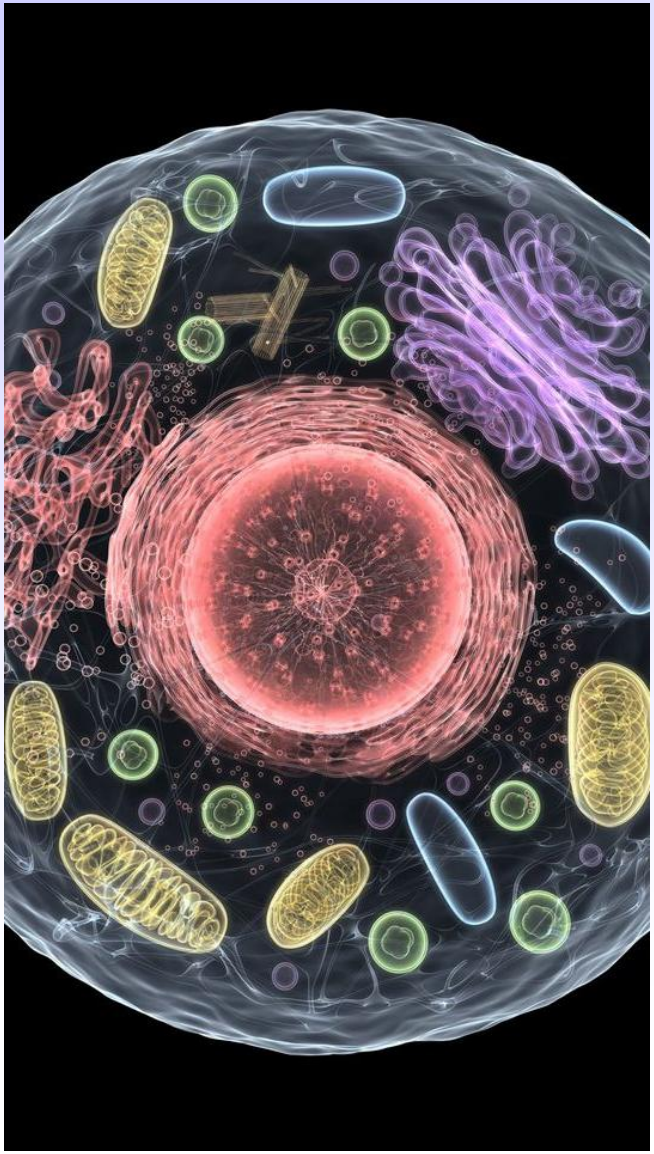
University of Teramo

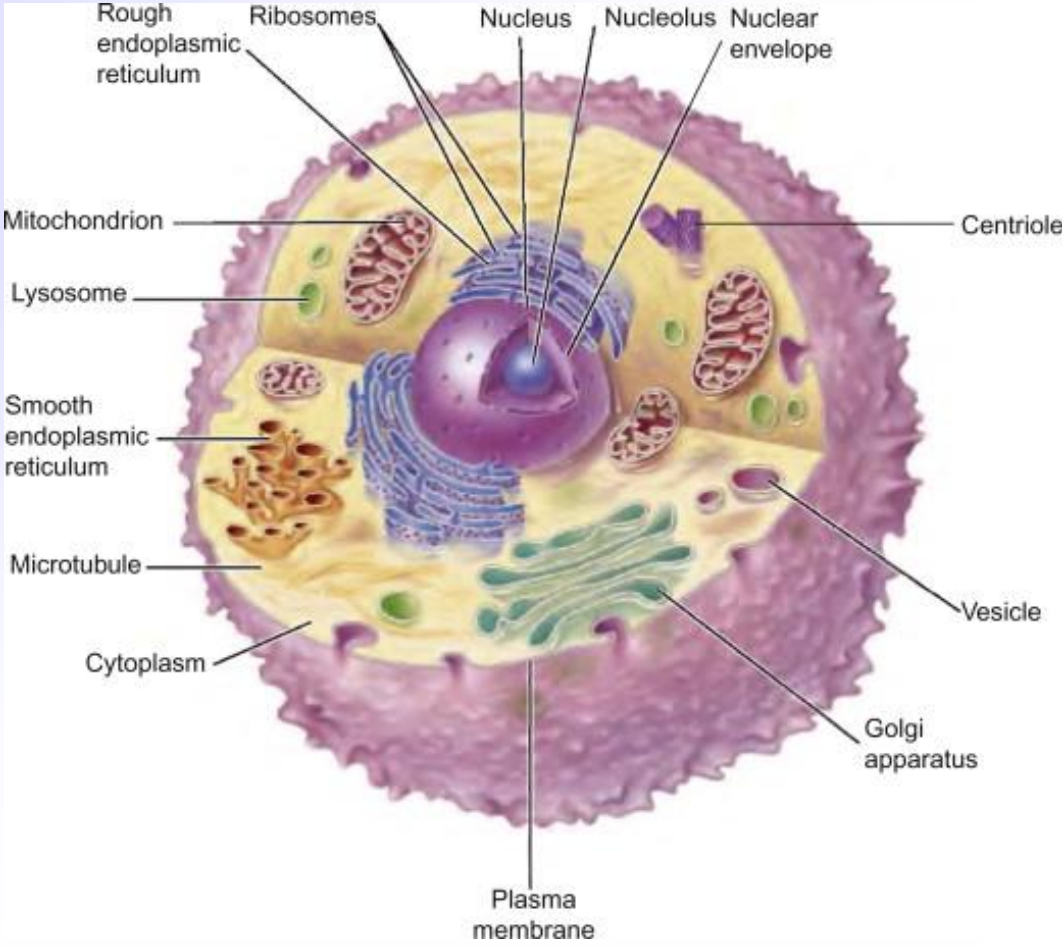
Degree Program in Biotechnology

COURSE OF CYTOLOGY AND HISTOLOGY

Prof. Mauro

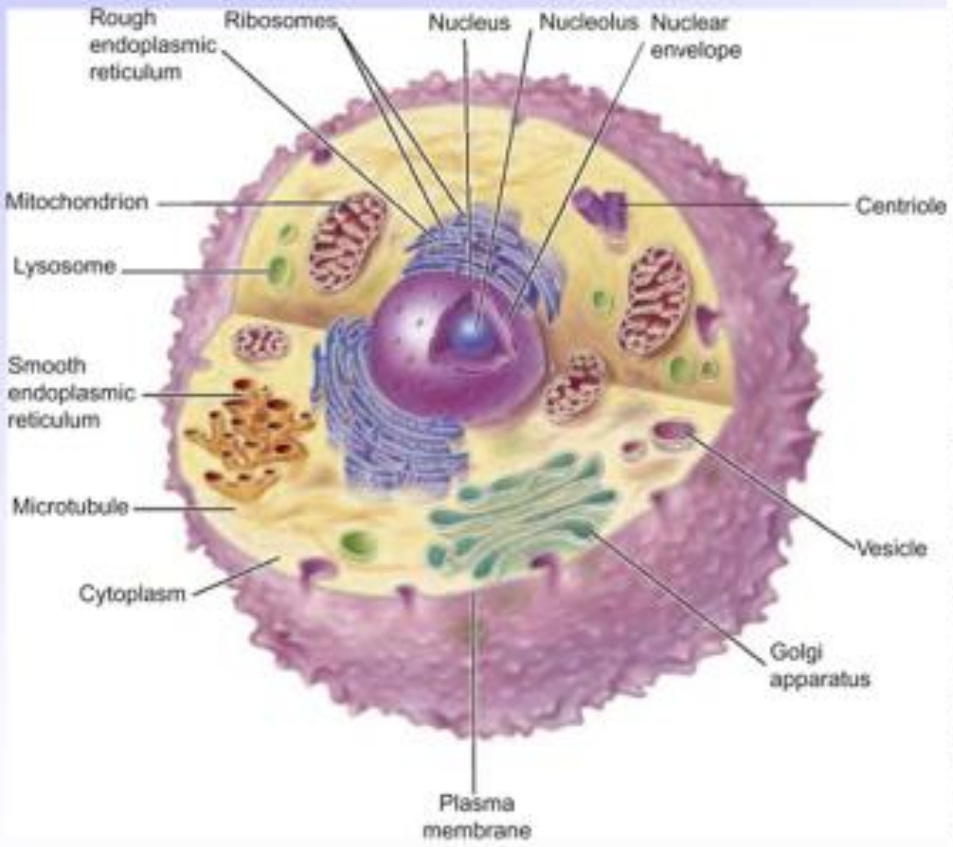
Eukaryotic cell

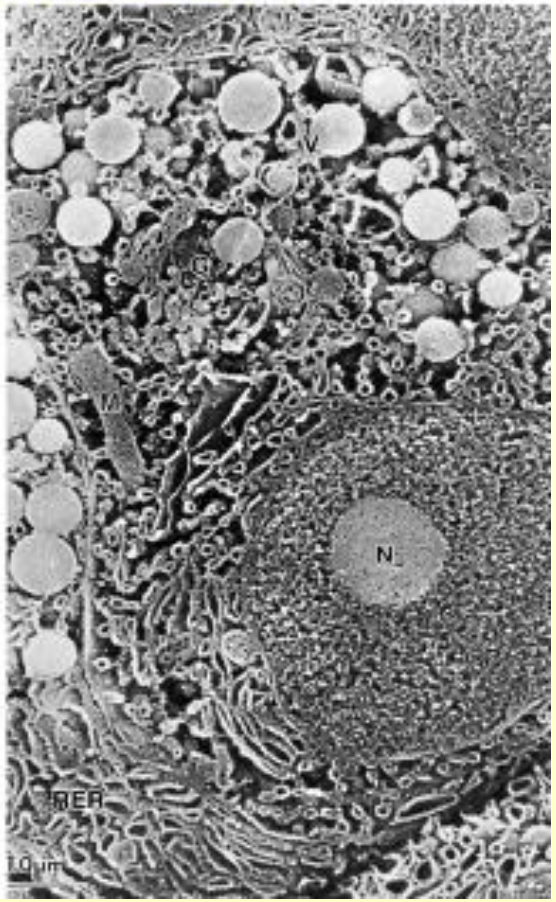




CITOPLASM AND ORGANELLES

Organization of the protoplasm of a eukaryotic cell





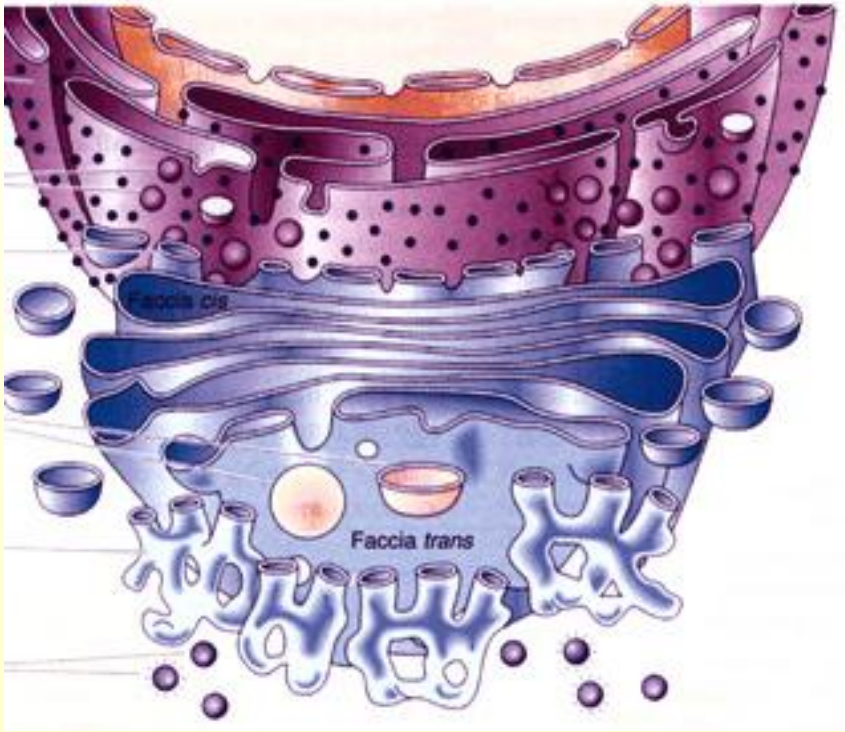
CELL ORGANELLES

Nucleus

Endoplasmic Reticulum

Golgi Apparatus

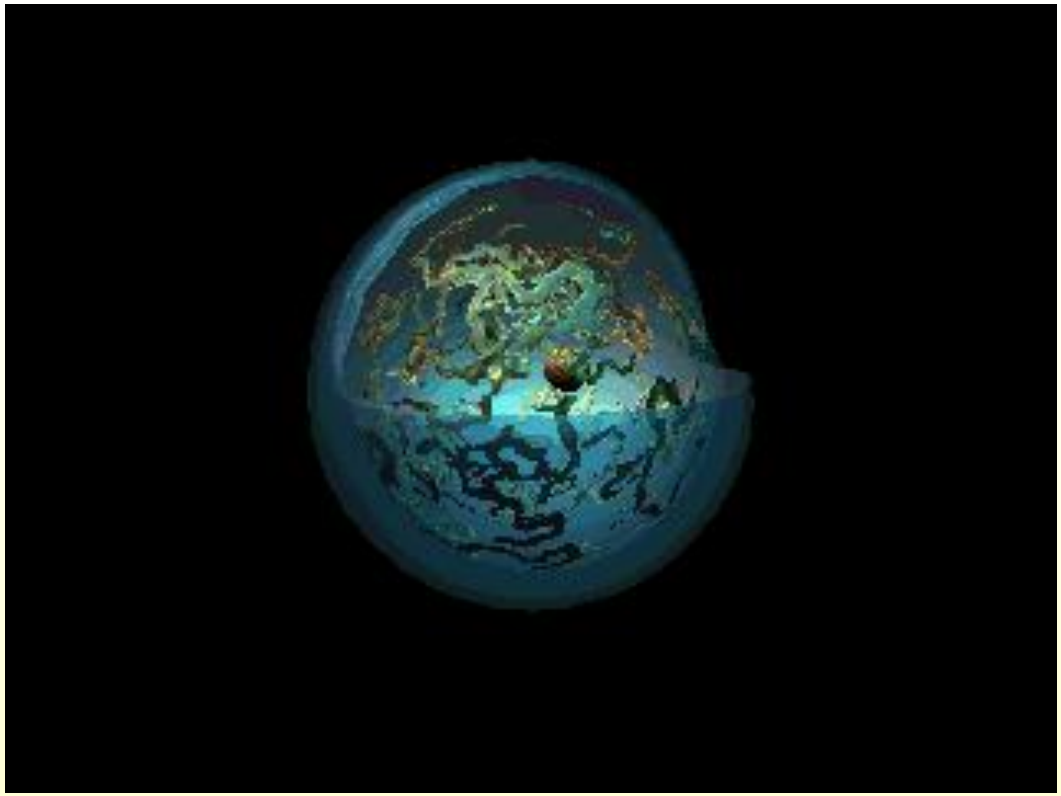
Membrane Vacuolar System



Mitochondria

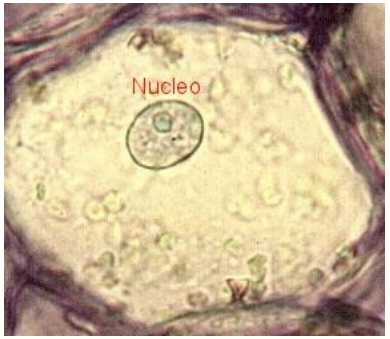
Lysosomes

Nucleus



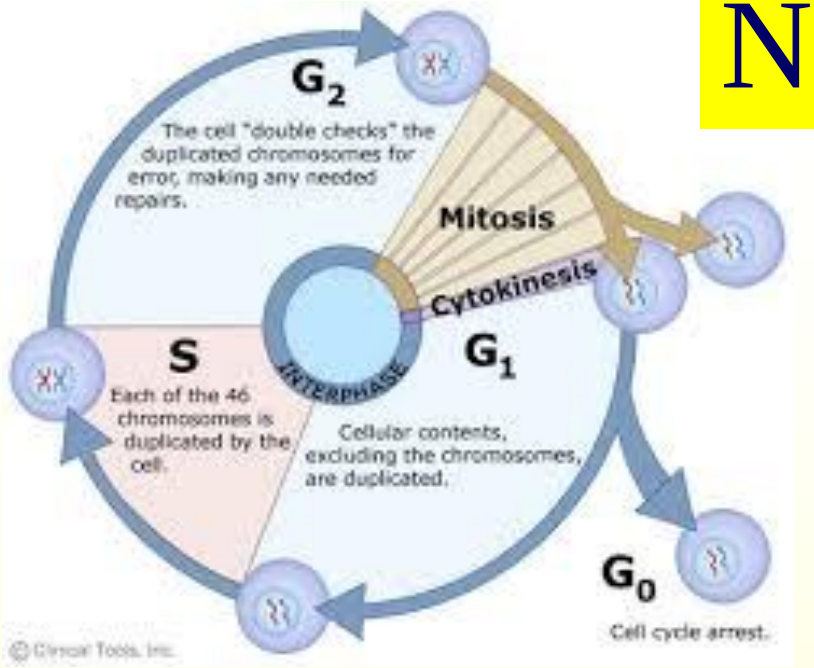
