

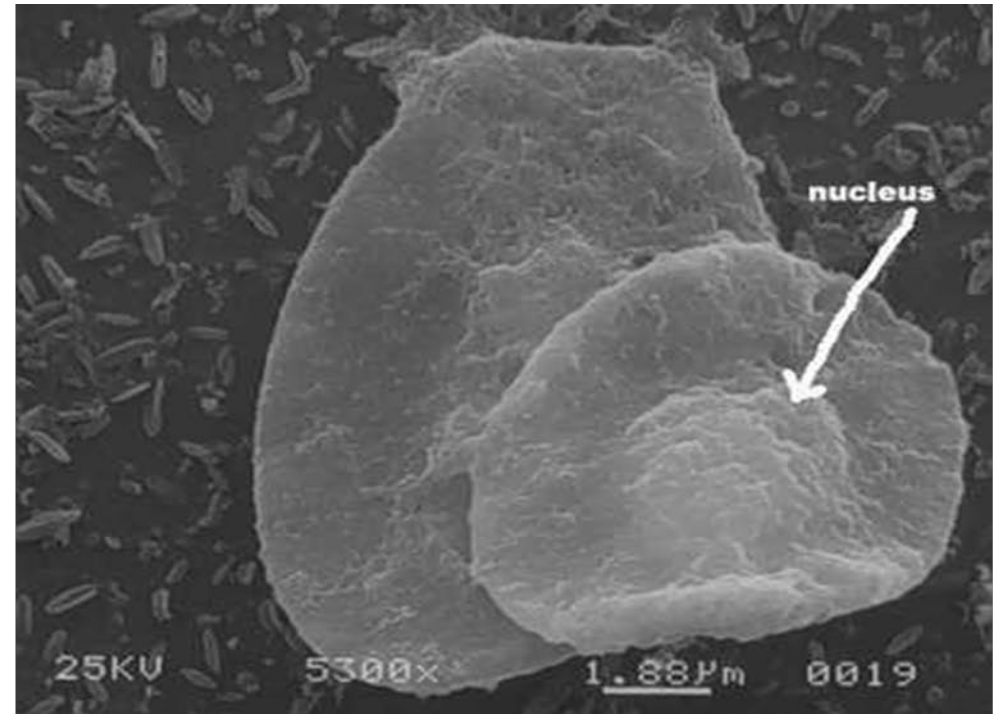
MSc I Sem – Life Sciences

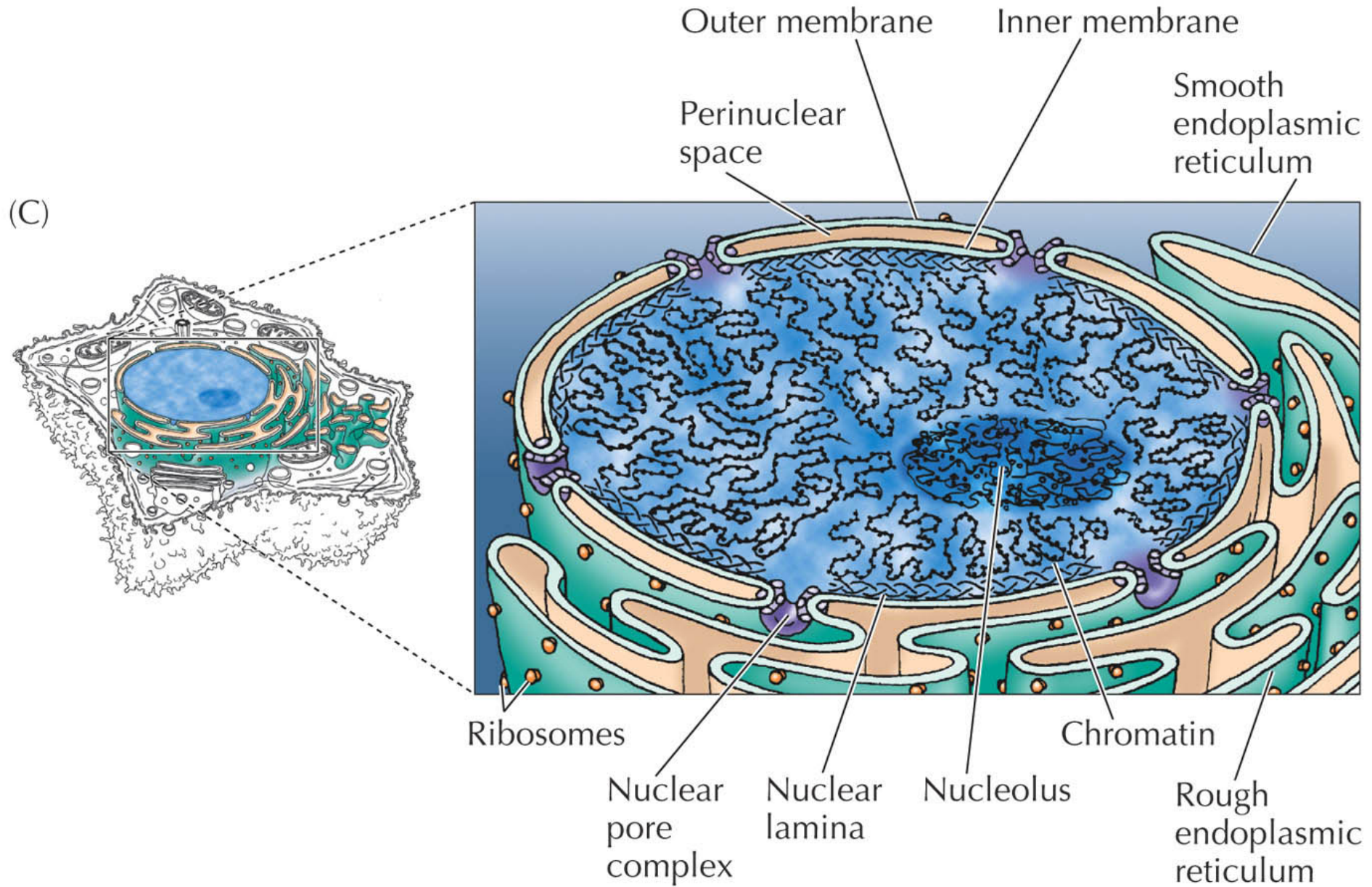
Course – Cell Biology

Nucleus

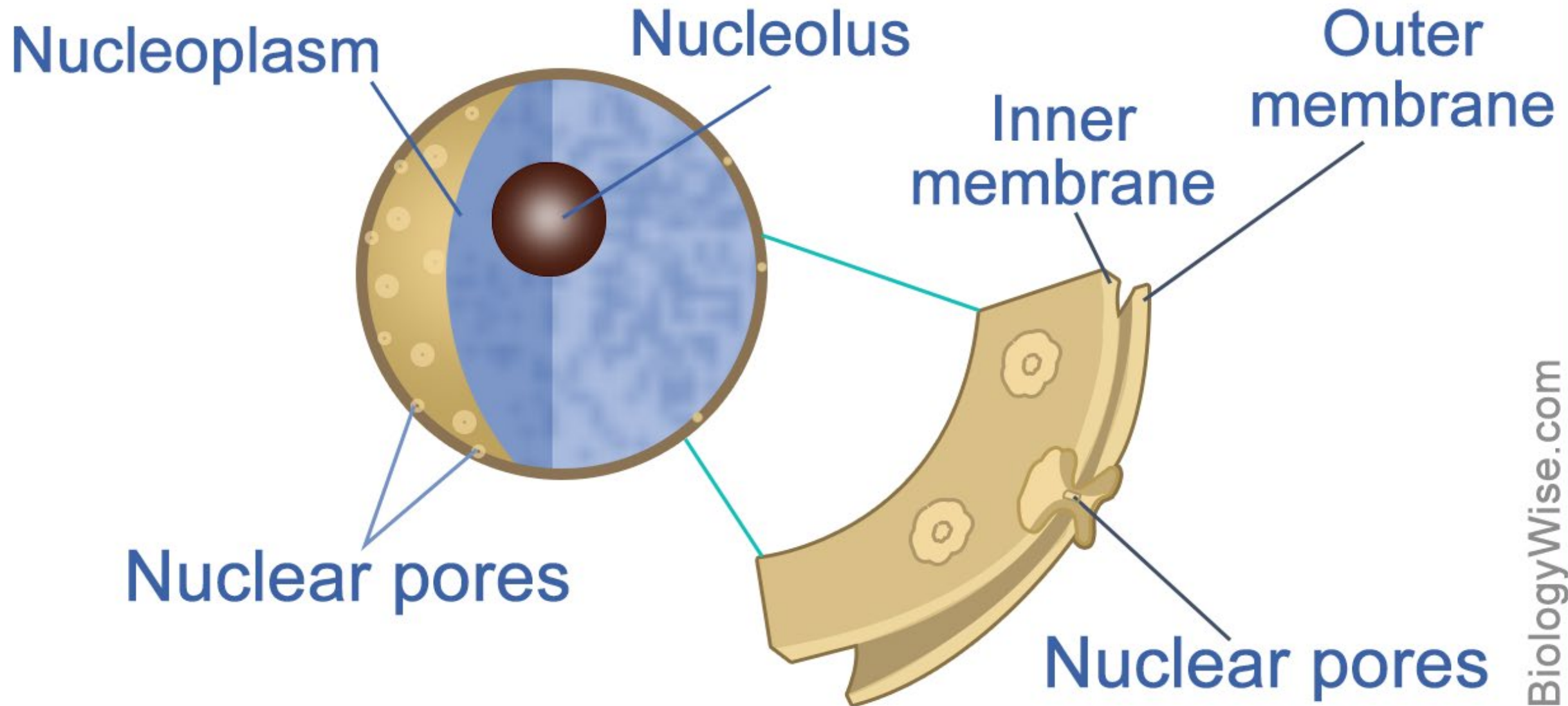
Nucleus

- The nucleus was also described by **Franz Bauer in 1804**
- **Robert Brown** is known to discover in 1831 (Scottish botanist in a talk at the Linnean Society of London).
- Nucleus is a membrane-enclosed organelle found in mostly type of cells. It contains most of the cell's genetic material, organized as multiple long linear DNA molecules in complex form of chromosomes.
- The function of the nucleus is to maintain the integrity of these genes and to control the activities of the cell by regulating gene expression.
- The nucleus is, therefore, the control center of the cell.
- The nucleus is the largest cellular organelle in animal cells.
- In **mammalian cells**, the average diameter of the nucleus is **approximately 6 micrometers (μm)**, which occupies about 10% of the total cell volume.
