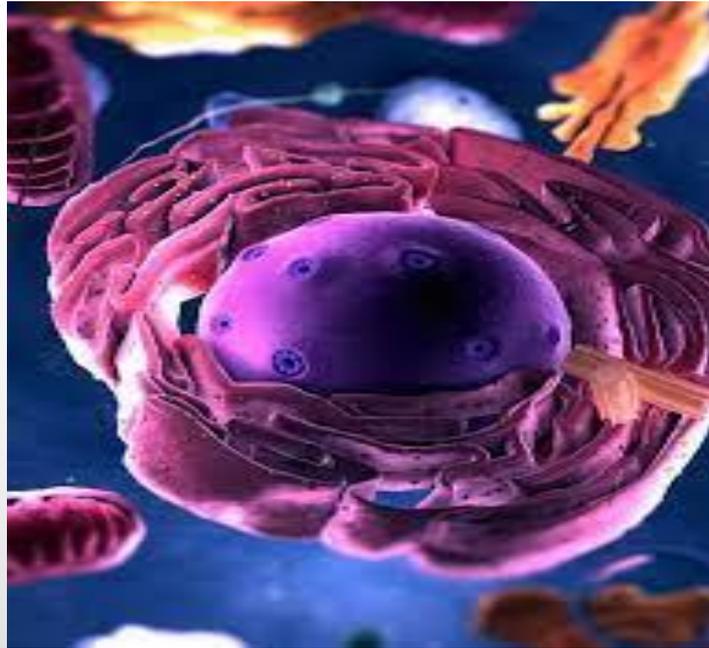




NUCLEUS



Cell Biology

Semester 1, Year 1

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Associate professor of Human histology & Cell Biology



Learning objectives:

1. Define the nucleus.
 2. Describe the structure of the nucleus.
 3. Predict functions of the nucleus.
- 

THE NUCLEUS (INTERPHASE NUCLEUS)

Definition:

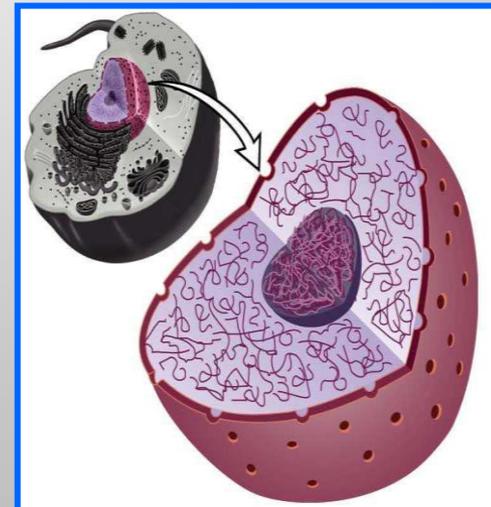
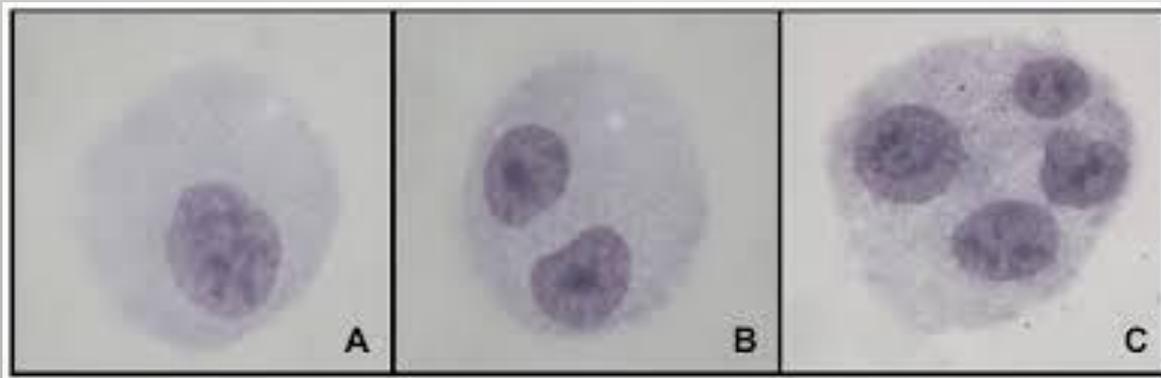
Present in all cells, except **RBCs and platelets (not true cells)**. •

Number: •

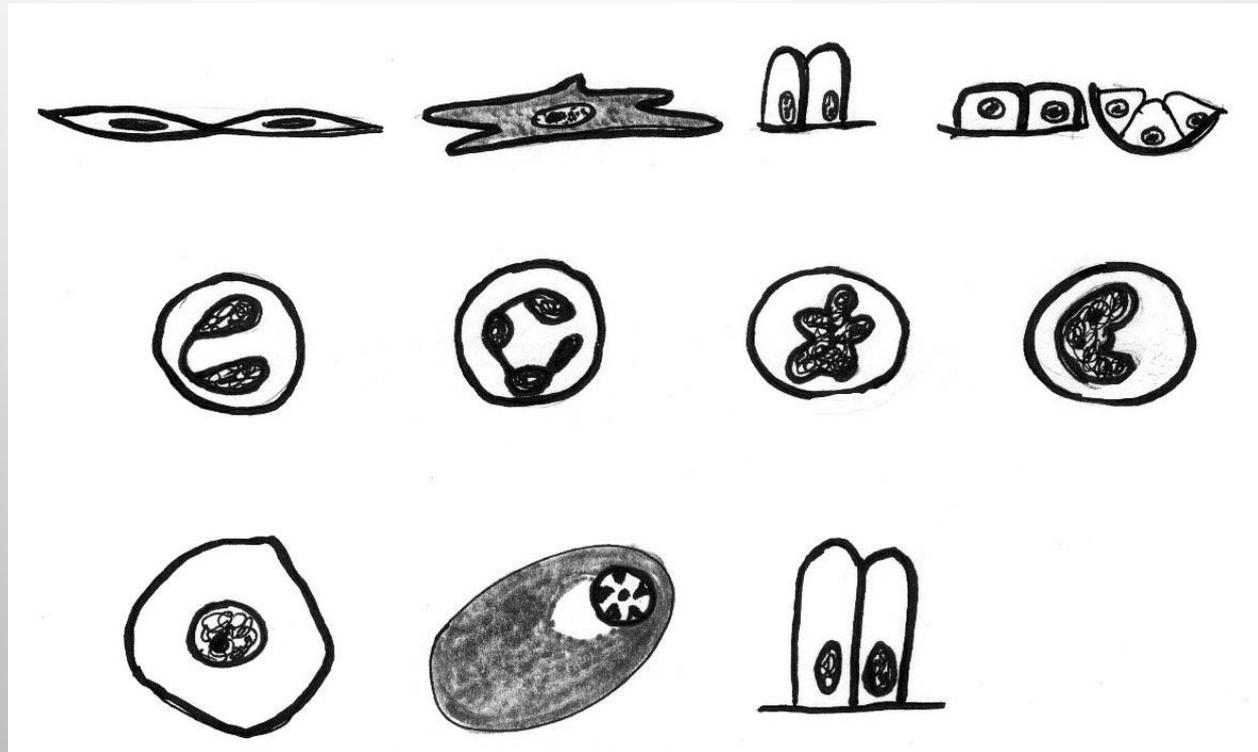
usually one nucleus is present in each cell (**mononucleated**) •

some cells have two nuclei (**binucleated**) as liver cells and •

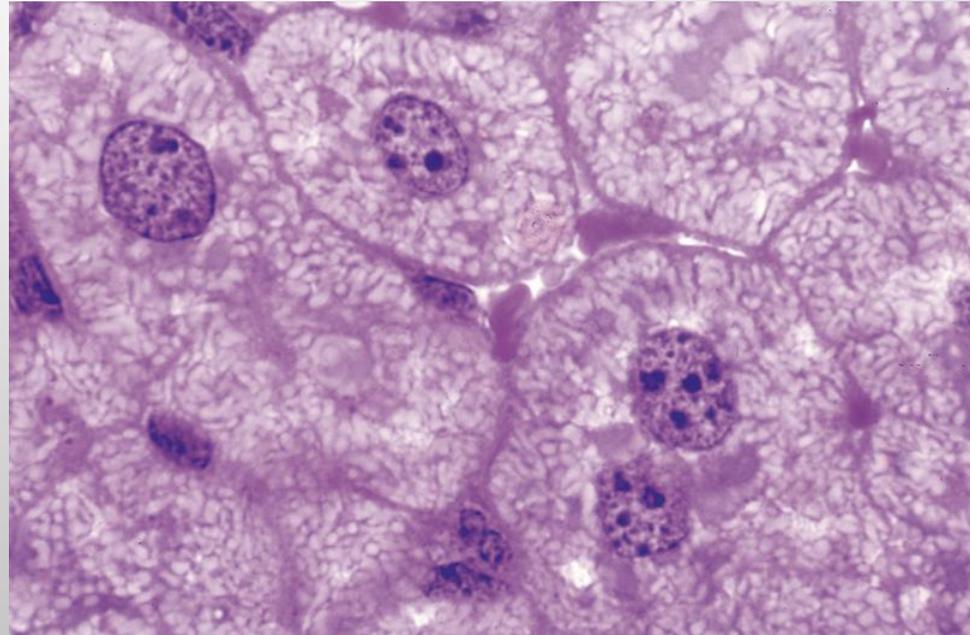
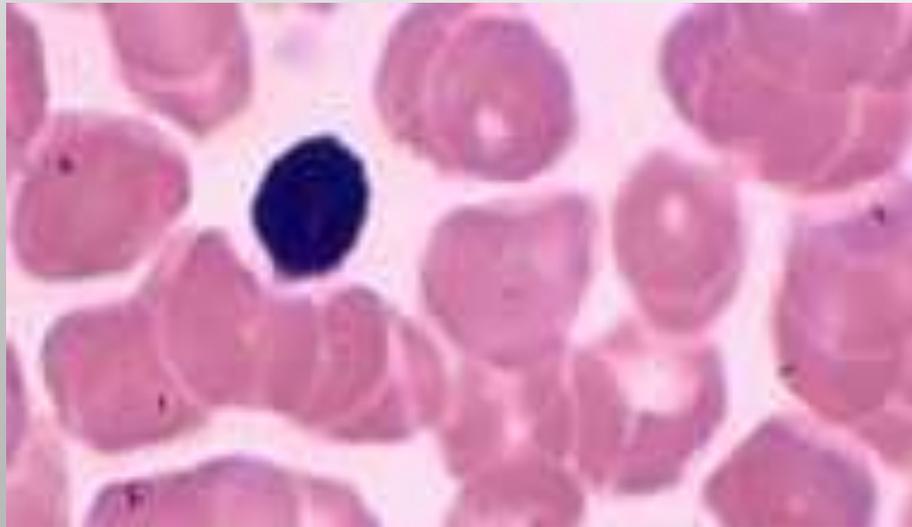
some have more than two nuclei (**multinucleated**) as •
osteoclasts & skeletal muscles.



- **Position**: usually central, but may be eccentric, basal or peripheral. Nucleus is always present in the wider part of the cell.
- **Shape**: rounded, flattened, oval, kidney-shaped, segmented, lobulated, or bilobed (horse shoe).



- **LM:**
- Dark blue with basic stains as hematoxylin, methylene blue.
- Its basophilia is due its content of DNA & RNA.
- Appearance: according to cell activity it may appear:
- Lightly stained (vesicular): pale with fine extended chromatin (open face nucleus) and prominent nucleolus, e.g. Nerve cells nucleus & liver cell nucleus
- Deeply stained (condensed): masses of dense condensed chromatin granules (closed face nucleus), e.g. Small lymphocytes.



