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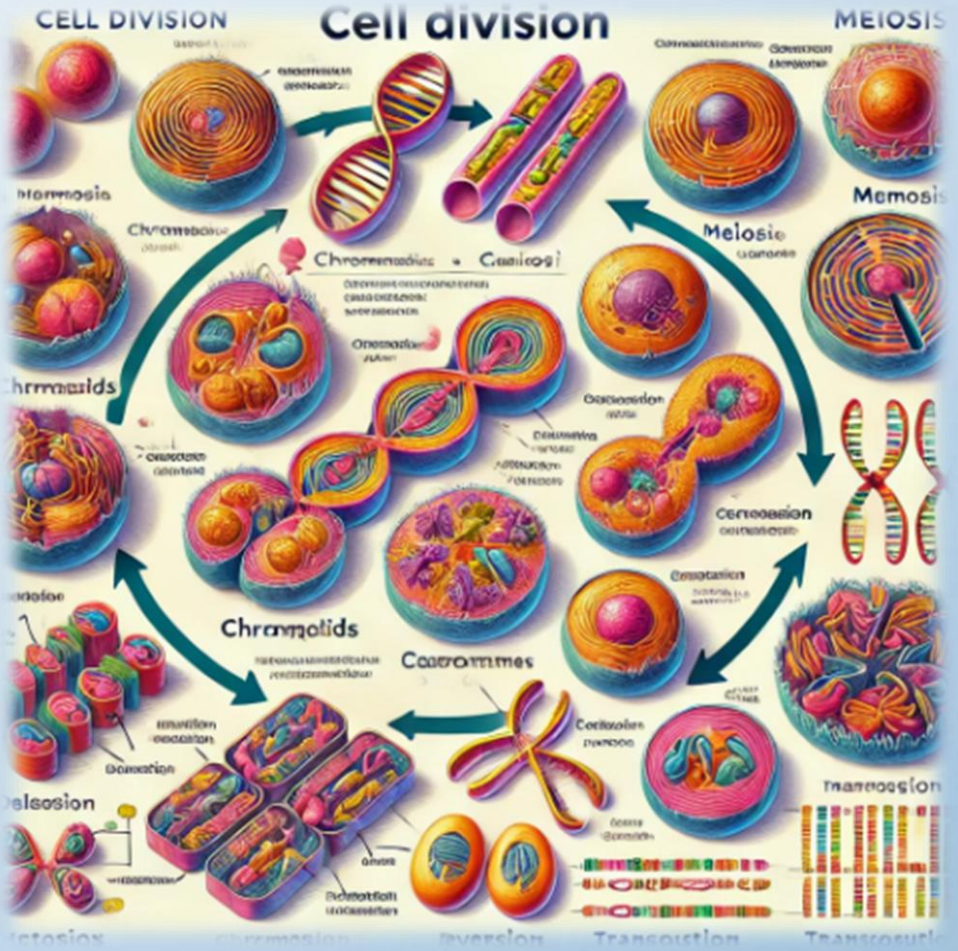
# Biological Science

## Module 1 Class 2

## Cell Division, Chromosome & Mutation

## GEN COM COE

Department of Bio Sc. & Environment

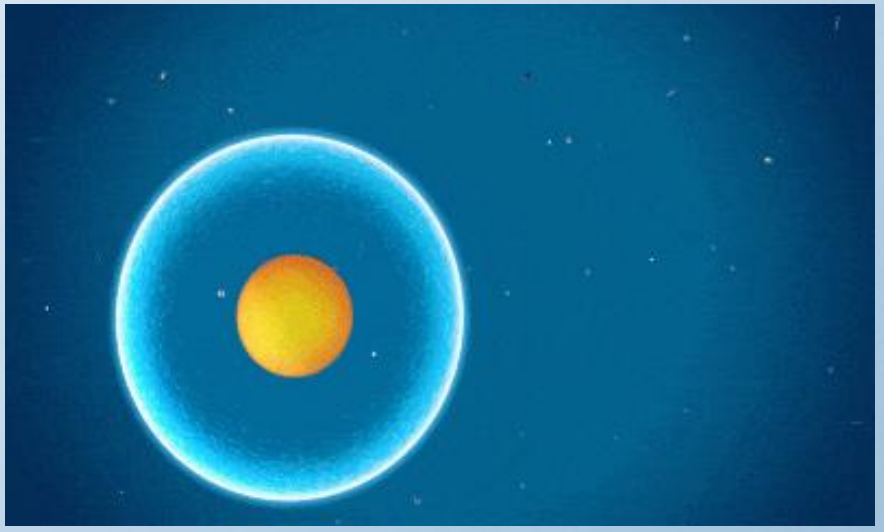


# Types of cell division

**There are three types of cell division**

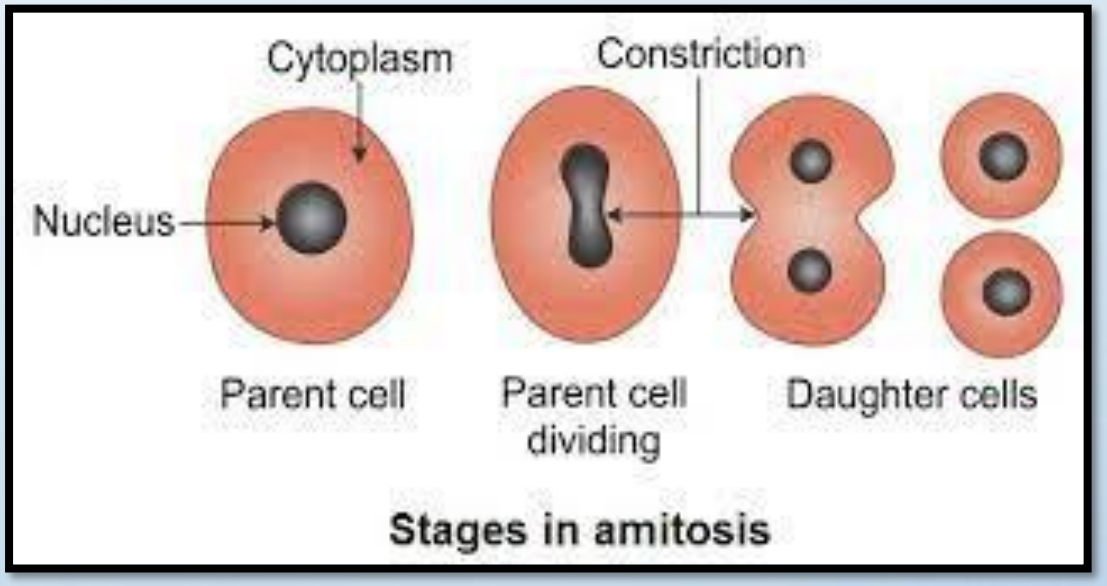
- **Amitosis** ✓ (No nucleus and cytoplasm division)
- **Mitosis** ✓
- **Meiosis** ✓

Without



# Amitosis

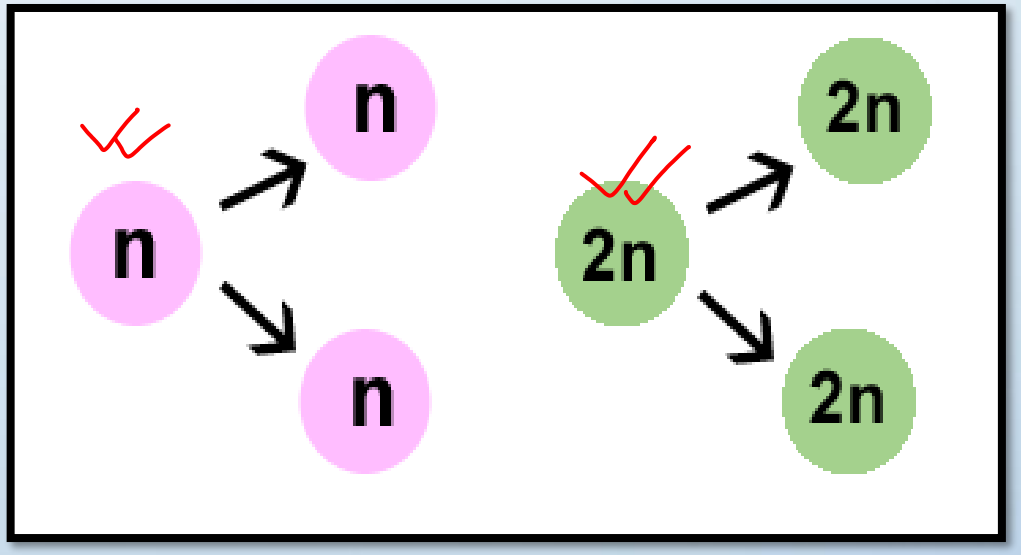
- Amitosis is the most simplest process of cellular division which majorly takes place in the lower organisms like bacteria.
- This type of cellular division is a **primitive type of division.**
- This is also known as **direct cell division.**



Stages in amitosis

# Mitosis

- In mitosis chromosome number in daughter cell is same as in parent cell, that's why it is called **Equational cell division**. / সমবিভাজন
- It is possible both in haploid as well as in diploid cell.



# Significance of Mitosis



1. **Growth and development**: Enables organisms to grow by increasing cell number.
2. **Tissue repair**: Replaces damaged or dead cells in tissues.
3. **Asexual reproduction**: Facilitates reproduction in unicellular and some multicellular organisms.
4. **Genetic stability**: Ensures daughter cells are genetically identical to parent cells.
5. **Regeneration**: Helps regenerate lost body parts in certain organisms.

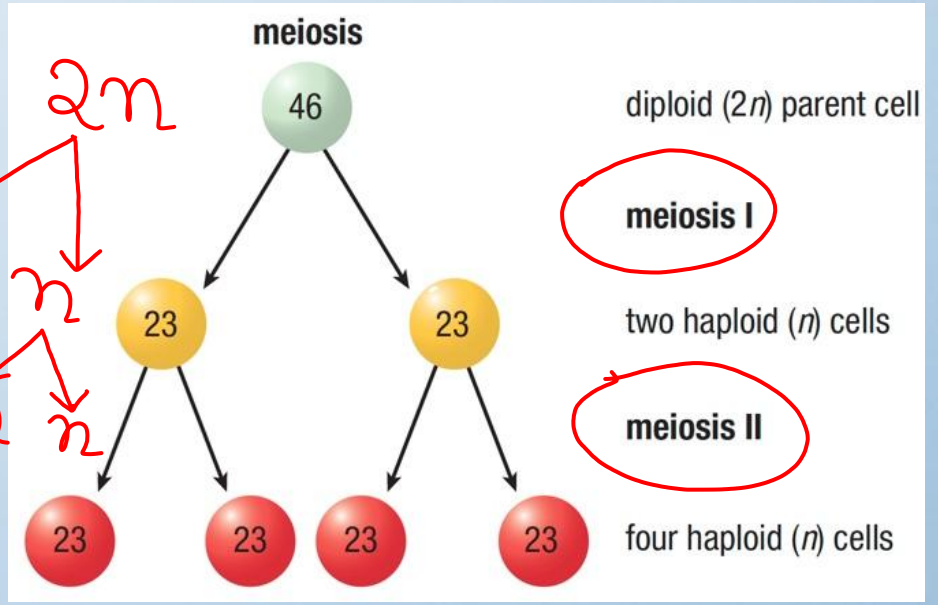
→ Autotomy

# Meiosis

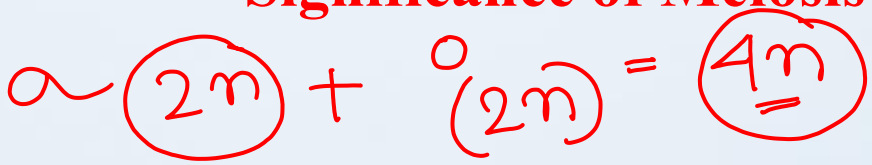
↳ হ্রাস বিভাজন।

- In meiosis chromosome number becomes half than the mother cell. That's why it is called **reductional cell division.**
- It is special type of cell division . Here cell divides twice. It composed of Meiosis I and meiosis II .**Meiosis II is just like mitosis.**
- **It is possible only in diploid cell**

$n \rightarrow \frac{1}{2}n$



# Significance of Meiosis



1. **Chromosome number reduction**: Halves the chromosome count to maintain stability across generations.
2. **Genetic diversity**: Promotes variation through crossing over and independent assortment.
3. **Gamete formation**: Produces haploid cells essential for sexual reproduction.
4. **Evolutionary advantage**: Supports adaptation and survival through genetic variation.
5. **Prevents polyploidy**: Avoids chromosome duplication in offspring.

# Cell cycle

- **CELL CYCLE** → Interphase (Preparation) → 23 hrs
  → Mitotic phase (Division) → 1 hrs

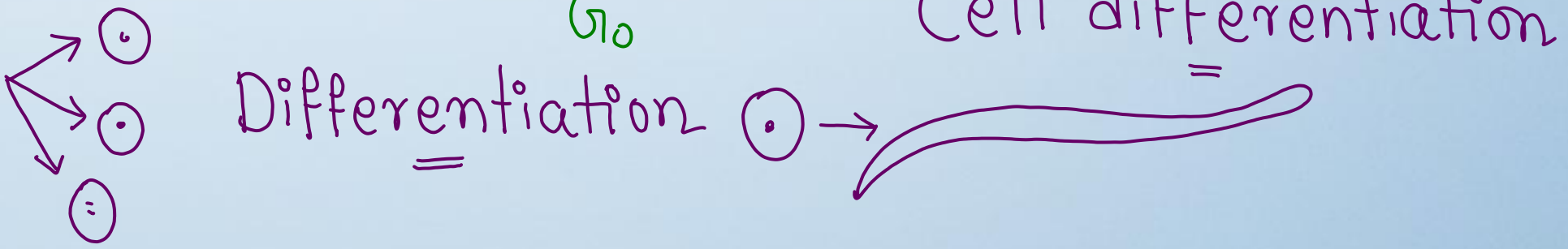
The cell cycle is an ordered series of events involving cell growth and cell division that produces two new daughter cells.

- **Exact sequence of cell cycle is:** $G_1 - S - G_2 - M$.
  → Karyokinesis (Nucleus div)
  → Cytokinesis (Cytoplasm div)
- **G0 STAGE IS OBSERVED BETWEEN- G1 & S (Nerve cell, Muscle cells are the example)**