- It appears as a dense, roughly spherical organelle.





NUCLEUS



Components of the nucleus

- 1. Nuclear envelope / membrane** (made-up of lipid bilayer): The nuclear membrane covers the nucleus. It allows materials to flow in and out of small pores.
- 2. Nuclear pore** (pores on the nuclear envelope): Allow small molecules to diffuse easily between nucleoplasm & cytoplasm. Controls passage of proteins & RNA protein complexes.
- 3. Nucleoplasm:** the viscous liquid inside, similar in composition to the cytosol.
- 4. Nucleolus:** subcellular organelle found inside nucleus, main function is to transcribe and modify ribosomal RNA (rRNA) and integrate ribosomal proteins to form immature ribosomes.
- 5. Genomic contents:** chromosome/chromatin.

Nucleus chemical composition:

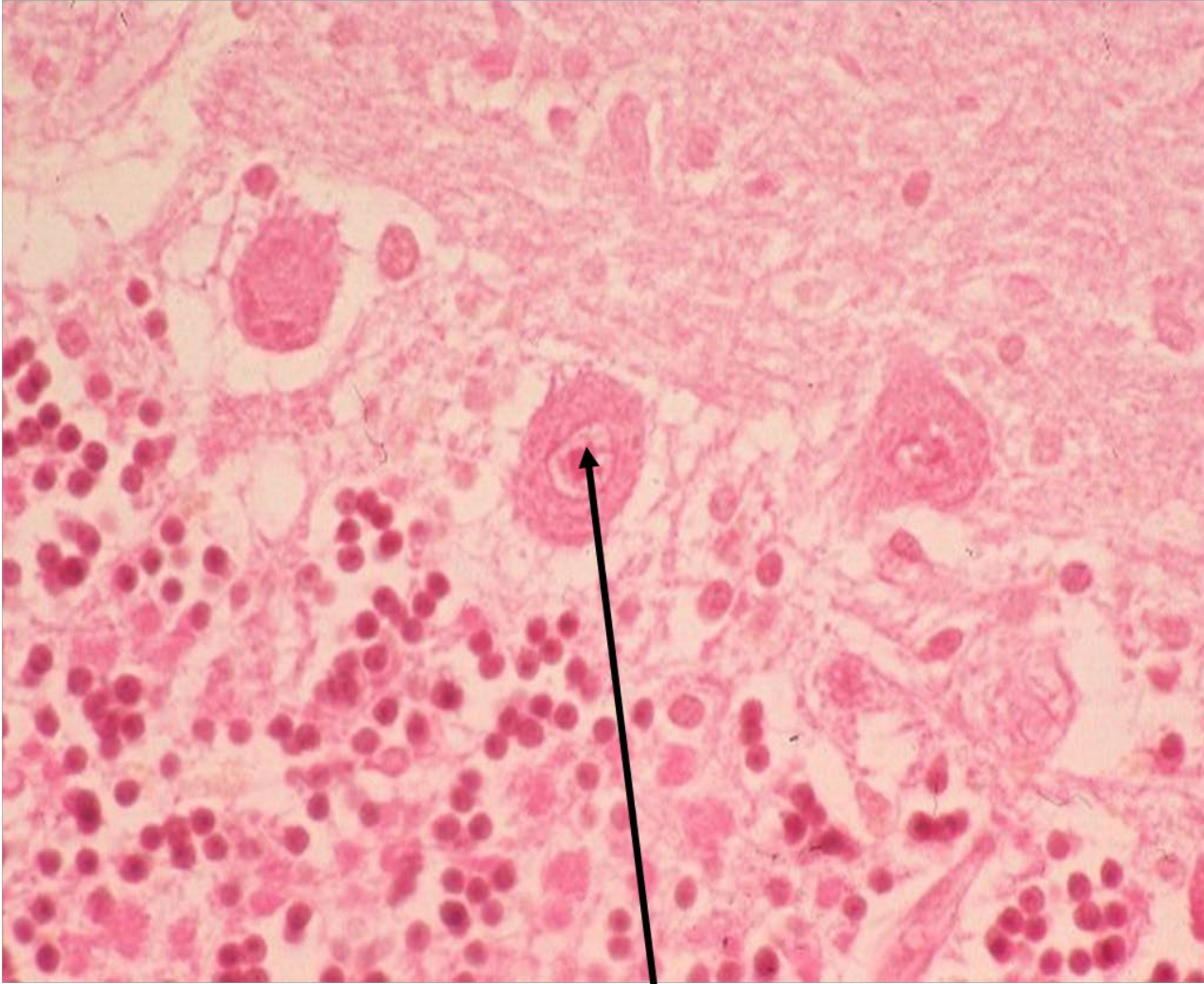
- 9-12 percent DNA
- 15 percent histone
- 65 percent enzymes, neutral proteins and acid proteins
- 5 percent RNA
- 3 percent lipids

