Lectures of Histology

(1st Stage)

First Semester 2024-2025

Anatomy and Histology Department

By

Prof. Dr. Khulood Naji Rasheed

* Mitochondria

Are membrane-enclosed relatively large organelles found scattered throughout the cytosol, represent the sites of aerobic respiration (because mitochondrion consumes oxygen and releases carbon dioxide, the entire process is called cellular respiration), in which mitochondria generate usable energy from oxidation of food molecules (the organic compounds such as sugars) to power cell's activities, i.e., they are generators of chemical energy to produce (ATP) which represent the main cell energy source. Mitochondria have their own DNA they are thus semi-autonomous organelles (Fig. 1). Some amino acids are formed in mitochondria, in addition to lipid metabolism (oxidation of fatty acids) also occurs in mitochondria.

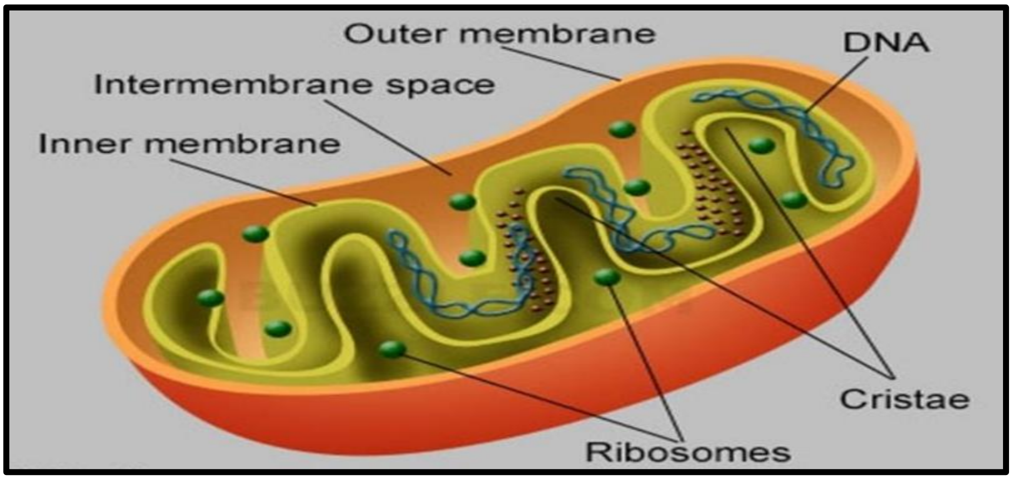


Fig. 1: Scheme of Mitochondrion.

Morphology

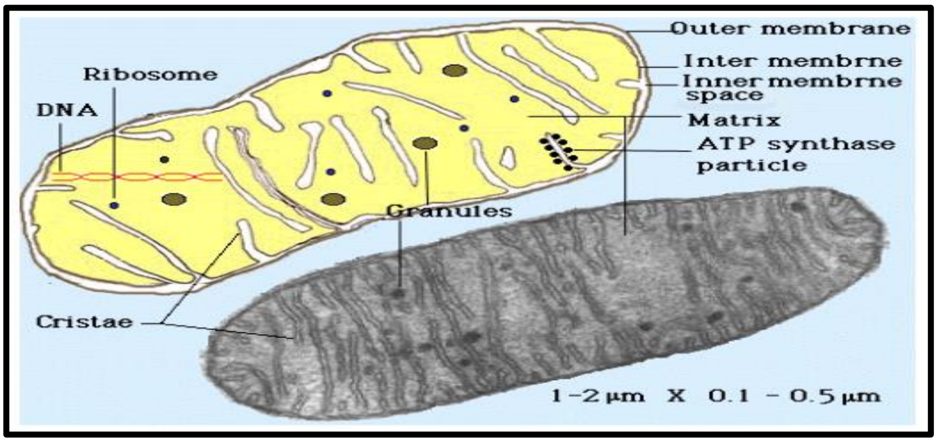
Morphologically mitochondria may be in form of filaments or small granules, spherical, cylindrical, dumbbell, racket shape, or rod-like shape (Fig. 2).

