Ultra-Structure and Organization of Cells and Organelles

"The Nucleus"

Nucleus Organelle:

- **Ultrastructure (or ultra-structure)** is the architecture or fine structure of cells and biomaterials that is visible at higher magnifications that cannot found on a standard **optical light microscope**. Ultrastructure can also be viewed with **scanning electron microscopy** and **super-resolution microscopy**.
- The **cell nucleus** (from Latin ***nucleus*** or ***nuculeus***= seed; pl: ***nuclei***) is **a membrane-bound organelle** found in **eukaryotic cells** (Figure 1).
- **Eukaryotic cells** usually have a **single nucleus** like **HeLa Cells** (Figure 2), but a few cell types, such as **mammalian red blood cells** (Figure 4), have **no nuclei**, and a few others including **osteoclasts** have many (Figure 3).
- Considering its importance in the storage and utilization of genetic information, the **nucleus** of a eukaryotic cell has a rather undistinguished morphology (**Figure 5**).
- The contents of the **nucleus** are present as a viscous, amorphous mass of material enclosed by a complex nuclear envelope that forms a boundary between the nucleus and cytoplasm.

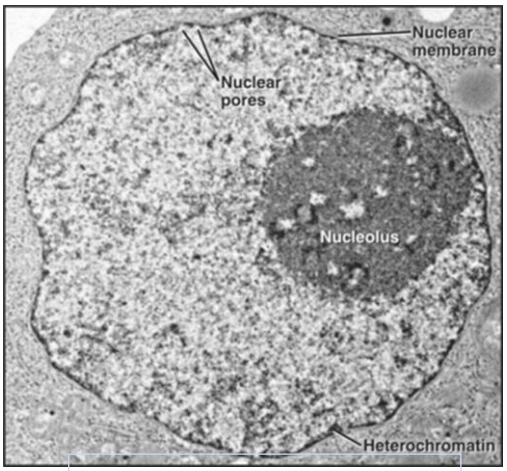


Figure1: Cell Nucleus

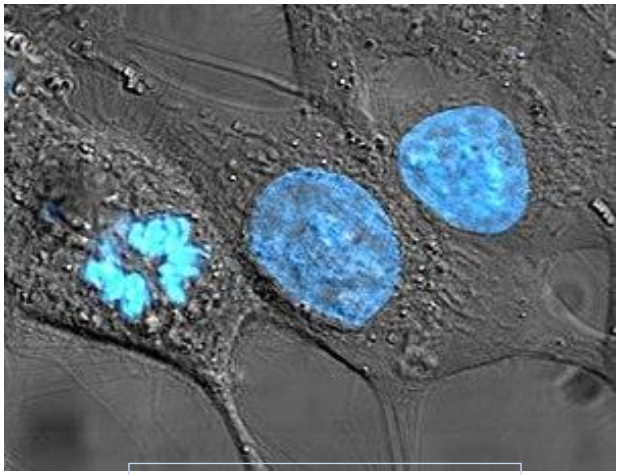


Figure2: HeLa Cell

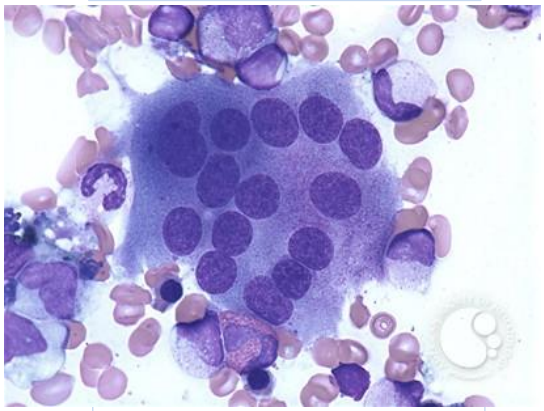