Some of the main functions of the nucleus include:

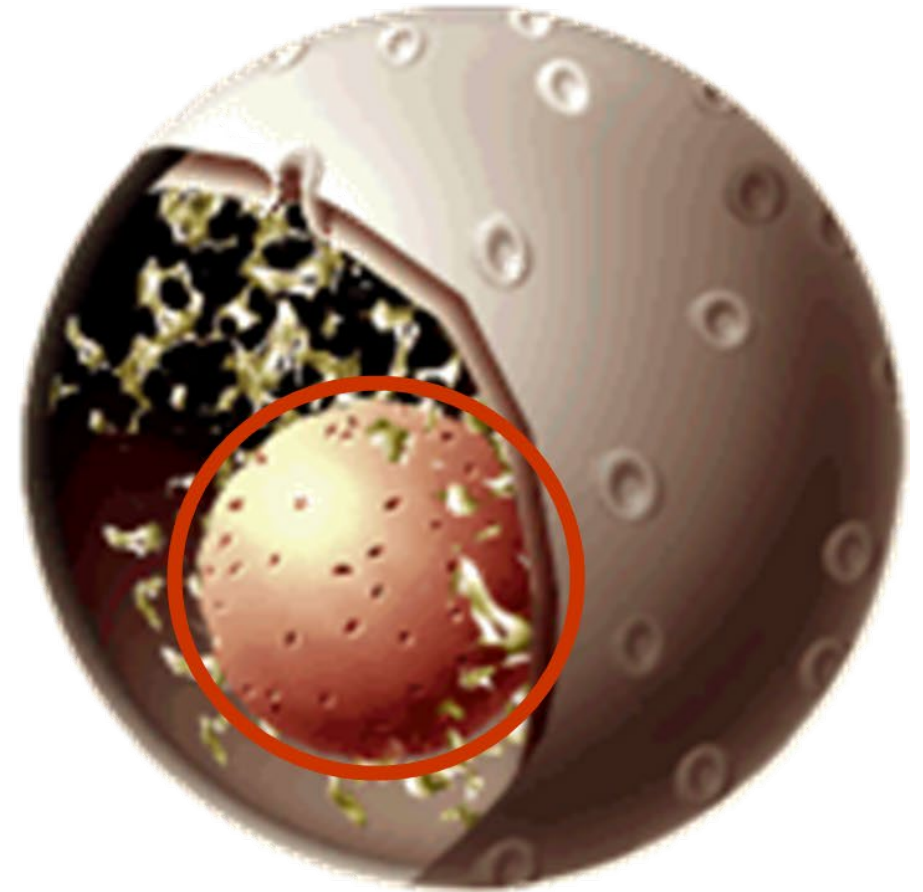
- Protein synthesis, [cell division](#), and [differentiation](#)
- Control the synthesis of enzymes involved in [cellular metabolism](#)
- Controlling hereditary traits of the organism
- Store DNA strands, proteins, and RNA
- Site of RNA transcription - e.g. mRNA required for protein synthesis

Nucleolus

- This round structure appears as a dark dot in the nucleus.

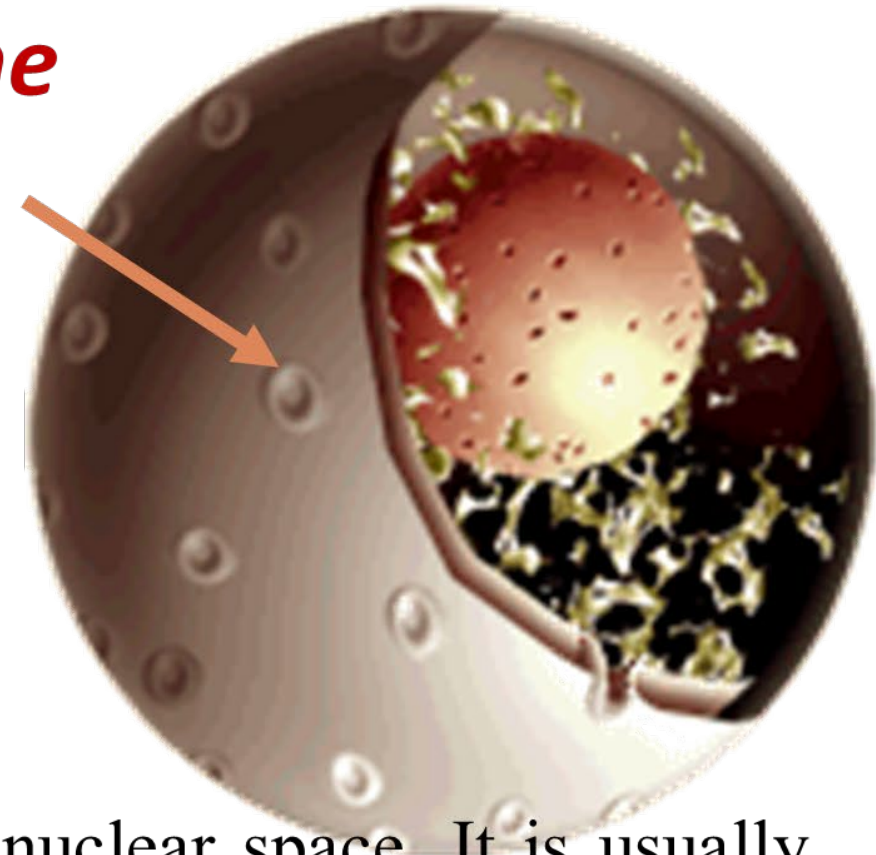


Ribosomes are made here.