Position

Mitochondria lie freely in cytoplasm, but they are located permanently near the region of the cell where more energy is needed. E.g., in cells of kidney tubules, they occur in the folds of basal regions near plasma membrane, in muscle cells mitochondria are grouped like rings around the I-band of myofibril, during the cell division they get concentrated around the spindle.

Number

They can vary in number according to the <u>activity, age, and type of cell</u>. The **growing**, **dividing**, and **actively synthesizing** cells contain more mitochondria than the others, i.e., their number is in a direct proportion to the **intensity of cell metabolism** (e.g., cardiac muscle, liver cells and cells of some urinary tubules have abundant mitochondria).



<u>Fig. 2:</u> Morphologically Mitochondrion.

Ultrastructure of Mitochondria

Electron microscope shows mitochondrion as a vesicle filled with a fluid or gel-like material represent the matrix (the space between cristae) which contains proteins, lipids, ribosomes, one or two DNA molecules, and dense granules. Mitochondria bounded by double membrane that resemble the plasma membrane in molecular structure (however, the two membranes differ in the kinds of protein and lipids they have, and in their properties) (Fig. 3).

<u>Cristae:</u> represent the <u>inner mitochondrial membrane</u> made up of infoldings (fingerlike folds) which extend inwards to varying degrees, and may fuse with those from the opposite side, dividing the mitochondrion into compartments. Cristae also <u>vary in number</u>, active cells may have numerous cristae compare with inactive cells. Remarkably, cristae are four or five times larger than the outer membrane. These folds serve an important function, they dramatically <u>increase the surface area</u> available to make ATP.

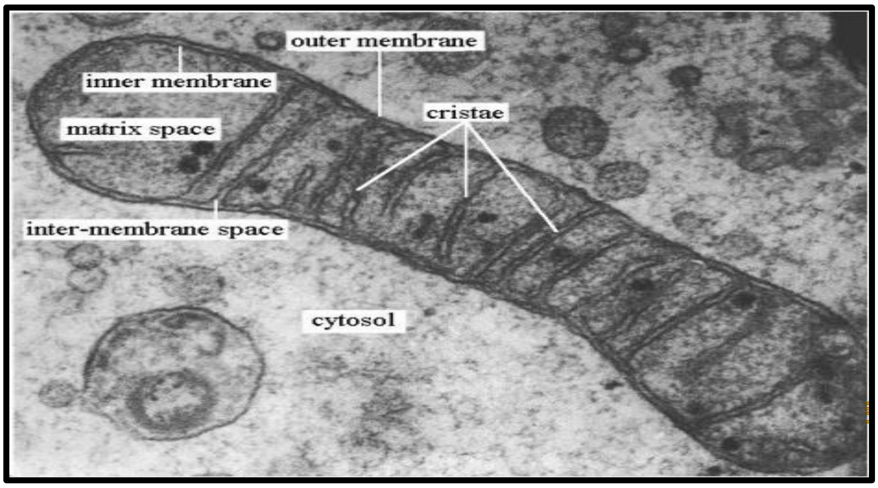


Fig. 3: **Mitochondrion by Electron Microscope.**

Biogenesis of Mitochondria

Formation of new mitochondria has been explained with the following hypothesis:

1. Replication: it is held that mitochondria are self-replicating organelles. New mitochondria arise by some type of splitting process from pre-existing mitochondria.

2. Origin from membrane: this hypothesis proposes that the mitochondria arise from the invaginations of plasma membrane, endoplasmic reticulum, Golgi apparatus or nuclear envelop.

