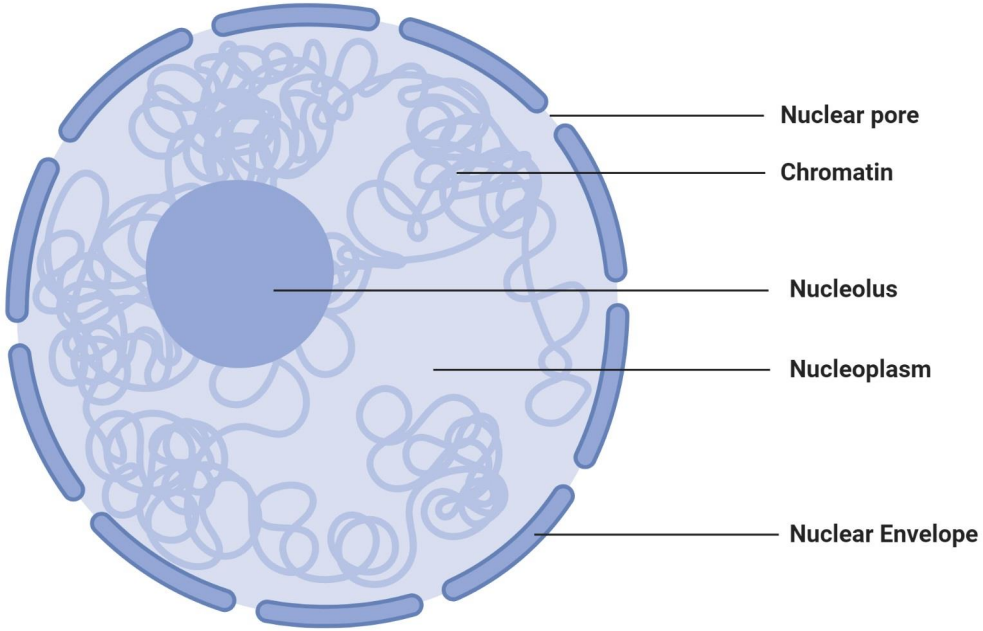
Nucleus



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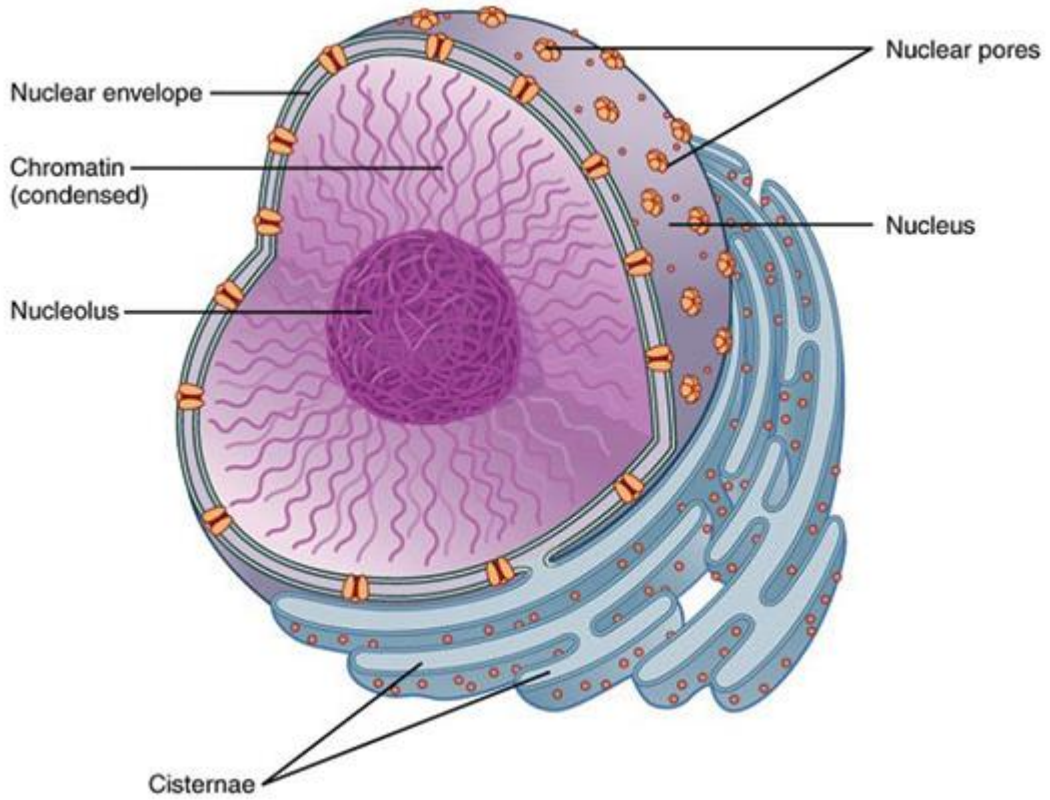
Nucleus



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Nucleus

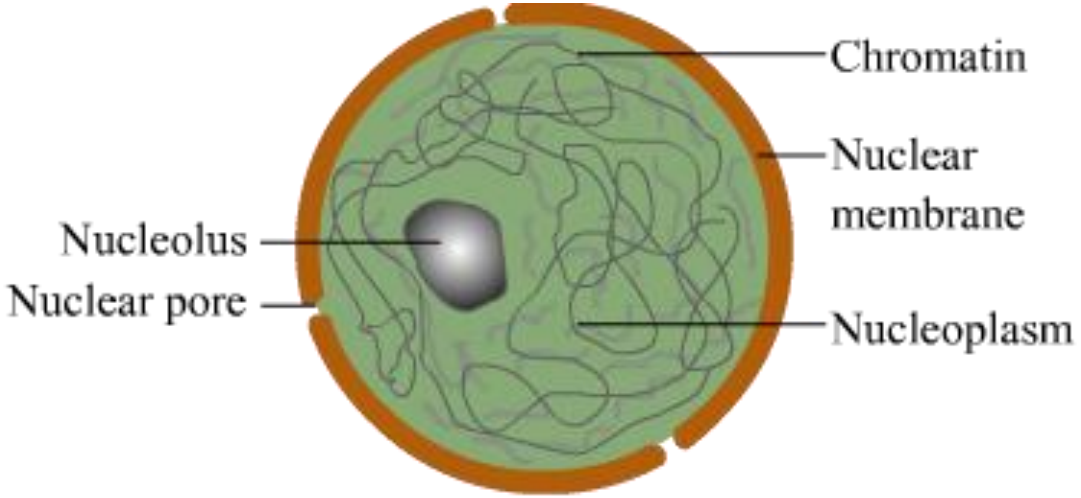
Discovery

- The detail structure of nucleus was preposed by Scottish botanist Robert Brown in 1931 in orchids cell

