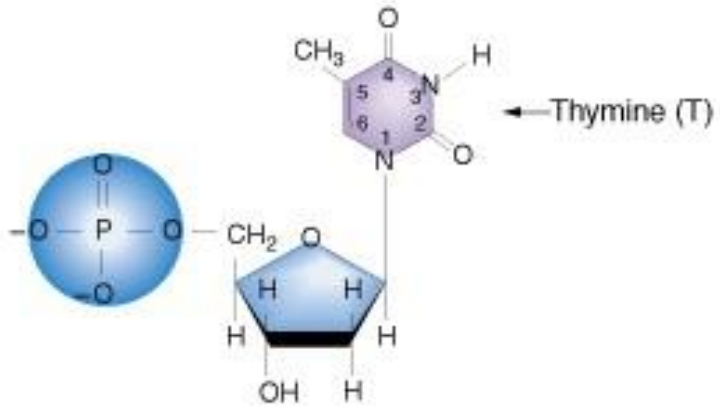


Deoxyguanosine 5'-phosphate (dGMP)

Pyrimidine nucleotides



Deoxycytidine 5'-phosphate (dCMP)



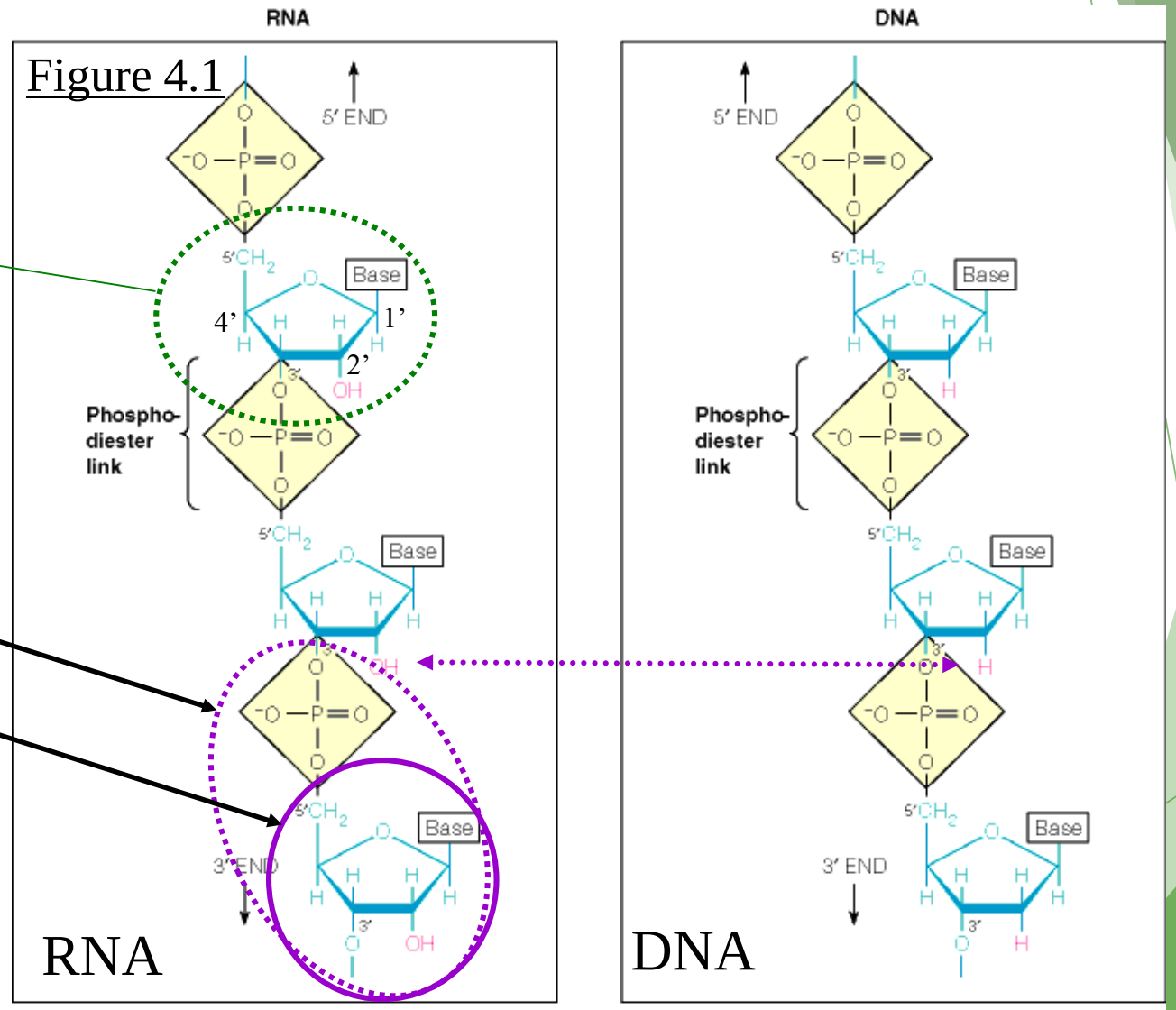
Deoxythymidine 5'-phosphate (dTMP)

Chemical Structure of DNA and RNA

The C is named 1'-5'

