

Nucleus structure and function



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The aim of this write up is to enable us know the structure of a nucleus and the purpose its serves in a living organism. But first what is this organelle called nucleus and where can it be found in a living organism?

Erin Cram expresses that the nucleus is a sub cellular compartment which can be found in any Eukaryotic cells, such as cells from an apple tree or a dog. Nucleus is roughly spherical unit which is located at the centre of a cell. It usually contains the chromosomes (which is composed of mainly nucleic acids), which are responsible for directing the cells activities and its surrounded by a membrane, in which case the membrane has pores of which various substances can pass through between the nucleus and the cytoplasm, a thick fluid that aggregate the bulk of cells.

The presence of a layer in the cell known as double lipid bilayer (nuclear membrane) separate the nucleus from the rest of the cells.

The nucleus contains many things. The most important is the DNA- it carries the hereditary information, a kind of genetic information that occurs in every living organism. Others are proteins that help DNA aggregates, help DNA to replicate itself, and help the genes in the DNA to be transcribed under the regulation to produce the RNA, The nucleus serves an important role as a marker that a cell is eukaryotic, a location that genetic information-DNA is stored; also a location that some DNA (genes) can be transcribed, which then can be translated in other parts of the cell with a degree of accuracy and designated area in the cell.

The nucleus is surrounded by double membrane layer which are inner and outer membranes filled with fluid area. The outer membrane of the nuclear

envelope is attached and combined with rough Endoplasmic Reticulum of the cytoplasm. Likewise ribosomes are also attached on outer membrane's external surface as well. As Marieb (2007) indicates that the inner membrane of the nuclear envelope consists of some proteins where they provide binding sites for the genetic materials such as chromosomes. However the main function of the nuclear envelope is that it separates the nucleoplasm and its contents from the cytoplasm otherwise both nucleoplasm which contains nucleolus with genetic information and cytoplasm interacts each other resulting failure of both genetic characteristics of the cell as well as the protein synthesis.

In the same way Solomon (2008) points out that like other biological membranes such as plasma membrane, nuclear envelope is selectively permeable and it contains nuclear pores. These pores are found on the nuclear envelope and they look like a small hole which controls the direction of substances and materials between cytoplasm and nucleus. Alberts et al (2010) express that some of the substances that needs to deliver for the nucleus enter from the cytoplasm and other molecules including RNA which are already made in the nucleus transported to cytoplasm.

Alberts et al (2010) states that nuclear pores contain about 30 different proteins, some of them are small which they can pass through inside the pores easily. However there are some large proteins and they require more energy than smaller proteins to transport between cytoplasm and nucleoplasm. Therefore to transport larger molecules through nuclear pores there is a system that directs these molecules via the pores. The system

stimulates larger molecules for movement and this signalling system is called " nuclear localization signal".

The cell membrane is made up of the outer and inner cell membrane with a trilaminar structure, which enclose the pre nuclear cistern between them by parallel-going process. Darnell J et al (1990) From the one side huddled to the inner nuclear membrane surface and from the other side from the peripheral chromatin of a eukaryotic nucleus there is a high -protein lamination (thickness 30-100 nm) out of filaments -which is called the nuclear lamina . Newport JW et al (1987) The lamina can be isolated biochemically, and remaining matrix has the same form and size like the treated cell and is only made out of lamina proteins which forms a stable fibular bonding polymer network . Lamina A, B1, B2 and C are those who built the lamina proteins. They belong to the family of the type 5 intermediate filaments. Intermediate filaments are structures built of proteins which increase the mechanic stability of a nucleus. A single monomer of the intermediate filaments is about 48 nm long and very thin. Type 5 is one of the six types of the intermediate filament (online last accessed 29/10/2010). The connection from the lamina with a cell membrane is achieved through lamina B according to Newport et al, because it has a special role when bonding with the membrane, while the other laminas connect to lamina B and transmit interaction between chromatin and the lamina. Dessev GN et al (1992) consider an indirect interaction between non lamina components of the nucleolus membrane and a lamina B receptor for possible. Pyrpasopoulou A et al (1996) The lamina, lamina- associating polypeptides and lamina B receptor connect to the DNA or interact with

chromatin via the histones and thereby influence chromosome position in the cell. The lamina is responsible for the retention of the nuclear form and as the base frame for the chromatin adherence regarding to Newport et al. Goldberg M & Bosman FT (1999) states the nuclear lamina is accountable for the integrity of the cell structure and therefore for the DNA-function, for the structural organisation of the chromatin, chromatin condensation and nucleolus formation. The mechanical continuity between the cytoskeleton and the cell contents is being assured by the lamina.

The nucleolus is the most prominent structure present in the nucleus of a eukaryotic cell. The small, dense and generally spherical composition is a knot of chromatin which can also be referred to as active DNA. David M. Prescott states that it is within this discrete organelle that the large and small subunits of the ribosomes are assembled following the import of ribosomal protein after they are synthesised within the cytoplasm, hence why the nucleoli is not present in prokaryotes due to ribosomal assembly taking place in the cytosol.

The site of ribosomal RNA transcription and pre-RNA processing (Olson et al., 2002), the nucleolus, is not membrane enclosed, and is resident within the nuclear matrix. Nucleoli form on one or more chromosomes at specific regions called nucleolar organisers (Prescott D M., 1988) and have varied sizes according to the ribosomal requirements of the particular cell. The larger the quantity of protein synthesis within a cell, the greater the ribosome requirements, therefore the increase in the nucleolus measurement, sometimes as large as to occupy 25% of the total volume of the nucleus (Davidson M W. 1995-2010).

