

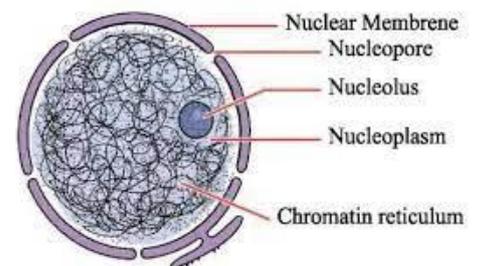
Nucleus

The cell nucleus is a membrane-bound structure that contains a cell's hereditary information and controls its growth and reproduction. It is the command center of a eukaryotic cell and is usually the most notable cell organelle in both size and function.

- ✓ The nucleus (nuclei, plural) the largest component of a cell, frequently appears as rounded, oval, flat, kidney shape, horse shoe shape, segmented or lobulated structure.
- ✓ Position of nucleus often near the center of the cell (central) but in some cells the nucleus located eccentric, basal or peripheral like in fat cells.
- ✓ Most cells have a single nucleus called mononucleated, some cells have two nucleus called binucleated as in liver cells (hepatocyte) or other cells may exhibit multiple nuclei called multinucleated as osteoclast and skeletal muscles. Or anuclear like red blood cells (RBCs)
- ✓ The nucleus stores genetic information. Every cell in the body contains the same genes.
- ✓ **L.M.:** it is basophilic; it may either be lightly stained (vesicular) like the nucleus of neuron (nerve cells) or be deep stained the details of its component are not seen like the nucleus of lymphocyte.
- ✓ The nucleus of a **non dividing** cell consists of the following components:

The nucleus consists of the following parts:

1. Nucleolemma or nuclear membrane (karyotheca)
2. Nuclear sap or karyolymph or nucleoplasm
3. Chromatin network
4. Nucleolus



1. Nuclear Envelope or nuclear membrane(karyotheca)

The nuclear envelope forms a selectively permeable barrier (double membrane) between the nucleus and cytoplasmic compartments.

Light microscopy appears as a basophilic line surrounding the nucleus.

Electron microscopy reveals that the envelope has two concentric membranes the outer one is called **ectokaryotheca** and inner one is termed **endokaryotheca** separated by a narrow perinuclear space. This space and the outer nuclear membrane are continuous with the extensive cytoplasmic network of the rough endoplasmic reticulum.

Closely associated with the inner nuclear membrane is a highly organized meshwork of proteins called the **nuclear lamina**, which stabilizes the nuclear envelope. Major components of this layer are the class of intermediate filament proteins called **lamins** that bind to membrane proteins and associate with chromatin in non-dividing cells.

The inner and outer nuclear membranes are bridged at nuclear pore complexes. Various core proteins of a nuclear pore complex called **nucleoporins**. Although ions and small solutes pass through the channels by simple diffusion, the pore complexes regulate movement of macromolecules between the nucleus and cytoplasm. Macromolecules shipped out of the nucleus include ribosomal subunits and other RNAs associated with proteins, while inbound traffic consists of chromatin proteins, ribosomal proteins, transcription factors, and enzymes.

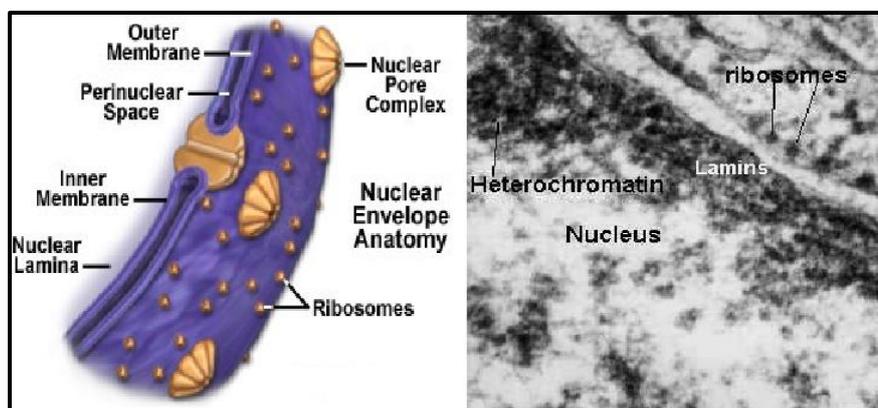


Figure: Nuclear envelop anatomy

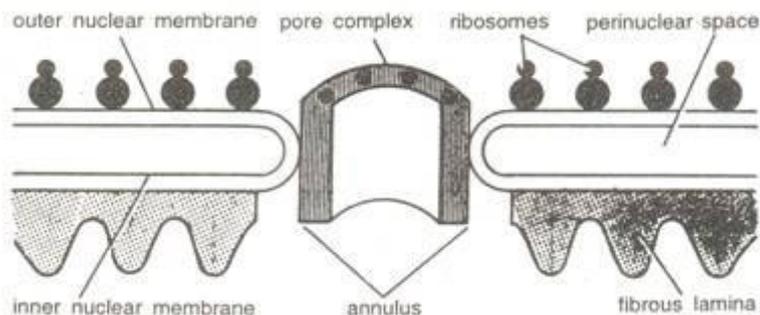
Medical Application

Certain mutations in the gene coding for lamin A are associated with a subtype of the disorder progeria, which causes premature aging.

Functions of nuclear envelope are to regulate the entry of proteins (histone and hormones) to the nucleus and export of RNAs from nucleus to the cytoplasm. Also encloses the nucleus and separates the genetic material of the cell from the cytoplasm of the cell. And it serves as a barrier to prevent passage of macromolecules freely between the nucleoplasm and the cytoplasm.