Nucleotide

Nucleoside



Nucleotides and Nucleosides

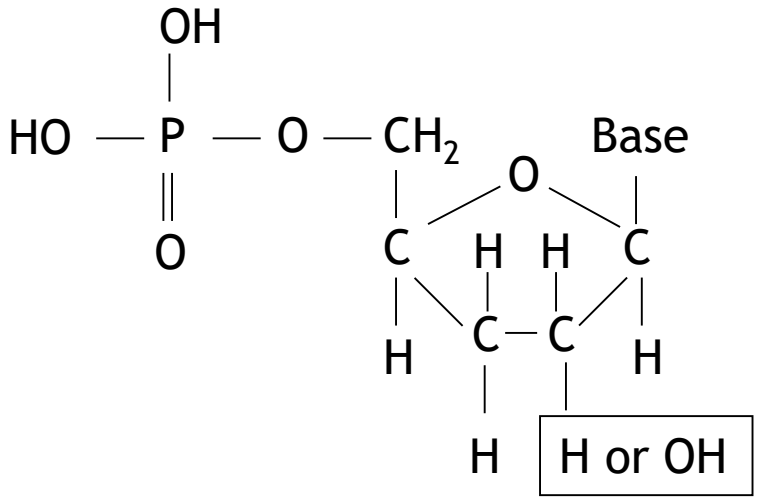
BASE	NUCLEOSIDE	DEOXYNUCLEOSIDE
Adenine	Adenosine	2-deoxyadenosine
Guanine	Guanosine	2-deoxyguanosine
Cytosine	Cytodine	2-deoxycytodine
Uracil	Uridine	Not usually found
Thymine	Not usually found	2-deoxythymidine

Nucleotides are nucleosides + phosphate

Nucleic Acids

make up 13-34% of the dry weight in bacteria
deoxyribonucleic acid (DNA) and ribonucleic acid (RNA)

Nucleotide: a building block



Nucleoside: base + sugar

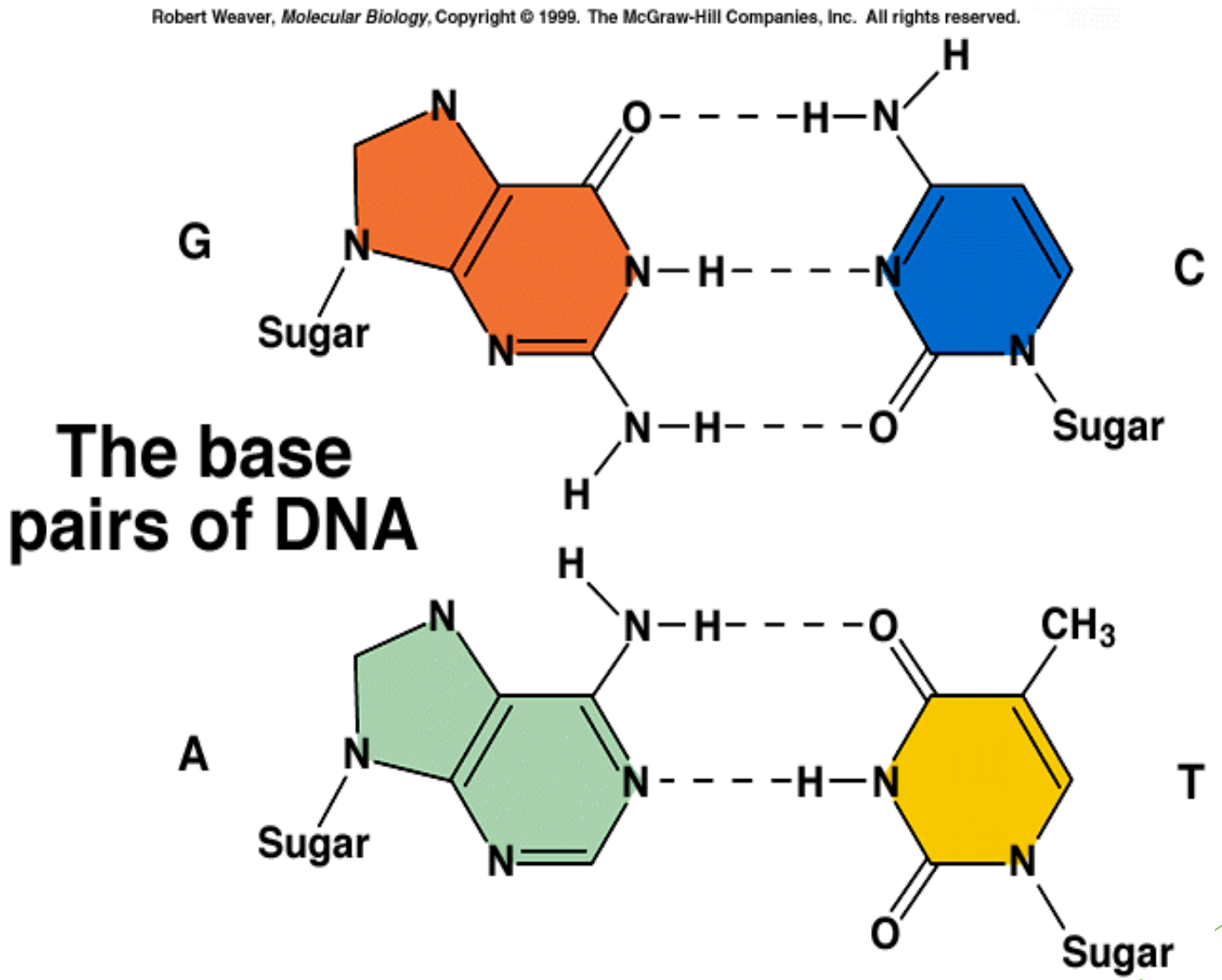
Sugar:
- RNA – ribose (OH)
- DNA – deoxyribose (H)

