# Nucleus

- The Nucleus is the largest a **membrane-enclosed** organelle which house most of the **genetic** information and regulatory machinery responsible for providing the cell with its unique characteristics
- It is the most obvious organelle

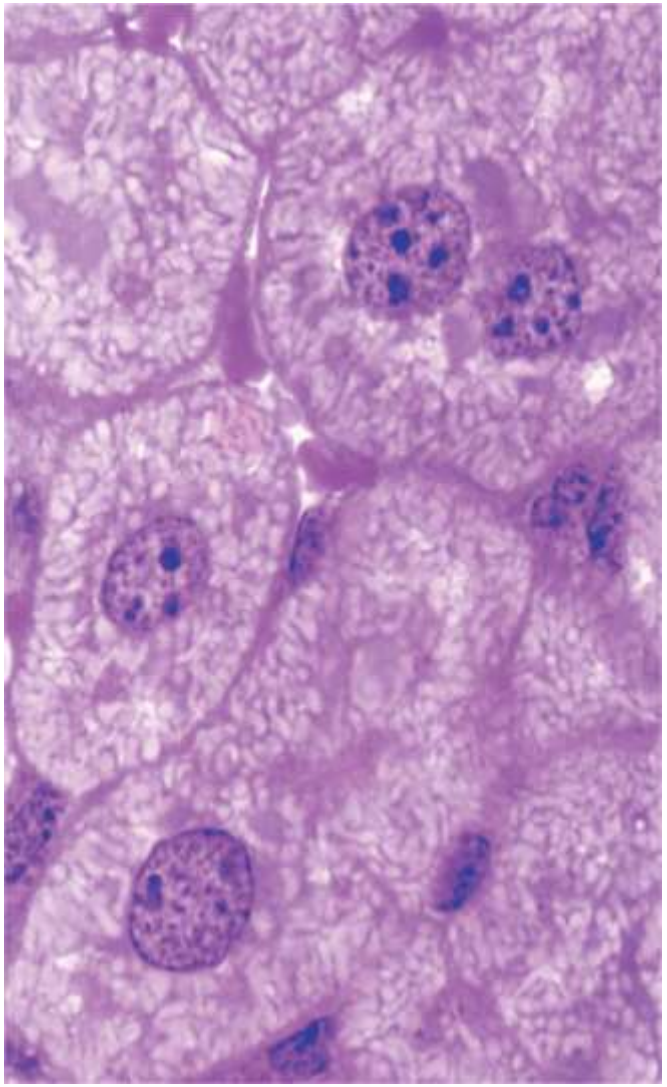
**LM: Basophilic**

- The nucleus (**controls** all cell activity)

**Functions**

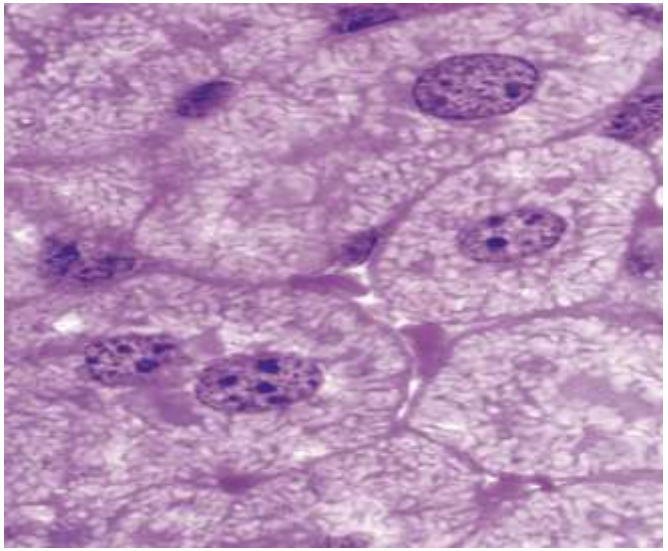
- It stores the cell's hereditary material (DNA)
- Site of DNA replication
- Site of DNA transcription to mRNA
- Ribosomal formation

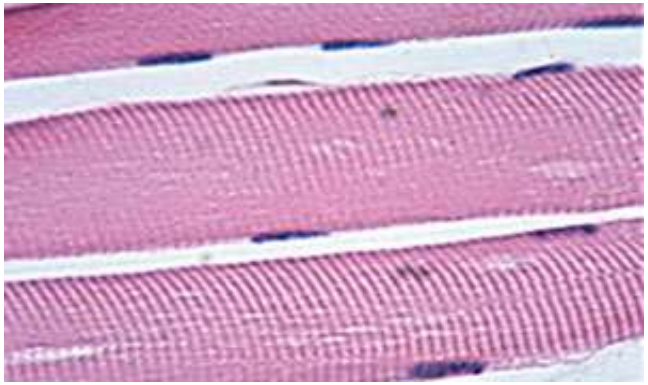
  **Nucleolus**: RNA & protein required for ribosomal synthesis
- It coordinates the cell's activities, which include growth, intermediary metabolism, protein synthesis, and reproduction (cell division) by regulating gene expression

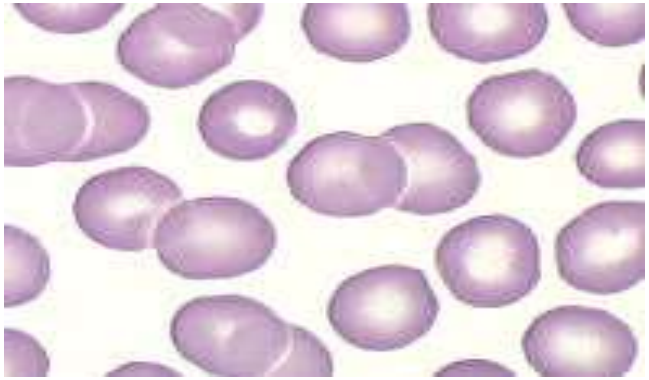


# Variable number

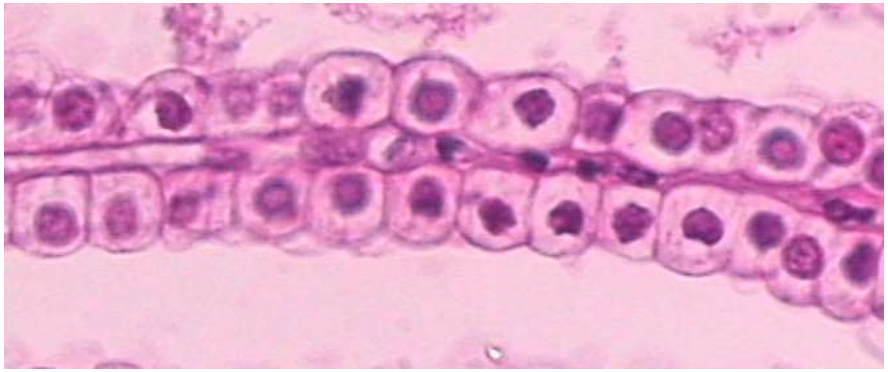
- **One = Mononucleated cells**
- **Two= Binucleated cells**
- **Multiple= Multinucleated cells**
- **No = Anucleated**