- **Structure of the nucleus:**

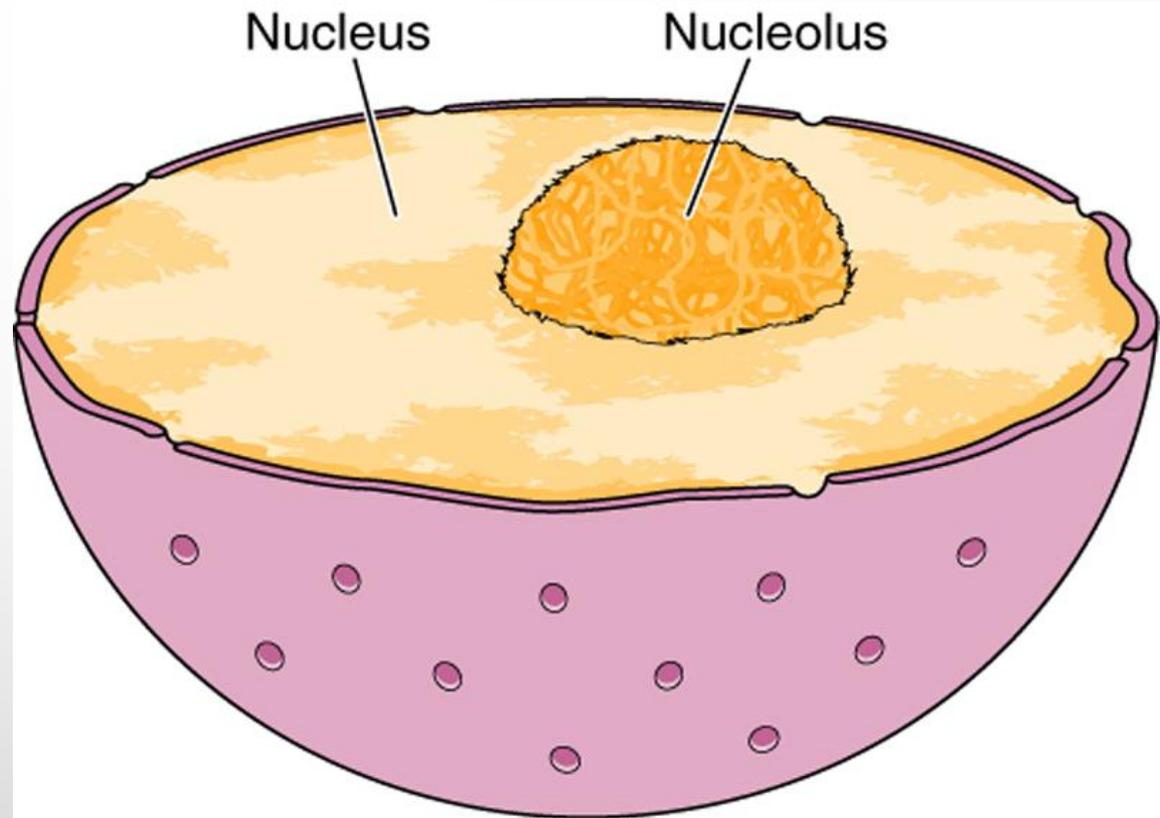
- **Four components:**

1-nuclear membrane
(envelope).

2-chromatin material.

3-nucleolus.

4-nuclear sap.

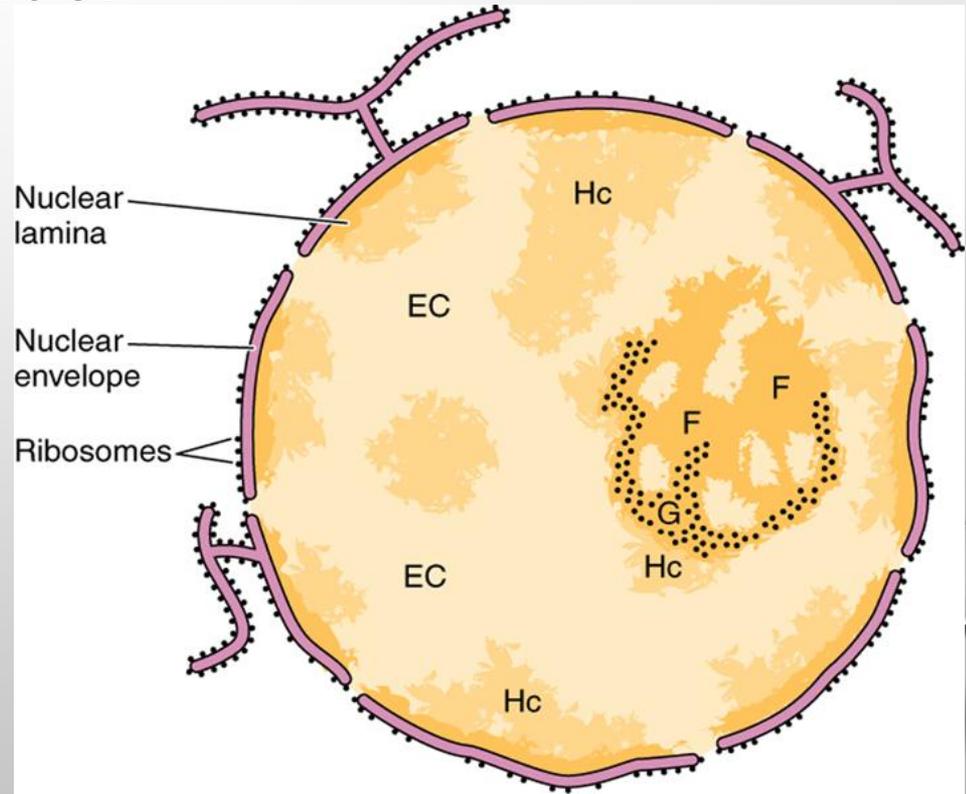


- **Structure of the nucleus**

- **1- nuclear membrane (nuclear envelope)**

- LM: blue line (basophilic)

Due to **chromatin** on its inner side & **ribosomes** on its outer side.



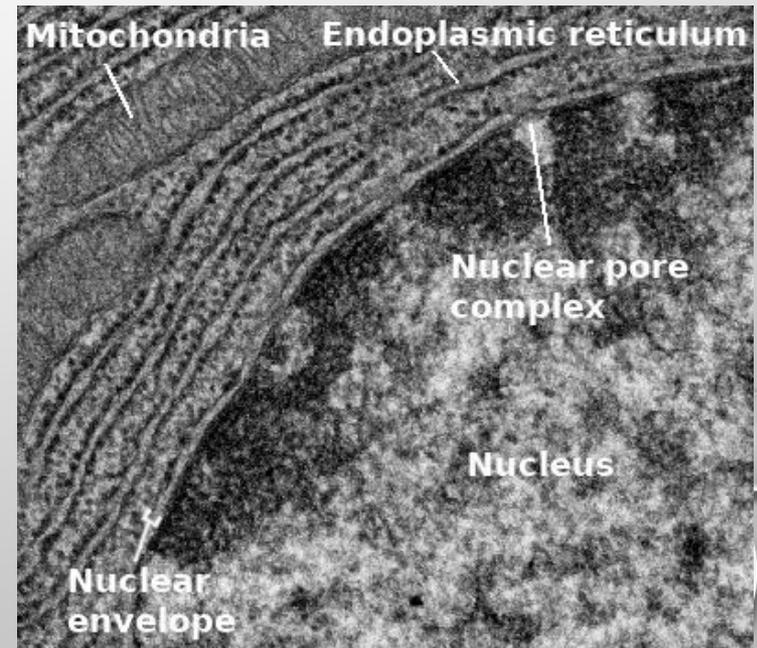
- E.M:

Double walled membrane separated by a **perinuclear space** and interrupted at intervals by **nuclear pores**.

Outer nuclear membrane (facing the cytoplasm):

It is rough & **granular** due to **ribosomes** attached to its outer surface, continuous with rER cisternae.

Function: **ribosomes** attached
formation of transmembrane
Proteins of nuclear membrane

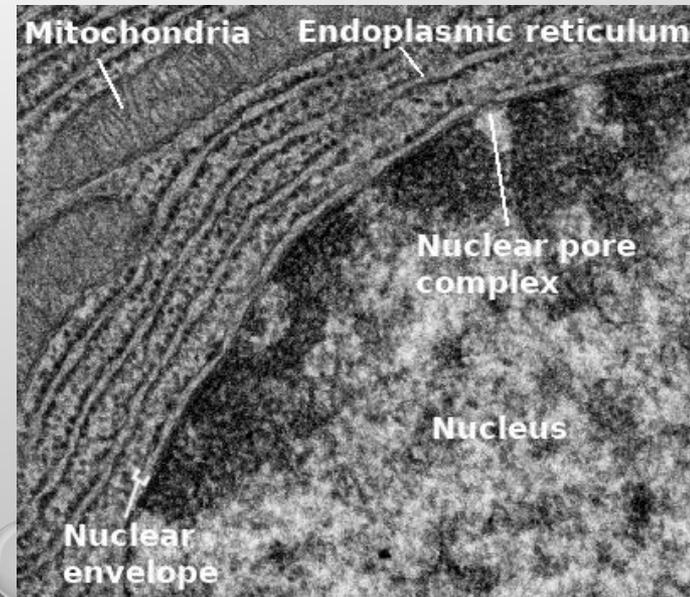
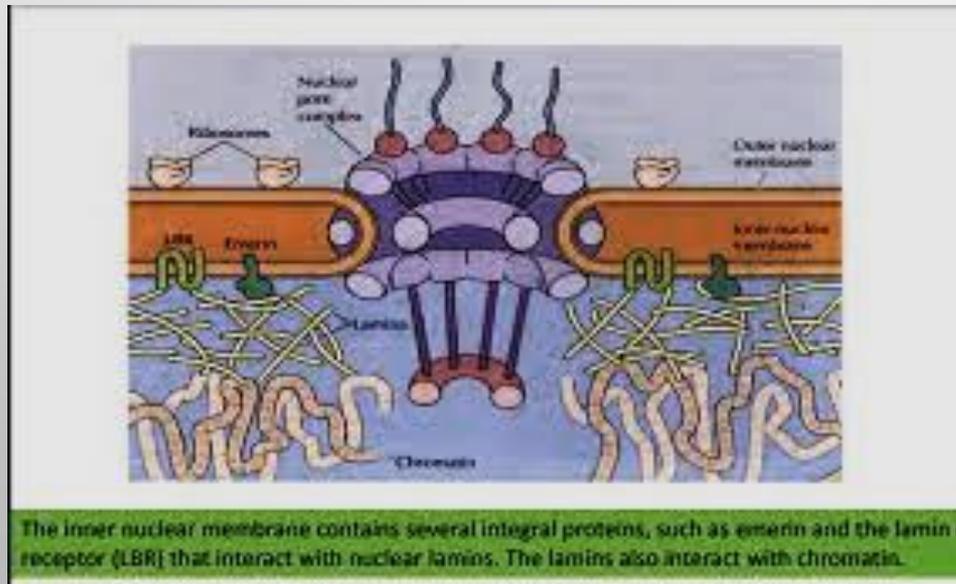


Inner nuclear membrane (facing the nucleus):

It is **fibrillar** due to attached chromatin

threads on its inner side (peripheral chromatin).

