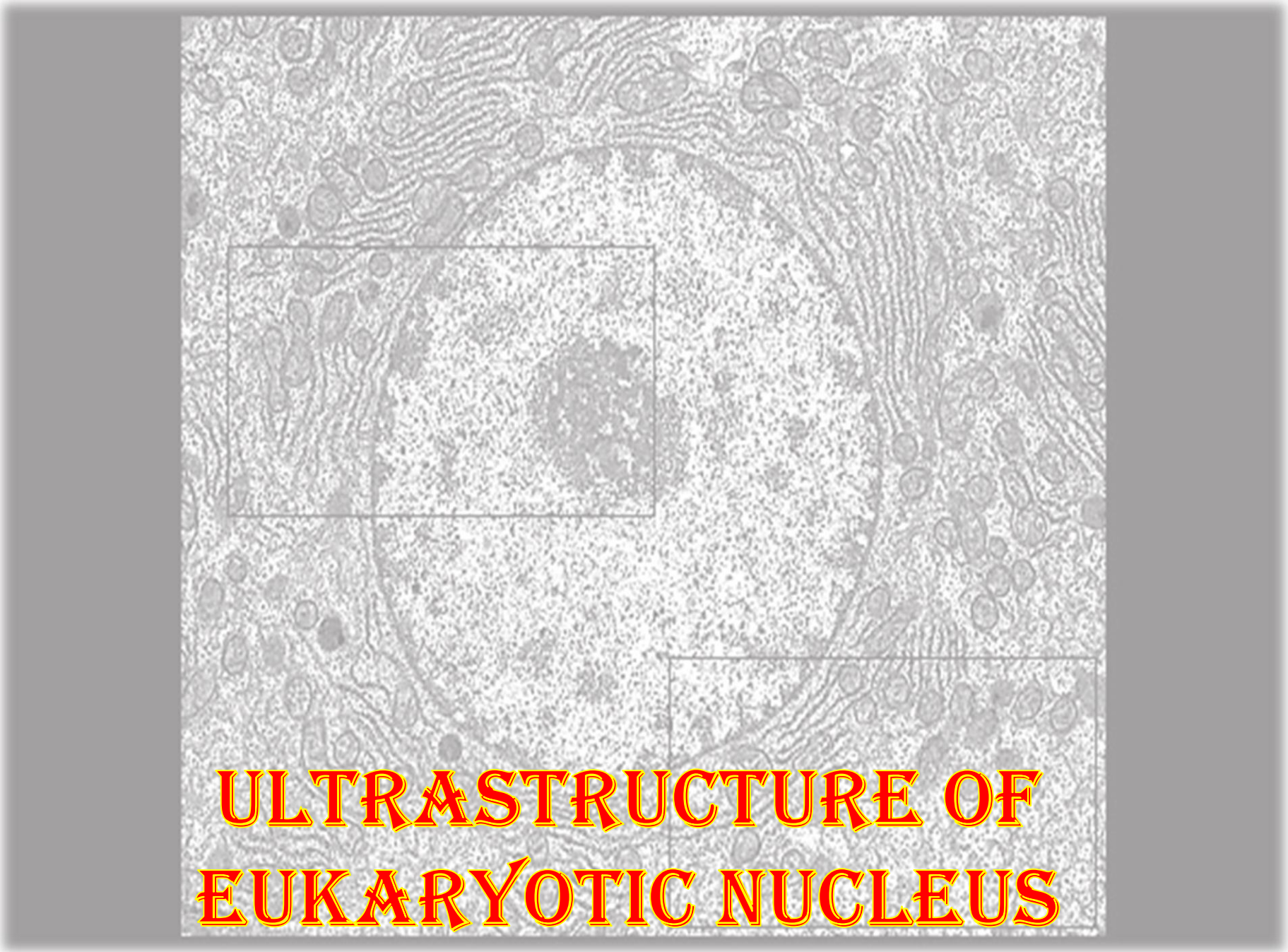
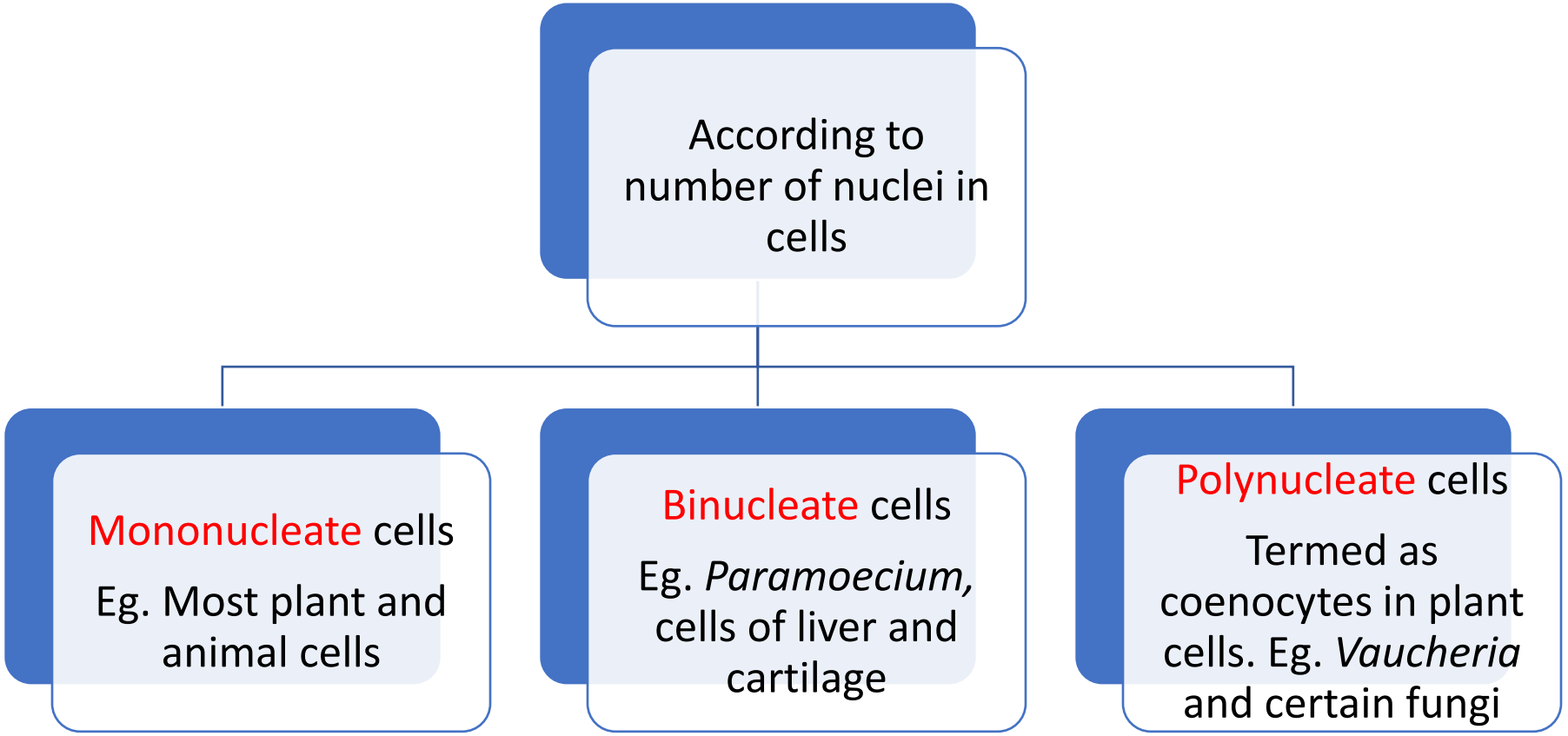


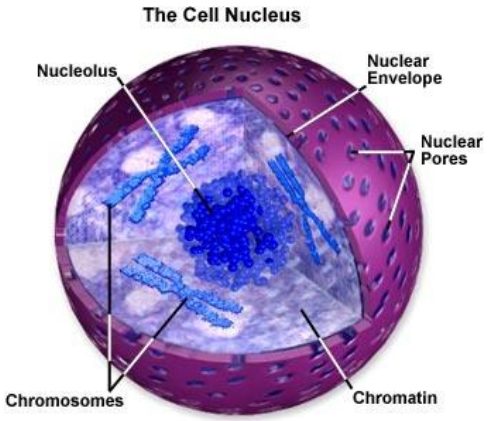
ULTRASTRUCTURE OF EUKARYOTIC NUCLEUS

- Nucleus – Heart of the cell; Brain of the cell.
- Controls different metabolic as well as hereditary activities of the cell.
- Greek word ‘karyon’.
- True nucleus in eukaryotes as compared to nucleoid in prokaryotes.
- Found in all eukaryotic cells of plants and animals. Exceptions – mature sieve tubes of phloem and mammalian RBCs.
- Position varies from centre to periphery.
- Mostly shifted to one side in plant cell due to large vacuole.