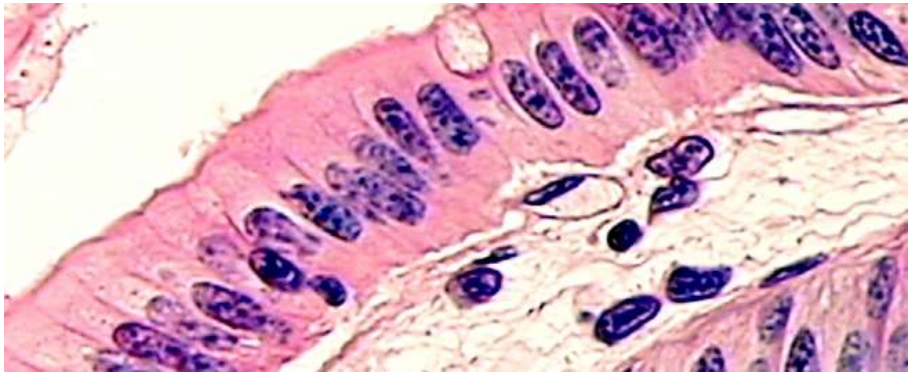




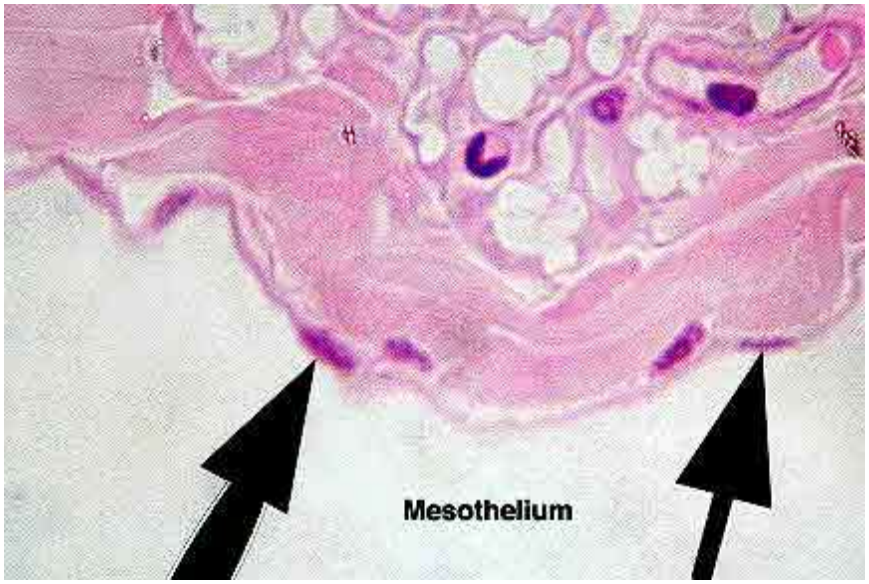
# Variable shape



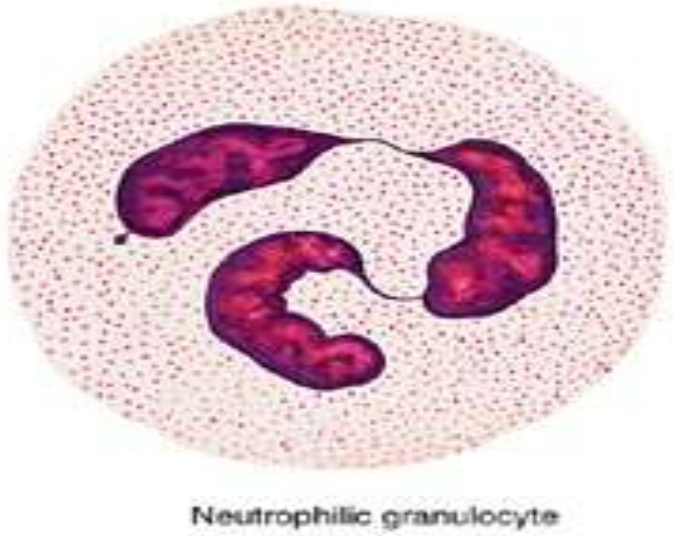
Rounded



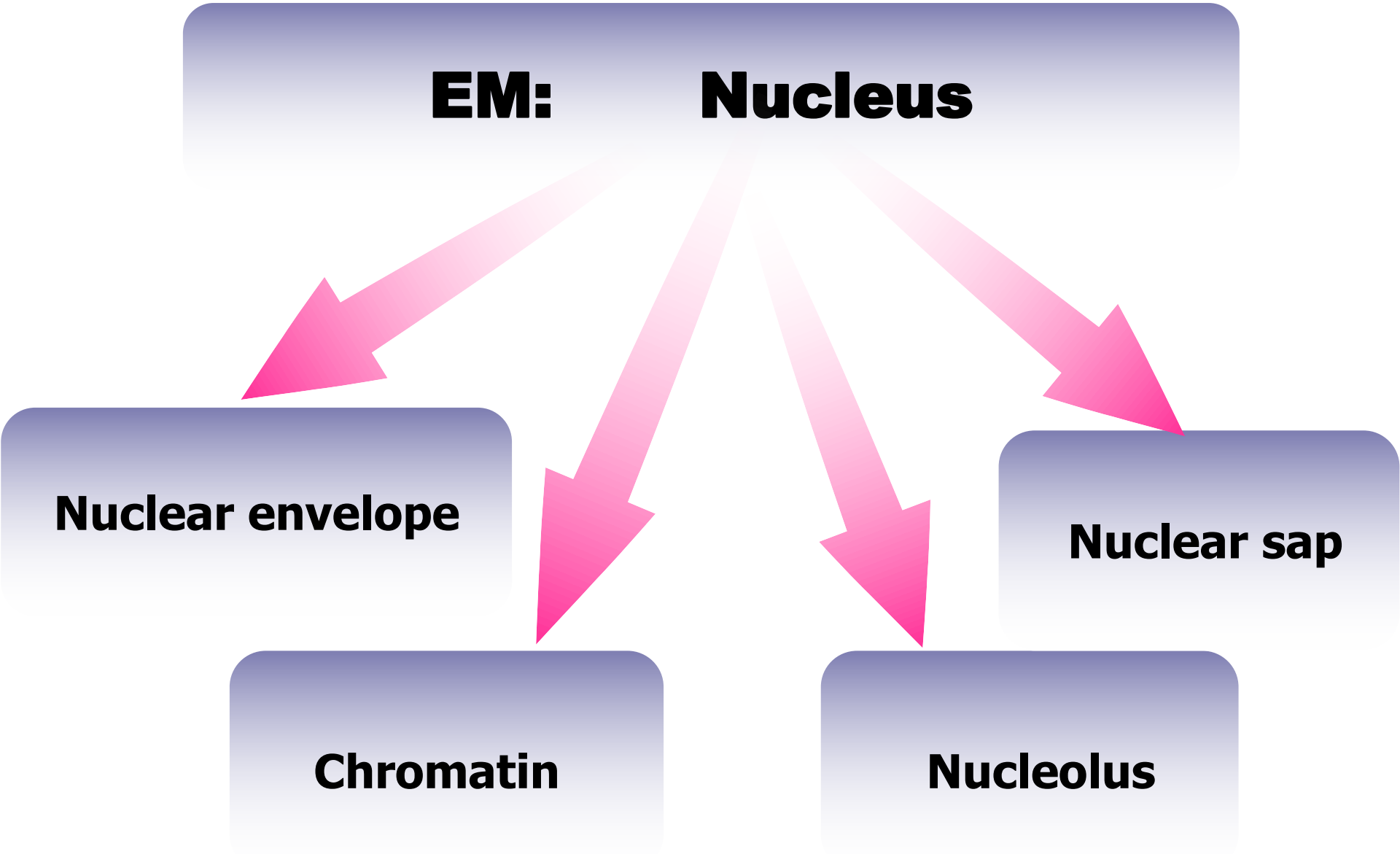
Oval




Flat

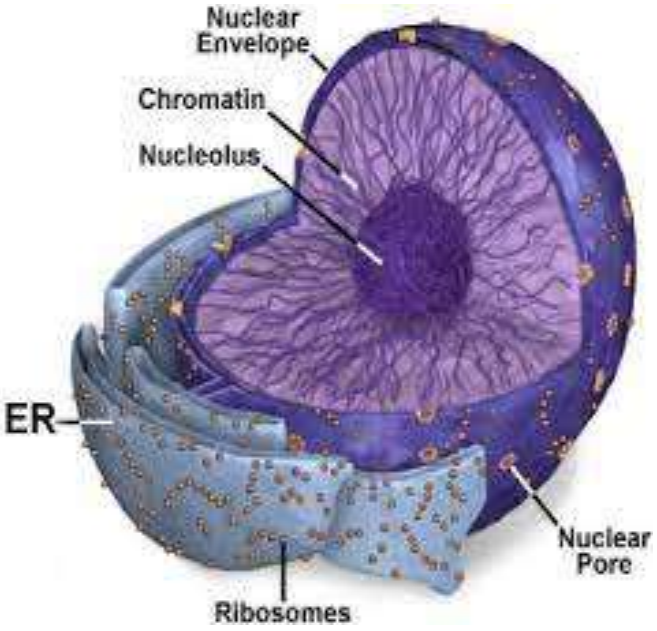


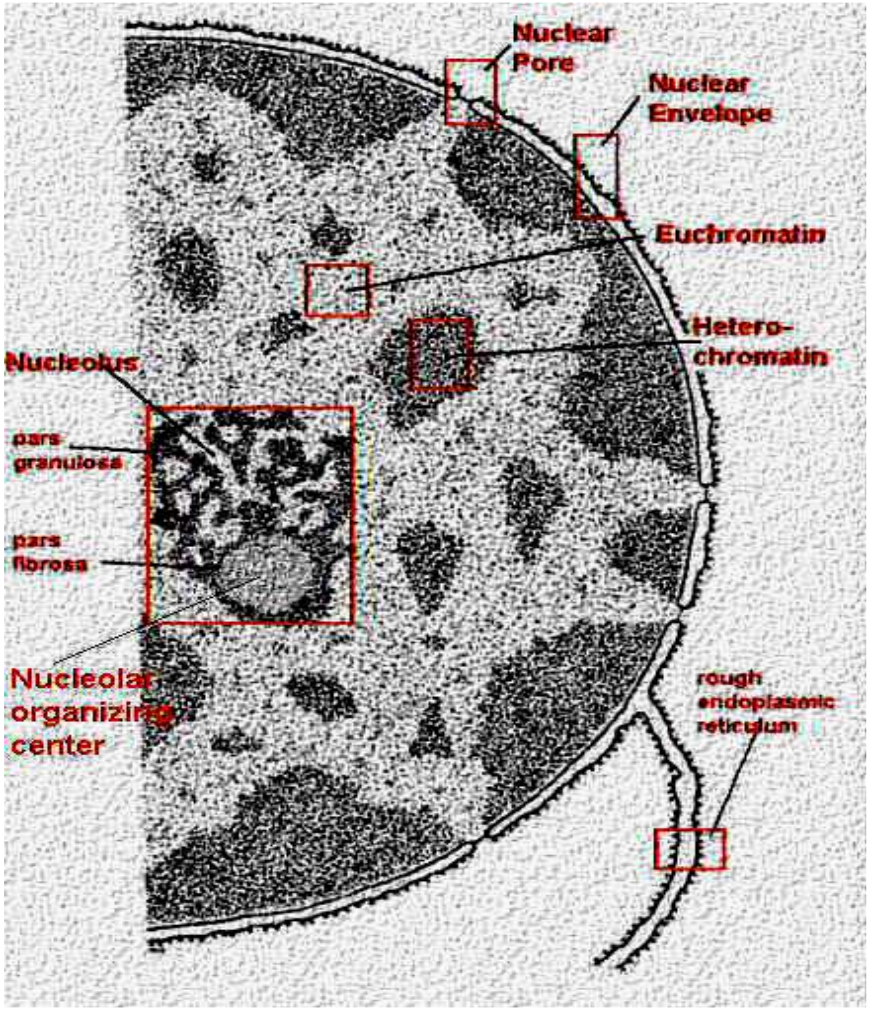

Lobulated


EM: Nucleus
Nuclear envelope
Chromatin
Nucleolus
Nuclear sap

# E.M STRUCTURE

1. Nuclear envelope, double membrane and nuclear pores
2. Chromatin, Chromosome, DNA and RNA
3. Nucleolus
4. Nucleoplasm

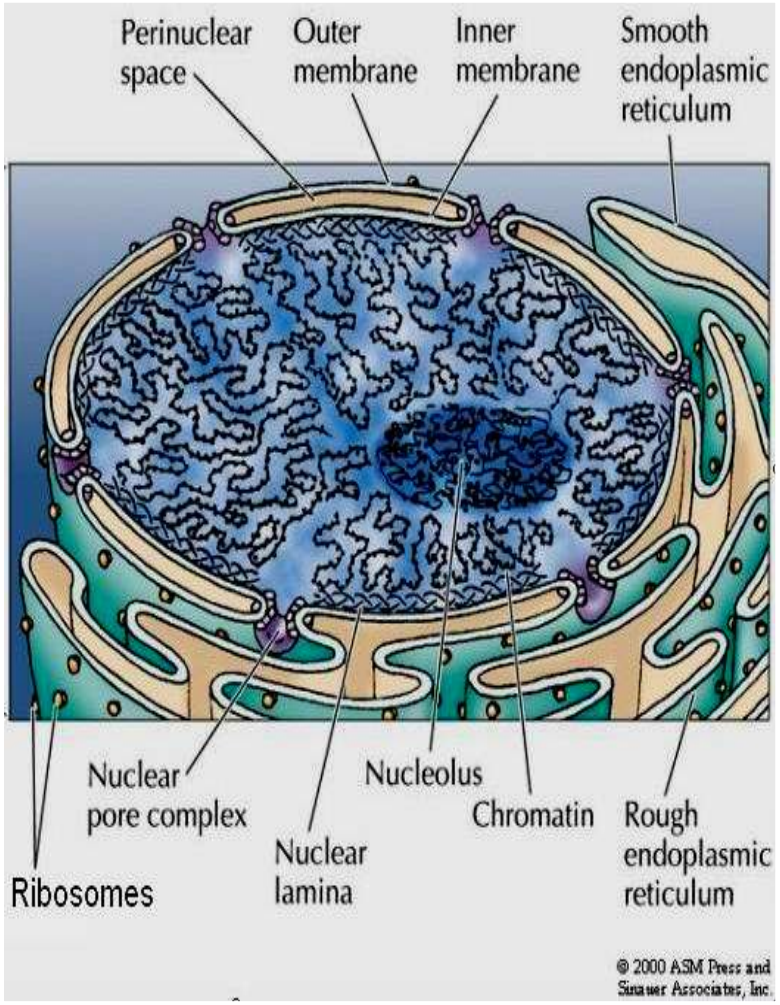


# Nuclear envelope (Nucleolemma)

## Structure

- External (outer) nuclear membrane
- Internal (inner) nuclear membrane
- Perinuclear space
- Nuclear pores
- Lamina densa (nuclear lamina)




## 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

## External nuclear membrane

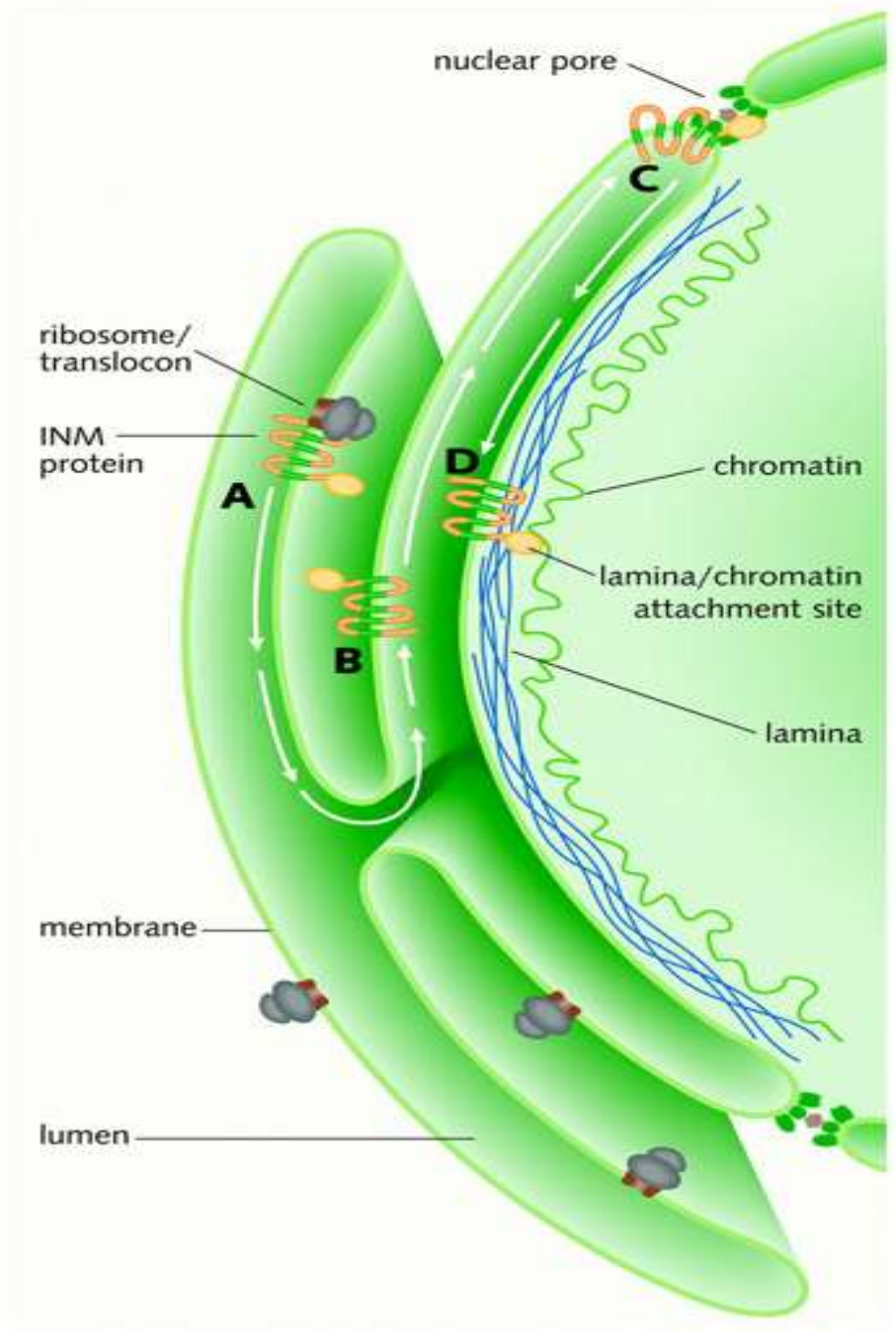
•Visible only by electron microscopy
•Ribosome attached on external face
•It **continues** with RER membrane