Bases:
- adenine (A), cytosine (C), guanine (G), thymine (T)
- RNA uses uracil (U) instead of thymine

- certain nucleotides serve as a storage of energy and reducing power
  e.g. **ATP -> ADP -> AMP**

hydrolysis (energy is released)

DNA Stabilization- Complementary Base Pairing

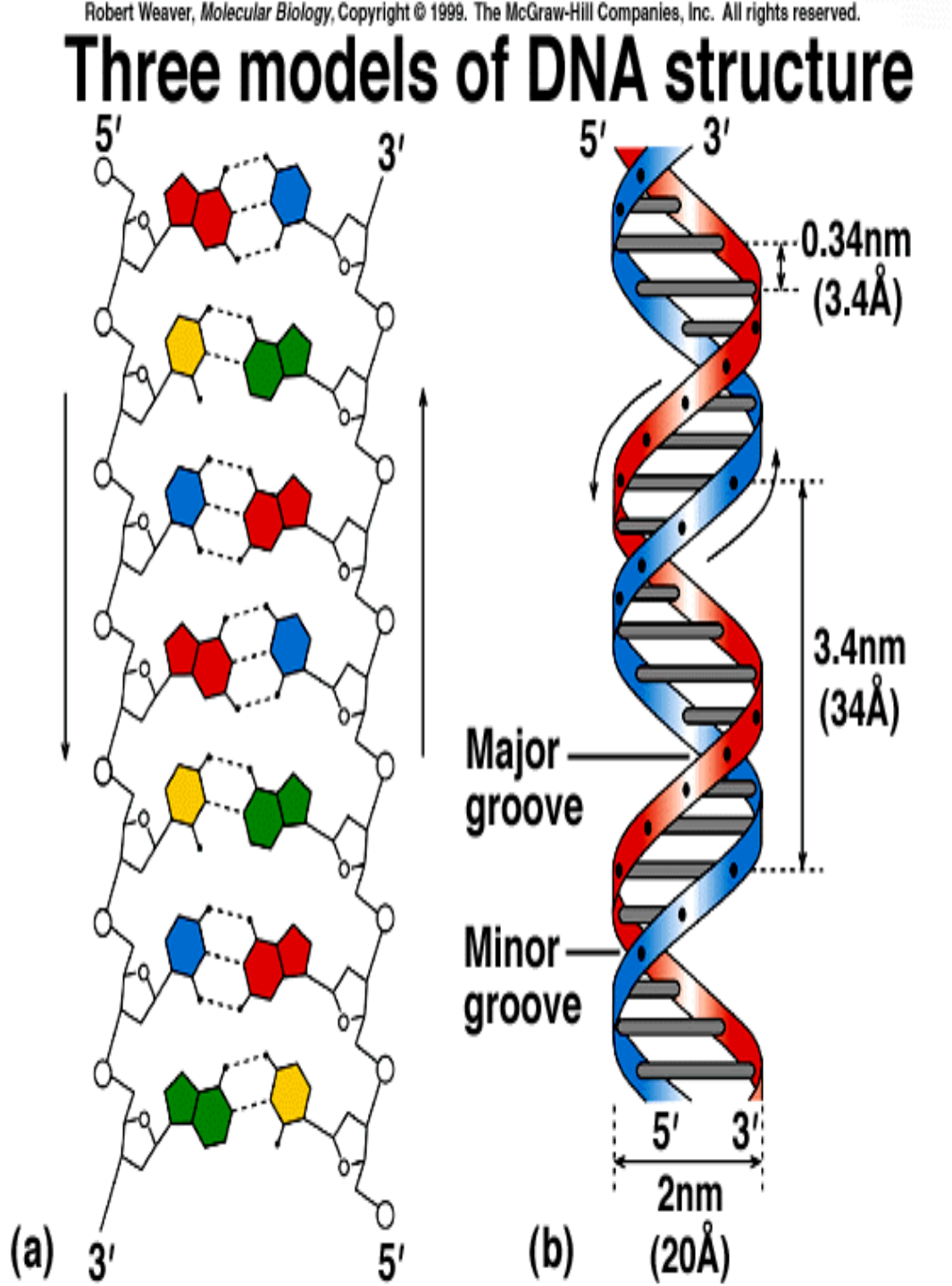


Advantages to Double Helix

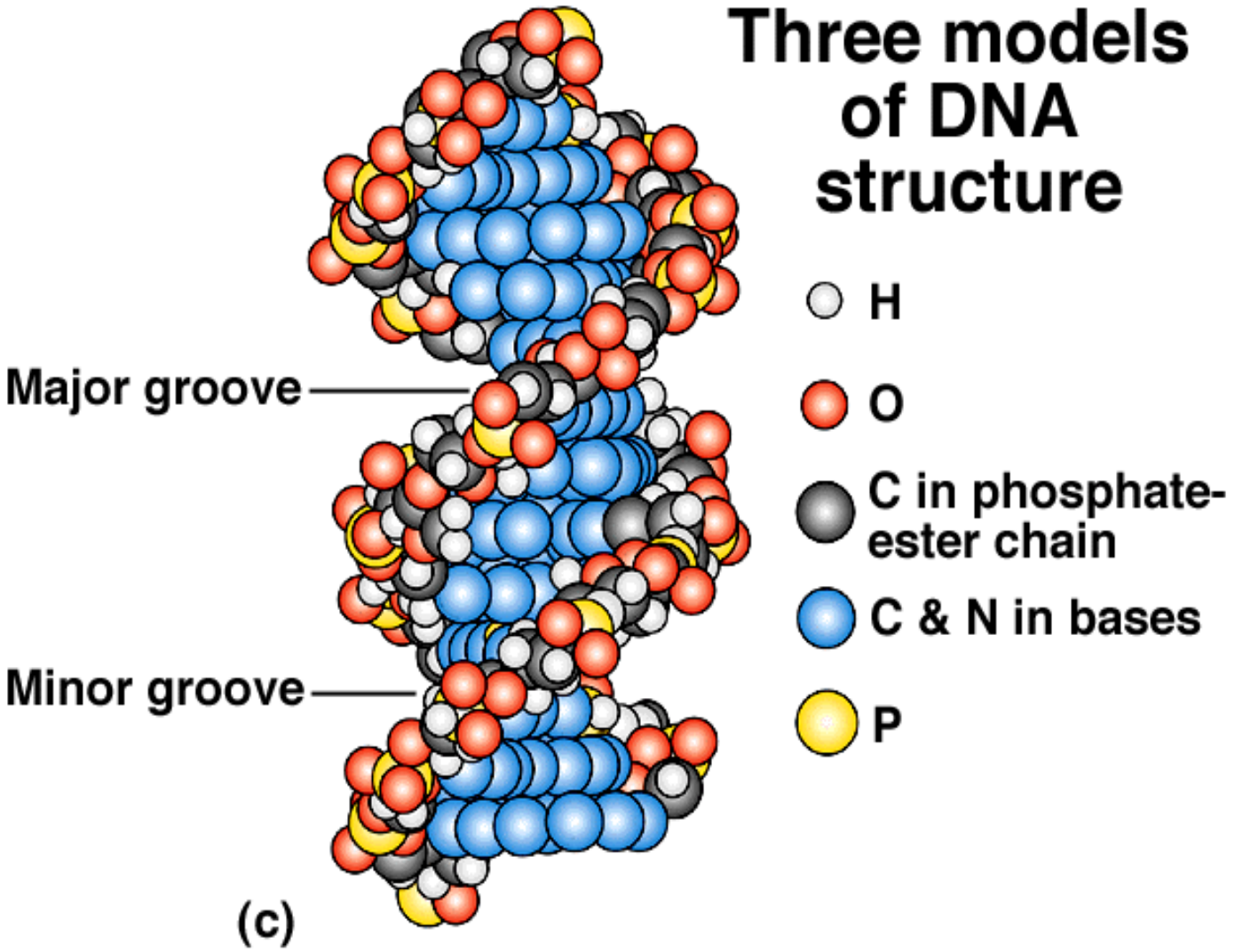
- Stability---protects bases from attack by H_2O soluble compounds and H_2O itself.
- Provides easy mechanism for replication

Physical Structure

- Chains are anti-parallel (i.e in opposite directions)
- Diameter and periodicity are consistent
  - 2.0 nm
  - 10 bases/ turn
  - 3.4 nm/ turn
- Width consistent because of pyrimidine/purine pairing