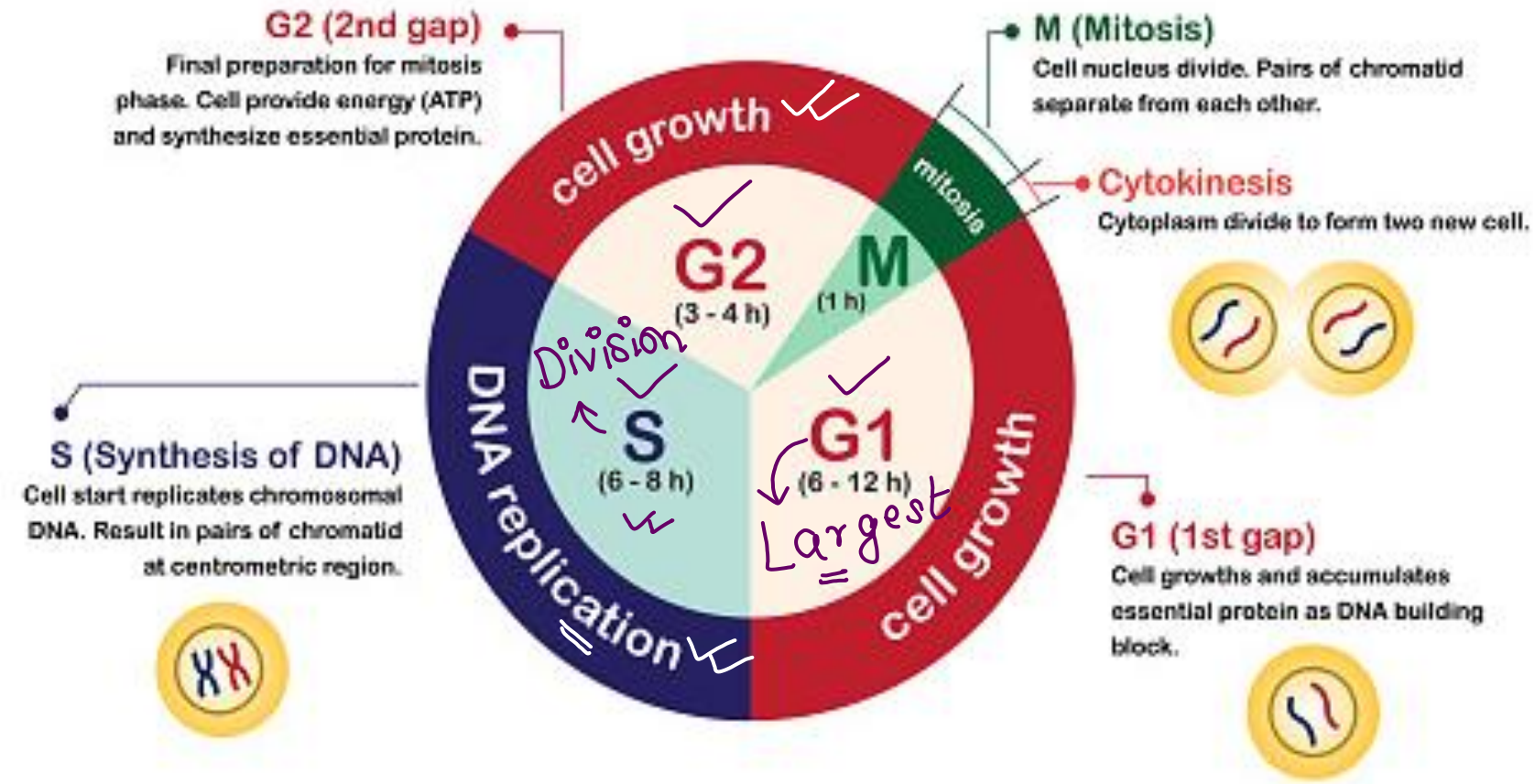
$G_0$

Division

Differentiation → Cell differentiation



# Cell cycle picture



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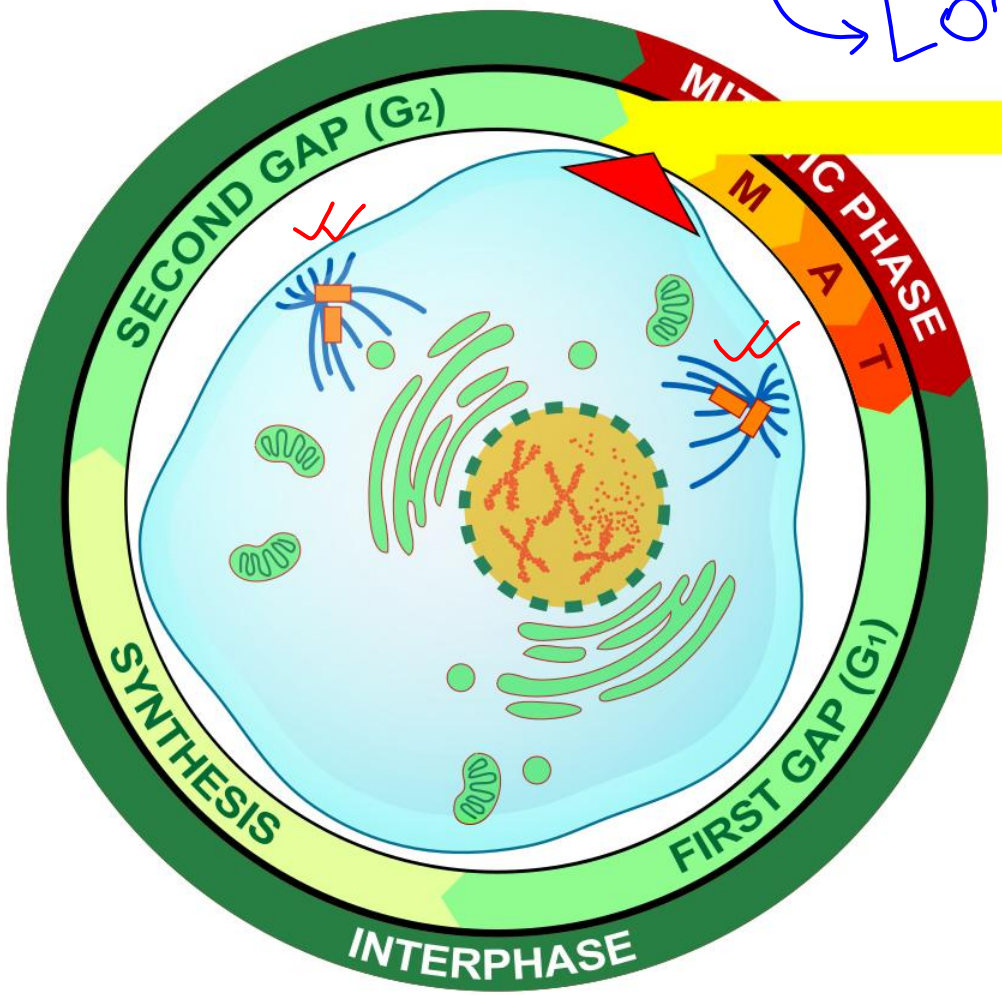
# Prophase

→ Longest of Karyokinesis =




*Nucleolus disappears

*Chromatin condenses into chromosomes

Dehydration =

*Separation of centrosomes

*Formation of the mitotic spindle → সিনট্রিওল

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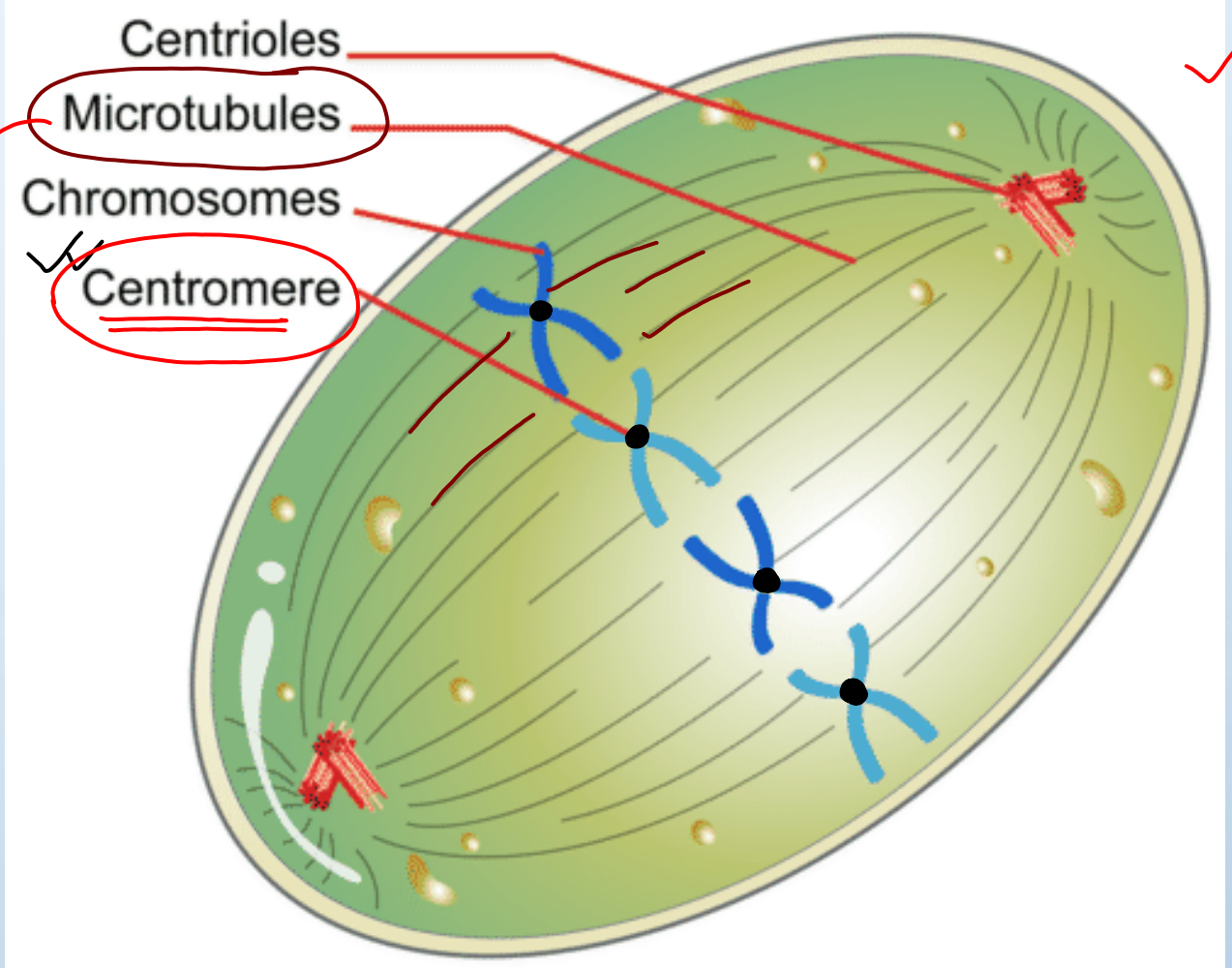
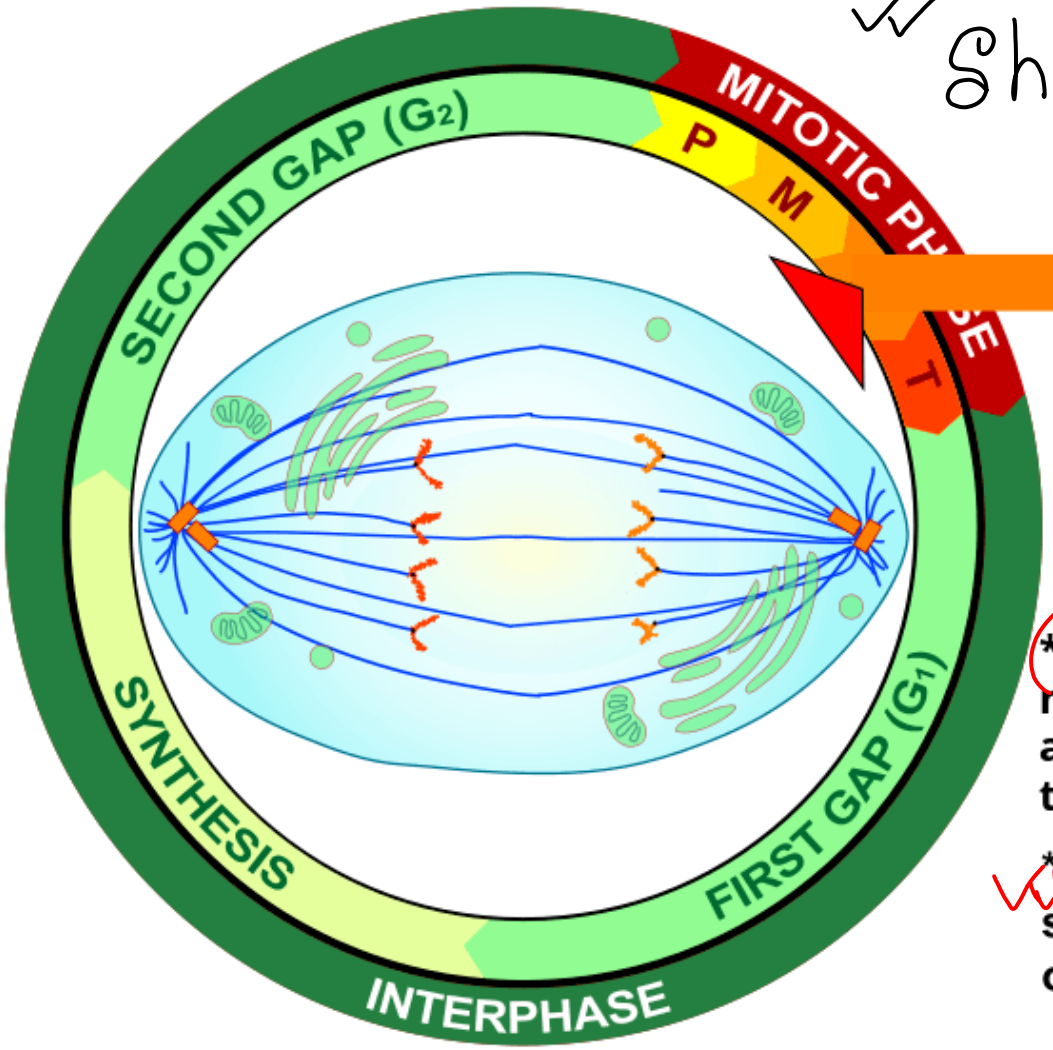
# Metaphase




Tubulin Protein

Best phase to observe/ Study chromosome

# Anaphase



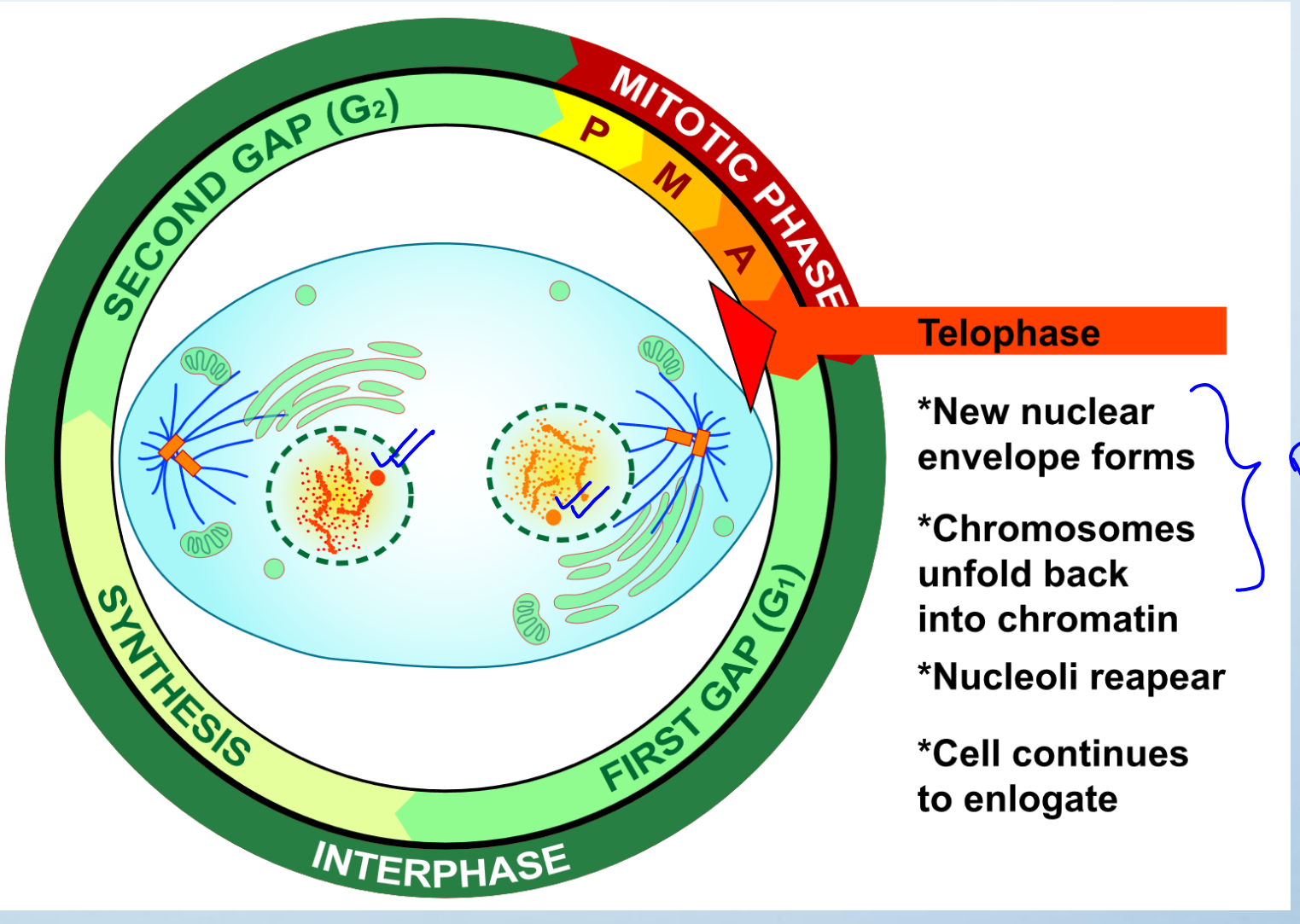

Shortest phase

Polar movement of chr

*Unattached microtubules push against each other to elongate cells

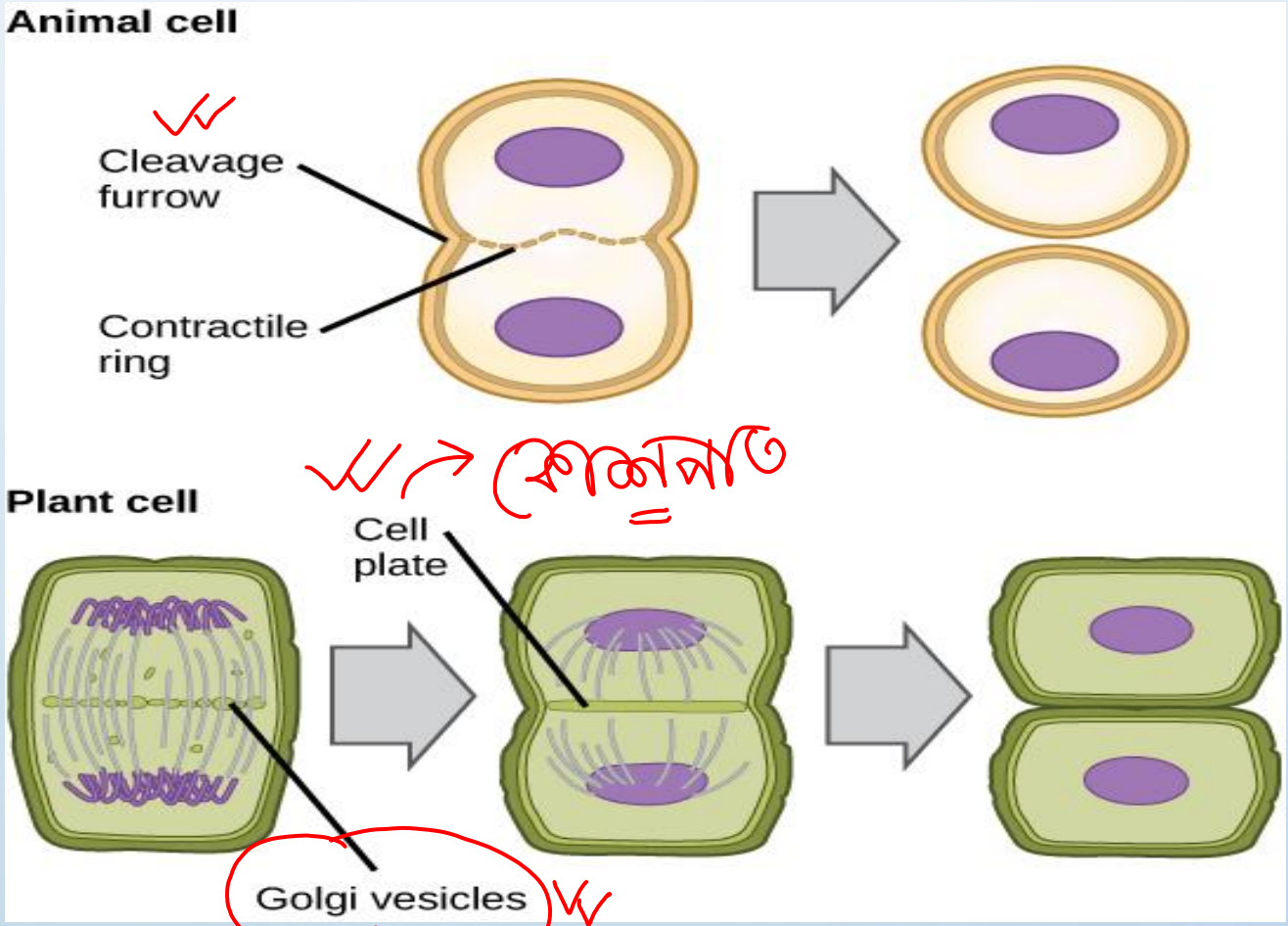
*Chromatids separate towards opposite poles

# Telophase




Rehydration of nucleus =

# Cytokinesis in Plant & Animal cell




- **Animal Cell:**
  - A contractile ring forms that constricts the cells inwards, called a cleavage furrow.
- **Plant Cell:**
  - A cell plate forms down the middle that separates the cell into two.

