



جامعة المستقبل  
AL MUSTAQBAL UNIVERSITY

**كلية العلوم**  
**قسم الادلة الجنائية**

**المحاضرة السادسة**

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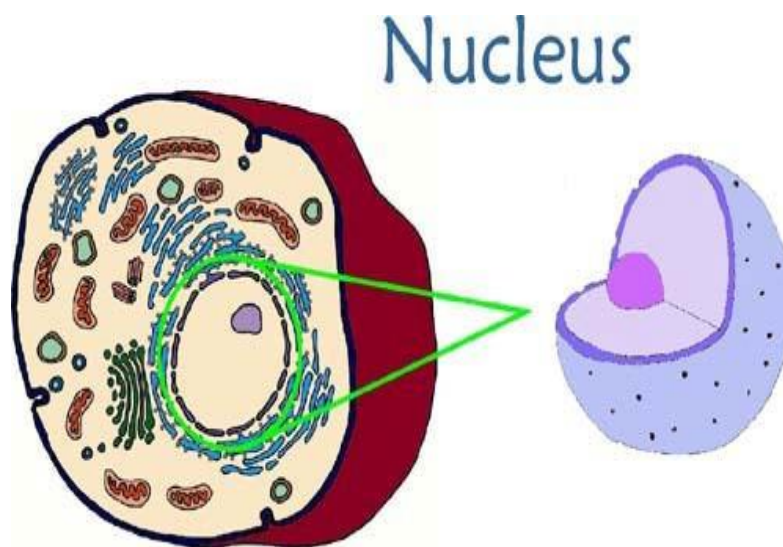
**المادة : الخلية**

**The Cell**

**المرحلة : الأولى**

**اسم الاستاذ: د. عماد هادي الطائي**

## Cell nucleus



## The Nucleus

- In cell biology, the nucleus referred to as the "control center", 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.



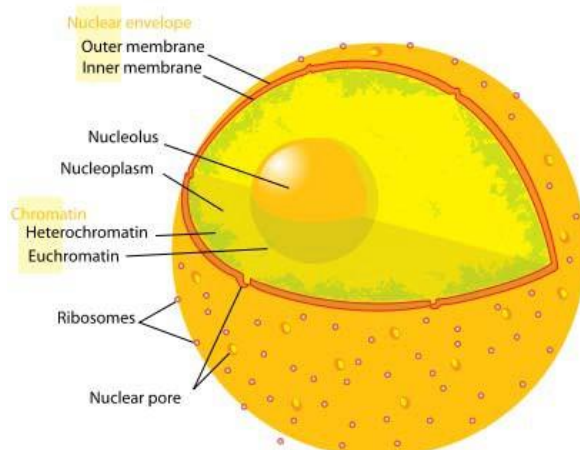
## The main structures making up the nucleus are the:

- **Nuclear envelope**, a double membrane that encloses the entire organelle and separates its contents from the cellular cytoplasm.
- **Nuclear lamina**, within the nucleus that adds mechanical support, much like the cytoskeleton supports the cell as a whole.
- **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 contents are not uniform, and a number of subnuclear 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.
- The nucleus is the largest cellular **organelle** in animals.
- In mammalian cells, the average diameter of the nucleus is approximately 6 micrometers ( $\mu\text{m}$ ), which occupies about 10% of the total cell volume.
- The viscous liquid within it is called nucleoplasm, and is similar in composition to the cytosol found outside the nucleus. It appears as a dense, roughly spherical organelle

- The nuclear envelope otherwise known as nuclear membrane consists of two cellular membranes, an inner and an outer membrane, arranged parallel to one another and separated by 10 to 50 nanometers (nm).
- The nuclear envelope completely encloses the nucleus and separates the cell's genetic material from the surrounding cytoplasm
- Serving as a barrier to prevent macromolecules from diffusing freely between the nucleoplasm and the cytoplasm.
- **The outer nuclear membrane is continuous with the membrane of the rough endoplasmic reticulum (RER), and is similarly studded with ribosomes.**
- The space between the membranes is called the perinuclear space and is continuous with the RER lumen

## Nuclear Envelope

The eukaryotic cell nucleus. Visible in this diagram are the ribosome- studded double membranes of the nuclear envelope, the DNA (complexed as chromatin), and the nucleolus. Within the cell nucleus is a viscous liquid called nucleoplasm, similar to the cytoplasm found outside the nucleus.