## The perinuclear space

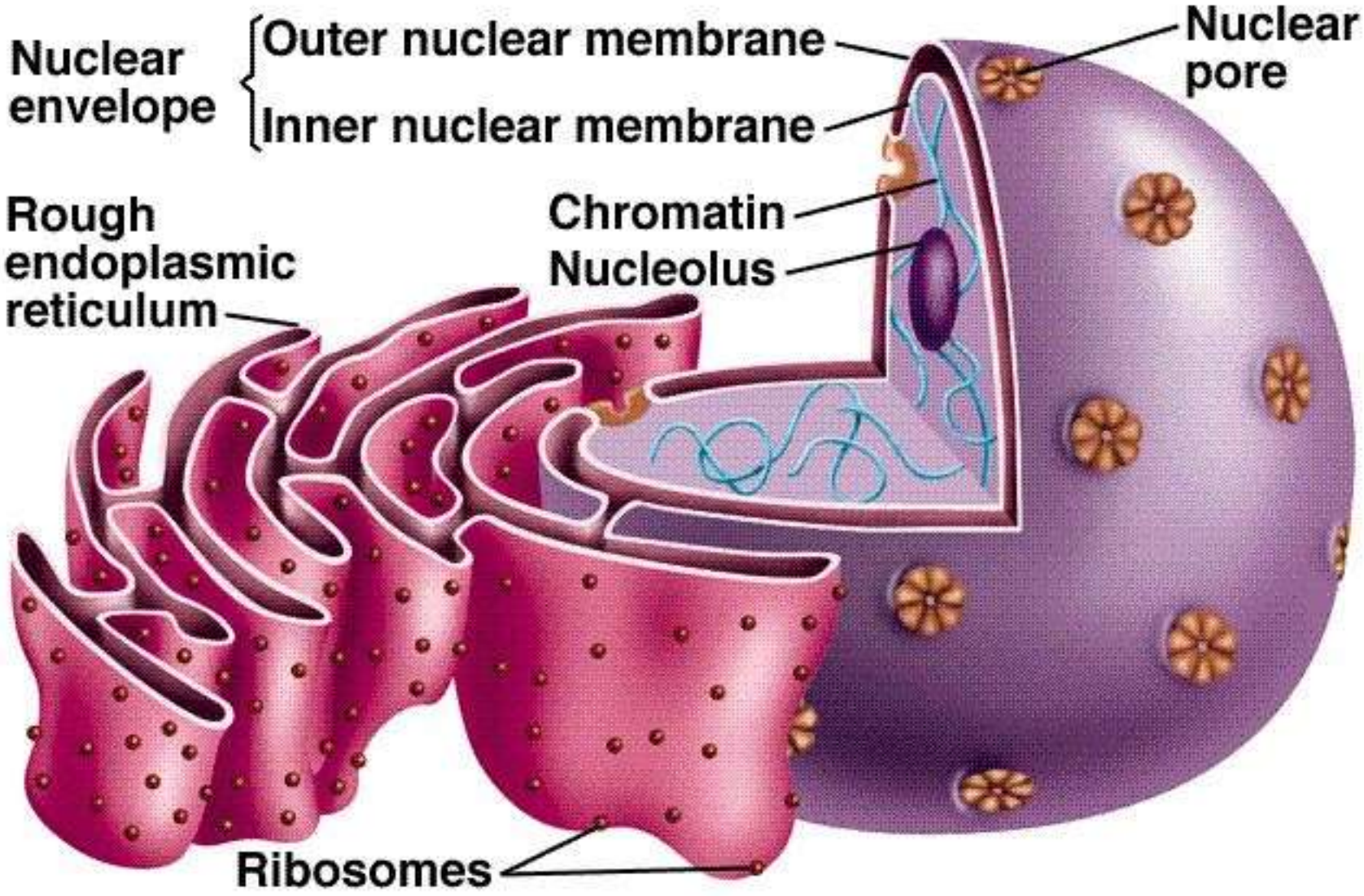
•It **communicates** with the RER internal space
•Contains the same molecules as RER
•Contains **Ca2**+

## Internal nuclear membrane

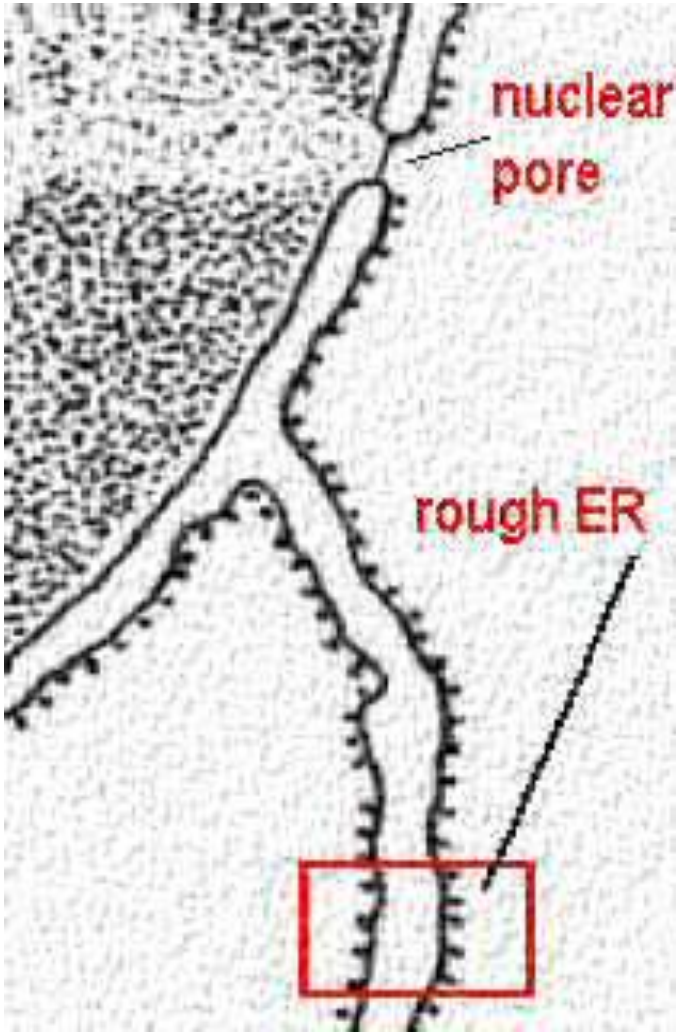
•Visible only by electron microscopy;
•The inner surface of the nuclear envelop is bound to a thin filamentous network (*lamins polypeptides*) called the **nuclear lamina.**