# Incidents of Prophase-1 Of Meiosis

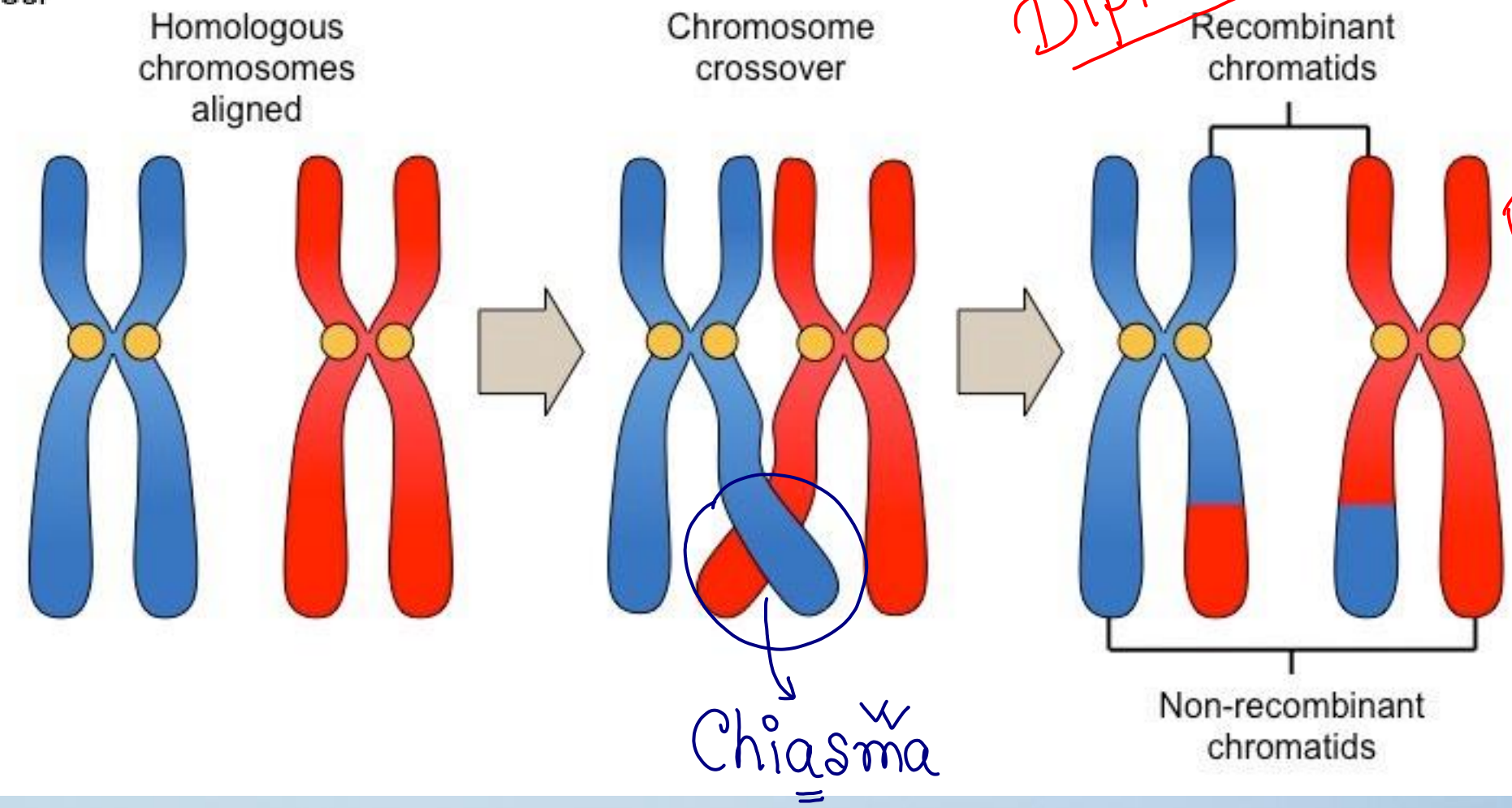
***Prophase 1 of Meiosis 1*** *is divided into five sub-stages. They are as follows-*

- ***Leptotene-*** *Bouquet stage.*
- ***Zygotene-*** *Chromosome pairing formation occurs (Synaptonemal complex).*
- ***Pachytene-*** *Crossing over b/w two chromosome (*V.V.I)*
- ***Diplotene-*** *Abolition of Chaisma.*
- ***Diakinesis-*** *Ring, Diamond, Hat-Shaped chromosomes occur.*

Synapsis

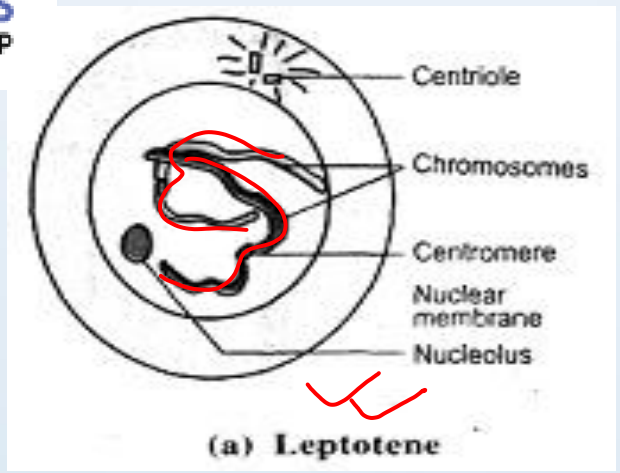
# Crossing Over

Diplotene

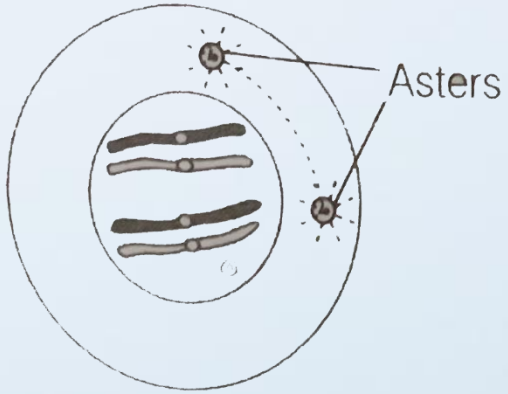



Formation of Chr. with new characters

# Incidents of Prophase -1 Of Meiosis

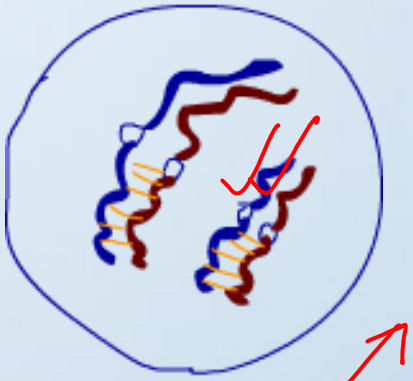


(a) Leptotene

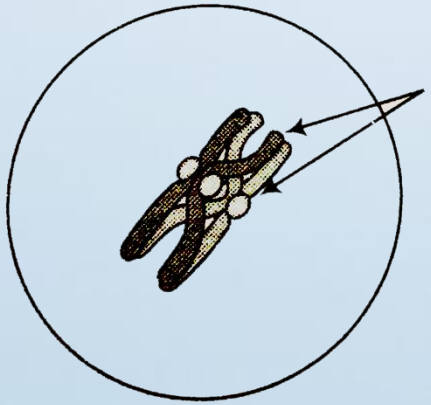


Zygotene

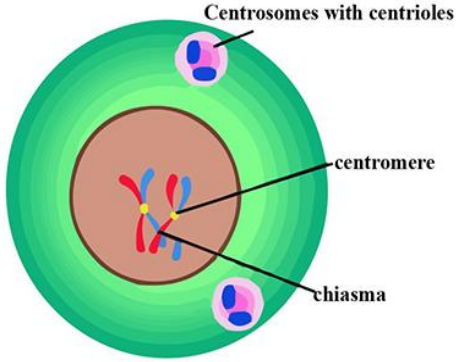
synaptonemal complex


ZYGOTENE

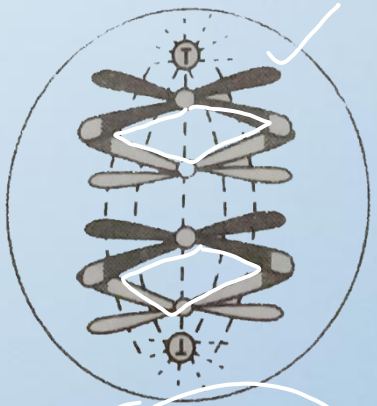
Synapsis



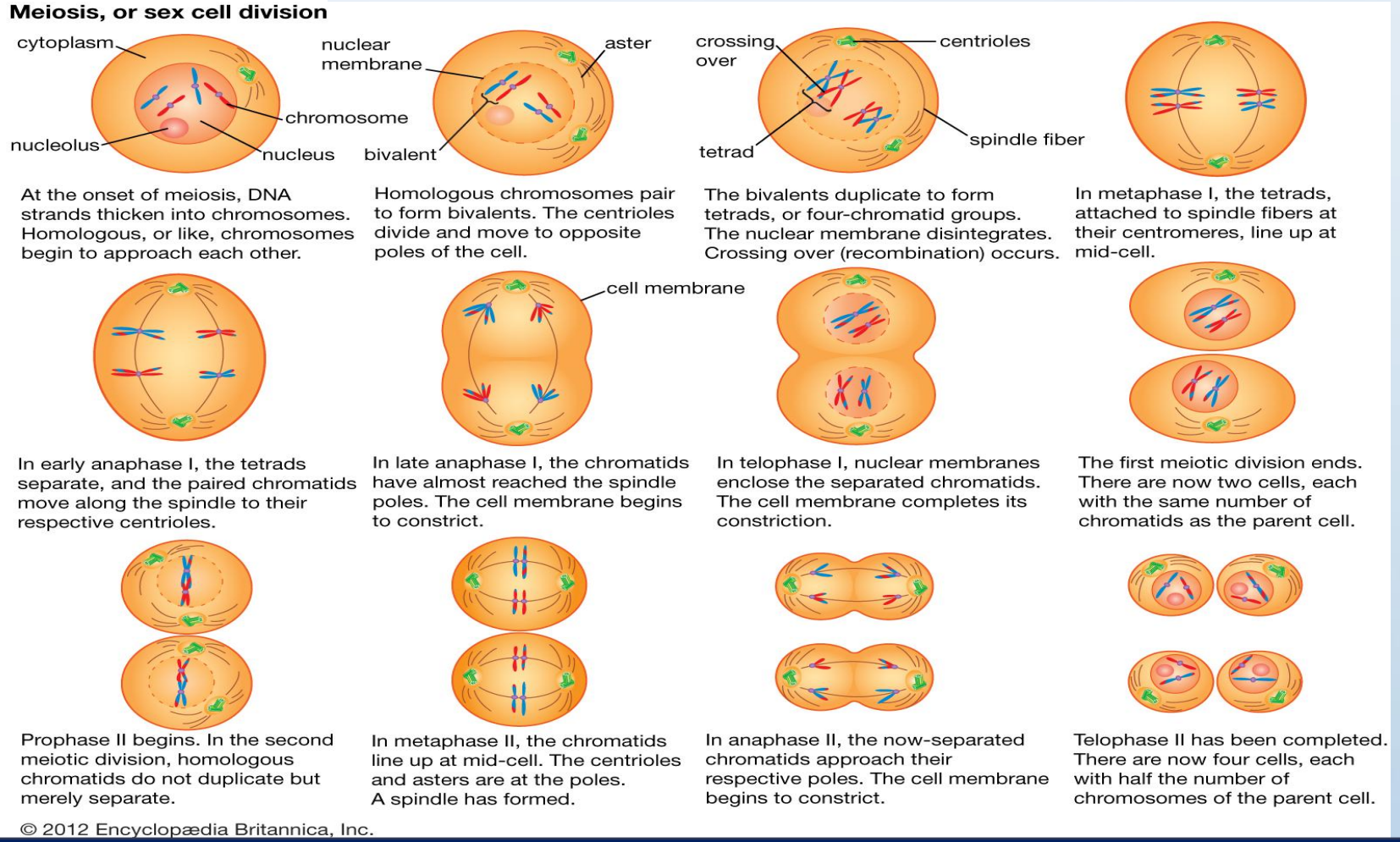
Pachytene



DIPLOTENE


Diakinesis

# Other stages of Meiosis (Zoomed View suggested)

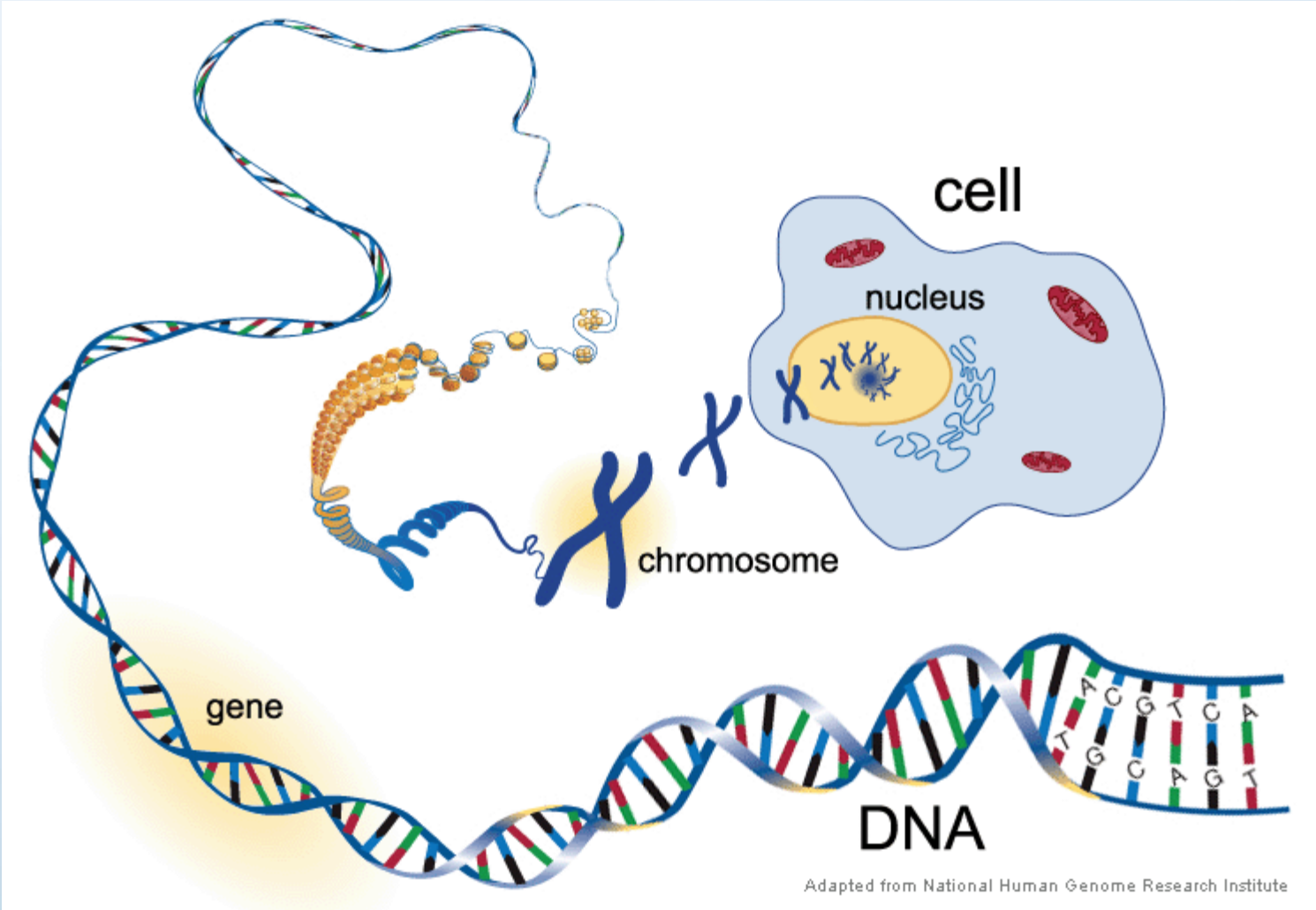


# Chromosome Structure

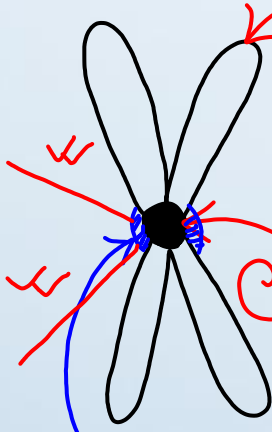
(Nucleo-protein)

- **What is a chromosome?-** A thread-like structure of nucleic acids and protein found in the nucleus of most living cells, carrying genetic information in the form of genes.
- **Chromosome were 1st observed-** Strasburger
- **Chromosome were 1st discovered by-** Walter Flemming.
- **Chromosome the term 1st time coined by-** W. Waldeyer.