Nuclear pores

The nuclear membrane possesses a number of nuclear pores or **annuli**, which vary from 40 to 145 per square micro-meter in nuclei.



The materials exchanged between nucleus and cytoplasm must traverse the nuclear pore complexes. Thus, annuli or pores control the passage of some molecules and particles, even some ribosome components, between nucleus and cytoplasm. This exchange is very selective and allows passage of only certain molecules of either low or very high molecular weight. The nuclear envelope is a diffusion barrier for ions as small as K^+ , Na^+ or Cl^- .

On the other hand, very large structures such as ribosomal subunits, which are assembled in the nucleolus, are able to leave the nucleus through the nuclear pore complexes.

✚ The unit membranes of karyotheca are composed of protein and lipid, like plasma membrane.

2. Chromatin material

Chromatin is the combination of DNA molecules and proteins (HISTONES). Chromatin can coil tightly to form visible chromosomes during cell division. Most of the time, however, the chromatin is uncoiled. Individual chromosomes cannot be distinguished and the chromatin appears grainy in electron micrographs of the nucleus.

(This will be discussed in details in next lectures)

3. Nucleolus

- ✓ Micrographs of a nucleus do show one or more dark regions of the chromatin with spongy appearance. These are nucleoli (sing., **nucleolus**).
- ✓ The nucleolus is a generally spherical, highly basophilic subdomain of nuclei in cells.
- ✓ The nucleolus is not surrounded by a membrane, it is a densely stained structure found in the nucleus.

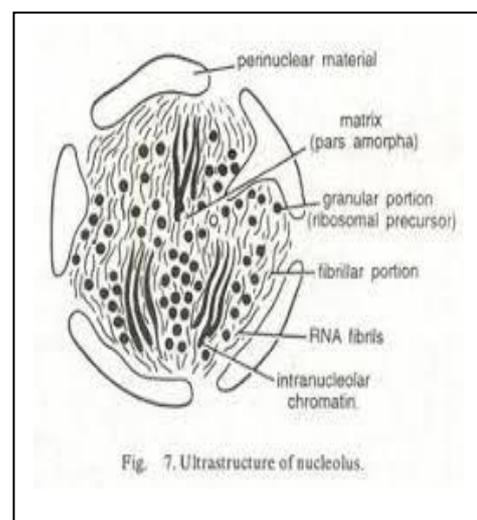


Fig. 7. Ultrastructure of nucleolus.

- ✓ The intense basophilia of nucleoli is due not to heterochromatin but to the presence of densely concentrated ribosomal RNA (rRNA) that is transcribed, processed, and complexed into ribosomal subunits in nucleoli.
- ✓ Chromosomal regions (satellite stalk of acrocentric chromosomes) with the genes for rRNA organize one or more nucleoli in cells requiring intense ribosome production
- ✓ Molecules of rRNA are processed in the nucleolus and very quickly associate with the ribosomal proteins imported from the cytoplasm via nuclear pore complexes. The newly organized small and large ribosomal subunits are exported back to the cytoplasm through those same nuclear pores.
- ✓ **Nucleolus Functions:** The nucleolus is mainly involved in the production of subunits which then together form ribosomes. Therefore, nucleolus plays an important role in rRNA synthesis and the production of ribosomes in eukaryotic cells.

4. Nucleoplasm or nuclear sap or karyolymph

- ✓ Chromatin is immersed in a semi fluid medium called the **nucleoplasm**.
- ✓ A nucleoplasm has a different composition from cytoplasm.
- ✓ The nucleus contains a transparent, semi-solid, granular and homogeneous matrix during interphase called as nuclear sap or karyolymph.
- ✓ karyolymph is a fluid substance containing many particles and network. Primarily it is composed of proteinous material and is the main site for enzyme activity.
- ✓ This nuclear sap also shows variable appearance during different stages of cell division.

❖ **Nuclear constituents:**

The nucleus contains RNA, DNA, proteins of two kinds, histone and nonhistone; some lipids; various organic phosphorus compounds; and various inorganic compounds, mostly salts.

Deoxyribonucleoproteins:

- ✓ These largely form the chromosomes; consist primarily of **histone** and **DNA** in about equal amounts. However, chromosomes also contain non-histone proteins in smaller amounts.

- ✓ Unlike histones (basic), most of the nonhistone proteins are acidic, and they vary qualitatively in different cell types of the same organism.
- ✓ Both histones and nonhistone proteins are synthesized in the cytoplasm and enter the nucleus through the nuclear envelope.
- ✓ Histones are synthesized only when DNA is replicated, whereas nonhistone proteins are synthesized continuously.
- ✓ Histones induce a compact structure in the chromosome.
- ✓ Histones are also considered as stabilizers against heat damage and against nucleases.
- ✓ Activation and repression of genes expression are thought to be carried out by nonhistone proteins.
- ✓ The mechanism by which this is done in eukaryotic cells is less clear than it is in prokaryotic cells.
- ✓ All the proteins are synthesized in the cytoplasm and then transported into the nucleus.

➤ **Functions of nucleus are:**

1. Controls the heredity characteristics of an organism.
2. Responsible for regulation of protein synthesis (gene expression), cell division, growth and differentiation.
3. Stores heredity material in the form of deoxy-ribonucleic acid (DNA) strands.
4. Stores ribonucleic acid (RNA) in the nucleolus.
5. Site for transcription process in which messenger RNA (m RNA) are produced for protein synthesis.
6. Regulates the integrity of genes and gene expression.

So, the nucleus called the control center of a cell.