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Cell nucleus

In cell biology, the **nucleus** (pl. *nuclei*) is a membrane-enclosed organelle found in eukaryotic cells. It contains most of the cell's genetic material, organized as multiple long linear DNA molecules in complex with a large variety of proteins, such as histones, to form chromosomes. The genes within these chromosomes are the cell's nuclear genome. 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 main structures making up the nucleus are the nuclear envelope, a double membrane that encloses the entire organelle and unifies its contents from the cellular cytoplasm. The viscous liquid within it is called nucleoplasm, and is similar in composition to the cytosol found outside the nucleus. The nucleoskeleton (which includes nuclear lamina) is a mesh work within the nucleus that adds mechanical support, much like the cytoskeleton, which supports the cell as a whole. Because the nuclear membrane is impermeable to large molecules, nuclear pores are required to allow movement of molecules across the envelope. These pores cross both of the membranes, providing a channel that allows free movement of small molecules and ions. The movement of larger molecules such as proteins is carefully controlled, and requires active transport regulated by carrier proteins. Nuclear transport is crucial to cell function, as movement through the pores is required for both gene expression and chromosomal maintenance. The interior of the nucleus does not contain any membrane-bound sub compartments, its contents are not uniform, and a number of *sub-nuclear bodies* exist, made up of unique proteins, RNA molecules, and particular parts of the chromosomes. The best-known of these is the nucleolus, which is mainly involved in the assembly of ribosomes. After being produced in the nucleolus, ribosomes are exported to the cytoplasm where they translate mRNA.

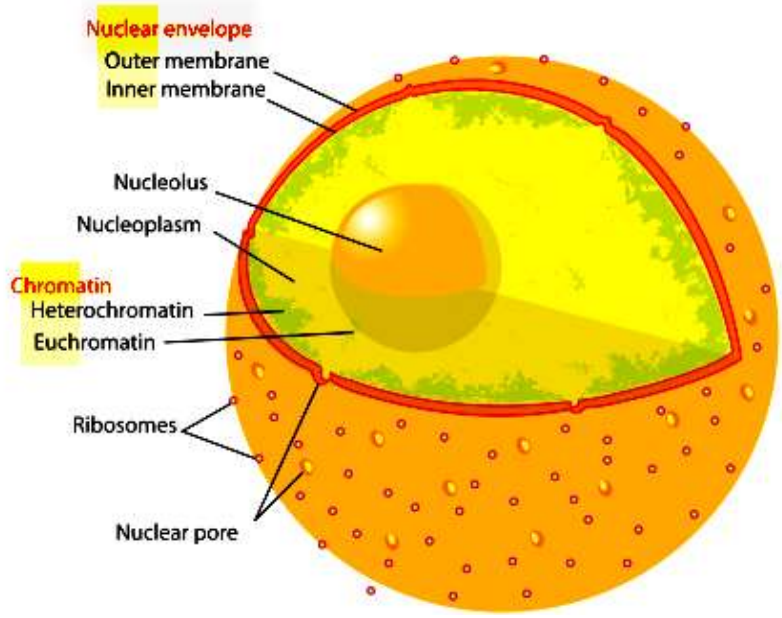
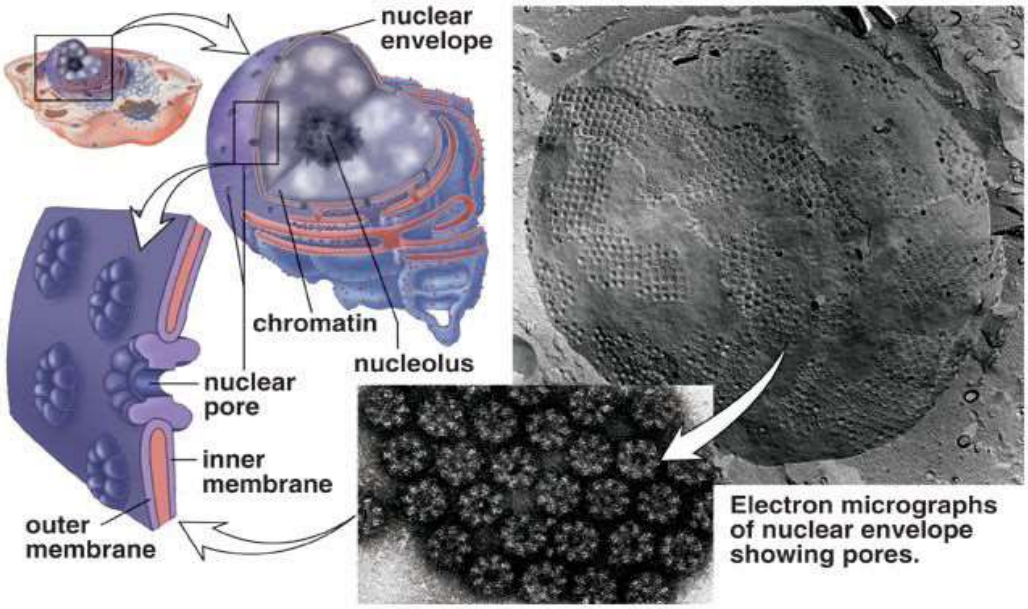
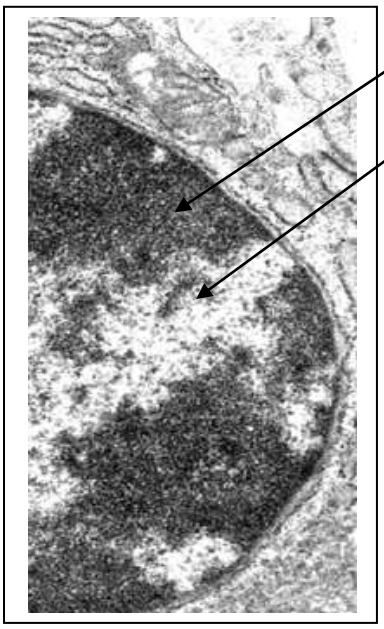