# Location of chromosome inside the cell



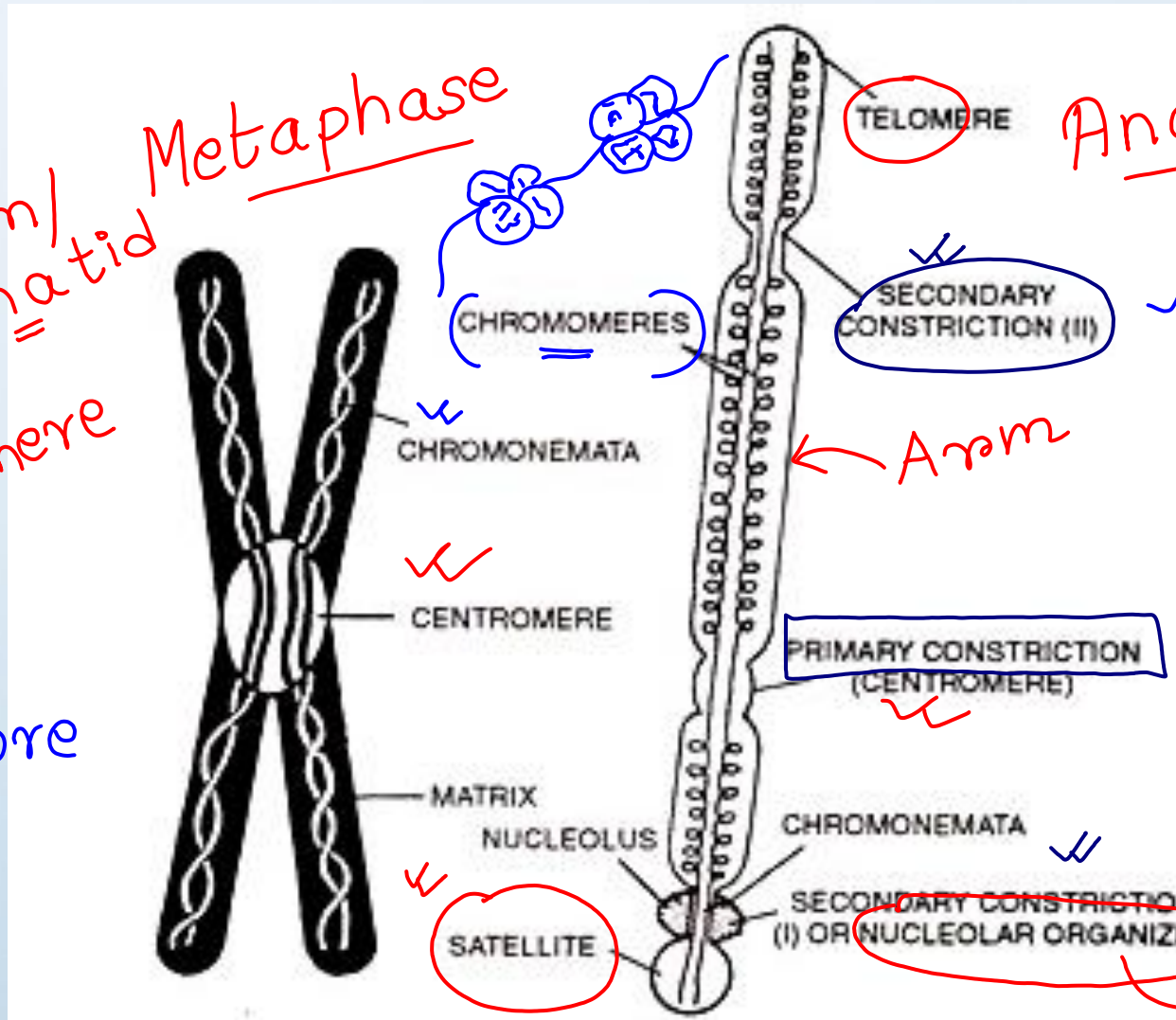
# Chromosome structure



Arm/ Chromatid

Centromere

Kinetochore




Metaphase

Anaphase

Arm

5 pairs

SAT chr

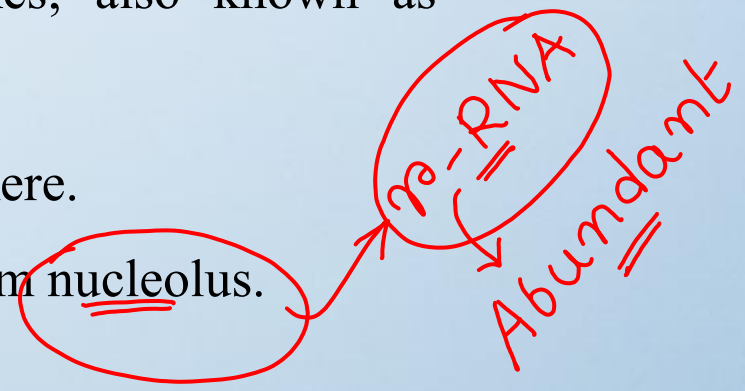
13, 14, 15, 21, 22

NOR = Nucleolus

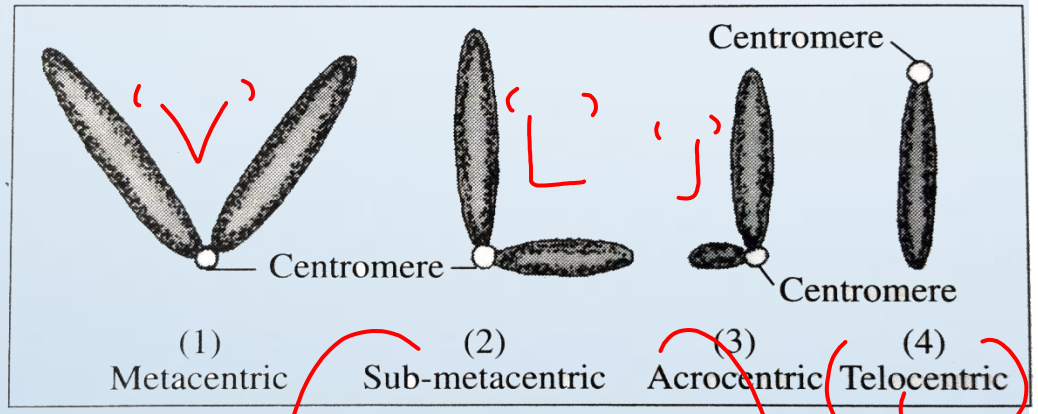
# Description of chromosome parts

Chromosomes are coiled thread-like structures observed in the matrix and consist of-

- **Chromatids**: Arm of chromosome.
- **Centromere**: Joining point or primary constriction of chromosomes; also known as kinetochore.
- **Secondary constrictions**: One or more constrictions other than centromere.
- **Nucleolar organizers**: Additional constrictions that are necessary to form nucleolus.
- **Telomeres**: End of the chromosome.
- **Satellites**: Terminal knob-like structure present in some specific Chromosome known as SAT-chromosome. Pair no 13, 14, 15, 21 & 22 are SAT Chromosome in human.



# Types of chromosome according to position of centromere




Types of Chromosomes

- The chromosomes are classified into four types, they are the following:
  - **Telocentric**: the centromere is located at the end of the chromosome.
  - **Acrocentric**: these are rod-like chromosomes having a very small arm and a very long arm.
  - **Sub-metacentric**: these chromosomes are L-shaped having unequal arms.
  - **Metacentric**: these chromosomes are V- shaped . They have arms equal in length.

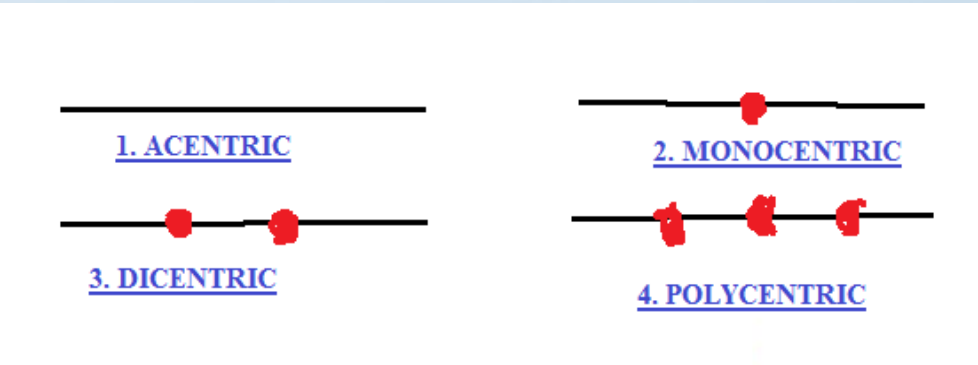
X

Y

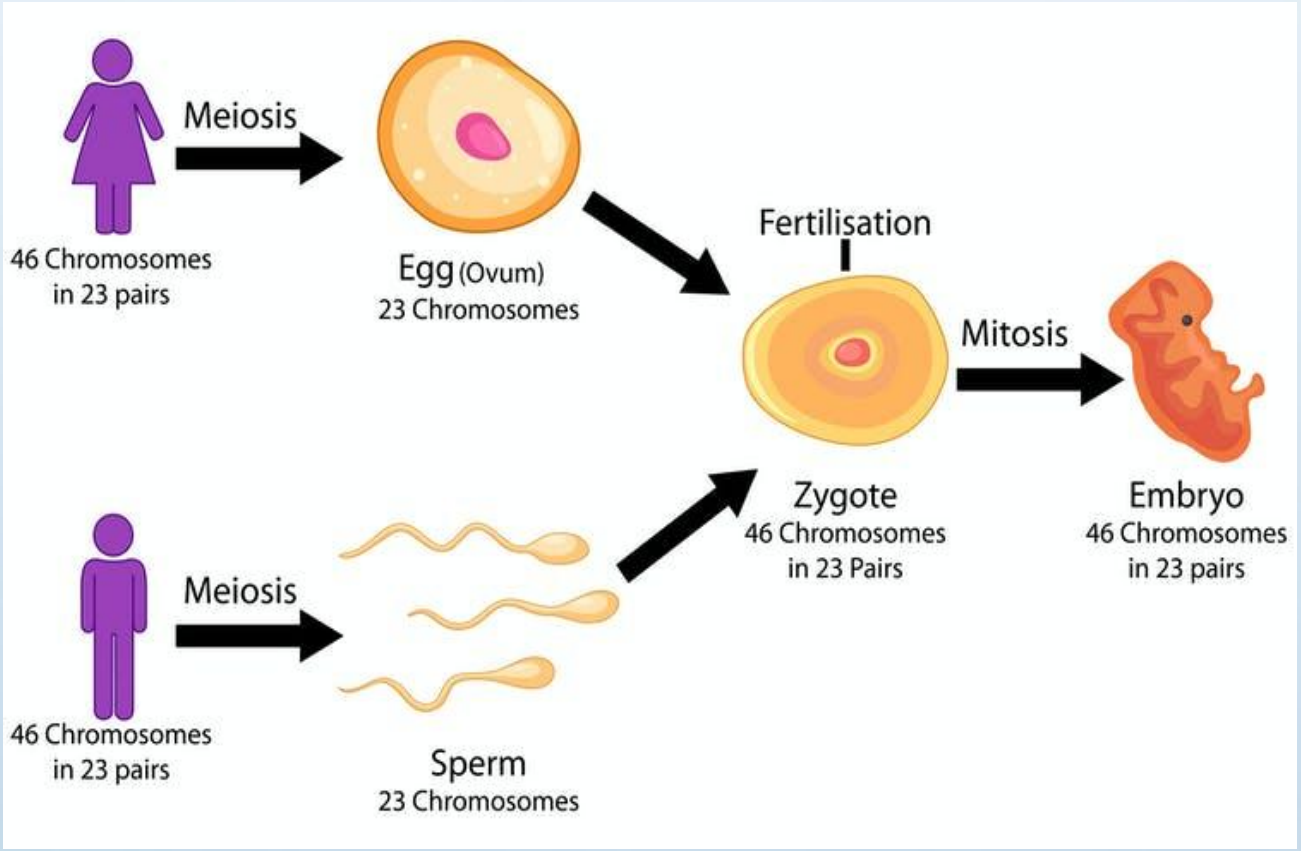
Absent in humans

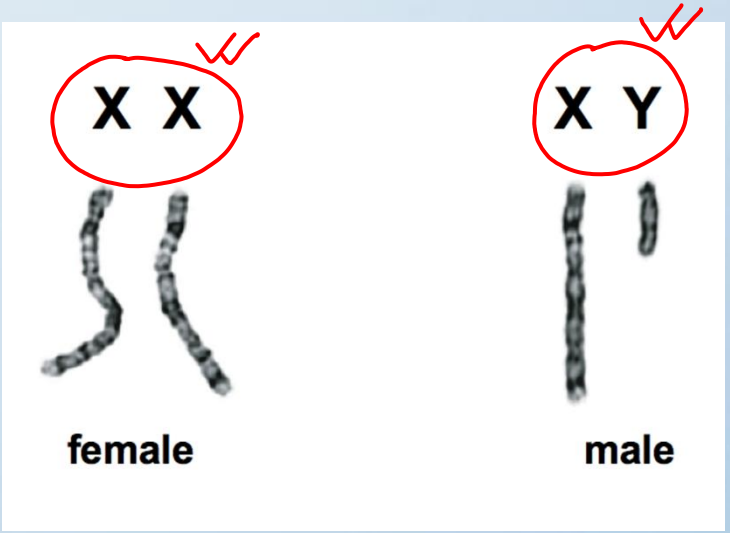
## Types of chromosome according to number of centromere

- **Acentric Chromosome-** Absence of centromere.
- **Monocentric Chromosome-** Single centromere present.
- **Dicentric chromosome-** Double no. of centromere present.
- **Polycentric Chromosome-** More than 2no. of centromere present.



# Chromosome classification based on function



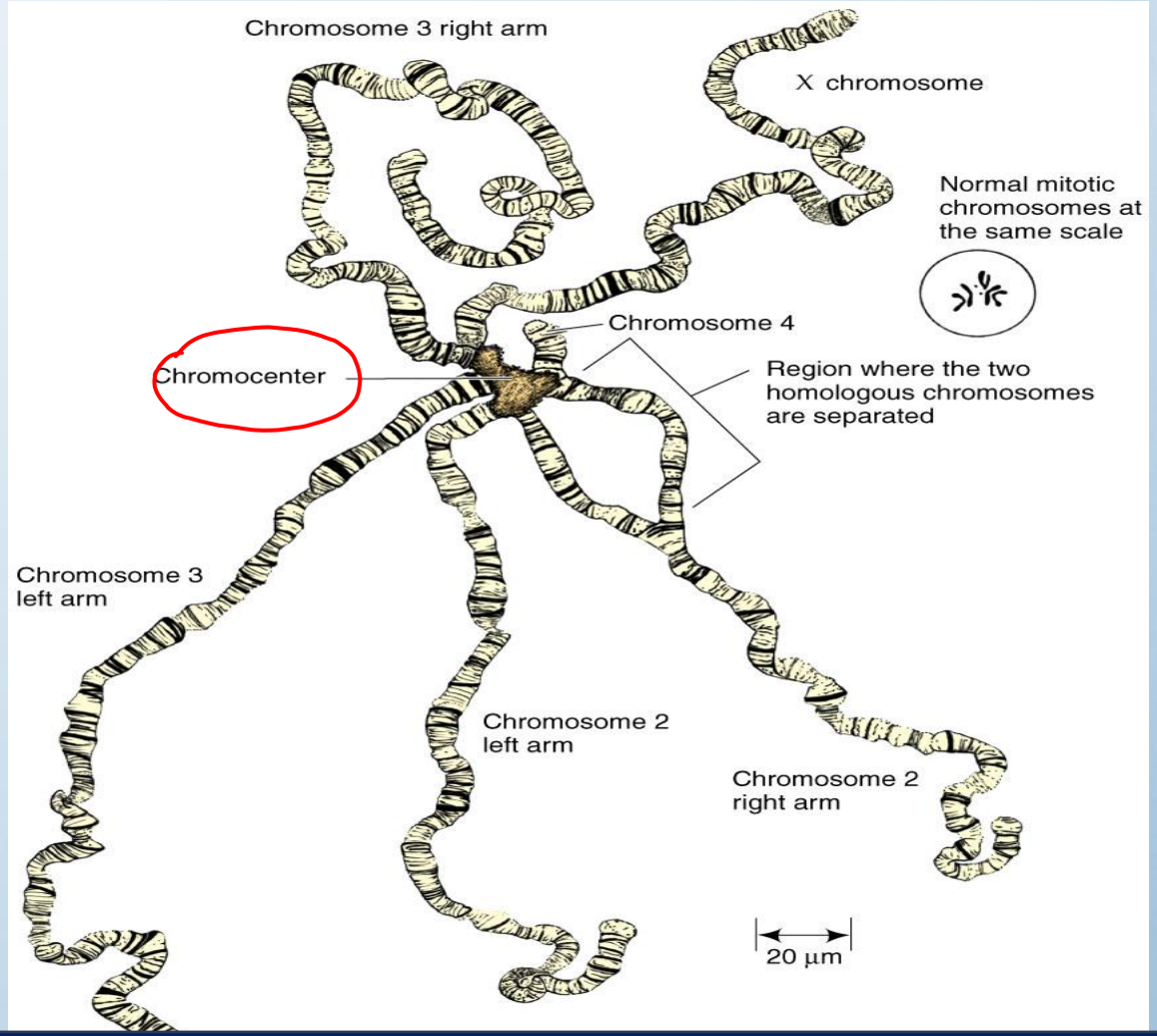



# Giant chromosome

- As the name suggests, the giant chromosomes are very large in size as compared to normal chromosomes.
- They are also called **mega chromosomes**.
- The Giant chromosomes are of two types; Lampbrush chromosome and Polytene chromosome.
- The term '*giant chromosome*' was given by *Winchester*.
- Their synthesis takes place by means of - **Endomitosis** → Only nucleus division occurs