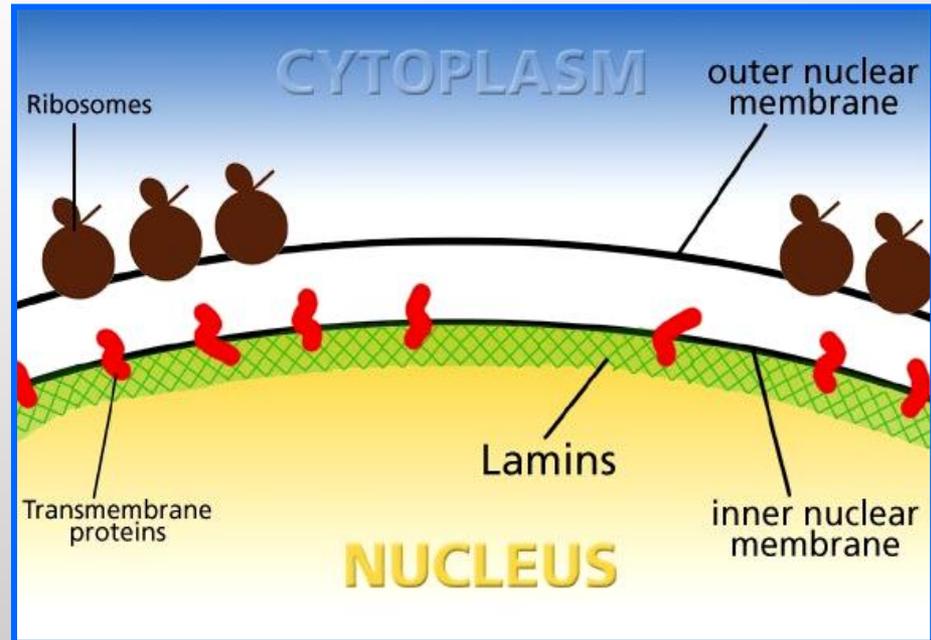
The inner surface of the nuclear envelop is bound to a thin filamentous network (lamins polypeptides) called the nuclear lamina.



Nuclear lamina

a network of **intermediate filaments** composed of various **lamins**

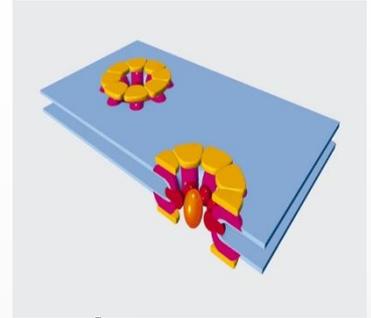
The lamina acts as a site of **attachment** for chromosomes and provides structural **stability** to the nucleus. The lamins have been associated with **various genetic** disorders collectively termed **laminopathies** (e.g. a rare form of muscular dystrophy).



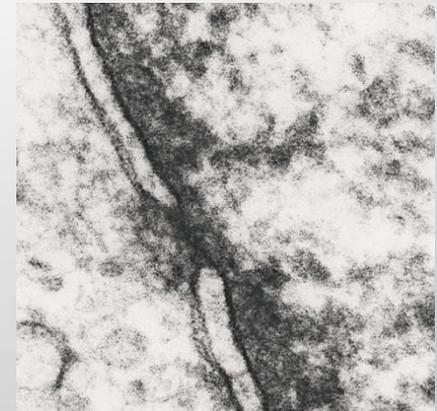
Nuclear envelope (Nucleolemm) function

- Separates the enclosed nuclear compartment from cytoplasm
- Maintains the shape of nucleus
- Controls exchanges between nucleus and cytoplasm
- Important role in organization of nucleus content

Nuclear pores



- Circular openings at intervals
- The outer & inner membranes fuse together and be continuous as diaphragms
- The diaphragms are formed of 8 proteins radially arranged called **annulus & a plug at the center**



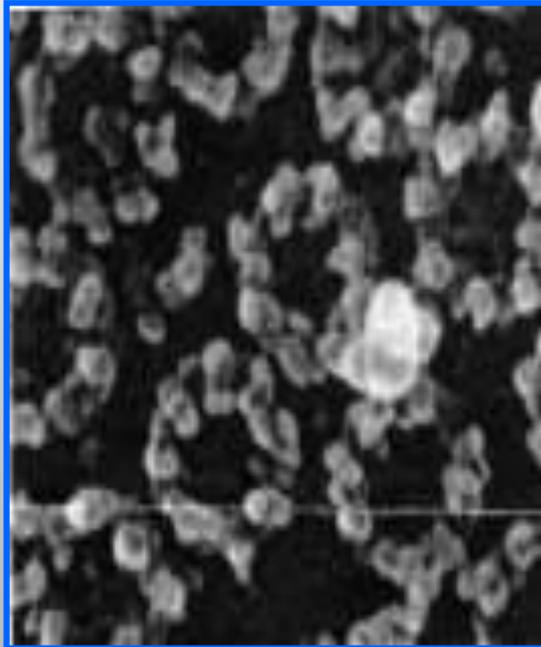
All called **nuclear pore complex**

- There are 3000-4000 nuclear pores
- **Dynamic** structures – their number grows if it's necessary

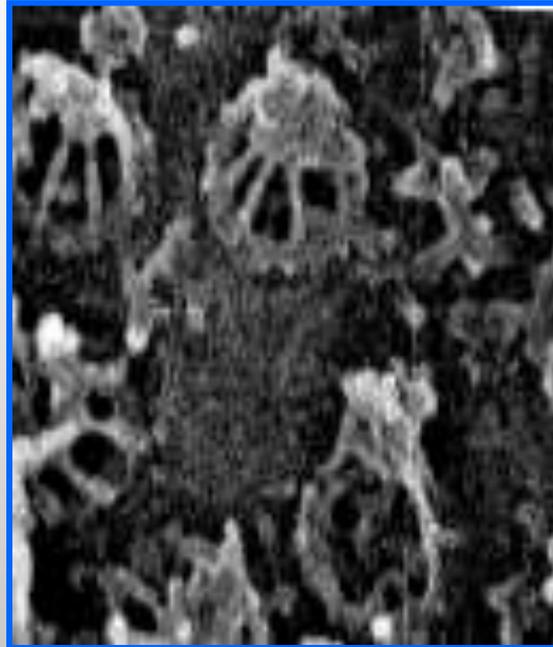
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- The nuclear pores are the gateways across which movement of **RNAs** and **proteins** takes place between the nucleus and cytoplasm in both direction.
- Proteins synthesized in the cytoplasm cross the nuclear envelop to initiate replication and transcription of genetic material. Similarly, mRNA, tRNA and ribosomal subunits built in the nucleus cross through the nuclear pores to the cytoplasm.

The Nuclear Pore Complex



Cytoplasmic face



Nuclear face

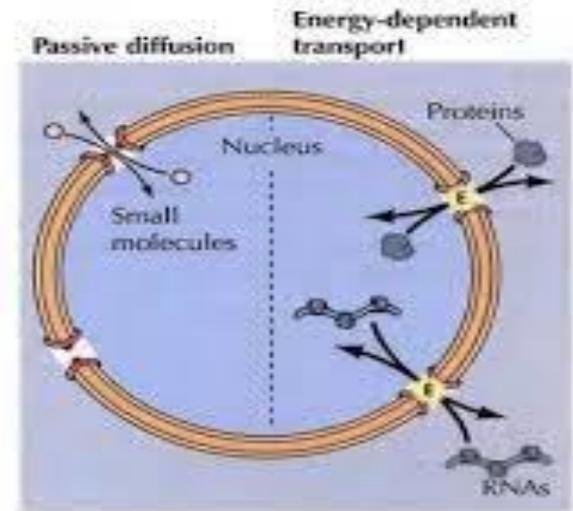


FIGURE 9.6 Molecular traffic through nuclear pore complexes. Small molecules are able to pass rapidly through open channels in the nuclear pore complex by passive diffusion. In contrast, macromolecules (proteins and RNAs) are transported by a selective, energy-dependent mechanism.

- **Octagonal** symmetry
- **8 fold** repetition of **glycoprotein** subunits (**Nucleoporins** or **Nups**)
- Nucleoporins: **symmetrical** on cytoplasmic and nuclear sides

Nucleoplasm

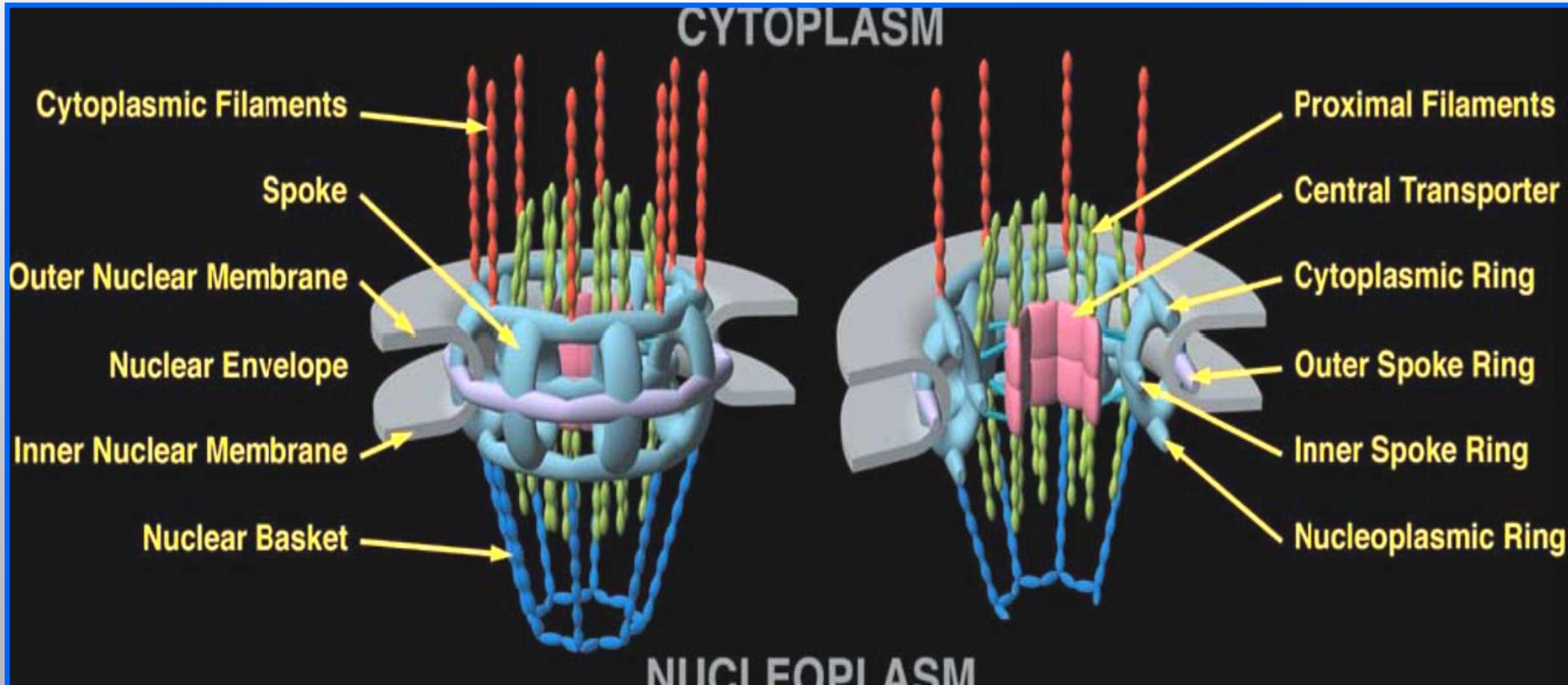
Nuclear Basket
Nuclear Ring
Filaments

Nuclear Membrane

Central Transporter
Spoke Ring (inner & outer)