Nuclear Membrane

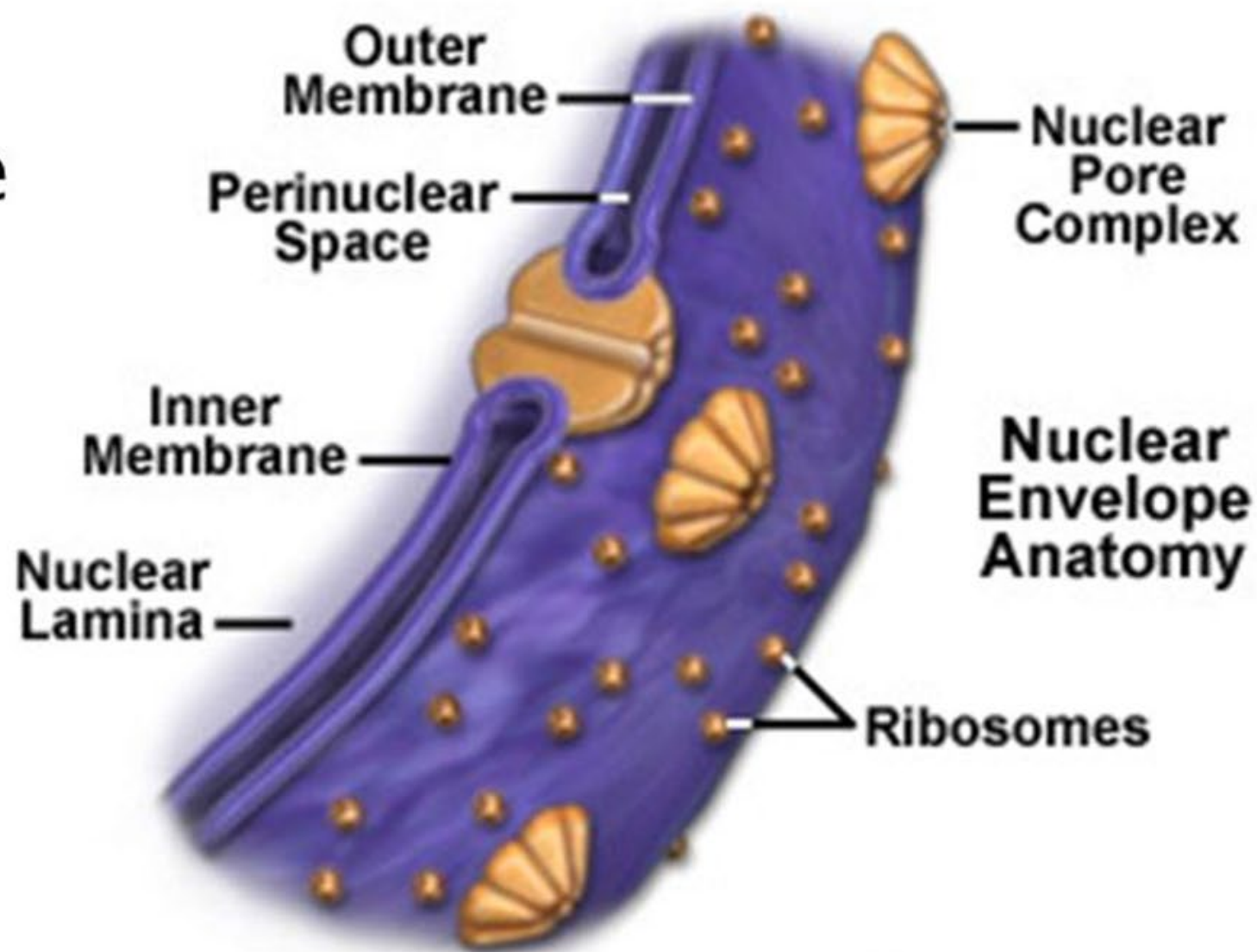
- The nuclear membrane covers the nucleus.
- It allows materials to flow in and out through small nuclear pores.
- The nuclear envelope/nuclear membrane is made up of two lipid bilayer membranes.
- The nuclear envelope consists of an inner nuclear membrane, and an outer nuclear membrane.



The space between the membranes is called the perinuclear space. It is usually about 20–40 nm wide. The outer nuclear membrane is continuous with the endoplasmic reticulum membrane. The nuclear envelope has many nuclear pores that allow materials to move between the cytosol and the nucleus. Intermediate filaments form a lamina internally to the inner nuclear membrane, and more loosely externally to the outer nuclear membrane to give structural support to the nucleus.

Nuclear membrane

- ▶ Also called the nuclear envelope
- ▶ Double membrane
- ▶ Porous



The Nuclear Membrane

The nuclear membrane is one of the aspects that distinguish eukaryotic cells from prokaryotic cells. Whereas eukaryotic cells have a nucleus bound membrane, this is not the case with prokaryotes (e.g. bacteria) that lack membrane-bound organelles.

As with the other cell organelles of eukaryotic organisms, the nucleus is a membrane-bound organelle. The nuclear membrane, like the cell membrane, is a double-layered structure that consists of phospholipids (forming the lipid bilayer nucleus envelope).

Present on the nuclear membrane are nuclear pores (made up of proteins) through which substances enter or leave the cell (RNA, proteins, etc). While the lipid bi-layers are separated by a thin space between them (perinuclear cisterna), studies have shown them to be fused at the pores. Nuclear membrane pores are occupied by dense granules/fibrillar material arranged in a cylindrical manner.

Fibrous lamina - The fibrous lamina is part of the nuclear cytoskeleton that is attached to the inner layer of the nuclear membrane. It consists of fine protein filaments and serves to provide mechanical reinforcement to the bilayer membrane.

Some of the other functions of the nuclear lamina include:

- Can play a role in regulating gene expression
 - Serves as anchor sites for the pore complexes of the nuclear
 - It regulates material entering or exiting the cell
- * The nuclear membrane is connected to the endoplasmic reticulum in a manner that creates continuity between the nucleus and the external environment (through the lumen of the ER).

Nucleoplasm

Also known as karyoplasm/nucleus sap, the nucleoplasm is a type of protoplasm composed of enzymes, dissolved salts, and several organic molecules. In addition, the nucleoplasm helps cushion and thus protect the nucleolus and chromosomes while also helping maintain the general shape of the nucleus.

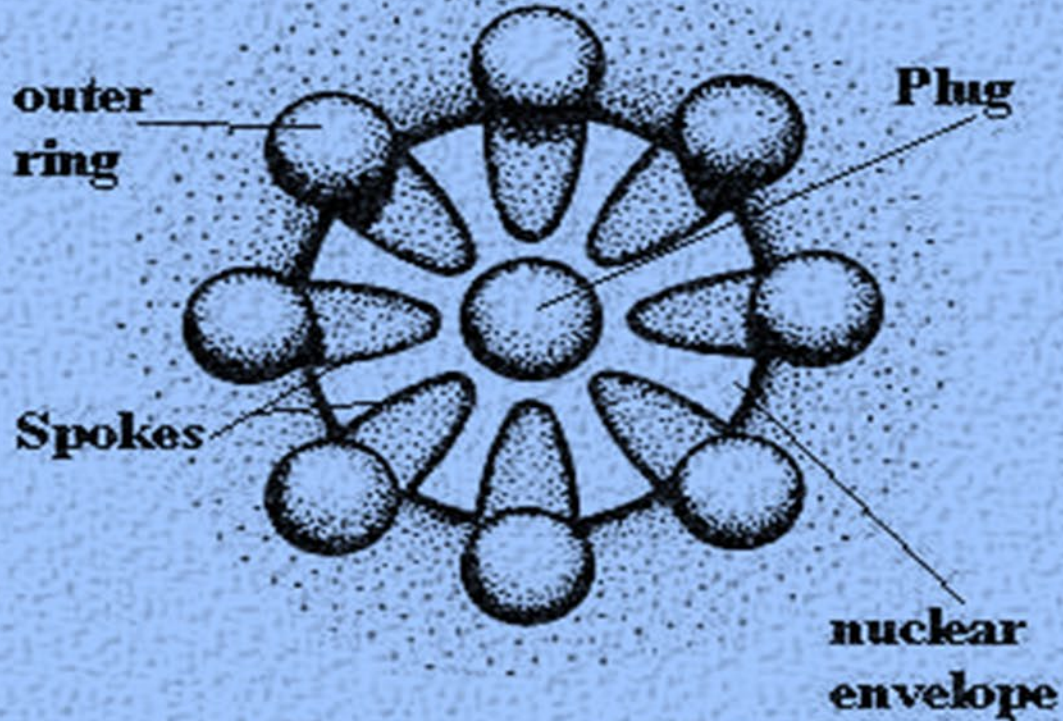
Nucleolus

In the same way that the nucleus is the most prominent organelle of the cell, the nucleolus is the most prominent structure of the nucleus. Unlike the nucleus, however, this dense structure lacks its own membrane.