The largest organelle in the cell and an essential component of almost all cell types; its removal causes cell death..

Nucleus

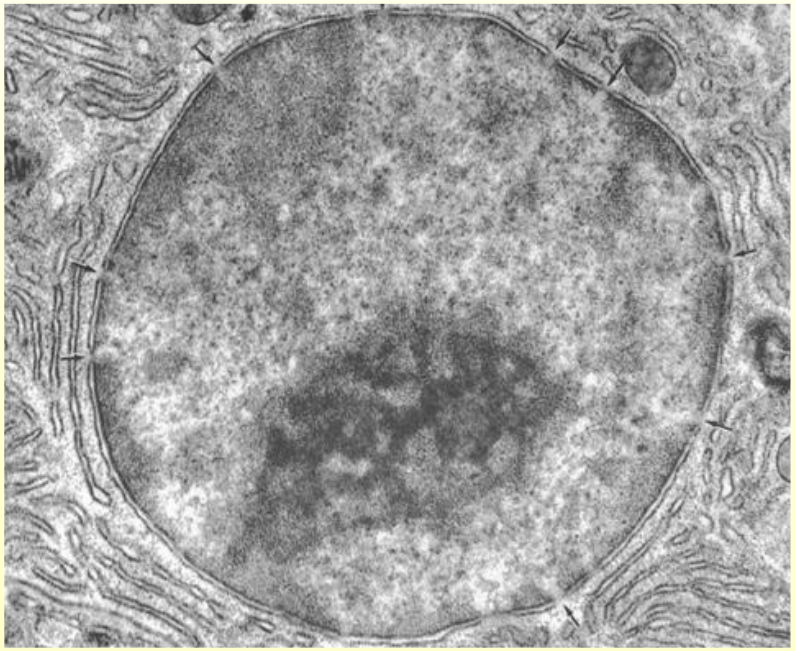


•It can be considered the **center** from which all orders regulating the life of the cell originate.
•It constitutes the **site of genetic information**; it contains the **genetic material**.
•Inside it, **DNA** is stored in the form of chromatin, and within it take place the **replication of nuclear DNA** and its **transcription into RNA**.
•It is the site of **mechanisms essential for gene expression** and **cell duplication**.
•Considering the role and importance of DNA, the nucleus can be regarded as the **“coordinator”** and **“controller”** of the activities that occur within the cell.

