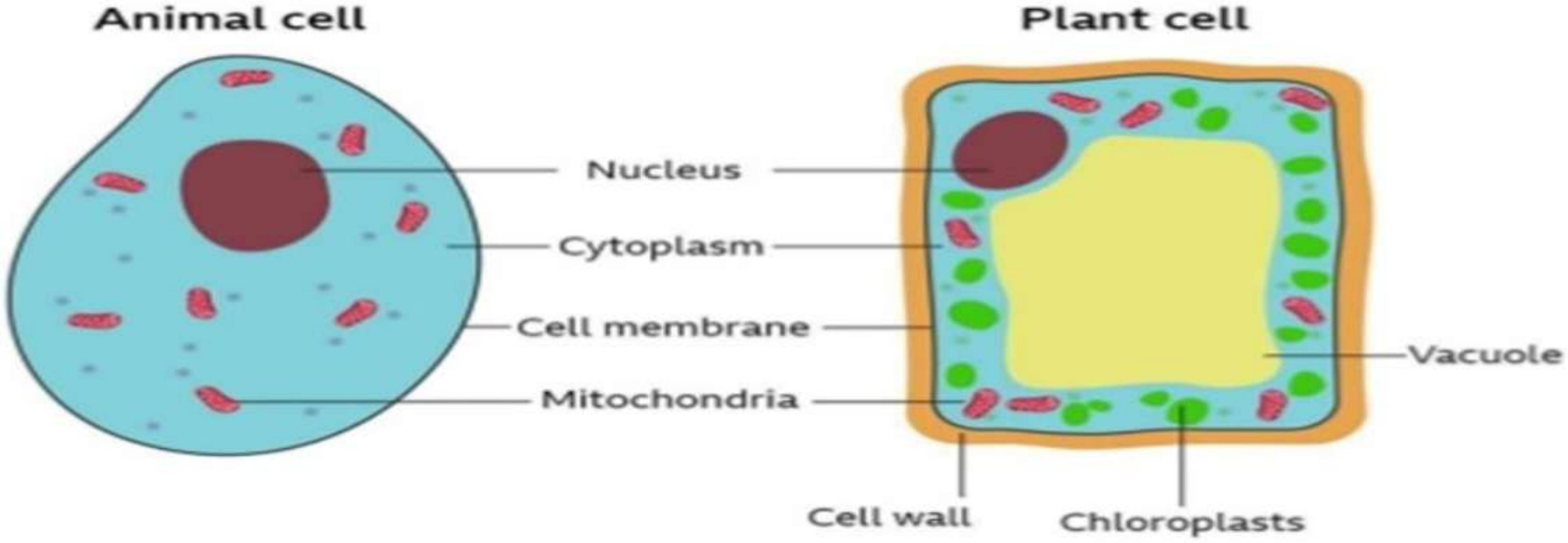
ARJUNA NEET BATCH

Unit -3
NCERT Discussion
CELL: STRUCTURE AND FUNCTION



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8.5.4 Mitochondria

Mitochondria (sing.: mitochondrion), unless specifically stained, are not easily visible under the microscope. The number of mitochondria per cell is variable depending on the physiological activity of the cells. In terms of shape and size also, considerable degree of variability is observed. Typically it is sausage-shaped or cylindrical having a diameter of 0.2-1.0μm (average 0.5μm) and length 1.0-4.1μm. Each mitochondrion is a double

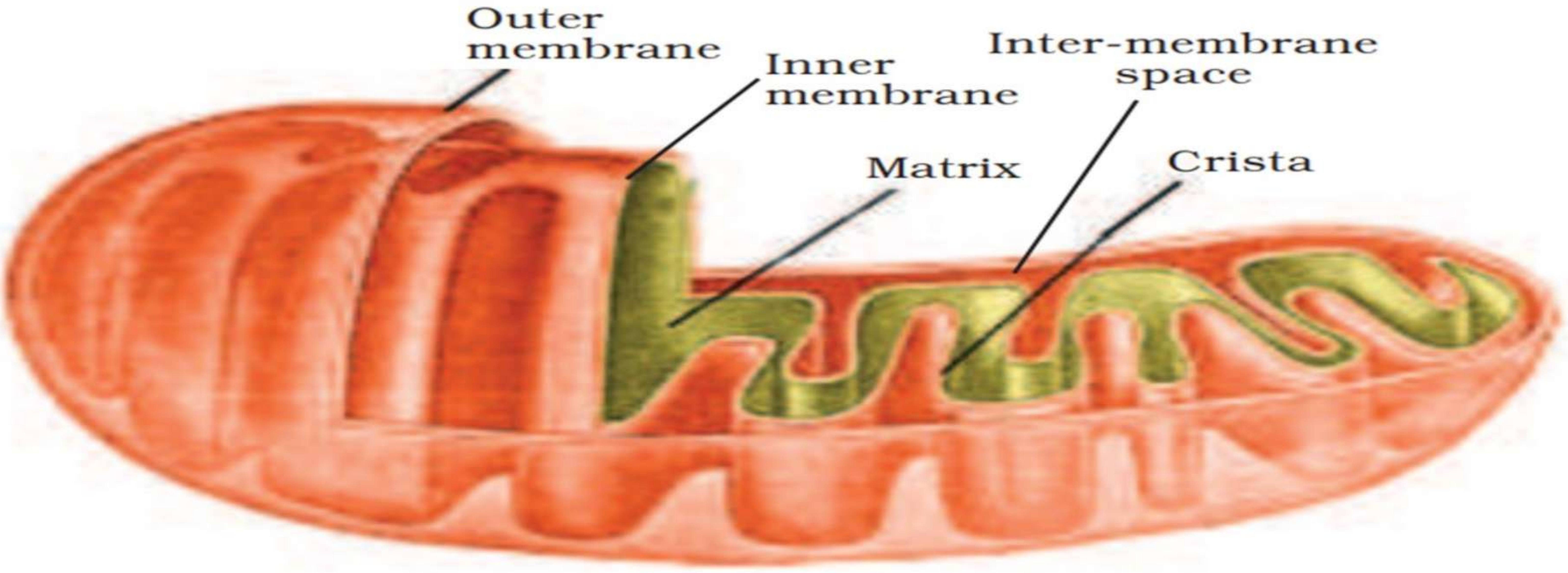


Figure 8.7 Structure of mitochondrion (Longitudinal section)