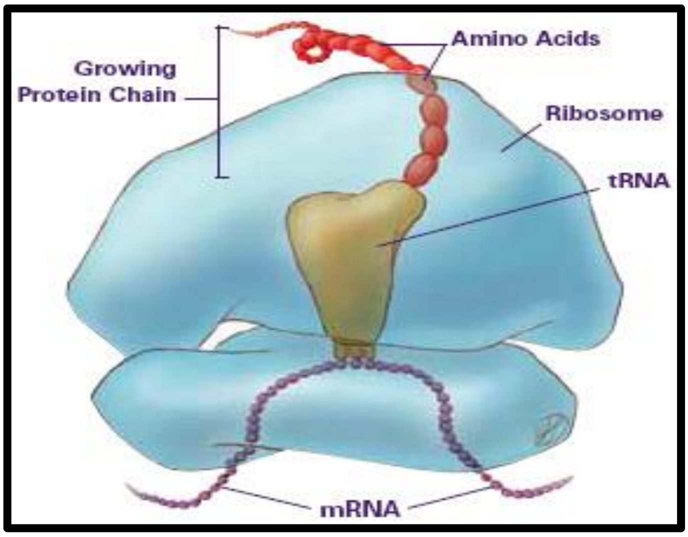
3. Prokaryotic origin: it is believed that mitochondria are originated from bacteria. It is supported by evidence:

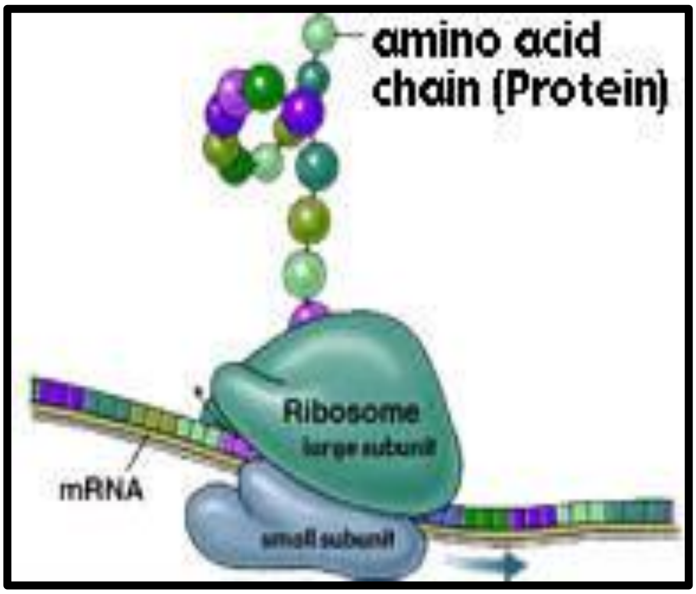
- enzymes of respiratory chain, which in case of bacteria, are localized in plasma membrane that can be compared with the inner membrane of mitochondrion.
- in some bacteria, plasma membrane forms membranous projections (called mesosomes) like cristae of mitochondria. These mesosomes possess respiratory chain enzymes.
- mitochondrial DNA is circular as it is in bacteria. Replication process of mitochondria is similar to bacteria.
- ribosomes in mitochondria are similar in size to that of bacterial ribosomes.
- chloramphenicol inhibits the synthesis of protein in mitochondria as well as in bacteria.

* Ribosomes

Are small dense and granular ribonucleoprotein (i.e., RNA and proteins) particles found attached to outer surface of endoplasmic reticulum and nucleus as well as freely scattered in cytoplasm, and mitochondrial matrix. Ribosomes are not surrounded by a membrane. They are site of protein synthesis in a cell.

A functional ribosome has two subunits of different sizes bound to a strand of mRNA. The core/center of the small ribosomal subunit is a highly folded rRNA chain associated with more than 30 unique proteins, while the core/center of the large subunit has three other rRNA molecules and nearly 50 other basic proteins (small ribosomal subunit reads mRNA, while the large subunit binds amino acids to form a polypeptide chain) (Fig. 4).





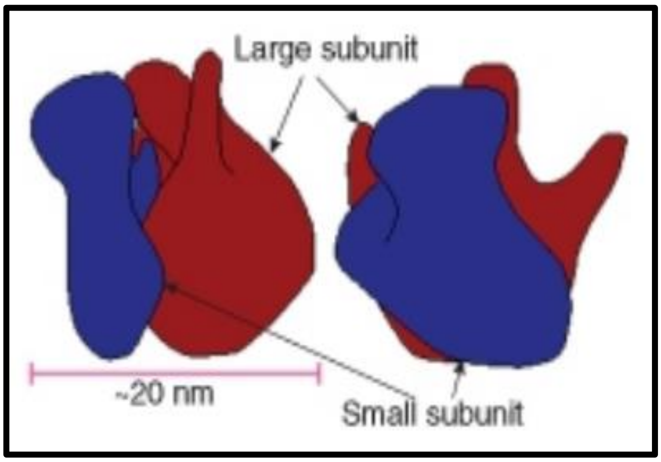


Fig. 4: Two subunits make up a Ribosome (intracellular protein factory).