# Polytene chromosome

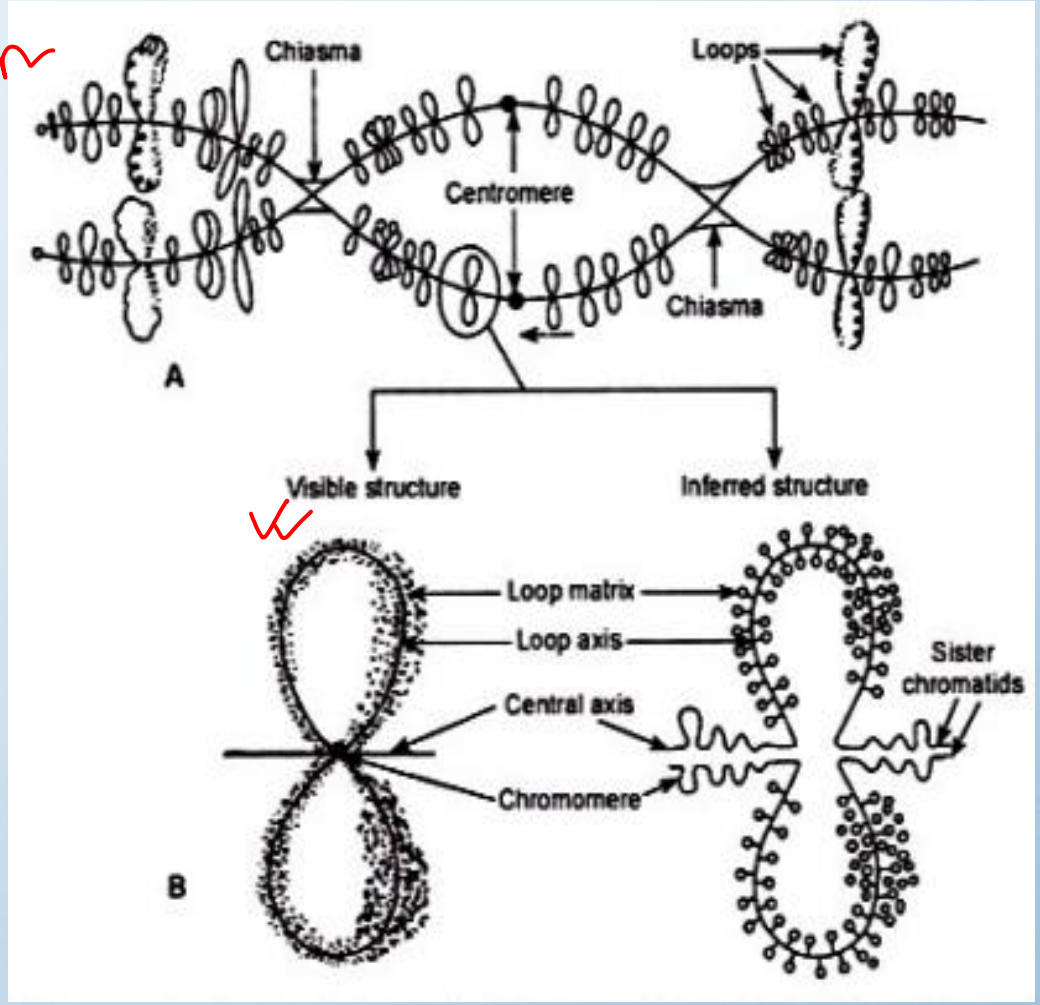
- **Discoverer:** First observed by Balbiani in 1881.
- **Place of Occurrence:** Found in the salivary glands of certain dipteran insects (e.g., *Drosophila melanogaster*).
- **Characteristics:**
  - Gigantic chromosomes formed by repeated rounds of DNA replication without cell division (endoreplication).
  - Display distinct banding patterns, used as a cytogenetic map for gene studies.
- **Significance:** Crucial for studying gene activity, chromosomal structure, and genetic regulation.



# Lampbrush chromosome

Like lamp cleaning brush

- **Discoverer:** Described by Walther Flemming in the late 19th century.
- **Place of Occurrence:** Found in the oocytes of amphibians (e.g., *Xenopus laevis*) and other vertebrates.
- **Characteristics:**
  - Large, looped chromosomes visible during meiotic prophase I.
  - Loops are active transcription sites, producing RNA for oocyte development.
- **Significance:** Vital for understanding gene expression and chromatin organization

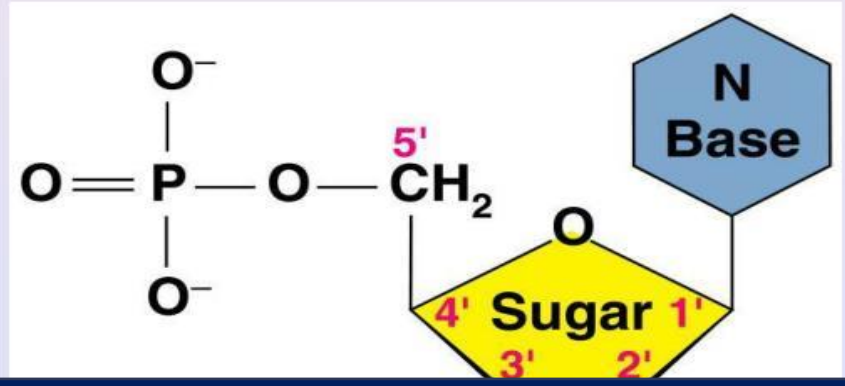


# Components of Chromosome

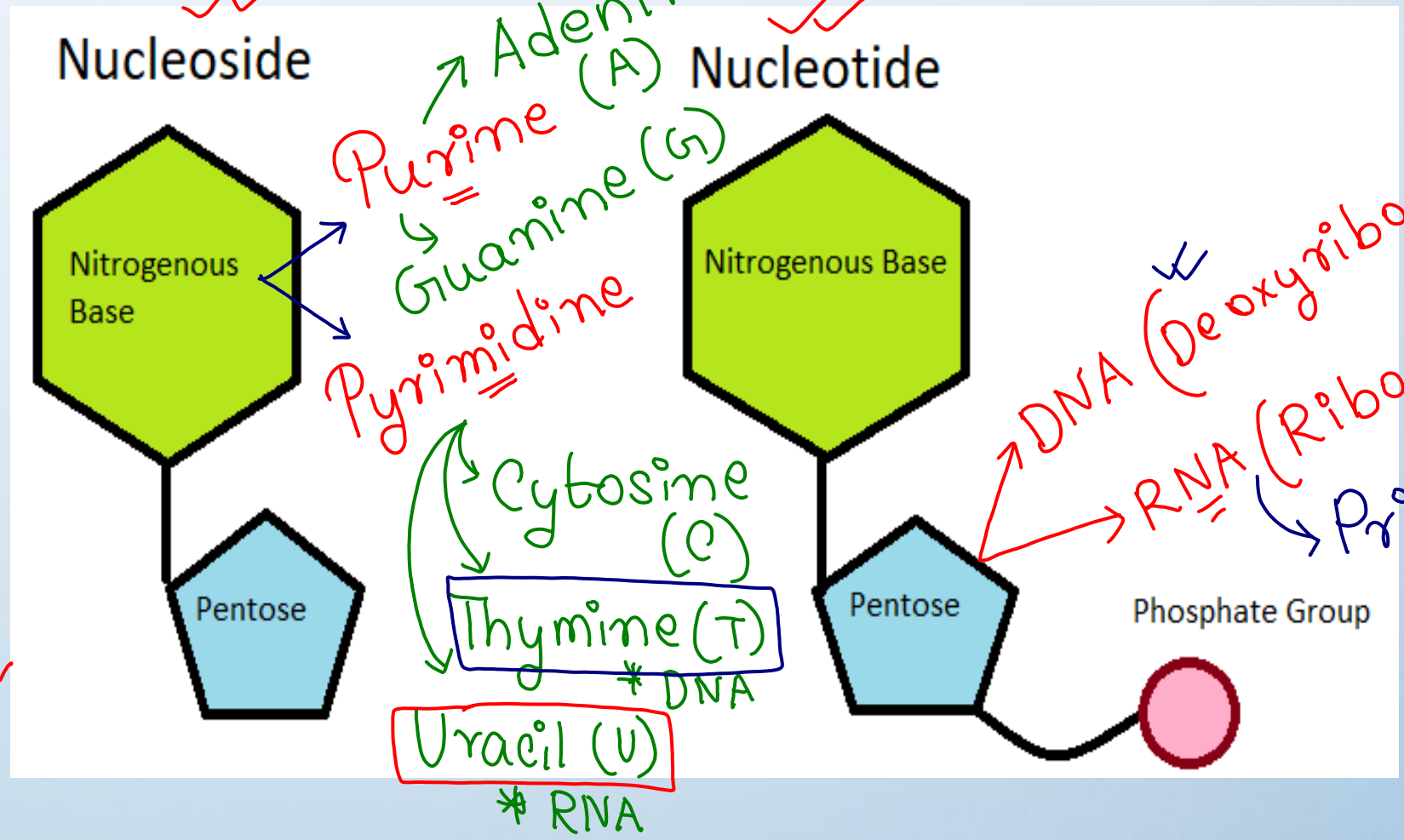
## Nucleic Acids

- **Nucleic acids** are molecules that store information for cellular growth and reproduction
- There are two types of nucleic acids:

  - **deoxyribonucleic acid (DNA)** and **ribonucleic acid (RNA)**
- These are polymers consisting of long chains of monomers called nucleotides
- A **nucleotide** consists of a nitrogenous base, a pentose sugar and a phosphate group:



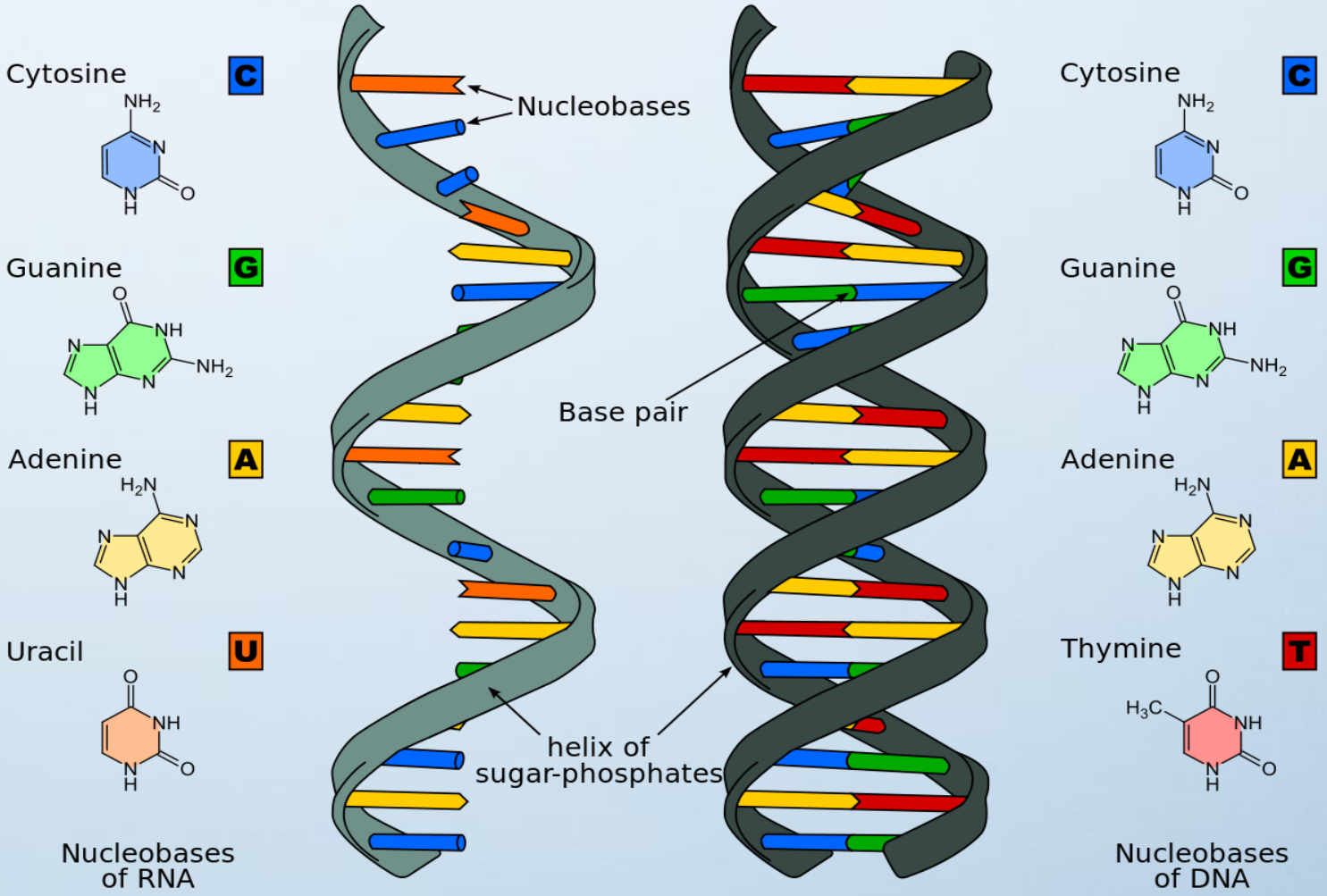
# SIDE VS. TIDE



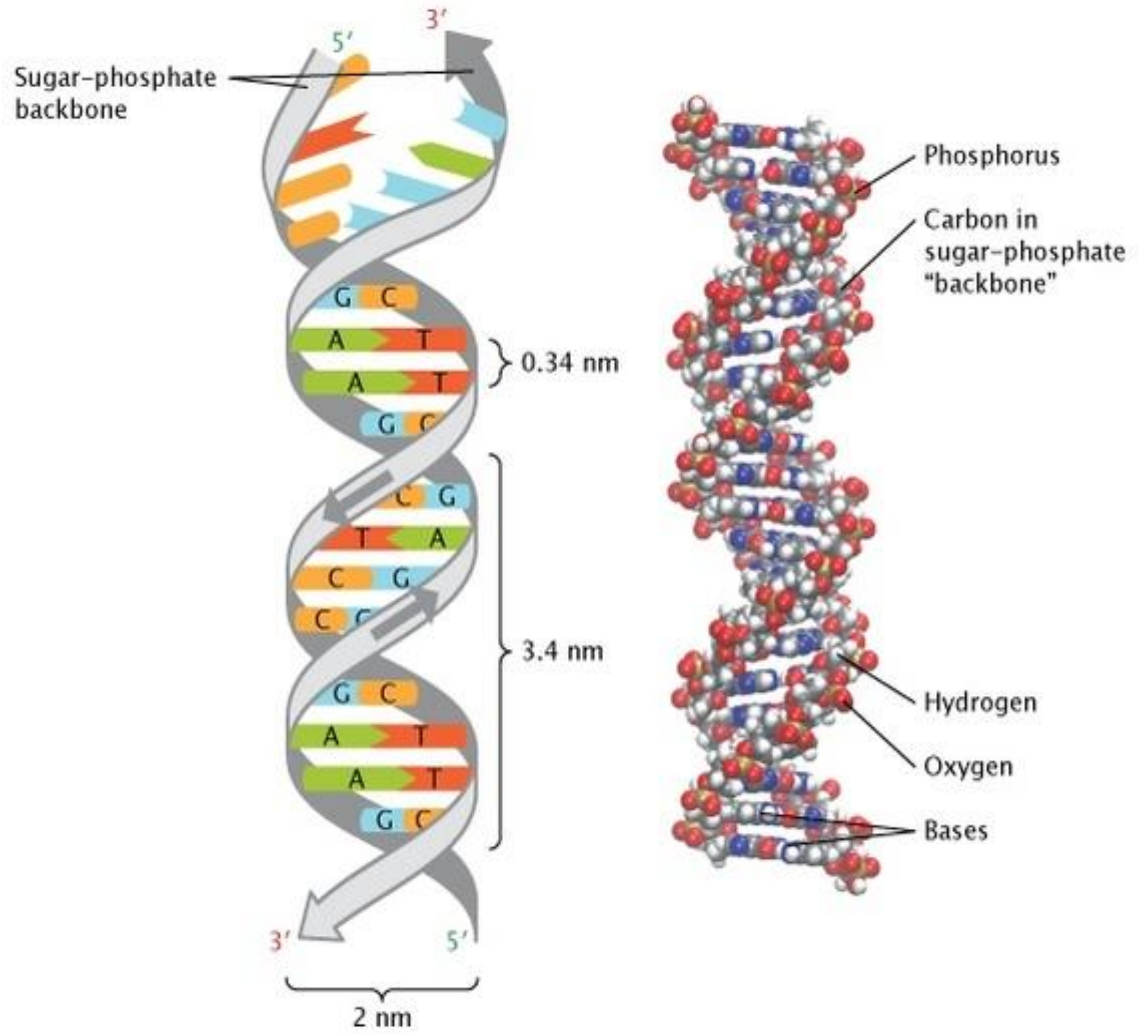

DNA
A=T
G≡C

RNA
A=U
G≡C

# RNA & DNA

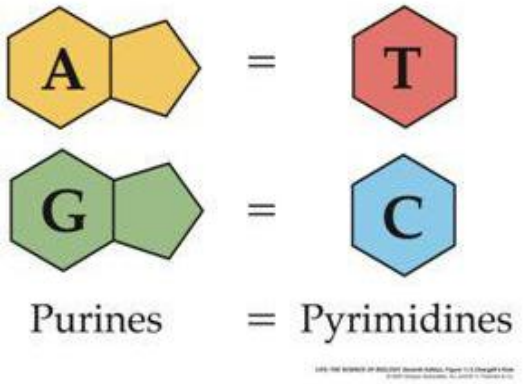

Cytosine
C
Guanine
G
Adenine
A
Uracil
U
Nucleobases of RNA
Nucleobases
Base pair
helix of sugar-phosphates
RNA
Ribonucleic acid
DNA
Deoxyribonucleic acid
Cytosine
C
Guanine
G
Adenine
A
Thymine
T
Nucleobases of DNA