Nucleus



The **nucleus** is a dynamic structure whose morphology changes during the different phases of the Cell Cycle: Division and Interkinesis (the period between two successive divisions)

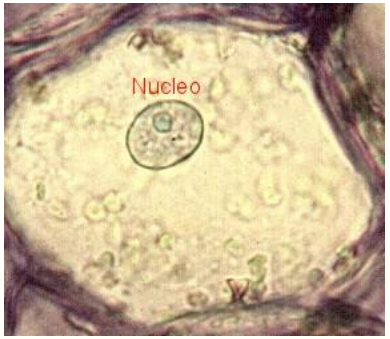


The size of the nucleus is related to the amount of DNA present and is proportional to that of the cytoplasm.

Nucleus volume/cytoplasm volume
N/P= nucleoplasmic index

Constant in somatic cells

Nucleus



It **is generally rounded in shape** and, in animal cells, it **is often located in the central region of the cytoplasm**, although may vary in different cells type based on:

1. THE MORPHOLOGY

2. THE SIZE

3. THE POSITION WITHIN THE CELL

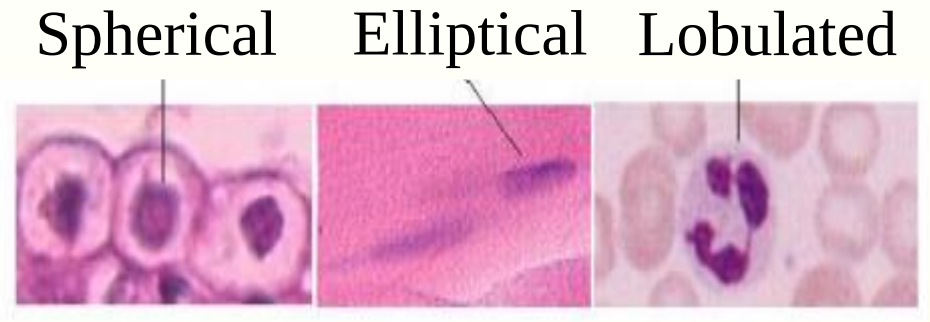
4. THE NUMBER OF NUCLEI

Nucleus

SHAPE

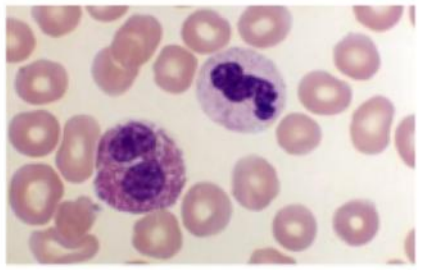
•Correlated with that of the cell

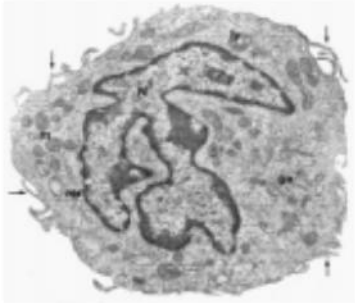
- Spherical
- Elliptical
- Lobulated

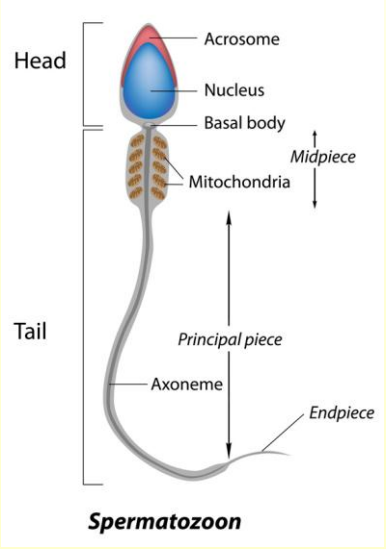


•Sometimes completely irregular

- Polymorphonuclear leukocytes
- Sperm cells



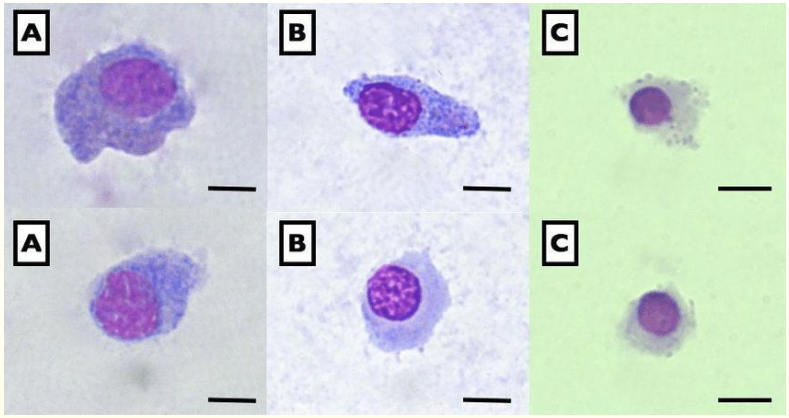




Nucleus

SIZE

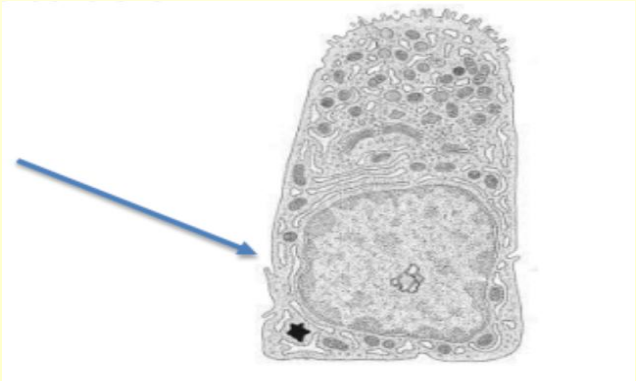
•Variable, but often proportional to that of the cell



POSITION

•Variable, but characteristic of each cell type

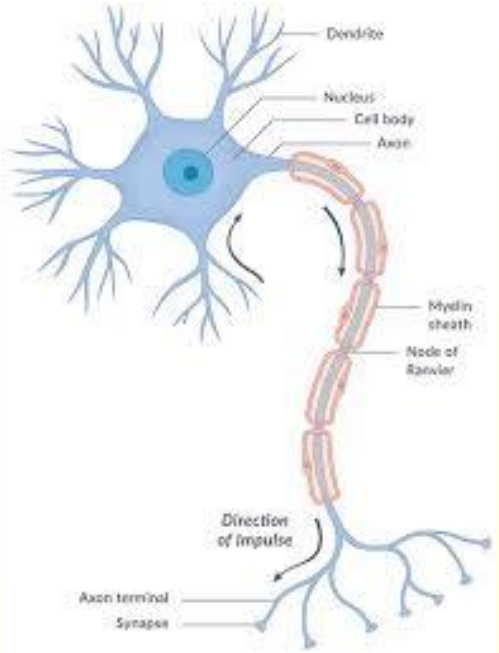
- For example:
  – **Embryonic cells:** central nucleus
  – **Secretory cells:** eccentric (off-center) nucleus



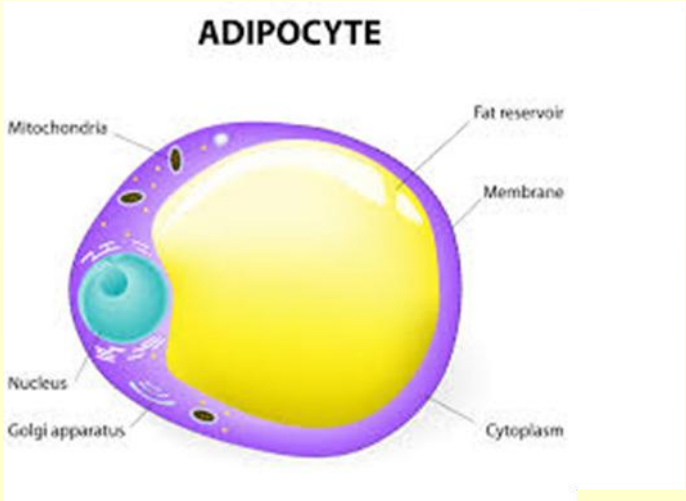
Nucleus

POSITION

Neurons: the nucleus is centrally located within the cell body.
The cytoskeleton forms a scaffold that keeps the position of the nucleus stable.

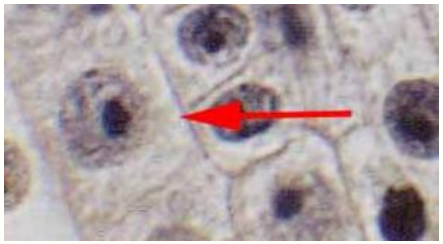


Adipocytes: the lipid droplet pushes the nucleus toward the periphery.



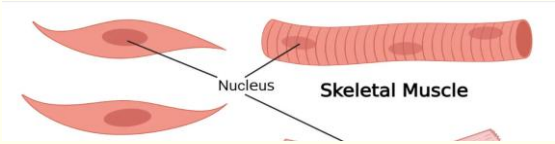
Nucleus

Normally, eukaryotic cells are mononucleated.