Structure of Ribosome

Ribosomes are of **two types** 70S (found in Prokaryotic cells and in the mitochondria of Eukaryotic cells) and 80S (found just in the cytoplasm of Eukaryotic cells). Ribosomal proteins are themselves synthesized in cytoplasmic ribosomes but are then imported to the nucleus where they associate with newly synthesized rRNA. The ribosomal subunits thus formed then move from the nucleus to the cytoplasm where they are reused many times, for translation of any mRNA strand.

Functions of Ribosome

Location of ribosome in a cell determines the kind of protein it makes:

1. attached ribosomes to endoplasmic reticulum: will synthesize proteins which will used **inside the cell or outside** the cell:

- integral proteins for cellular membranes.
- lysosomal proteins.
- secretory proteins for export as secretions.

2. free ribosomes (floating through cell): produce structural and enzymatic proteins for use **in the cell itself**. These proteins include glycolytic enzymes and most extrinsic membrane proteins.

* Nucleus

Is the depot of genome and the source of informational macromolecules that govern the synthetic activities of the cytoplasm. It is surrounded by a bilaminar nuclear envelop having pore complexes that permit the nuclear-cytoplasmic transport of materials. The **shape** of nucleus is variable according to cell type. It is generally spheroid, but ellipsoid, flattened, dumbbell or trilobed nuclei may also occur in certain cells. Most cells contain a single nucleus. Cells with two nuclei are known as binucleate cells. Sometimes more than two nuclei are present in a single cell, such cells are called polynucleate/multinucleated cells (or syncytial cells e.g., osteoclast). **Size** of nucleus is not constant and is generally correlated with DNA content (is variable depending upon the number of chromosomes).

Structure of Nucleus

Nucleus consists of various parts. It is bounded by a nuclear envelop or karyotheca. Within the envelope is a clear fluid substance called nucleoplasm or nuclear sap. Suspended in the nucleoplasm are network of protein-containing fibrils called nuclear matrix (fine intermingled nucleoprotein filaments collectively referred to as the chromatin) and one or more spherical bodies known as nucleoli (singular, nucleolus) (Fig. 5).

