

Chapter 4

Eucaryotic Cell Structure and Function

Eucaryotic and Procaryotic cells differ in the use of their cell membranes.

- EC have membrane delimited nuclei
- Play a role in the structure of many other organelles.

Organelles (little organ):

- Are intracellular structures that perform specific functions in cells similar to that of organs in the body.
- Relation of organelles to the cell and that of organs to the whole body
- Structurally more complex than the prokaryotic cell due to the use of the internal membranes.

Cytoplasmic Matrix:

- Homogenous substance where larger organelles lie
- One of the most important and complex parts of the cell
- The environment of the organelles and the location of many important biochemical processes.
- Responsible for the physical changes seen in the cells
- **Water is a large part of the cytoplasmic matrix**
 - 70 to 85% by weight
 - Two different types of Cellular water
 - 1). Bulk or free water: normal or osmotically active water
 - 2). Bound water or water of hydration:
 - Bound to the surface of the proteins and other macromolecules
 - Osmotically inactive
 - More ordered than bulk

(Some evidence that bound water is the site of many metabolic processes)

 - **Very High** protein content
 - pH – usually around 6.8 – 7.0 (neutral)

Microfilaments:

- Probably all EC have
- Minute protein filaments either scattered within the CM or organized into networks and parallel rays.
- Involved in **cell motion and shape changes (Example amoeboid movement)**
 - Inhibited by a drug, **Cytochalasin B** which disrupts microfilament structure and often inhibits cell movements
- Actin: similar to actin contractile protein of muscle tissue.
 - *Listeria monocytogenes* makes use of eukaryotic actin to move rapidly through the host cell.

Microtubule:

- Also located in the CM and shaped like a thin cylinder
- Has tubular nature
- Complex composed of two slightly different spherical protein subunits - **tubulins**
 - Beta tubulin
 - Alpha tubulin

Purpose:

- (1) Help maintain cell shape
 - Protozoa contain microtubules

 - The drug: **colchicines** effects heart and embryonic cells with the simultaneously losing their microtubules and their characteristic shapes.
- (2) Involved with microfilaments in cell movements
 - Found in *mitotic spindle* , *cilia*, and *flagella*
- (3) Participate in intracellular transport processes

Intermediate filaments – another filamentous component found in the cytoplasm. Alone with the microtubules and microfilaments are the major components that make up the **Cytoskelton**.

Cytoskelton: plays a role in both cell shape and movement.

(Prokaryotic cells lack a true, organized cytoskeleton and may not possess actinlike proteins).

Endoplasmic Reticulum:

- Also in the CM

- An irregular network of branching and fusing membraneous tubules and many flattened sacs called **cisternae**.

Two different types:

(1). **Rough endoplasmic reticulum (RER) or Granular endoplasmic reticulum (GER).**

- A large portion of ER is studded on its outer surface with ribosomes functioning to synthesize a lot of proteins for the purpose of secretion.

(2). **Smooth or agranular ER (SER or AER)**

- **ER** lacks ribosomes and the cells function to produce large quantities of lipids.

Functions of ER:

- (1). Transport proteins, lipids and other materials through the cell.
- (2). Major site of cell membrane synthesis

Golgi Apparatus:

- Membranous organelle composed of flattened, saclike cisternae stacked on each other.
- Membranes lack bound ribosomes
- Usually 4-8 cisternae in a stack
 - the edge of each cisternae contain a complex network of ***tubules and vesicles***.

Cisternae has polarity because the ***two ends*** are different.

- ***Sacs on the cis or forming face*** are associated with the ER and differ from the
- ***Sacs on the trans or maturing face*** in thickness, enzyme content and degree of vesicle formation.

Material is transported from Cis to Trans cisternae by vesicles that bud off the cisternae edges and move to the next sac.

Functions:

- ***Packages materials and prepares them for secretion.***
- ***Synthesis of lysosome***

Materials moves from the ER → Golgi Apparatus.

Vesicles bud off the ER, travel to the GA and fuse with the cis cisternae.

- Most proteins entering GA from ER are glycoproteins.
- GA modifies proteins and then send the proteins on their way to the proper location.

Lysosomes:

- Synthesized by GA and ER
- Found in protozoa, some algae, and fungi, plants and animals
- Spherical and enclosed in a ***single membrane***

Functions:

Involved in intracellular digestion and contain

- ***hydrolases:*** enzymes needed to digest macromolecules.

Endocytosis:

- ***cells takes up solutes or particles by enclosing them in vacuoles and vesicles pinched off from its plasma membrane.***
 - ***Vacuoles and vesicles*** membrane-delimited cavities containing fluids and solid material.
 - ***Vacuoles*** are larger cavities
 - ***Vesicles*** are smaller cavities

Two Major forms of Endocytosis:

1. Phagocytosis

- *Large particles and microorganisms are enclosed in a **phagocytic vacuole** or **phagosome** and engulfed.*

2. Pinocytosis

- *Small amounts of the surrounding liquid with its solute molecules are pinched off as tiny **pinocytotic vesicles** (**pinocytic vesicles**) or **pinosomes**.*

Together they are called endosomes because they are formed by endocytosis.

- ***Lysosomes** digest material inside endosomes*
- ***Primary lysosomes:** fuse with phagocytic vacuoles to yield*
- ***Secondary lysosomes:** lysosomes with material being digested
Often called **food vacuoles**.*

Digested nutrients leave the 2^o Lysosome → enter the cytoplasm.