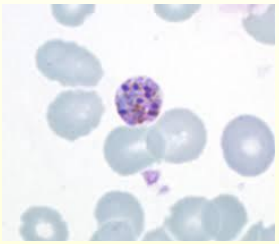


POLYNUCLEATED CELLS:

•**Syncytia** → fusion of cells

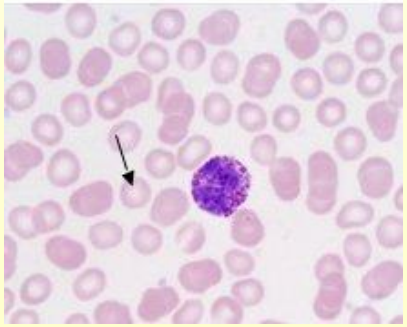


•**Plasmodia** → cells in which nuclear divisions are not followed by cell division



CELLS WITHOUT A NUCLEUS:

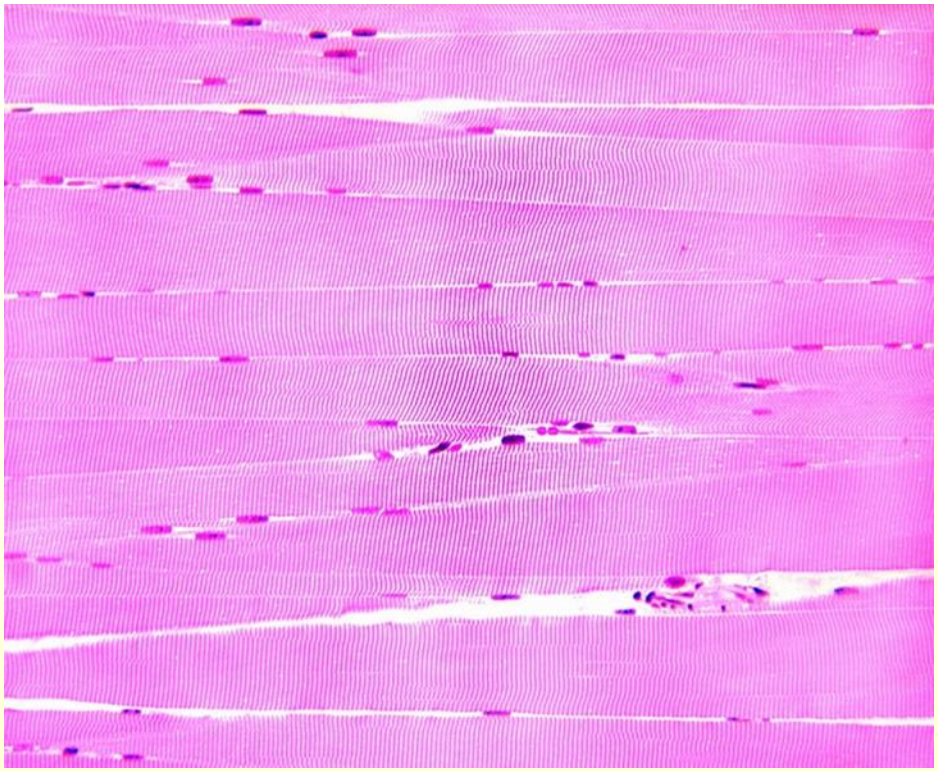
•**Red blood cells** in mammals lose their nucleus during differentiation; in fact, their only function is to transport gases involved in respiration.

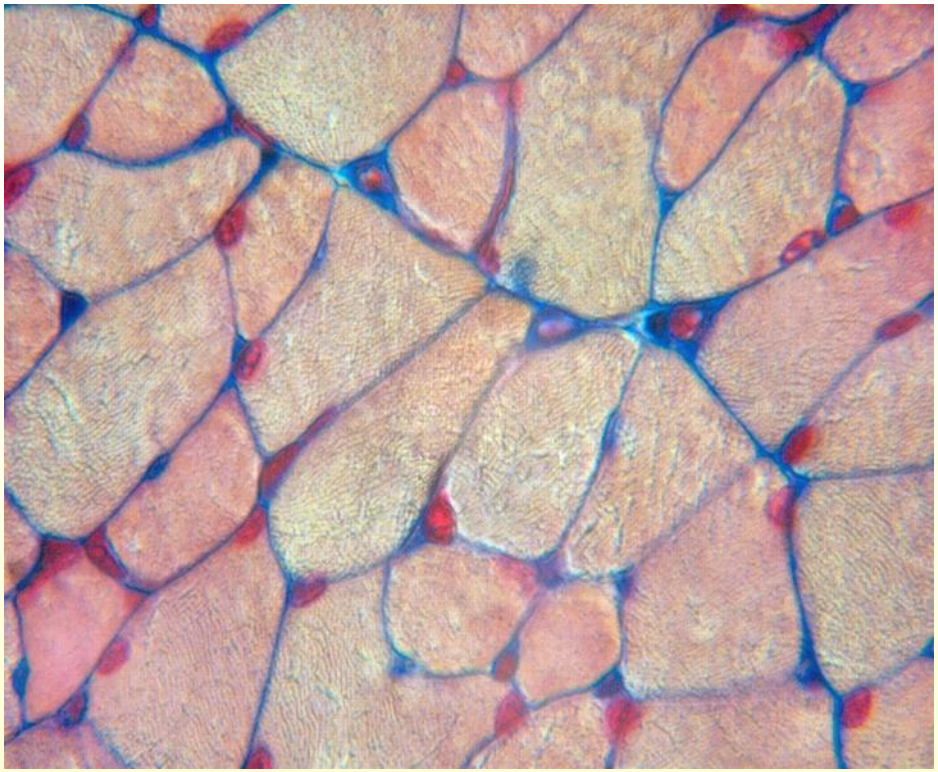


•**Platelets**

•**Cornified scales of the skin**

Nucleus





Polynucleated cells - Syncytia: multiple cells join their nuclei in the same cytoplasm (e.g., striated muscle fibers).

NUCLEUS: structure

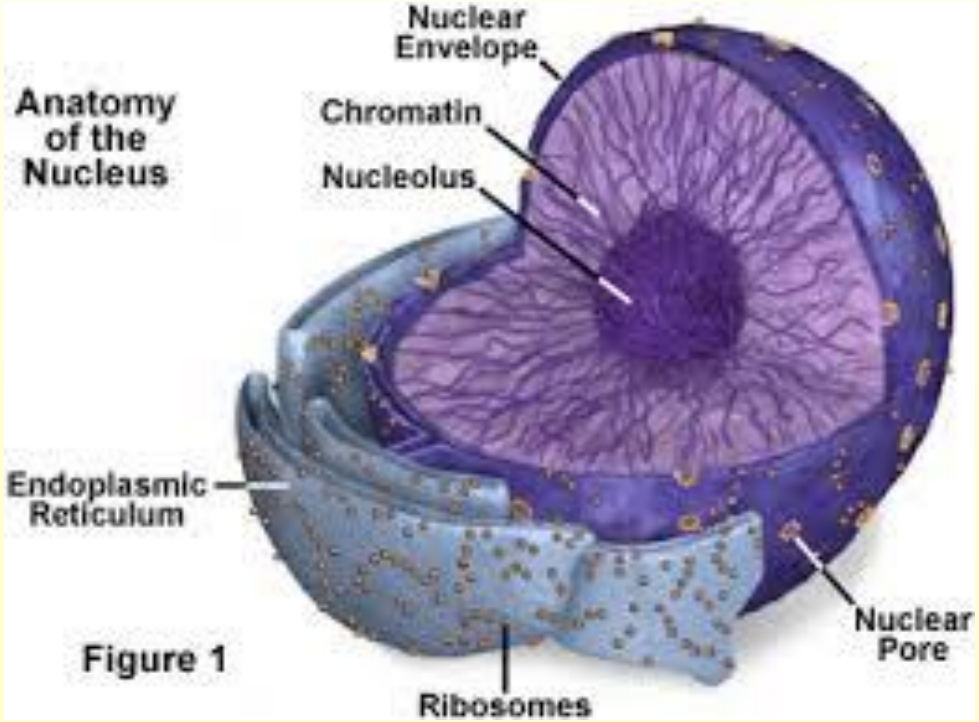
The nucleus is made up of four main components:

1. Nuclear membrane or nuclear envelope

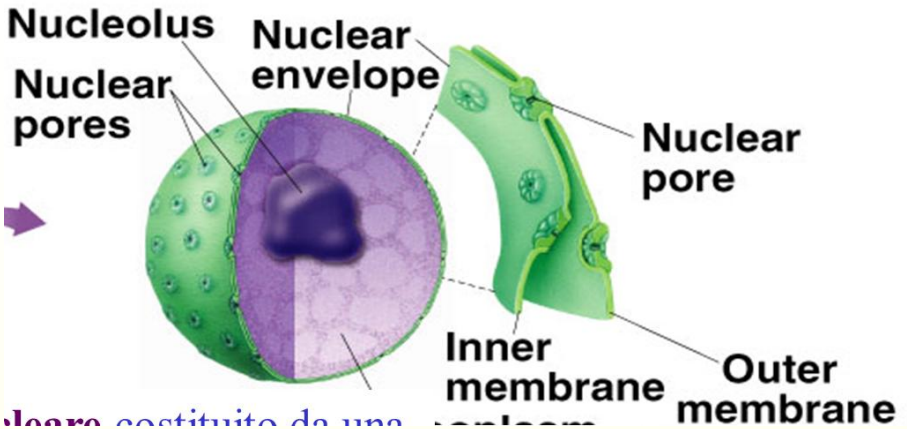
2. Nucleoskeleton

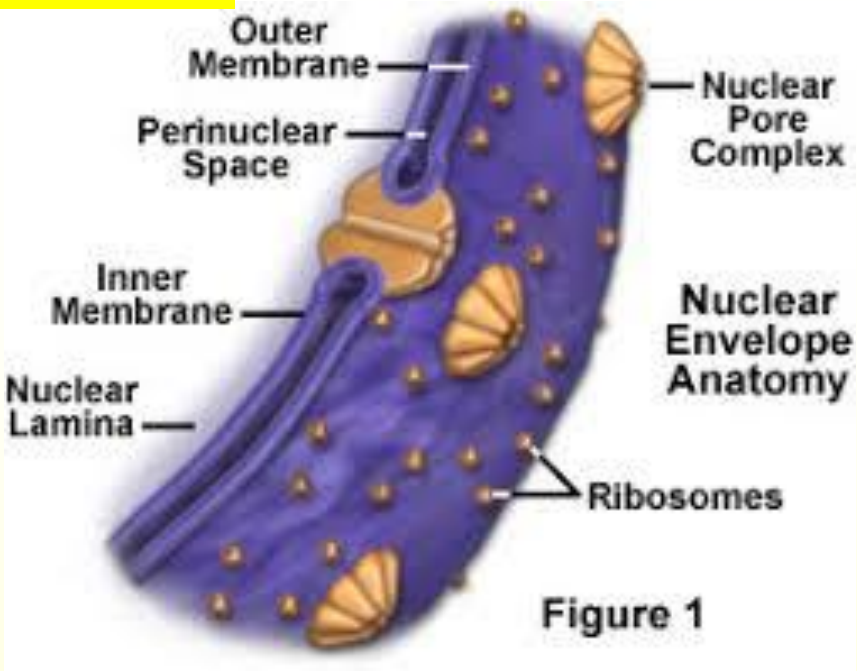
3. Chromatin

4. Nucleolus



NUCLEUS: structure



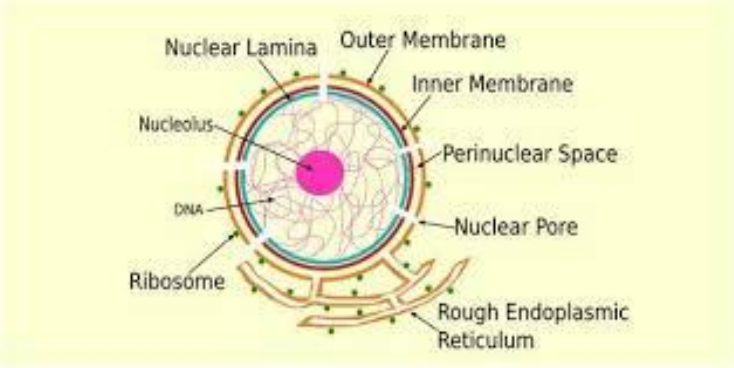


Nuclear envelope consisting of a **double membrane:**

-Inner nuclear membrane (6 nm)