membrane dividing its lumen distinctly into two aqueous compartments, i.e., the outer compartment and the inner compartment. The inner compartment is called the **matrix**. The outer membrane forms the continuous limiting boundary of the organelle. The inner membrane forms a number of infoldings called the cristae (sing.: crista) towards the matrix (Figure 8.7). The cristae increase the surface area. The two membranes have their own specific enzymes associated with the mitochondrial function. Mitochondria are the sites of aerobic respiration. They produce cellular energy in the form of ATP, hence they are called 'power houses' of the cell. The matrix also possesses single circular DNA molecule, a few RNA molecules, ribosomes (70S) and the components required for the synthesis of proteins. The mitochondria divide by fission.

mit $\xrightarrow{F}$ mit, mit

8.5.5 Plastids

Plastids are found in all plant cells and in euglenoides. These are easily observed under the microscope as they are large. They bear some specific pigments, thus imparting specific colours to the plants. Based on the type of pigments plastids can be classified into **chloroplasts, chromoplasts** and **leucoplasts.**

→ chl a, chl b → carotene, xanthophyll

① The chloroplasts contain **chlorophyll** and carotenoid pigments which are responsible for trapping light energy essential for photosynthesis. In the ② chromoplasts fat soluble **carotenoid** pigments like carotene, xanthophylls and others are present. This gives the part of the plant a yellow, orange or red colour. ③ The leucoplasts are the colourless plastids of varied shapes and sizes with stored nutrients: **Amyloplasts** store carbohydrates (starch), e.g., potato; **elaioplasts** store oils and fats whereas the **aleuroplasts** store proteins.

→ proteinoplast

→ oleoplast

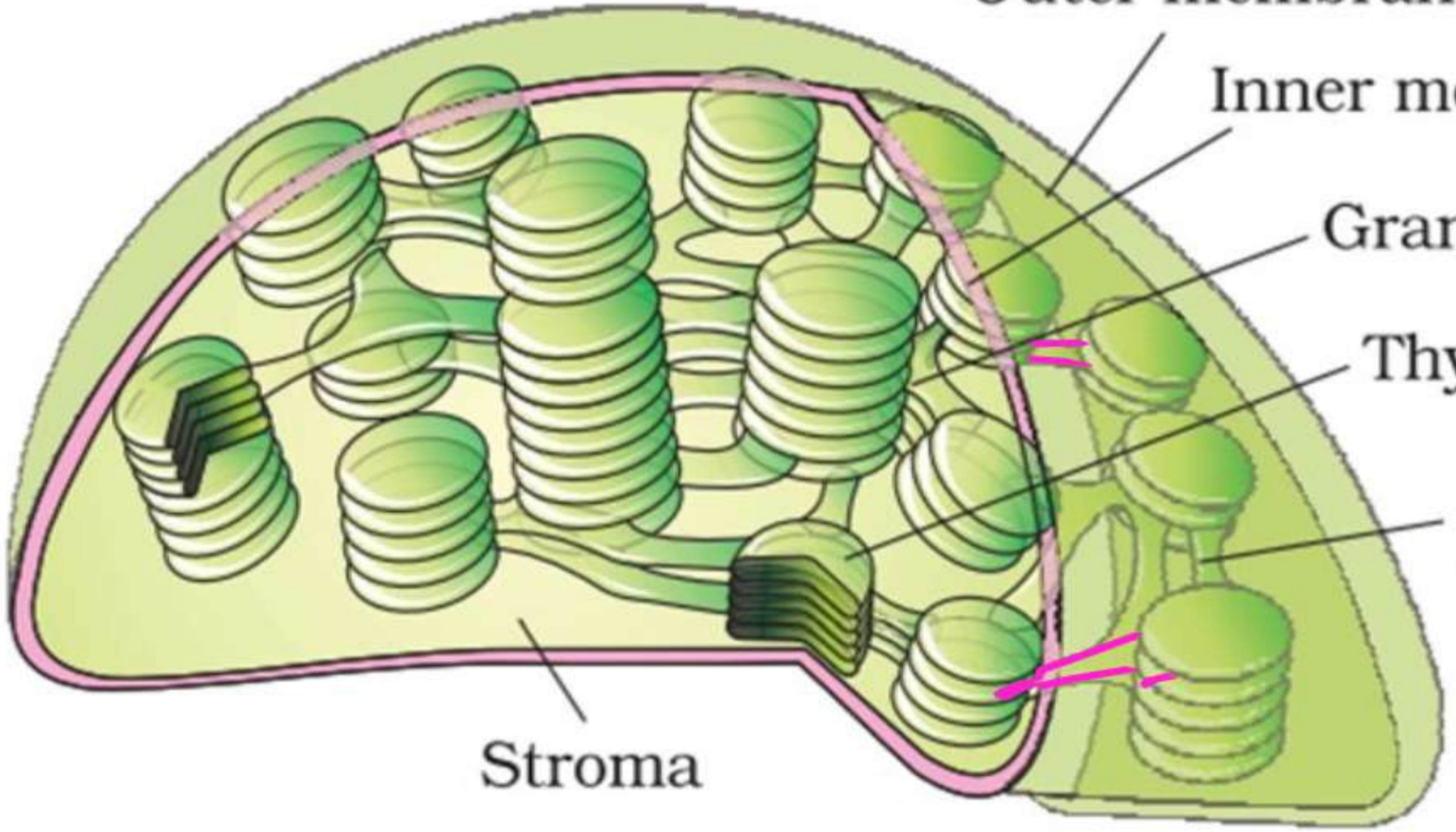
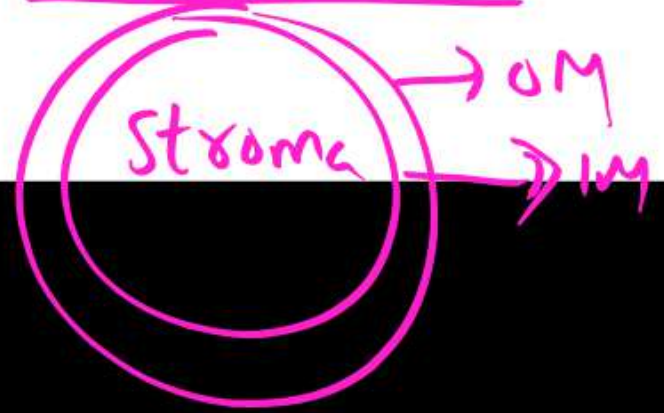