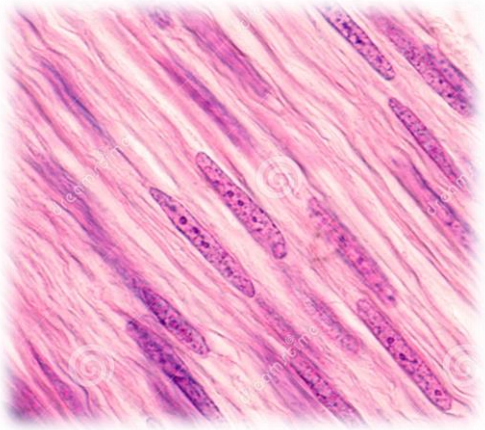
MORPHOLOGICAL ASPECTS OF NUCLEUS



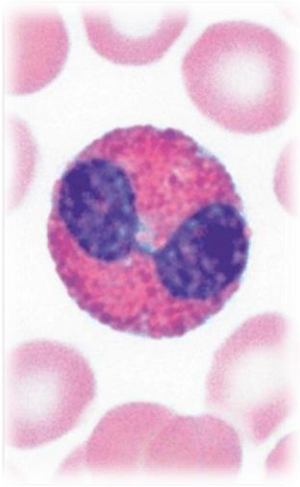
DIFFERENT SHAPES OF NUCLEUS



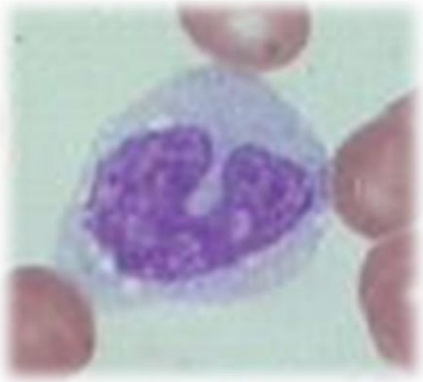
Spherical



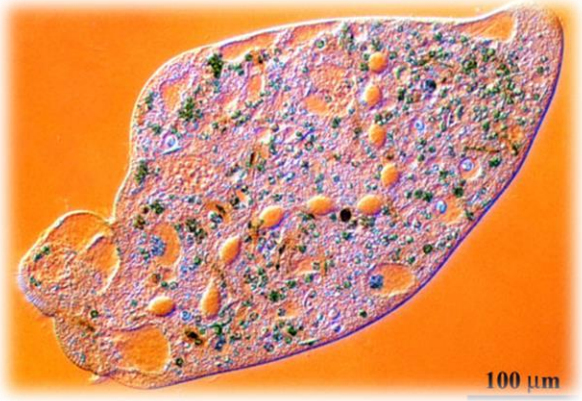
Fusiform



Bilobed



Horse-shoe shaped

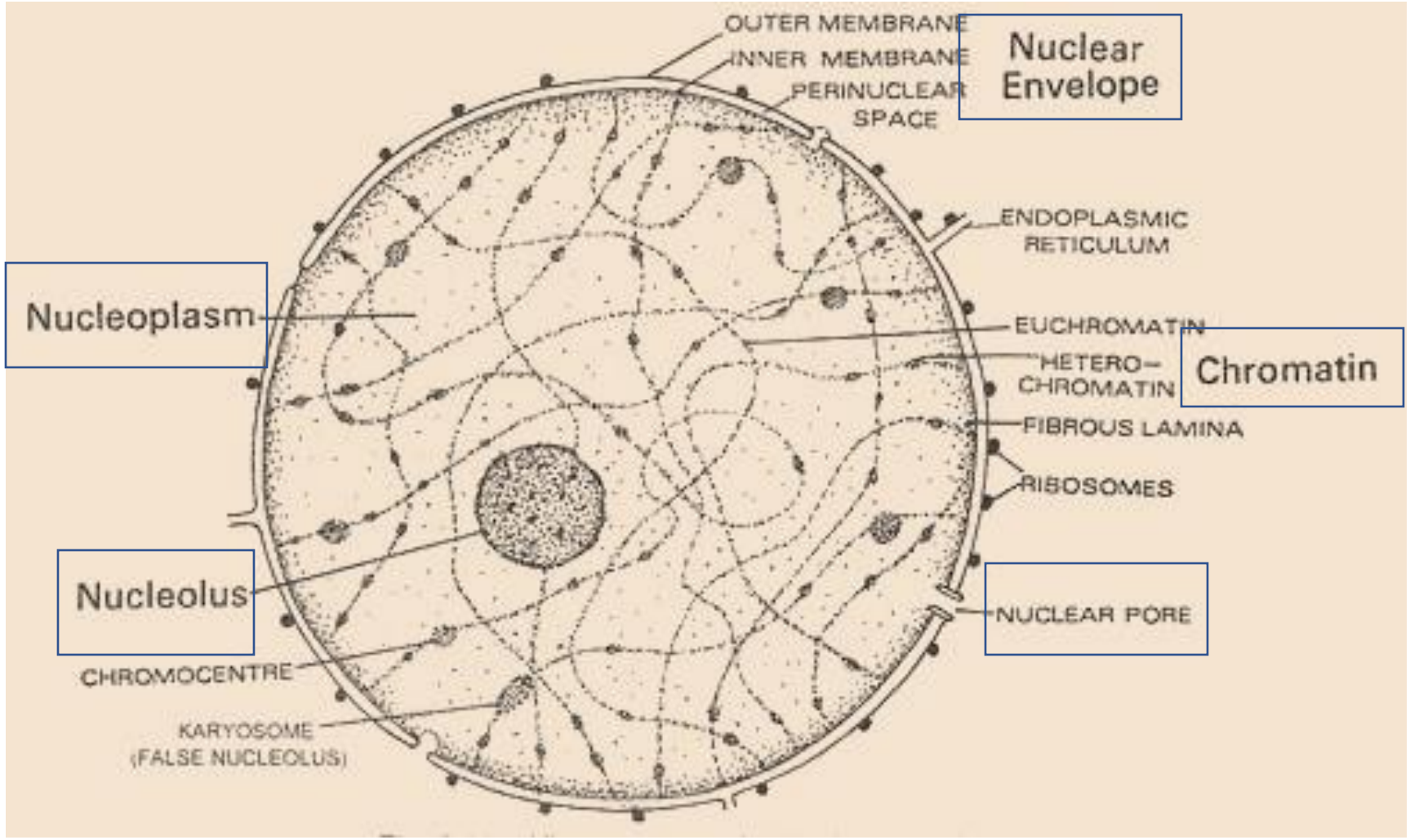


Moniliform (beaded)

NUCLEUS – SIZE VARIATIONS

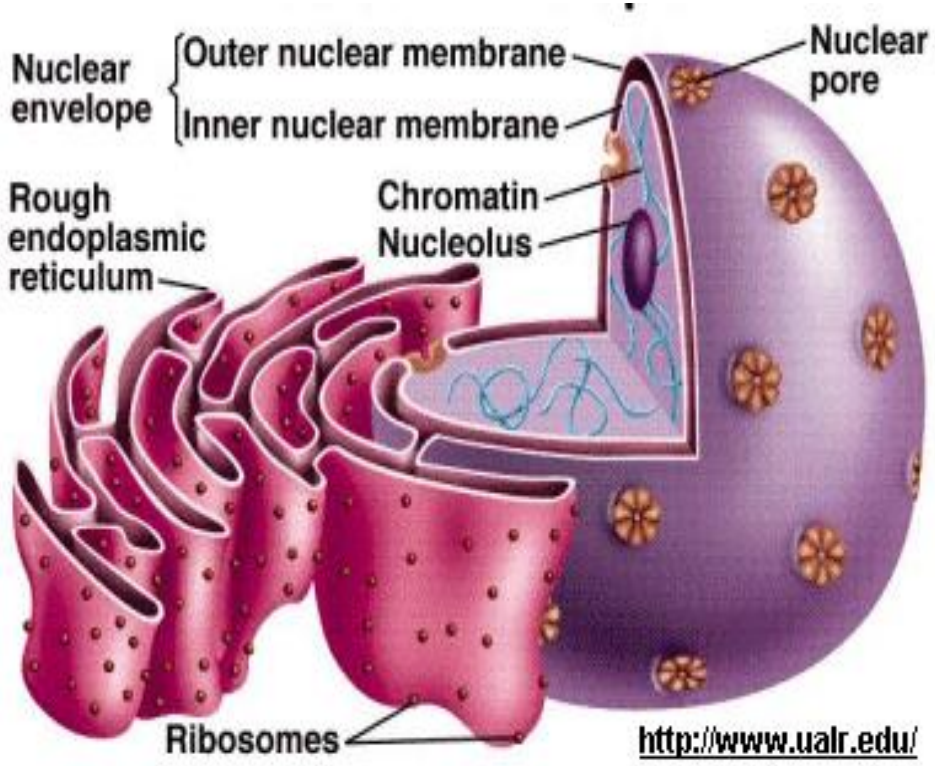
- Generally occupies 10% of the cell volume.
- Size varies from 3 µm to 25 µm.
- Contains diploid set of chromosomes.
- Size of nucleus directly proportional to amount of cytoplasm.
- Haploid cells contain smaller nuclei as compared to that of diploid cells.
- Size of nucleus overall depends on volume of the cell, amount of DNA and proteins and metabolic phase of the cell.