-Outer nuclear membrane (6 nm)

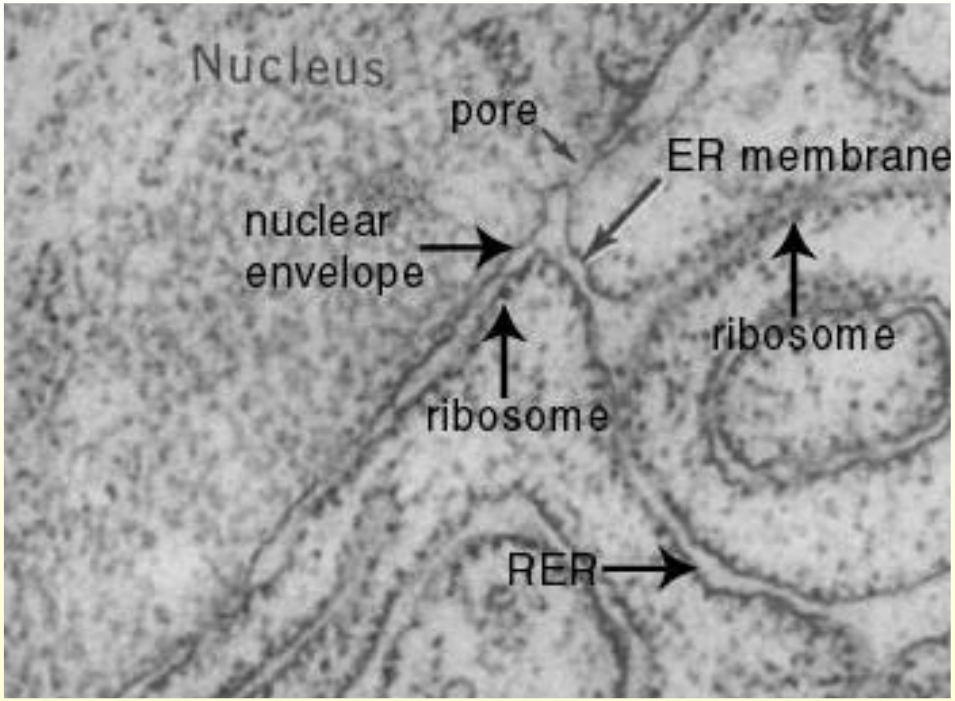
They are separated from the **perinuclear space** (30-50 nm)

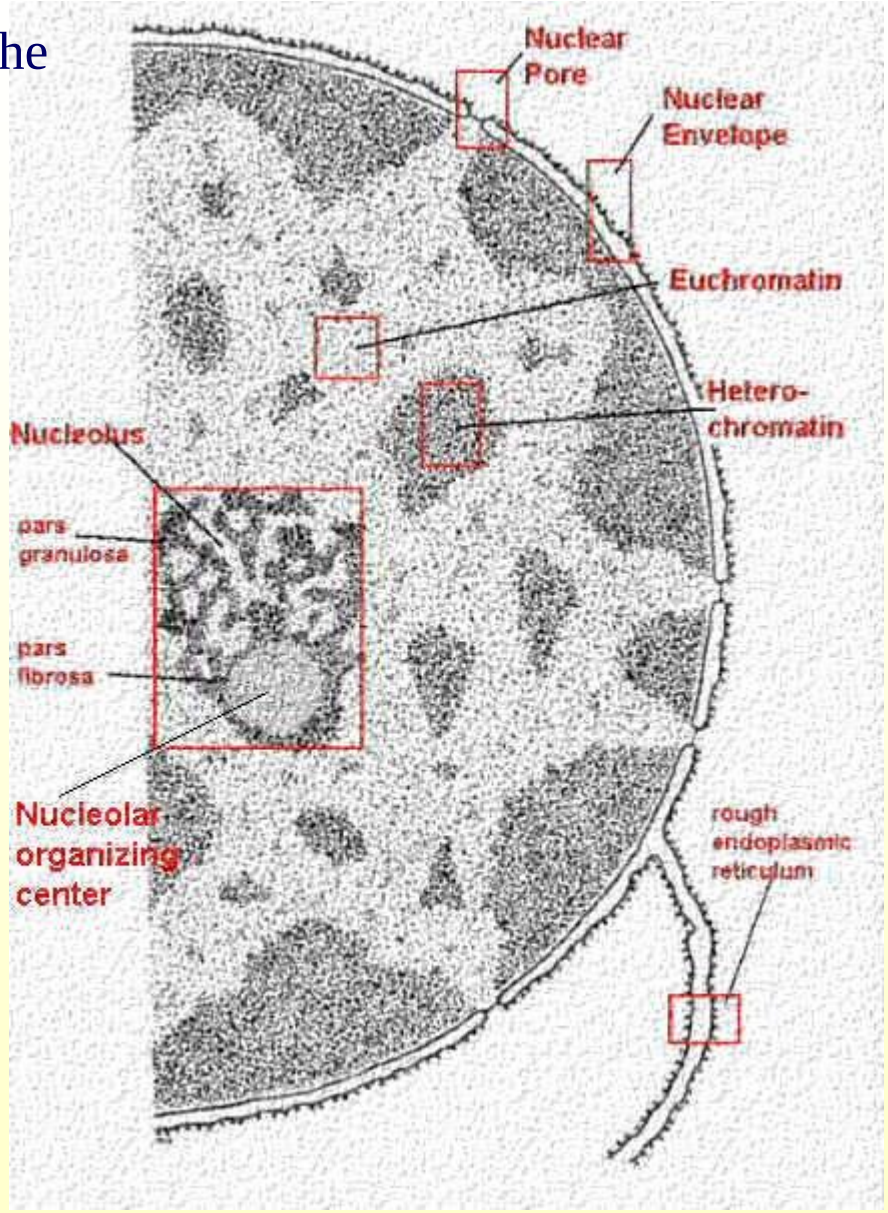


The outer nuclear membrane continues with the Rough Endoplasmic Reticulum (RER.)

NUCLEUS: structure

The outer nuclear membrane continues with the rough endoplasmic reticulum (RER.)