Figure 8.8 Sectional view of chloroplast

Majority of the chloroplasts of the green plants are found in the mesophyll cells of the leaves. These are lens-shaped, oval, spherical, discoid or even ribbon-like organelles having variable length (5-10μm) and width (2-4μm). Their number varies from 1 per cell of the *Chlamydomonas*, a green alga to 20-40 per cell in the mesophyll.

Like mitochondria, the chloroplasts are also double membrane bound. Of the two, the inner chloroplast membrane is relatively less permeable. The space limited by the inner membrane of the chloroplast is called the stroma. A number of organised flattened membranous sacs called the **thylakoids**, are present in the stroma (Figure 8.8). Thylakoids are arranged in stacks like the piles of coins called grana (singular: granum) or the intergranal thylakoids. In addition, there are flat membranous tubules called the stroma lamellae connecting the thylakoids of the different grana. The membrane of the thylakoids enclose a space called a lumen. The stroma of the chloroplast contains enzymes → RUBISCO required for the synthesis of carbohydrates and proteins. It also contains small, double-stranded circular DNA molecules and ribosomes. Chlorophyll pigments are present in the thylakoids. The ribosomes of the chloroplasts are smaller (70S) than the cytoplasmic ribosomes (80S).



8.5.6 Ribosomes

Ribosomes are the granular structures first observed under the electron microscope as dense particles by George Palade (1953). They are composed of ribonucleic acid (RNA) and proteins and are not surrounded by any membrane.

rRNA

The eukaryotic ribosomes are 80S while the prokaryotic ribosomes are 70S. Here 'S' (Svedberg's Unit) stands for the sedimentation coefficient; it indirectly is a measure of density and size. Both 70S and 80S ribosomes are composed of two subunits.

Sun → plant → Animals

Sun → Animals

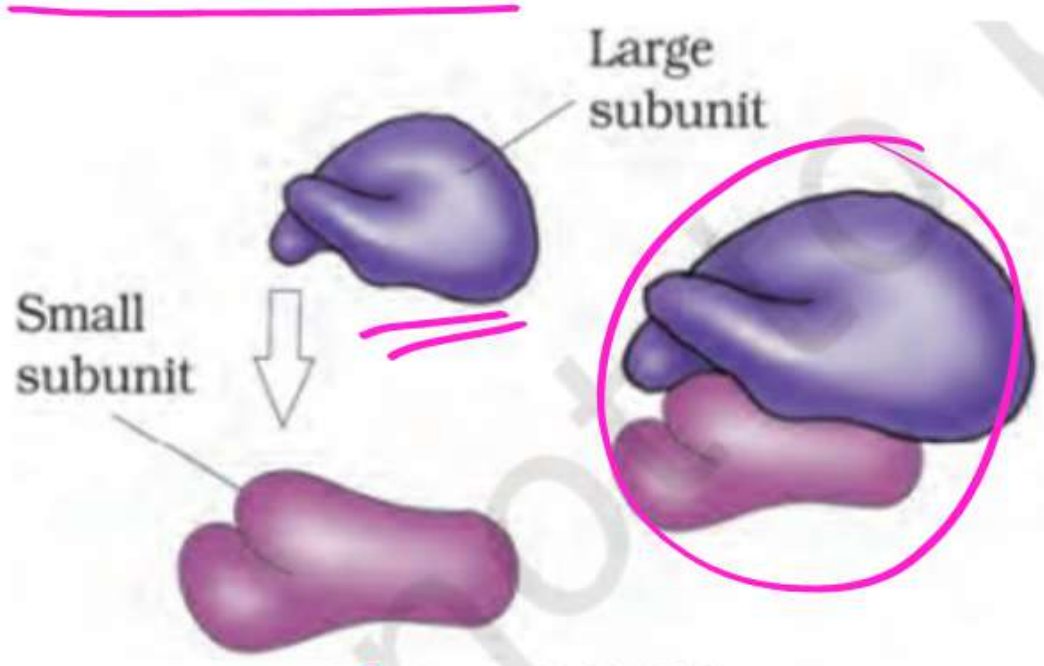


Figure 8.9 Ribosome

8.5.7 Cytoskeleton

An elaborate network of filamentous proteinaceous structures present in the cytoplasm is collectively referred to as the **cytoskeleton**. The cytoskeleton in a cell are involved in many functions such as mechanical support, motility, maintenance of the shape of the cell.