NUCLEUS – Ultrastructure



Nucleus is composed of nuclear membrane, nucleoplasm, chromatin fibres and nucleolus.

- Nuclear Membrane- Nuclear Pore Complex and Nucleocytoplasmic Transport
- Nucleolus-irregularly shaped structures which function in synthesis of rRNA and ribosome assembly
- Nucleoplasm-fluid substance present within the nucleus
- Chromatin Network-Arrangement of the nuclear genetic material in the nucleus- euchromatin and heterochromatin

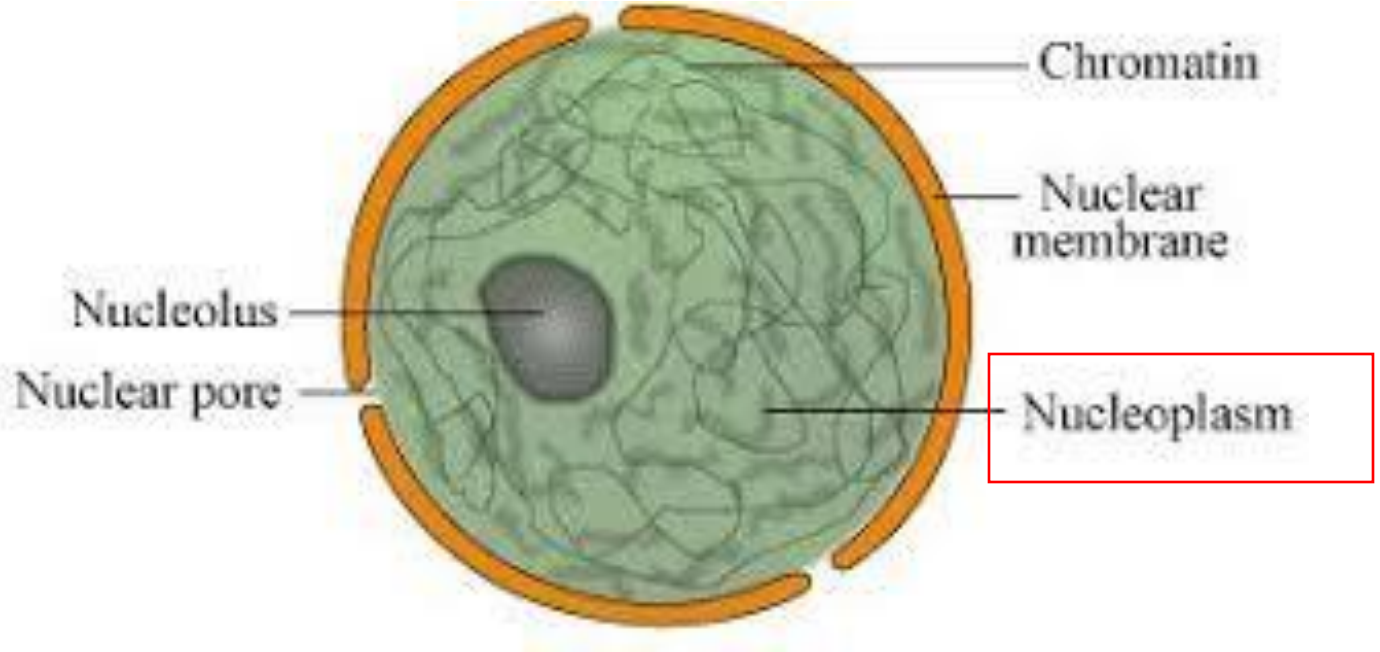


1. The Nuclear Envelope

- It is a **boundary** which separates the nuclear contents from the cytoplasm. It is also known as **karyotheca**.
- Presence of a **distinct** nuclear membrane marks the evolutionary transition of prokaryotes to eukaryotes.

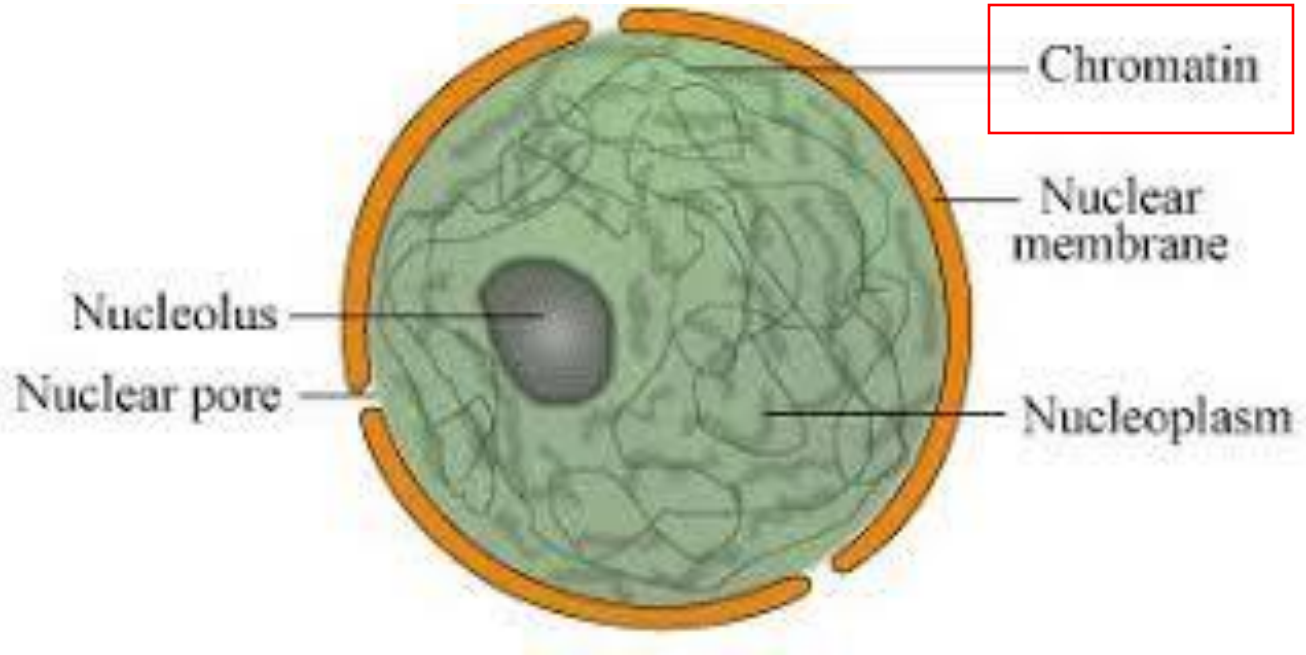
2. The Nucleoplasm

"Space between nuclear membrane and nucleolus is filled with a transparent, semi-solid, granular and slightly acidophilic ground substance or matrix known as the nuclear sap or nucleoplasm or the karyolymph".



3. The Chromatin Fibres

"Nucleoplasm contains many thread-like, coiled and much elongated structures which take readily the basic stains such as basic fuschin. These thread-like structures are called as chromatin".