Figure3: Cell Nucleus

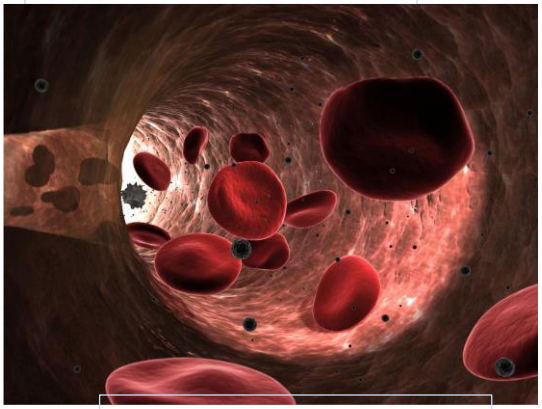
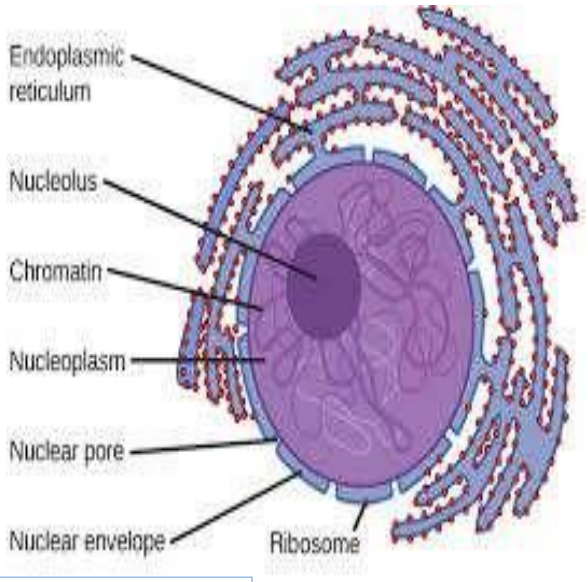


Figure4: RBC Cells

Included within the **nucleus** of a typical interphase (*i.e.*, nonmitotic) cell are:

1) the chromosomes, which are present as highly extended nucleoprotein fibers, termed chromatin.
2) one or more nucleoli, which are irregularly shaped electron-dense structures that function in the synthesis of ribosomal RNA and the assembly of ribosomes.
3) the nucleoplasm, the fluid substance in which the solutes of the nucleus are dissolved; and
4) the nuclear matrix, which is a protein-containing fibrillar network.



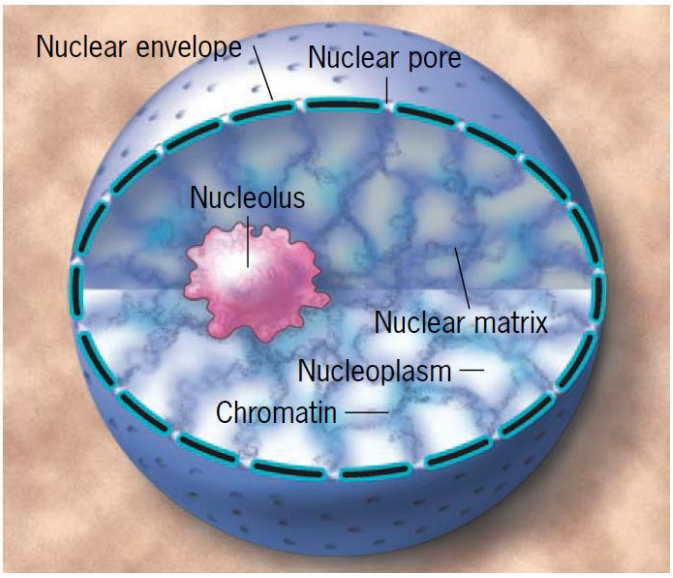
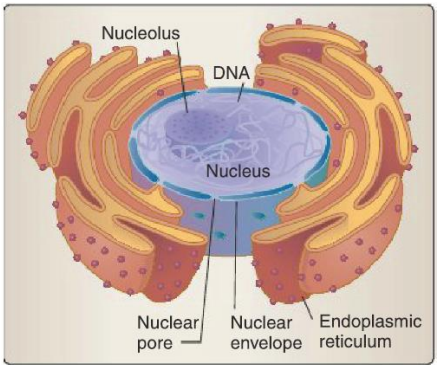


Figure 5

- **Nucleus** is the most important organelle in the cell. It distinguishes eukaryotic from prokaryotic cells. By housing the cell's genome, the nucleus serves both as the repository of genetic information and as the cell's control center. DNA replication, transcription, and RNA processing all take place within the nucleus.
- **A nucleus** is a double-membraned eukaryotic cell organelle that contains the genetic material. It appears in an oval shape averages 5µm in width. It often lies in the center of a cell. The nucleus was the first organelle to be discovered. Nuclei 1st discovered and named by Robert Brown.