*When lysosomes has large quantities of indigestible material – **residual body**.*

- *Lysosomes join with phagosomes for defensive purposes and to acquire nutrients.*
- *Invading bacteria ingested by a phagocytic cell, are destroyed when lysosomes fuse with the phagosome.*

Autophagic Vacuole: *a secondary lysosome where the cell can selectively digest portions of their cytoplasm.*

- *Autophagy plays a role in the normal turnover or recycling of cell constituents.*
- *A cell can survive a period of starvation by selectively digesting portions of itself to remain alive.*

Lysosomes accomplish all of their task without releasing their digestive enzymes into the cytoplasmic matrix, which would destroy the cell. The lysosomal membrane retains digestive enzymes and other macromolecules while allowing small digestion products to leave.

- *The intricate complex of membranous organelles:
Golgi apparatus, Lysosomes, Endosomes and associated structures main function is the **import and export materials**.*
- ***ER manufactures secretory proteins and membrane** → **Golgi Apparatus***
- ***Golgi Apparatus** → **forms secretory vesicles that fuse with the plasma membrane and released material to the outside.***

- *Lysosomes are also produced that fuse with endosomes to digest material acquired thru phagocytosis and pinocytosis.*

Eucaryotic Ribosomes:

- *associated with the ER or free in the CM*
- *Larger than the bacterial (prokaryotic) 70S ribosome*
- *60S and 40S subunit*
- *Sedimentation Coefficient of 80S and a MW of 4 million*
- *Bound to ER to form RER*

Functions:

Synthesis proteins (both free and RER-bound)

Proteins made on the ribosomes of the RER:

- *enter the lumen for transport, often for secretion or*
- *are inserted into the ER membrane as integral membrane protein*

Free Protein: sites of synthesis for nonsecretory and nonmembrane proteins

- *some proteins are inserted into **nucleus, mitochondrion and chloroplast***
- ***Chaperons*** *aid in the proper folding of protein after synthesis*
 - *Assist the transport of proteins into eukaryotic organelles*
- *Several ribosomes usually attach to a single messenger RNA and simultaneously translate its message into protein*
- *Messenger RNA and ribosomes are called **polyribosomes or polysomes.***

Mitochondria: (Mitochondrion s.)

- *Found in most EC*
- *Called the **POWERHOUSE** of the cell*
- *Place where Tricarboxylic acid cycle activity and the generation of ATP by the electron transport and oxidative phosphorylation*
- *Cylindrical structures (about the same size of bacterial cells).*
- *Cells can have as many as 1000 or more*
 - *A few cells have a singular giant tubular mitochondrion twisted into a continuous network permeating the cytoplasm (some yeasts, unicellular, algae, and trypanosome protozoa)*

Mitochondrial Structure:

- Bound by **TWO** membranes
 - An **Outer mitochondrial membrane** separated from an **inner mitochondrial membrane** by a **intermembrane space**.
 - **Cristae** (crista) Special infoldings of the inner membrane, greatly increasing its surface area.
 - Cristae shape differs in mitochondrial species
 - **Inner Membrane:** encloses the **mitochondrial matrix:** a dense matrix containing ribosomes, DNA, and large calcium phosphate granules.
 - **Ribosomes:** Mitochondrial ribosomes are smaller than cytoplasmic ribosomes and resemble bacterial in several ways:
 1. Size
 2. Subunit composition
 3. Closed circular DNA
 - **Each mitochondrial compartment** is different from others in **chemical and enzymatic composition**.
 - ** **Outer and Inner membrane** : possess different lipids
 - ** **Inner Membrane:** enzymes and electron carriers involved in ET and OP (formation of ATP).

F1 particles –Spheres are attached by stalk to its inner surface and synthesize ATP during cellular respiration.
 - ** **Matrix:** enzymes of the TCA and Beta oxidation pathway for fatty acids
 - ** **The mitochondrion uses its DNA and ribosomes are used to synthesize some of its own protein.**
 - Mutation in mDNA often lead to serious disease in human.
 - Most mprotein are manufactured under the direction of the nucleus
 - Mitochondria reproduce by binary fission.

Chloroplasts:

- *A plastid that contain chlorophyll and use light energy to convert CO₂ and water to carbohydrates and O₂.*

Plastids:

Cytoplasmic organelles of algae and higher plants that often possess pigments such as chlorophylls and carotenoids and are the site of synthesis and storage of food reserves.

- ***The site of photosynthesis.***
- *Chloroplasts are variable in size and shape*
- *Oval*
- *Encompassed by two membranes*

Stroma: *a matrix lies within the inner membrane.*

- *Contains DNA, ribosomes, lipid droplets, starch granules, and thylakoids.*

Thylakoids: *a complex internal membrane system whose most prominent components are flattened, membrane-delimited sacs.*

Photosynthetic reactions are separated structurally in the chloroplast

- ***Stroma***
The formation of carbohydrate from CO₂ and water, the dark reaction, takes place in the stroma.
- ***Thylakoid Membranes***
 - *The trapping of light energy to generate ATP, NADPH, and O₂ the light reaction,*
 - *Where chlorophyll and ET components are found.*
 - *In some algae, several disklike thylakoids are stacked on each other like coins to form grana (granum)*

*Chloroplasts of many algae contain a **pyrenoid**.*

Pyrenoid:

- *A dense region o protein surrounded by starch or another polysaccharide.*
- *Participate in polysaccharide synthesis.*