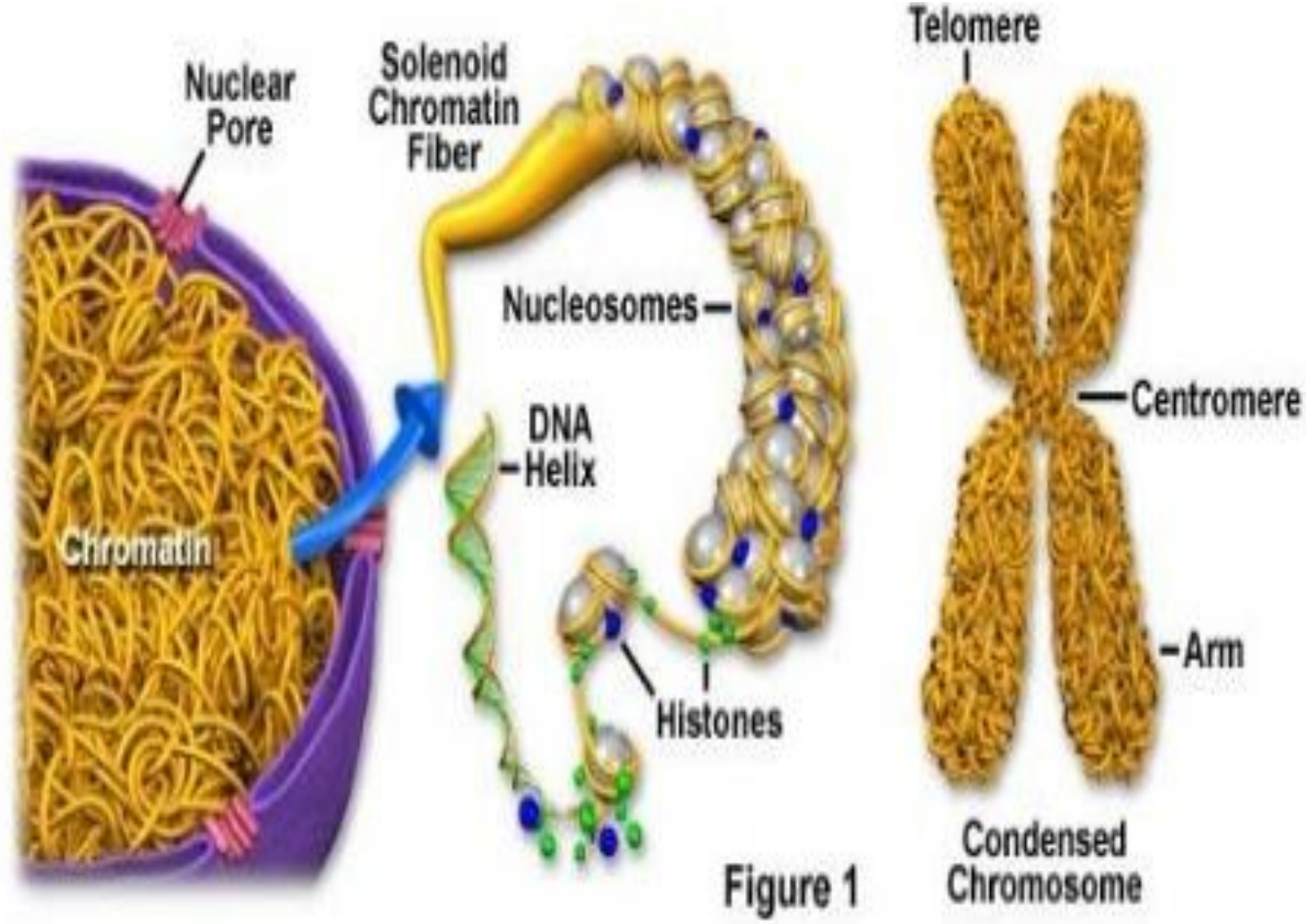
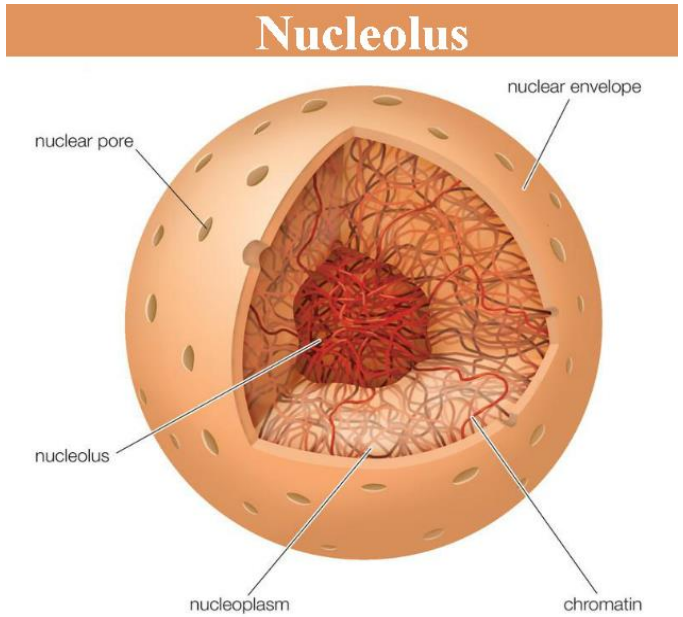

Nuclear Pore
Solenoid Chromatin Fiber
Telomere
Nucleosomes
Centromere
DNA Helix
Chromatin
Arm
Histones
Condensed Chromosome

Figure 1

4. Nucleolus

- First detected by Fontana in 1874.
- Relatively large, prominent, spherical body located either in central or peripheral part of nucleus.
- Not bounded by any limiting membrane.
- Intact organization maintained by Ca^{+2} ions.



FUNCTIONS OF THE NUCLEUS

1. Contains hereditary material called chromatin which bear genes.
2. Chromatin part of nucleus contains all genetic information required for growth and development aspects of organism.
3. Controls cell metabolism and other activities through formation of all types of RNA concerned with respective enzymes.
4. Formation of ribosomes occurs in nucleus.
5. Variations caused by changes in genetic material takes place in nucleus.
6. Nucleus directs synthesis of some structural proteins and chemicals required for cell growth and maintenance.
7. Directs cell differentiation by allowing certain sets of genes to operate.
8. Cell division requires nucleus replication i.e. karyokinesis.
9. Enclosure of DNA in nuclear envelope ensures its protection and also export of mRNA becomes controllable.
10. Nuclear membrane provides surface for attachment of structural elements of cytoplasm
11. Nuclear sap is the site of enzyme activity.
12. Traffic in and out of nucleus is mediated by nuclear pores.

ULTRASTRUCTURE OF CHROMOSOMES

- Chromosomes are filamentous bodies which are typically present in nucleus and which become visible during cell division.
- Chromatin in the interphase nucleus represents an aggregation of chromosomes.
- Chromosomes not visible in active nucleus due to their high water content, but are clearly seen during cell division.
- First seen by Hofmeister (1848) and were called so by W. Waldeyer (1888).

NUMBER OF CHROMOSOMES IN EUKARYOTIC CELLS

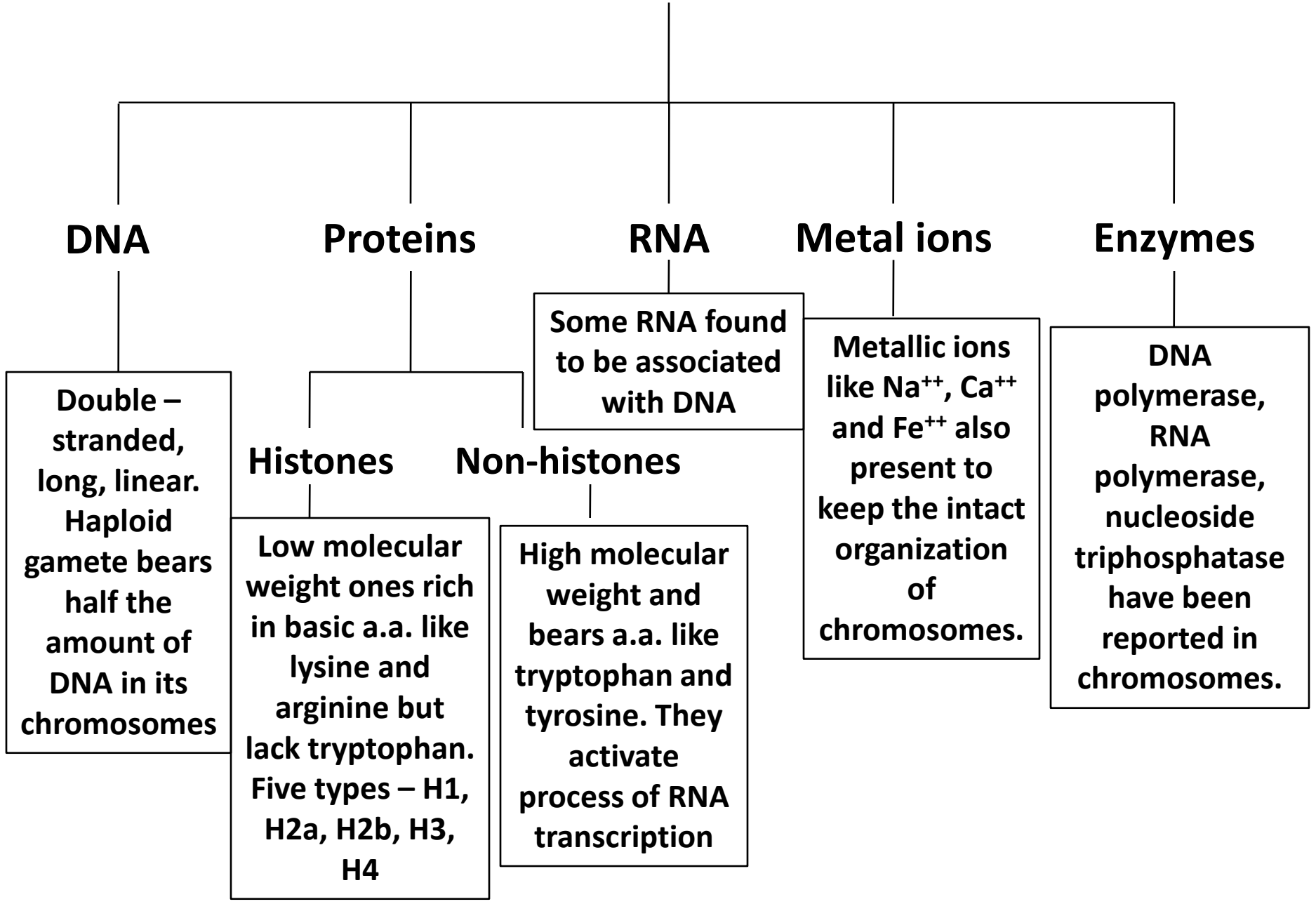
- Eukaryotic cells have fixed number of chromosomes per cell, which is its diploid number (2n).
- Haploid number (n) = 1 has been reported in

  Ascaris megalocephala.
- No. and composition helps to determine sex. Eg., males of some insect species and roundworms have one chromosome less than females.
- Largest chromosome number reported in Adder's tongue fern (*Ophioglossum*) in which 2n = 1262.
- Chromosome no. used in identification of species and in tracing relationship within species.