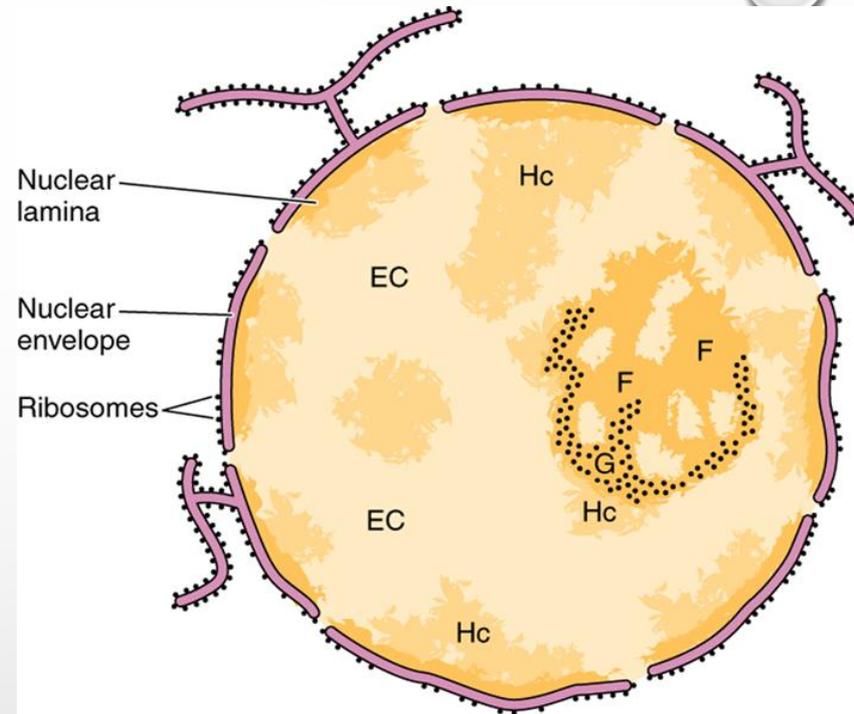
Cytoplasm

Cytoplasmic Ring
Cytoplasmic Filaments



2- chromatin

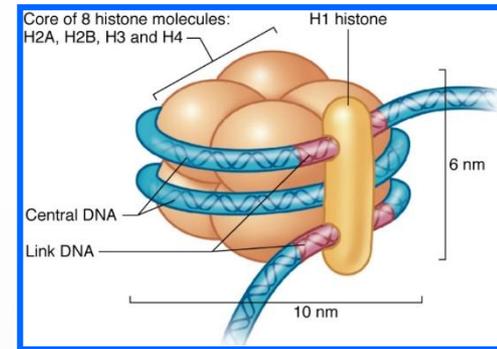
- **Definition:**
- **Particles threads that present in inter phase nucleus**
- **It represents the genetic material**
- **Formed of nucleoproteins (DNA + histone).**



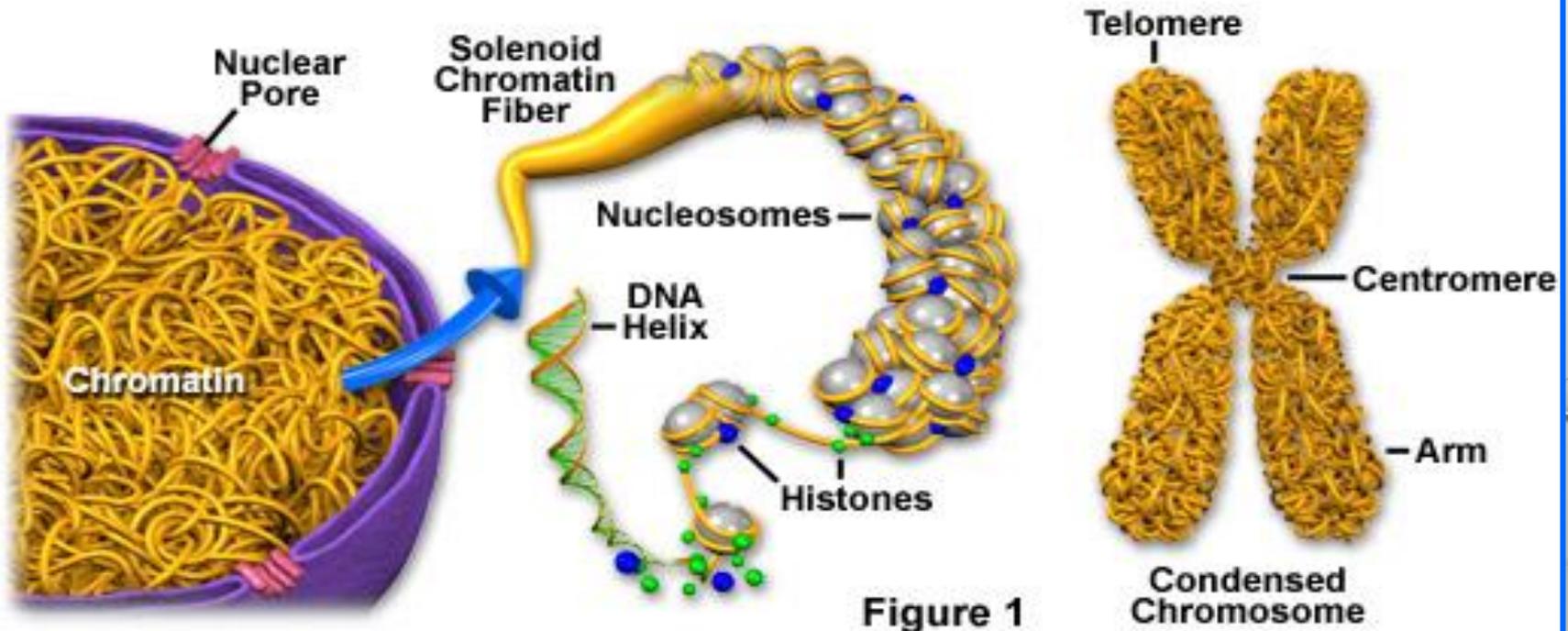
LEVELS OF CHROMATIN ORGANIZATION (Chromatin Packing)

In general terms, there are three levels of chromatin organization:

1. the "**beads on a string**" structure, **DNA** wraps around **histone** proteins forming **nucleosomes**