Diagram of cell nucleus

Electron micrograph of the cell nucleus, X 15,000. *The features labeled are heterochromatin (H), euchromatin (E), and the nucleolus (Nu). The presence of the nucleolus and the large amount of rough endoplasmic reticulum in the cytoplasm suggest that the cell is in an active state, i.e. making lots of proteins.*



The nucleus consists of fibrillar material termed chromatin



Chromatin in nuclei exists as:

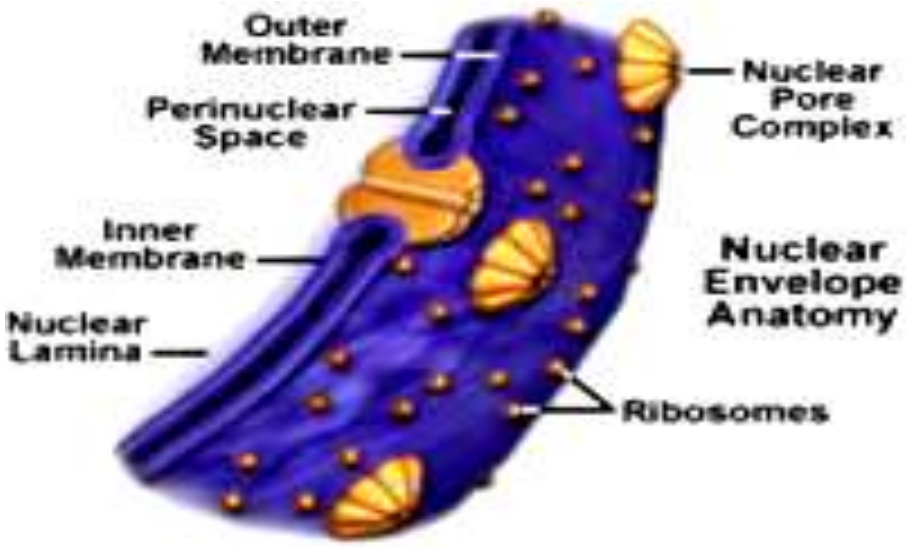
a. heterochromatin - closely packed or condensed fibrils, where DNA is inactive.