DIPLOID CHROMOSOME NUMBER IN SOME PLANTS

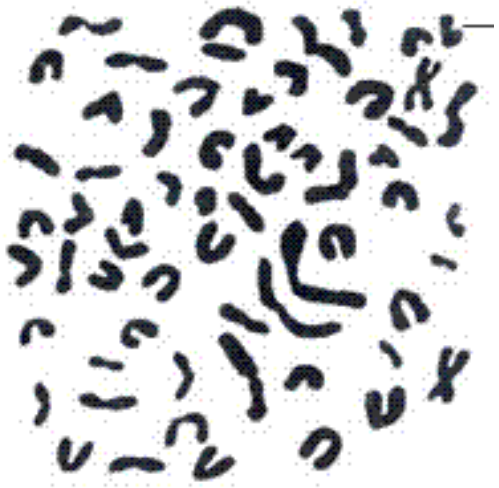
Common Name	Botanical Name	Diploid (2n) No.
Cabbage	*Brassica oleracea*	18
Cotton	*Gossypium hirsutum*	52
Cherry	*Prunus carasus*	32
Garden pea	*Pisum sativum*	14
Sunflower	*Helianthus annus*	34
Potato	*Solanum tuberosum*	48
Onion	*Allium cepa*	16
Wheat	*Triticum vulgare*	42
Rice	*Oryza sativa*	24

Chromosomes – Chemical Composition



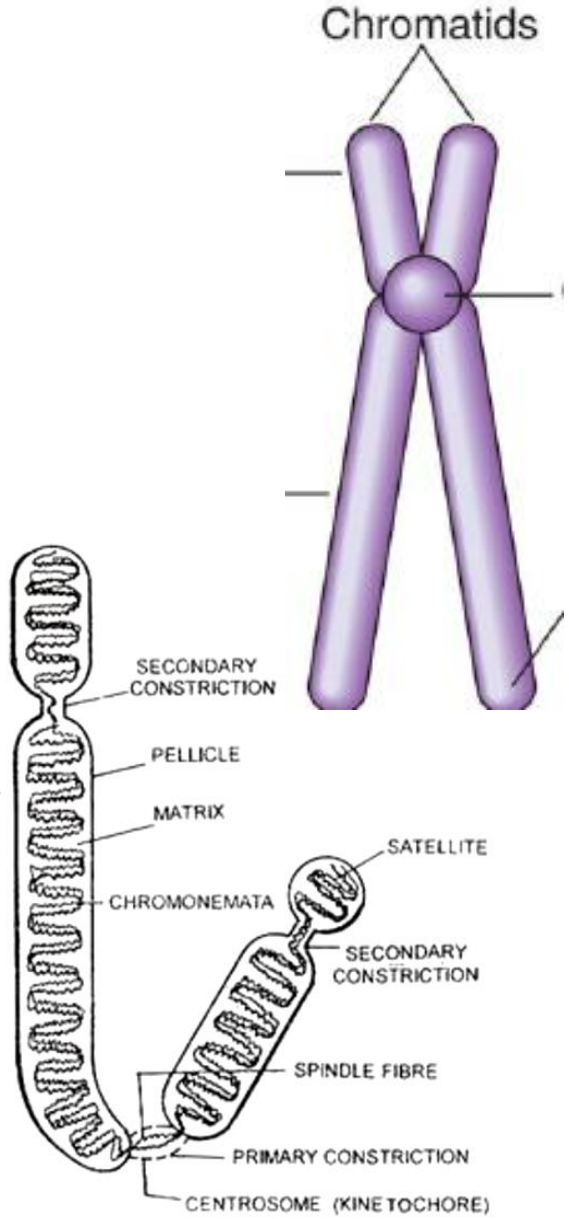
CHROMOSOMES – SIZE VARIATIONS

- Varies from species to species.
- Metaphase chromosome usually varies from 0.1 µm to 33 µm in length and 0.2 µm to 2 µm in thickness.
- Usually chromosomes in plant cells are larger as compared to those in animals.
- Even chromosomes of different pairs in nucleus of same cell differ in size.



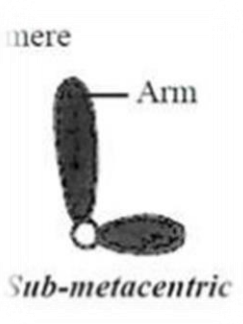
SINGLE CHROMOSOME – STRUCTURE

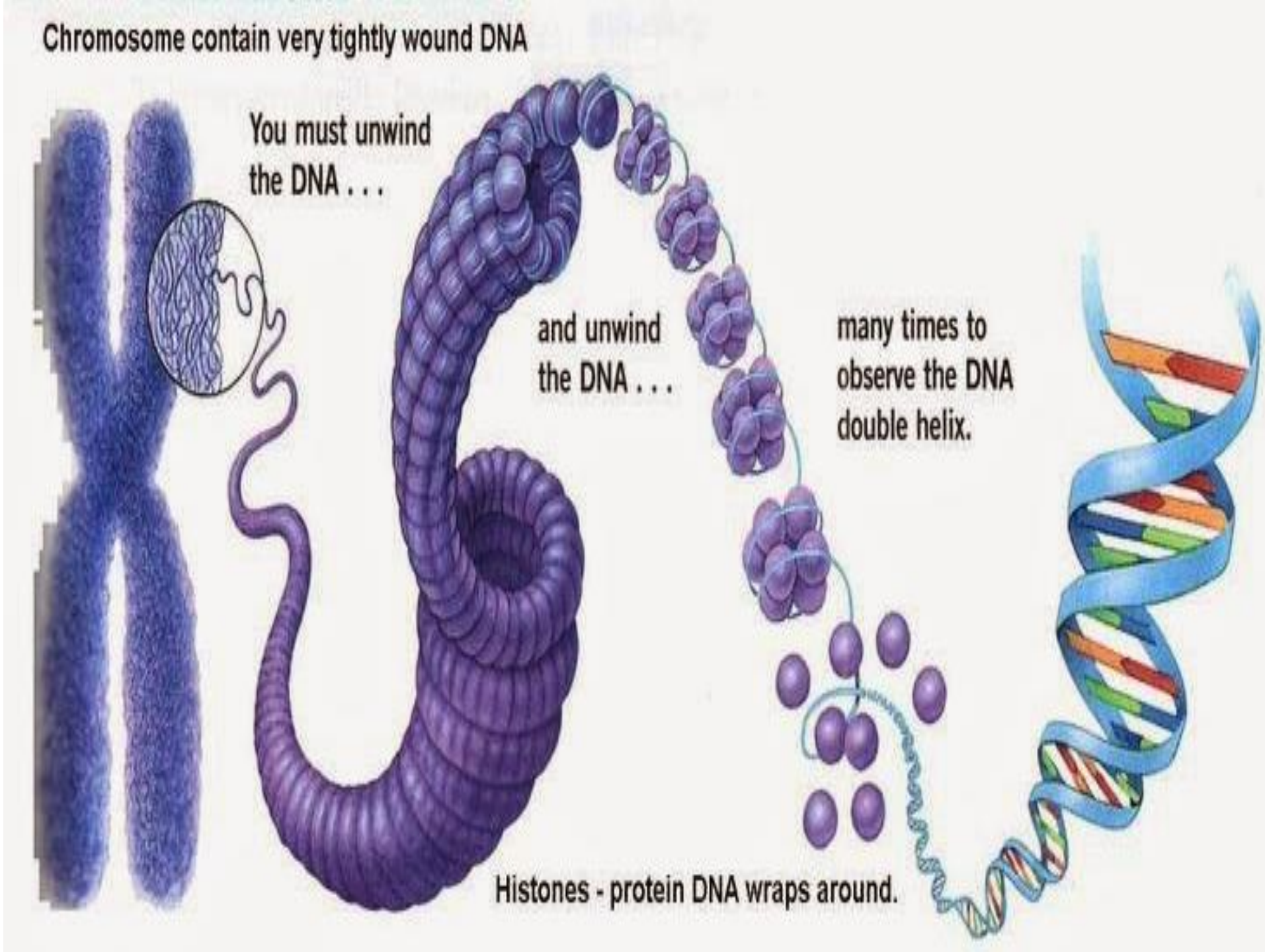
- Two identical chromatids lying side by side attached together at centromere or primary constriction.
- Each centromere bears plate-like kinetochore from where microtubules join chromosomes at the time of cell division.
- Monocentric chromosomes – with one centromere.
- Dicentric or polycentric – two or more centromeres.
- Acentric – Chromosome may break into two such that only one part gets centromere and other doesn't.
- Few may have secondary constriction acting as site for formation of nucleoli during interphase, called as nucleolar organizers. (nucleolar chromosomes).
- Telomeres – terminal ends of chromosomes. When broken, free ends without telomeres become sticky helping in binding.