movement

SMS

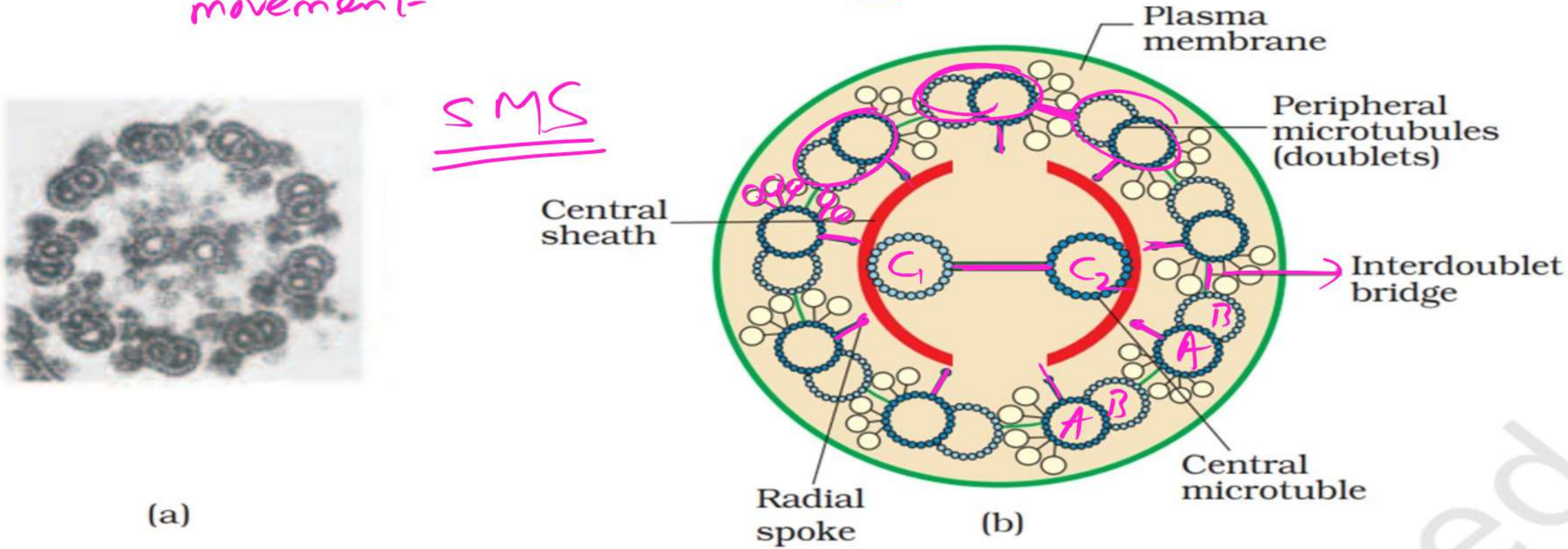


Figure 8.9 Section of cilia/flagella showing different parts : (a) Electron micrograph (b) Diagrammatic representation of internal structure

8.5.8 Cilia and Flagella

Cilia (sing.: cilium) and flagella (sing.: flagellum) are hair-like outgrowths of the cell membrane. Cilia are small structures which work like oars, causing the movement of either the cell or the surrounding fluid. Flagella are comparatively longer and responsible for cell movement. The prokaryotic bacteria also possess flagella but these are structurally different from that of the eukaryotic flagella.

PK flagella

The electron microscopic study of a cilium or the flagellum show that they are covered with plasma membrane. Their core called the **axoneme,** possesses a number of microtubules running parallel to the long axis. The axoneme usually has nine pairs of doublets of radially arranged peripheral microtubules, and a pair of centrally located microtubules. Such an arrangement of axonemal microtubules is referred to as the 9+2 array (Figure 8.9). The central tubules are connected by bridges and is also enclosed by a central sheath, which is connected to one of the tubules of each peripheral doublets by a radial spoke. Thus, there are nine radial spokes. The peripheral doublets are also interconnected by linkers. Both the cilium and flagellum emerge from centriole-like structure called the basal bodies.