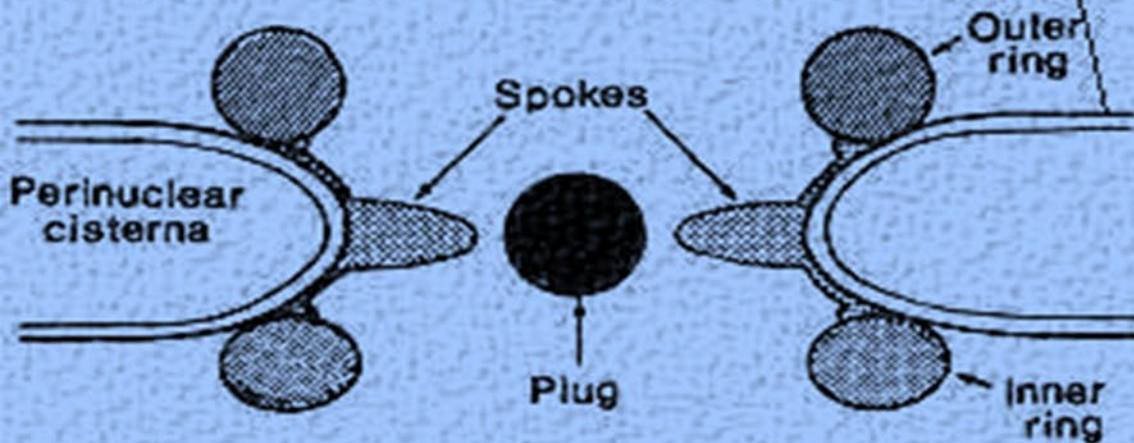
During cell division (mitosis), the nucleolus breaks up only to reform from specific sections of the chromosomes after mitosis.

- * Although the nucleolus is the most prominent (and thus visible) structures of the nucleus, its size is largely dependent on the level of ribosome production as well as the different types of molecular processes that occur in the nucleus.
- * The nucleolus is the site of transcription and processing of the ribosomal gene.
- * In some organisms, the nucleus contains as many as four nucleoli.