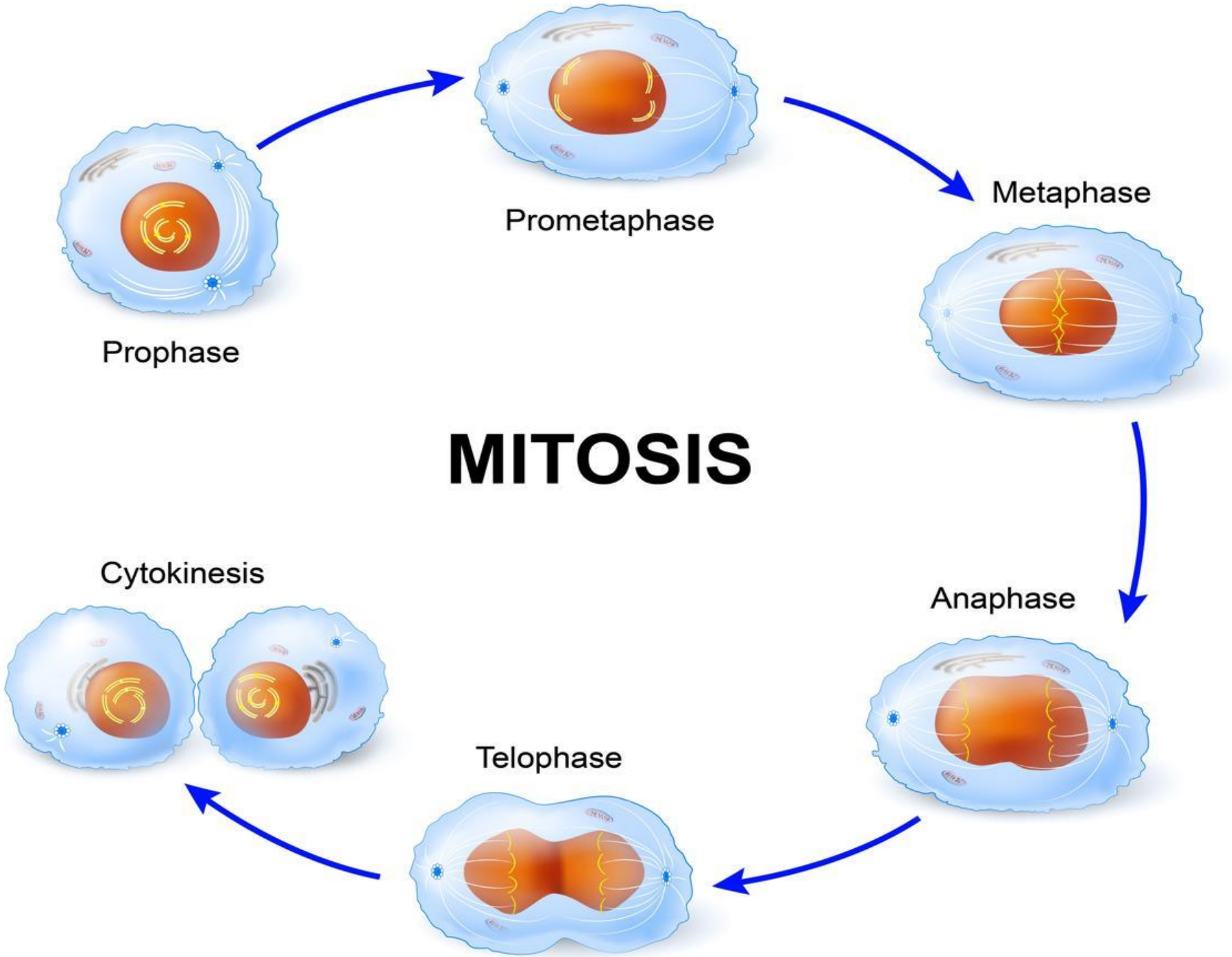


Types of Chromosomes based on shape

Telocentric	Acrocentric	Submetacentric	Metacentric
Centromere present at the proximal end on a rod like chromosome. Chromosome appears I – shaped.	Rod-shaped chromosomes with centromere very near the proximal end and thus has a small arm on this end. Chromosome appears L-shaped.	Chromosomes are L or J-shaped with centromere slightly away from mid-point so that two arms are unequal.	Chromosomes are V-shaped in which centromere lies in middle of chromosome, so that two arms are almost equal.




Chromosome contain very tightly wound DNA
You must unwind the DNA . . .
and unwind the DNA . . .
many times to observe the DNA double helix.
Histones - protein DNA wraps around.


Prophase
Prometaphase
Metaphase
MITOSIS
Anaphase
Telophase
Cytokinesis

It is also called ‘indirect cell division’ or ‘somatic cell division’ or ‘equational division’.

In this, mature somatic cell divides in such a way that chromosome number is kept constant in daughter cells equal to those in parent cell, so the daughter cells are quantitatively as well as qualitatively similar to the parental cell.

Mitosis - Discovery

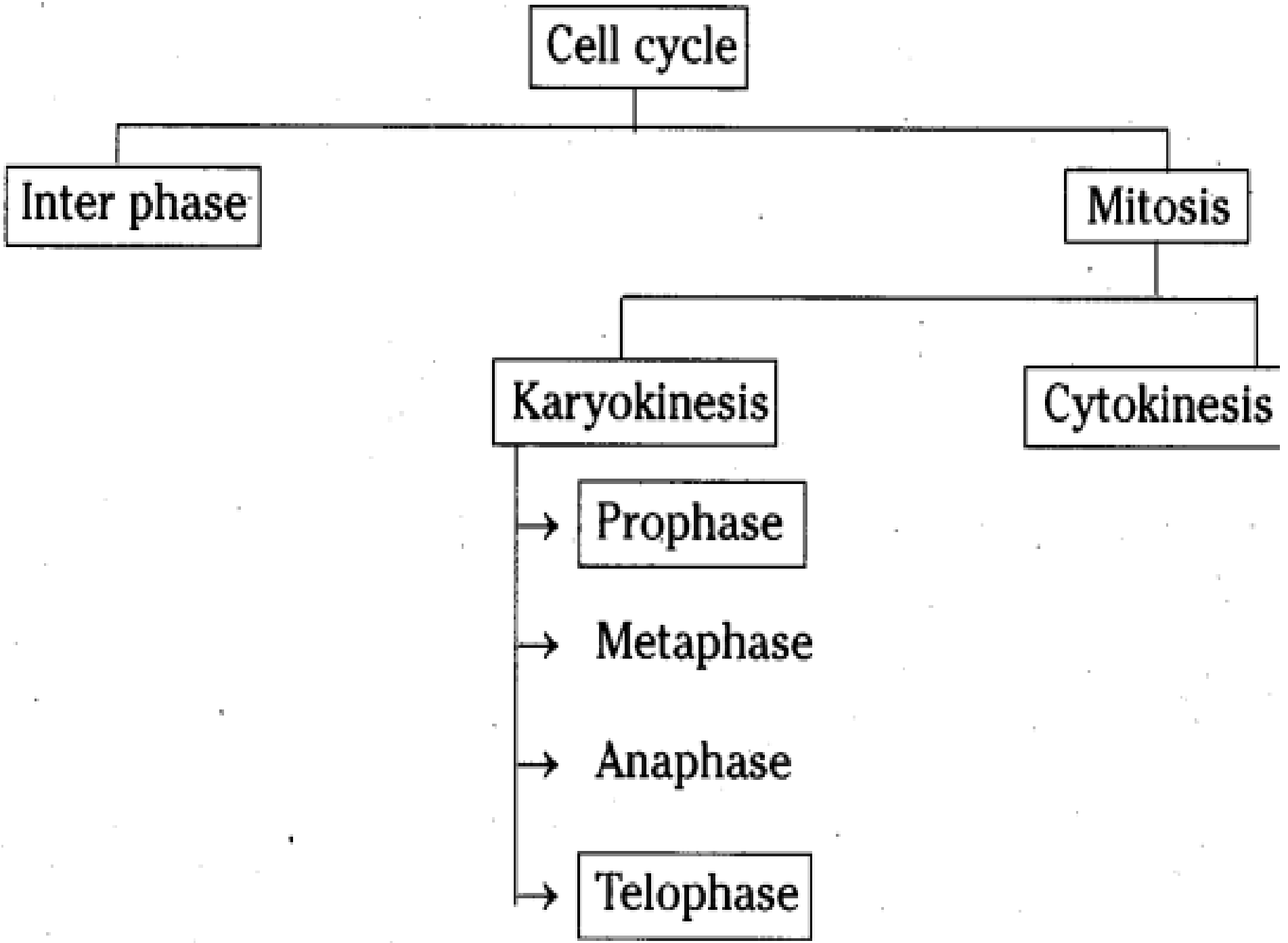
- Discovered in plant cells by a German biologist Strasburger (1875).
- Discovered in animal cells by another German biologist W. Flemming (1879).
- Term ‘mitosis’ was given by Flemming (1882).
- *Mito* – thread; *osis* – state.

Mitosis – Time taken

Ranges from 30 minutes to 3 hours. Time is species – specific but also depends upon type of tissue, temperature, etc.

Mitosis – Occurrence

Mitosis occurs in both somatic as well as germ cells. In plants, it takes place in meristematic tissue of root and shoot apex. It also occurs during embryonic development.