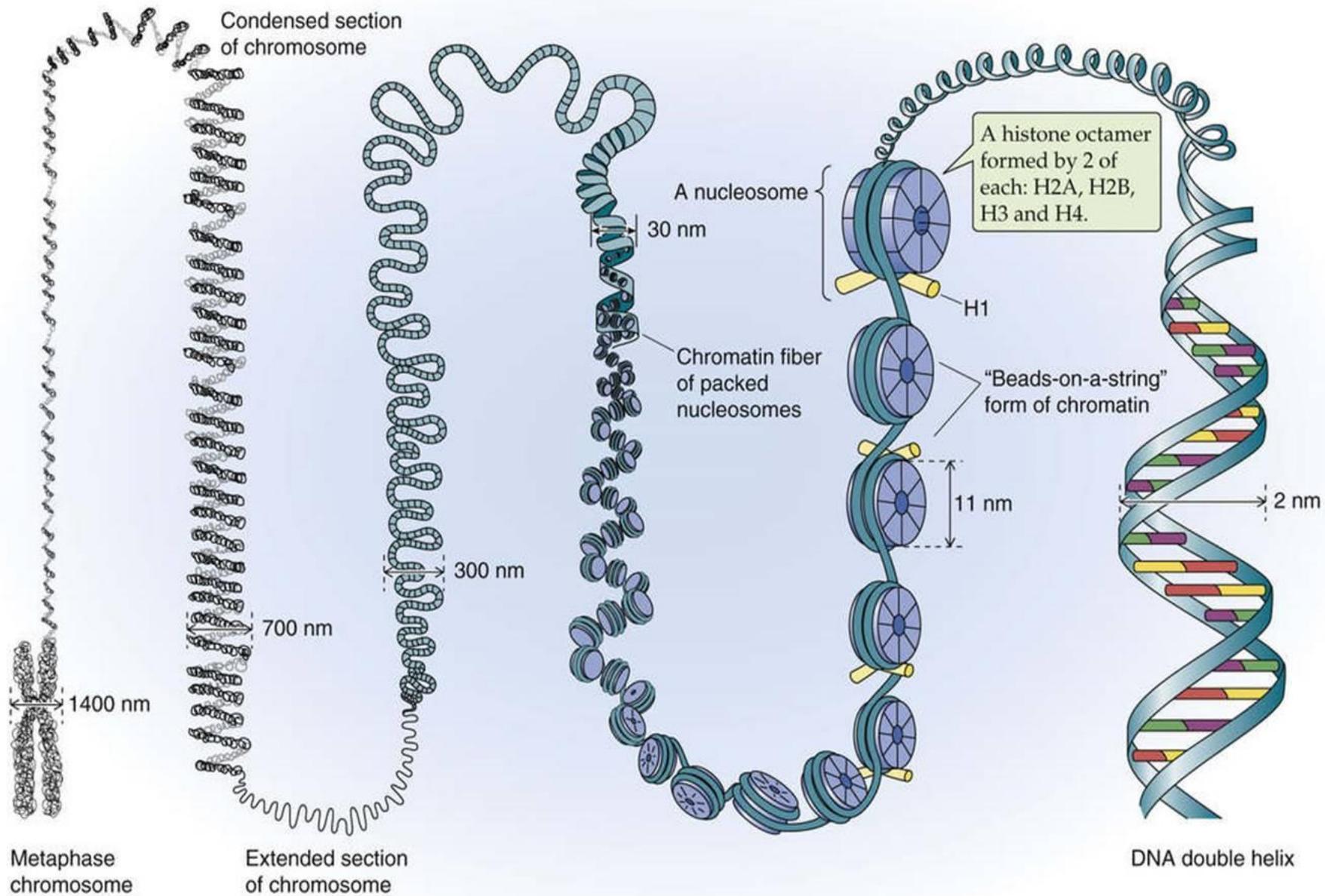


Chromatin and Condensed Chromosome Structure



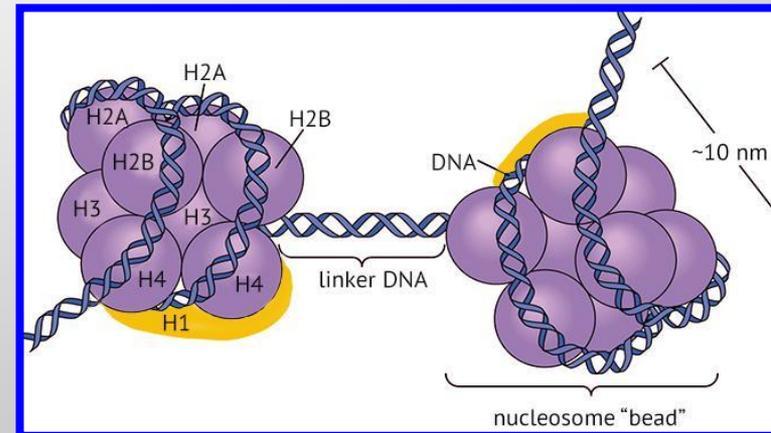
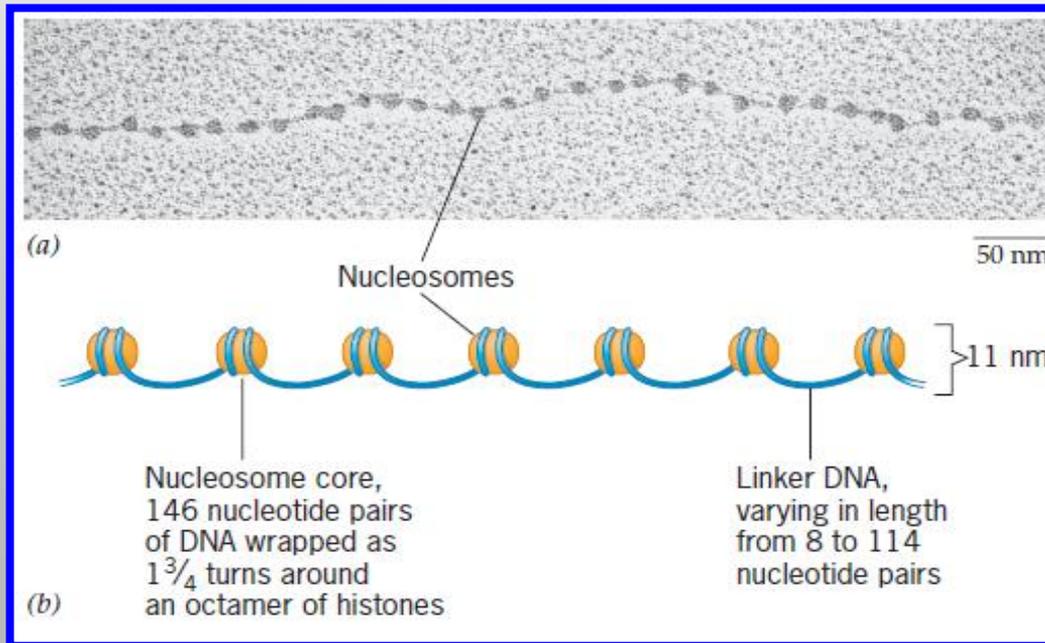


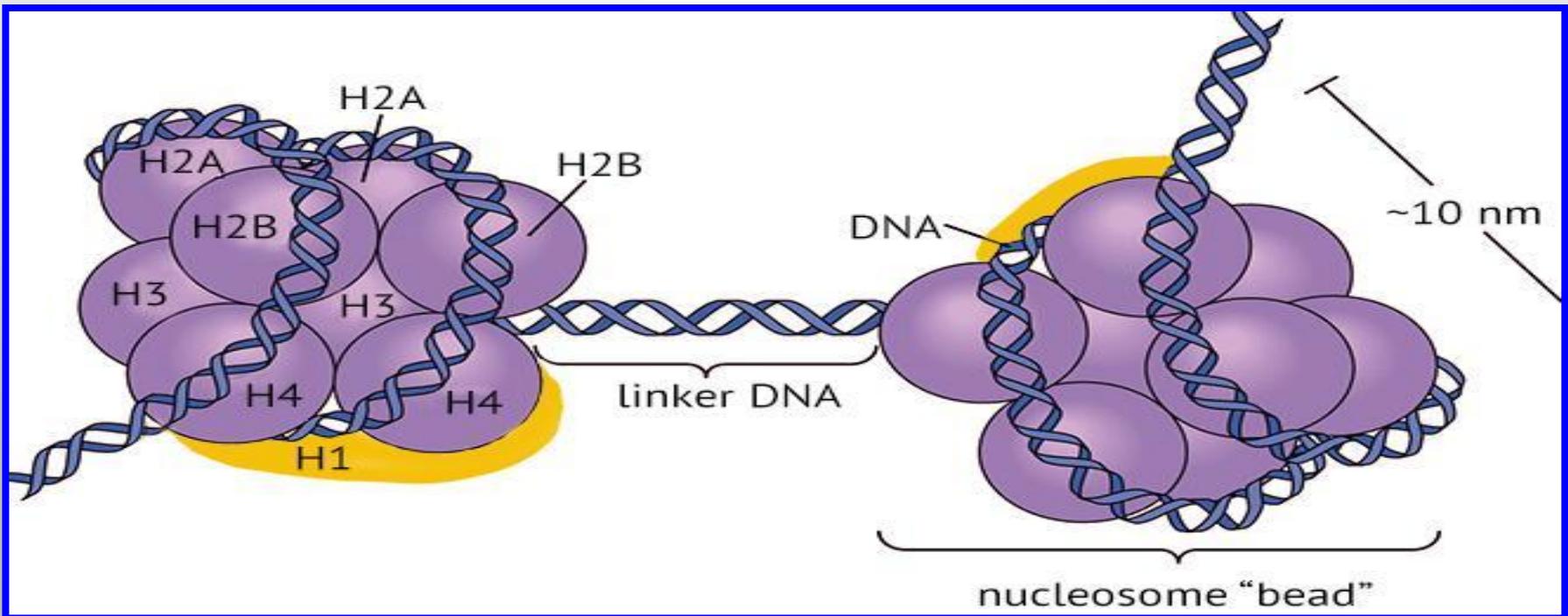
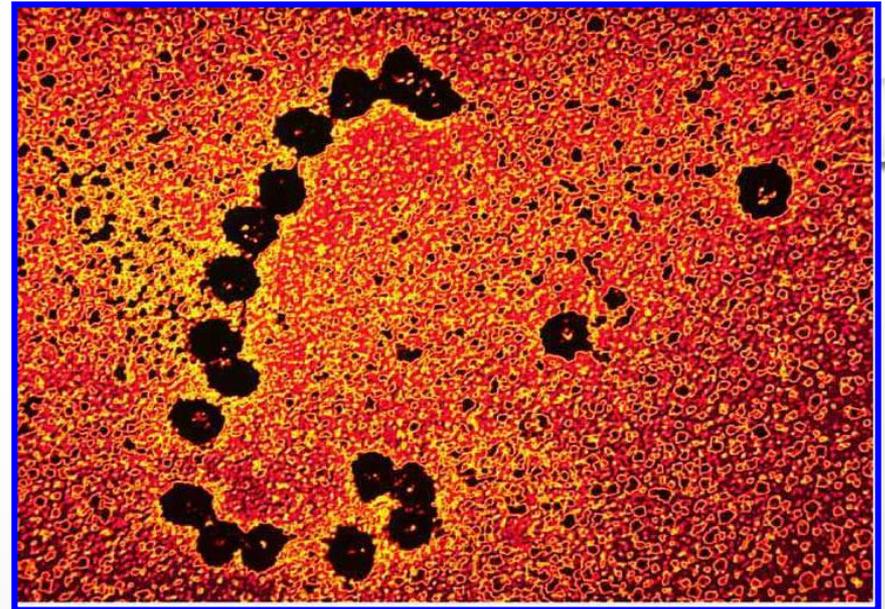
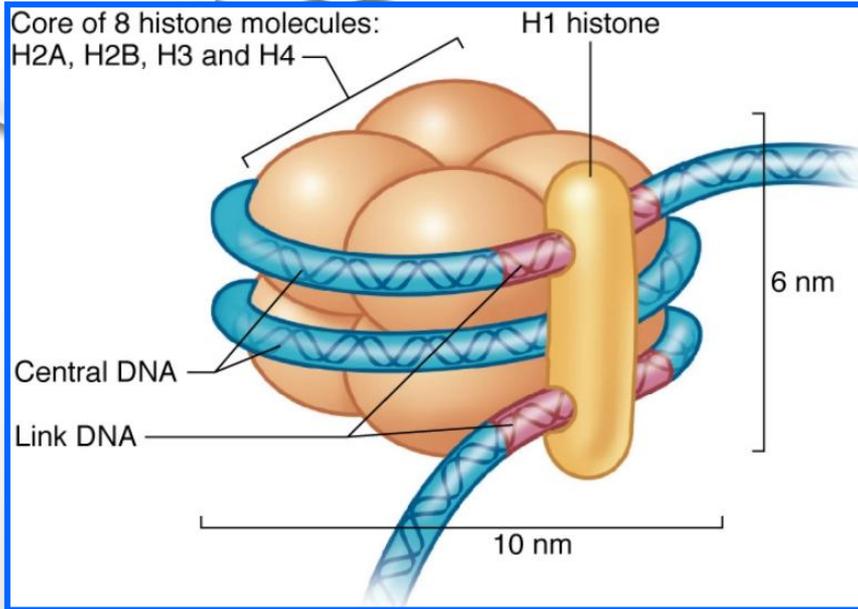
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1. The "beads on a string"

- DNA and histones are organized into repeating subunits called **nucleosomes**
- **nucleosomes** composed of **two loops** of DNA wrapped around a **protein core** (eight **histone** molecules)
- A **nucleosome core** particle consists of supercoiled DNA wrapped **almost twice** around disk shaped complex of 8 histone molecules
- the **linker** histone, resides outside the nucleosome and binds to the linker DNA that connects one nucleosome to the next.