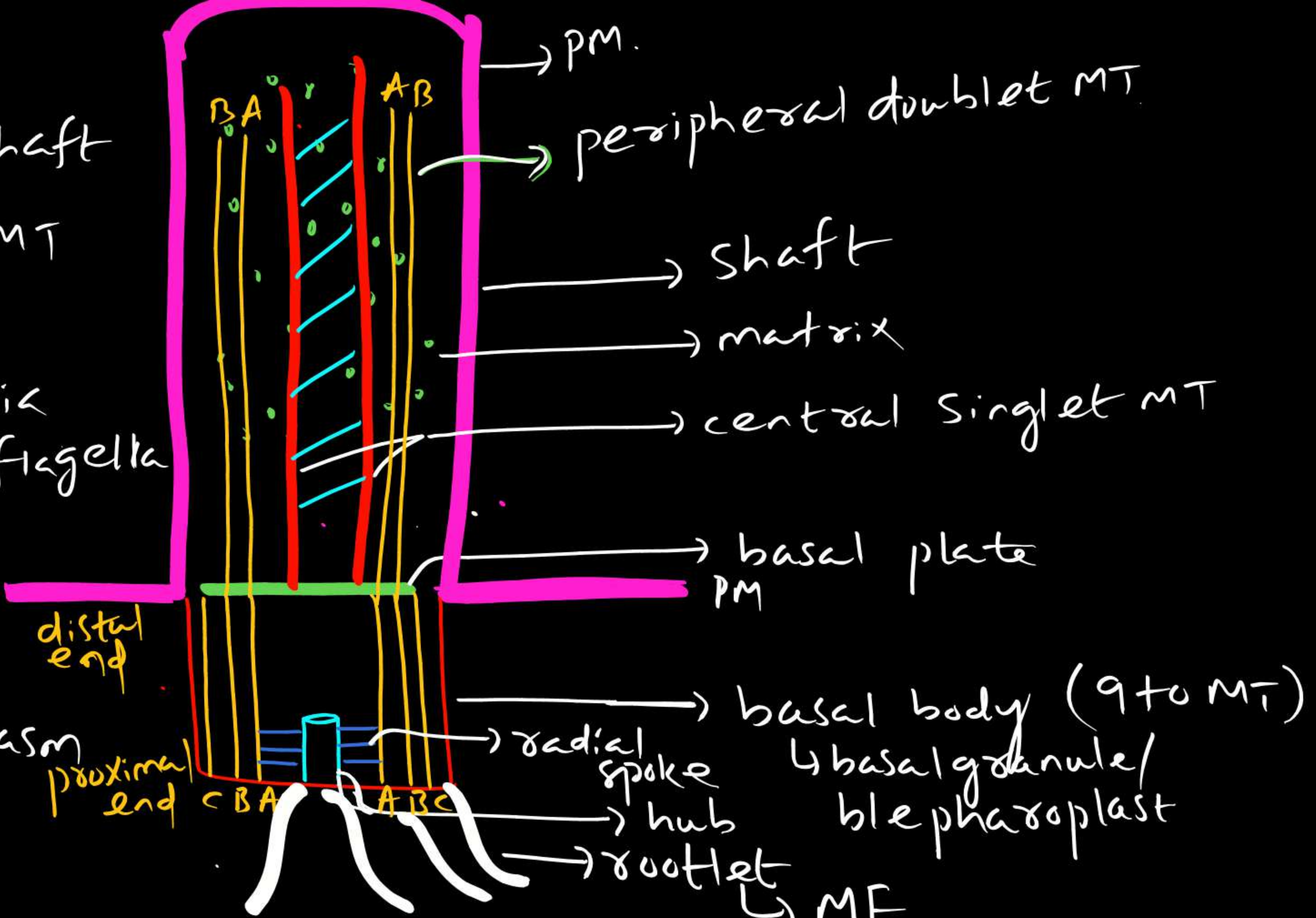
$20 = 9 \times 2 + 2 \times 1$

A-B linker

matrix + Axoneme ⇒ shaft

Axoneme ↳ 9+2 MT

fig: L.S. of cilia and EK flagella



8.5.9 Centrosome and Centrioles

Centrosome is an organelle usually containing two cylindrical structures called centrioles. They are surrounded by amorphous pericentriolar materials. Both the centrioles in a centrosome lie perpendicular to each other in which each has an organisation like the cartwheel. They are made up of nine evenly spaced peripheral fibrils of tubulin protein. Each of the peripheral fibril is a triplet.The adjacent triplets are also linked. The central part of the proximal region of the centriole is also proteinaceous and called the **hub**, which is connected with tubules of the peripheral triplets by radial **spokes** made of protein. The centrioles form the basal body of cilia or flagella, and spindle fibres that give rise to spindle apparatus during cell division in animal cells.

8.5.10 Nucleus

Nucleus as a cell organelle was first described by Robert Brown as early as 1831. Later the material of the nucleus stained by the basic dyes was given the name **chromatin** by Flemming.

