Notes on cell junction, nucleus, peroxisomes, and lysosome

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Cell junction

A **cell junction** is a type of structure that exists within the tissue of some multicellular organisms. Cell junctions consist of multiprotein complexes that provide contact between neighbouring cells or between a cell and the extracellular matrix. They also build up the paracellular barrier of epithelia and control the paracellular transport. Cell junctions are especially abundant in epithelial tissues.

Cell junctions are especially important in enabling communication between neighboring cells via specialized proteins called communicating junctions. Cell junctions are also important in reducing stress placed upon cells.

Types:
There are three major types of cell junctions:

- Anchoring junctions (Adherens junctions, desmosomes and hemidesmosomes)
- Gap junctions (communicating junction)
- Tight junctions (occluding junctions)

1) Anchoring Junctions: Three types of anchoring junctions are observed-

i. Desmosomes: Desmosomes can be visualized as rivets through the plasma membrane of adjacent cells. Intermediate filaments composed of keratin or desmin are attached to membrane-associated attachment proteins that form a dense plaque on the cytoplasmic face of the membrane.

ii. Hemidesmosomes: Hemidesmosomes form rivet-like links between cytoskeleton and extracellular matrix components such as the basal laminae that underlie epithelia. Like desmosomes, they tie to intermediate filaments in the cytoplasm.

iii. Adherens Junctions: Adherens junctions share the characteristic of anchoring cells through their cytoplasmic actin filaments. Similarly to desmosomes and hemidesmosomes, their transmembrane anchors are composed of cadherins. The cytoskeletal actin filaments that tie into adherens junctions are contractile proteins and in addition to providing an anchoring function, adherens junctions are thought to participate in folding and bending of epithelial cell sheets.

2) Communicating (GAP) junctions:
Communicating junctions, or gap junctions allow for direct chemical communication between adjacent cellular cytoplasm through diffusion. This is possible due to six connexin proteins, interacting to form a cylinder with a pore in the centre. This protrudes across the cell membrane, and when two adjacent cell connexons interact, they form the gap junction channel. Connexon pores vary in size, polarity and therefore can be specific depending on the connexin proteins that constitute each individual connexon

Gap junctions play vital roles in the human body including their role in the uniform contractile of the heart muscle. They are also relevant in signal transfers in the brain, and their absence shows a decreased

cell density in the brain. Retinal and skin cells are also dependent on gap junctions in cell differentiation and proliferation.

3) Tight Junctions

Found in vertebrate epithelia, tight junctions act as barriers that regulate the movement of water and solutes between epithelial layers. Tight junctions are classified as a paracellular barrier which is defined as not having directional discrimination.The movement is largely dependent upon solute size and charge. There is evidence to suggest that the structures in which solutes pass through are somewhat like pores. Physiological pH plays a part in the selectivity of solutes passing through tight junctions. Most tight junctions are slightly selective for cations. Tight junctions present in different types of epithelia are selective for solutes of differing size, charge, and polarity.

Proteins found in Tight Junction:

There have been approximately 40 proteins identified to be involved in tight junctions. These proteins can be classified into four major categories

i. **Scaffolding Proteins** — organise the transmembrane proteins, couple tranmembrane proteins to other cytoplasmic proteins as well as to actin filaments.

ii. **Signalling Proteins** — involved in junctions assembly, barrier regulation, and gene transcription.

iii. **Regulation Proteins** — regulate membrane vesicle targeting.

iv. **Transmembrane Proteins** — including junctional adhesion molecule (JAM), occludin, and claudin. Claudin protein molecule is responsible for the selective permeability between epithelial layers.