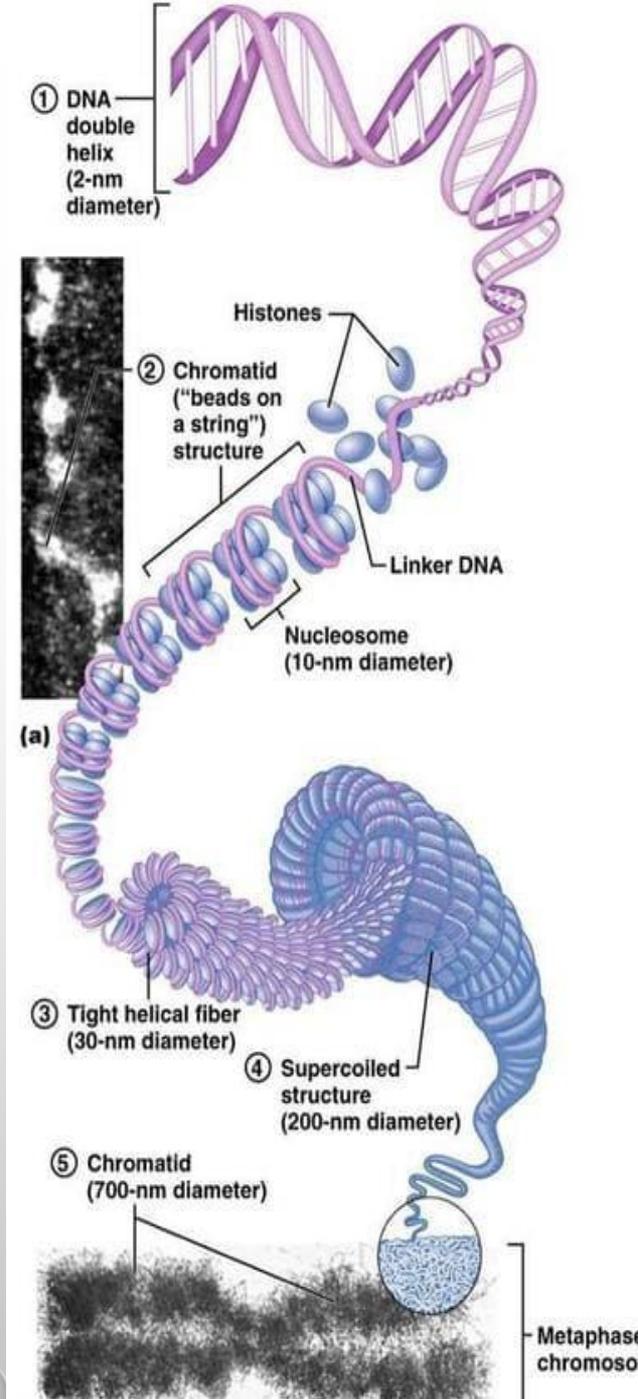


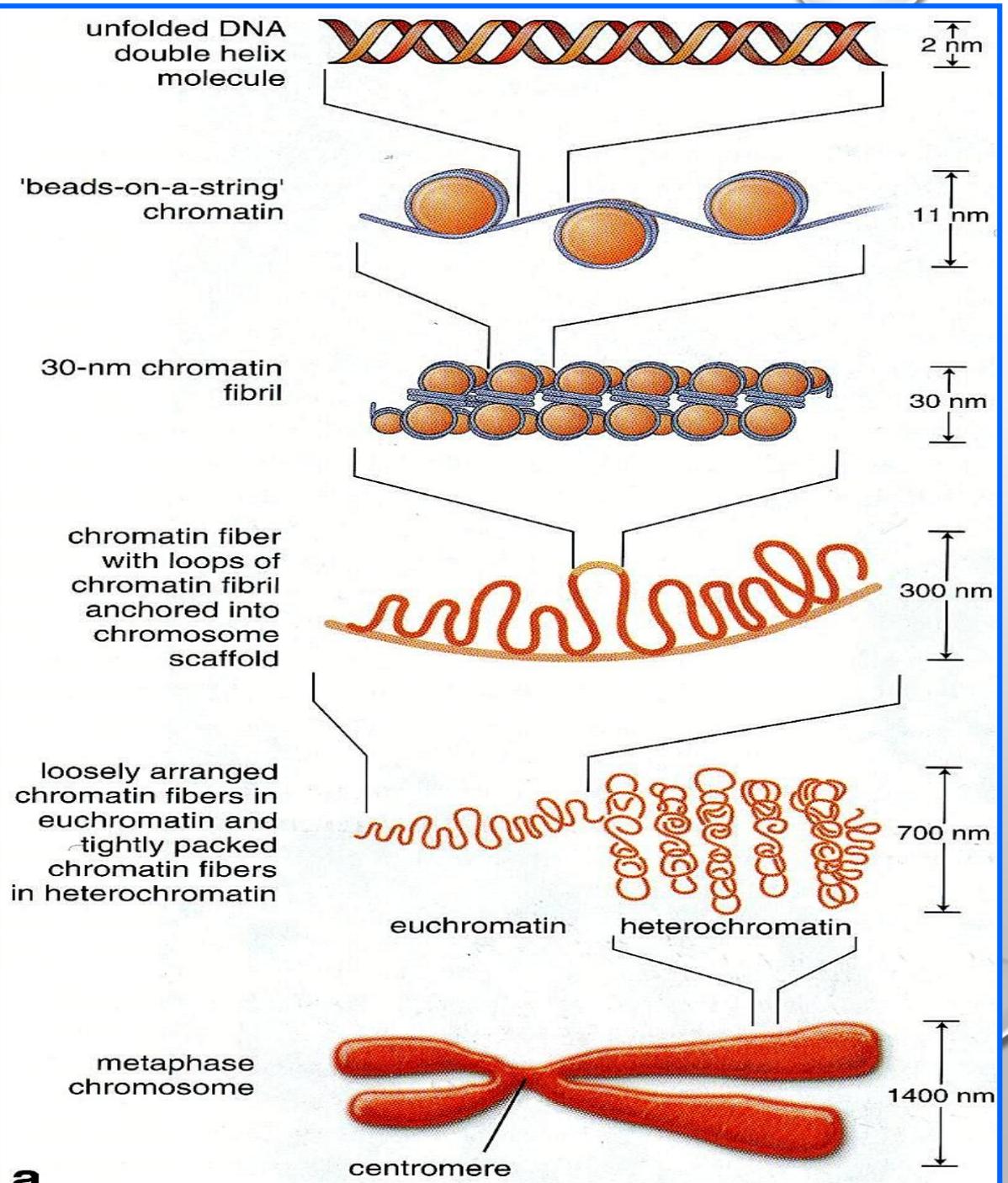
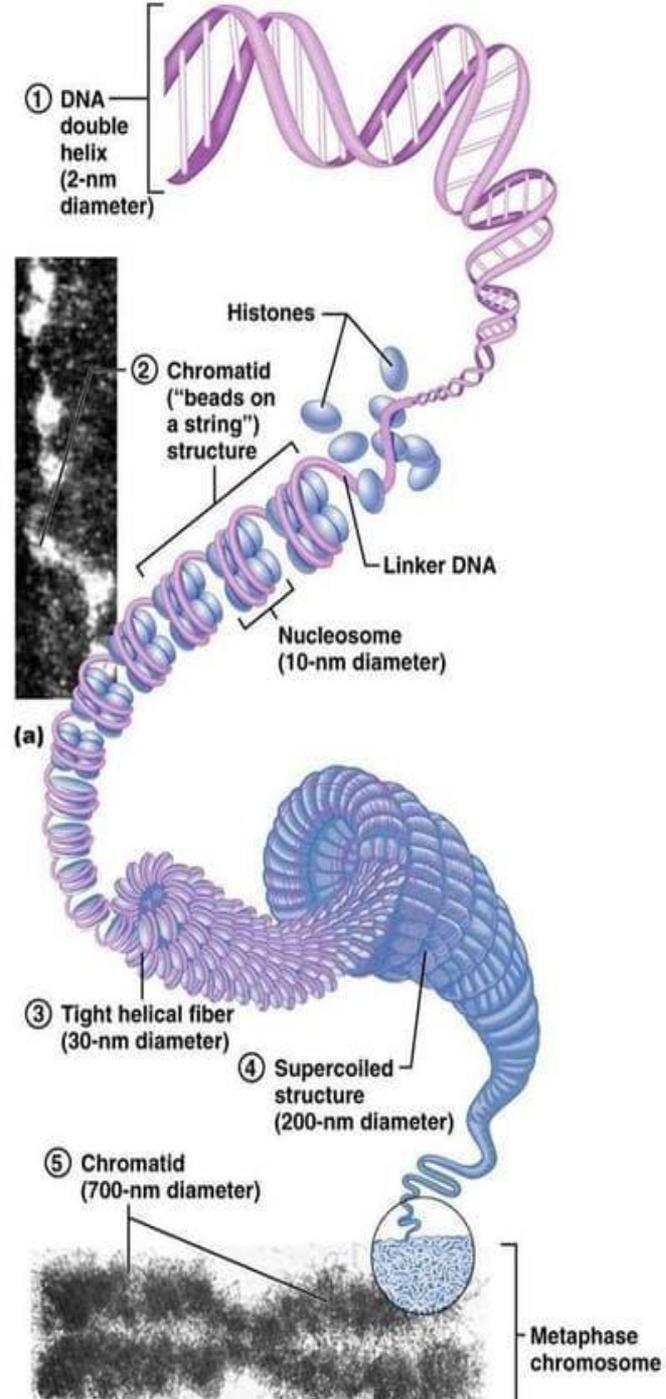
- It is formed of DNA + histone proteins.

Repeating nucleosomes with intervening "linker" DNA form a 10nm fiber (beads on a string).

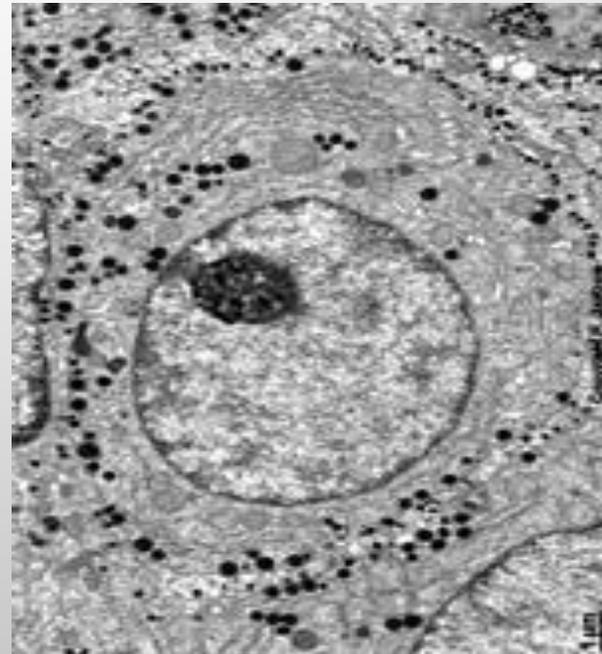
This chain of nucleosomes is packed to form a 30nm fiber.

Higher orders of packaging gives the compact structure 700nm seen in the metaphase of the dividing cell known as the chromatid of a chromosome.