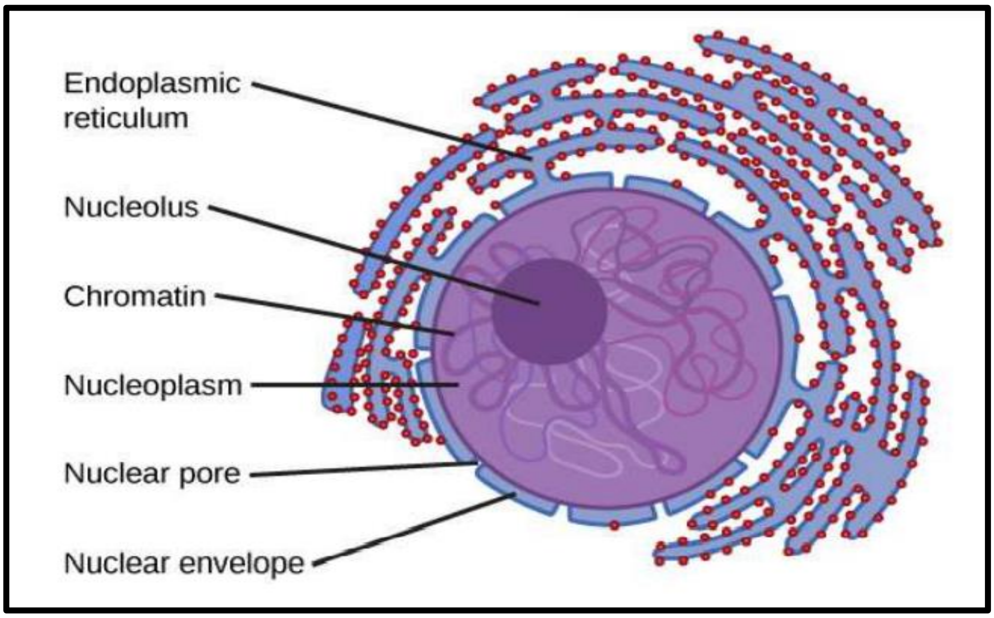


Fig. 5: **Structure of Nucleus.**

Functions of Nucleus

- directs the synthesis of structural proteins.
- regulates cell metabolism by directing the synthesis of enzymes.
- contains genetic information for reproduction (when needed).
- site for the formation of ribosome subunits which represent the site of protein synthesis.

Nuclear Envelope

It separates the nucleoplasm from cytoplasm. It consists of two membranes (outer and inner) of lipoprotein likes the plasma membrane. The two membranes are separated by a space called the perinuclear space. The outer membrane (faced to cytoplasm) is studded with ribosomes so is rough and continuous with RER at certain places. While the inner membrane is free of ribosomes, but has a dense layer closely associated with its inner or nucleoplasm surface called nuclear lamina which is a network of filaments composed of proteins (nuclear lamina supports inner membrane and gives it shape, as well as connects chromatin to it) (Fig.6).

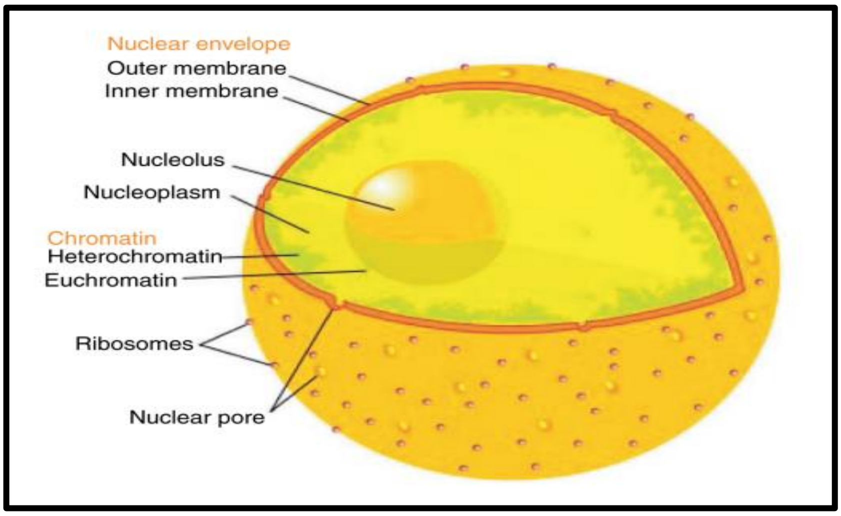


Fig. 6: Nuclear Envelope.

Nuclear pores

They are formed by fusion of the inner and outer membranes of the nuclear envelope in some places. There may be 1000 to 10,000 pores per nucleus. Nuclear pore is called the pore complex which is nearly cylindrical, projects into both cytoplasm and nucleoplasm. The pore complex consists of two rings (the annuli) one located at the cytoplasmic rim of the pore and the other at the nucleoplasmic rim.

Each annulus comprises eight symmetrically arranged subunits and sends a spoke into the pore. Ions and small molecules of the size of monosaccharide, disaccharides or amino acids pass freely between the nucleus and cytoplasm. Pore complexes do control the passage of larger molecules, such as RNA and proteins, and of ribosomal subunits. The pore complexes also act as a barrier to some molecules such as DNA of chromosomes (Fig. 7).