View from the top of the pore



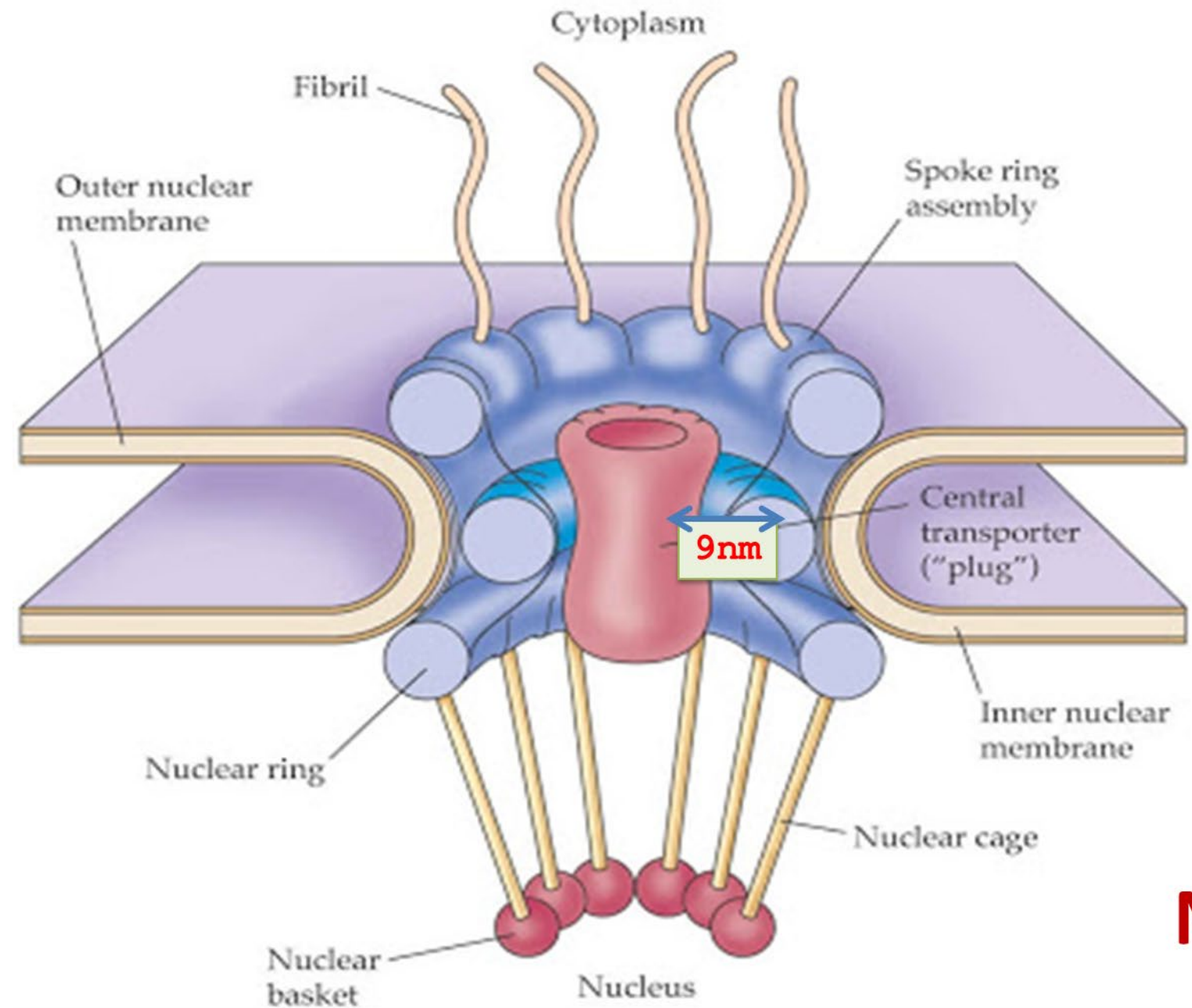
View from the side of the pore



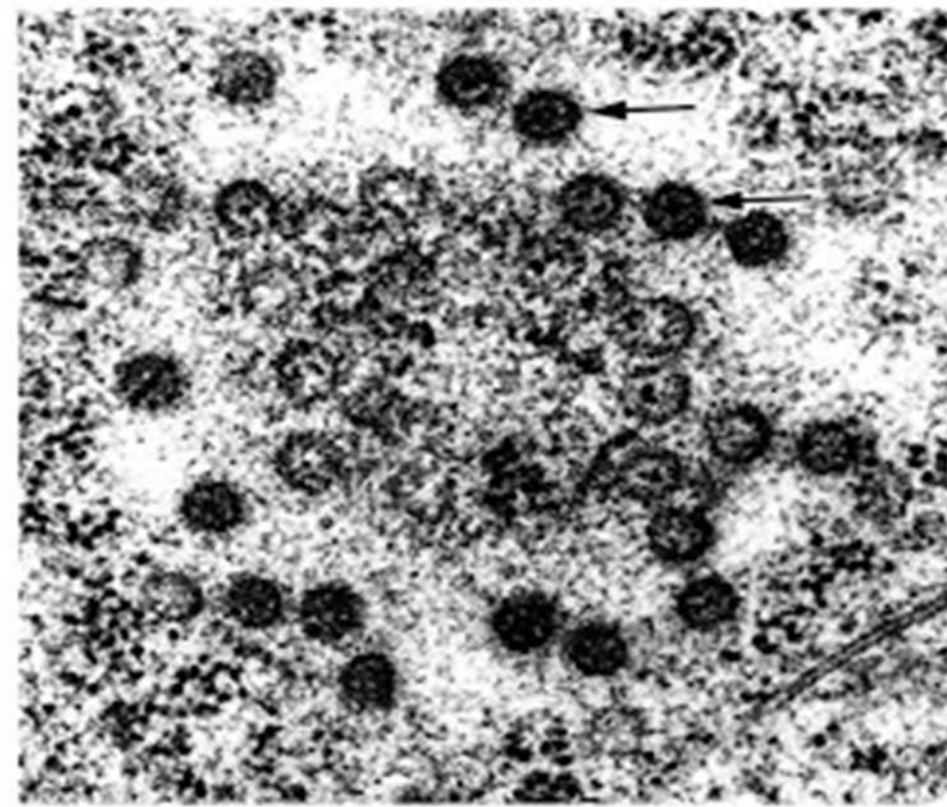
Nuclear Pore Complex

- Allow small molecules to diffuse easily between nucleoplasm & cytoplasm
- Control passage of proteins & RNA protein complexes
 - **Import:** proteins moving in to be incorporated into nuclear structure or to catalyze nuclear activities
 - **Export:** RNA / RNA-protein complexes to the cytoplasm

(A)

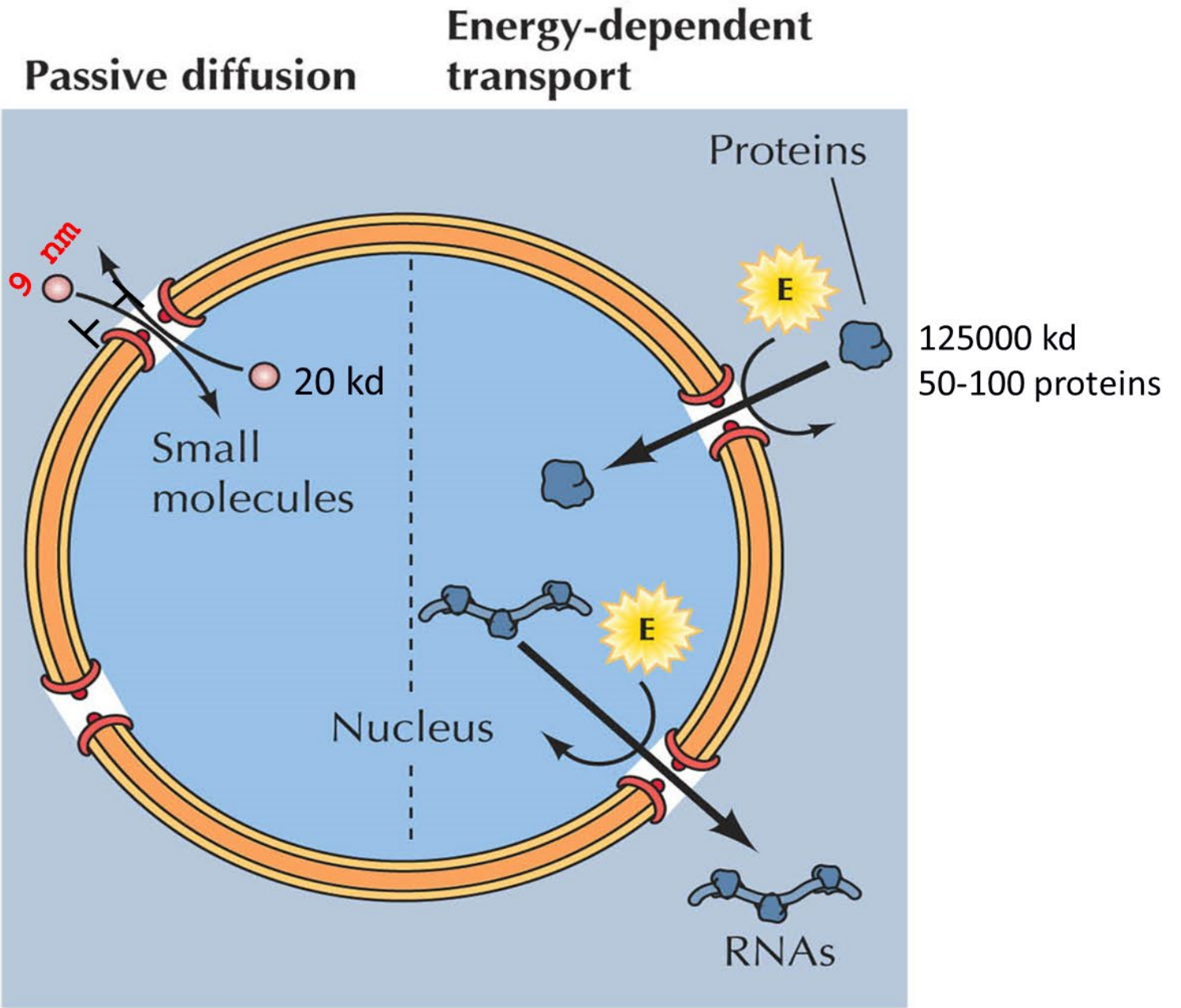


(B)



Nuclear Pore Complex

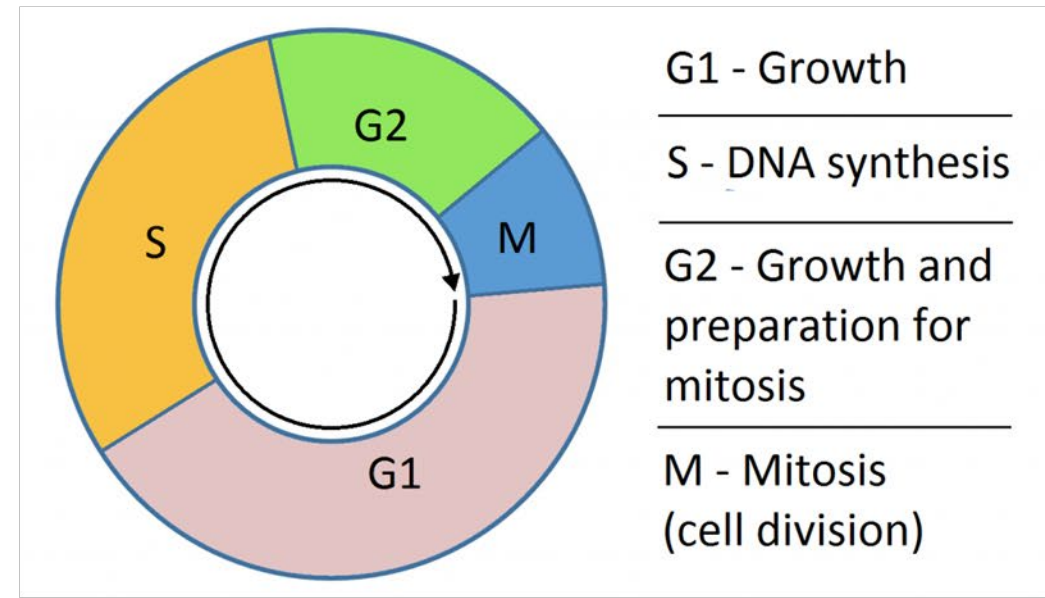
Molecular Traffic through Nuclear Pore Complexes