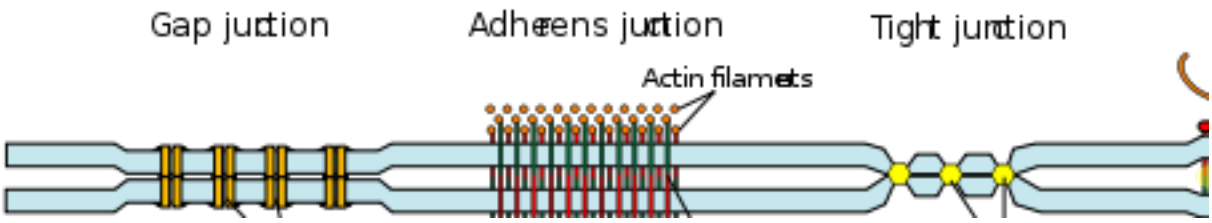

Fig:-Cell Junction

Nucleus

In the **nucleus** is a membrane-enclosed organelle found in eukaryotic cells. It contains most of the cell's genetic material, with a large variety of proteins, such as histones, to form chromosomes. The function of the nucleus is to maintain the integrity of genes and to control the activities of the cell by regulating gene expression — the nucleus is, therefore, the control center of the cell.

Structures:

The nucleus is the largest cellular organelle in animals. In mammalian cells, the average diameter of the nucleus is approximately 6 micrometers (μm), which occupies about 10% of the total cell volume.

Nuclear envelope-

The nuclear envelope, or 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. The space between the membranes is called the perinuclear space.

Nuclear pores-

Nuclear pores provide aqueous channels through the envelope and 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 several hundred 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. Most proteins, ribosomal subunits, and some DNAs are transported through the pore complexes

Chromosomes

The nucleus contains the majority of the cell's genetic material in the form of DNA molecules organized into structures called chromosomes. In most of the cells these are organized in a DNA-protein complex known as chromatin.

There are two types of chromatin.

- **Euchromatin** - is the less compact DNA form and contains genes that are frequently expressed by the cell.
- **Heterochromatin** - is the more compact form, and contains DNA that are infrequently transcribed. This structure is further categorized into facultative heterochromatin, and constitutive heterochromatin.

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.

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. The main roles of the nucleolus are to synthesize rRNA and assemble ribosomes.

Under electron microscope, the nucleolus can be seen to consist of three distinguishable regions:
the innermost fibrillar centers (FCs), surrounded by the dense fibrillar component (DFC), which is bordered by the granular component (GC).

Other subnuclear bodies-

Besides the nucleolus, the nucleus contains a number of other non-membrane-delineated bodies. These include Cajal bodies, Gemini of coiled bodies, polymorphic interphase karyosomal association (PIKA), promyelocytic leukaemia (PML) bodies, paraspeckles, and splicing speckles. Other subnuclear structures appear as part of abnormal disease processes.

Cajal bodies: A nucleus typically contains between 1 and 10 compact structures called Cajal bodies or coiled bodies (CB), whose diameter measures between 0.2 μm and 2.0 μm depending on the cell type. CBs are involved in a number of different roles relating to RNA processing, maturation, and mRNA modification.

Gems: Gems are similar in size and shape to CBs. Unlike CBs, gems do not contain small nuclear ribonucleoproteins (snRNPs), but do contain a protein called survivor of motor neurons (SMN).

RAFA and PTF domains: RAFA domains, or polymorphic interphase karyosomal associations, were first described in 1991. Their function is unclear. They have been found to often associate with discrete domains defined by dense localization of thetranscription factor PTF, which promotes transcription of snRNA.

PML bodies: Promyelocytic leukaemia bodies (PML bodies) are spherical bodies found scattered throughout the nucleoplasm, measuring around 0.2–1.0 μm. They are known by a number of other names, including nuclear domain 10 (ND10), Kremer bodies, and PML oncogenic domains. They are often seen in the nucleus in association with Cajal bodies and cleavage bodies. It has been suggested that they play a role in regulating transcription.

Paraspeckles: Paraspeckles are irregularly shaped compartments in the nucleus. Their structures alter in response to changes in cellular metabolic activity.

Splicing speckles: Speckles are subnuclear structures that are enriched in pre-messenger RNA splicing factors and are located in the interchromatin regions of the nucleoplasm of mammalian cells.