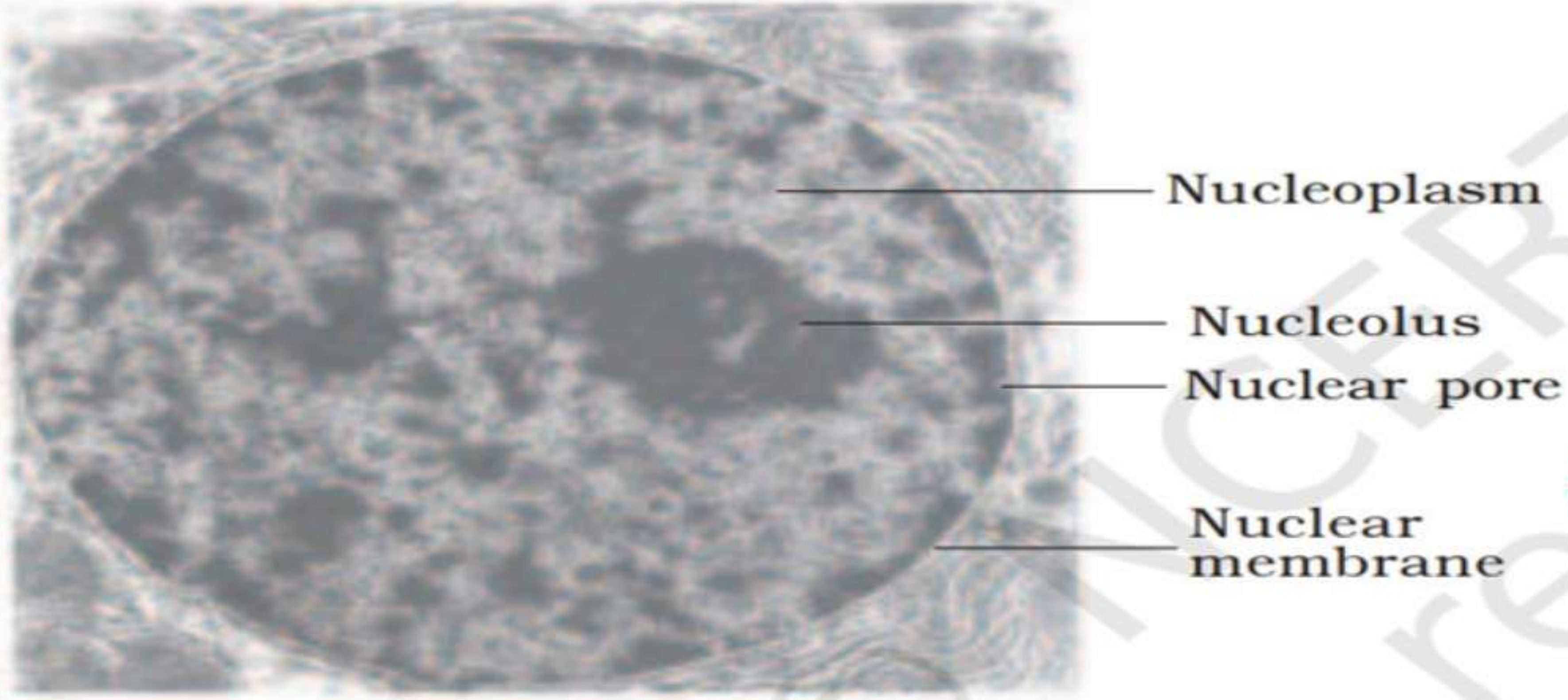


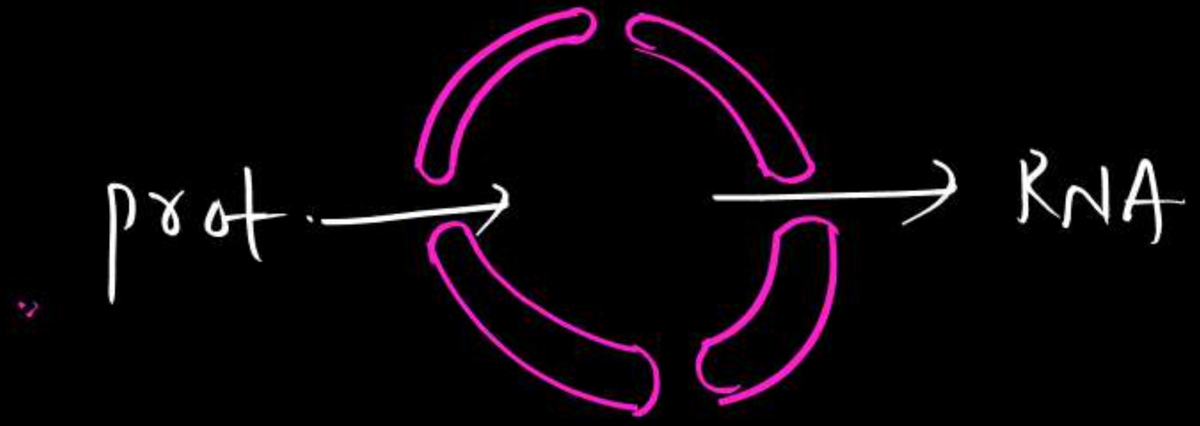
Figure 8.10 Structure of nucleus

The interphase nucleus (nucleus of a cell when it is not dividing) has highly extended and elaborate nucleoprotein fibres called chromatin, nuclear matrix and one or more spherical bodies called **nucleoli** (sing.: nucleolus) (Figure 8.10). Electron microscopy has revealed that the nuclear envelope, which consists of two parallel membranes with a space between (10 to 50 nm) called the **perinuclear space**, forms a barrier between the materials present inside the nucleus and that of the cytoplasm. The outer membrane usually remains continuous with the endoplasmic reticulum and also bears ribosomes on it.

80S

At a number of places the nuclear envelope is interrupted by minute pores, which are formed by the fusion of its two membranes. These nuclear pores are the passages through which movement of RNA and protein molecules takes place in both directions between the nucleus and the cytoplasm. Normally, there is only one nucleus per cell, variations in the number of nuclei are also frequently observed. *Can you recollect names of organisms that have more than one nucleus per cell?* Some mature cells even lack nucleus, e.g., erythrocytes (RBC) of many mammals and sieve tube cells of vascular plants. *Would you consider these cells as 'living'?* Yes

The nuclear matrix or the **nucleoplasm** contains nucleolus and chromatin. The nucleoli are spherical structures present in the nucleoplasm. The content of nucleolus is continuous with the rest of the nucleoplasm as it is not a membrane bound structure. It is a site for active ribosomal RNA synthesis. Larger and more numerous nucleoli are present in cells actively carrying out protein synthesis.



You may recall that the interphase nucleus has a loose and indistinct network of nucleoprotein fibres called chromatin. But during different stages of cell division, cells show structured **chromosomes** in place of the nucleus. Chromatin contains DNA and some basic proteins called **histones**, some non-histone proteins and also RNA. A single human cell has approximately two metre long thread of DNA distributed among its forty six (twenty three pairs) chromosomes. You will study the details of DNA packaging in the form of a chromosome in class XII.