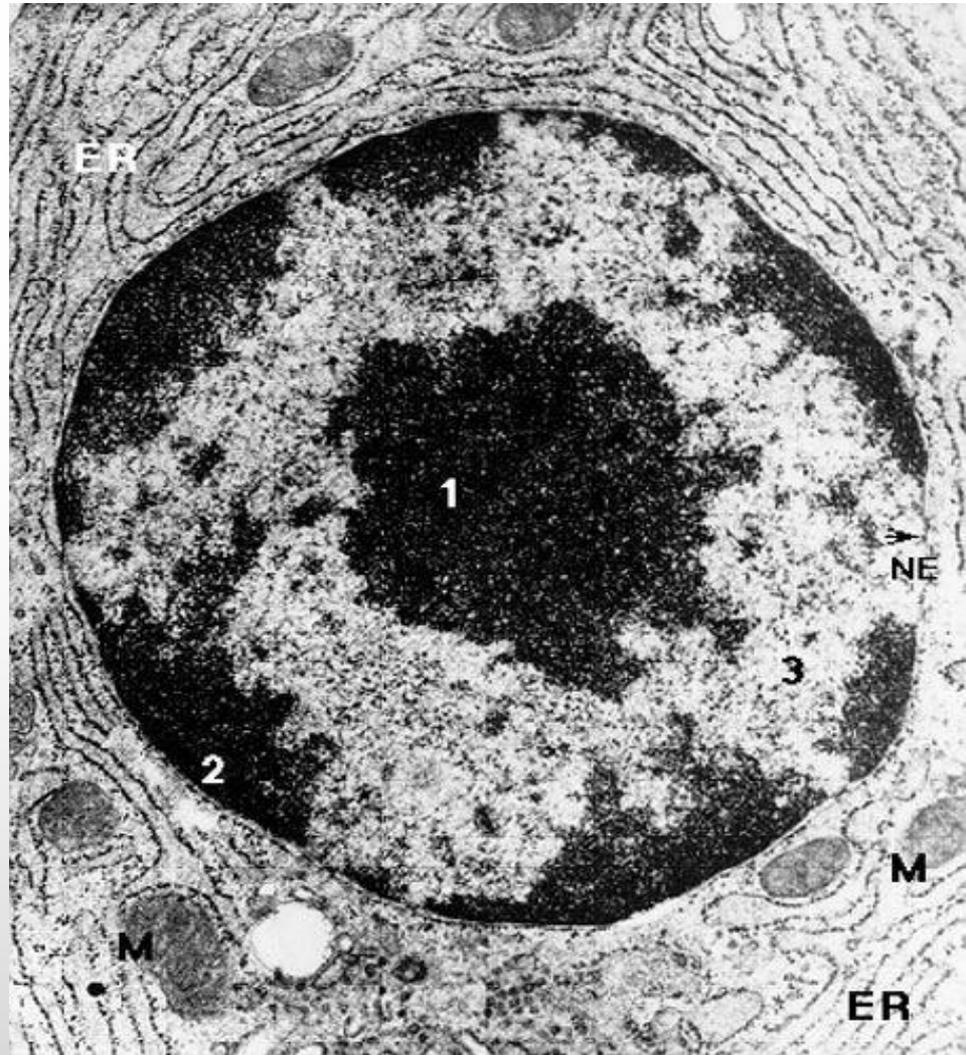




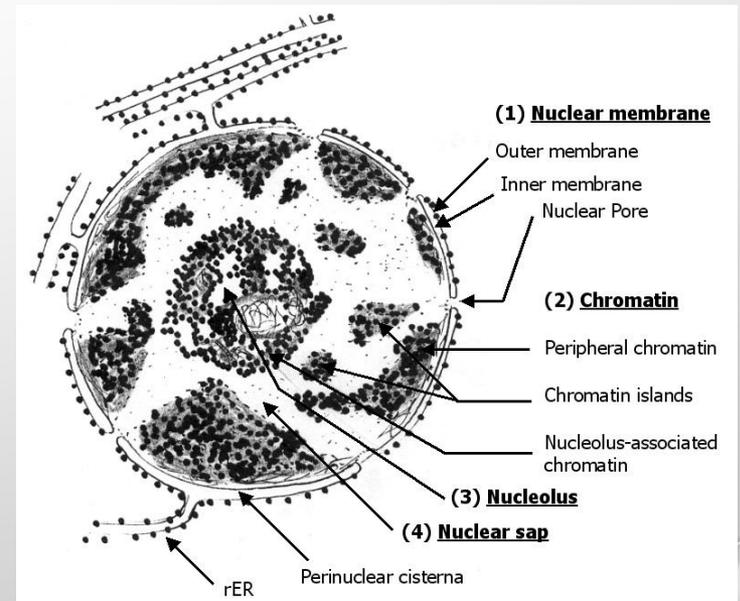
- **chromatin**
- Have two forms according to cell activity:
- 1-euchromation (extended or active):
- Not visible in LM which makes the nucleus pale in staining (vesicular nucleus).
- It represents extended (uncoiled) chromosomes.
- Contains the active genes that direct protein synthesis in protein-forming cells.



2- Hetrochromatin (condensed or inactive): Appears dark in LM (condensed nucleus) as it represents coiled chromosomes, and contains the inactive genes.

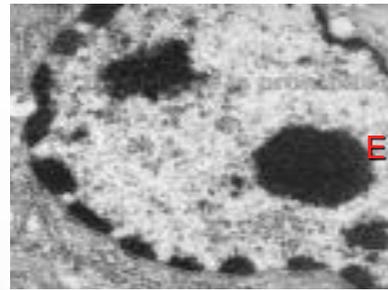


- **Sites of heterochromatin:**
- **A) peripheral chromatin:** attached to the inner surface of nuclear membrane.
- **B) chromatin islands:** aggregated clumps scattered in the nuclear sap.
- **C) nucleolus-associated chromatin:** condensed around the nucleolus.

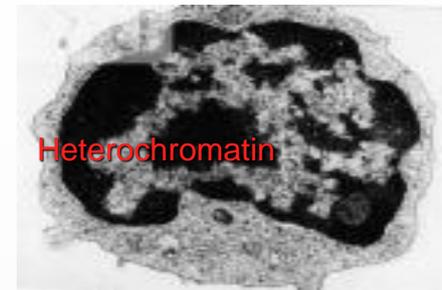


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COMPARISON BETWEEN EUCHROMATIN AND HETEROCHROMATIN



Euchromatin



Heterochromatin

Euchromatin

Heterochromatin

1- L/M

- Pale nucleus
- Can not be seen.

- Visible as blue basophilic granules

2- E/M

- Very fine threads in-between the condensed parts of chromatin.

- appears as (black) electron dense granules distributed throughout the nucleus.

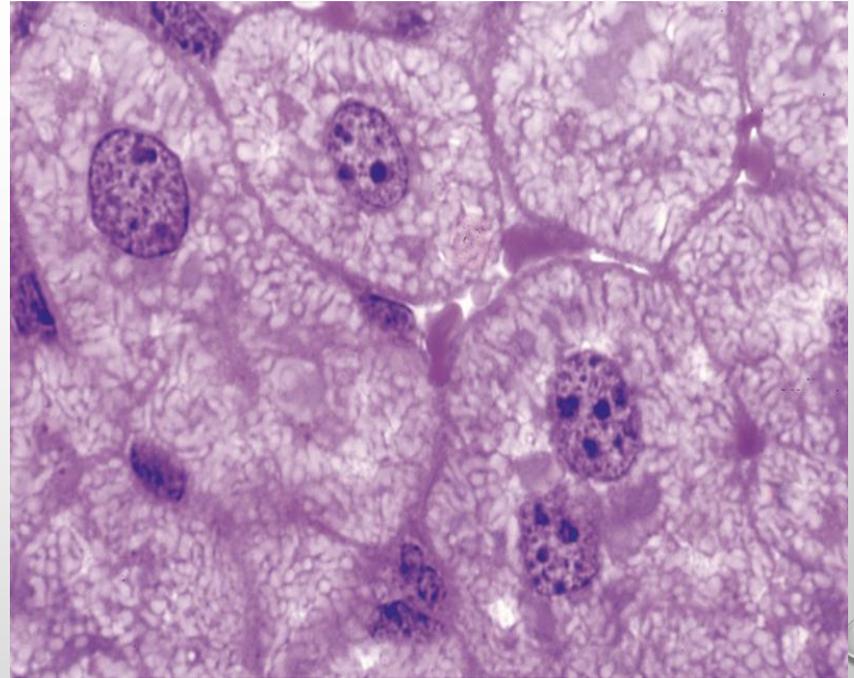


- **Functions of chromatin:**

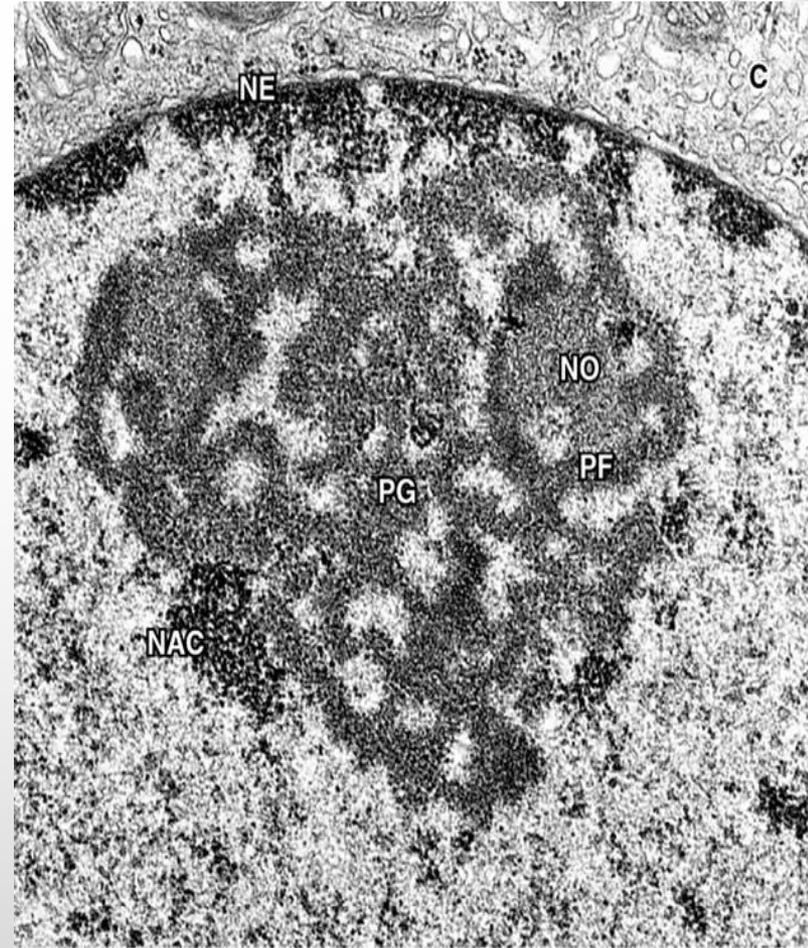
- **1- carries genetic information.**
- **2- directs & controls protein synthesis.**
- **3- formation of RNA (mRNA, rRNA & tRNA).**

3-nucleolus

- LM:
- Rounded, deeply basophilic mass, as
It is rich in nucleic acids
And surrounded with
Chromatin.
- Usually one or two in
Each nucleus.



- E.M.:
- Spongy appearance, not limited by membrane. It has dark and light areas.