Cell cycle
Inter phase
Mitosis
Karyokinesis
Cytokinesis
Prophase
Metaphase
Anaphase
Telophase

Stages of Mitosis in Plant cells

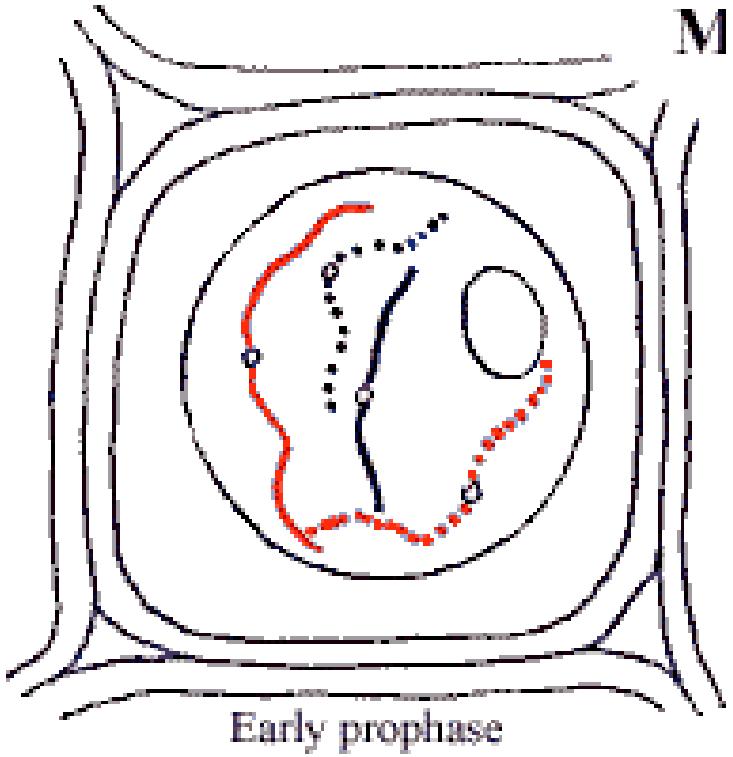
A. KARYOKINESIS

It consists of four phases based on the position and morphology of chromosomes.

1. Prophase

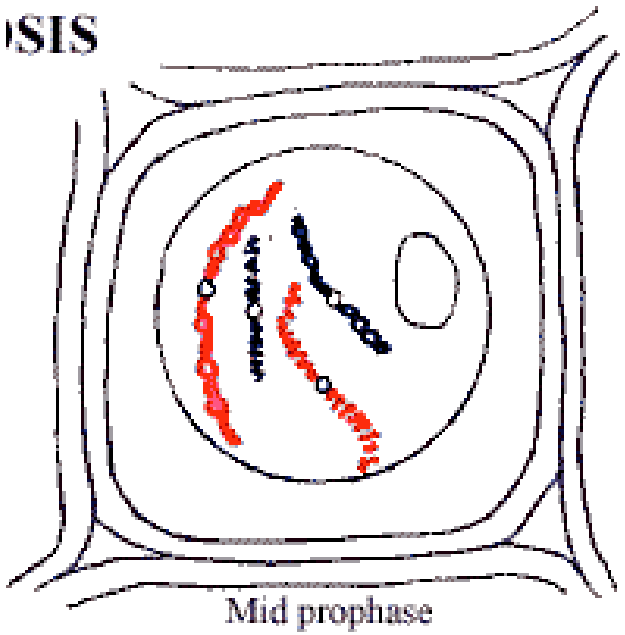
Pro – first; *phasis* – stage. It is the stage of longest duration. Takes place for about 71 minutes in onion root tip cells. (About 102 minutes in neuroplasts of grasshopper!). It is again of three sub-phases: early prophase, mid prophase and late prophase.

1.a. Early Prophase



- Characterized by formation of asters (anastral in plant cells) and condensation of chromatin.
- Dividing cell becomes spherical shaped with more viscous cytoplasm.
- Nuclear chromatin condenses into long, thin, thread-like chromosomes by dehydration and spiralization. Each chromosome formed of two sister chromatids joined together at the centromere or kinetochore.

1.b. Mid Prophase



- Characterized by more condensation of chromosomes so that they become shorter and thicker. Proteinous matrix deposited around the chromosomes. Chromosomes become distinct from each other. So the somatic cells increase in size but decrease in number.

  Further elongation of the microtubules producing the spindle fibres.

- Nuclear membrane (fragments merge into ER) and nucleolus (sheds its RNA over the chromosomes) start disappearing.

1.c. Late Prophase

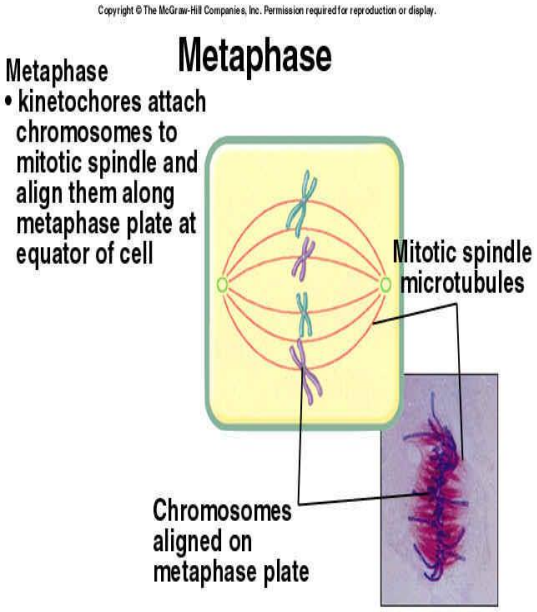
- Nearly complete disappearance of nuclear membrane and nucleolus.

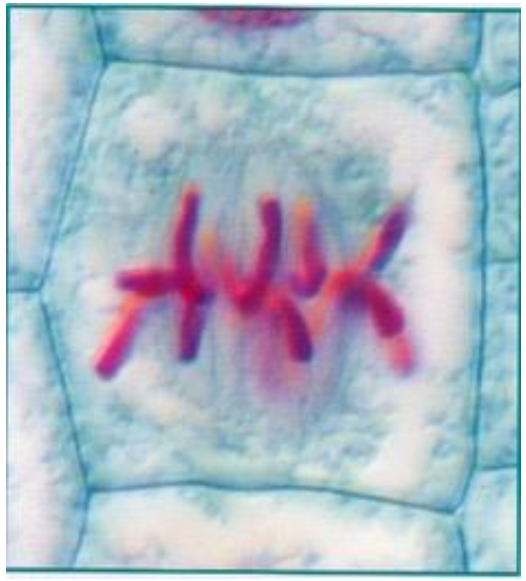
  Further condensation of chromosomes. It may be up to 1/25 of their length in the early prophase.

  Chromosomes move towards the nuclear membrane leaving a clear central area.

  Spindle is formed of two types of spindle fibres – chromosomal or discontinuous fibres (which extend from pole to the kinetochores) and continuous or interpolar fibres (which extend from pole to pole).

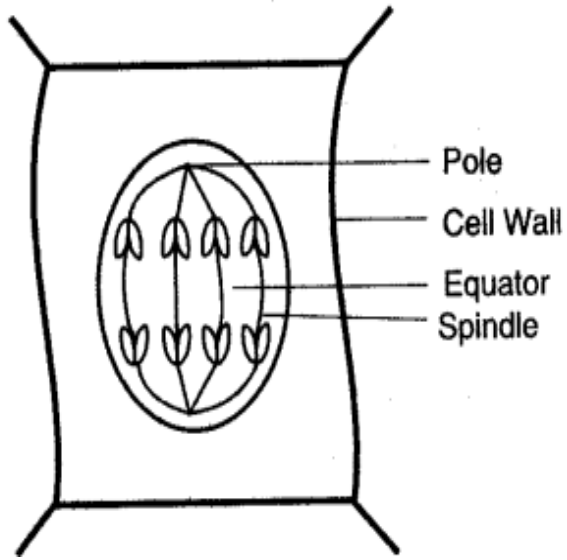
2. Metaphase

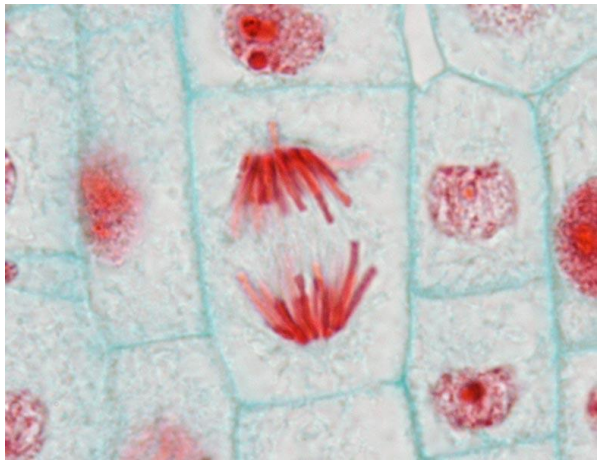




- It takes about 2 – 10 minutes.
- Chromosomes arrange at equator in one equatorial or metaphase plate arranged perpendicular to longitudinal axis of spindle.
- Smaller chromosomes lie near the centre of the equator, while larger chromosomes are peripheral in position.
- Each centromere is joined by two chromosomal fibres, one from each pole.
- Centromeres lie at the equator while arms are directed towards the poles.