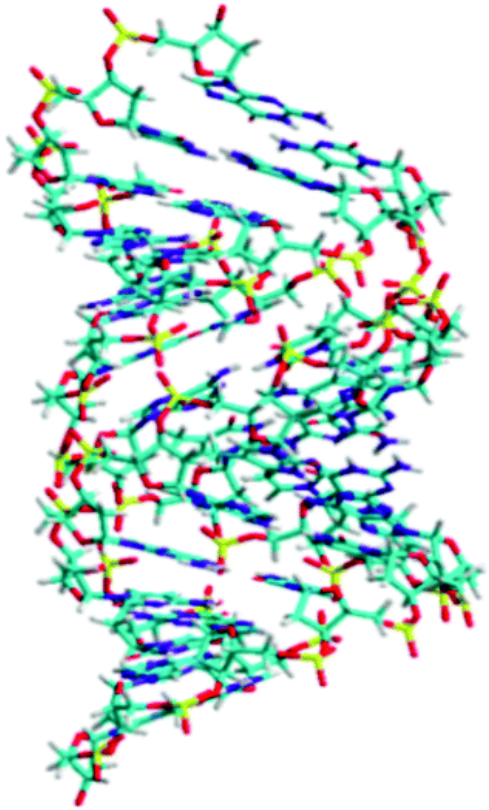


Physical Structure

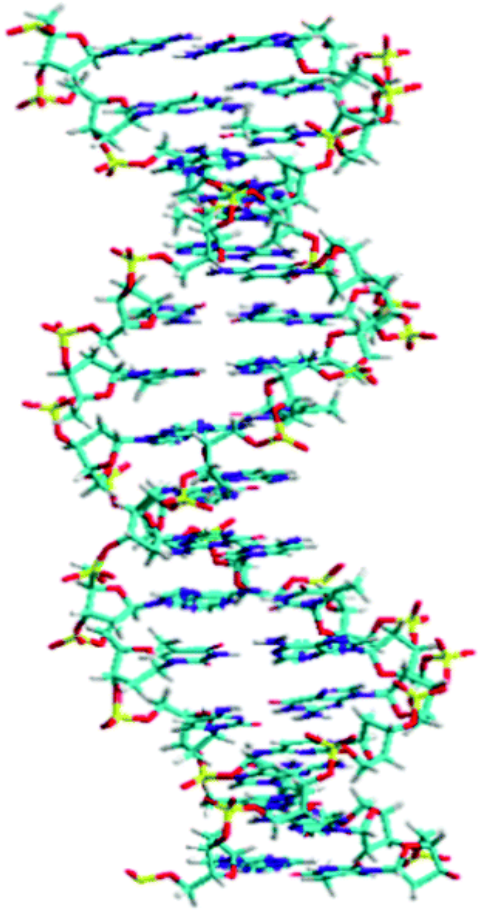


FORMS OF DNA

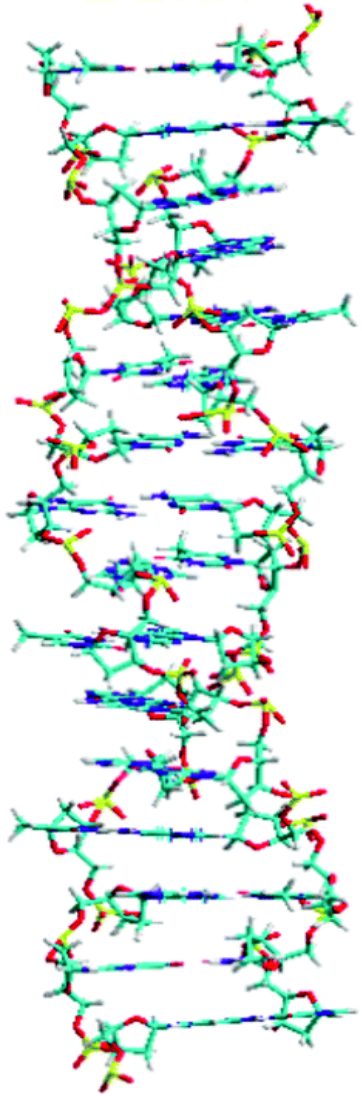
A-DNA



B-DNA



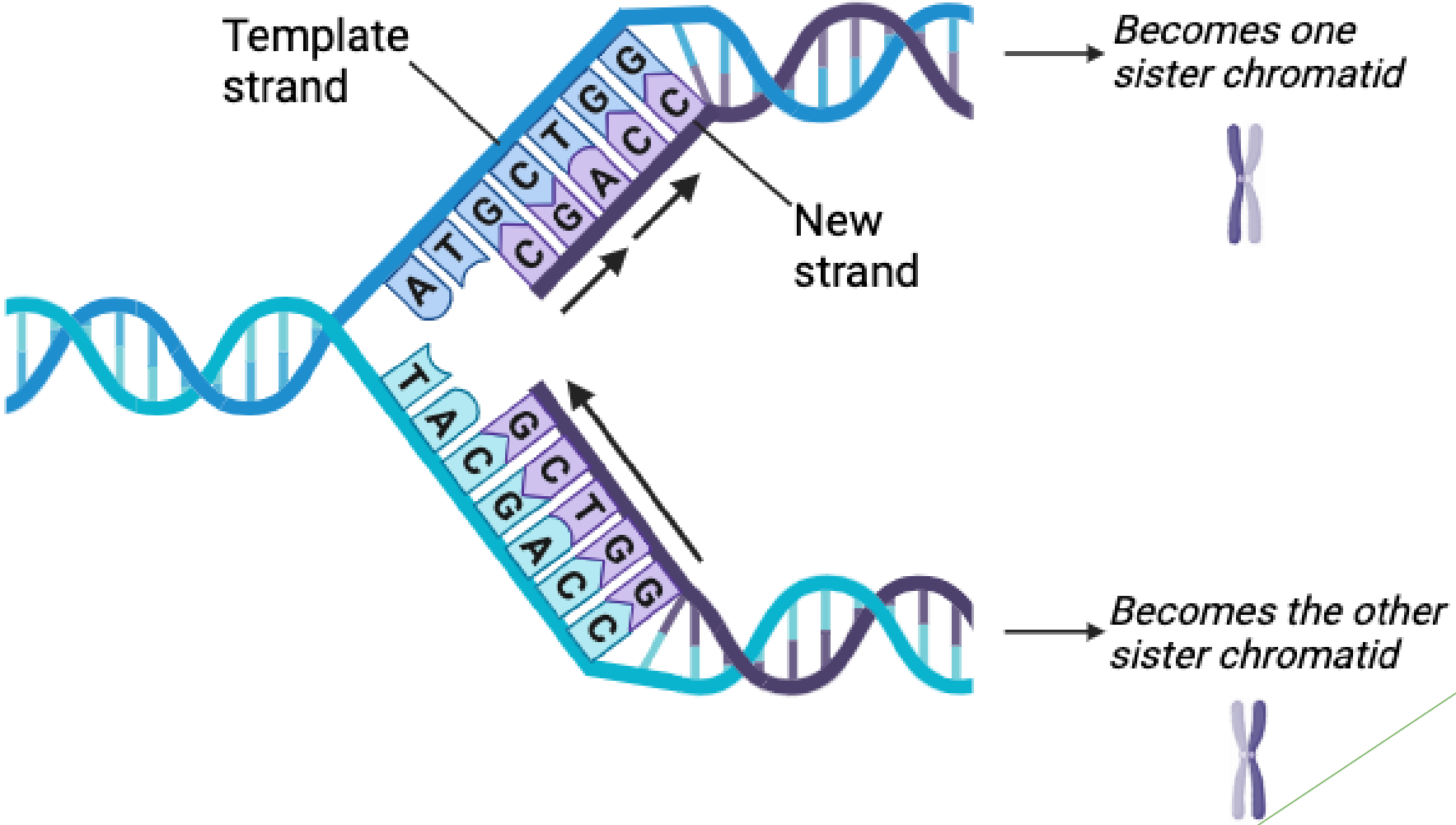
Z-DNA



Cells, genome, gene and DNA

- Almost all cells of a living organism contain an identical set of codes describing the genes and their regulation
- This code is encoded as one or more strands of DNA
- Cells from the different parts of an organism have the same DNA
- Genome: entire complement of DNA molecules of each organism
- Overall function of genome: Control the generation of molecules (mostly proteins) that will
  - Regulate the metabolism of a cell and its response to the environment, and
  - Provide structural integrity.

DNA replication



Branches Of Bioinformatics

- A living cell is a system where cellular components such as genome, the gene transcript, and the proteins interact with each other, and these interactions determine the fact of the cell. e.g Whether a stem cell is going to become a liver cell or a cancer cell.

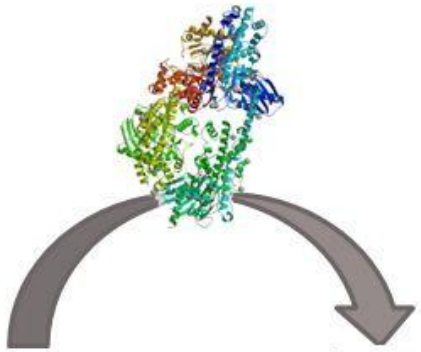
The three branches of bioinformatics...