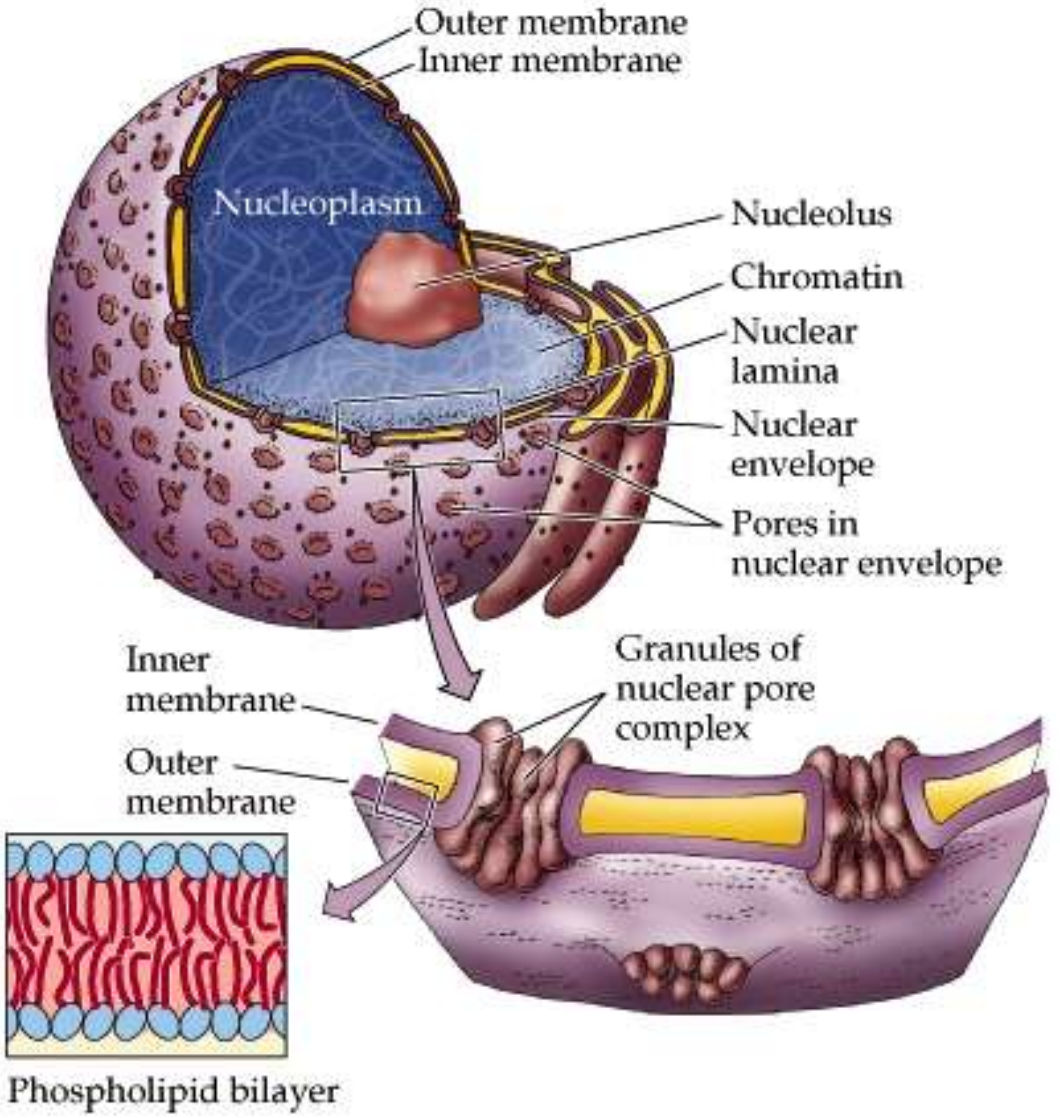


# Nuclear Envelope



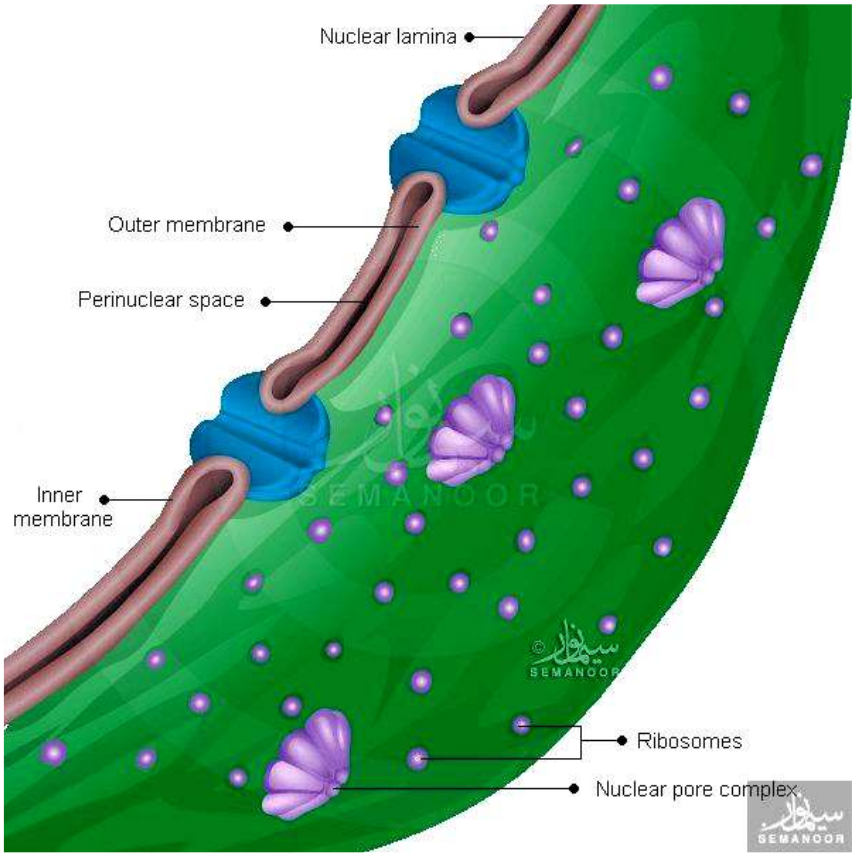
# Nuclear envelope



# THE NUCLEAR PORE

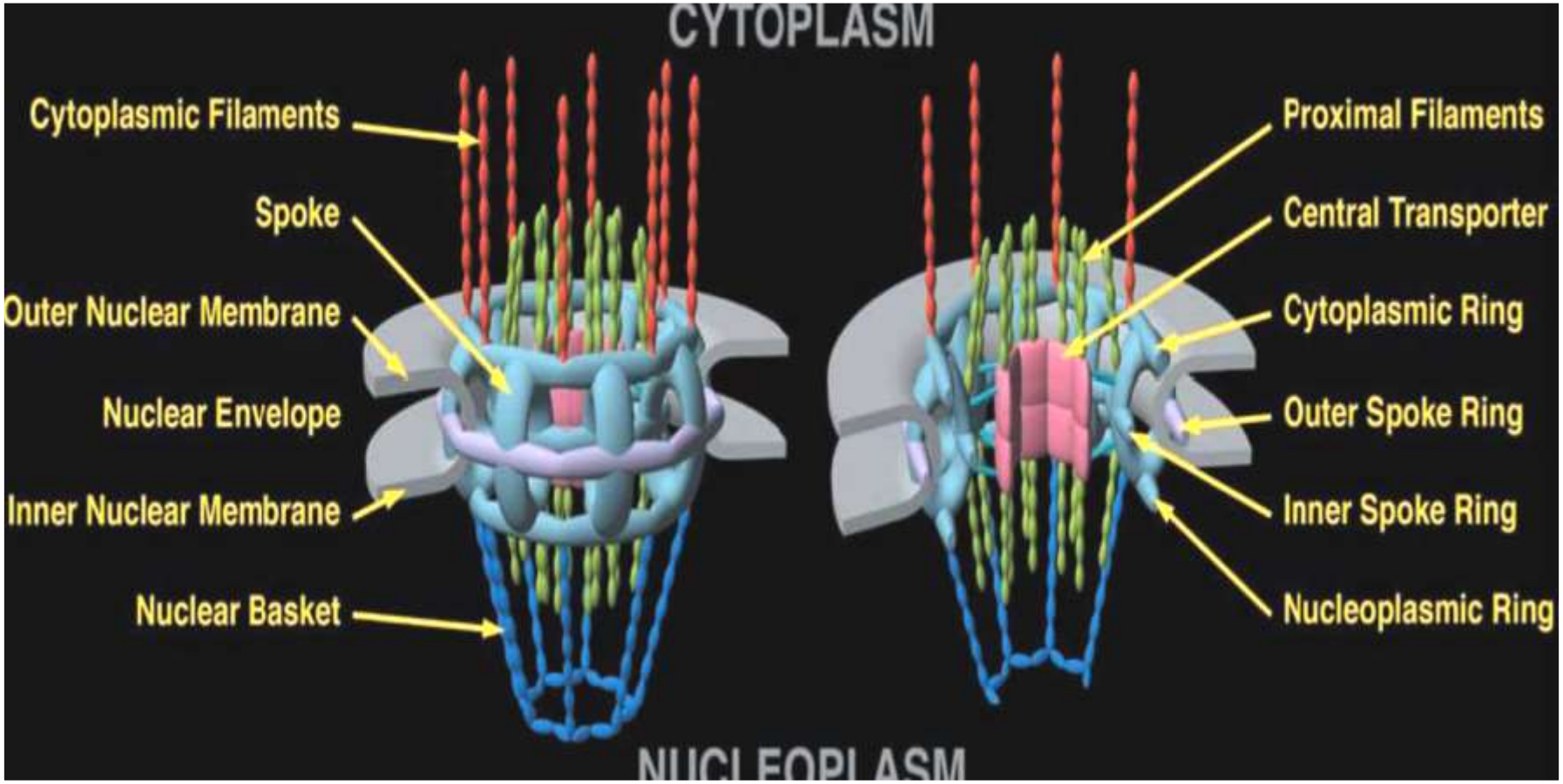
•Openings in the nuclear envelope, Area where the nuclear envelope is **interrupted**
•Regulates **exchanges** between nucleus and cytoplasm
•Ensures the selective **transport** for big molecules
•**Dynamic** structures – their number grows if it's necessary
•The nuclear pores are the gateways across 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**.**

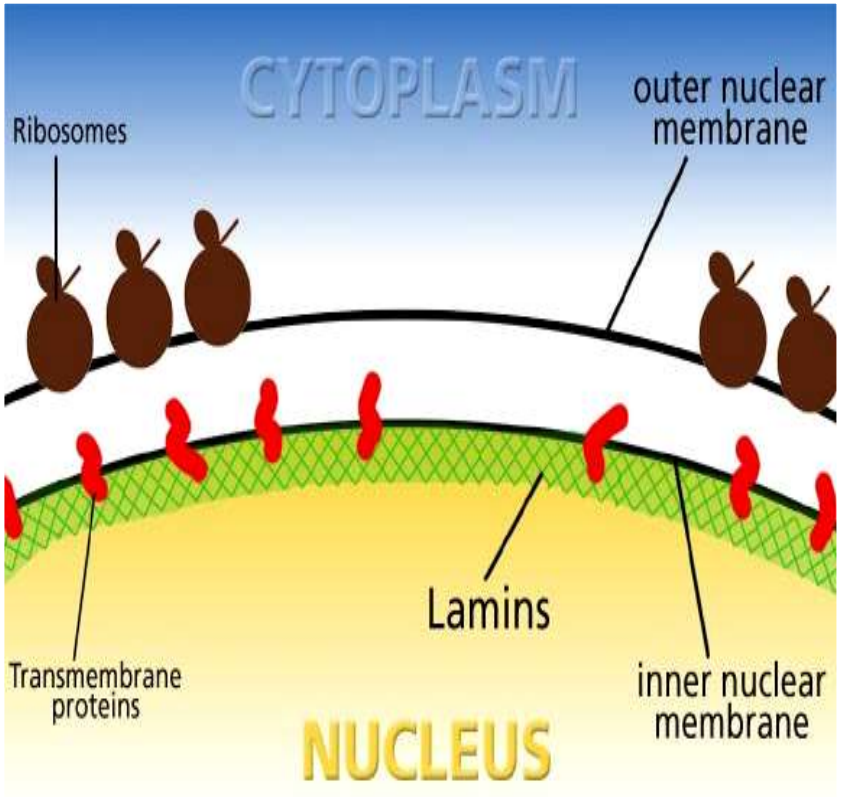


**Nucleoplasm**
Nuclear Basket
Nuclear Ring
Filaments

**Nuclear Membrane**
Central Transporter
Spoke Ring (inner & outer)

**Cytoplasm**
Cytoplasmic Ring
Cytoplasmic Filaments






# Nuclear lamina

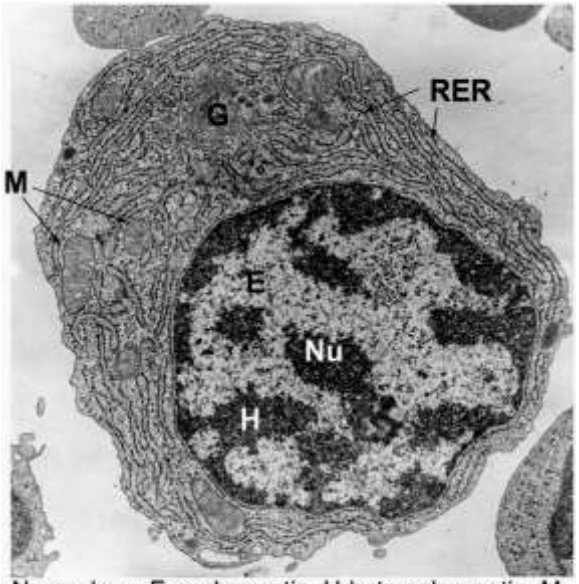
a network of **intermediate filaments** composed of various **lamins**

The lamina acts as a site of **attachmen**t 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).**

# CHROMATIN

Is the combination of **DNA** and **proteins** that make up the contents of the nucleus of a cell, that is usually **dispersed** in the **interphase** and condensed to form **chromosomes** in mitosis and meiosis.



Nu-nucleus, E-euchromatin, H-heterochromatin, M-mitochondria, RER-rough endoplasmic reticulum, G-golgi complex

## Functions

■Package DNA into a smaller volume to fit in the cell

■Strengthen the DNA to allow

mitosis and meiosis i.e. prevent DNA damage

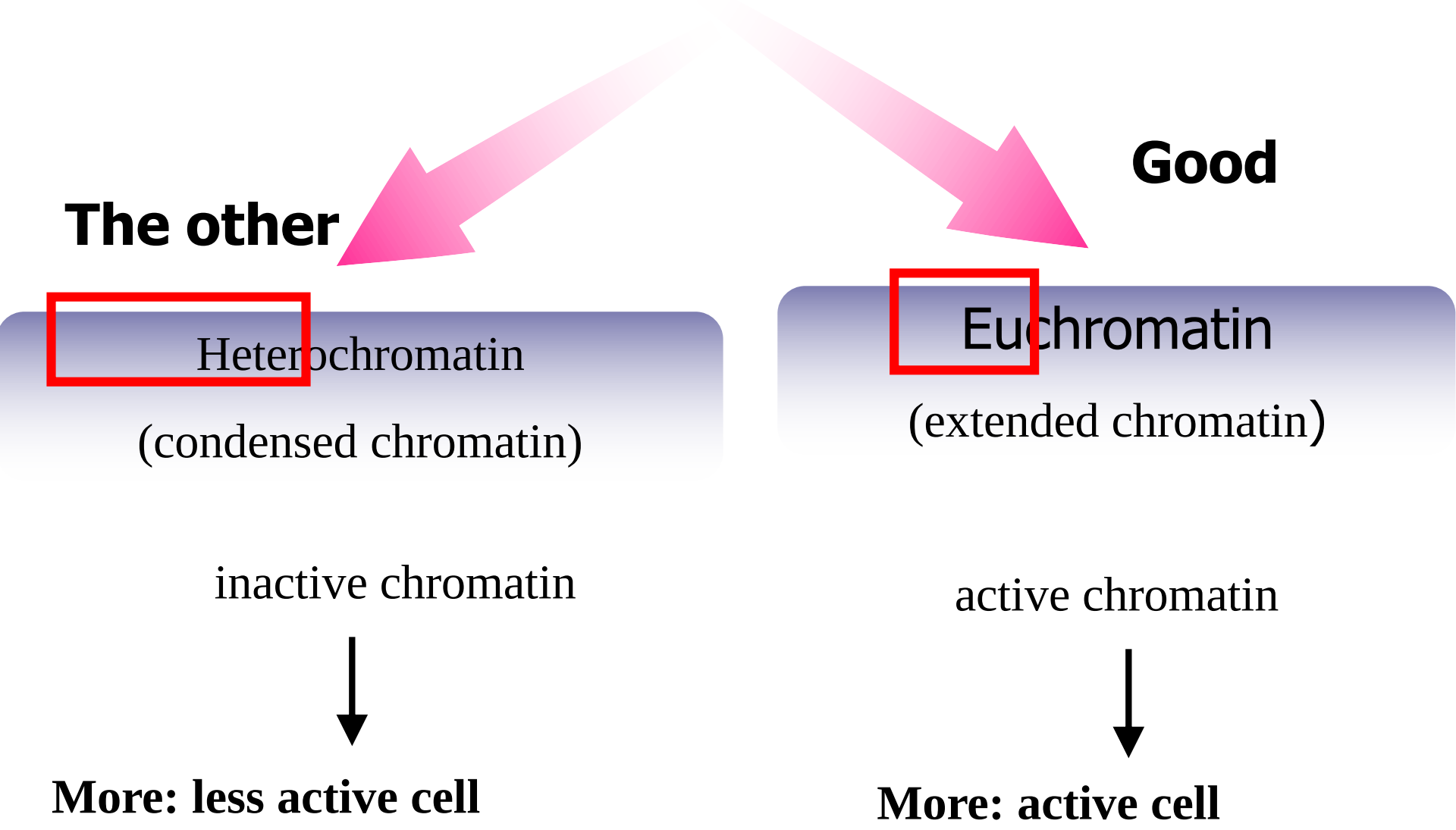
■Control gene expression and DNA replication

## Types (During **interphase** // **no** cell division)

**1- Euchromatin:** is a **lightly packed** (**less dense**) form of chromatin that is **rich** in gene concentration, and is often under **active transcription**. It is found in both eukaryotes and prokaryotes.