3. Anaphase



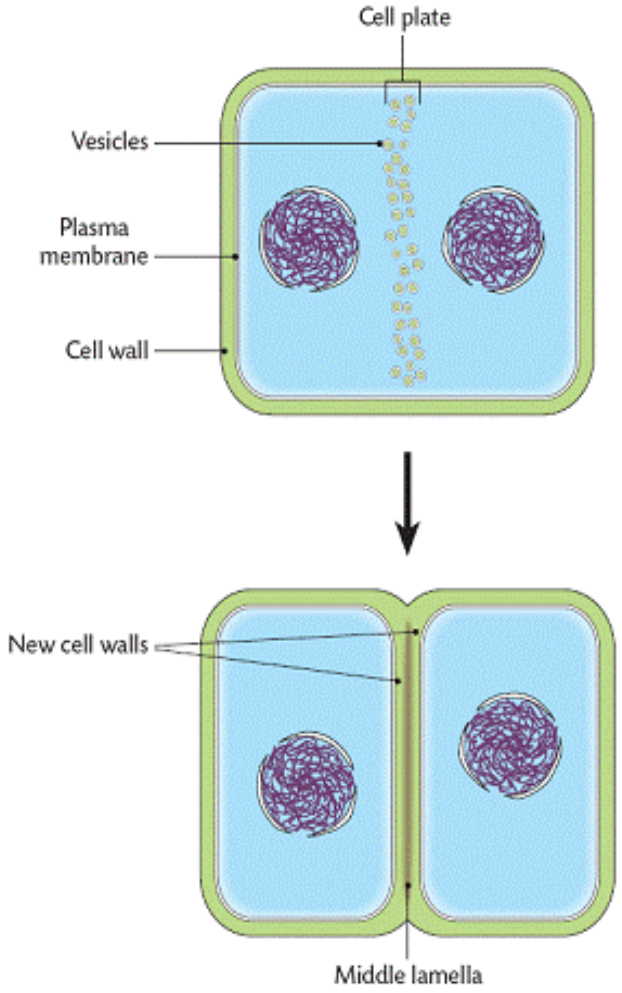


- It is of shortest duration (only 2 – 3 minutes).
- Each centromere splits, so that two sister chromatids have their own centromere and daughter chromosomes are formed. Each daughter chromosome is formed of only one chromatid.
- Proteinous inter-zonal fibres are developed between centromeres of daughter chromosomes.
- Daughter chromosomes move towards opposite poles and may be V-shaped or J-shaped or rod-shaped..
- Anaphase ends when all daughter chromosomes reach the opposite poles. So anaphase divides the nuclear matter into two equal and similar halves, hence called equational division.

4. Telophase

- It takes place for about one hour. It involves changes which are opposite to prophase.
- At each pole, chromosomes are surrounded by new nuclear membrane formed from ER elements.
- Nucleolus is reformed.
- Chromosomes decondense by hydration and de-spiralling to form a network, nuclear chromatin.
- Astral and spindle fibres are absorbed in cytoplasm.
- Two daughter nuclei are produced and the cell becomes ready for cytokinesis.

Cytokinesis in Plant cells



- New cell wall is formed during cytokinesis of plant cell division by cell plate formation.
- A number of elements, called phragmoplasts, are derived from ER and Golgi body.
- These elements line up at the equator and later fuse to form a cell plate which finally grows on both sides and forms middle lamella.
- The middle lamella is deposited with cellulose, calcium pectate, etc to form the cell wall.

Significance of Mitosis…

- It keeps the chromosome number constant and genetic stability in daughter cells, so the linear heredity of an organism is maintained. All the cells are with similar genetic constituents.
- It helps in growth and development of zygote into adult through embryo formation.
- It provides new cells for repair and regeneration of lost parts and healing of wounds.
- It helps in asexual reproduction by fragmentation, budding, stem cutting, etc.

…Significance of Mitosis

- Details of mitosis are similar in all living organisms showing evolutionary inter-relationships between them.
- It also restores the nucleo-cytoplasmic ratio.
- Somatic variations when maintained by vegetative propagation can play important role in speciation.
- Mitosis keeps a check on the cell size and maintains a favourable surface area / volume ratio which increases the exchanging power of the cell.

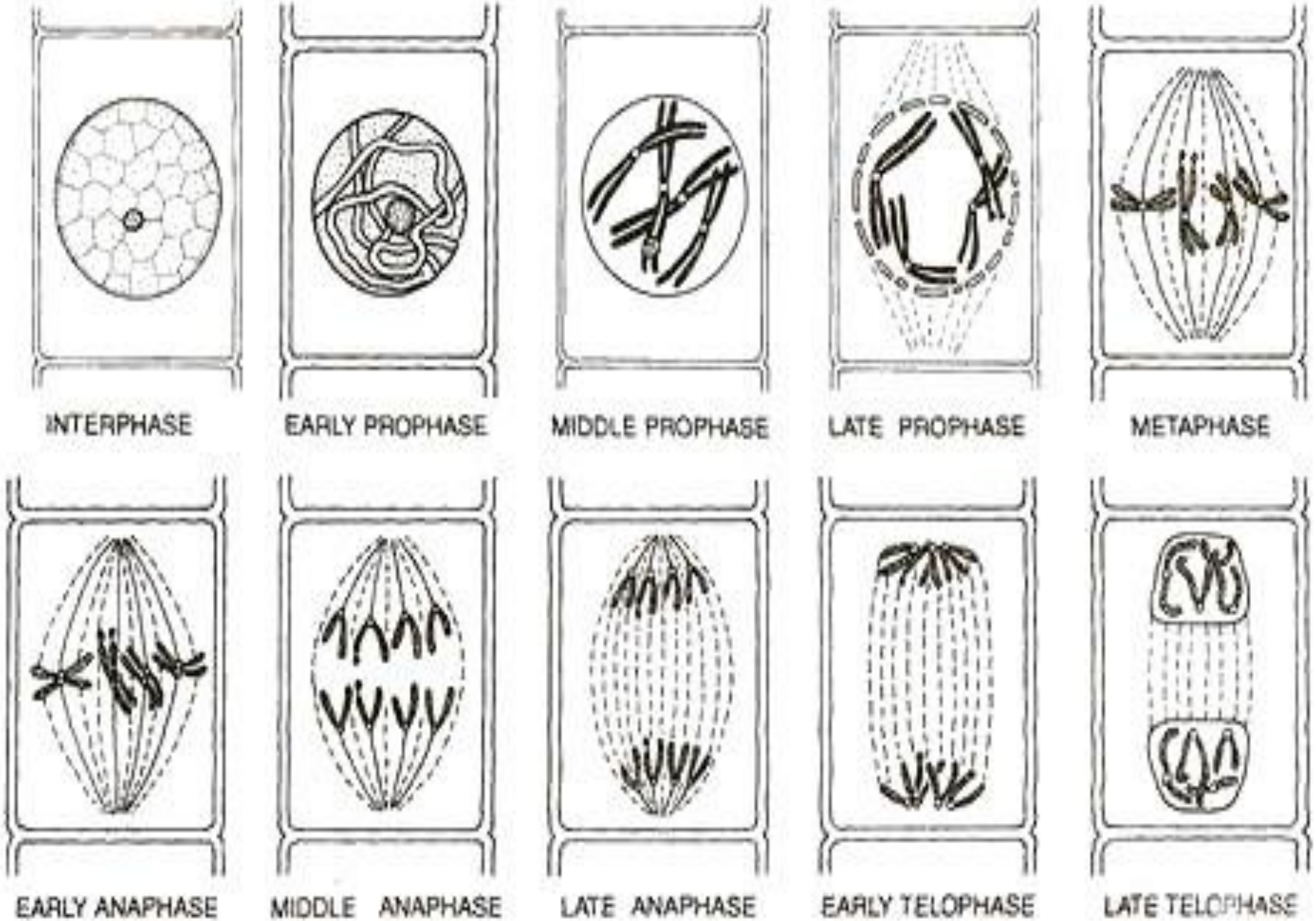


Fig. 10.7. Different stages of mitosis in a plant cell.

Quick recap ..

1. Mitosis is also known as _____ division.
2. Nucleus is better known as the _____ of the cell. (lungs/kidney/brain)
3. The shortest phase in karyokinesis of mitosis is _____.
4. Sister chromatids are attached at a point called as _____.
5. The primary constriction in a chromosome is also called as _____. (kinetin / kinetochore / chromomere)
6. _____ are produced in the nucleolus. (ER / ribosomes / chromosomes)
7. _____ are the sites of protein synthesis. (Ribosomes / Chromosomes / Nucleus)
8. Grana are present in the _____. (Matrix / Cytoplasm / Stroma)
9. Cell wall is absent in _____. (bacteria / *Chlorella* / *Amoeba*)
10. Important components of the plasma membrane are lipids and _____. (carbohydrates / microtubules / proteins)


Best Of Luck
For Your Exams