| **ORGANELLE** | **STRUCTURE** | **FUNCTION** |
| --- | --- | --- |
| **MEMBRANOUS** |
| **ENDOPLASMIC RETICULUM** | * the ER is a network of folded membranes 🡪 interconnected membranous tubules and flat, curving sacs (arranged in parallel) that branch throughout the cell
* continuous with the nuclear membrane
 |
| * **ROUGH ER** is studded with ribosomes
* Ribosomes attach transiently to receptor proteins in the ER membrane during protein synthesis
* The first few amino acids (signal peptide) of many proteins are attracted to these receptors – this forces the synthesized protein into the ER membrane or lumen
* Note: ribosomes producing proteins that do not have an initial sequence attractive to these receptors remain free in the cytoplasm
 | * processes (i.e. folds, combines) and transports proteins synthesized by ribosomes
* these proteins are destined to leave the cell via the Golgi apparatus
* integral membrane proteins and enzymes for lipid synthesis
 |
| * **SMOOTH ER** lacks ribosomes

 * Usually an extension of the rough ER
* Note that the distribution and abundance of different types of ER provide insight into the function of cells
 | * Most functions are associated with the synthesis of lipids and CHO’s
* Synthesis of cholesterol, steroid hormones, and lipoproteins (lipid portion)
* Inactivates and detoxifies drugs (in the liver)
* the SER stores calcium (in muscle cells)
 |
| **GOLGI APPARATUS** | * The Golgi complex consists of 3 to 20 flattened, membranous sacs called cisternae that are stacked on one another
* The forming face is closest to the nucleus and receives vesicles containing proteins from the ER.
* The maturing face is nearest the cell membrane and pinches off vesicles for export.
 | * Receives proteins from the rough ER
* stores, modifies and packages proteins into vesicles
* vesicles contain proteins for export from the cell
* vesicles containing digestive enzymes form lysosomes
* attaches polysaccharides to form glycoproteins
 |
| **LYSOSOMES** | * a single membrane bound structure produced by the Golgi apparatus that contain digestive enzymes
* found in large numbers in WBCs which carry out phagocytosis
 | * digest macromolecules or bacteria that are in the cell
* digest worn-out organelles (**autophagy**)
* cause self-destruction of cells when injured (**autolysis)**
 |
| **PEROXISOMES** | * similar to lysosomes but smaller
* Not produced by the Golgi apparatus (but appear to be self-replicating)
* contain several enzymes, including peroxidase and catalase
 | * detoxify various substances such as alcohol and formaldehyde
* detoxify free radicals (oxygen with an extra electron; very toxic to cells) by converting them to H2O2 which is then converted to water
 |
| **MITOCHONDRIA** | * double membraned - consist of a smooth outer membrane and a folded inner membrane surrounding the interior matrix.
* The inner folds are called cristae – act as a catalytic surface for the enzymes involved in the ETC
* The matrix is the region enclosed by the inner membrane – contains DNA, RNA, ribosomes, and most enzymes of the TCA cycle (3 are in the inner membrane). The mitochondria make many, but not all, of the proteins required for synthesis of other mitochondria and proteins of oxidative metabolism
* The number of mitochondria/cell varies in proportion to the metabolic activity of the cell
 | * called the “powerhouses of the cell” because they produce ATP
* site of oxidative metabolism
* consume oxygen, breakdown nutrients and produce ATP and CO2 (byproduct)
 |
| **NUCLEUS**  | * largest organelle and prominent feature of the cell
* The nuclear membrane is a double phospholipids bilayer. The outer membrane is continuous with the ER and may have ribosomes attached.
* Nuclear pores (8 protein ring) perforate the envelope. They are formed in areas where inner and outer membranes merge. They are selective to what will pass through them – RNA and some proteins can freely move between the nucleus and cytoplasm.
* Nucleoplasm contains water, salts, nutrients, nucleotides, enzymes and chromatin.