- 1. Genomics
- 2. Transcriptomics
- 3. Proteomics

The World of Omes

DNA

mRNA



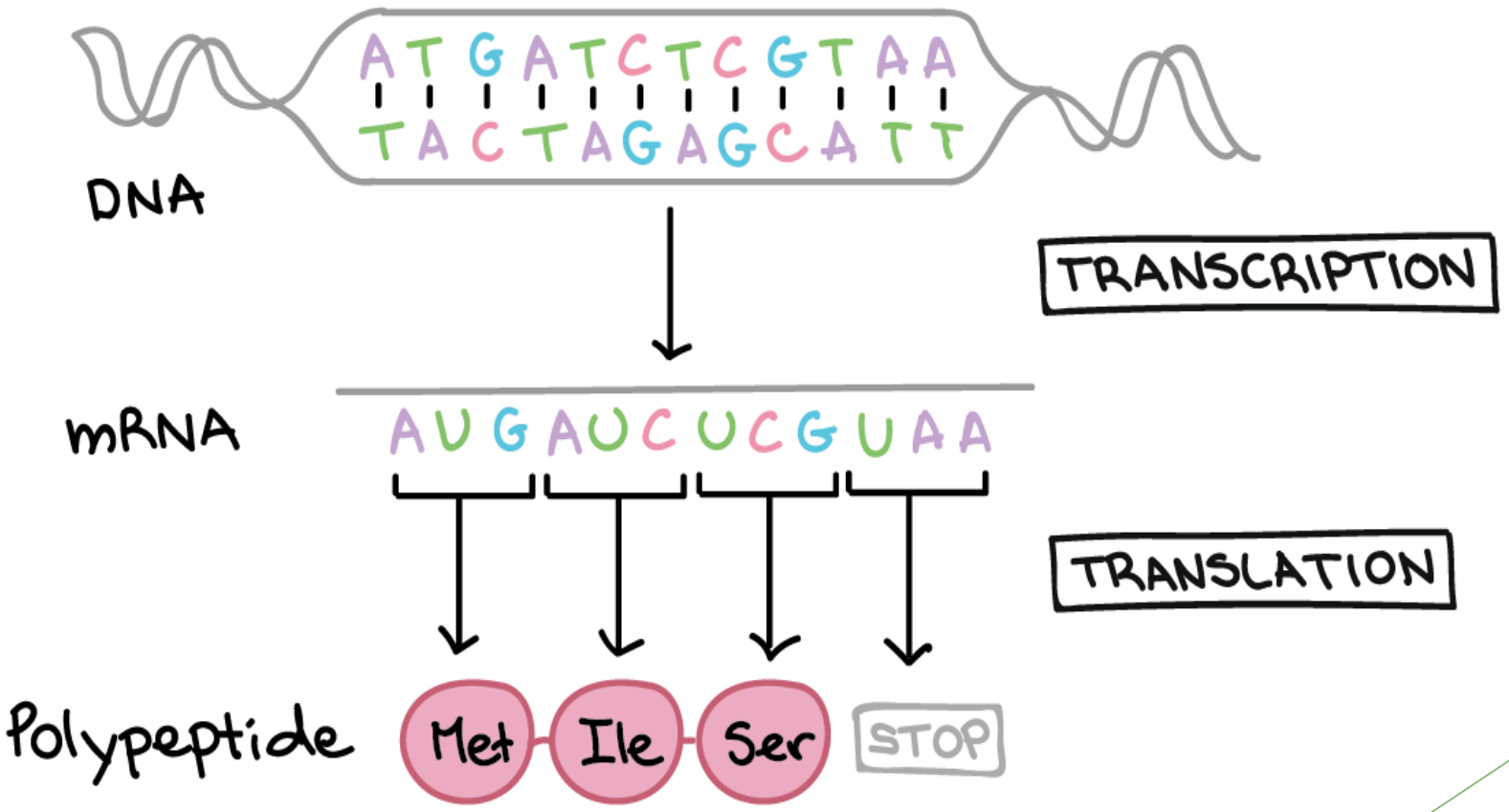
Protein

Metabolites

http://www.pdb.org/pdb/images/2nzt_bio_r_500.jpg

- Genome
- Transcriptome
- Proteome
- Metabolome

THE CENTRAL DOGMA



Genomics

- Genomics play a significant role in modern biological research in which the nucleotide sequences of all the chromosomes or an organism are mapped and the location of different genes and their sequence are determined.
- This involves extensive analysis of the nucleic acids through molecular biology techniques before the data are ready for processing by Computer.