Ultra-Structure of Nucleus (Structure of Nuclear envelope):

The nuclear envelope has a complex structure consisting of:

1. **Two nuclear membranes** separated by a perinuclear space measuring about 20–40 nm across.
2. Underlying **nuclear lamina**.
3. The nucleus is surrounded by a system of two concentric membranes, called **the inner** and **outer nuclear membranes**.
4. The inner and outer nuclear membranes are joined at **nuclear pore complexes**.

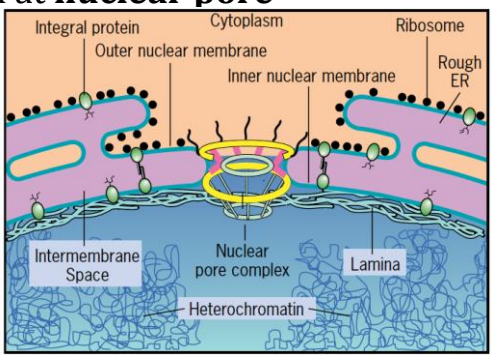


Figure 6

The Nuclear Envelope:

- The separation of a cell's genetic material from the surrounding cytoplasm may be the single most important feature that distinguishes eukaryotes from prokaryotes, which makes the appearance of the nuclear envelope a landmark in biological evolution.

- The nuclear envelope consists of two cellular membranes arranged parallel to one another and separated by10 to 50 nm (Figure 6). The membranes of the nuclear envelope serve as a barrier that keeps ions, solutes, and macromolecules from passing freely between the nucleus and cytoplasm.
- The two membranes are fused at sites forming circular **pores** that contain complex assemblies of proteins. The average mammalian cell contains several thousand nuclear pores.
- The outer membrane is generally covered with ribosomes and is continuous with the membrane of the **rough endoplasmic reticulum (RER)**. The space between the membranes is continuous with the **ER lumen** (Figure 6).

- The inner surface of the nuclear envelope of animal cells is bound by integral membrane proteins to a thin filamentous meshwork, called the nuclear lamina (**Figure 7**). The nuclear lamina provides mechanical support to the nuclear envelope, serves as a site of attachment for chromatin fibers at the nuclear periphery, The filaments of the nuclear lamina are called **lamins**.