**2- Heterochromatin:** is a **tightly packed** (**dense**) form of DNA that is **inactive (no transcription)** and remains compact during interphase. Heterochromatin plays a role in **gene regulation** and the **protection** of the integrity of chromosomes

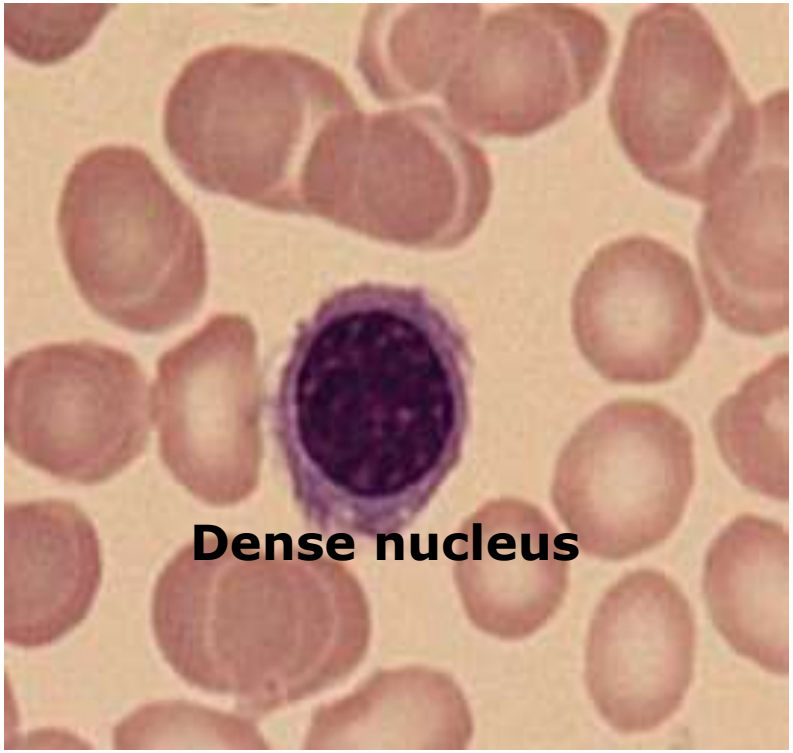
# Types of Chromatin



# Nucleus

Closed face

open face



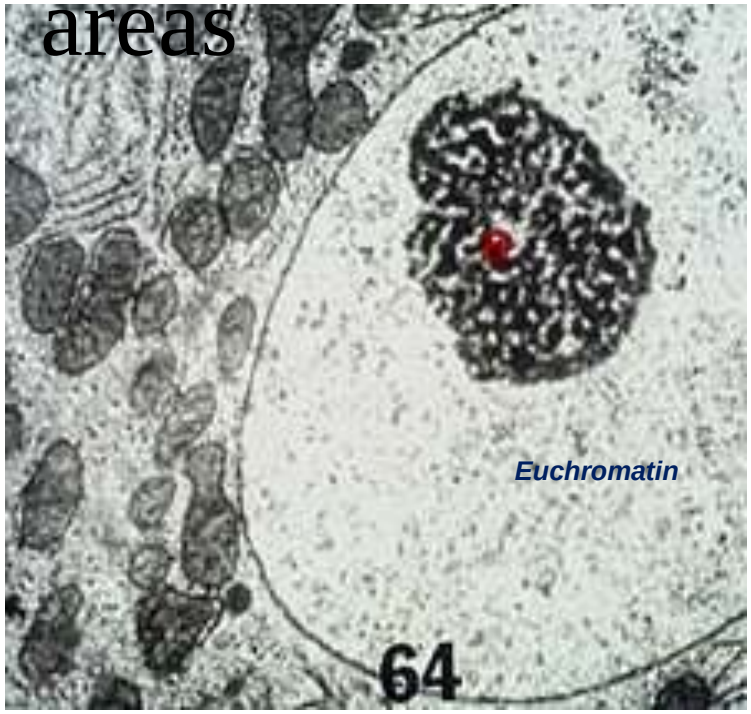

more Heterochromatin
Inactive cell


more Euchromatins
Active cell

# Chromatin

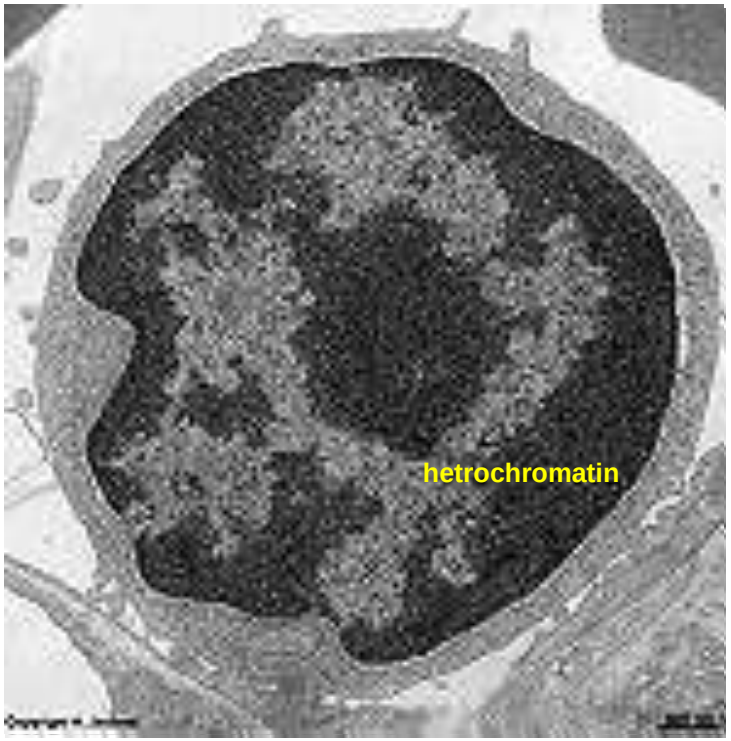
## Euchromatin

electron lucent areas.



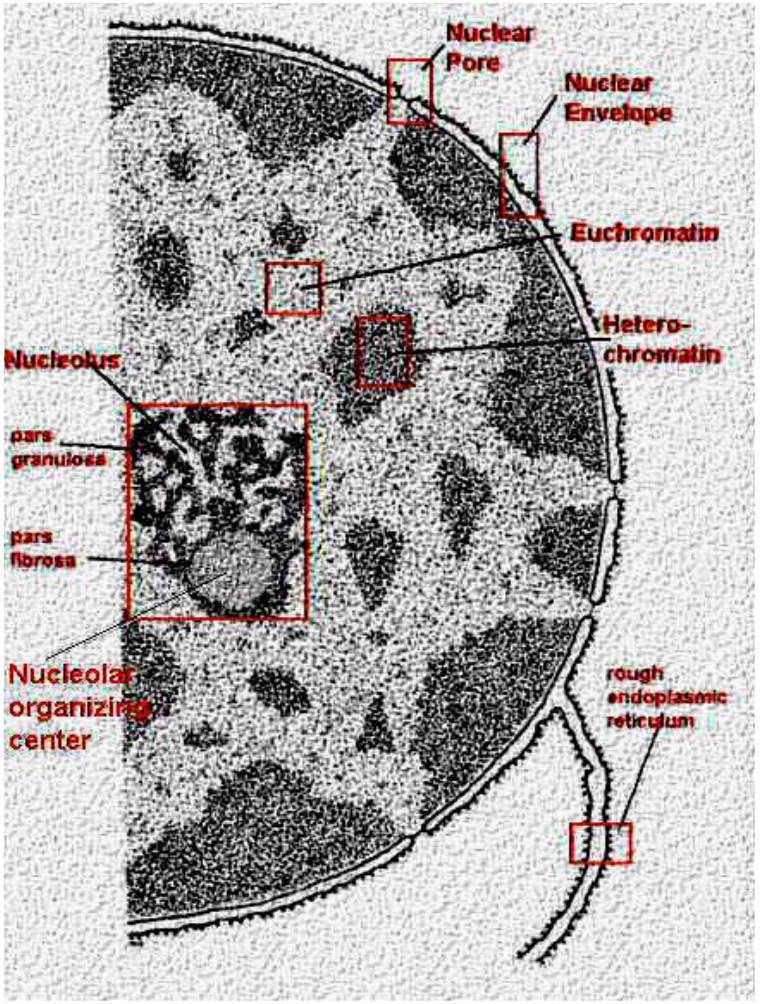

## Heterochromatin

electron dense



# Distribution of heterochromatin

- -Peripheral Heterochromatin
- -Islands chromatin
- - Nucleolus associated Chromatin



# The Nucleolus

The **nucleolus** (plural **nucleoli**) is a **non-membrane** bound structure composed of **proteins** and **nucleic acids** found within the nucleus

It is the **most dense** (prominent) structure of the cell, and frequently is located in central area of nucleus

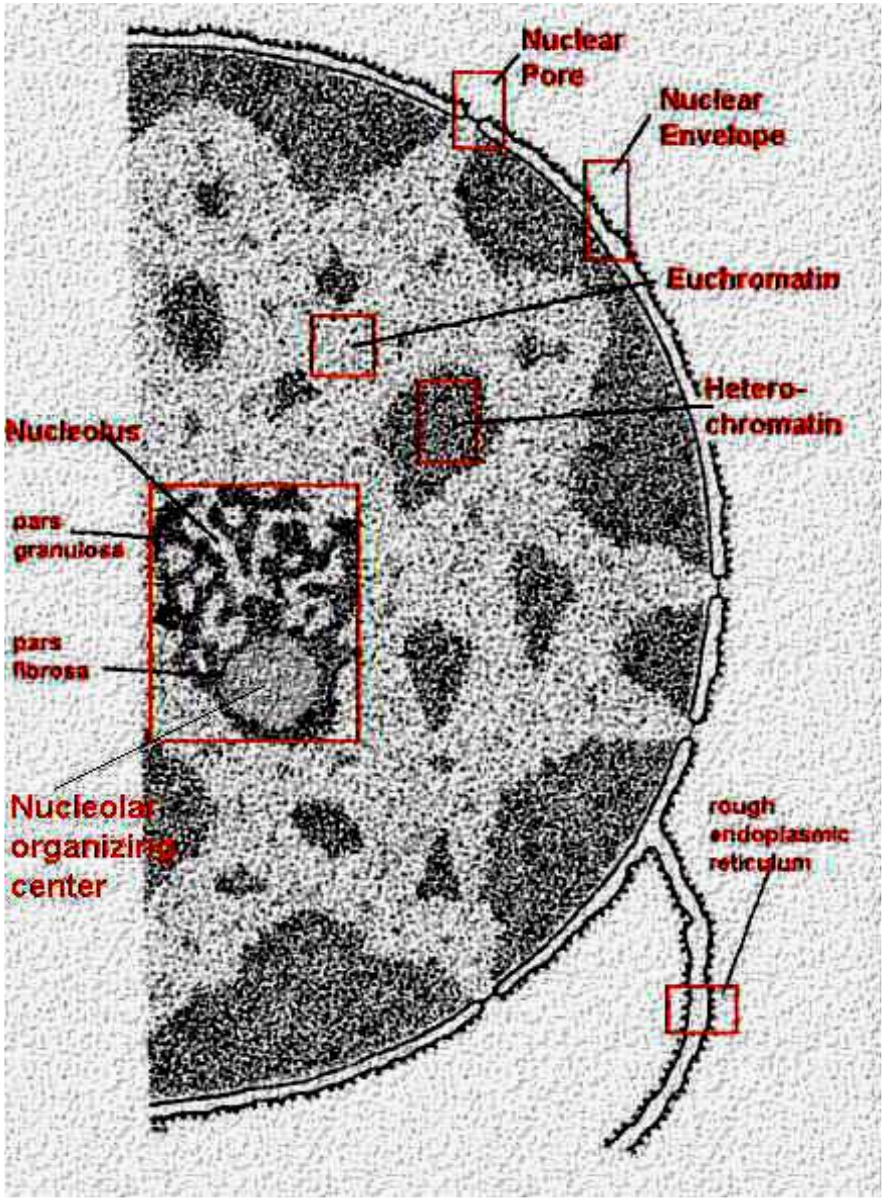
**<u>Function</u>,** site of **rRNA synthesis,** initial ribosomal **assembly**

