The Chromatin

Within the nuclear membrane there is jelly like substance (karyolymph or nucleoplasm) rich in proteins.

In the karyolymph, fibrillar structures form a network called ***chromatin fibrils***, which gets condensed to form distinct bodies called Chromosomes during cell division.

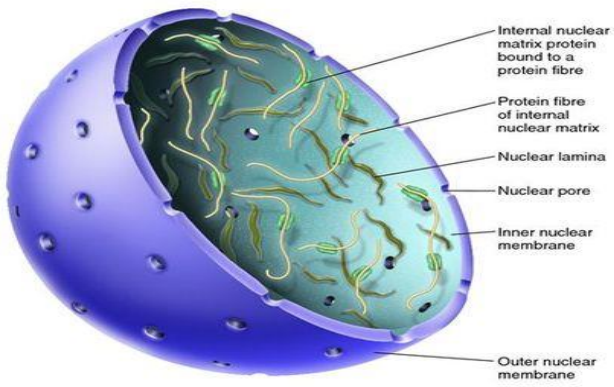
On staining the chromosomes, two regions can be identified in the chromatin material **Heterochromatin** (dark) and **Euchromatin** (light).

Heterochromatin has less DNA and genetically less active than Euchromatin which has more DNA and genetically more active.

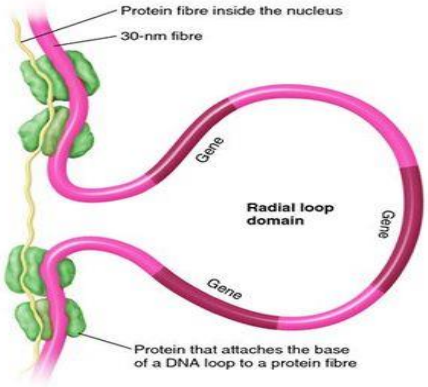
Number of chromosomes is fixed in an organism. During cell division chromosomes divide in a manner that the daughter cells receive identical amounts of hereditary matter .

The nuclear matrix have structural role in the cell where is responsible for maintaining the shape of the nucleus and the organization of chromatin.

Moreover, the nuclear matrix participates in several cellular processes, such as DNA replication, gene expression, cell signaling and differentiation.

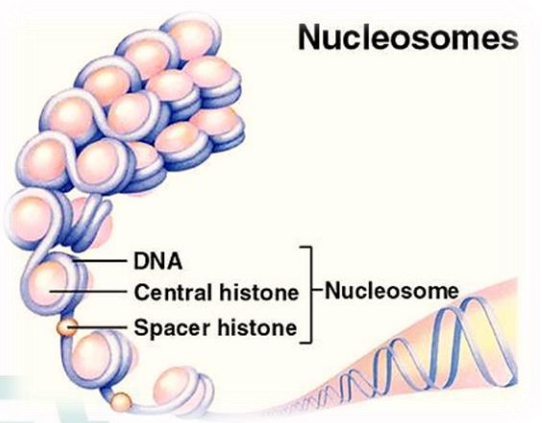


(a) Proteins that form the nuclear matrix



(b) Radial loop domain bound to a protein fibre

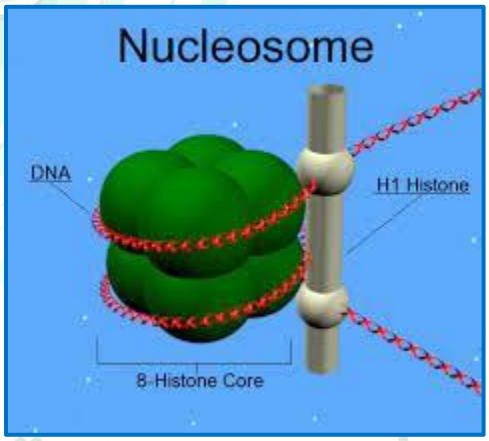
The nucleus contains loosely coiled fibers called chromatin that dispersed throughout the nucleus. It is composed of coiled strand of nucleic acids (DNA) bound to basic proteins called histones that play a role in the regulation of DNA function.



The chromatin is usually arranged in repeating units of small particles called nucleosomes, which consist of core of protein histone surround by double stranded of helical DNA. A nucleosome consists of 147 base pairs of DNA that is wrapped around a set of 8 histones called an octamer.