* Chromatin is a complex of DNA and histone proteins that carry the instructions for the synthesis of proteins (histone proteins help package DNA and play a role in the regulation of the expression of genes)
* Nucleoli are specialized parts of specific chromosomes, containing DNA and RNA. This is the site of RNA synthesis and assembly of ribosomes. Cells may contain one or many.
 | * storage and processing of genetic information
* regulation of cellular activites
* control of protein synthesis (including ribosomes)
* reproduction and cell differentiation
* control of metabolic activities

NOTE: RBCs don’t have a nucleus (limited lifespan and cannot divide) |
| **NONMEMBRANOUS** |
| **RIBOSOMES** | * not membrane bound
* consist of two parts – a large and small subunit composed of ribosomal RNA and protein
* occur (1) free in the cytoplasm, (2) attached to the endoplasmic reticulum, or (3) inside mitochondria
 | * site of protein synthesis
* ribosomes free in the cytoplasm participate in the synthesis of soluble proteins that function in the cell’s cytoplasm
* ribosomes bound to the ER participate in synthesis of proteins for inclusion into membranes and export out of cells
 |
| **CYTOSKELETON** | The cytoskeleton includes microfilaments, microtubules, and intermediate filaments that form a three-dimensional lattice structure in the cell. |
| * **MICROFILAMENTS** are rod-like structures (smallest)
* composed of actin and other proteins, arranged singly or in bundles
* form a band just beneath the plasma membrane (strength to cell and maintain cell shape)
 | * components of the contractile apparatus in muscle cells (muscle contraction)
* involved in cytokinesis
* cell movement (i.e. WBCs)
* links transmembrane proteins to cytoplasmic proteins
* stiffen microvilli (fingerlike projections of the cell membrane that increase the cell surface area)
 |
| * **INTERMEDIATE FILAMENTS** are composed of fibrous proteins
* Have a high tensile strength (durable)
* i.e. keratin fibres of skin are specialized intermediate filaments that make the skin strong and able to resist stretching
* i.e. neurofilaments strengthen the long axons of neurons
 | * provide a supporting framework within the cell and stabilize the position of organelles
* **strengthen the cell** (give it tensile strength – resists pulling) and help maintain its shape
* form specialized attachments with the cell membrane
 |
| * **MICROTUBULES** are long, hollow tubes formed by the protein tubulin
* Largest and primary components of the cytoskeleton
* Able to assemble and disassemble quickly
 | * provide strength and rigidity to cell 🡪 **give cells shape**
* give cells motility 🡪 structural component of cilia and flagella
* anchor organelles and guide the movement of organelles and vesicles
* structural component of centrioles 🡪 form the mitotic spindles during cell division (migrate chromosomes)
 |
| **CELL EXTENSIONS** | * specialized projections of the cytoskeleton involved in movement (surrounded by the plasma membrane)
 |
| * **FLAGELLA** long projections and usually occur singly
* Contain 9 pairs of microtubules and two unpaired microtubules in the centre
 | * Provide mobility to sperm (only example of a flagellum in the human)
* Move by bending caused by the sliding of the enclosed microtubules
 |
| * **CILIA** are short and *numerous* hairlike microtubule projections
* Contain 9 pairs of microtubules and two unpaired microtubules in the centre (same structure as flagella)
* found in the respiratory and reproductive tracts
 | * move objects along a cell surface (versus flagella that move cells)
* Move by bending caused by the sliding of the enclosed microtubules (same as flagella)
 |
| * **MICROVILLI** are small fingerlike projections of the cell
 | * allow for increased surface area for absorption
 |
| **CENTROSOME** | * Centrosomes are composed of a pair of centrioles (at right angles) and pericentriolar material
* each centriole is composed of nine clusters of 3 microtubules arranged in a circular pattern (no central pair as seen in cilia and flagella)
* note – RBCs, skeletal muscle cells, cardiac muscle cells, and typical neurons do not have centrioles (unable to divide)
 | * essential for chromosome movement during cell division (centrioles form the spindle apparatus during cell division)
 |
| **PROTEASOMES** | * Hollow cylinder of proteolytic enzymes with regulatory proteins at ends
 | * destroy unneeded, damaged, or faulty proteins in a living cell
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