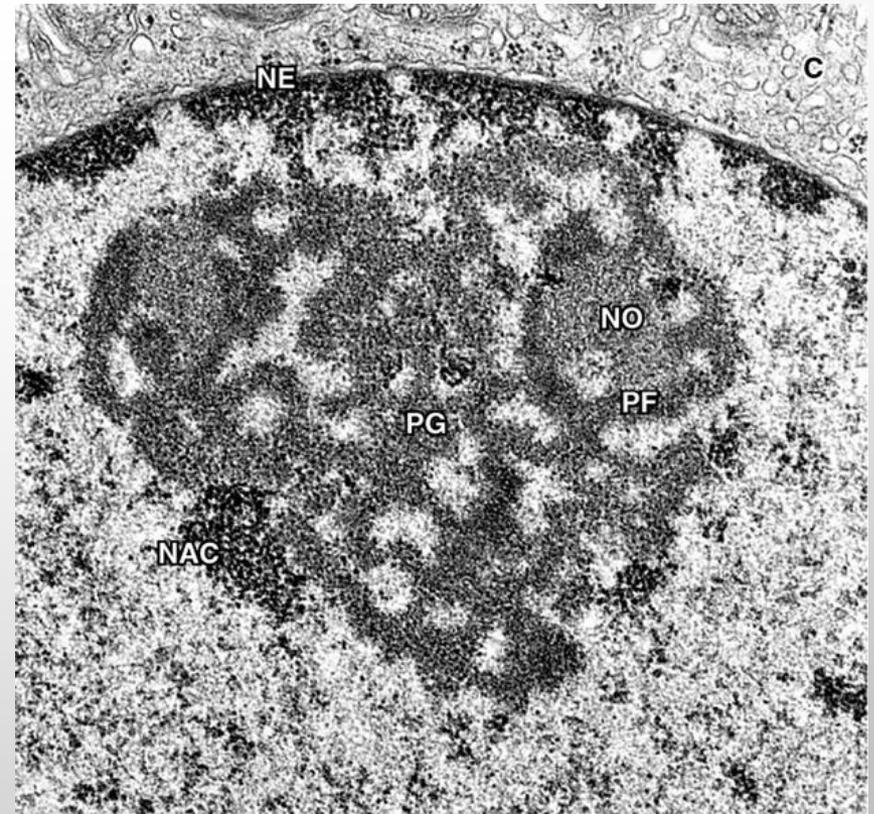


The dark areas

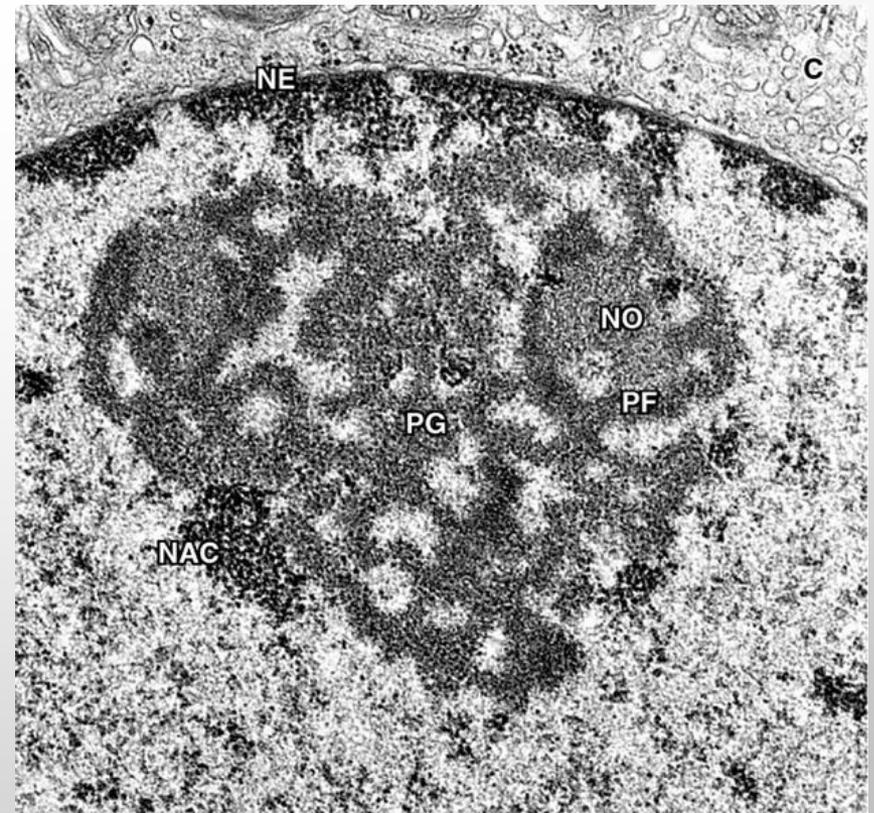
- Pars amorpha
(NO):

Central filaments of
DNA

Organized center



- Pars fibrosa :
Strands of newly
formed rRNA

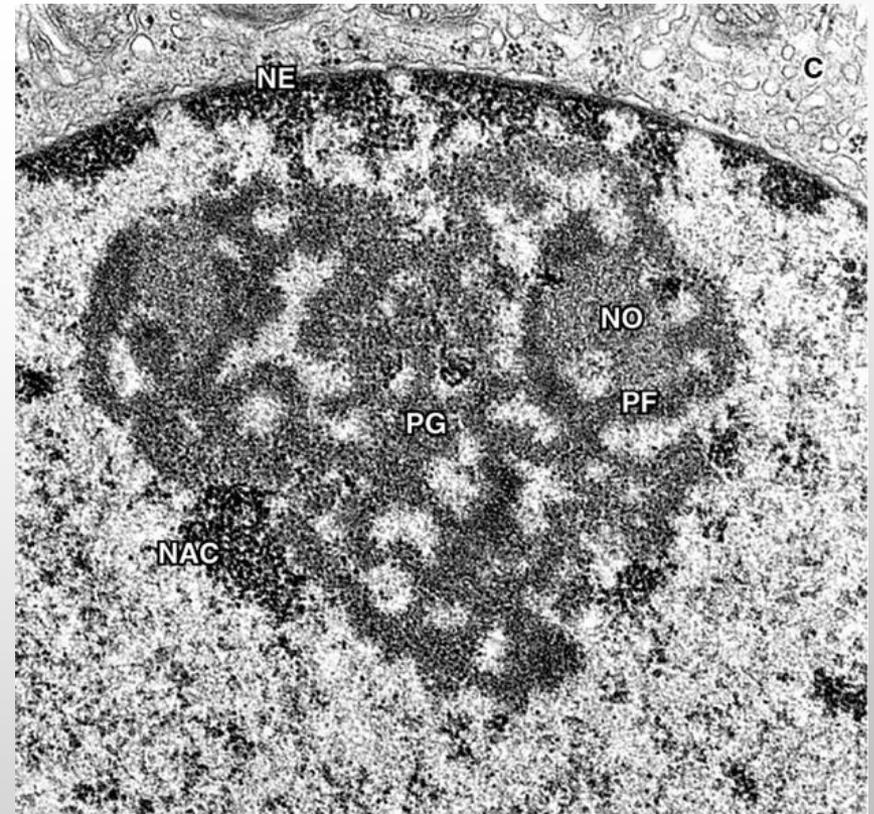


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- Pars granulosa

Granules of mature
rRNA

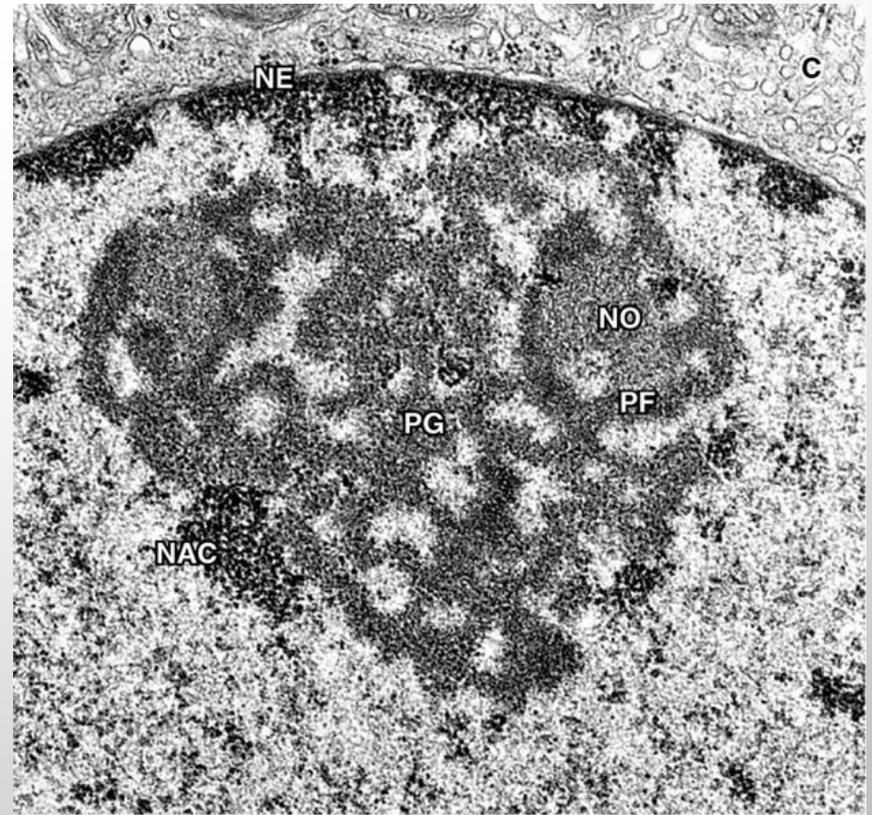
Both pars amorpha &
pars fibrosa are
called
nucleolonema



- The light areas :the nucleolar sap

- Functions of the nucleolus

Formation of rRNA & (ribosomes)

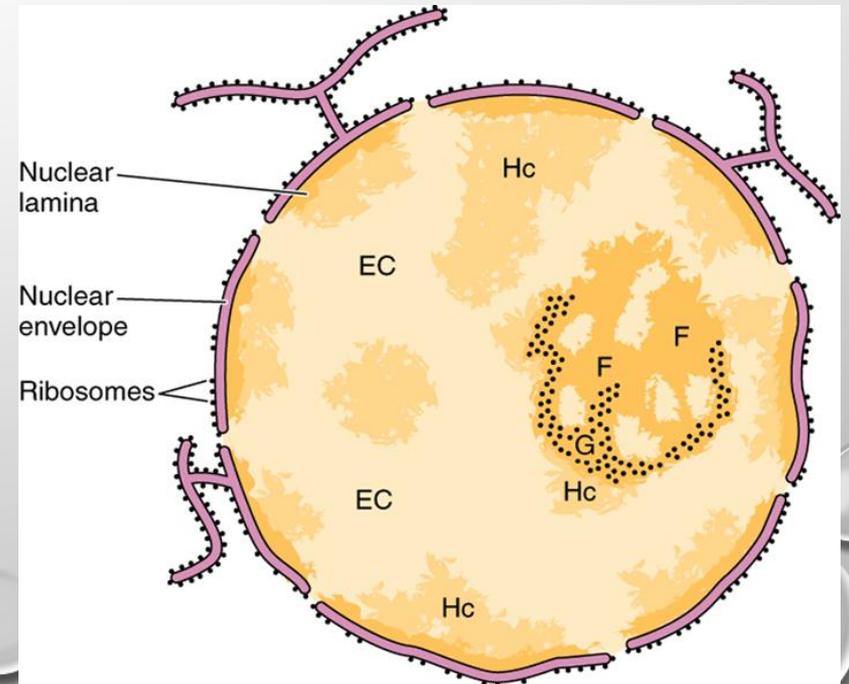


- **4- nuclear sap**

- **Definition:**

- A colloidal solution that fills the spaces between chromatin material and nucleolus.

- Formed of: nucleoproteins, enzymes, sugars, calcium, potassium & phosphorous ions.



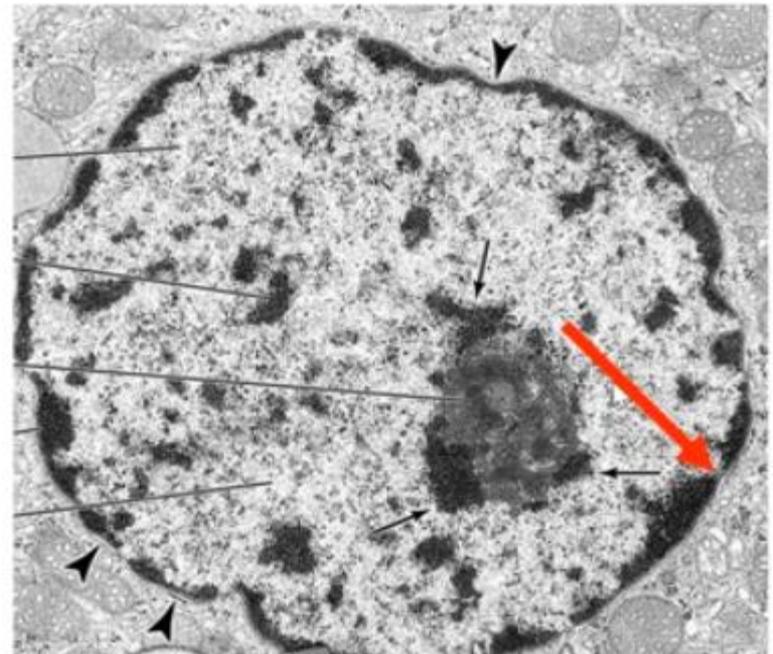


• **Functions of the nucleus**

- 1- it carries all the genetic information and hereditary factors.
- 2- it controls all the cell functions including protein synthesis.
- 3- it is responsible for the formation of rna.
- 4- it directs cell division.

Which statement is the best to describe the pointed structure by the red arrow?

- 1- It is uniformly distributed.
- 2- The number increases with decreases the cell activity.
- 3- It allows passages of molecules only in one direction.
- 4- Fusion of the outer and inner membranes marks at its site.





Thank You