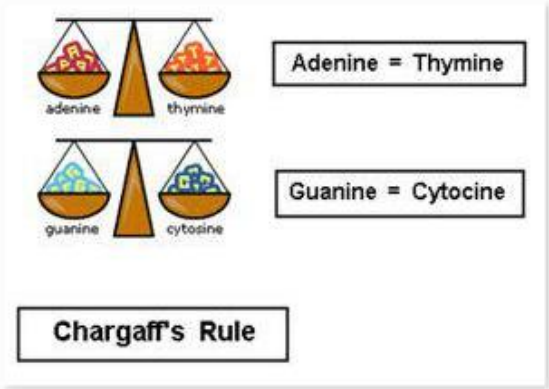
# DNA Double helix model



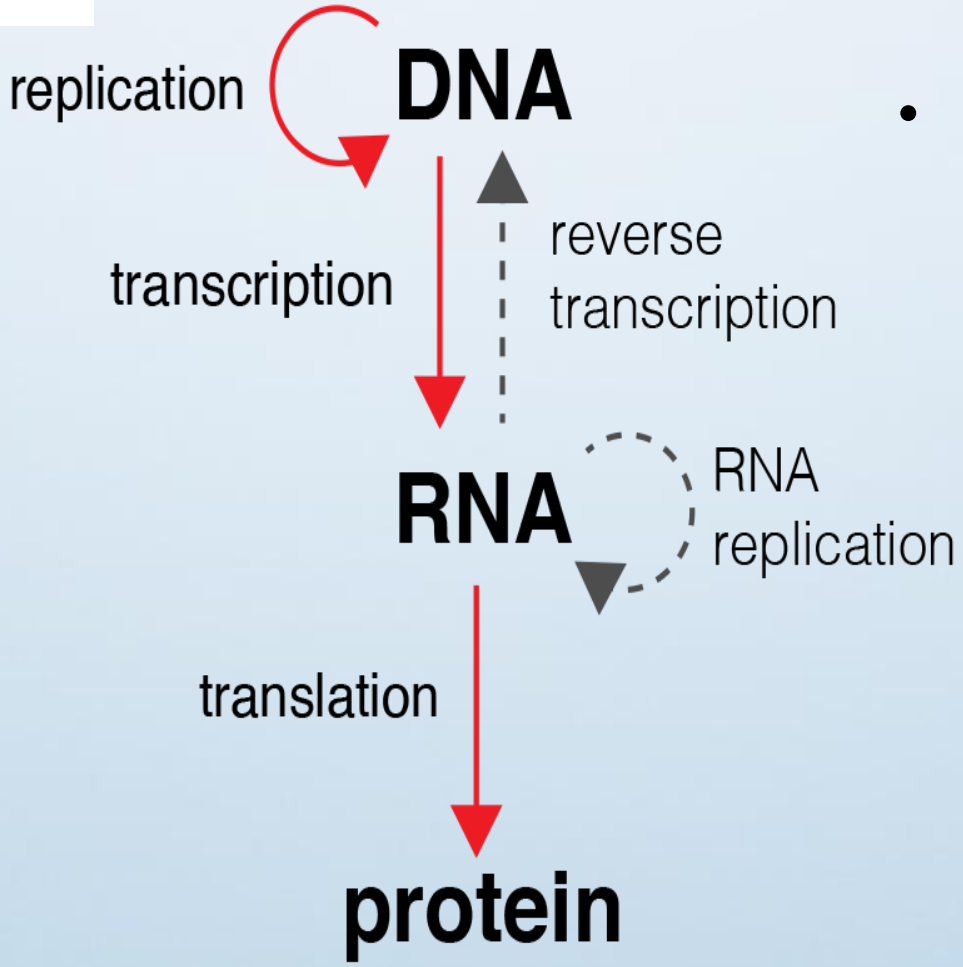

# Chargaff's rule

- Percentages of adenine and thymine bases are almost equal in any sample of DNA
  - Same thing is true for guanine and cytosine
- Chargaff's Rule: A=T and G=C
  - Samples from all organisms obey this rule

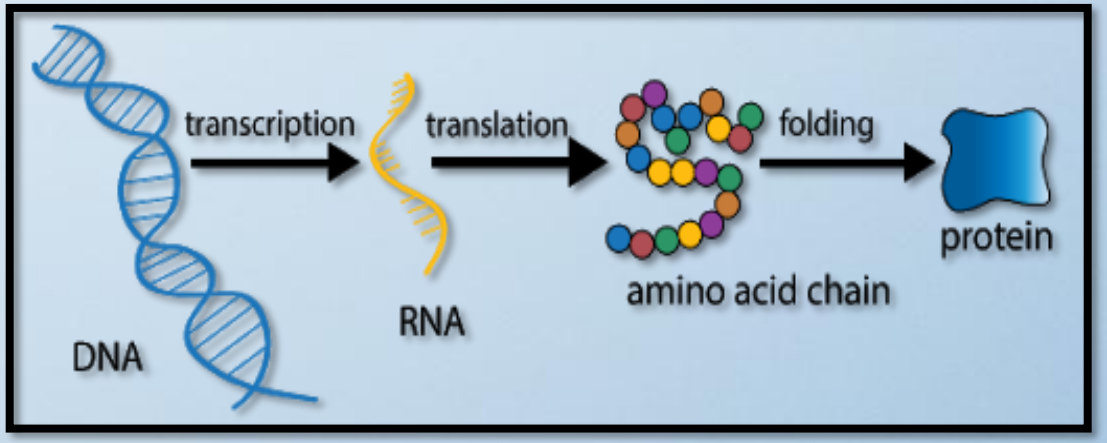


# Central Dogma

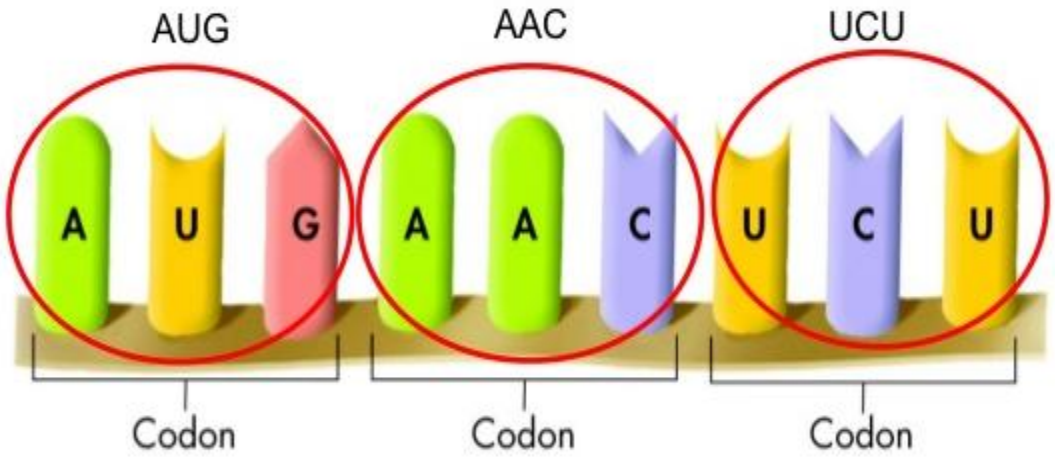


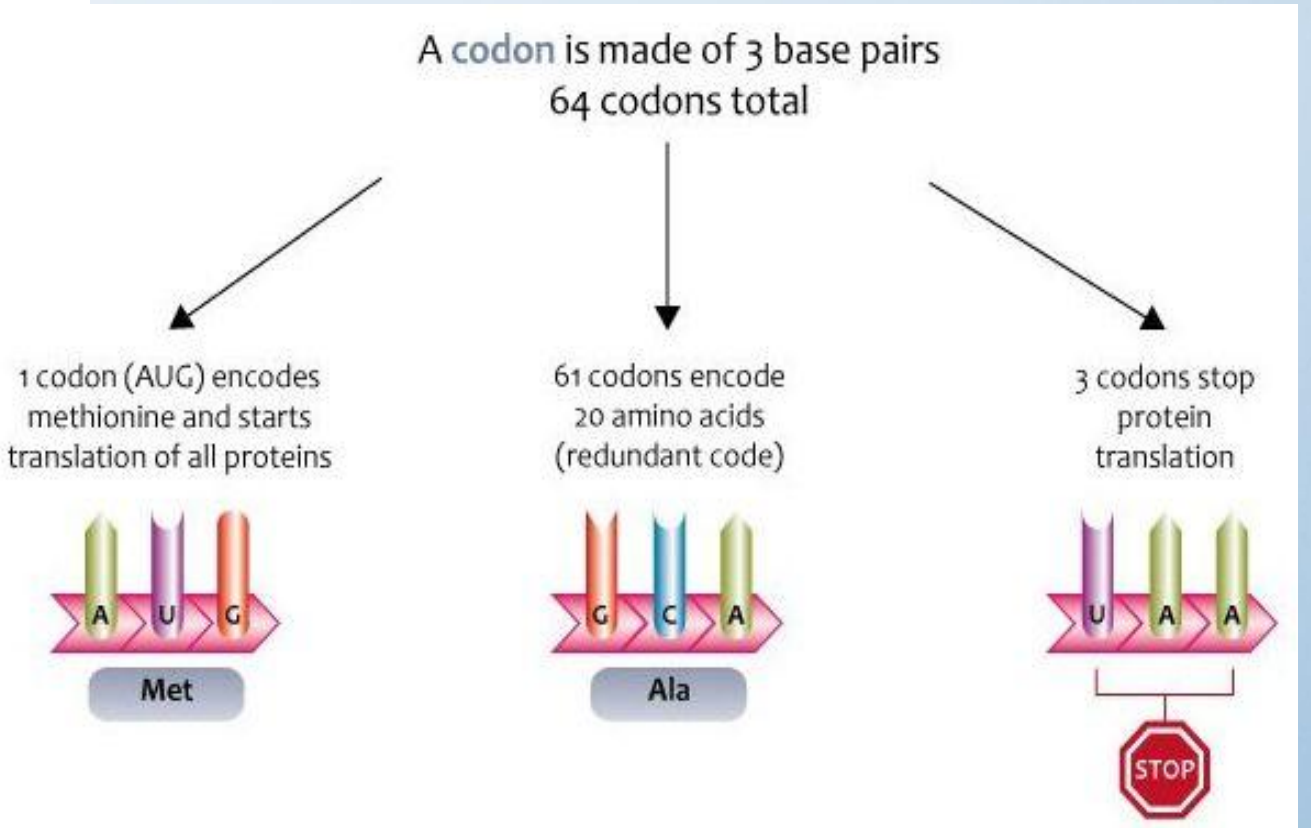

- The principle of Central Dogma was given by Francis Crick.
- Reverse transcription is observed in retro virus like HIV as they have specific enzyme reverse transcriptase. It was discovered by Temin & Baltimore. Hence, Teminism.

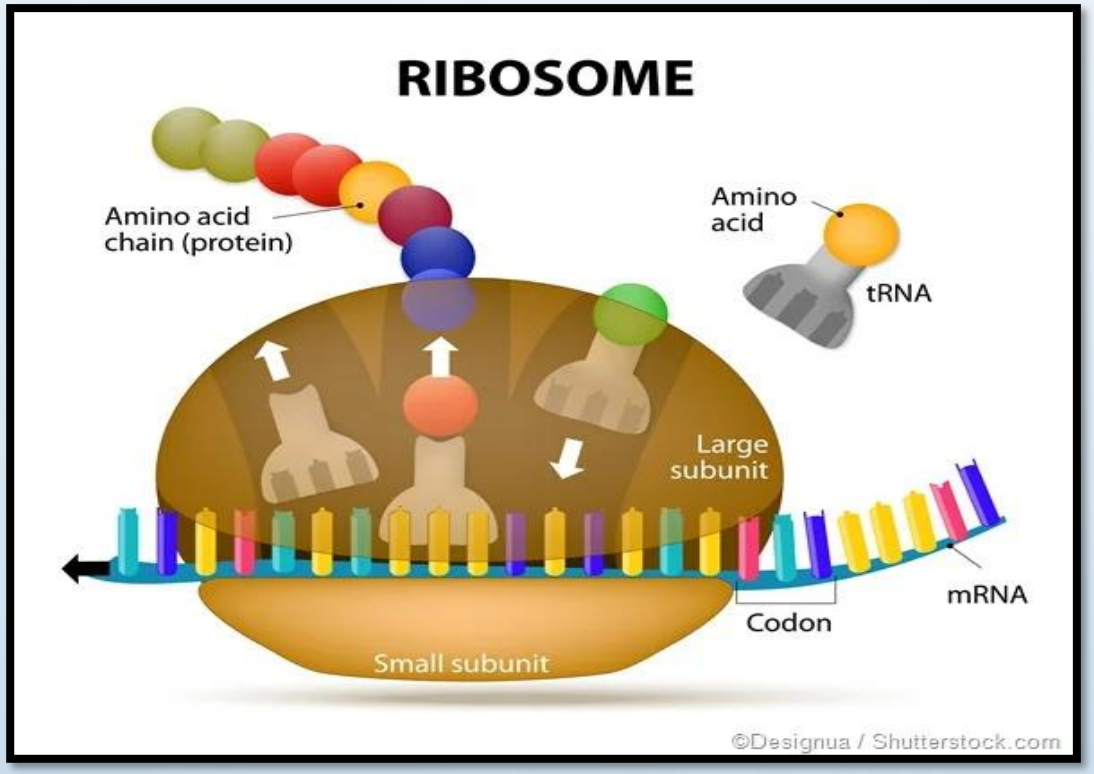


# Codon

- The genetic code is read in three-letter groupings called codons.
- A codon is a group of three nucleotide bases in messenger RNA that specifies a particular amino acid.




RIBOSOME
Amino acid chain (protein)
Amino acid
tRNA
Large subunit
mRNA
Codon
Small subunit
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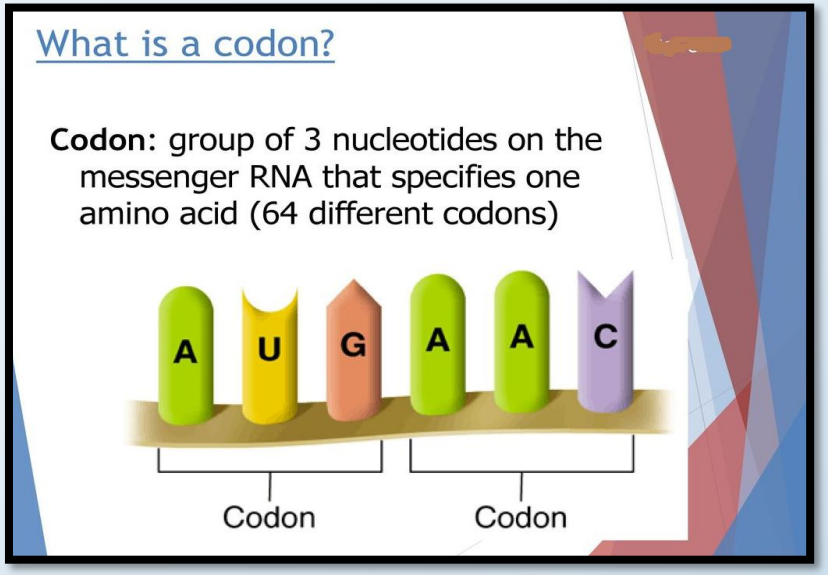
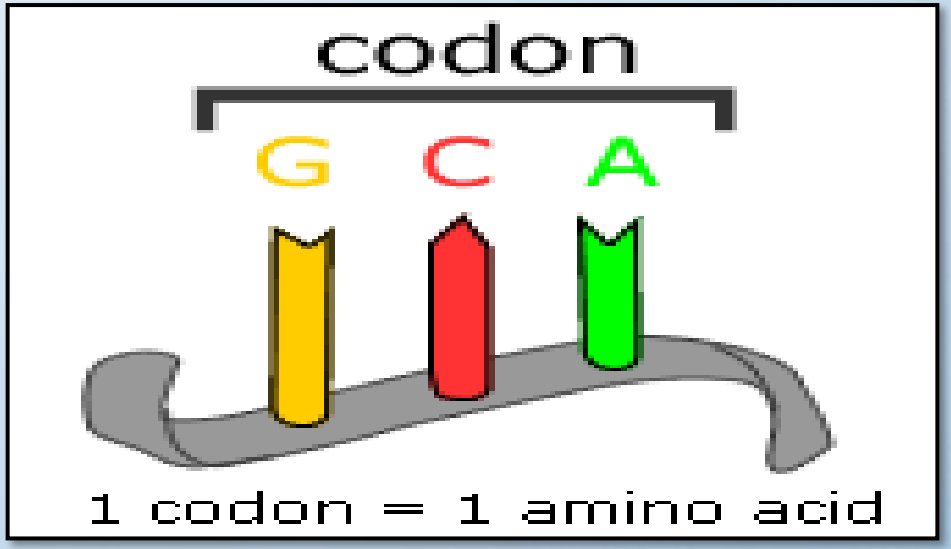
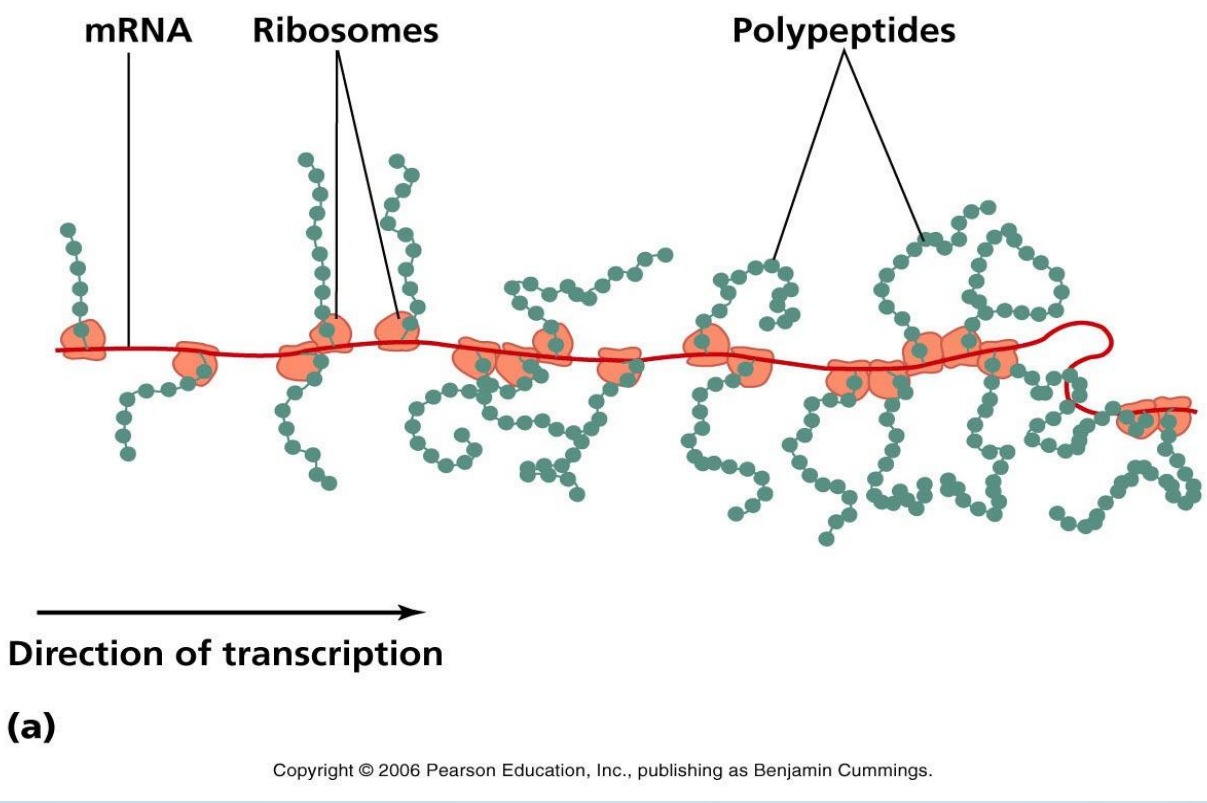