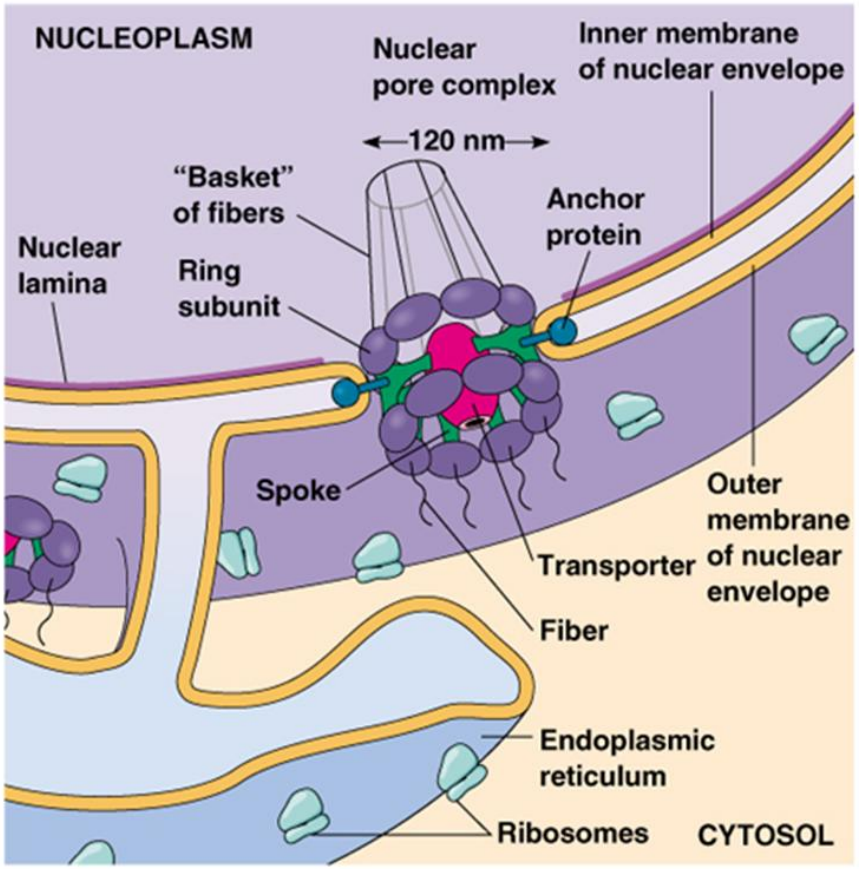




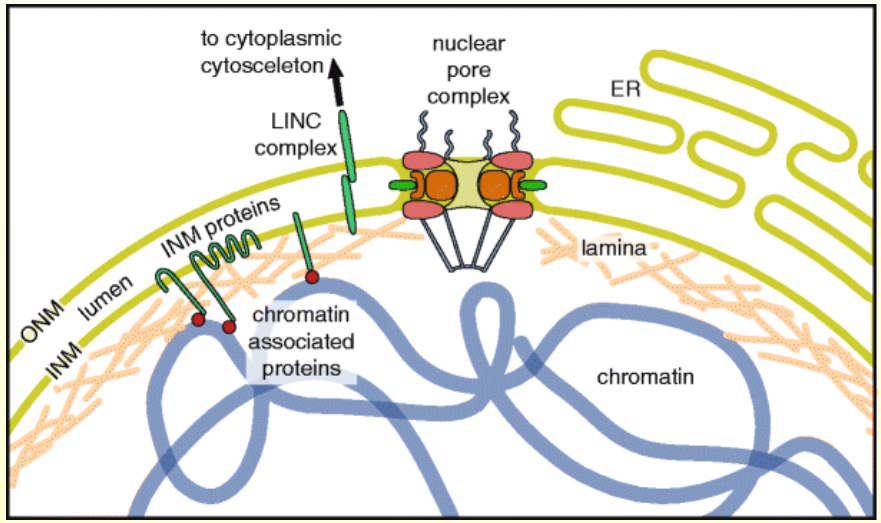
The inner nuclear membrane is in contact with the nuclear contents and the nuclear lamina.

NUCLEUS Structure: The Nuclear Pore

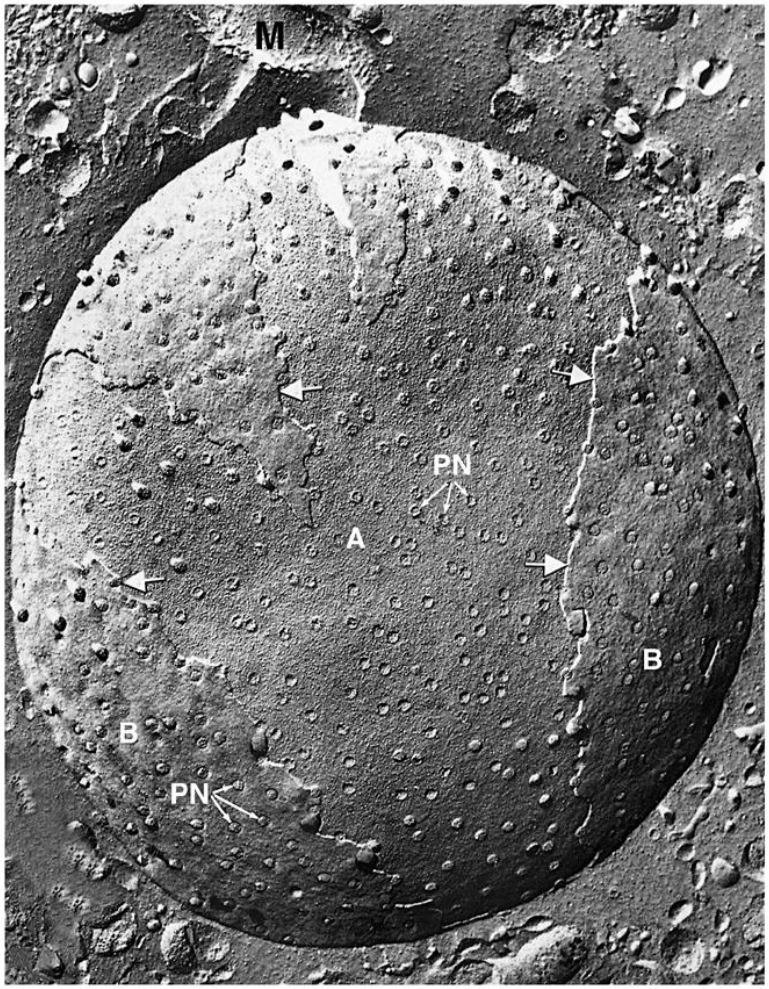
The **nuclear envelope is not a continuous barrier** because the inner and outer membranes fuse at certain points, creating a free space that takes the form of a **proteic channel**, referred to as a **NUCLEAR PORE**.
The surface of the nuclear envelope is dotted with interruptions.

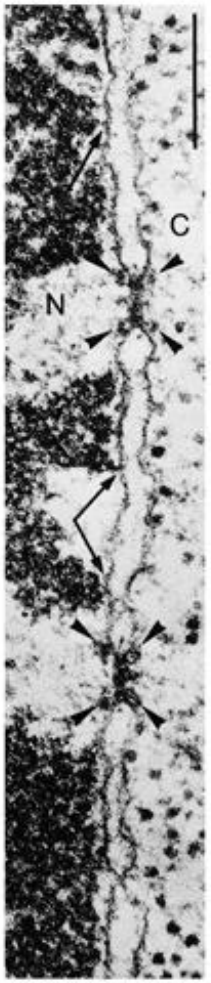


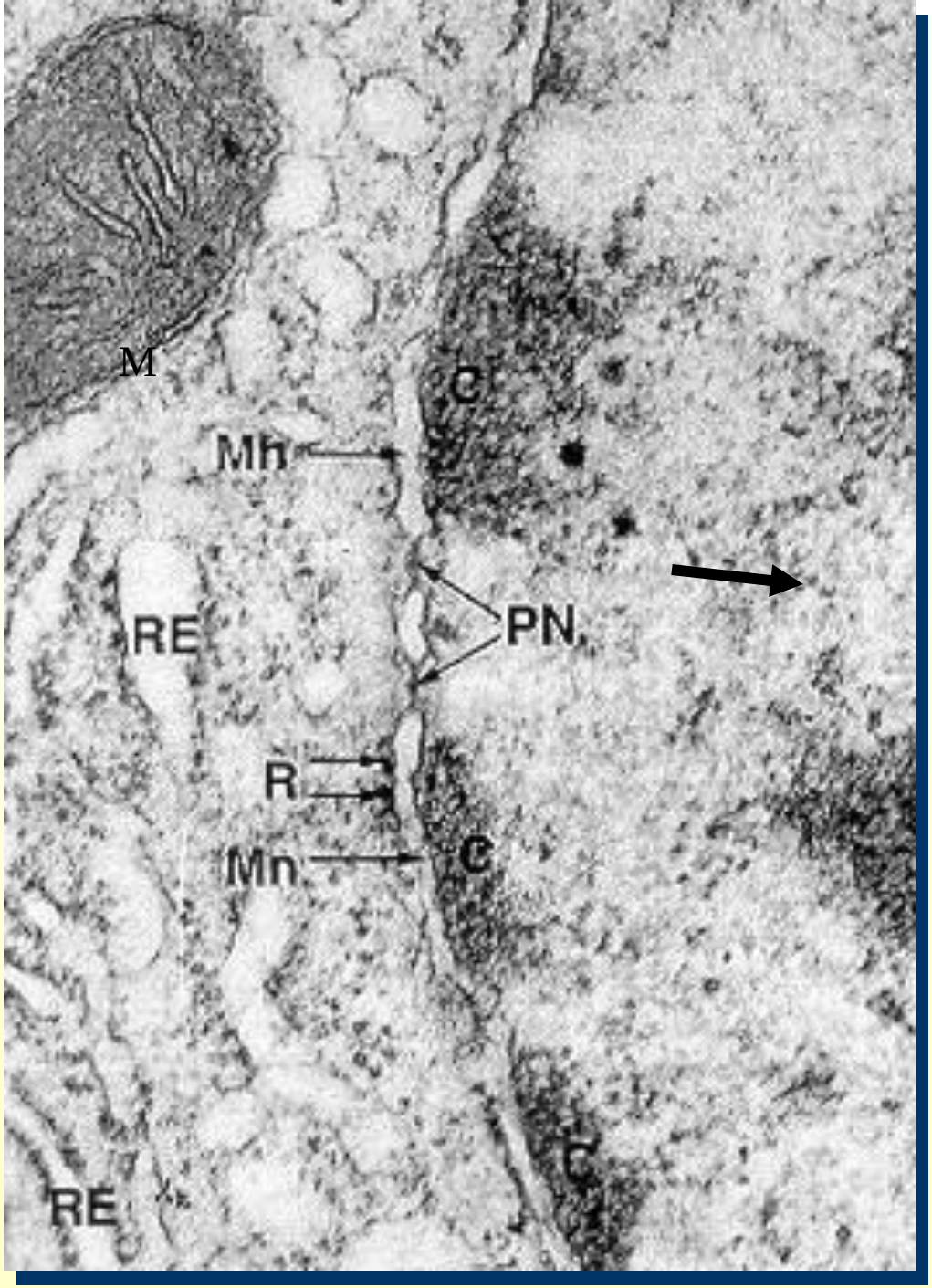
(b) Location of nuclear pores in nuclear membrane