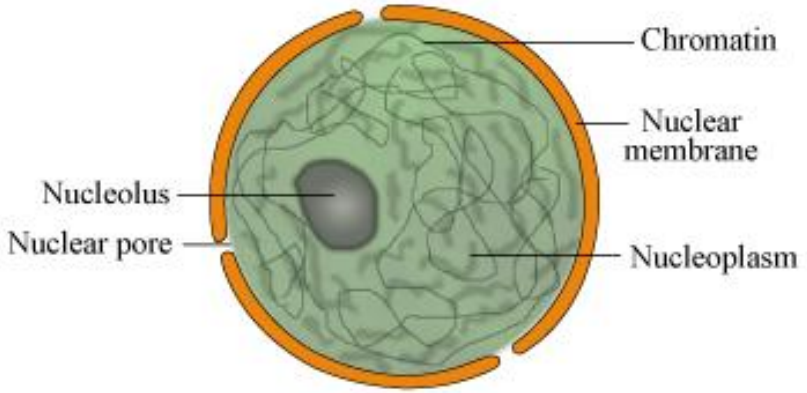
Nucleus

Definition

- A nucleus is defined as a double-membraned eukaryotic cell organelle that contains the genetic material.



Introduction



- The nucleus is a essential organelle & responsible to regulate almost all forms of cellular activities

- Mostly, every type of cell that exists is categorized on the basis of the absence or presence of the nucleus within its cell (categorized either as a prokaryotic or eukaryotic cell.)

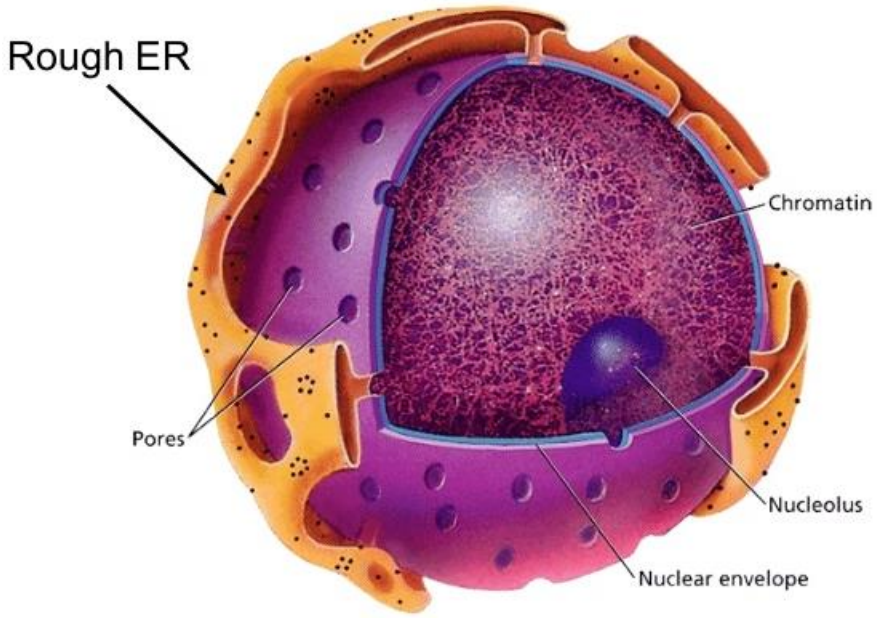
- The majority of human cells have a single nucleus, although there are several cell types that have multiple nuclei (e.g. osteoclasts) or don't have a nucleus at all (erythrocytes).

Introduction

- The nucleus can be described as the command center of a eukaryotic cell and is commonly the most prominent organelle in a cell accounting for about 10 percent of the cell's volume.

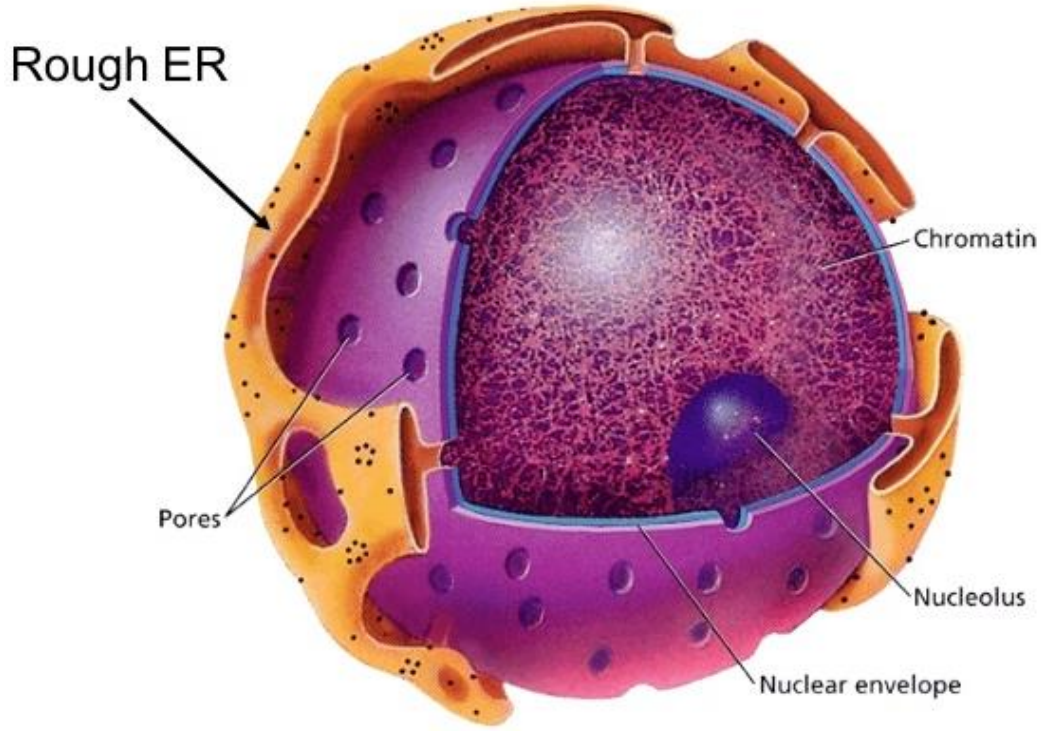
- The nucleus is separated from the rest of the cell or the cytoplasm by a nuclear membrane.

- As the nucleus regulates the integrity of genes and gene expression, it is also referred to as the control center of a cell.