What is a codon?
Codon: group of 3 nucleotides on the messenger RNA that specifies one amino acid (64 different codons)
A U G A A C
Codon
Codon

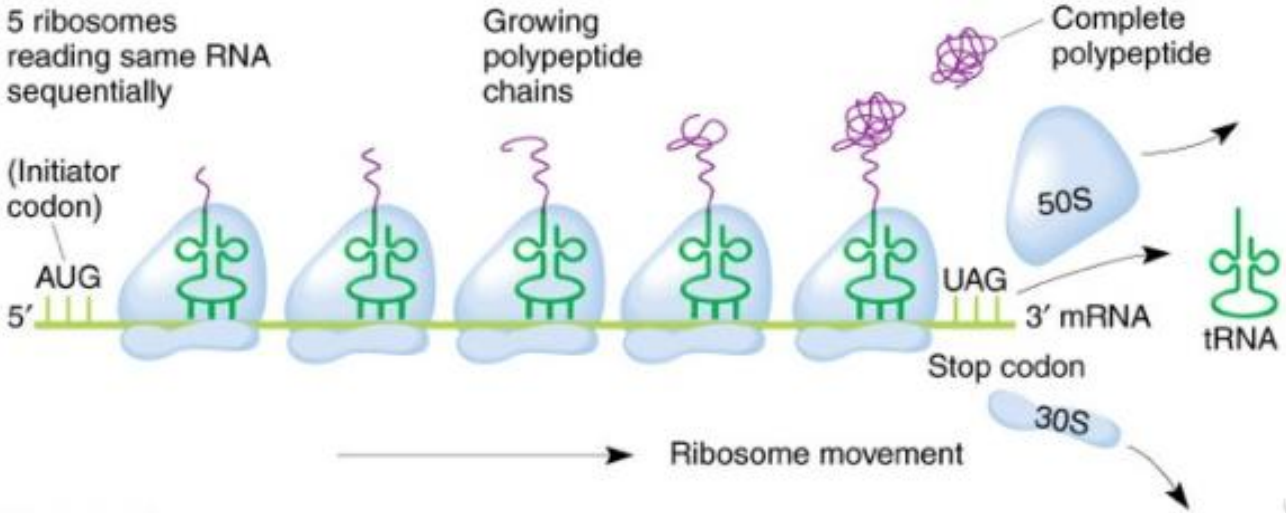

codon
G C A
1 codon = 1 amino acid

# Polysomes





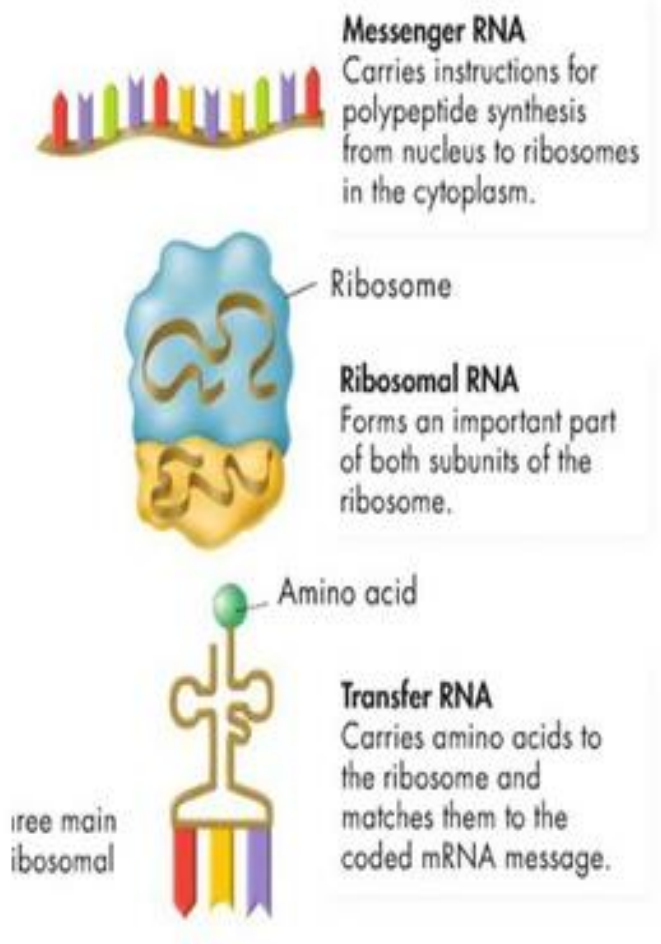

**Polysome or polyribosome:** a number of ribosomes translating the same transcript.




***Polysomes are formed during translation.***

# Role of different RNAs

- Three different types of RNA:
  - mRNA (messenger) used as template to make proteins
  - rRNA (ribosomal) makes up ribosomes
  - tRNA (transfer) matches amino acids to mRNA to help make proteins

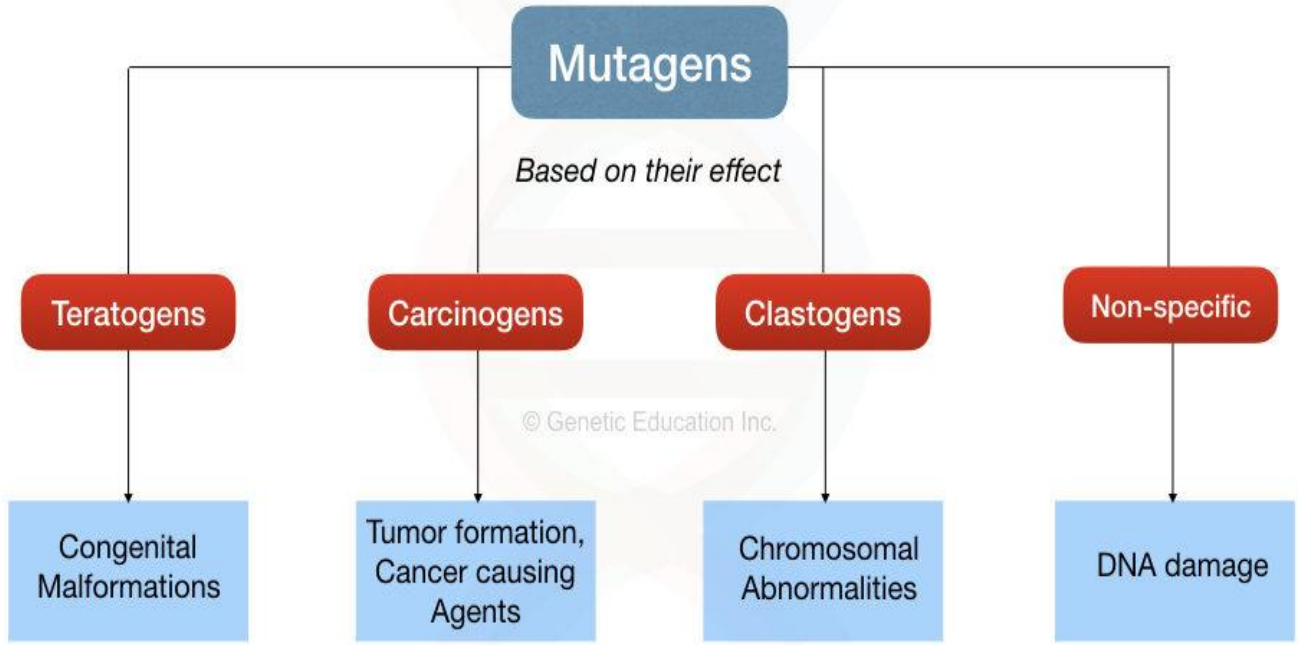


# Mutation & Mutagen

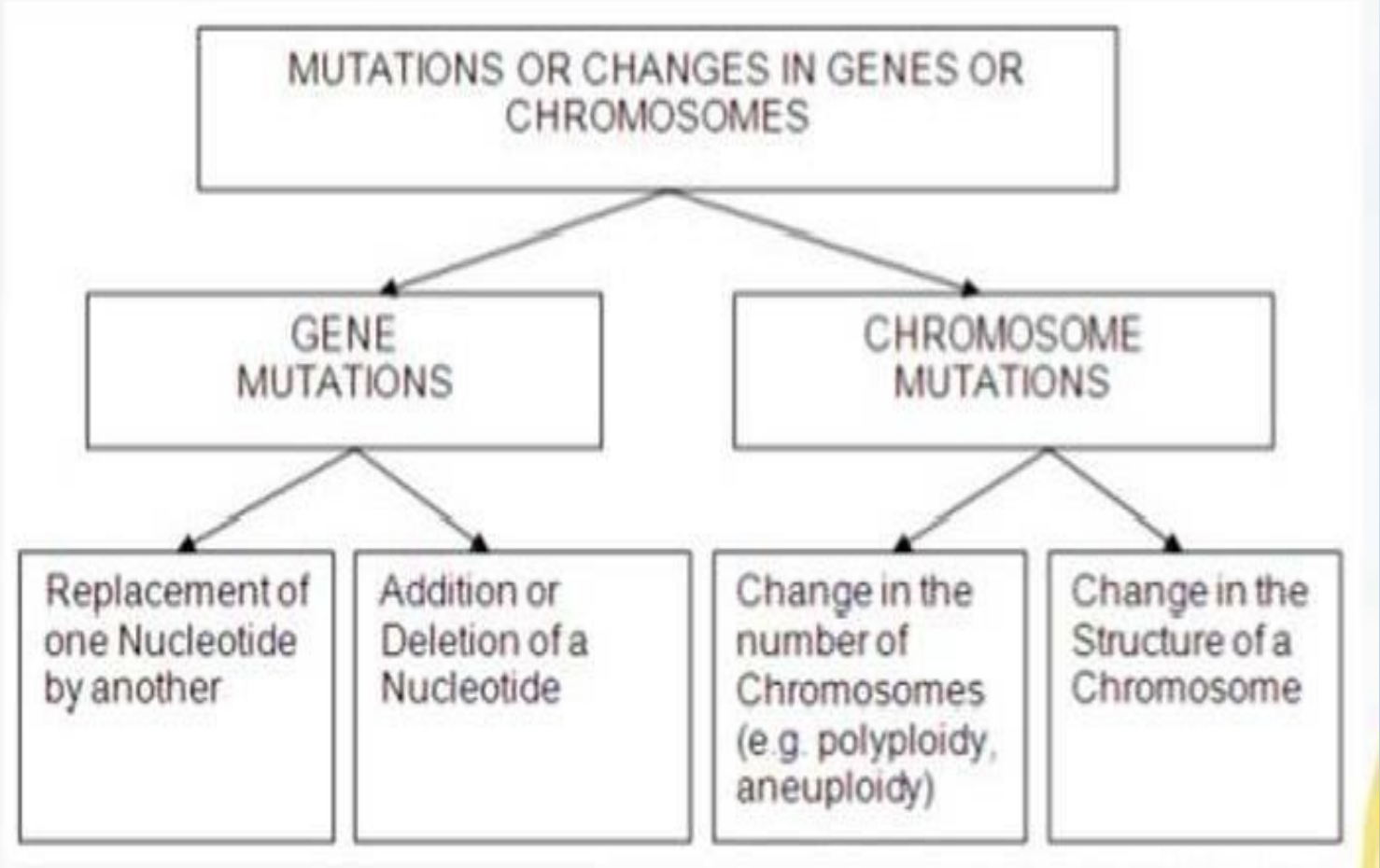
## Definition

- A mutation is a sudden change in the genetic material of a cell that can be passed on from the cell to its daughter cells during the process of cell division.

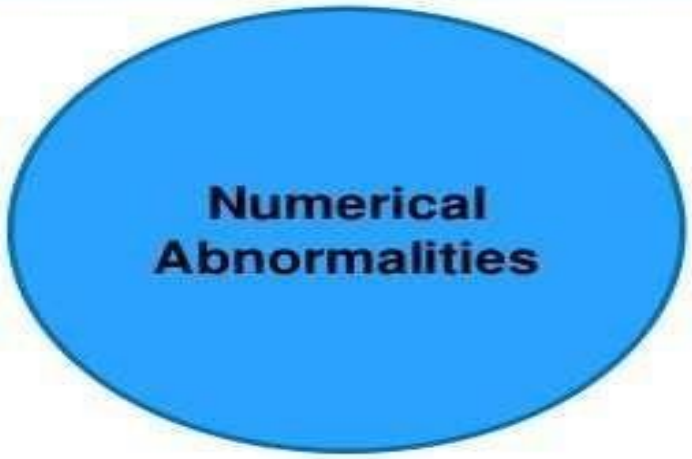
- Substances that causes mutation are called mutagen. They may be- Physical, chemical or biological.