**<u>Structure</u>,**

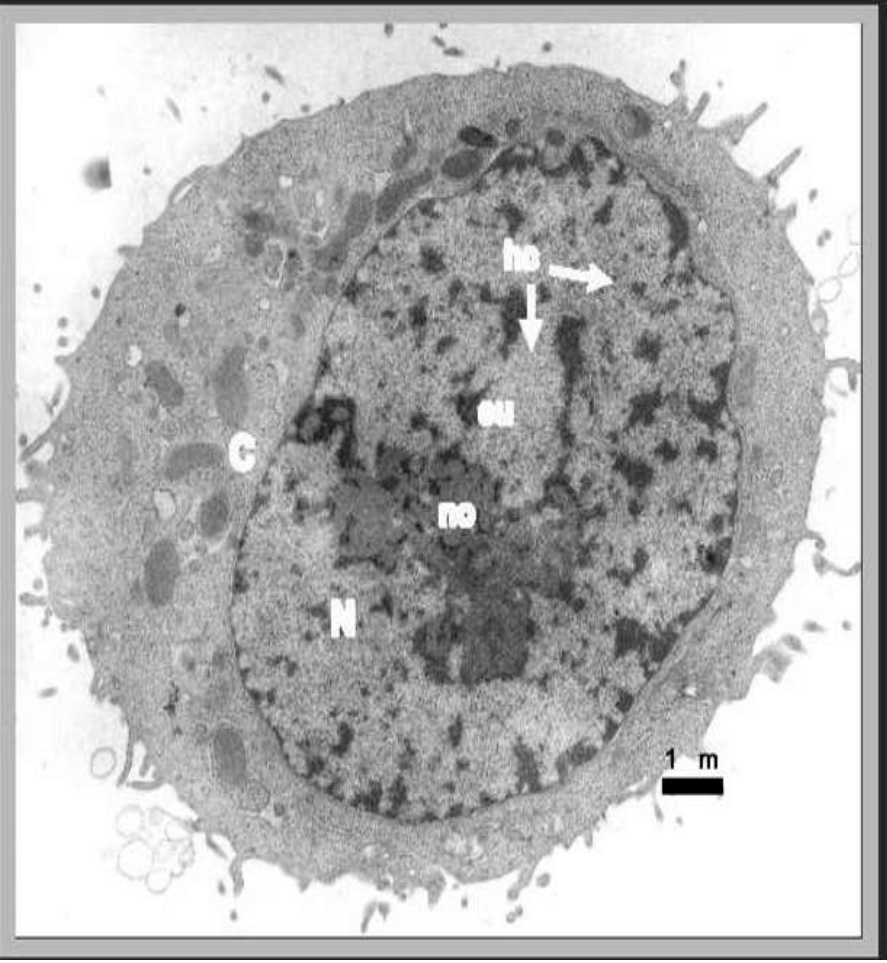
**-fibrillar centers,** filaments of chromatin

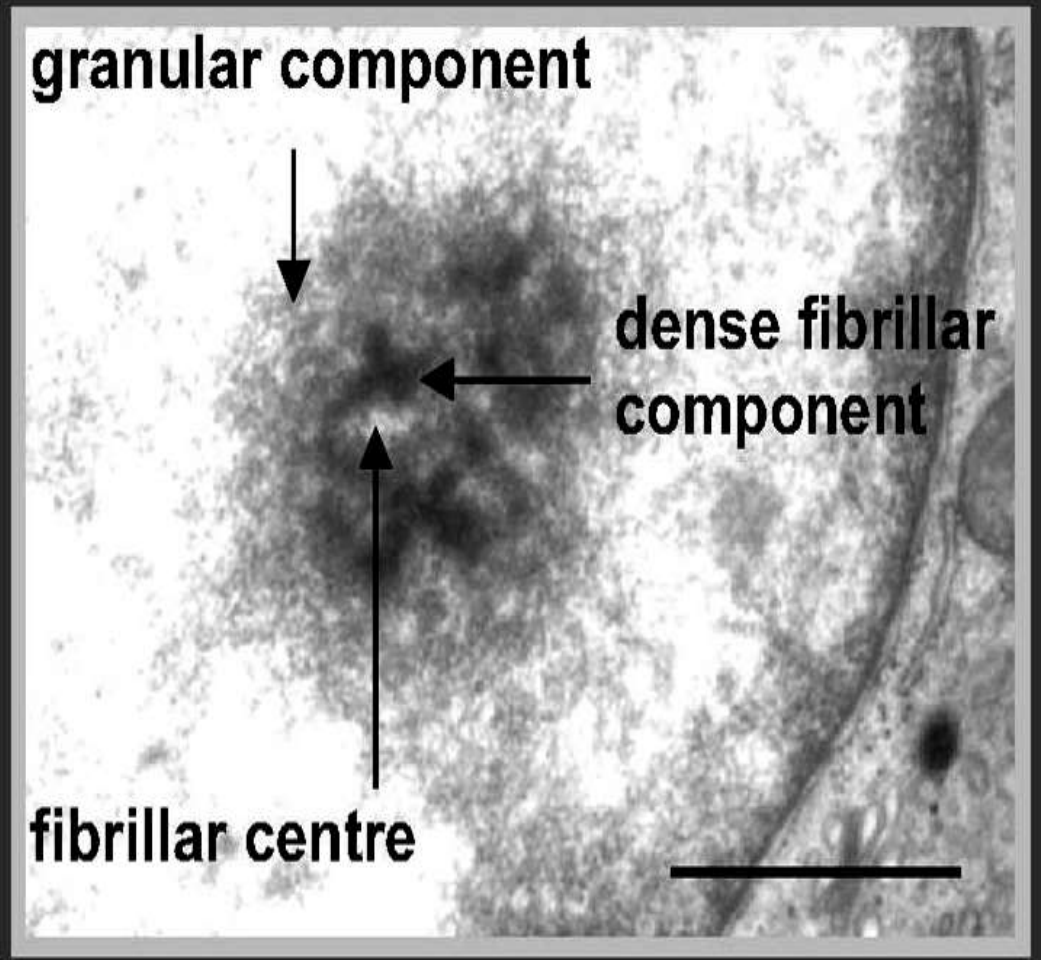
**-pars fibrosa,** newly transcribed rRNA

**-pars granulosa,** rRNA bound to ribosomal proteins that are beginning to **assemble** into ribosomes



# Ultrastructure of the nucleolus



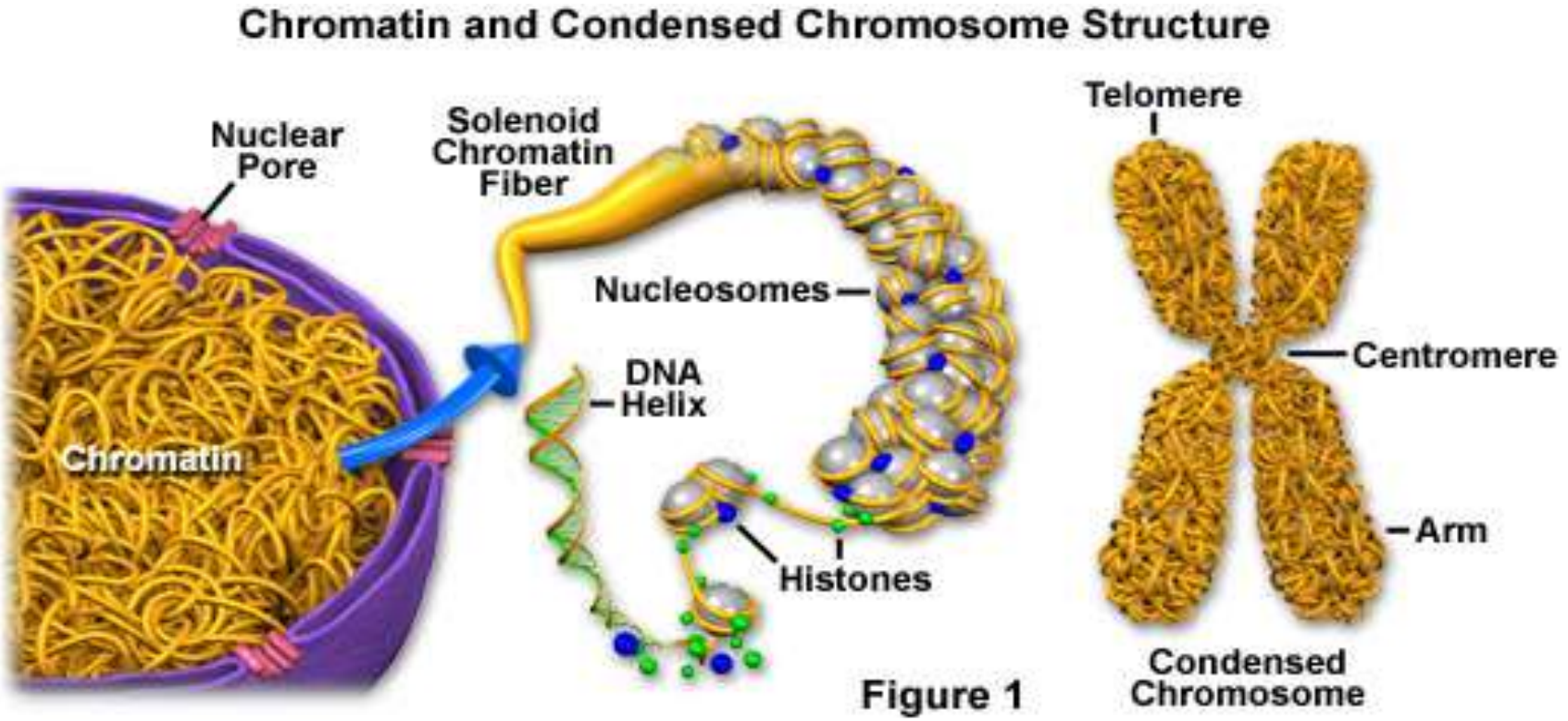
## Nucleoplasm (nucleus sap) or karyoplasm

- **Analogy** with cytoplasm, that part of the nuclear contents other than the nucleolus.
- Highly **viscous** liquid that surrounds the chromosomes and nucleolus
- Many substances such as **nucleotides** and **enzymes** are dissolved in the nucleoplasm
- A network of **fibers** known as the **nuclear matrix** can also found in the nucleoplasm