Genomic Materials

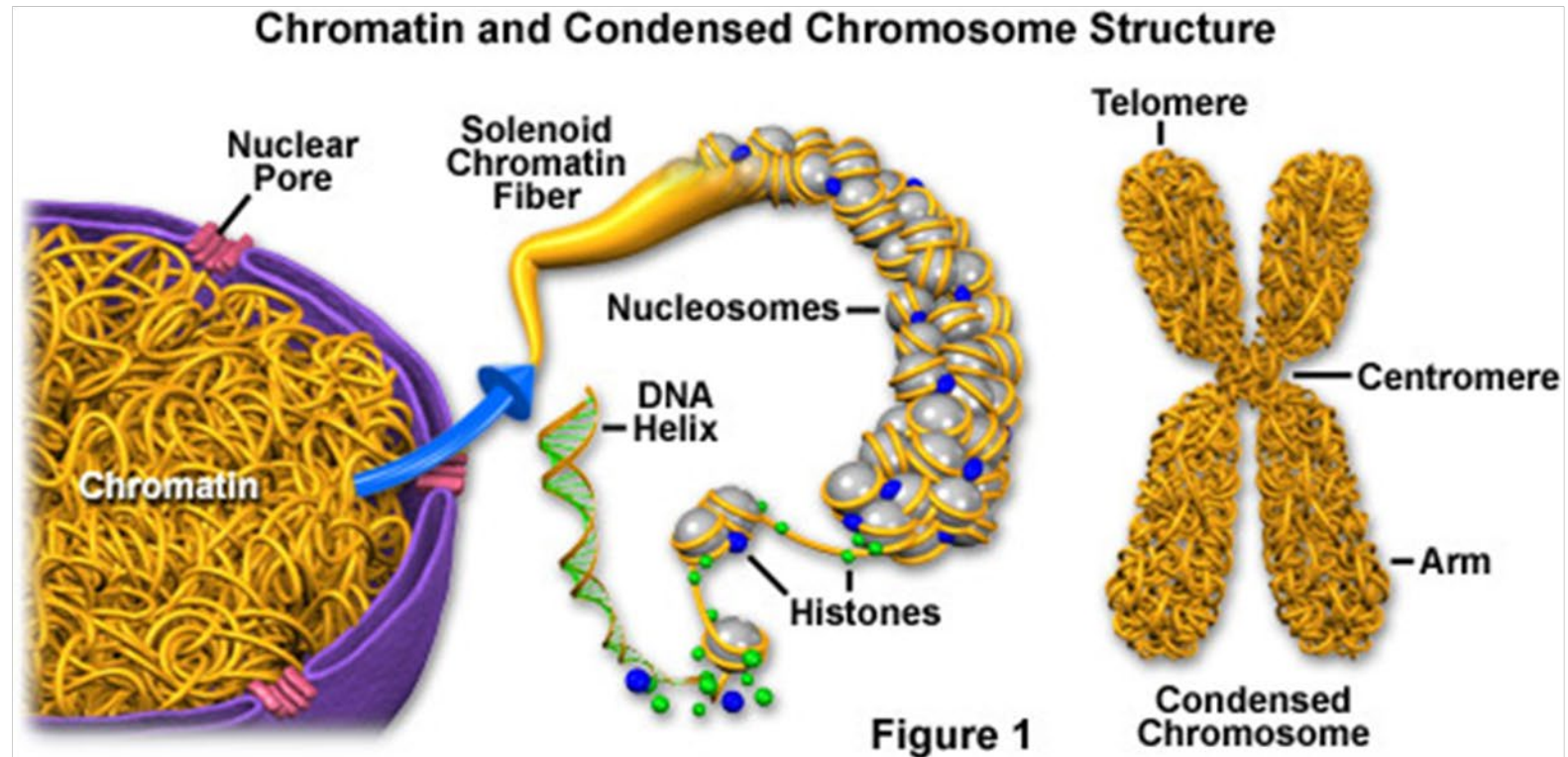
Interphase Nucleus:

In interphase, the chromatin is not yet condensed. Cell performs normal functions.

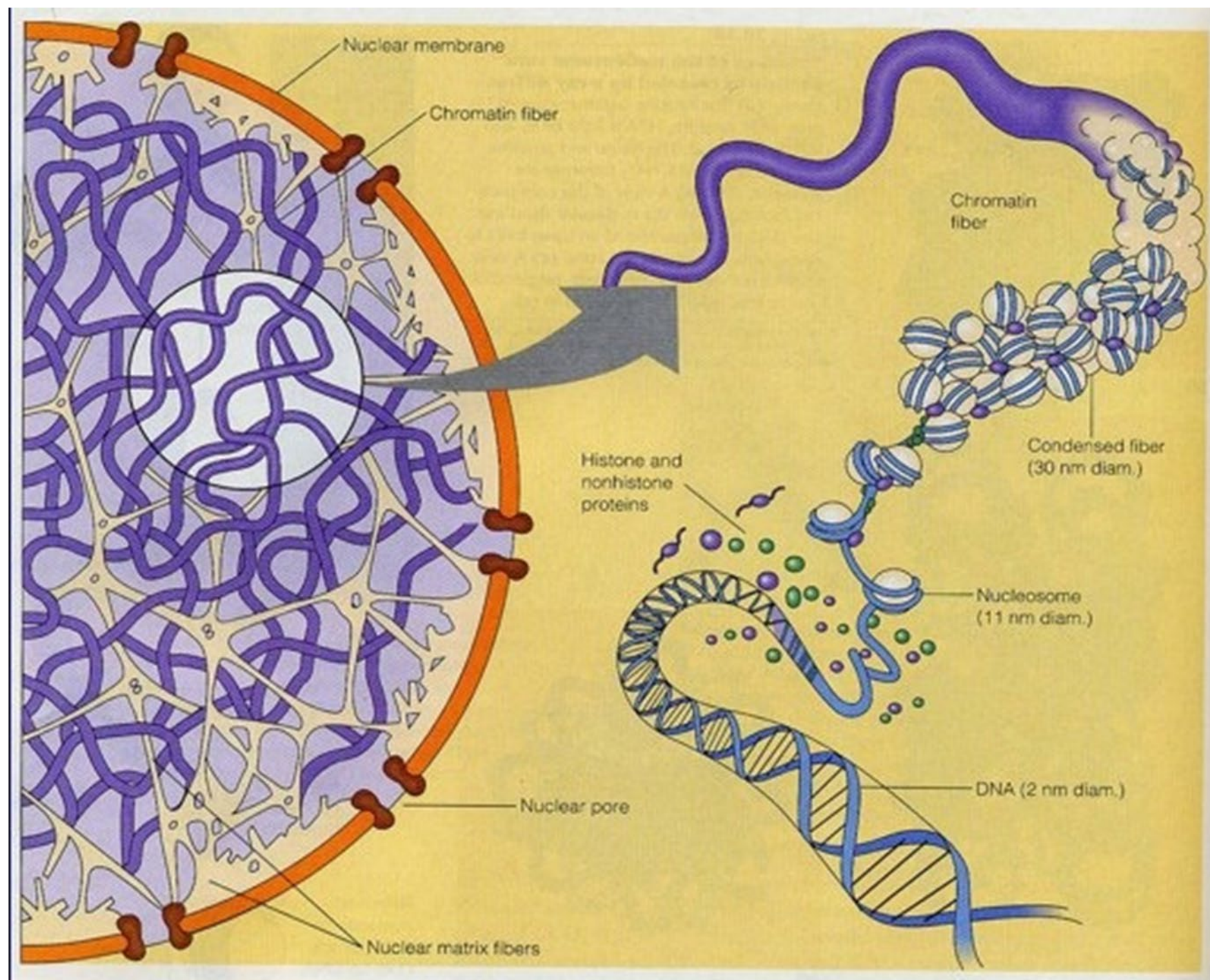


Mitotic Metaphase

Nucleus: chromatin is condensed and organized in the form of chromosomes.