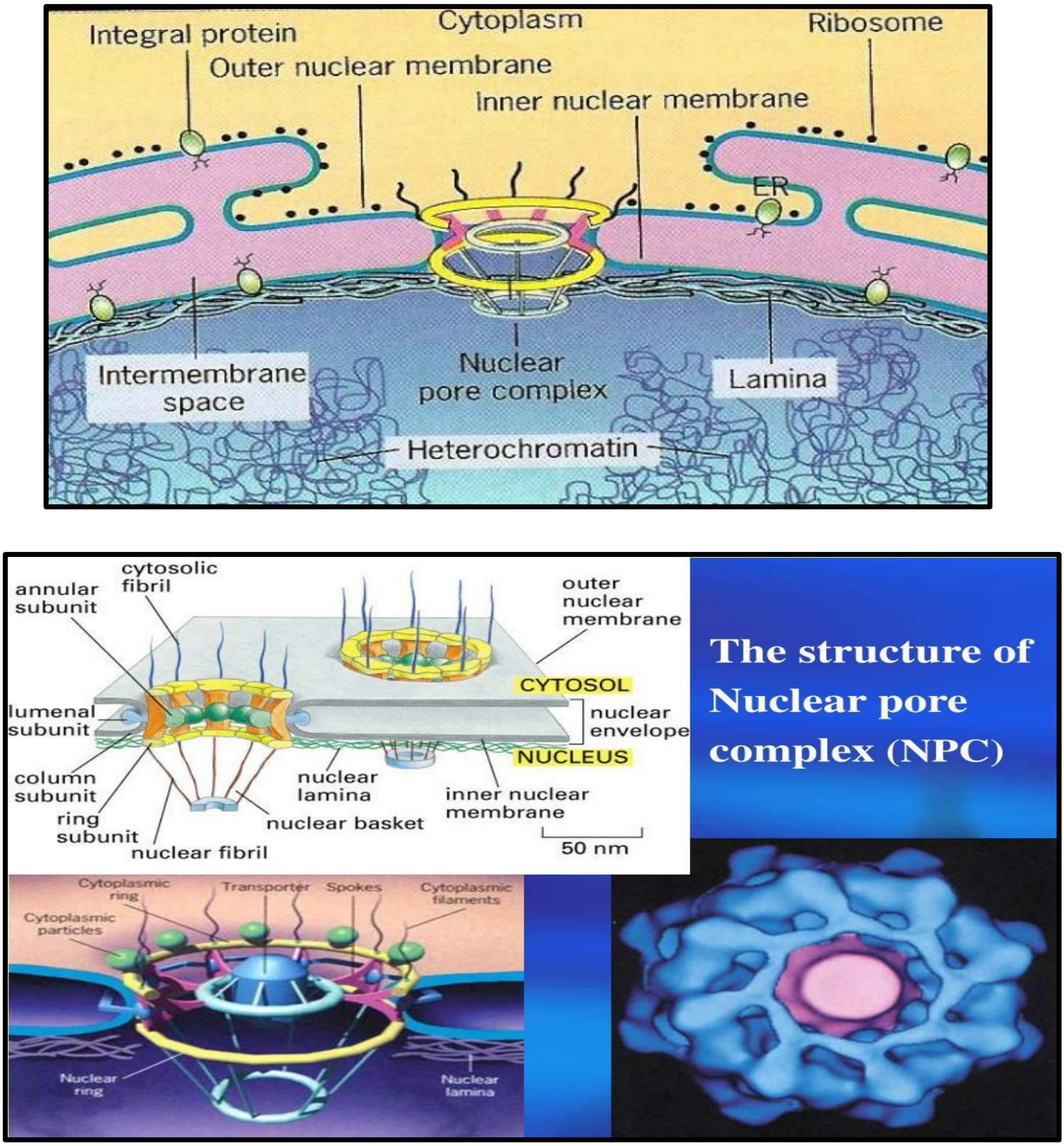


Fig. 7: **Nuclear Pore Complex.**

Chromatin

It is found in an interphase (non-dividing) nucleus, like fine filaments that lie crisscross to give the appearance of a diffuse network often referred to as nuclear/chromatin reticulum. Chromatin filaments are simply extremely extended chromosomes (during cell division, they form short, thick, rodlike bodies known as chromosomes by condensing and tight coiling). There are two types of chromatins according to their features: **Heterochromatin** and **Euchromatin** (Fig.8).