- It is a science that attempts to describe a living organisms in terms of the sequence of its genome.

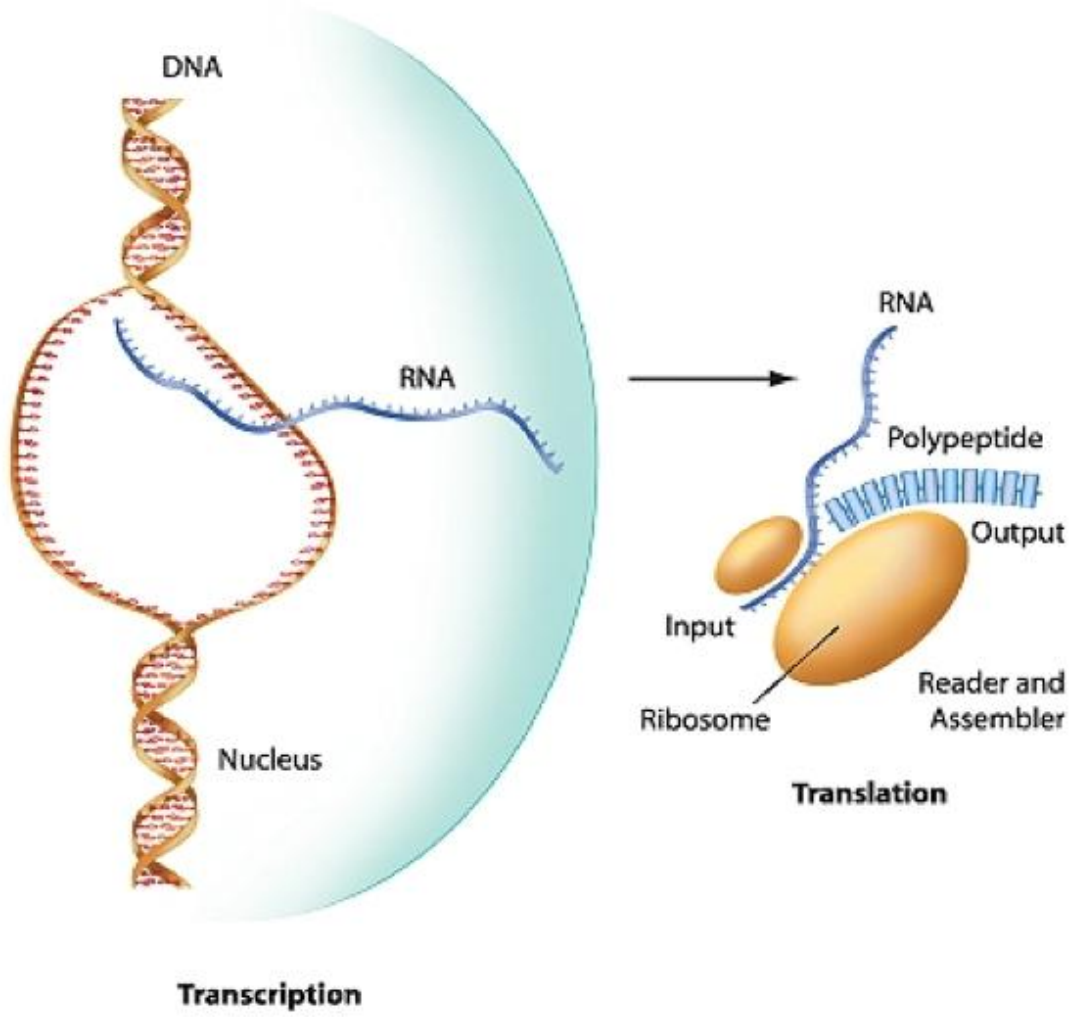
Genomics

- genomics uses technique of molecular biology and bioinformatics to identify cellular components such as proteins & rRNA, and analyse the sequences attributed to the structural genes regulatory sequences, and non-coding sequence.
- The first automatic DNA sequencer was developed in 1986 by Leroy Hood.
- *Haemophilus influenzae* was the first bacterium to be sequenced in 1995.
- A human genome contains about 30,000 to 60,000 protein coding genes, but only a subset of them is expressed in a particular cell type at a particular time.