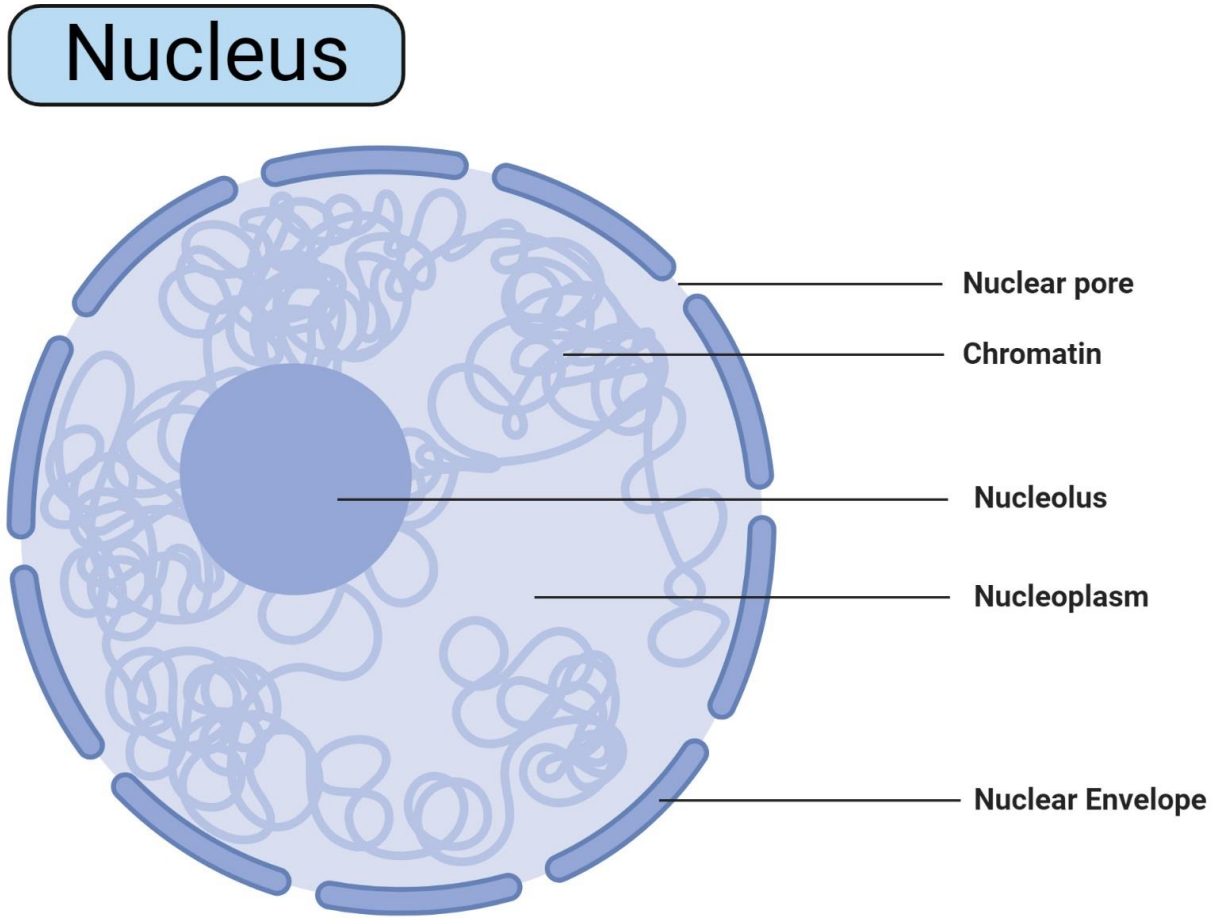
Shape

- The nucleus is normally around 5-10 μm in diameter in many multicellular organisms, and the largest organelle in the cell.
- The smallest nuclei are approximately 1 μm in diameter and are found in yeast cells.
- Mostly the shape of the nucleus is spherical
- Usually cells have one nucleus but many at times there are multinucleated cells.



Structure of Nucleus

- **The structure of a nucleus encompasses**
  i. Nuclear membrane
  ii. Nucleoplasm
  iii. Chromosomes
  iv. Nucleolus.



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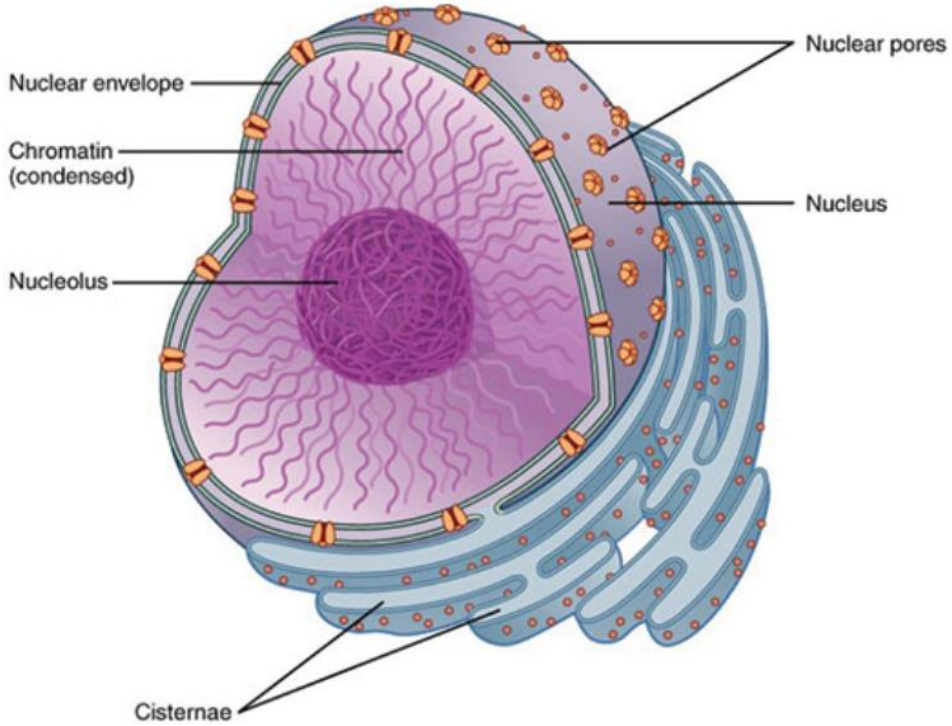
Structure of Nucleus