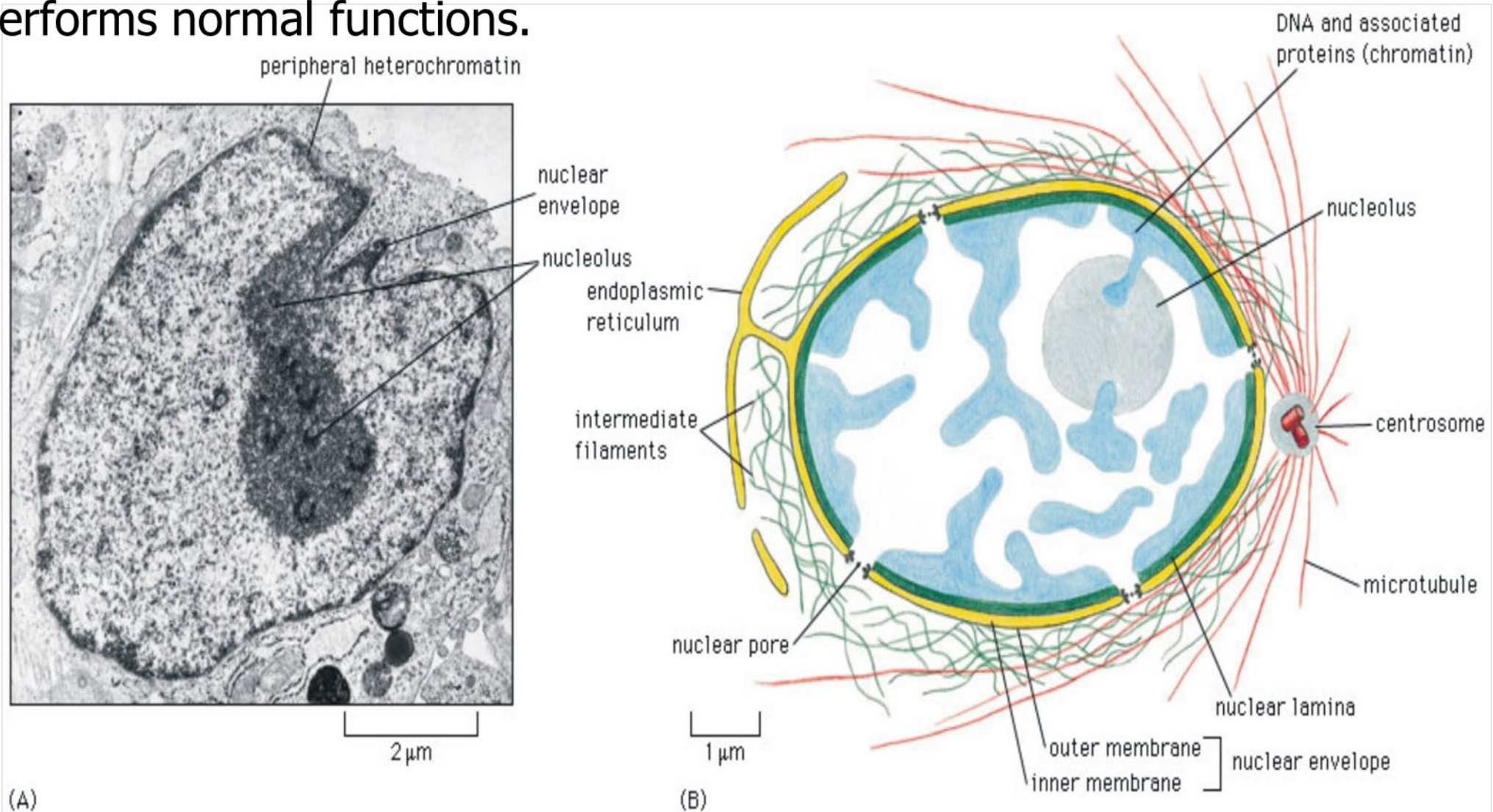


Model for Organization of Chromatin in the Interphase Cell Nucleus



Interphase Nucleus

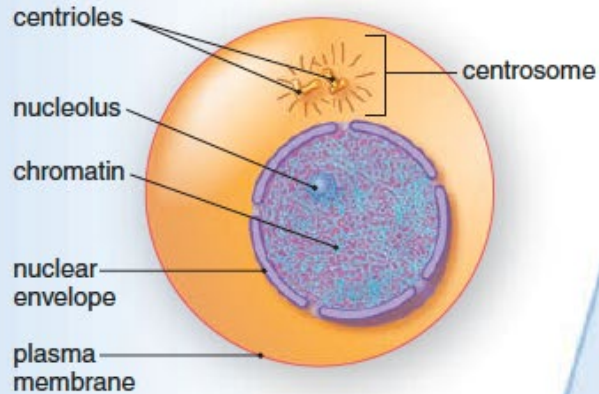
- In interphase, the **chromatin** is not yet condensed.
- Cell performs normal functions.



Cell cycle G₁, S, G₂

Cell cycle M: Phases of mitosis

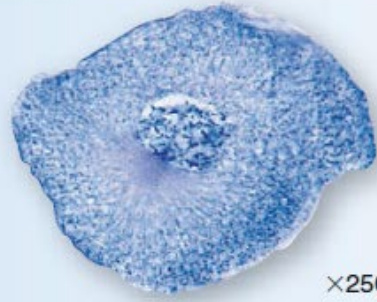
Interphase



Interphase

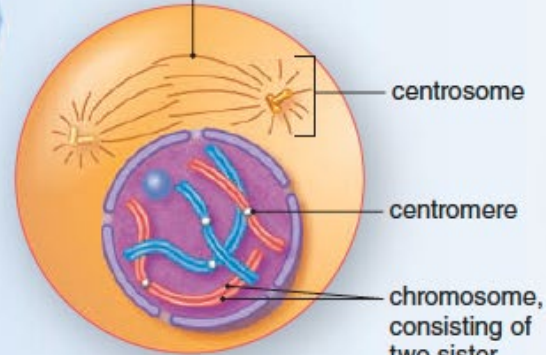
During interphase, the eukaryotic cell duplicates the contents of the cytoplasm, and DNA replicates in the nucleus. The duplicated chromosomes are not yet visible. A pair of centrosomes is outside the nucleus.

Prophase



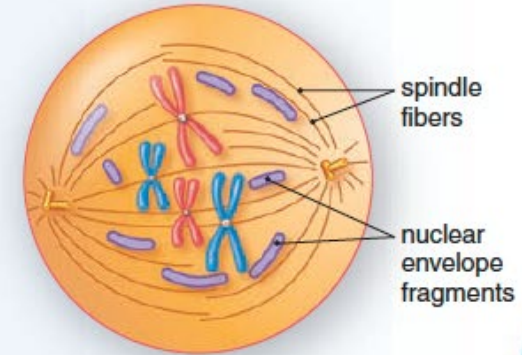
x250

early mitotic spindle



x250

chromosomes



Prophase

During prophase, the chromosomes are condensing. Each consists of two sister chromatids held together at a centromere. Outside the nucleus, the spindle begins to assemble between the separating centrosomes.

Prophase continues with the disappearance of the nucleolus and the breakdown of the nuclear envelope. Spindle fibers from each pole attach to the chromosomes at specialized protein complexes on either side of each centromere. During attachment, a chromosome first moves toward one pole and then toward the other pole.

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