TranscriptOmics

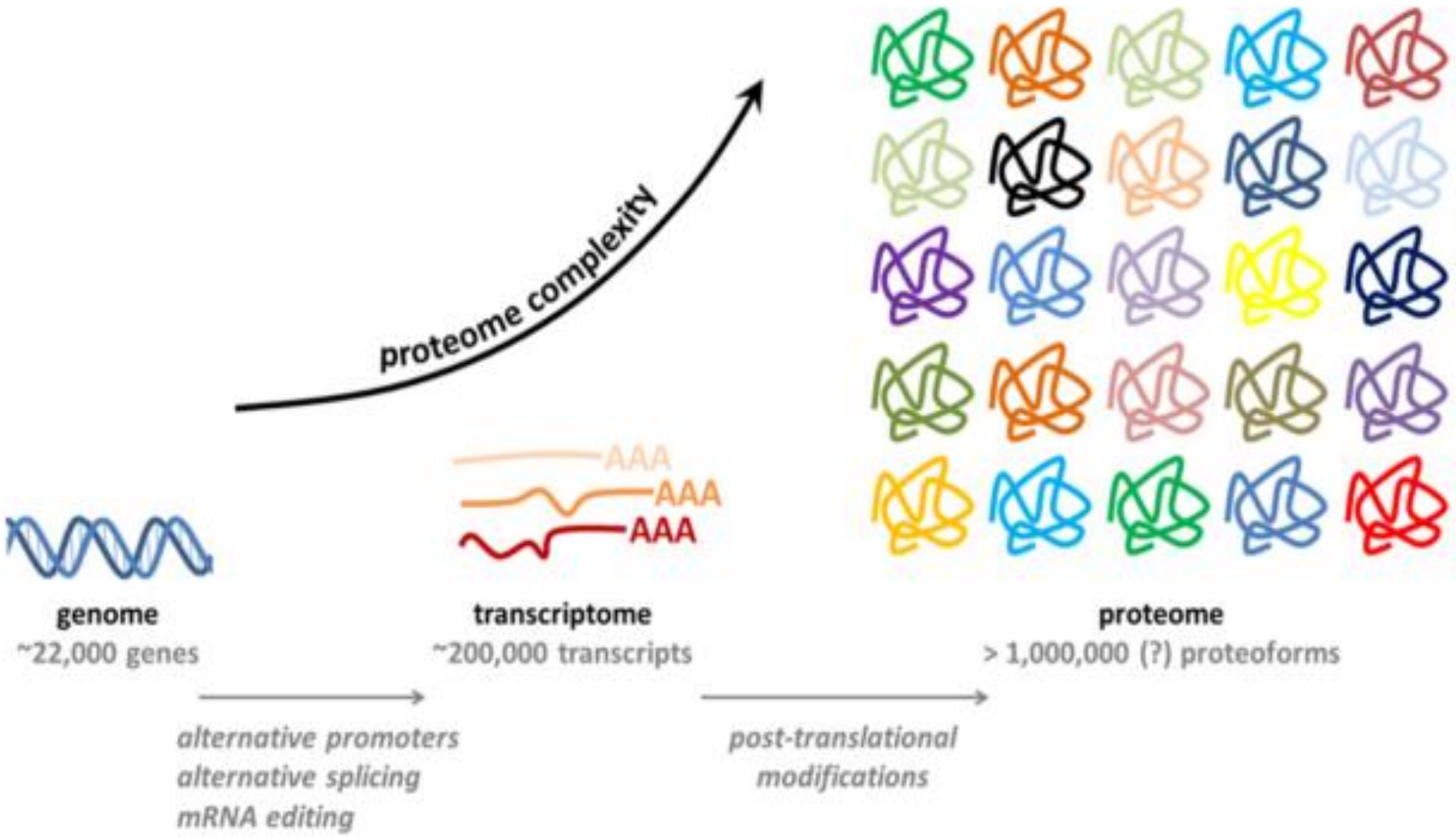
- Transcriptomics is the study of the transcriptome, which includes the whole set of mRNA molecules in one or a population of biological cells.
- This study helps us to know the expression level of genes which helped biologists to routinely monitor the gene expression between the control cells and treatment cells.

Central dogma



Proteomics:

- Proteomics represents the earliest to identify a major sub- class of cellular components, the proteins and their interactions also determining its 3D structure and relating it to the function of the protein.
- Before computer processing comes into the picture, extensive data, particularly through crystallography and nuclear magnetic resonance (NMR).
- Metabolic proteins such as haemoglobin and insulin have been subjected to intensive proteomic investigation.
- The term 'proteomics' was coined to make an analogy with genomics.
- Scientists feel that the bioinformatics of proteins is crucial, to understands the cellular components and the interactions completely.


proteome complexity
AAA
AAA
AAA
genome
~22,000 genes
transcriptome
~200,000 transcripts
proteome
> 1,000,000 (?) proteoforms
alternative promoters
alternative splicing
mRNA editing
post-translational
modifications

Homework

- **Summarize the main differences between DNA & RNA**
- **Numerate the chemical bonds in DNA molecule and the location of each.**

I have a tool to detect ChatGPT answers 😂