i. Nuclear membrane

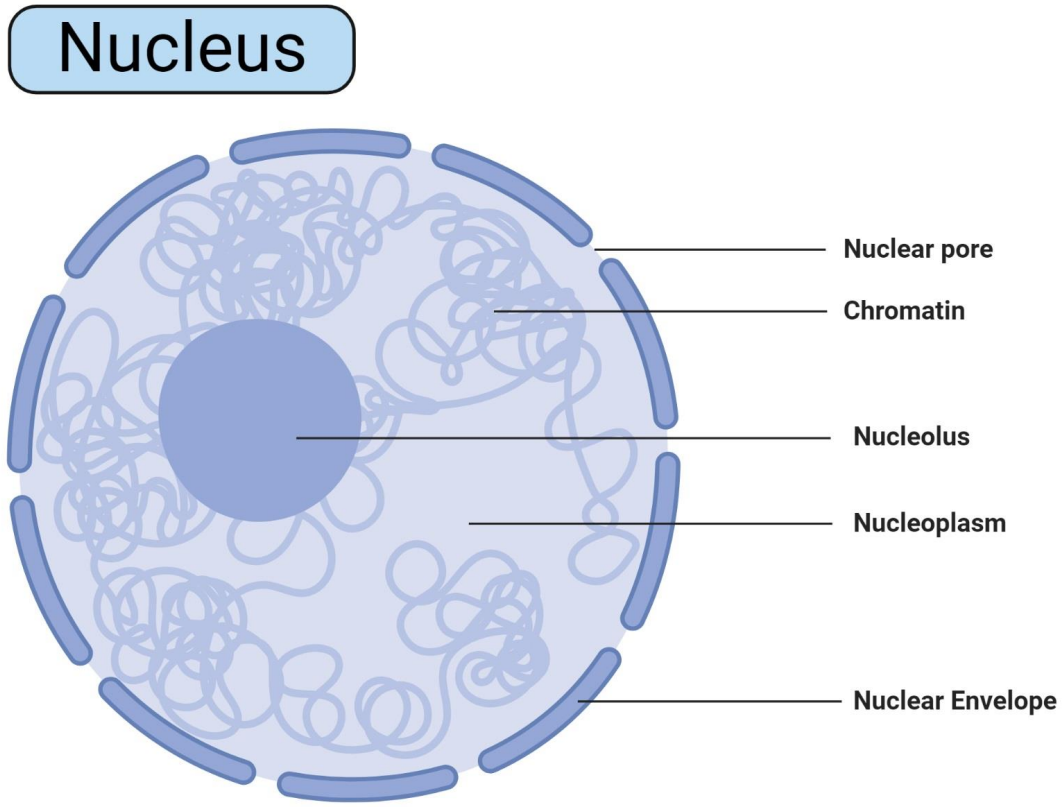
- The nuclear membrane is a double-layered structure that encloses the contents of the nucleus. The outer layer of the membrane is connected to the endoplasmic reticulum.
- Like the cell membrane, the nuclear envelope consists of phospholipids that form a lipid bilayer.
- The envelope helps to maintain the shape of the nucleus and assists in regulating the flow of molecules into and out of the nucleus through nuclear pores.
- The nucleus communicates with the remaining of the cell or the cytoplasm through several openings called nuclear pores.



i. Nuclear membrane

- Such nuclear pores are the sites for the exchange of large molecules (proteins and RNA) between the nucleus and cytoplasm.

- A fluid-filled space or perinuclear space is present between the two layers of a nuclear membrane.



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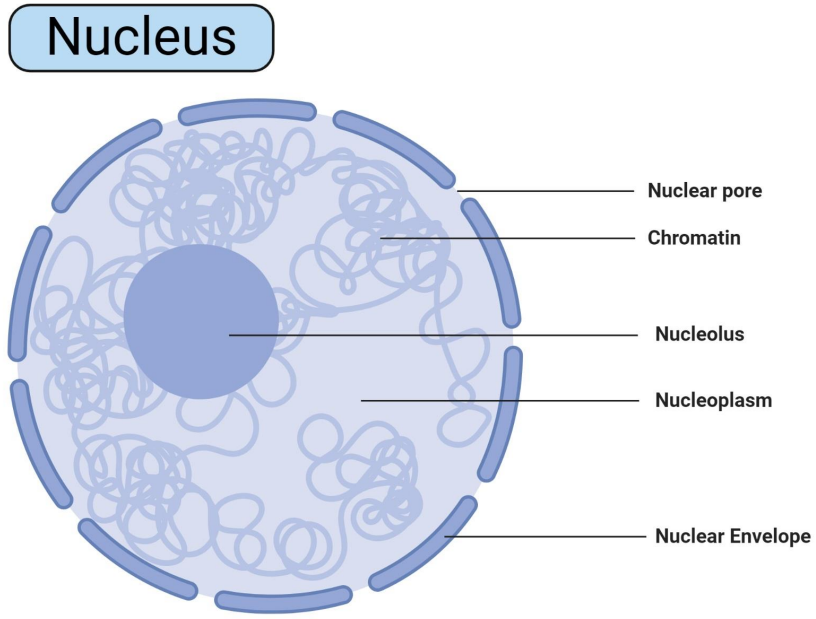
ii. Nucleoplasm

- Nucleoplasm is the gelatinous substance within the nuclear envelope.
- Also called karyoplasm, this semi-aqueous material is similar to the cytoplasm and is composed mainly of water with dissolved salts, enzymes, and organic molecules suspended within.
- The nucleolus and chromosomes are surrounded by nucleoplasm, which functions to cushion and protect the contents of the nucleus.



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- Nucleoplasm also supports the nucleus by helping to maintain its shape.
- Additionally, nucleoplasm provides a medium by which materials, such as enzymes and nucleotides (DNA and RNA subunits), can be transported throughout the nucleus.
- Substances are exchanged between the cytoplasm and nucleoplasm through nuclear pores.

iii. Chromosomes

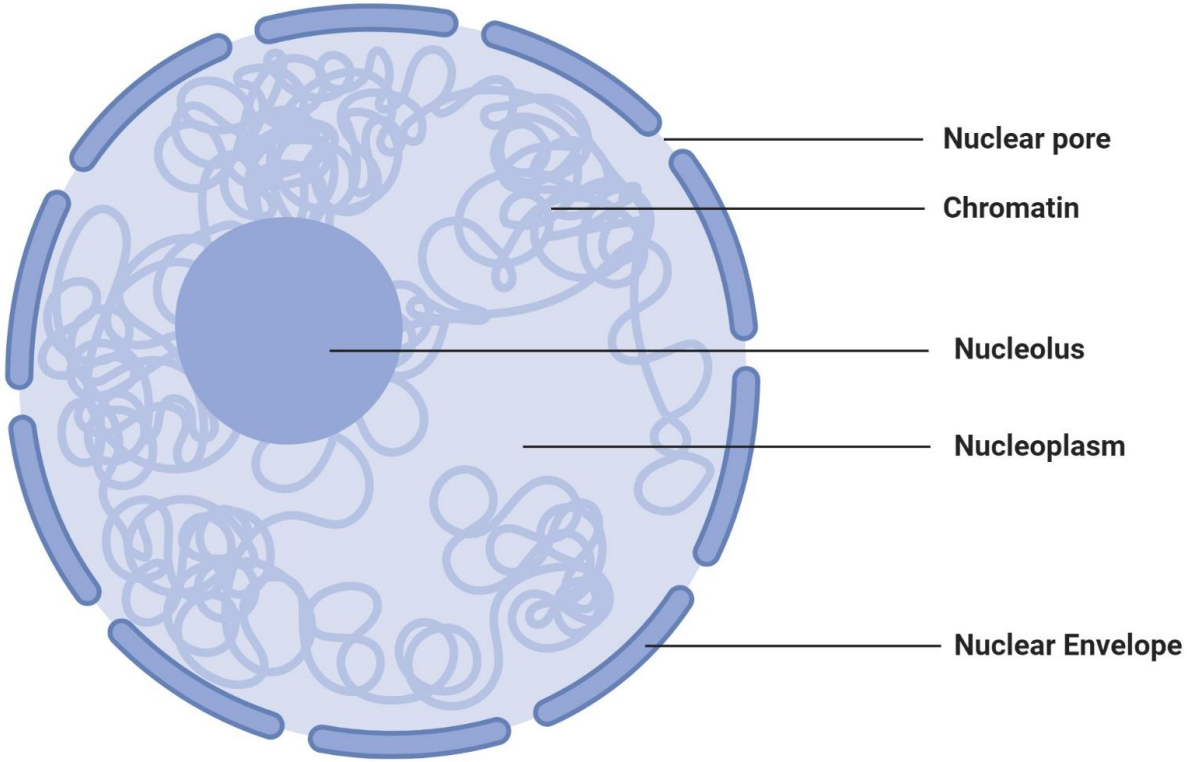
- The nucleus is the organelle that houses chromosomes.
- Chromosomes consist of DNA, which contains heredity information and instructions for cell growth, development, and reproduction.
- Chromosomes are present in the form of strings of DNA and histones (protein molecules) called chromatin.
- When a cell is “resting” i.e. not dividing, the chromosomes are organized into long entangled structures called chromatin.
- The chromatin is further classified into heterochromatin and euchromatin based on the functions.
- The former type is a highly condensed, transcriptionally inactive form, mostly present adjacent to the nuclear membrane. On the other hand, euchromatin is a delicate, less condensed organization of chromatin, which is found abundantly in a transcribing cell.