## LEVELS OF CHROMATIN ORGANIZATION (Chromatin Packing)

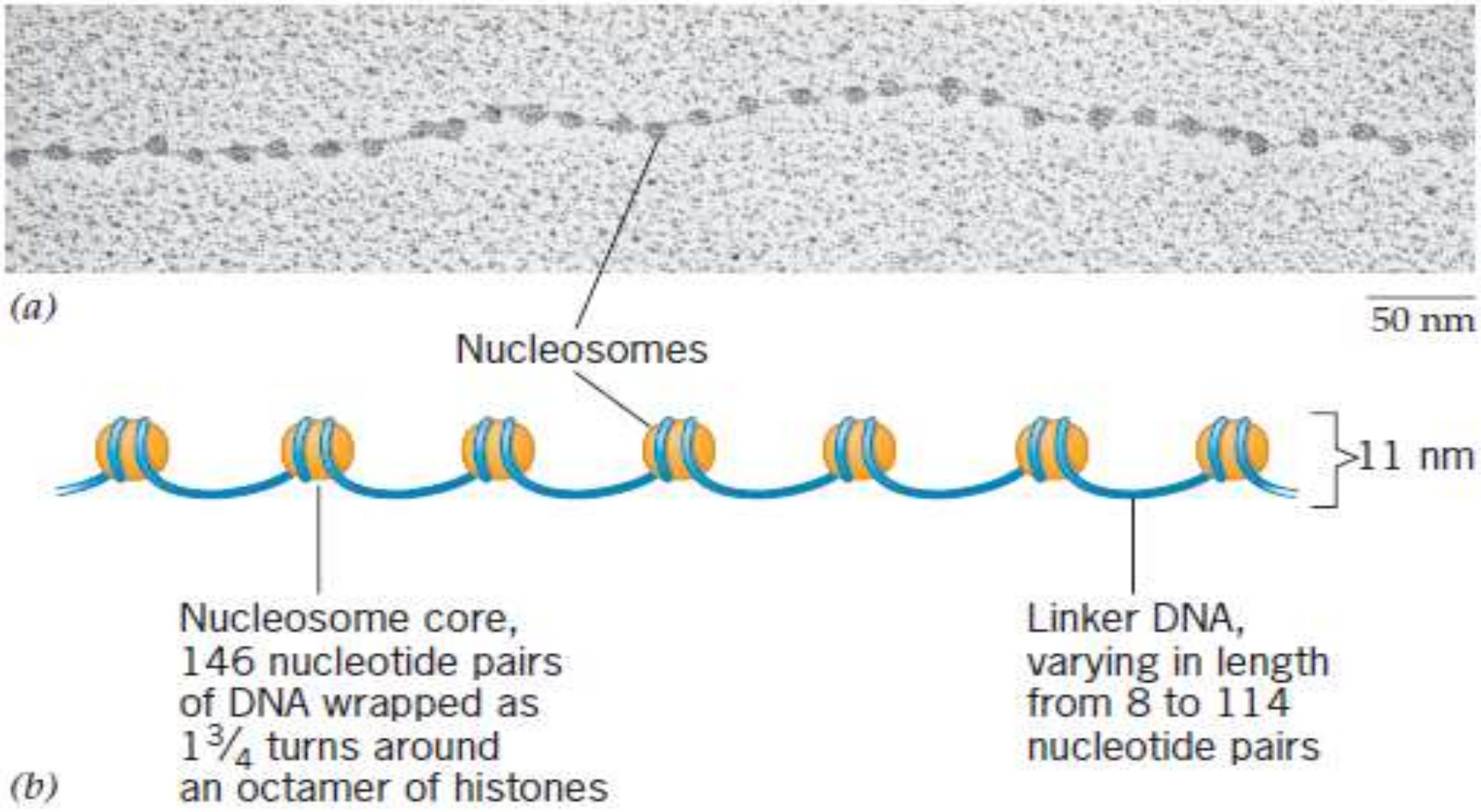
In general terms, there are three levels of chromatin organization:

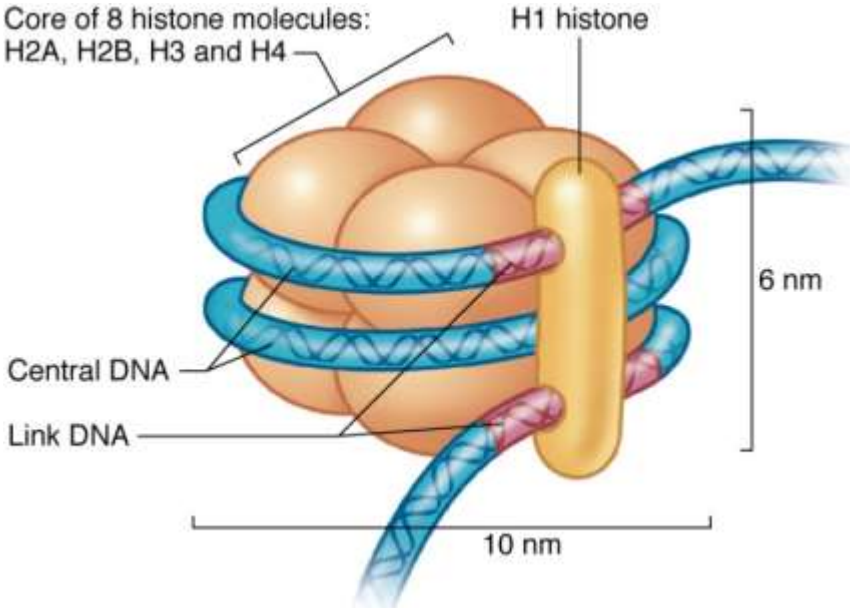
1. the "**beads on a string**" structure, **DNA** wraps around **histone** proteins forming **nucleosomes**
2. **30 nm fiber**, chromatin appears in **interphase** cells as tiny dots and fibers of 30 nm thickness
3. Higher-level DNA packaging of the 30 nm fiber into the **metaphase chromosome** (during mitosis and meiosis).

