CHAPTER 10

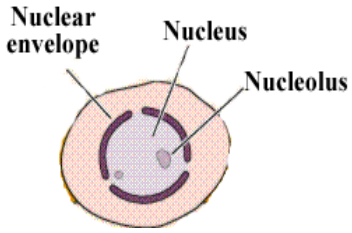
10 NUCLEUS

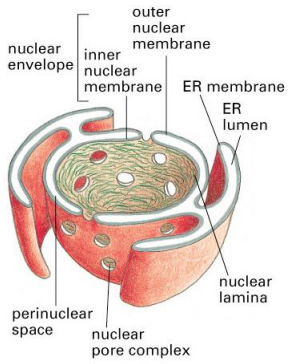
10.1 Ultrastructural organization of the nucleus

Nucleus component include the following;

i) Nuclear envelope - double membrane.
ii) Nucleoplasm (or nuclear sap)
iii) Nucleoli (spherical).
iv) Chromatin fibres (when dispersed throughout the nucleus)
v) Nuclear matrix.

10.1.1 Nuclear envelope : Structure , organization and functions





Nuclear membrane it is a double membrane consisting of outer and inner membrane

a) Outer membrane
- adjacent to cytoplasm.
- On the outer surface , it contains cytoplasmic ribosomes which may exhibit points of continuity of membrane and the Endoplasmic Recticulum.
- Microtubules, microfilament and intermediate filaments associated with outer membrane help to anchor the nucleus and maintain it's proper shape.

b) Inner membrane
- It is adjacent to nuclear interior.

c) Perimeter space: it varies between 15 and 30 nm and it is found between outward inner membrane.
d) Nuclear lamina
- made of protein lamins.
- closely adheres to the nucleoplasmic surface of the inner membrane .

e) Nuclear pores
- about 60nm in diameter
- they pass through both membranes of the nucleus.

- cells with transcriptionally active nuclei have larger numbers of pores than metabolically inactive nuclei.

Functions of the nuclear membrane

i) Mediate the transfer of material between nucleus and cytoplasm e.g. proteins , RNAs.
ii) Nuclear pores allow passive diffusion and smaller and smaller molecules and mediated transport for larger molecules.
iii) Facilitate spatial organization of the cell by serving as an anchoring point for other structures e.g chromatin fibres are attached at multiple sites to the nuclear lamina.
here exists connection between outer nuclear membrane and other organelles e.g MT. ER. Golgi complex
iv) Oxidative metabolism - nuclear envelope have been found to contain enzymes and proteins involved in electron transfer and oxidative phosphorylation.

10.2 Nucleoplasm (nuclear sap).

Is an amorphous fluid-like material that contains the soluble material of the nucleus. Components of the nucleoplasm include proteins , RNA and ribonucleoprotein complexes and small molecules.

a) Protein .e.g. enzymes

Function - involved in metabolic pathway.
- replication and transcription of DNA
- regulation of chromatin structure and function.

b) RNA and Ribonucleoprotein complexes

Function - contain RNAs which are implicated in the processing of mRNAs
- contain particles which are precursors of cytoplasmic ribosomes
- contain messenger RNA precursors e.t.c.

c) Small molecules.
- Include coenzymes , metabolites and ions all dissolved in nucleoplasm.
- Contain nucleotide and nucleoside precursors utilized in the synthesis of DNA and RNA.

10.3 The Nucleolus: Structural components of nucleolus

Most cells have one or two (sometimes can go up to thousands). The nucleolar organizing regions (NOR) are special sites which directs the formation of nucleolus. Components of nucleolus inclide;

i) Fibrils - it is about 5nm in diameter
- predominate the core of the nucleolus
ii) Nucleolar cortex- surround the fibrillar core.
iii) Ribonucleoprotein granules- it is about15nm in diameter
iv) Nucleolar matrix-- fibrils and granules are embedded here.
v) Chromatin fibres - from the nucleus organizers they are seen projecting into nucleolus from the surrounding chromatin.

Functions of the nucleolus - it site where ribosomes are made.

10.4 Chromatin fibre

Called chromosomes when they are condensed into larger and more discrete structures.
Composition - protein 60 – 70%
- DNA 30 – 40%
- RNA a few percent.