iv. Nucleolus

- Contained within the nucleus is a dense, membrane-less structure composed of RNA and proteins called the nucleolus.
- Some of the eukaryotic organisms have a nucleus that contains up to four nucleoli.
- The nucleolus contains nucleolar organizers, which are parts of chromosomes with the genes for ribosome synthesis on them.
- The nucleolus helps to synthesize ribosomes by transcribing and assembling ribosomal RNA subunits. These subunits join together to form a ribosome during protein synthesis.
- The nucleolus disappears when a cell undergoes division and is reformed after the completion of cell division.

Nuclear membrane

- Estable and Sotelo (1951) described the structure of a nucleolus under the light microscope.
- According to them, nucleolus consists of a continuous coiled filament called the nucleolonema embedded in a homogenous matrix, the pars amorpha.
- Diameter – 100- 300 A



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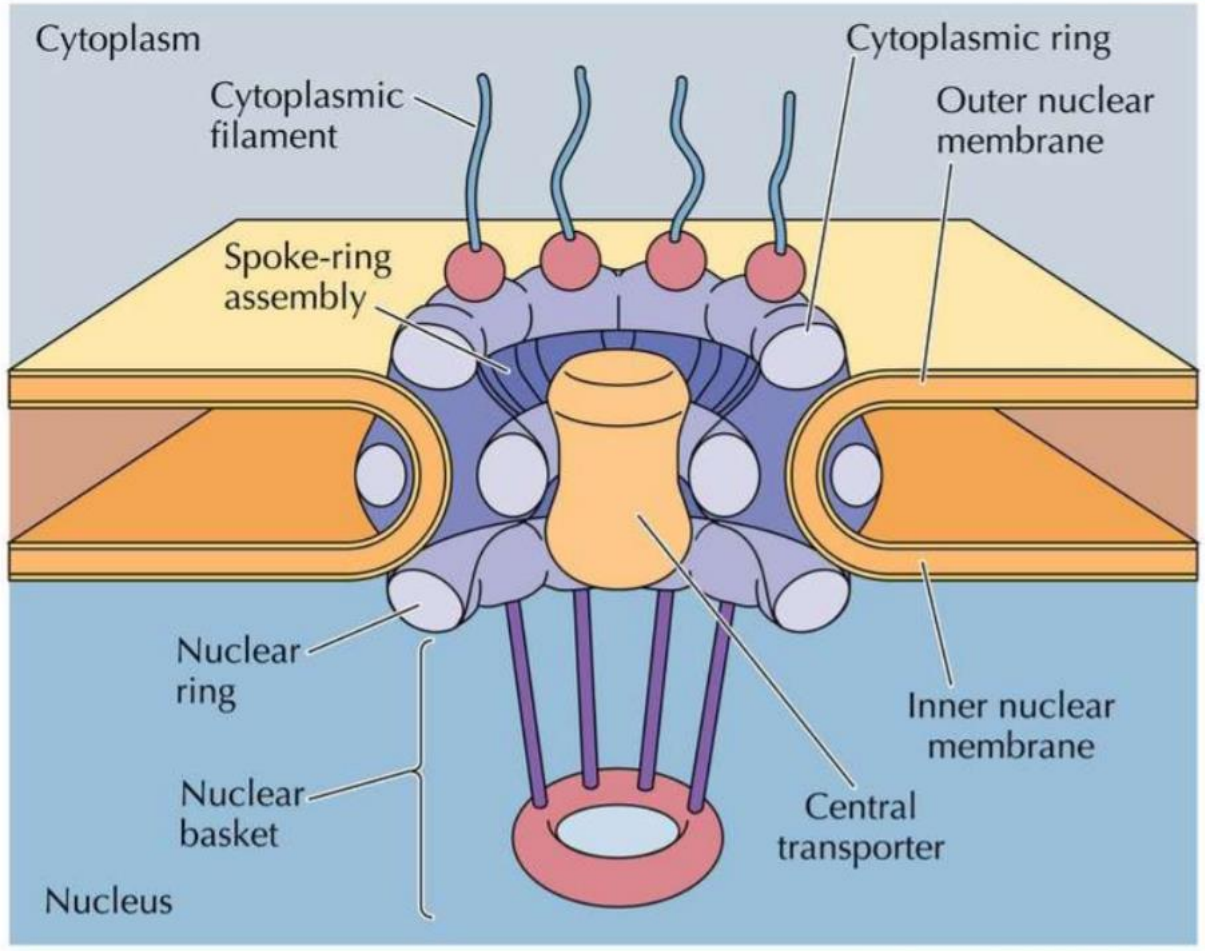
Nuclear Pore Complex

- **Pore Diameter- 800 A°**
- **Molecule enter – 500 A°**
- **No. of pore – 1000- 10000/ nucleus**



Nuclear Sap / Nuclear Matrix

- The body of nucleus within the nuclear envelope is made up of a dense jelly-like mass which is composed of two elements, each of which dynamic in nature & has complex chemical composition.
- These elements of nuclear sap are the nuclear gel or Karyolymph & chromatin

Nuclear Gel

- It is highly granular, containing fibrous material.
- It is rich in proteins, which account for more than 90 % the material.
- The small % of DNA, RNA & Phospholipids is also present

Nuclear Gel

- The proteins are largely acidic & they have an unusual property of expanding & contracting under the influence of Ca ions & Mg ions.
- In this region, events like replication of DNA, Transcription & transport of substances take place.