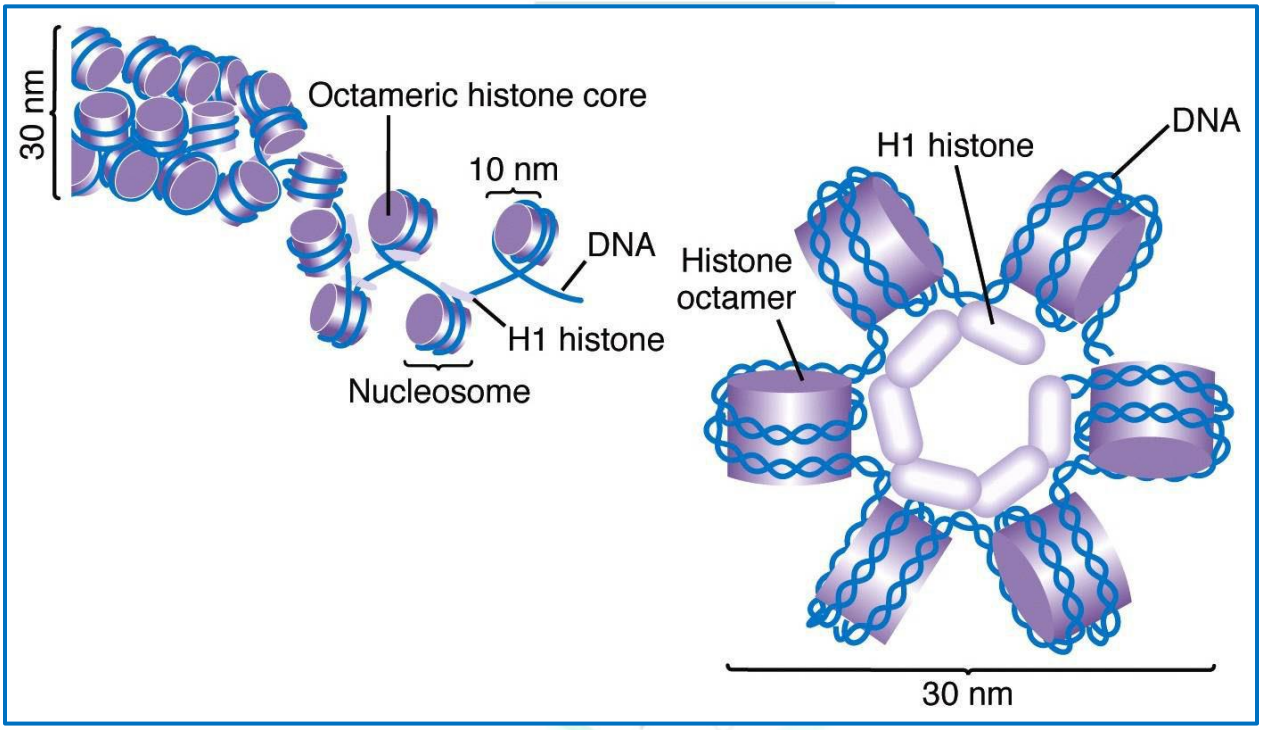
Nucleosomes: the subunits of chromatin

The compaction of DNA is achieved by winding it around a series of small proteins called histones. Histones are composed of positively charged amino acids that bind tightly to and neutralize the negative charges of DNA. There are five classes of Histone. Four of them, called H2A, H2B, H3, and H4, contribute two molecules each to form an octamer, an eight-part core around which two turns of DNA are wrapped. The resulting beadlike structure is called the Nucleosome.



The DNA enters and leaves a series of nucleosomes, linking them like beads along a string in lengths that vary between species of organism or even between different types of cell within a species. A string of nucleosomes is then coiled into a solenoid configuration by the fifth histone, called H1. One molecule of H1 binds to the site at which DNA enters and leaves each nucleosome, and a chain of H1 molecules coils the string of nucleosomes into the solenoid structure of the chromatin fiber.

Nucleosomes not only neutralize the charges of DNA, but they have other consequences. First, they are an efficient means of packaging. DNA becomes compacted by a factor of six when wound into nucleosomes and by a factor of about 40 when the nucleosomes are coiled into a solenoid chromatin fiber. The winding into nucleosomes also allows some inactive DNA to be folded away in inaccessible conformations, a process that contributes to the selectivity of gene expression.