NUCLEUS Structure: The Nuclear Pore





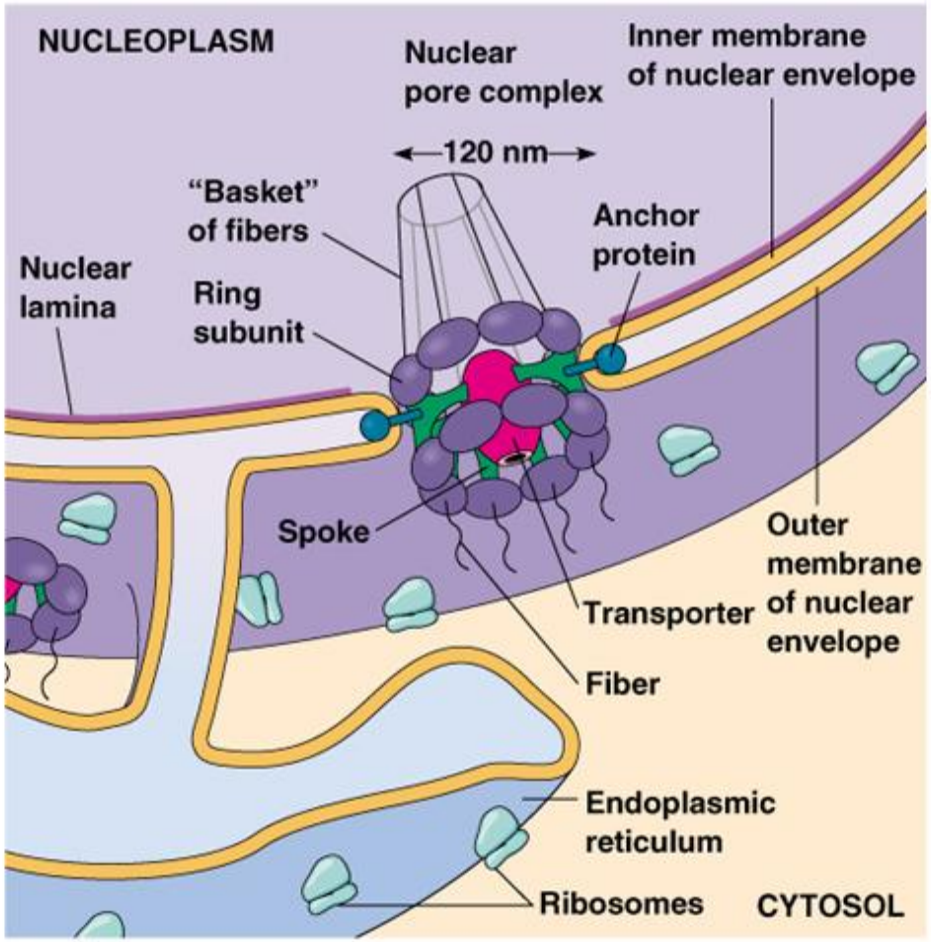


NUCLEUS Structure: The Nuclear Pore

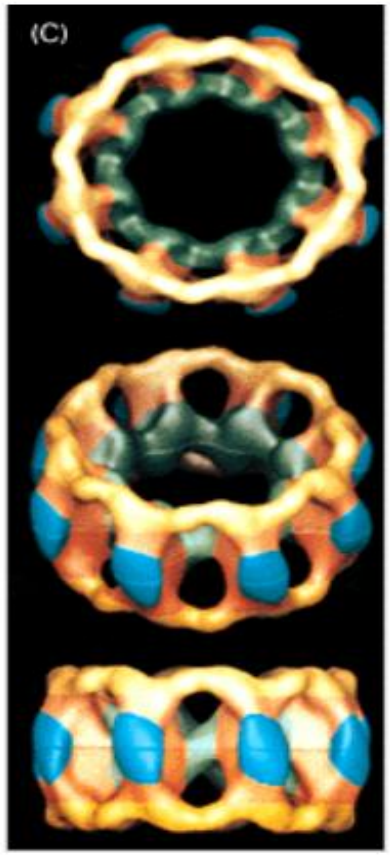
Each pore, under electron microscopy, appears to contain an electron-dense structure: **the pore complex.**

- **Mh** = outer nuclear membrane
- **MN** = inner nuclear membrane
- **PN** = nuclear pores
- **M** = mitochondria
- **RE** = endoplasmic reticulum
- **C** = chromatin

NUCLEUS Structure: The Nuclear Pore

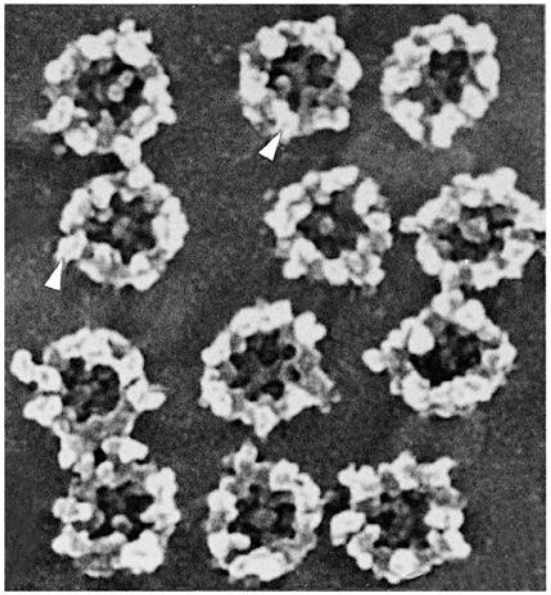


(b) Location of nuclear pores in nuclear membrane

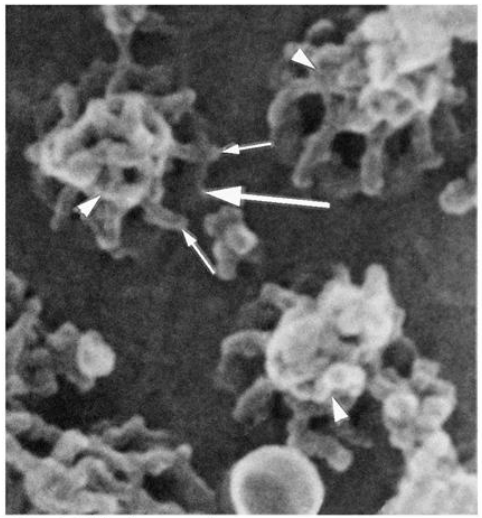


nuclear pore complex (approximately 120 nm). The complex is organized in such a way as to allow the formation of channels (10-15 nm) that mediate the selective passage of substances.

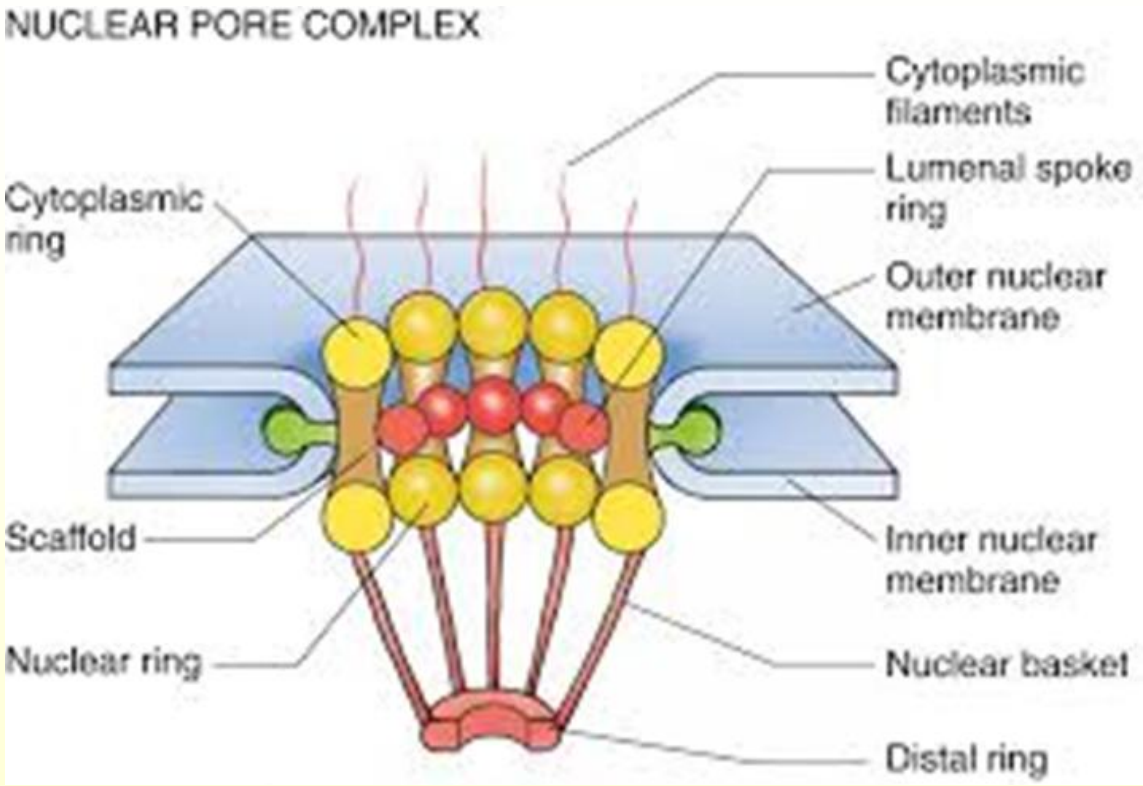
NUCLEUS Structure:
The Nuclear Pore



OOBA © 2005 edi.ermes milano



OOBA © 2006 edi.ermes milano



.

The pore is a protein ring with a central channel. The whole structure is stabilized by the nuclear lamina.

The most abundant class of proteins are nucleoporins.