Every chromosome essentially has a primary constriction or the **centromere** on the sides of which disc shaped structures called **kinetochores** are present (Figure 8.11). Based on the position of the centromere, the chromosomes can be classified into four types (Figure 8.12). The **metacentric** chromosome has middle centromere forming two equal arms of the chromosome. The **sub-metacentric** chromosome has centromere slightly away from the middle of the chromosome resulting into one shorter arm and one longer arm. In case of **acrocentric** chromosome the centromere is situated close to its end forming one extremely short and one very long arm, whereas the **telocentric** chromosome has a terminal centromere.

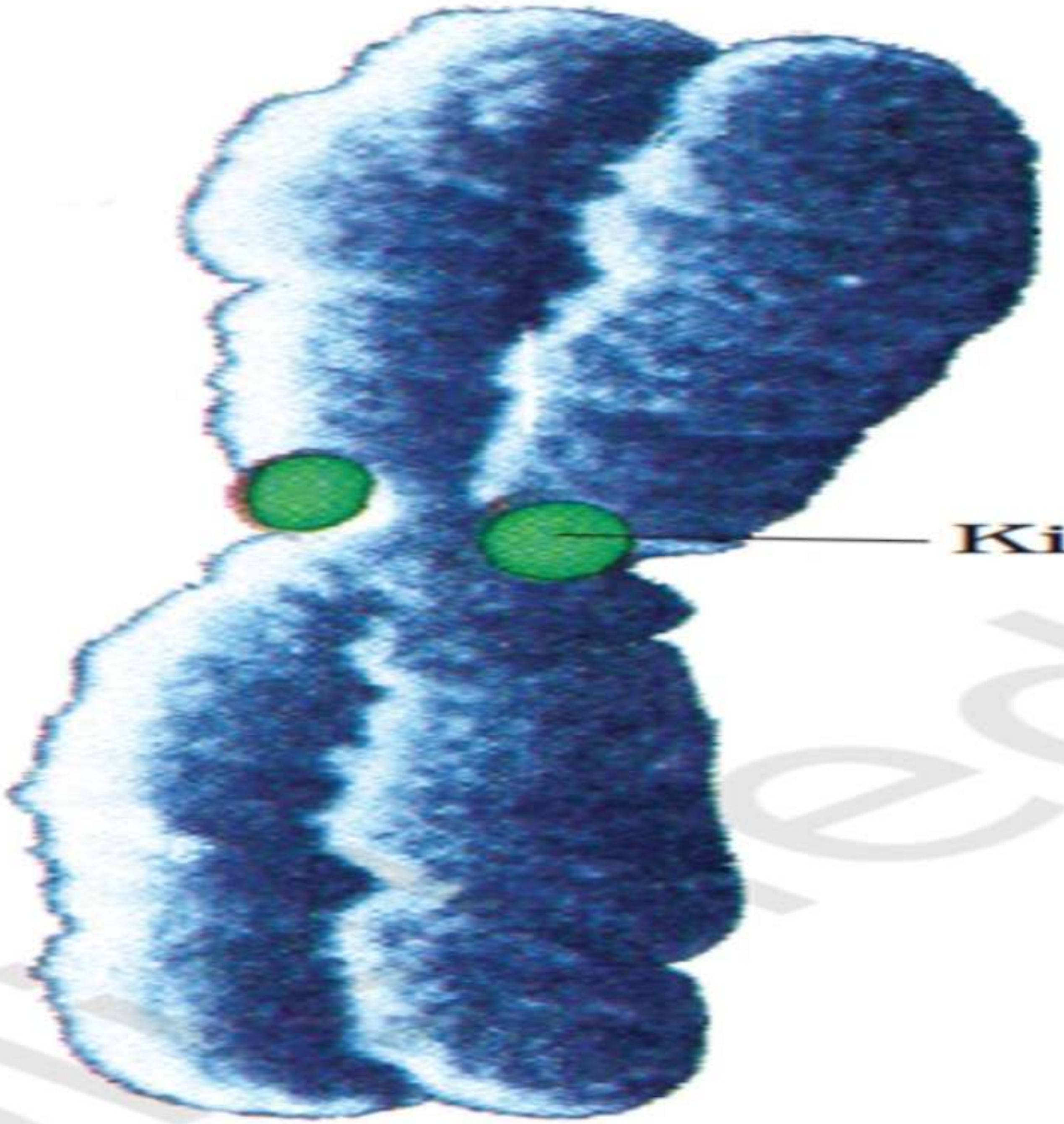


Figure 8.11 Chromosome with kinetochore

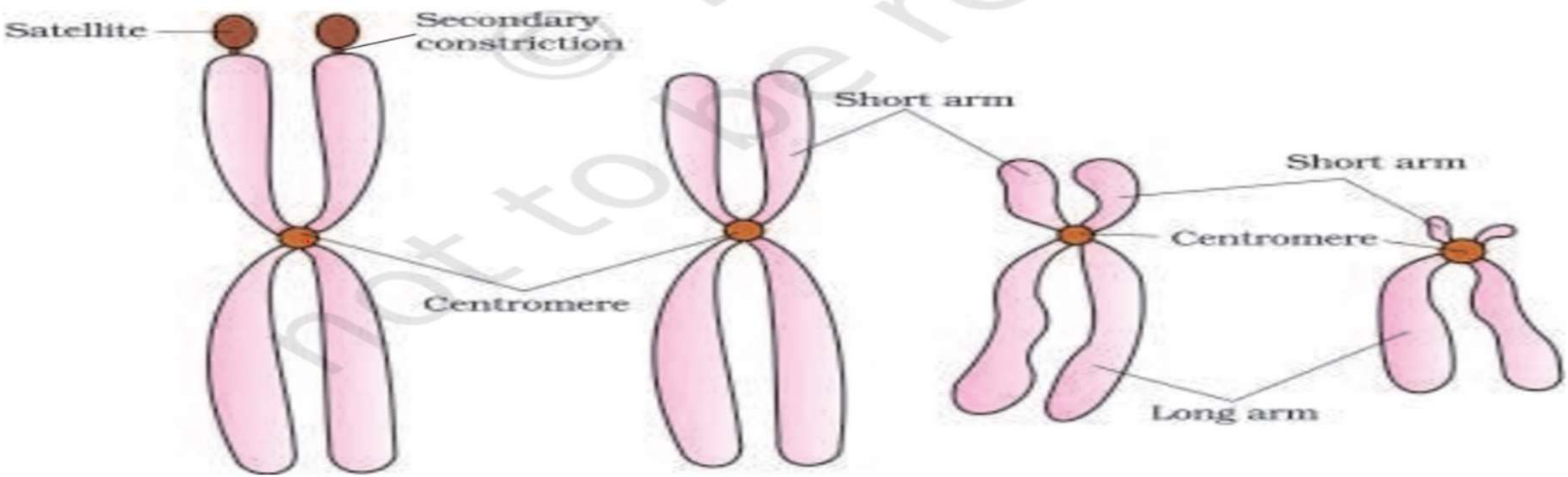


Figure 8.12 Types of chromosomes based on the position of centromere

Sometimes a few chromosomes have non-staining secondary constrictions at a constant location. This gives the appearance of a small fragment called the **satellite**.

SUMMARY

All organisms are made of cells or aggregates of cells. Cells vary in their shape, size and activities/functions. Based on the presence or absence of a membrane bound nucleus and other organelles, cells and hence organisms can be named as eukaryotic or prokaryotic.

A typical eukaryotic cell consists of a cell membrane, nucleus and cytoplasm. Plant cells have a cell wall outside the cell membrane. The plasma membrane is selectively permeable and facilitates transport of several molecules. The endomembrane system includes ER, golgi complex, lysosomes and vacuoles. All the cell organelles perform different but specific functions. Centrosome and centriole form the basal body of cilia and flagella that facilitate locomotion. In animal cells, centrioles also form spindle apparatus during cell division. Nucleus contains nucleoli and chromatin network. It not only controls the activities of organelles but also plays a major role in heredity.

Endoplasmic reticulum contains tubules or cisternae. They are of two types: rough and smooth. ER helps in the transport of substances, synthesis of proteins, lipoproteins and glycogen. The golgi body is a membranous organelle composed of flattened sacs. The secretions of cells are packed in them and transported from the cell. Lysosomes are single membrane structures containing enzymes for digestion of all types of macromolecules. Ribosomes are involved in protein synthesis. These occur freely in the cytoplasm or are associated with ER. Mitochondria help in oxidative phosphorylation and generation of adenosine triphosphate. They are bound by double membrane; the outer membrane is smooth