TOPIC: CELL STRUCTURE:NUCLEUS

LECTURE NO:10
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Nuclear Matrix:-

The nuclear matrix is a network of thin, criss-crossing, protein- containing fibrils that are connected at their ends to the nuclear envelope. It forms a sort of nuclear skeleton. It remains intact after the chromatin and DNA have been removed.

Functions:

It maintains the shape of the nucleus.

Chromatin fibers are anchored to nuclear matrix.

The machinery for various nuclear activities, such as transcription and replication, is associated with the matrix.

It has also been implicated in the processing of newly formed RNA molecules and their transport through the nucleus.

Chromatin:-

The term chromatin was first coined **by Flemming in 1879.** The chromatin occurs in an interphase (non-dividing) nucleus as fine filaments, the **chromatin fibers**. The fibers lie criss-cross so as to give the appearance of a diffuse network often referred to as the nuclear or chromatin reticulum. The chromatin occupies most of the nucleus. The chromatin fibers are simply extremely extended chromosomes. A chromatin fiber is normally about 100Å in diameter. A fiber thicker than 100Å appears to be coiled or folded, a fiber thinner than 100Å seems to have less protein content associated with it. Chromatin fibers typically appear

approximately 250Å in diameter. During cell division, the chromatin fibers, by condensing and tight coiling, form short, thick, rod like bodies known as **chromosomes.**

Upon staining, this diffuse network of chromatin material shows light stained and dark stained areas. After cell division, the chromosomes change back into chromatin fibers. Most of the chromatin fibers become uncoiled, extended and scattered in the nucleoplasm. These represent the **euchromatin** (true chromatin) of the interphase nucleus. They are stained lightly.

The term **heterochromatin** is applied to those chromosomal regions that stain darker than others. They remain c**o**iled and compacted in the interphase too. Heterochromatin represents relatively inactive parts of the chromosomes. It contains less DNA and more RNA than the euchromatin. Few mutations occur in this region. Little or no mRNA is synthesized here. Most of the DNA in heterochromatin is highly repeated DNA which is never, or very seldom, transcribed. Heterochromatin is of two types: **constitutive and facultative**. The DNA of constitutive heterochromatin is permanently inactivated and remains in the condensed state at all times. It occurs at several places: adjacent to the centromere of the chromosome, at the ends (telomeres) of the chromosomes, at certain portions within the euchromatin, and adjacent to the nuclear envelope. Facultative heterochromatin is partly
condensed and inactivated. **One X-chromosome in female mammals is condensed to form the heterochromatic Barr body.**

Nucleosomes: In 1974, Kornberg and Thomas proposed that a chromatin fiber is a chain of similar subunits called nucleosomes (Fig. 3). The nucleosome consists of a core particle wrapped by DNA strand. The core particle is an octamer of **8 histone**

molecules, two each of the histones H2A, H2B, H3 and H4. The DNA strand forms 1½ or 1¾ turns around the core and consists of 140 nucleotides. Each nucleosome is connected to the next by a short DNA linker of 60 nucleotides. A nucleosome and a linker together have a total average length of 200 nucleotides and are together referred to as a chromatosome. A molecule of histone H1 is associated with each DNA linker and it serves to pack nucleosomes together. Thus, a chromatin fiber is a chain of beads, a bead (nucleosome) is about 100Å wide and DNA linker is about 140Å long. Nucleosomes represent the lowest level of chromatin organization. Chromatin fiber appears about 250Å thick in electron micrographs. which suggests that the 100Å thick chromatin fiber is either packed into a spiral or solenoids, containing 6 nucleosomes per turn or 6 nucleosomes are organized into a cluster, or super bead, thereby increasing the DNA packing by 5 folds. The thicker filament is maintained by H1 histone protein. The non-histone proteins do not occur in the nucleosome structure of chromatin. Nucleosomes are not formed in prokaryotes.

Functions:

The chromatin fibers form chromosomes during cell division.

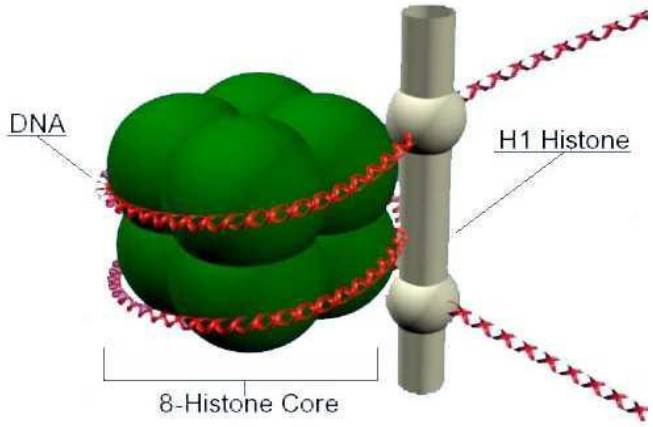

Fig. 6.3: Nucleosome

Nucleolus (Little Nucleus):-

The nucleolus was discovered in 1781 by **F. Fontana** in the slime from the eel skin. It is present in the nucleus of most cells, but is inconspicuous or absent in sperm cells and in muscle cells. It is usually spherical, but may have other forms. The number of nucleoli in a nucleus varies in different species. The nucleoli disappear during cell division, and are reformed at specific sites, the nucleolar organizers or nucleolar organizer regions (NORs), of certain chromosomes, the nucleolar chromosomes, at the end of cell division before the chromosomes become diffuse. Position of the nucleolus in the nucleus is often eccentric. However, it occupies a specific position on its chromosome.