b. euchromation - loosely packed fibrils, where active transcription occurs

The amount of euchromatin reflects the state of activity of the nucleus**.** Nuclei of cells that are actively synthesising proteins have a large amount of euchromatin (e.g. neurons renewing their organelles; plasma cells producing antibodies). Cells that are not actively synthesizing protein have heterochromatic nuclei (e.g. circulating lymphocytes are inactive cells in transit; sperm cells have very closely packed heterochromatin)

The Nuclear Envelope

The nuclear envelope is a double-layered membrane that encloses the contents of the nucleus during most of the cell's lifecycle. The outer nuclear membrane is continuous with the membrane of the rough endoplasmic reticulum (**ER**), and like that structure, features numerous ribosomes attached to the surface. The outer membrane is also continuous with the inner nuclear membrane since the two layers are fused together at numerous tiny holes called nuclear pores that perforate the nuclear envelope. These pores regulate the passage of molecules between the nucleus and cytoplasm, permitting some to pass through the membrane, but not others. The space between the outer and inner membranes is termed the **perinuclear space** and is connected with the lumen of the rough ER.



Nuclear Envelope

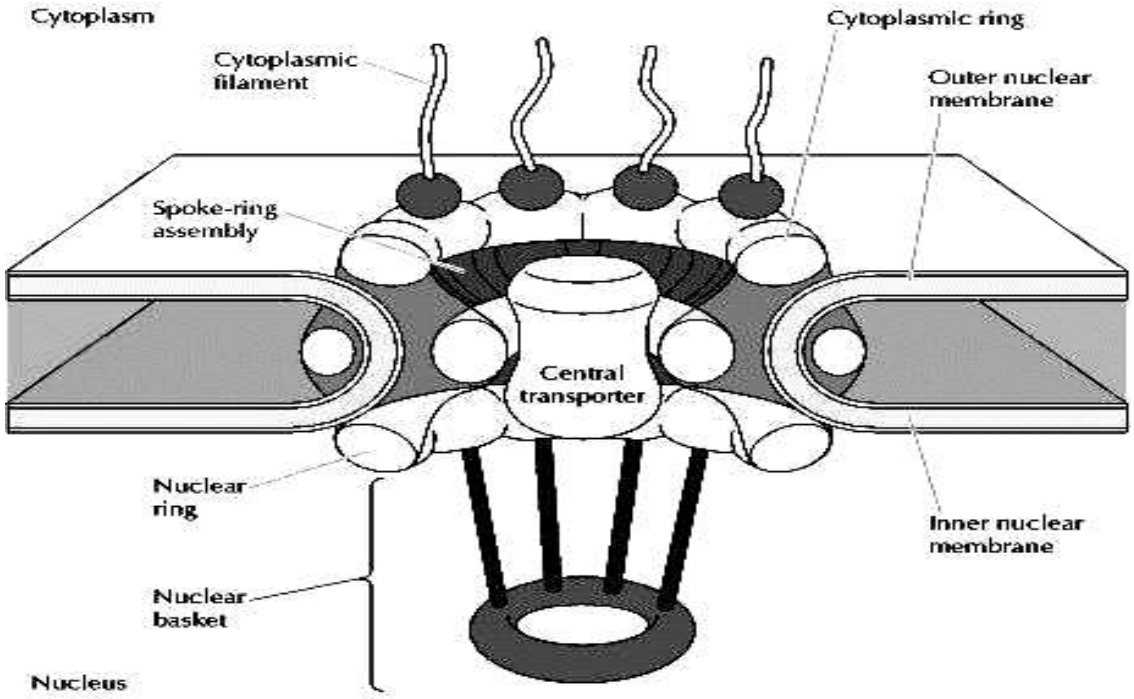
Structural support is provided to the nuclear envelope by two different networks of intermediate filaments. Along the inner surface of the nucleus, one of these networks is organized into a special mesh-like lining called the **nuclear lamina**, which binds to chromatin, integral membrane proteins, and other nuclear components. The nuclear lamina is also thought play a role in directing materials inside the nucleus toward

the nuclear pores for export and in the disintegration of the nuclear envelope during cell division and its subsequent reformation at the end of the process. The other intermediate filament network is located on the outside of the outer nuclear membrane and is not organized in such a systemic way as the nuclear lamina.