The Chromatin

- The outer compartments of the nuclear matrix include nucleolus & chromatin.
- The chromatin is present in a condensed form called heterochromatin. Which is present in patches near the nuclear envelope, either scattered in the interior or surrounding nucleoli.

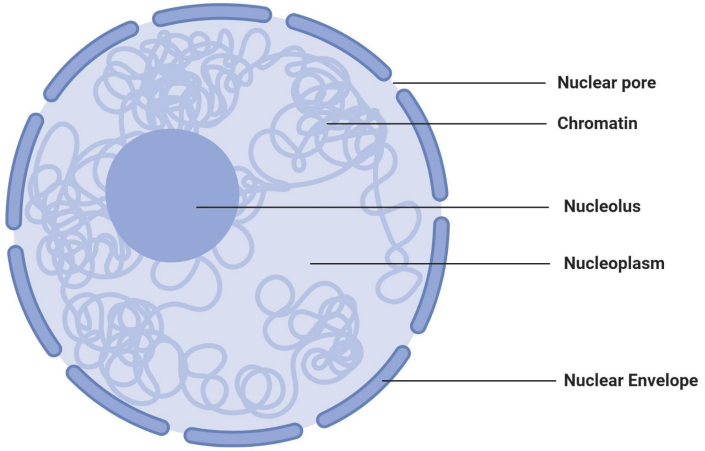
Functions

i. DNA Replication

ii. DNA transcription

iii. Post transcriptional Processing

Nucleolus



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- First recognized by Fontona in 1874.
- It is generally spherical in shape.
- The no. of nucleoli in each nucleus depends on the species or the sets of chromosome
- The no. of nucleoli in each cell may be 1,2,3 or 4
- The size of the nucleolus depends on the synthetic activity of the cell.
- The size varies 1 to 5 μm in diameter.

Nucleolus

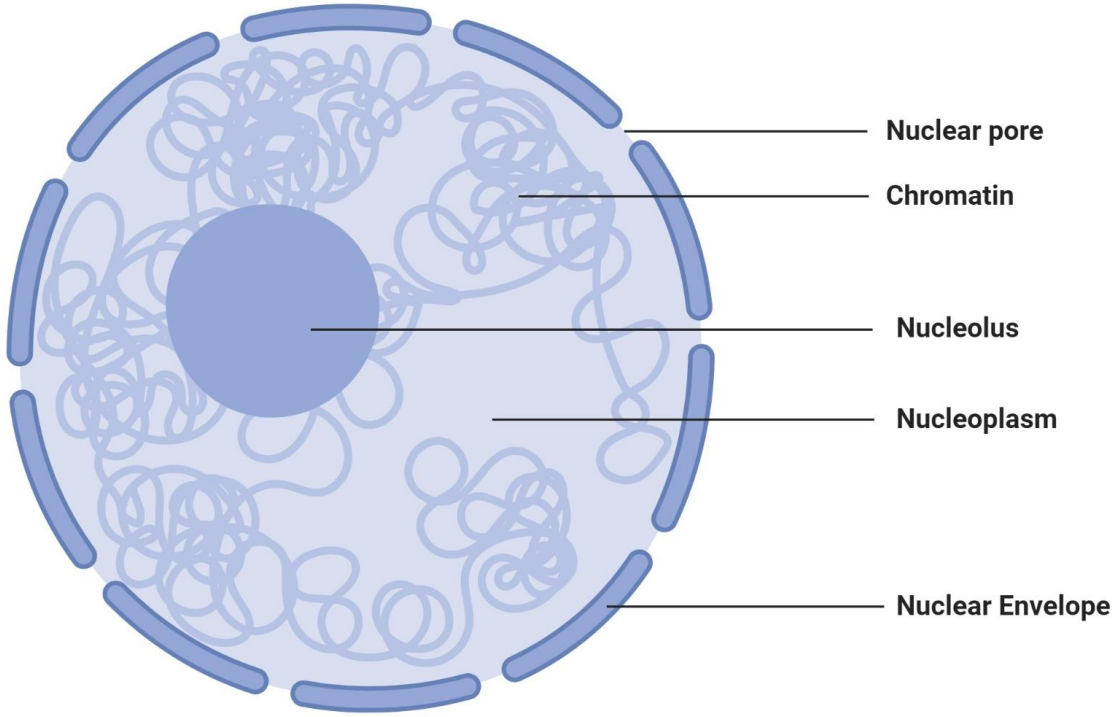
Chemical composition

- 5 to 10 % of the nucleolus is made up of RNA & remaining part is made-up of protein.
- The main protein components are phosphoprotein, acid phosphatase, nucleoside phosphorylase & NAD synthesizing enzymes have been localized I the nucleolus.
- It is surrounded by a ring of Feulgen positive chromatin which actually represents the heterochromatin regions of chromosomes.

Nucleolus

General Organization

- Under the light microscope, the nucleus appear as a fluid or semisolid homogeneous body.
- It shows 4 main compartment
    - i. Granules
    - ii. Fibrils
    - iii. Matrix
    - iv. Chromatin



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Nucleolus

Granules

- The granular region generally occurs densely at the periphery of the nucleus.
- These granules are 150 to 200 A° in diameter
- The granules contain ribo-nucleoprotein in which RNA & proteins are in ratio 1 : 2 .

Fibrils

- It is also known as nucleolonema.
- Mainly composed by many fine fibers called fibrils.
- They are made up of ribonucleic proteins & with 50 – 80 A in length.
- Both granules & fibrils are digested by ribonucleases enzyme.

Nucleolus

Matrix

- This is also called as amorphous or proteinous region.
- The granules & fibrils are point out that nuclear matrix is the major site whose DNA replication first takes place & later association with the nuclear envelop.
- Nuclear matrix is also the site of transcription because a certain amount of residual RNA is found associated with the matrix protein.