The nucleolus is a dense, somewhat rounded, dark staining organelle. It is without a limiting membrane. Calcium ions keep it intact. It consists of four regions.

Fibrillar Region or Nucleolonema- It contains indistinct fibrils about 50-100Å in diameter. The fibrils represent the long rRNA precursor molecules in early stages of processing before the processing enzymes have cut off segments from them.

Granular Region- It contains spherical, electron dense particles, about 150-200 Å in diameter and with fizzy outline. The granules are ribosomal subunits (rRNA + ribosomal proteins) that are nearly ready for transport to the cytoplasm.

Amorphous Region or Pars Amorpha- It is a structure-less proteinaceous matrix in which the granular and fibrillar regions are suspended.

Nucleolar Chromatin- It consists of 100 Å thick chromatin fibers. The latter are a part of the nucleolar chromosome which follows a tortuous path through the granular and

fibrillar components of the nucleolus. This part contains many copies of DNA that directs the synthesis of ribosomal RNA. The rest of the nucleolar chromosome lies in the nucleoplasm.

Functions-

The nucleolus synthesizes and stores rRNA.

It also stores ribosomal proteins received from the cytoplasm.

It forms ribosomal subunits by wrapping the rRNA by ribosomal proteins. The ribosomal subunits pass out through the nuclear pores into the cytoplasm. Here the subunits join to form ribosomes when needed. Thus, it is the nucleolus which provides machinery (ribosomes) for protein synthesis.

The nucleolus also plays a role in cell division.

Importance of Nucleus:

The nucleus is the control center of a cell. It regulates all metabolic activities of the cell and stores entire hereditary information. A cell without nucleus cannot survive.

Summary:

Nucleus is absent in prokaryotic cells but it is the most conspicuous organelle of eukaryotic cell. Whole of the genome is present in the nucleus thus; it is the source of informational macromolecules. It is surrounded by bilaminary nuclear envelop having pore complexes that permit the nuclear cytoplasmic transport of materials. The size of nucleus is not constant and it is correlated with the DNA content. Nucleus consists of nuclear envelope that separates nucleoplasm from the cytoplasm and it consists of two unit membranes, the

outer and the inner and each unit membrane is a trilaminar lipoprotein sandwich like plasma membrane and the two unit membranes are separated by perinuclear space. Nuclear pores present in the nuclear envelope are loaded with an apparatus called the pore complex, which act as a barrier to some molecules such as a DNA of chromosome. A transparent fluid the "nucleoplasm" is present inside the nucleus that contains raw materials, enzymes and metal ions. It provides turgidity to the nucleus and supports the matrix, chromatin material and nucleoli. The nuclear matrix is a network of thin criss-crossing protein containing fibrils that forms a sort of nuclear skeleton. The fine filaments present in the non-dividing nucleus are the chromatin fiber that occupies most of the nucleus and the nucleosome consists of a core particle wrapped by DNA strand. Nucleolus is present in various forms. It disappears during cell division and is reformed at specific sites known as nucleolar organizer regions of certain chromosomes at the end of the cell division. The nucleolus synthesizes and stores RNA and ribosomal proteins received from the cytoplasm. It plays important role in cell division.

Glossary:-

Neutrophil: Neutrophil are the most abundant type of granulocyte and the most abundant type of white blood cell in most mammals. They form an essential part of the innate immune system.

Karyotheca: A double membrane at the boundary of the nucleoplasm is called karyolymph. It has regularly spaced pores covered by a disc-like nuclear pore complex and a space between the two membranes; the outer membrane is continuous at intervals with the rough endoplasmic reticulum.

Karyolymph: It is the fluid or gel-like substance of the nucleus in which the chromatin material, nucleolus, and other particulate elements of the nucleus are suspended.

Annuli: It is a ring-shaped object, structure, or region.

Heterochromatin: Heterochromatin represents relatively inactive parts of the chromosomes.
They stain darker than others and remain coiled and compacted in the interphase.

Euchromatin: The uncoiled chromatin fibers, extended and scattered in the nucleoplasm represent the euchromatin (true chromatin) of the interphase nucleus. They are stained lightly.

Constitutive heterochromatin: The DNA of constitutive heterochromatin is permanently inactivated and remains in the condensed state at all times.

Facultative heterochromatin: Heterochromatin that is partly condensed and inactivated is called facultative heterochromatin.

DNA linker: Linker DNA is double-stranded DNA in between two nucleosome cores that, in association with histone H1, holds the cores together.

Histone proteins: Histones are highly alkaline proteins found in eukaryotic cell nuclei that package and order the DNA into structural units called nucleosomes.

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