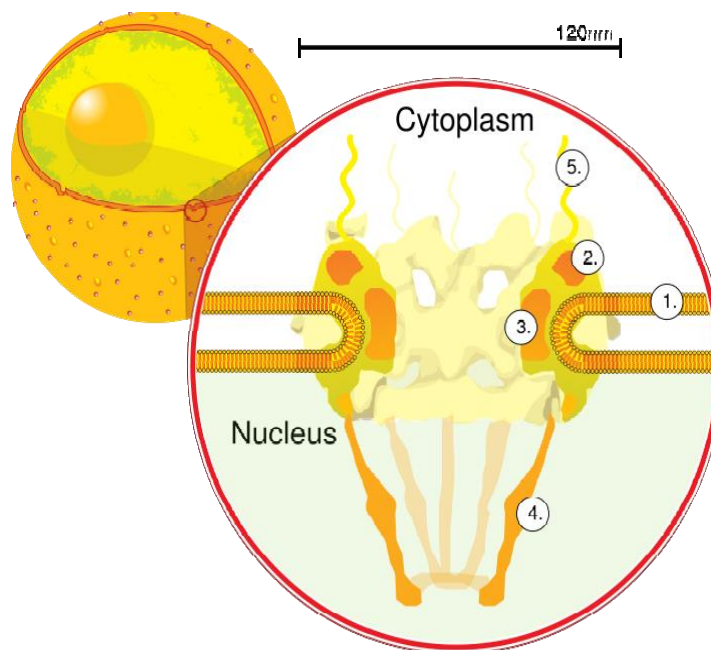


## Nuclear pores

- **Nuclear pores**, which provide aqueous channels through the envelope, are composed of multiple proteins, collectively referred to as nucleoporins.
- The pores are about 125 million daltons in molecular weight and consist of around 50 (in yeast) to 100 proteins (in vertebrates).
- **The pores are 100 nm in total diameter**; however, the gap through which molecules freely diffuse is only about 9 nm wide, due to the presence of regulatory systems within the center of the pore
- **This size allows the free passage of small water-soluble molecules while preventing larger molecules, such as nucleic acids and larger proteins**, from entering or exiting the nucleus.
- These large molecules must be actively transported into the nucleus instead.
- The nucleus of a typical mammalian cell will have about 3000 to 4000 pores throughout its envelope
- Each of which contains a donut-shaped, eightfold-symmetric ring- shaped structure at a position where the inner and outer membranes fuse.
- Attached to the ring is a structure called the *nuclear basket* that extends into the nucleoplasm, and a series of filamentous extensions that reach into the cytoplasm.
- Both structures serve to mediate binding to nuclear transport proteins
- Most proteins, ribosomal subunits, and some RNAs are transported through the pore complexes in a process mediated by a family of transport factors known as karyopherins
- Those karyopherins that mediate movement into the nucleus are also called importins, while those that mediate movement out of the nucleus are called

exportins. Most karyopherins interact directly with their cargo, although some use adaptor proteins.

- **Steroid hormones such as cortisol and aldosterone, as well as other small lipid-soluble molecules involved in intercellular signaling can diffuse through the cell membrane and into the cytoplasm, where they bind nuclear receptor proteins that are trafficked into the nucleus.**
- There they serve as transcription factors when bound to their ligand; in the absence of ligand many such receptors function as histone deacetylases that repress gene expression.



**Figure : A cross section of a **nuclear pore** on the surface of the :  
(1) Nuclear envelope (2) Outer ring, (3) Spokes, (4) Basket (5) Filaments.**



## Nucleolus

- **The nucleolus** is a discrete densely stained structure found in the nucleus.
- It is not surrounded by a membrane, and is sometimes called a *suborganelle*.
- It forms around tandem repeats of rDNA, DNA coding for ribosomal RNA (rRNA).
- These regions are called nucleolar organizer regions (NOR).
- **The main roles of the nucleolus are to** synthesize rRNA and assemble ribosomes.
- The structural cohesion of the nucleolus depends on its activity, as ribosomal assembly in the nucleolus results in the transient association of nucleolar components, facilitating further ribosomal assembly, and hence further association.
- **The first step in ribosomal assembly is transcription of the rDNA, by a protein called** RNA polymerase I, forming a large pre-rRNA precursor.
- This is cleaved into the subunits 5.8S, 18S, and 28S rRNA.
- The transcription, post-transcriptional processing, and assembly of rRNA occurs in the nucleolus, aided by small nucleolar RNA (snoRNA) molecules, some of which are derived from spliced introns from messenger RNAs encoding genes related to ribosomal function.
- The assembled ribosomal subunits are the largest structures passed through the nuclear pores.