Chromatin classification

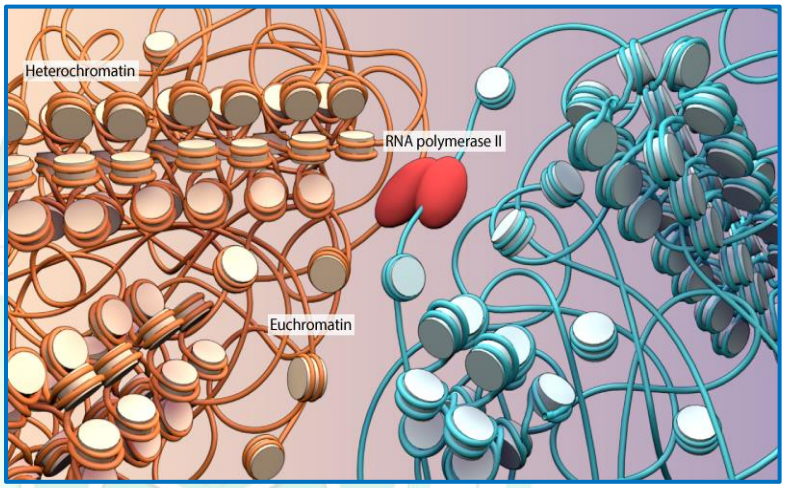
i. Heterochromatin

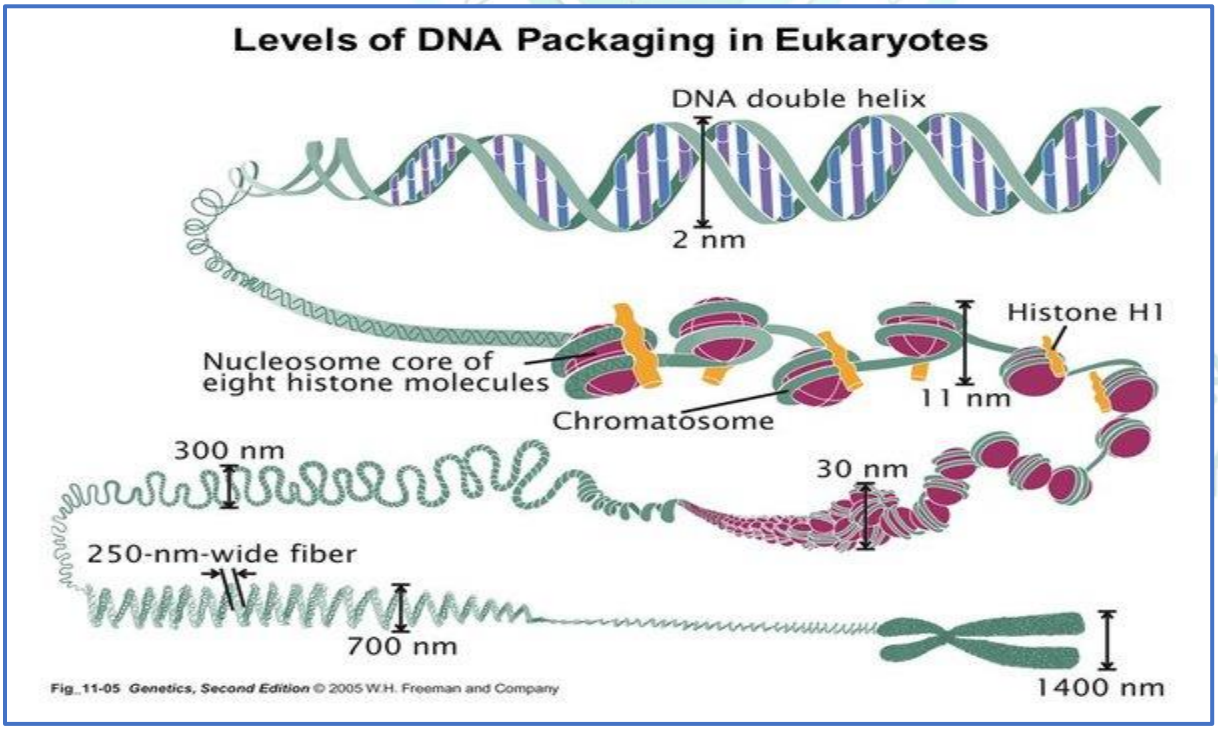
This is **condensed chromatin** and is therefore Genetically Inactive; that is, transcription is not occurring. Heterochromatin is seen associated with the nuclear envelope (**peripheral chromatin**), with the nucleolus (**nucleolar associated chromatin**), and scattered throughout the nucleus (**chromatin granules**). There are two types of heterochromatin:

- **Constitutive heterochromatin**, which is permanently inactive (e.g., centromere region of chromosome).
- **Facultative heterochromatin**, which may have been active in the past and may be so again in the future. It represents inactivated genes. The amount of facultative heterochromatin depends on the cell type and stage of development.

ii. Euchromatin

This is **extended chromatin** and is therefore Genetically Active; that is, transcription is occurring. At the EM level, Euchromatin appears as electron lucent regions interspersed among clumps of electron dense heterochromatin.





The main function of chromatin is to package DNA into a unit capable of fitting within the tight space of a nucleus.

Why is DNA Packaging required?

The length of the DNA is around 3 meters that need to be accommodated within the nucleus which is only a few micrometers in diameter. In order to fit in the DNA molecules into the nucleus, it needs to be packed into an extremely compressed and compact structure called chromatin. During the initial stages of DNA packaging, the DNA is reduced to an 11 nm fiber that denotes approximately 5-6 folds of compaction. This is achieved through a nucleosome order of packaging. There are three orders of DNA packaging .

1. The first order DNA packaging – Nucleosome.
2. The second order DNA packaging – Solenoid fibre.
3. The third order DNA packaging – Scaffold loop Chromatids Chromosome.