Chromatin

- Nucleus also contain electron dense chromatin material, usally at the periphery. It is composed of fibers of 100 A.
- The chromatin contain DNA which is serves to template for RNA synthesis,

Nucleolus

Functions

1. **Ribosome Formation:** Nucleolus is involved in the biogenesis of ribosomes

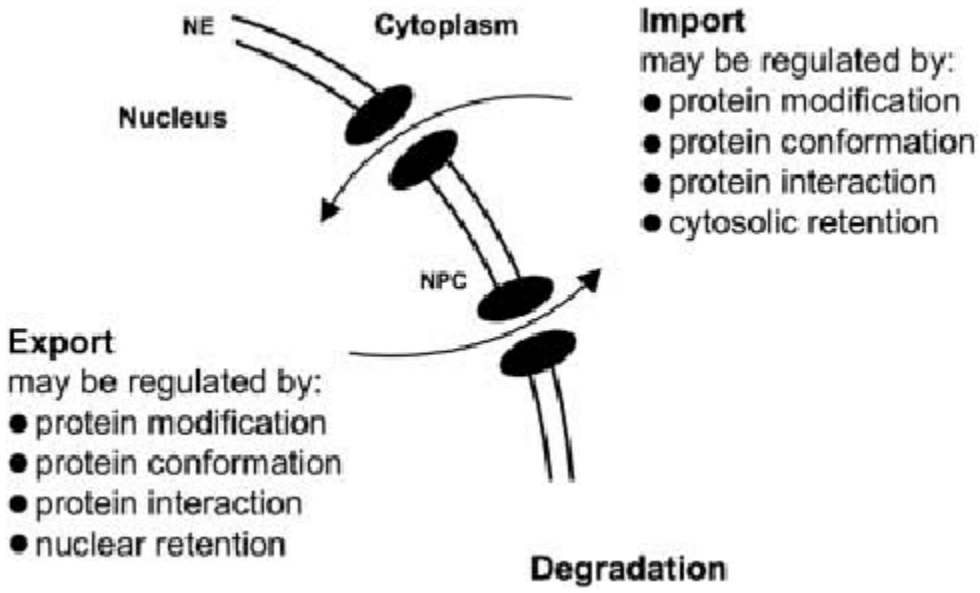
2. **RNA Production:**
   - ✓ Nucleus is one of the most active sites of RNA synthesis.
   - ✓ It produces about 70-90 % of cellular RNA in many cells.
   - ✓ It is also the sources of ribosomal RNA (rRNA).

3. **Protein Synthesis:**
   - ✓ Maggio (1960) & others have suggested that the protein synthesis take place in the nucleus.
   - ✓ Some cell biologist suggested that ribosomal proteins are synthesized by nucleolus

4. **Role in Mitosis:** The nucleus plays a significant role in mitosis.

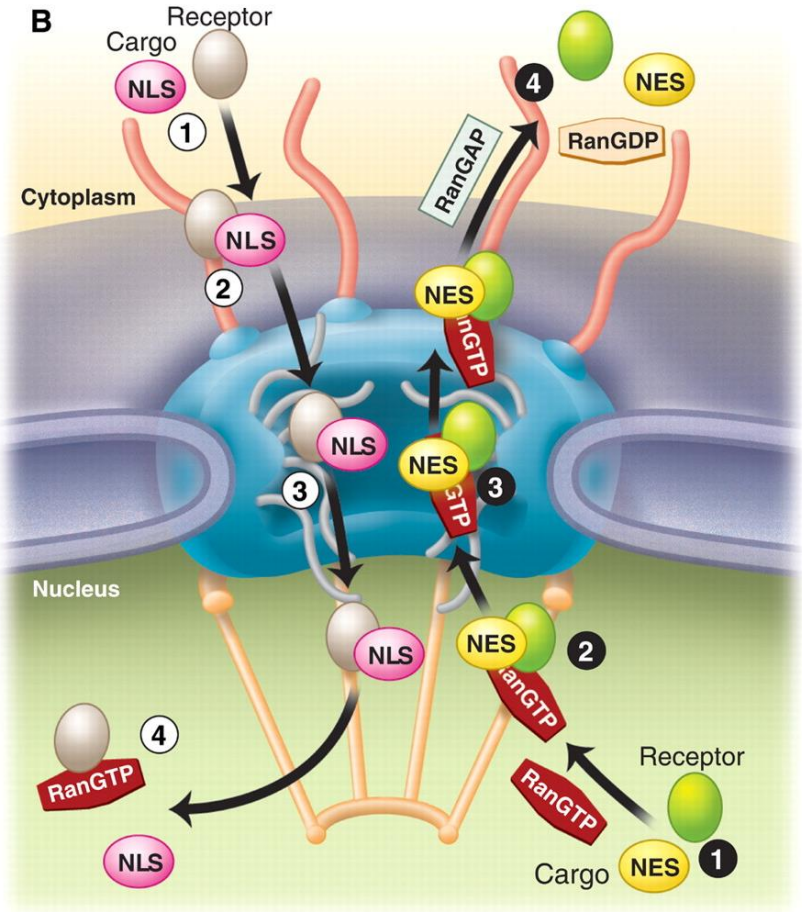
Nucleocytoplasmic Interaction

- Most of the nucleic acid like DNA and RNA of the cell are formed in the nucleus and those found in cytoplasm are supposed to have migrated there.
- Some of the exception is related to the DNA of some cytoplasmic organelles.
- m-RNA is formed in the nucleus in association with chromosomes. Ribosomal RNA is also formed in the nucleus, especially in the nucleolus.
- Since, some protein synthesis goes in the nucleus, m-RNA & ribosomes become associated with the nucleus, to form functional polysomes.



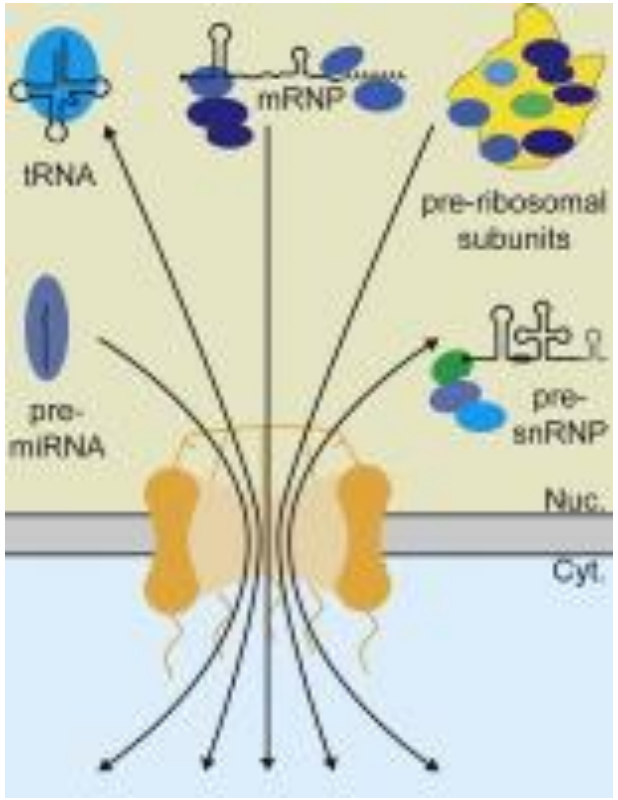
Nucleocytoplasmic Interaction

- Most polysomes are found in the cytoplasm and it is assumed that they migrate these through the pores in the nuclear membrane.
- Recently, evidence has been obtained for the existence of a particle which appear in the nucleus but rapidly becomes associated with polysomes in the cytoplasm.
- These particles contain a precursor of the 40 S ribosomal sub particle and possibly m-RNA. It may associate with 60 S sub particle forming molecule of m-RNA.
- Other ribosomes may then become attached and may be extensively reused in the cytoplasm.