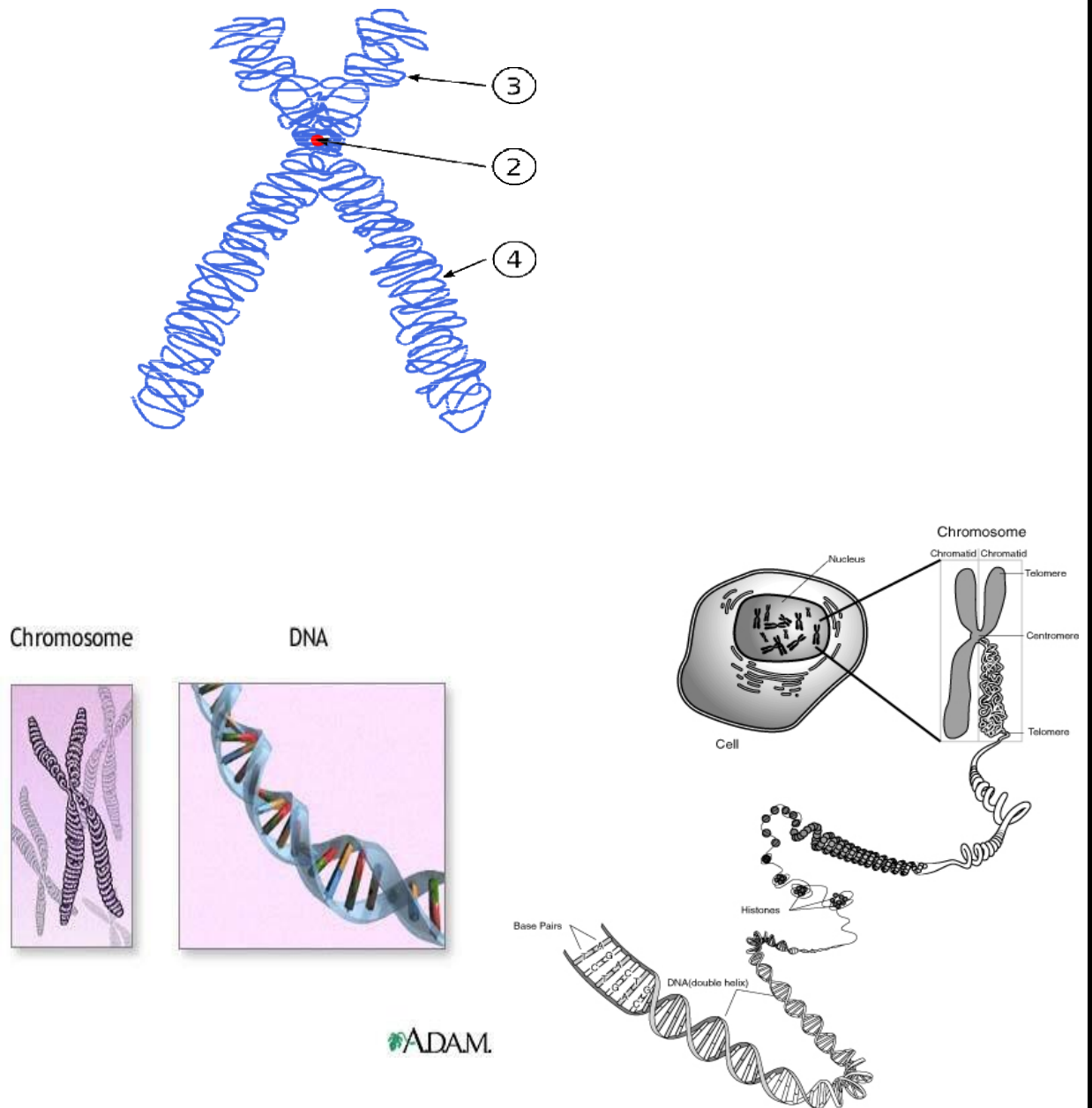
## **Nuclear Lamina**

- In animal cells, two networks of intermediate filaments provide the nucleus with mechanical support:
- The nuclear Lamina forms an organized network on the internal face of the envelope
- while less organized support is provided on the cytosolic face of the envelope.
- Both systems provide structural support for the nuclear envelope and anchoring sites for chromosomes and nuclear pores
- The nuclear lamina is mostly composed of Lamin proteins.
- Like all proteins, lamins are synthesized in the cytoplasm and later transported into the nucleus interior
- where they are assembled before being incorporated into the existing network of nuclear lamina.



## Chromosomes

- The cell nucleus contains the majority of the cell's genetic material, in the form of multiple linear DNA molecules organized into structures called chromosomes.
- During most of the cell cycle these are organized in a DNA-protein complex known as chromatin, and during cell division the chromatin can be seen to form the well defined chromosomes familiar from a karyotype.
- A small fraction of the cell's genes are located instead in the mitochondria.
- A chromosome is an organized structure of DNA and protein that is found in cells.
- It is a single piece of coiled DNA containing many genes, regulatory elements and other nucleotide sequences.
- In eukaryotes, nuclear chromosomes are packaged by proteins into a condensed structure called chromatin.
- Chromosomes may exist as either duplicated or unduplicated— unduplicated chromosomes are single linear strands, whereas duplicated chromosomes (copied during synthesis phase) contain two copies joined by a centromere.
- Compaction of the duplicated chromosomes during mitosis and meiosis results in the classic four-arm structure



**Figure :** Diagram of a duplicated and condensed metaphase eukaryotic chromosome. (1) Chromatid – one of the two identical parts of the chromosome after S phase. (2) Centromere – the point where the two chromatids touch, and where the microtubules attach. (3) Short arm. (4) Long arm.



## Chromatin

- There are two types of chromatin: Euchromatin is the less compact DNA form, and contains genes that are frequently expressed by the cell. The other type, Heterochromatin, is the more compact form, and contains DNA that are infrequently transcribed.
- This structure is further categorized into *facultative* heterochromatin, consisting of genes that are organized as heterochromatin only in certain cell types or at certain stages of development
- Heterochromatin that consists of chromosome structural components such as Telomeres and Centromeres
- During interphase the chromatin organizes itself into discrete individual patches, called *chromosome territories*
- Active genes, which are generally found in the euchromatic region of the chromosome, tend to be located towards the chromosome's territory boundary.