NUCLEUS Structure: The Nuclear Pore

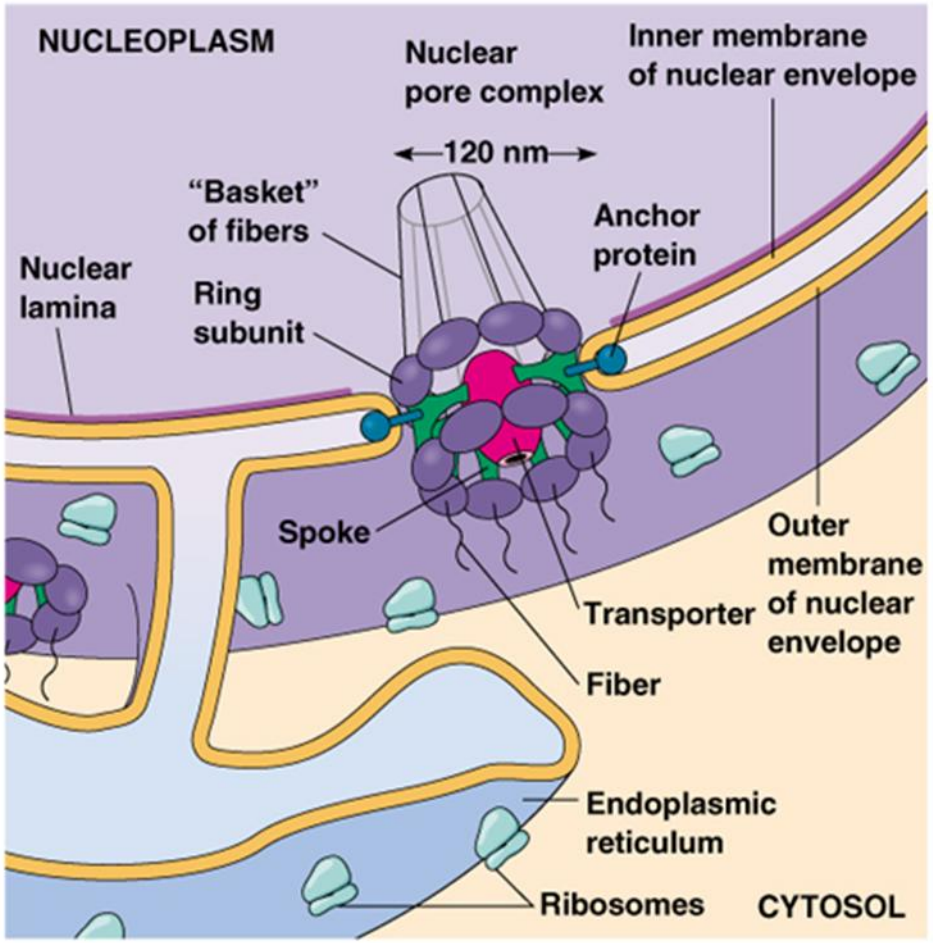
Octagonal organization:

•**8 proteins** are symmetrically arranged around the pore and protrude on both the cytoplasmic and nucleoplasmic sides, forming **2 concentric rings** anchored to the two membranes.

•Other proteins form **8 spokes** that extend from the rings toward the center of the pore, reaching a unit called the **transporter**.

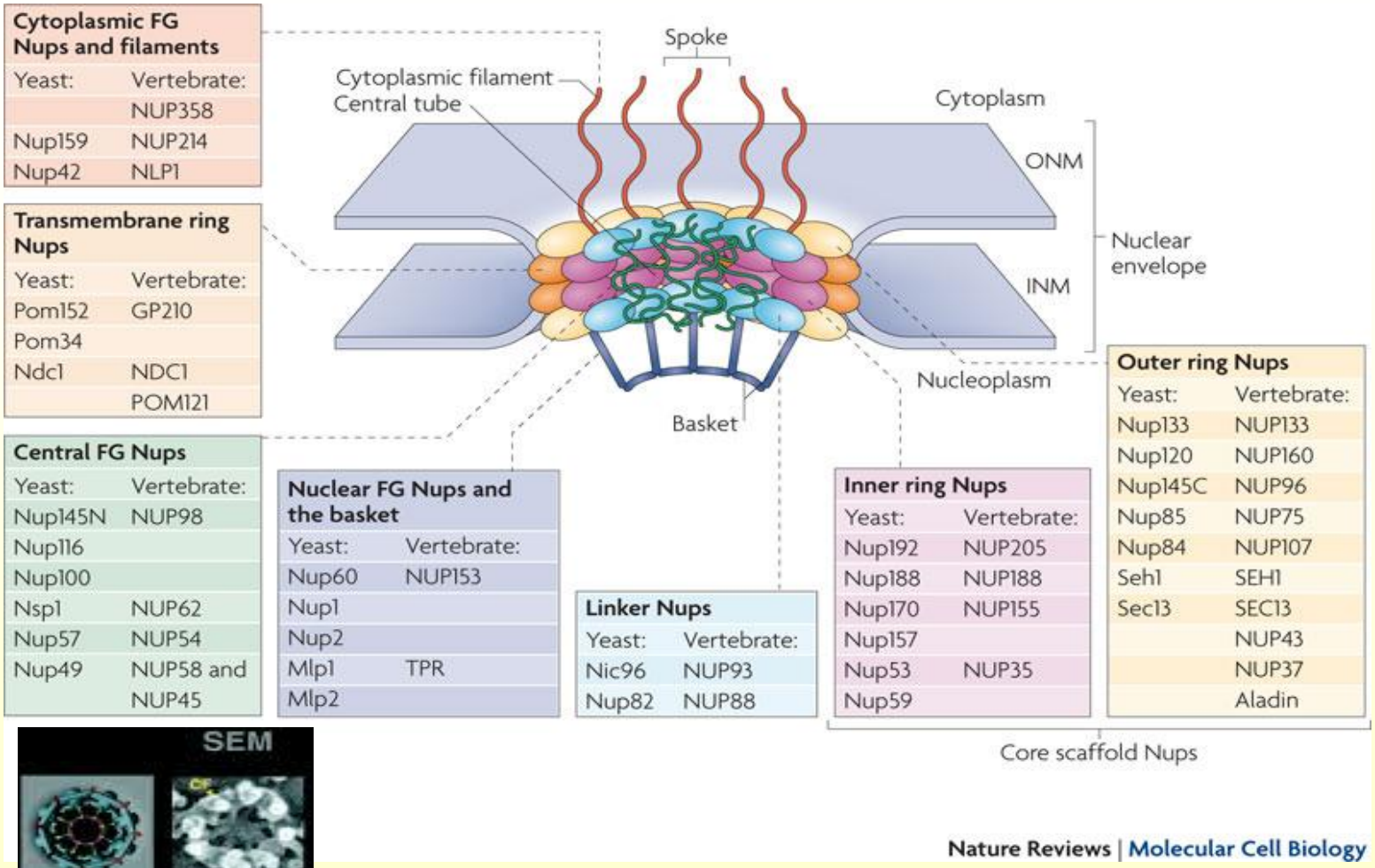
•There are also proteins that extend from the edge toward the perinuclear space, which are believed to serve as anchoring elements for the entire complex.

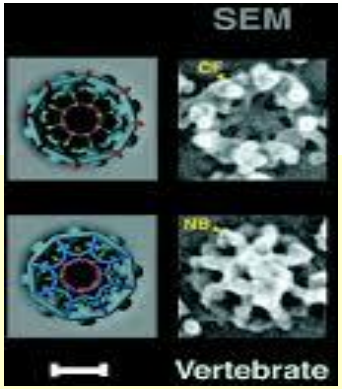
•In addition, **8 fibers** extend from the rings toward the cytosol and toward the nucleoplasm. Those projecting into the nucleus form a sort of **basket (nuclear basket),** as they are joined at their ends by a fibrous ring.



(b) Location of nuclear pores in nuclear membrane

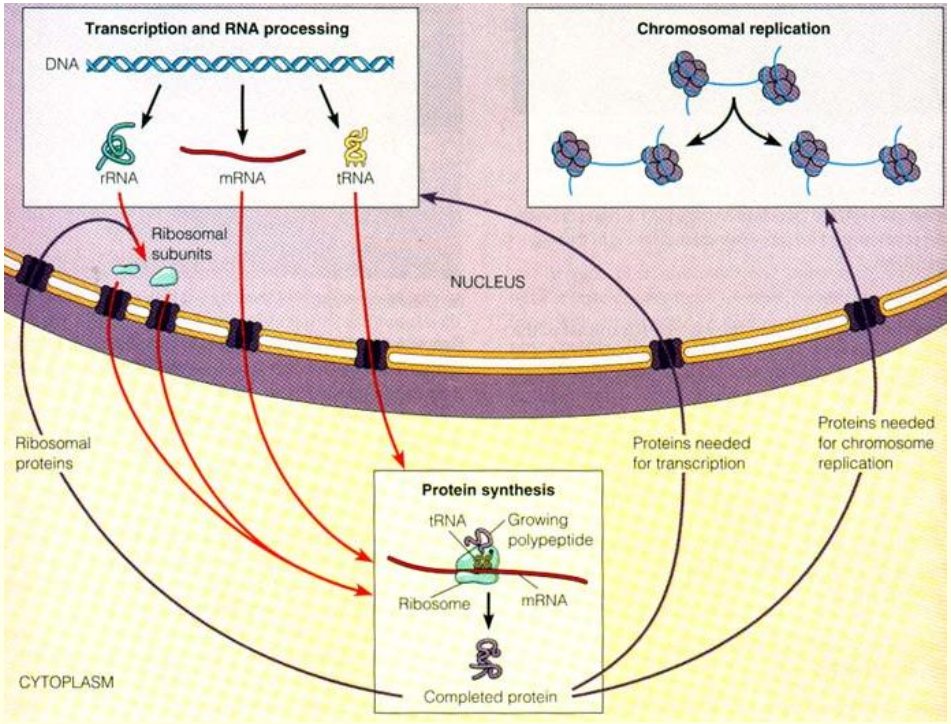
Nuclear Pore: structure





The margin of each pore appears as an electron-dense ring or annulus consisting of 8 globular particles that delimit a hole 15 nanometers in diameter.

Nuclear Pore: Function



Transport through the pore:
1.Nuclear proteins synthesized in the cytoplasm that need to enter the nucleus.
2.RNA molecules

Through the pore, **ions and small molecules** pass by **simple diffusion**, as well as **globular proteins** up to about **40 kDa** (e.g. ribosomal subunits precursors and mRNA–protein complexes).

In addition to molecular size, **transport through the pores is influenced by electrical charge**. Small, neutral, or positively charged proteins pass rapidly and accumulate in the nucleus.

However, **proteins such as ferritin**, with a diameter of **9.5 nm**, **cannot enter passively** and require **specific translocation systems**

Nuclear Pore: Function

Larger molecules, both to **enter** and to **exit** the nucleus, require specific **protein receptors**:

NUCLEAR IMPORT RECEPTORS (IMPORTINS)

NUCLEAR EXPORT RECEPTORS (EXPORTINS)

These receptors signal the pore to widen and allow the passage.