Nucleocytoplasmic Interaction

- Some polysomes remain free in the cell sap but become bound to the membranes of ER.
- Cytoplasmic nucleic acid is synthesized in the nucleus.
- RNA might act as template for a synthesis of more RNA in the cytoplasm.
- The cytoplasm might have DNA containing structure.
- In some amphibian eggs, large amount of DNA in cytoplasm is present. It may have function in regulating the early development of embryo.



Nucleocytoplasmic Interaction

- The cells of microorganisms and protozoa have self-replicating DNA containing particles called episomes. They exist free in the cytoplasm or in intimate association with the chromosome.

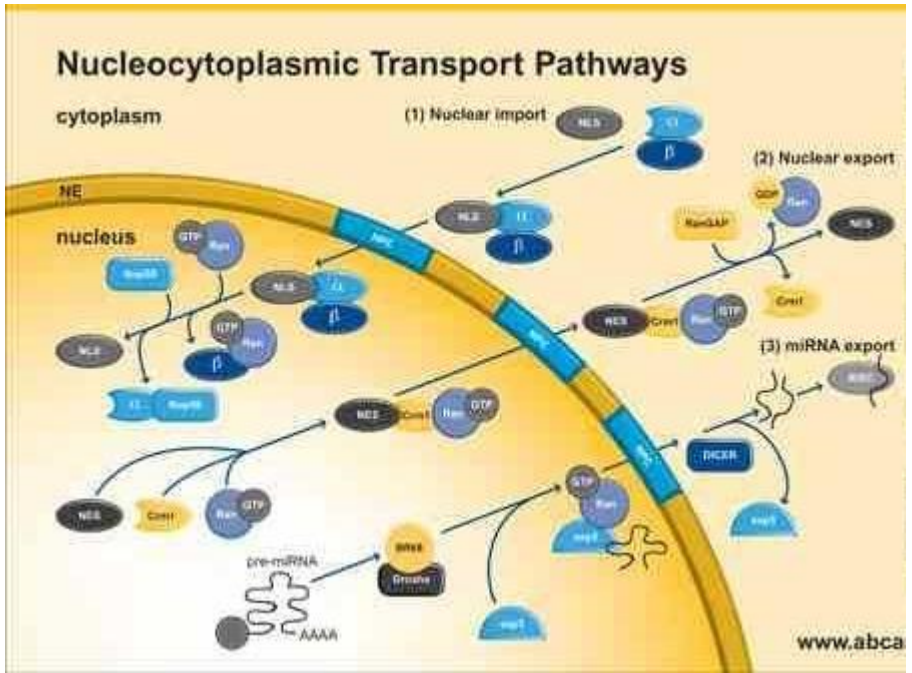
- Cellular activity is controlled by the nucleus and more specifically by DNA located in the chromosomes.

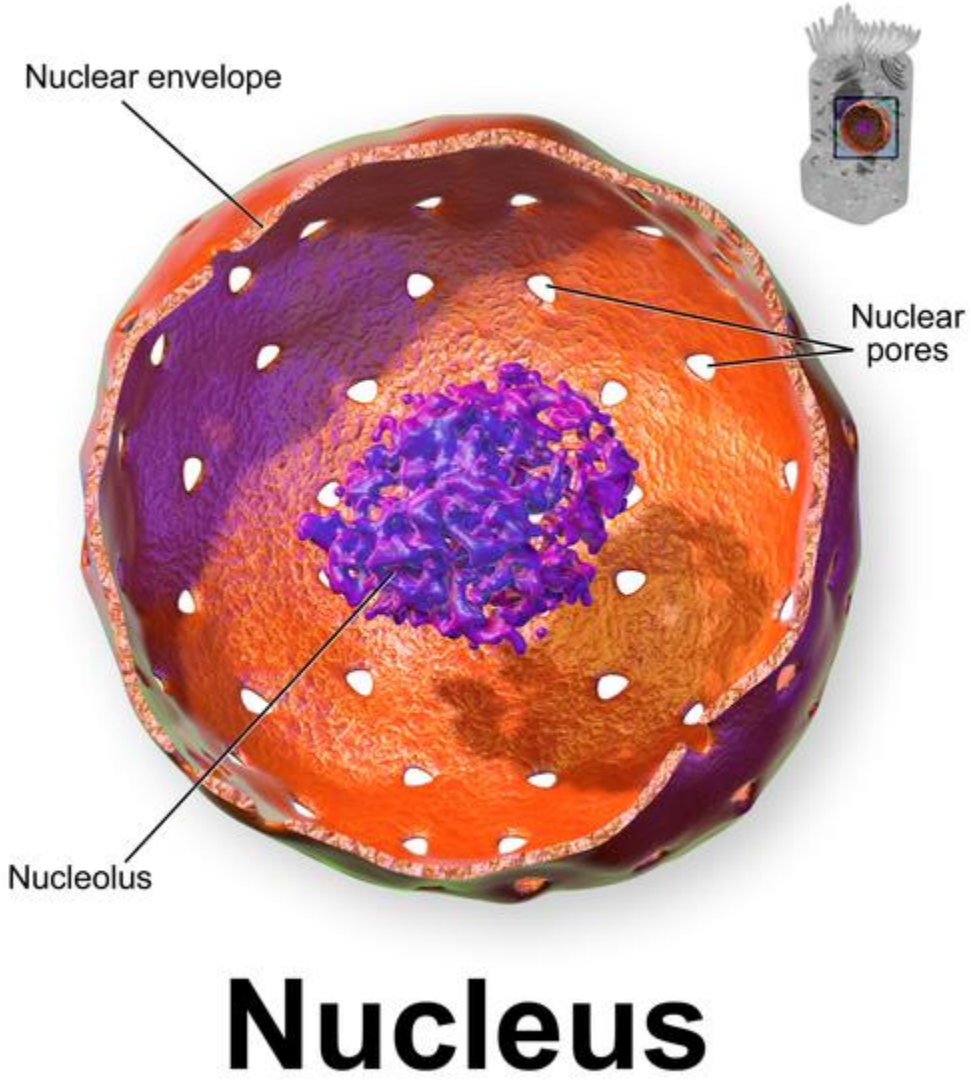
- The RNA involves in the protein synthesis originate in the nucleus and is then transferred to the cytoplasm. It is generally accepted that some macromolecule, small organic molecule, water and ions can pass across the nuclear envelope.

Nucleocytoplasmic Interaction

- These macromolecules can cross the nuclear envelope through nuclear pore, by active transport by blebbing and exchange through the endoplasmic reticulum.

- Many studies suggest that granular material of nucleolar origin pass from the nucleus to the cytoplasm, and may be involved in the biogenesis of ribosomes.





Nucleus

Thank You