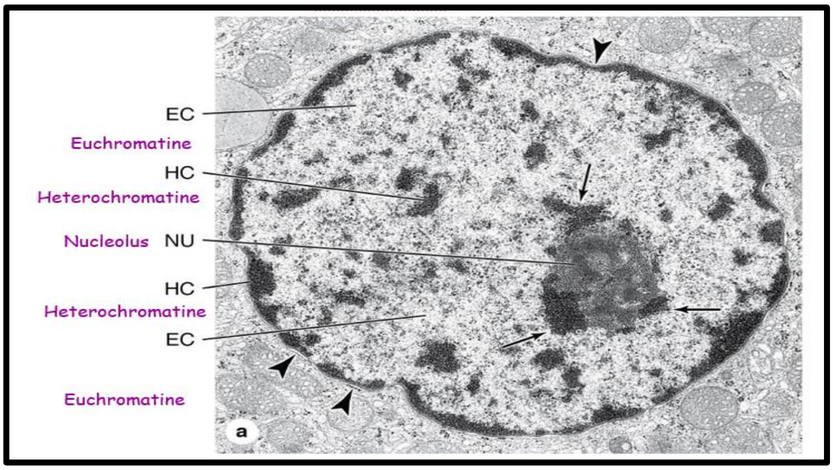


Fig. 8: Types of Chromatin.

Heterochromatin vs Euchromatin

More Information Online WWW.DIFFERENCEBETWEEN.COM

	Heterochromatin	Euchromatin
DEFINITION	Heterochromatin is the highly packed form of chromatin in the nucleus	Euchromatin is the loosely packed form of chromatin in the nucleus
ACTIVE VS INACTIVE	Generally inactive	Generally active
DNA CONTENT	Contains more DNA	Contains less DNA
OCCURRENCE IN THE GENOME	Less abundant	Around 90% of the total human genome is euchromatin
ORGANISMS	Only present in eukaryotes	Present in both prokaryotes and eukaryotes
TYPES	There are two types	Present in only one form
STAIN	Easily and highly stained	Stains lightly
LOCATION	Found at the periphery of the nucleus	Present in the inner body of the nucleus

Nucleolus

It is present in the nuclei of most cells but is unclear/indistinct. It is usually without a limiting membrane, as a small dense spherical structure in the nucleus of a cell during interphase (disappear during cell division) but may have other forms. The number of nucleoli in a nucleus varies in different species. it represents concentrated area of chromatin, RNA, and proteins (little nucleus).

Functions of Nucleolus

• synthesizes and stores rRNA.
• stores also ribosomal proteins received from cytoplasm.
• forms ribosomal subunits by wrapping rRNA by ribosomal proteins.

* Chromosome

Unique structure made up of chromatin. It controls cell's structure, metabolism, and play an important role in differentiation, heredity, mutation, and evolution. It is a threadlike structure of nucleic acids and protein, carrying genetic information in form of genes (Fig. 9).