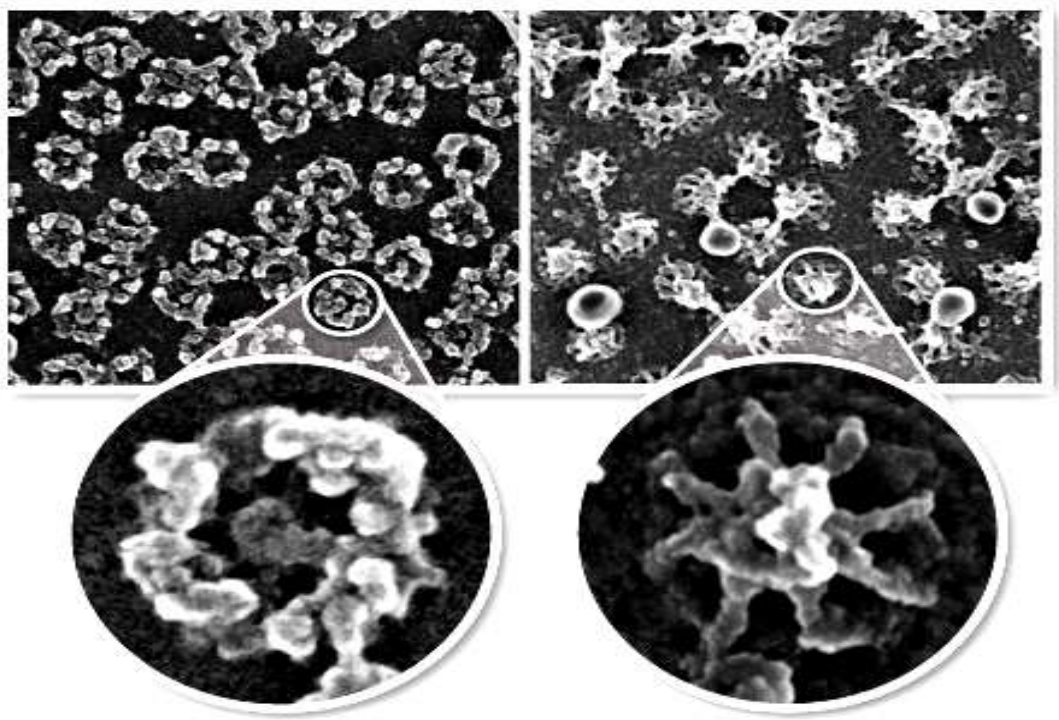
The amount of traffic that must pass through the nuclear envelope on a continuous basis in order for the eukaryotic cell to function properly is considerable. RNA and ribosomal subunits must be constantly transferred from the nucleus where they are made to the cytoplasm, and histones, gene regulatory proteins, DNA and RNA polymerases, and other substances required for nuclear activities must be imported from the cytoplasm. An active mammalian cell can synthesize about 20,000 ribosome subunits per minute, and at certain points in the cell cycle, as many as 30,000 histones per minute are required by the nucleus. In order for such a tremendous number of molecules to pass through the nuclear envelope in a timely manner, the nuclear pores must be highly efficient at selectively allowing the passage of materials to and from the nucleus.

Nuclear pore complexes

Visualization of nuclear pore complexes by electron microscopy reveals a structure with eightfold symmetry organized around a large central channel, which is the route through which proteins and RNAs cross the nuclear envelope. Detailed structural studies, including computer-based image analysis, have led to the development of three-dimensional models of the nuclear pore complex as in the figure below. These studies indicate that the nuclear pore complex consists of an assembly of eight spokes arranged around a central channel. The spokes are connected to rings at the nuclear and cytoplasmic surfaces, and the spoke-ring assembly is anchored within the nuclear envelope at sites of fusion between the inner and outer nuclear membranes. Protein filaments extend from both the cytoplasmic and nuclear rings, forming a distinct basketlike structure on the nuclear side.



Nuclear pore complex



The nuclear pore complex by scanning electron microscope as seen from the cytoplasm (left) and from inside the nucleus (right).