# TYPES OF MUTATION



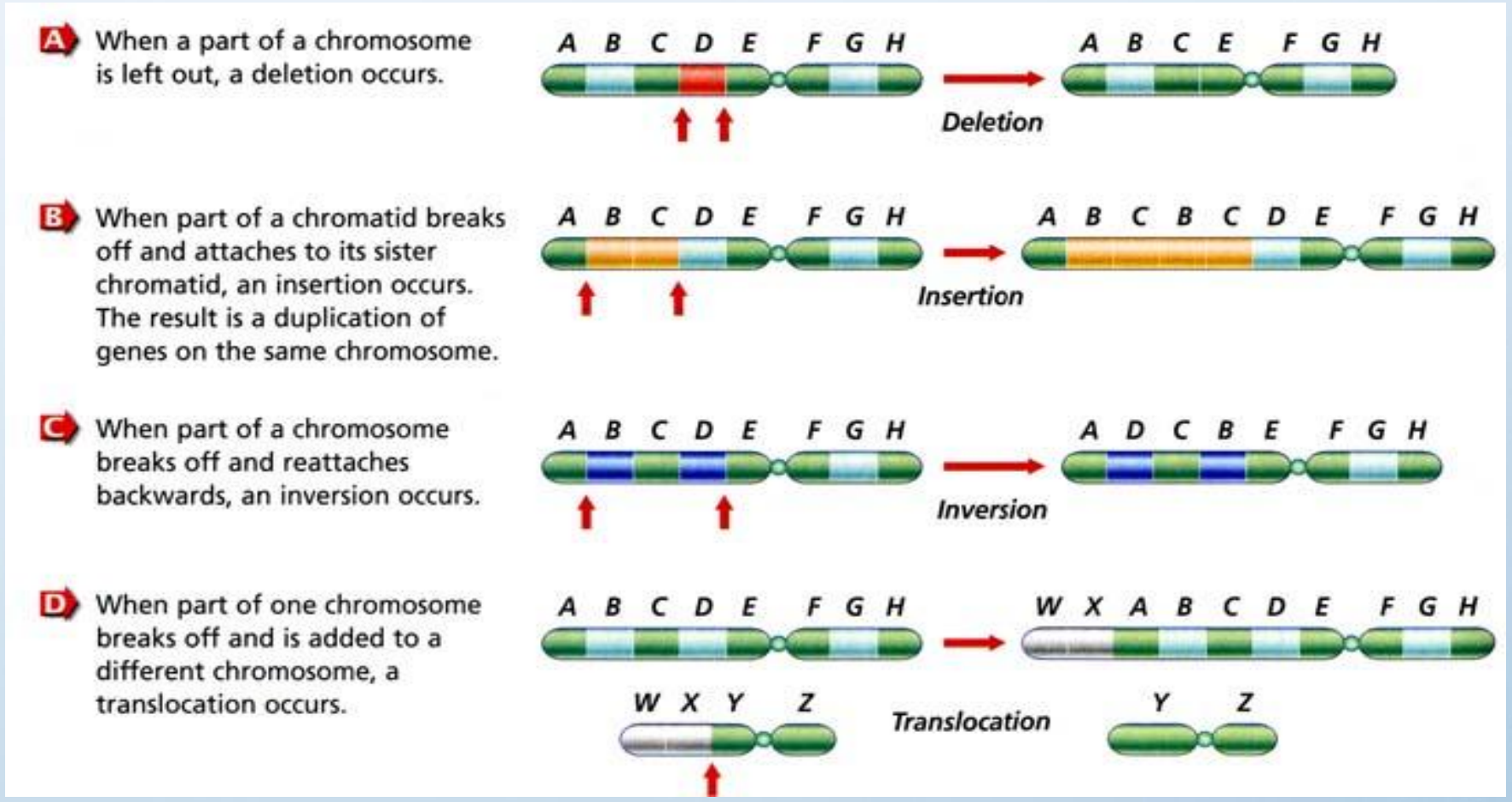
# Types of Chromosomal Abnormalities



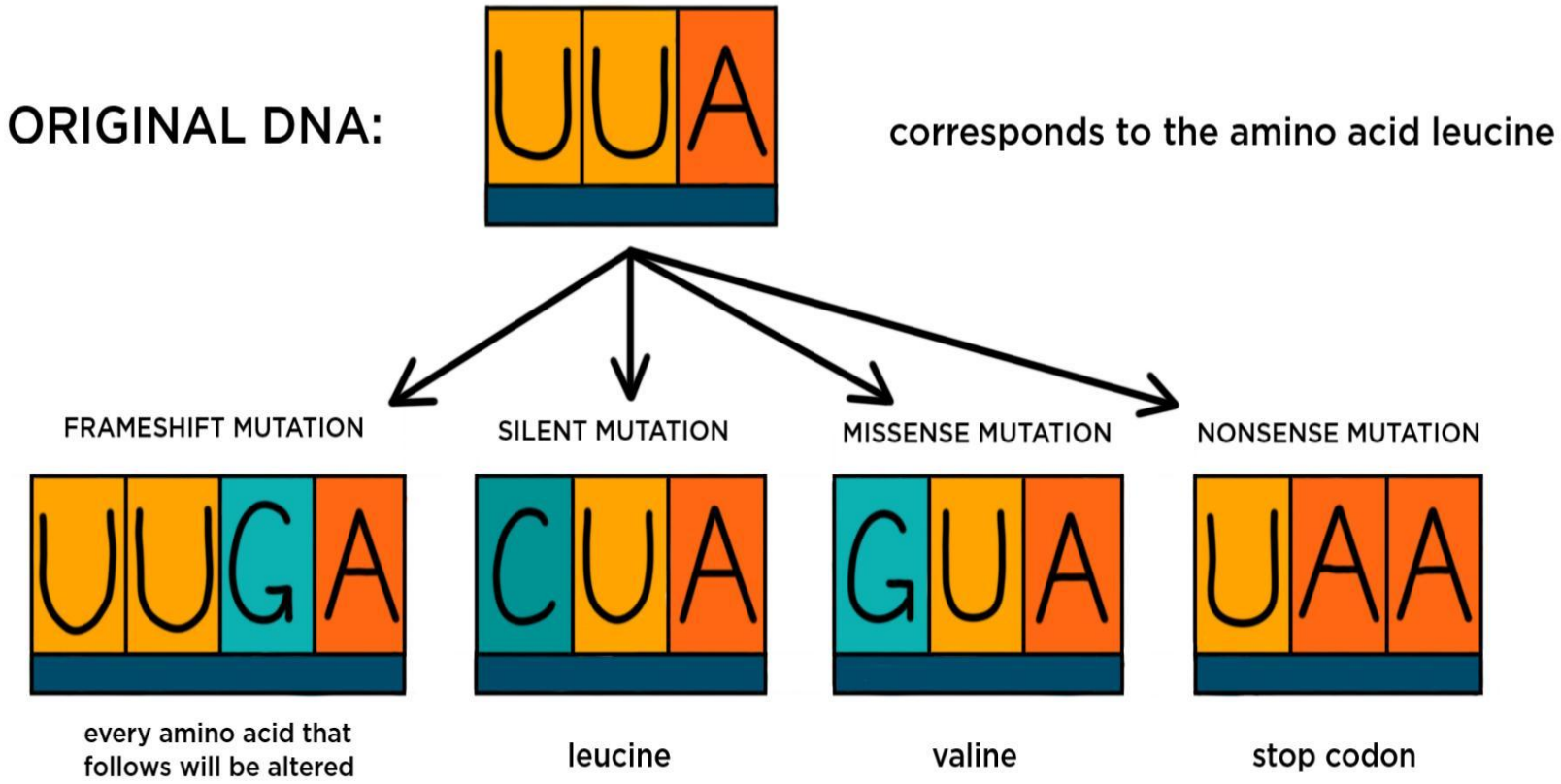

- aneuploidy
- polyploidy


- deletion
- duplication
- inversion
- translocation

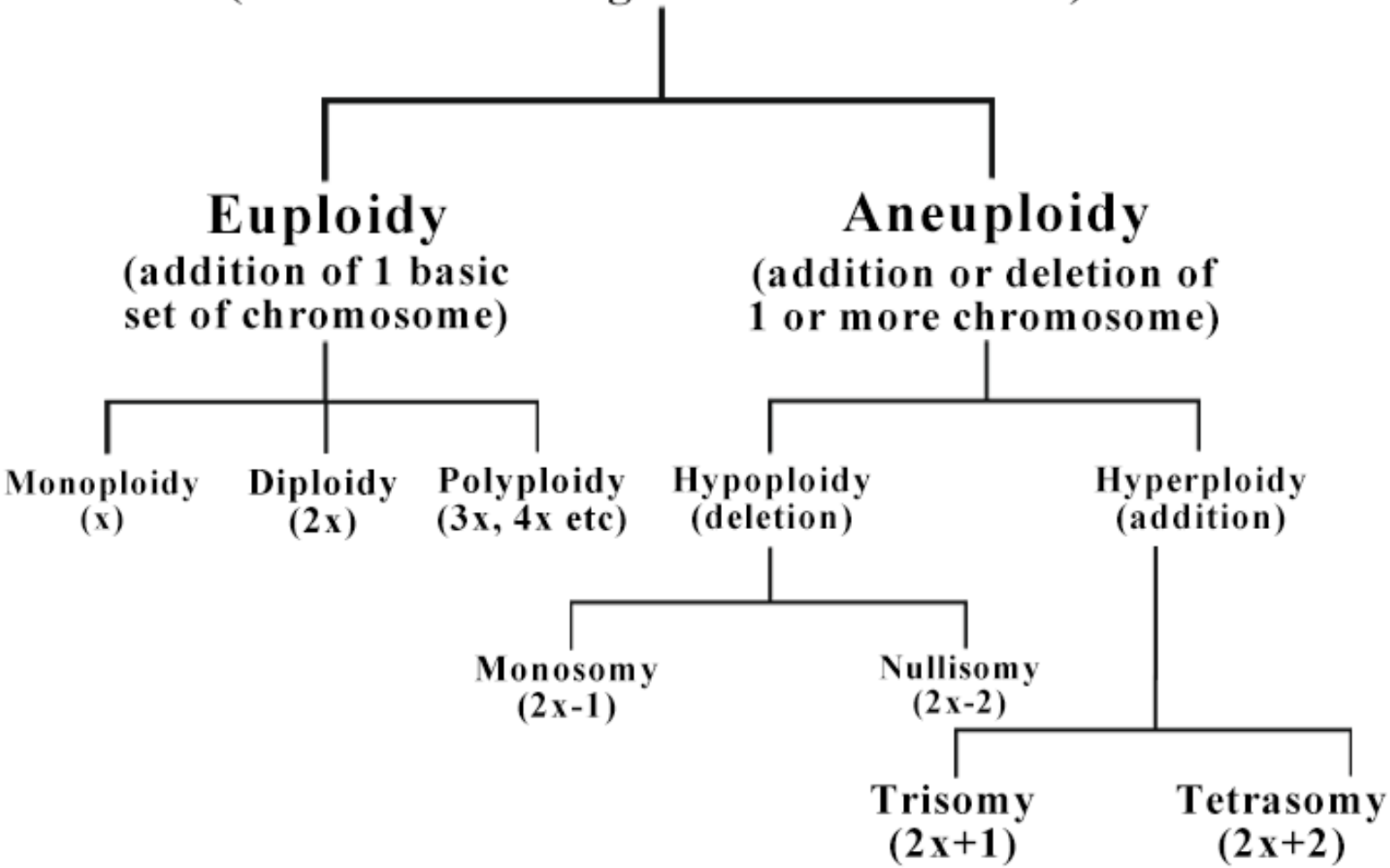
# Structural mutation



# What Are Point Mutations?



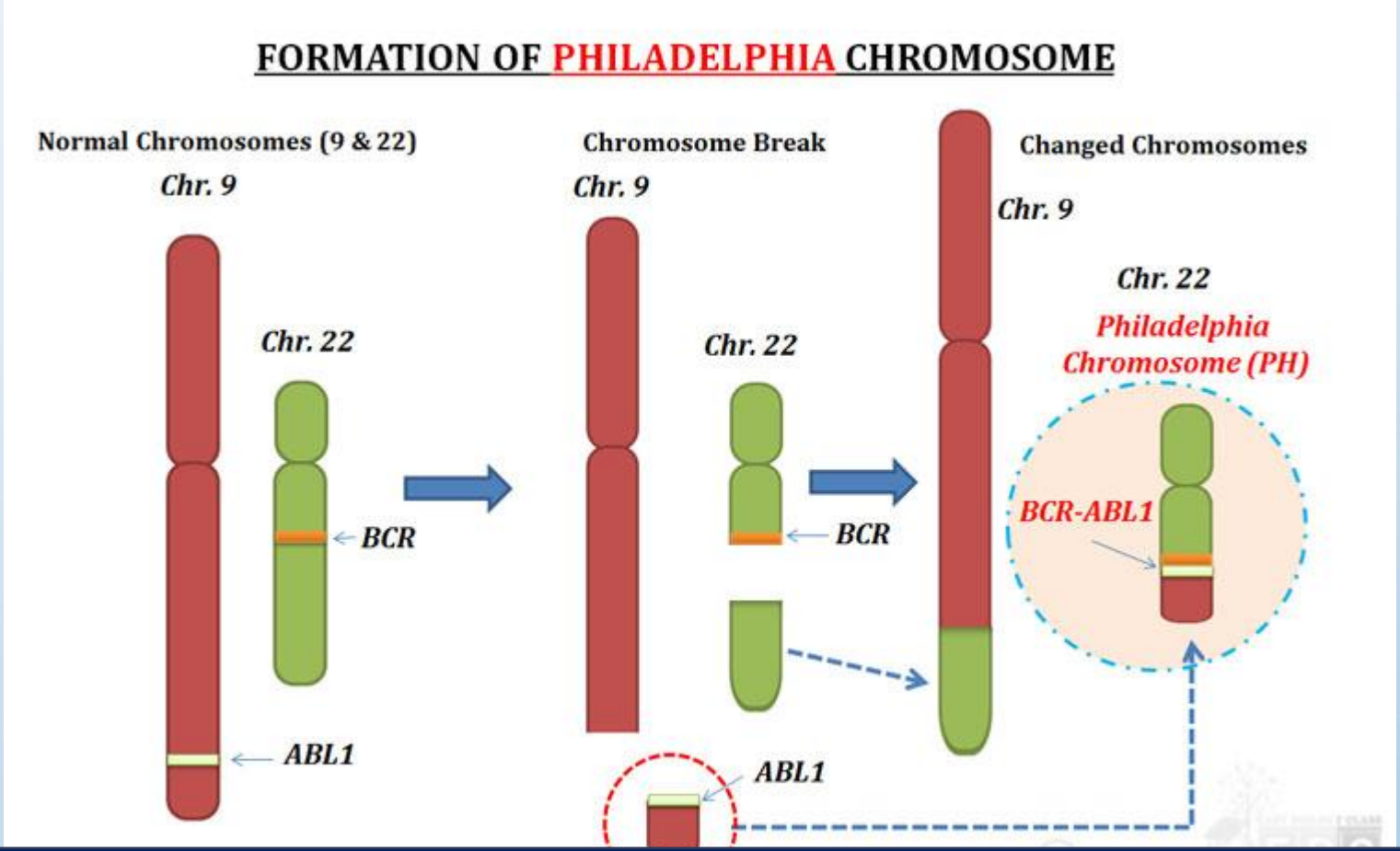
# Genomic Mutations
## (numerical changes in chromosomes)



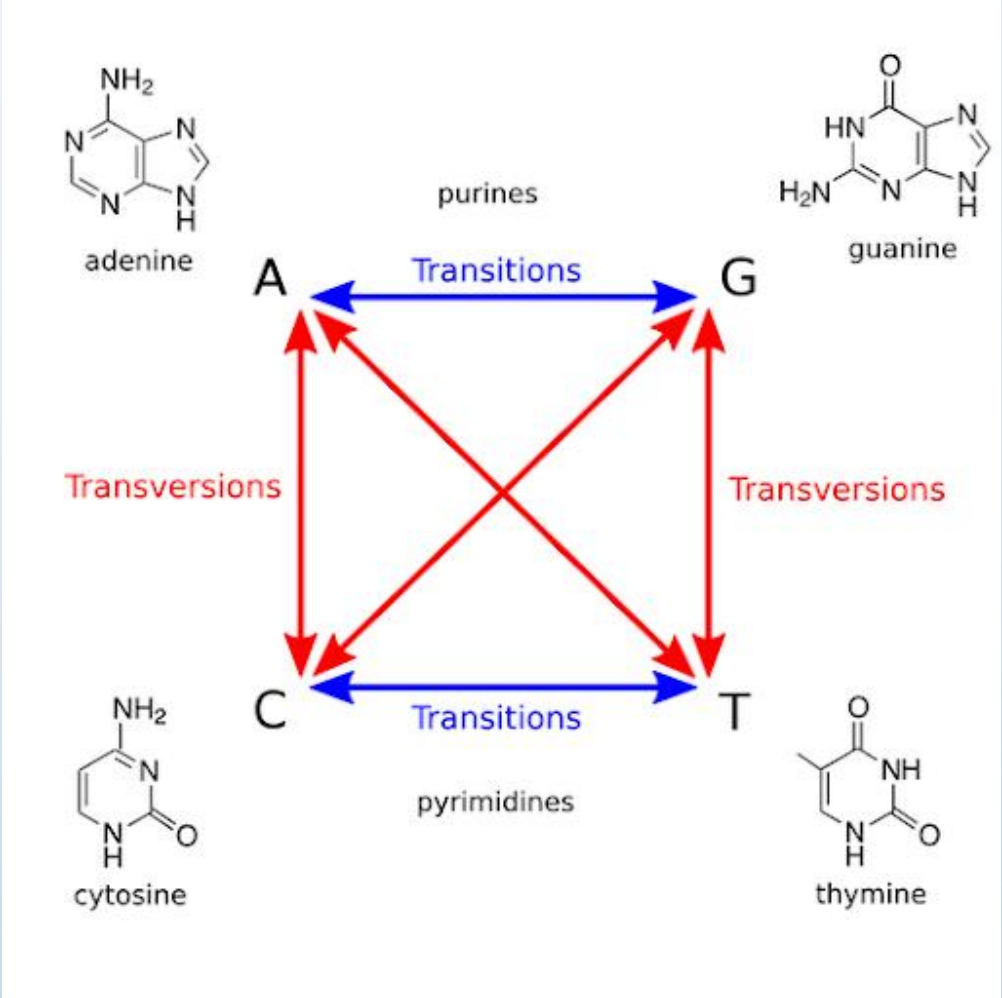
# Some Special Informations

- Down Syndrome:- 21st Chromosome Trisomy.
- Edward Syndrome:- 18th Chromosome Trisomy.
- Patau Syndrome:- 13th Chromosome Trisomy
- Klinefelter Syndrome:- ‘X’- Chromosome Trisomy.(XXY)
- Turner Syndrome:-‘X’- Chromosome Monosomy.(XO)

# Philadelphia chromosome (Example of translocation)



# Base shifting



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# Some important PYQ of this chapter

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**1. To study meiosis in plants, the best part would be (MPPSC Prelims)**

a. Shoot apex
b. Root apex
c. Anthers
d. Leaf cells

**Ans.** C (Anthers)

**Explanation:** *Meiosis occurs in germ cells. In anther, male gametes are formed through meiosis. Hence, option C is correct.*

**2. The sugar present in DNA is (UPPCS Mains)**

a. Glucose
b. Fructose
c. Deoxyribose
d. Ribose

**Ans.** C (Deoxyribose)

**Explanation:** *The deoxyribose sugar is found in DNA. It is variant of five carbon sugar called ribose.*

**3. Change in basic sequence of gene is known as – (UPPSC)**

a. Mutation
b. Transversion
c. Conjugation
d. Reproduction

**Ans.** a(Mutation)

**Explanation.** *Any changes in base sequence of gene is called mutation. It reflects the genotypic expression as well as phenotype of an organism.*

**4. Webbed neck is a characteristic of - (SSC CGL)**

a. Down's syndrome
b. Turner's syndrome
c. Klinefilter's syndrome
d. Cri-du-chat syndrome

**Ans.** b (Turner syndrome)

**Explanation:** *A webbed neck is a congenital skin fold that runs along the sides of the neck down to the shoulders. It is observed in Tuner syndrome individuals.*

5. **The pyrimidine bases in DNA are: [WBCS Prelims]**

a) Adenine and Guanine
b) Thymine and Adenine
c) Cytosine and Guanine
d) Thymine and Cytosine

**Ans.** d) Thymine and Cytosine

**Explanation**: *The pyrimidines found in DNA are Cytosine (C) and Thymine (T). They are capable of complementary base pairing with the purines Guanine (G) and Adenine (A) to form a double helix.*

**Some important book references**

1. Encyclopedia of General Sciences by Arihant Publication
2. Encyclopedia of General Sciences by Disha Publication
3. NCERT Notes 6-12 by Arihant/Mcgrawhill Publication
4. Competitive Bigyan by Santra Publications (For Bengali Medium)
5. Class 9-10 Biology Text Book Bengali version (Santra/Prantik)
6. WBCS General Studies Manual- Mcgrawhill (Good for other PSC exams also)

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***Thank You***

***In the next chapter, we will learn about Mendelian Genetics***

***See you next day***