Proteins in the chromatin fibre are divided into;
a) Histone proteins
b) Non – Histone proteins.

10.5 Proteins

Proteins found in the nucleus are histone and non-histone proteins

i) Histone proteins

They have higher content of lysine and arginnine which gives it a positive charge at physiological pH. There five basic Histone protiens that have been isolated; H_1, H_2A, H_2B, H_3, H_4. Chromatin contains nearly equal number of H_2A , H_2B , H_3 and H_4 molecules and each of these is nearly a half in number of that of H_1. Histone H_5 have been found in red blood cells and protamines found on sperms heads.

ii) Non – Histone proteins

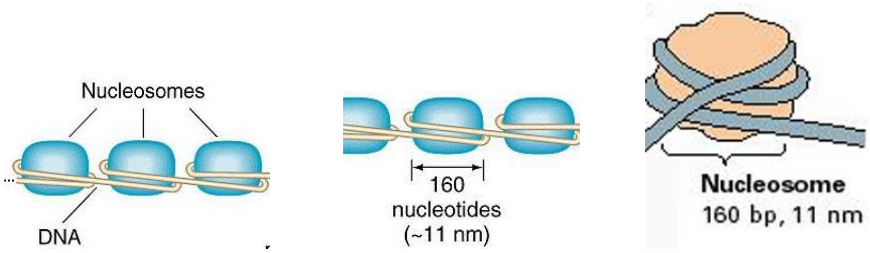
These include;
i) Enzymes involved in metabolism of DNA.
ii) High mobility group (HMG) proteins
iii) Other non – histone proteins.

Functions of non – histone proteins

i) May be involved in regulation of chromatin structure and function.

10.6 The nucleosome and chromatin structures

i) Nucleosome is made of two $H_3 – H_4$ and two $H_2A – H_2B$ (eight) histones i.e. octomers of histones. Naturally H_3 binds to H_4 and H_2A binds to H_2B to make complexes.
ii) Nucleosome is a 200bp DNA wound on histone octomers.
iii) Core particle of nucleosome - this is 160bp of DNA wound on histone ($H_3 – H_4$ and $H_2A – H_2B$) octomes
iv) Portion of DNA between 200 – 160bp is the linker DNA which joins one nucleosome to another.
v) Histone proteins facilitate packaging of nucleosome into higher levels of organisation.
vi) H_1 is associated with the linker DNA.
vii) Core of nucleosome is disk-like and measure 11nm in diameter and 5.7nm in length. Isolated nucleosome and nucleosome chain measure 10nm in diameter.



10.7 Solenoid structure of DNA

i) Solenoid DNA is 30nm in diameter.
ii) This packaging does not occur in absence of H_1.
iii) Therefore, H_1 mediates packaging of 10nm chain to 30nm solenoid.
iv) If 200bp stretch of DNA which is 70nm is packaged into 10nm in diameter, then the packaging ratio is 7.
v) When nucleosomes are packaged into helical arrays to form 30nm chromatin fibres, the packaging ratio increases to 40.
vi) During cell division, 30nm chromatin (solenoid) can be further condensed to have packaging ratio of 104.
vii) Protein backbone or scalffold consists of histone proteins and a mixture of other non – histone proteins that provide anchorage points to which long loops of DNA are attached.

10.8 Other ways of packaging chromatin fibre

i) Giant polythene chromatin- its is a excessively large chromosomes found in insects and certain other animals, including the lampbrush and polytene chromosomes.
ii) Lampbrush chromosomes formed during meiotic division of certain types of oocytes. It is a large chromosome found especially in the immature eggs of amphibians, consisting of two long strands that form many brushlike loops along the main axis of the chromosome

10.9 DNA packaging in prokalyotic cells

i) It lacks nucleosomes and Histone proteins.
ii) DNA is thought to be packaged in fibrils averaging 12nm in diameter.
iii) Digested bacterial DNA have been found to generate 120 base pair fragments in association with protein.
iv) These proteins are implicated to mediate DNA packaging.

10.10 The nuclear matrix

i) Is thought to be analogous to cytoskeletol filament network of cytoskeleton.
ii) Constituents of nuclear matrix - actin , proteins e.t.c.

Functions of nuclear matrix.

i) Thought to play a role in organising chromatin fibres involved transcription and replication.