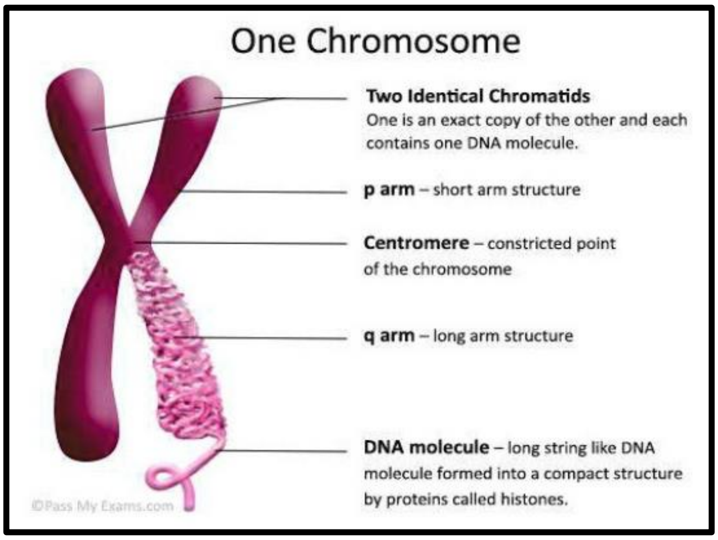


Fig. 9: **The Chromosome.**

Morphology of Chromosomes

At the time of cell division, the chromatin filaments condense and tightly coil up to form chromosomes which become distinct at metaphase stage (consist of two chromatids that are held together at one point called **centromere**). Chromosomes vary in number, size, shape, but they have remarkably uniform structure. The ends of chromosome are called **telomeres** which has function varies from the rest of chromosome (Fig. 10).

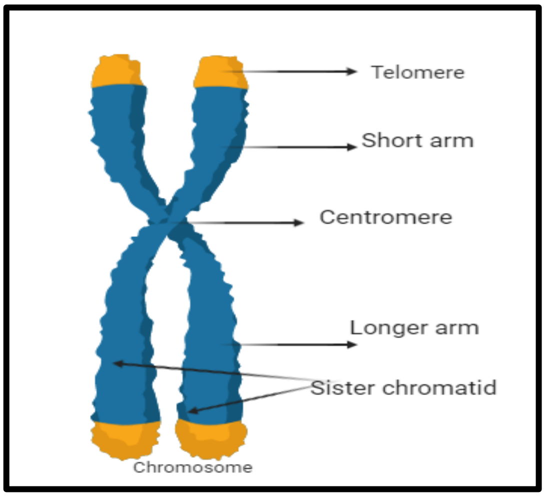


Fig. 10: **Ends of Chromosome.**

Types of Chromosomes

based on position of centromeres, chromosomes are classified as below (Fig.11):

(1) Metacentric: centromere is at the middle of chromosome, and the arms are equal. In anaphase stage the chromosome appears V-shaped.

(2) Submetacentric: centromere is near the center of the chromosome, and the arms are slightly unequal and in anaphase stage the chromosome appears J or L shaped.

(3) Acrocentric: centromere is near one end of the chromosome, and the arms are very unequal.

(4) Telocentric: centromere is at one end; in such chromosomes the arms are on one side only. The chromosome remains rod shaped in anaphase stage also.

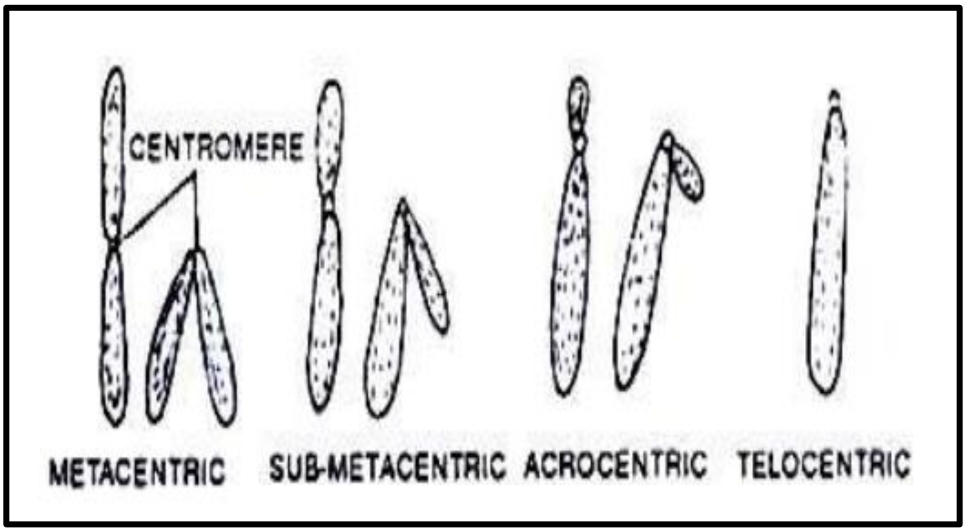


Fig. 11: **Type of Chromosome.**