Function:-

Cell compartmentalization: The nuclear envelope allows the nucleus to control its contents, and separate them from the rest of the cytoplasm. This is important for controlling processes on either side of the nuclear membrane. The compartmentalization allows the cell to prevent translation of unspliced mRNA.

Gene expression: Gene expression first involves transcription, in which DNA is used as a template to produce mRNA which is then translated protein. Since the nucleus is the site of transcription, it also contains a variety of proteins that either directly mediate transcription or are involved in regulating the process.

Processing of pre-mRNA: Newly synthesized mRNA molecules are known as primary transcripts or pre-mRNA. They must undergo post-transcriptional modification in the nucleus before being exported to the cytoplasm. RNA splicing, carried out by a complex called the spliceosome, is the process by which introns, are removed from the pre-mRNA and the remaining exons connected to re-form a single continuous molecule.

Peroxisomes

Peroxisomes, also called microbodies are small, membrane-enclosed organelles that appear in most eucariotic cells which contain enzymes involved in a variety of metabolic reactions, including several aspects of energy metabolism. They are about the size of lysosomes (0.5–1.5 µm). They have often a crystalline structure within the amorphous gray matrix. Peroxisomes are self replicating. In mammals and other vertebrates they are particularly large and abundant in hepatocytes and cells of the tubular portions of the nephrons.

Functions:

- Breakdown (by oxidation) of excess fatty acids.
- Breakdown of hydrogen peroxide (H_2O_2) by the enzyme catalase
- Participates in the synthesis of cholesterol.
- Participates in the synthesis of bile acids.
- Participates in the synthesis of the lipids used to make myelin.
- Breakdown of excess purines (AMP, GMP) to uric acid.

Lysosome

Lysosomes are membrane-enclosed organelles that contain an array of enzymes capable of breaking down all types of biological polymers—proteins, nucleic acids, carbohydrates, and lipids. Lysosomes function as the digestive system of the cell, serving both to degrade material taken up from outside They contain acid hydrolase enzymes that break down waste materials and cellular debris. They are found in animal cells. Lysosomes digest excess or worn-out organelles, food particles, and engulf viruses or bacteria. Lysosomes fuse with autophagic vacuoles and dispense their enzymes into the autophagic vacuoles, digesting their contents.

The size of a lysosome varies from 0.1–1.2 µm. At pH 4.8, the interior of the lysosomes is acidic compared to the slightly basic cytosol. The lysosomal membrane protects the cytosol, and therefore the rest of the cell, from the degradative enzymes within the lysosome.

Lysosomes are the cell's waste disposal system and can digest some compounds. They are used for the digestion of macromolecules from phagocytosis ,endocytosis and autophagy.

Other functions include digesting bacteria that invade a cell and helping repair damage to the plasma membrane.

Functions of Lysosomes:

A) CELLULAR DIGESTION: Lysosomal enzymes degrade proteins into dipeptides and carbohydrates onto monosaccharides.

B) AUTOPHAGY: By the process of autophagy lysosomes constantly remove cellular components like mitochondria etc. Cytoplasmic organelles become surrounded by smooth endoplasmic reticulum and lysosomes attach with it and discharge their contents into autophagic vacuole and the organelle is digested.

C) DEVELOPMENTAL PROCESSES: Many developmental processes involve shedding or remodelling of tissues with removal of whole cells and extracellular material.

D) EXOCYTOSIS: Contents of the primary lysosome may be released into the medium by exocytosis and it occurs during replacement of cartilage by bone during development where osteoclasts release lysosomal enzymes.

E) ENDOCYTOSIS: Lysosomes may fuse with vesicles or vacuoles formed by endocytosis and release their enzymes into it for digestion.The material for digestion may be food or a foreign body like parasite

F) ROLE IN GERM CELLS ANFD FERTILIZATION: The acrosome in spermatozoa may be considered as a special lysosome containing protease and hyaluronidase along with acid phosphatase .The lysosome in Ova help in digestion of stored food.