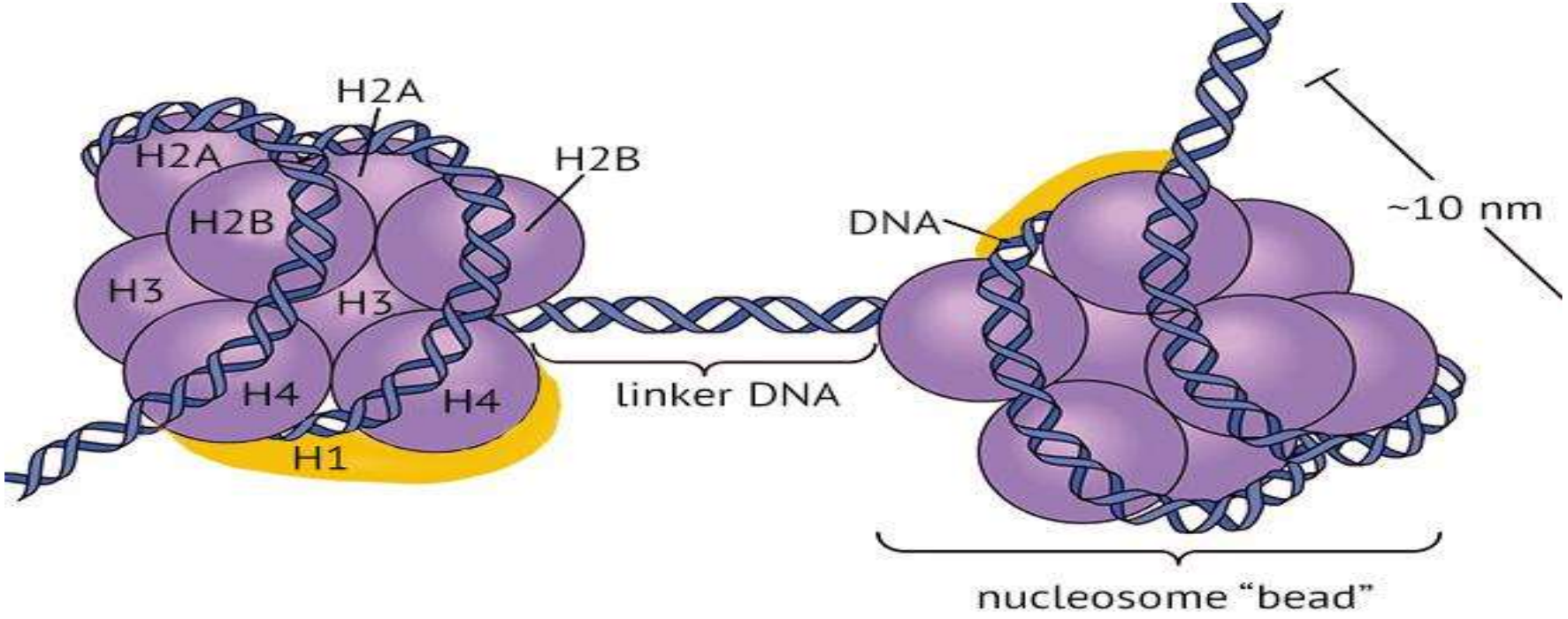


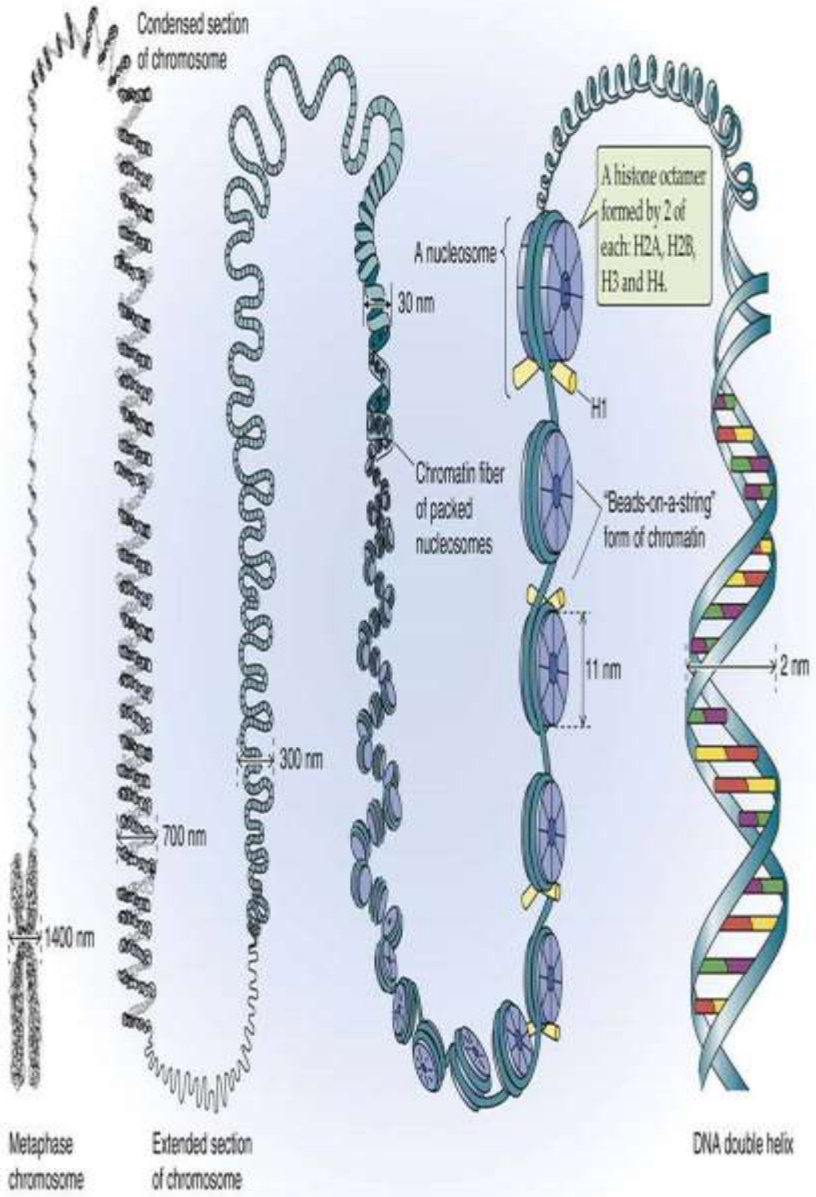
1. **The "beads on a string"**

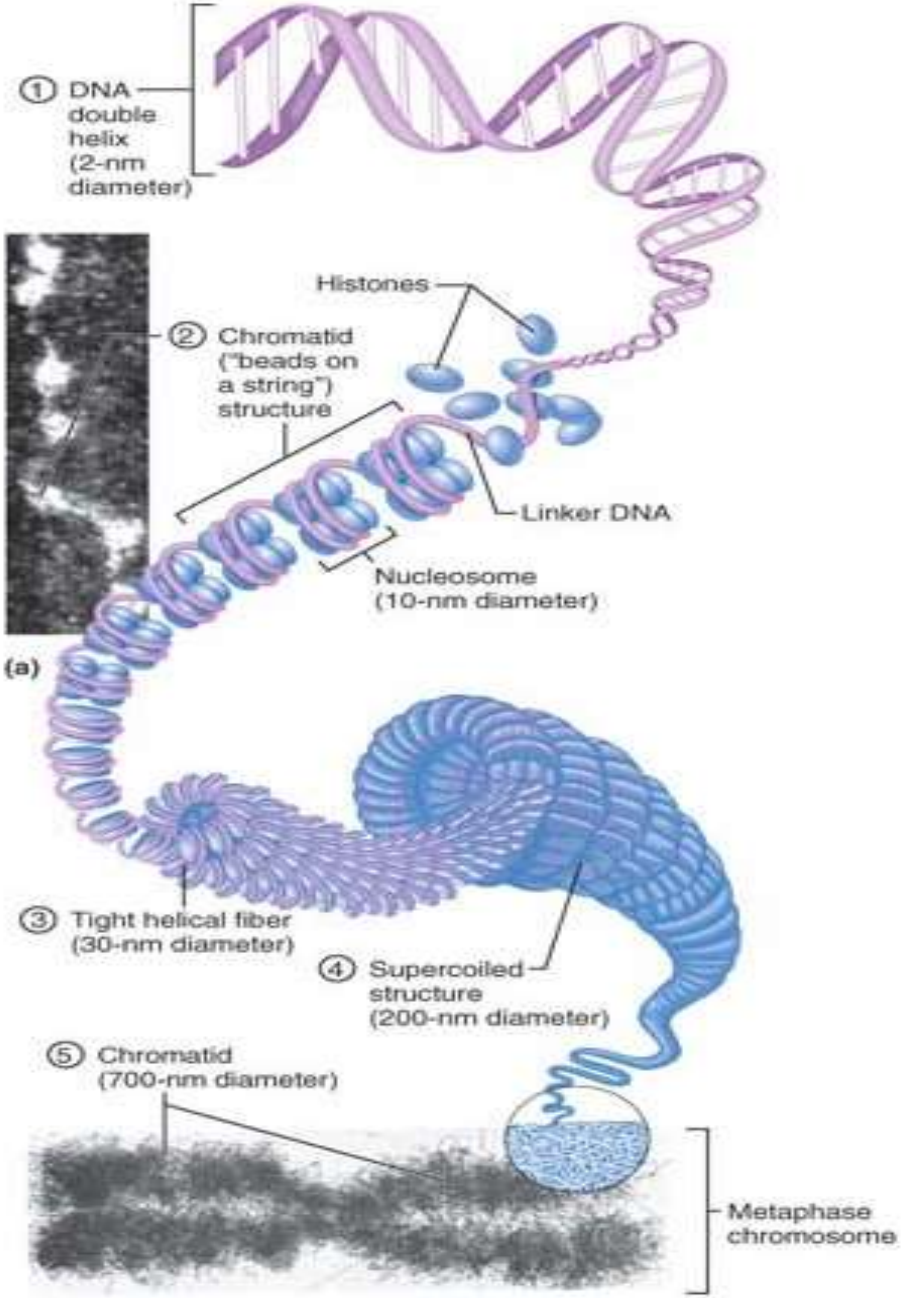
- DNA and histones are organized into repeating subunits called **nucleosomes**
- **nucleosomes** composed of **two loops** of DNA wrapped around a **protein core** (eight **histone** molecules, two copies of H2A, H2B, H3 and H4)

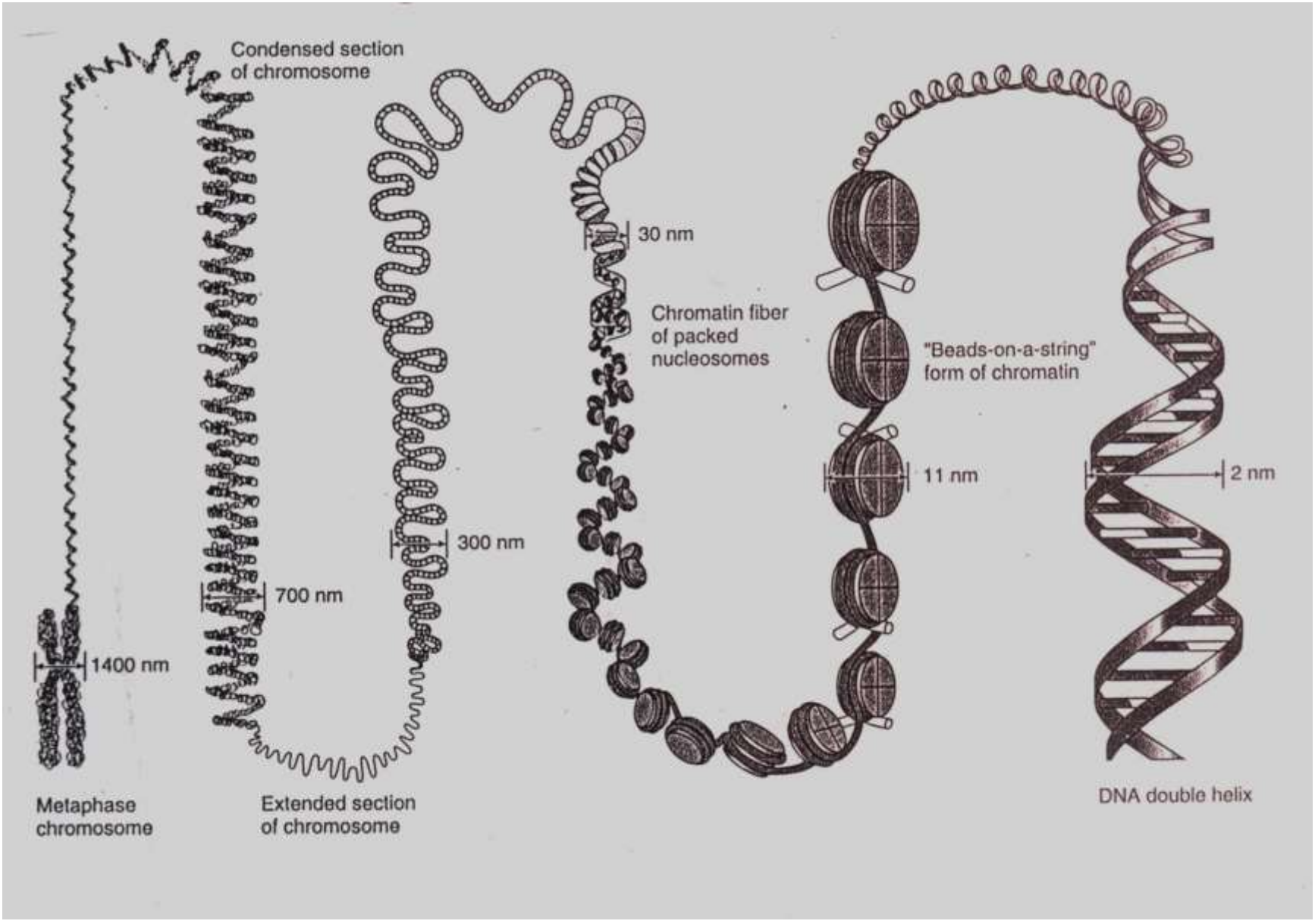


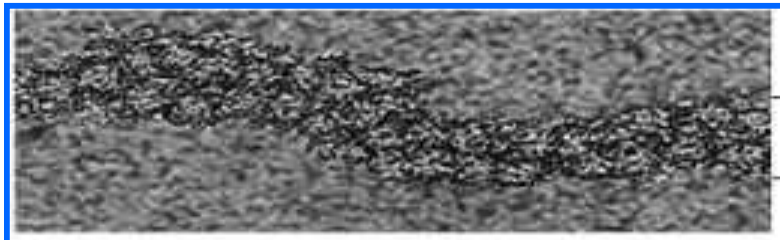

Core of 8 histone molecules:
H2A, H2B, H3 and H4
H1 histone
6 nm
Central DNA
Link DNA
10 nm


H2A
H2A
H2B
H2B
H3
H3
H4
H4
H1
linker DNA
DNA
~10 nm
nucleosome "bead"

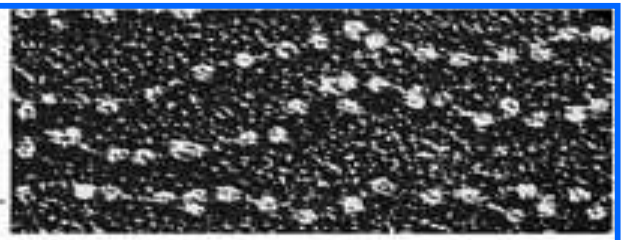

Condensed section of chromosome
1400 nm
700 nm
300 nm
30 nm
A nucleosome
A histone octamer formed by 2 of each: H2A, H2B, H3 and H4.
H1
Chromatin fiber of packed nucleosomes
"Beads-on-a-string" form of chromatin
11 nm
2 nm
Metaphase chromosome
Extended section of chromosome
DNA double helix


1 DNA double helix (2-nm diameter)
Histones
2 Chromatid ("beads on a string") structure
Linker DNA
Nucleosome (10-nm diameter)
(a)
3 Tight helical fiber (30-nm diameter)
4 Supercoiled structure (200-nm diameter)
5 Chromatid (700-nm diameter)
Metaphase chromosome

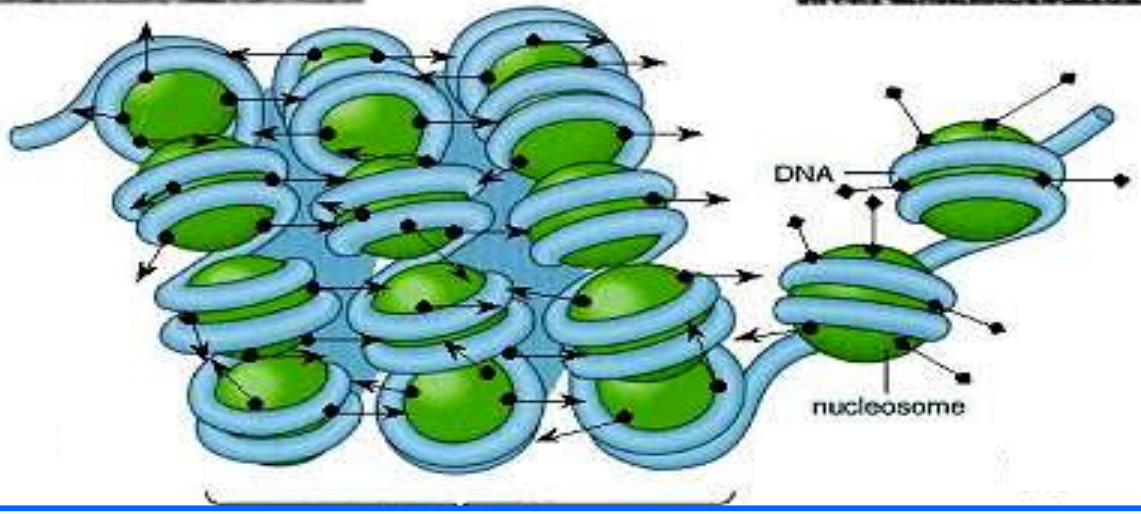

Condensed section
of chromosome
1400 nm
700 nm
300 nm
30 nm
Chromatin fiber
of packed
nucleosomes
"Beads-on-a-string"
form of chromatin
11 nm
2 nm
Metaphase
chromosome
Extended section
of chromosome
DNA double helix



**Chromatin fibers**

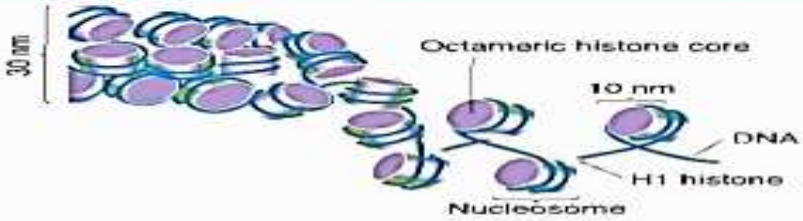


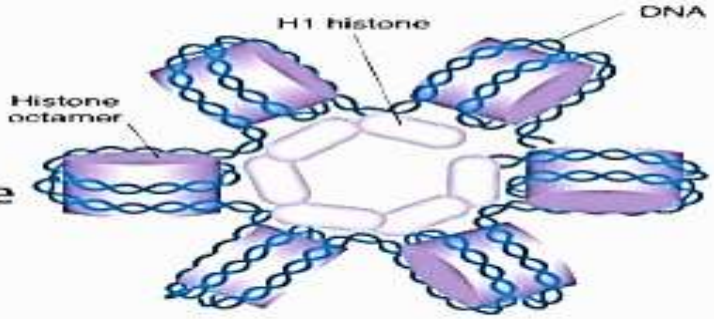
**30 nm chromatin fiber**




**11 nm (beads)**

# Second level of packing: Solenoids / chromatin




- Solenoid: H1 histones aggregate causing 6 nucleosomes to coil together
- 30 nm in diameter
- stack on top of each other forming the chromatin fiber

http://www.bio.miami.edu/dana/104/nucleosome.jpg