and inner one folds into several cristae. Plastids are pigment containing organelles found in plant cells only. In plant cells, chloroplasts are responsible for trapping light energy essential for photosynthesis. The grana, in the plastid, is the site of light reactions and the stroma of dark reactions. The green coloured plastids are chloroplasts, which contain chlorophyll, whereas the other coloured plastids are chromoplasts, which may contain pigments like carotene and xanthophyll. The nucleus is enclosed by nuclear envelope, a double membrane structure with nuclear pores. The inner membrane encloses the nucleoplasm and the chromatin material. Thus, cell is the structural and functional unit of life.

Exercises

1. Which of the following is not correct?
   (a) Robert Brown discovered the cell.
   (b) Schleiden and Schwann formulated the cell theory.
   (c) Virchow explained that cells are formed from pre-existing cells.
   (d) A unicellular organism carries out its life activities within a single cell.

2. New cells generate from
   (a) bacterial fermentation
   (b) regeneration of old cells
   (c) pre-existing cells
   (d) abiotic materials

3. Match the following

	Column I		Column II
(a)	Cristae	(i)	Flat membranous sacs in stroma
(b)	Cisternae	(ii)	Infoldings in mitochondria
(c)	Thylakoids	(iii)	Disc-shaped sacs in Golgi apparatus

4. Which of the following is correct:
   (a) Cells of all living organisms have a nucleus.
   (b) Both animal and plant cells have a well defined cell wall.
   (c) In prokaryotes, there are no membrane bound organelles.
   (d) Cells are formed *de novo* from abiotic materials.

5. What is a mesosome in a prokaryotic cell? Mention the functions that it performs.
6. How do neutral solutes move across the plasma membrane? Can the polar molecules also move across it in the same way? If not, then how are these transported across the membrane?
7. Name two cell-organelles that are double membrane bound. What are the characteristics of these two organelles? State their functions and draw labelled diagrams of both.
8. What are the characteristics of prokaryotic cells?
9. Multicellular organisms have division of labour. Explain.
10. Cell is the basic unit of life. Discuss in brief.
11. What are nuclear pores? State their function.
12. Both lysosomes and vacuoles are endomembrane structures, yet they differ in terms of their functions. Comment.
13. Describe the structure of the following with the help of labelled diagrams.
    (i) Nucleus (ii) Centrosome
14. What is a centromere? How does the position of centromere form the basis of classification of chromosomes. Support your answer with a diagram showing the position of centromere on different types of chromosomes.