Davidson M W. also declares that, although eukaryotic cells mainly hold a single nucleolus, several are likely also; however, amongst the members of identical species, the specific number of nucleoli is permanent. Each diploid cell present in the human body consists of just one nucleolus, after cell division as during this process, ten smaller nucleoli appear until finally they combine into a single larger nucleolus.

DNA organises in to complex structures called chromosomes, which contain as much Deoxyribonucleic acid as Protein. Due to chromosomes DNA is packaged and segregated in the cell division and transmitted to daughter cells and transcribes to RNA molecules and used in protein synthesis.

Chromosomes are located inside the nucleus and are made up of genes that are found in DNA. They contain a single strand of DNA, regulatory elements and nucleotide sequences. Chromosomes take part in the processes of mitosis and meiosis, chromosomes appear in H or X shapes and contains a characteristic shape to carry the hereditary material of the cell. This information is used to controls every part of the cell and each part of the cell is unique because of the whole chromosomes. The DNA molecule can be in the form of linear or circular and contains many nucleotides, which are joined to form long chains.

Toole (2004) shows that chromosomes are found in both eukaryotic and prokaryotic cells. They are linear and larger in eukaryotic cells, smaller and circular in prokaryotic cells. Chromosomes cannot be seen even under a microscope but they can be discrete during a cell division. They consist of widely spread areas of darkly staining material called chromatin. When they are visible, they appear long, thin threads around 50 micrometres long. They

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are made up of two strands called chromatids which are joined together to form centromere. This centromere may vary in different chromosomes; a chromosome with only one centromere is called monocentric and more than one centromere is called polycentric. A centromere contains two kinetochores inside and each of them is made up of protein fibres (70% forms histones), deoxyribonucleic acid (15%) and ribonucleic acid (10%). This centromere allows the movement of the chromatids and if any part of the centromere is damaged the chromosome cannot move into the anaphase.

In order for a long length DNA strand to fit into a chromosome they are highly coiled and folded into a specific shape. This DNA then holds its position by proteins, which are called histones, and combines with a complex known as chromatin. Isenberg (1979) Eukaryotic cells contain 5 types of histones H1, H2A, H2B, H3 and H4. All histones have a high content of the basic amino acid residues Arginine and Lysine.

Anon 2006 (online) Chromosomes are divided into four different position groups and these are; telocentric chromosome and acrocentric chromosomes both have rod shape structure, sub-metacentric chromosome which has an L shaped structure and metacentric chromosomes have a V shaped structures. Due to their shapes and their functions they can either be an autosomes or sex chromosomes. Autosomes are the chromosomes which are found in all the body cells, human have 46 chromosomes (or 23 pairs) all together but two of the chromosomes are sex chromosomes.

Sex chromosomes are involved to determine the sex of an organism. To determine the males have the two sex chromosomes as XY and females have two sex chromosomes as XX Greider (1999) indicates that the telomeres are specialised structures, comprising DNA and protein, which cap the end of eukaryotic chromosomes.

The main functions of telomeres are to maintain structural integrity of a chromosome, if lost the resulting chromosome end is unstable. Telomeres fuse with broken chromosomes, this helps it to be involved in recombination events and degrading, also ensures that there are no free ends on DNA and ensures complete replications. Helps to obtain the three dimensional shape of the nucleus and the chromosomes, chromosomes telomere rich end shows the 3' end.

Containing the DNA of the nucleus chromatin is only found in eukaryotes (plant or animal cells). Chromatin is divided into 46 molecules which are packed inside the nucleus and approximately it is 6 feet of DNA. Chromatin has an unusual packaging in the way it can fit in the nucleus. In order for DNA to work, this can be fitted into the nucleus which is like a ball of string. Rather than doing this; combining it with proteins into an exact and the structure, it has been pressed in a dense string like fibre is produced a chromatin.

According to the information indicated by M. W. Davidson, (1995); some small proteins are covered by DNA strand which are called histones creating a bead like structures named as nucleosomes. These are combined by DNA

strand and the appearance of the chromatin (which are not condensed) under the microscope can be seen as beads on a string view.

The collection of nucleosomes is pressed with a factor of six. After it has been coiled into a denser structure, it compacts the DNA by a factor of 40. The structure of the DNA in this way has some functions. The DNA is neutralized by the negative charge of it and a positive charge of histone molecules. In this way, DNA uses less space and the ones that are not active are placed into inaccessible places.

In addition, the information from 'Anon', 2000, What is Chromatin?, [online] states that; there is basis function of chromatin. This means compacting of DNA strands. If we look at the cells of mammals; 2m of DNA is compressed into a 10 micro meter diameter. So, with this value we can imagine the degree of how the chromatin has been compacted. We can think of it as a book of genetic data. This data is placed in the chromatin structure and it can be used when it's needed. This is the function of chromatin, so it can package the data.

Moreover, other functions of chromatin is that it strength the DNA and helps replication as well as transcription during cell division. We cannot find DNA in the nuclei of the cell with its naked form. Accompanying with some kinds of proteins when the process of acetylation (means the process of introducing an acetylation group into compound) is happening the structure of the chromatin gets loosened and easy replication occurs ad well as the DNA transcription. This process helps the cell division to occur. There are some

moments when the chromatin gets modified during the cell division process.

There are also 2 types of chromatin; euchromatin and heterochromatin.

Euchromatin has the active DNA and involved in transcribing RNA to produce proteins used in growth and cell function whereas heterochromatin has the inactive DNA and it is the most condensed one.