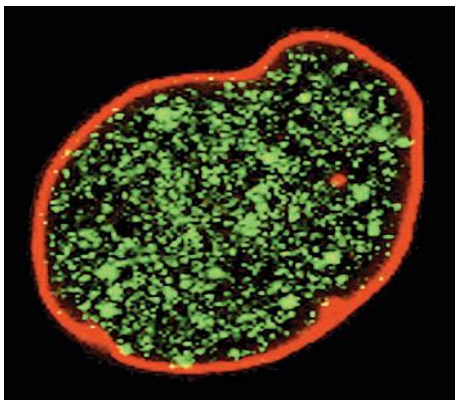


Figure 7.Nuclear lamina

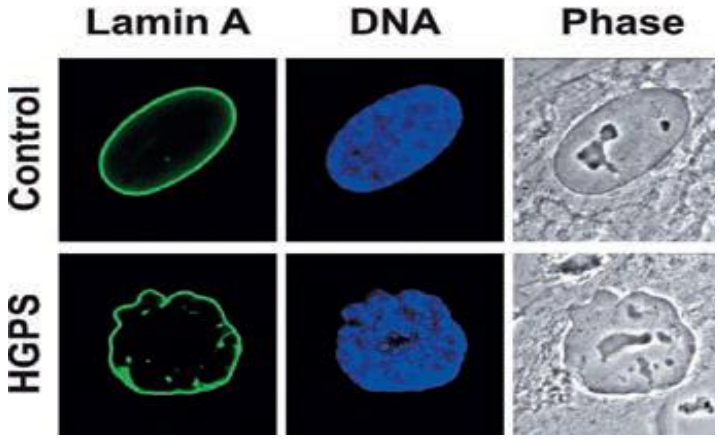


Figure 8. The nuclear lamina

- **Mutations** in one of the lamin genes (LMNA) are responsible for a number of diverse human diseases, including a rare form of muscular dystrophy (called EDMD2) in which muscle cells contain exceptionally fragile nuclei. Mutations in LMNA have also been linked to a disease, called Hutchinson- Gilford progeria syndrome (HGPS), that is characterized by premature aging and death during teenage years from heart attack or stroke (Figure 8).

Chromosomes and Chromatin:

- **Chromosomes** are composed of DNA and associated protein, which together is called **chromatin**. The orderly packaging of eukaryotic DNA depends on **histones**, a remarkable group of small proteins that possess an unusually high content of the basic amino acids arginine and lysine. Histones are divided into five classes (H1, H2A, H2B, H3 and H4), which can be distinguished by their arginine/lysine ratio.
- **Histones** interact with the backbone of the DNA molecule, which is identical in all organisms. DNA and histones are organized into repeating subunits, called **nucleosomes** (**Figure 9**).

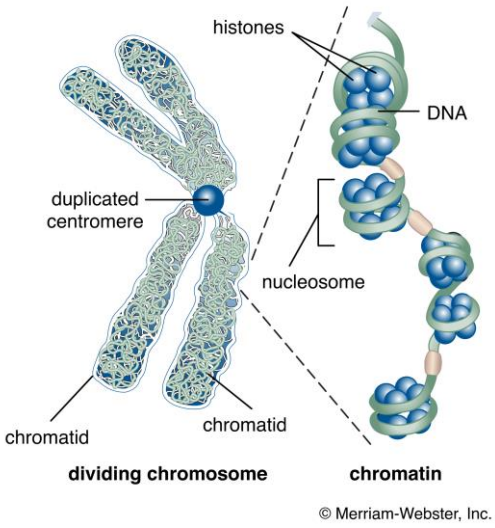
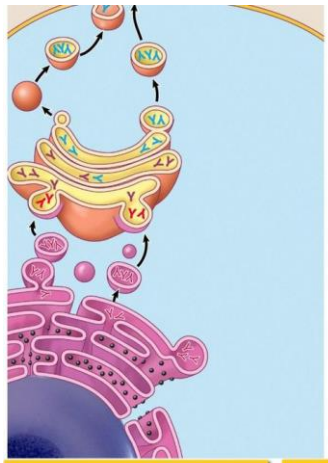
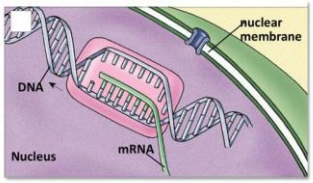


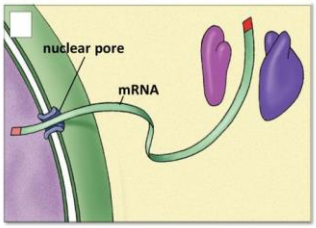
Figure 9

The Structure of the Nuclear Pore Complex and Its Role in Nucleocytoplasmic Exchange:

- The **nuclear envelope** is the barrier between the nucleus and cytoplasm, and nuclear pores are the gateways across that barrier. Unlike the plasma membrane, which prevents passage of macromolecules between the cytoplasm and the extracellular space, the **nuclear envelope** is a hub of activity for the movement of RNAs and proteins in both directions between the nucleus and cytoplasm.
- The **replication** and **transcription** of genetic material within the nucleus require the participation of large numbers of proteins that are synthesized in **the cytoplasm** and transported across the nuclear envelope.
- Conversely, the **mRNAs, tRNAs, and ribosomal subunits** that are manufactured in **the nucleus** must be transported through the **nuclear envelope** in the opposite direction.







production of mRNA from DNA in nucleus

mRNA out of nucleus through nuclear pore