

1.2 (B.2.2) Organelles and compartmentalization

Organelles within a cell have a **structure** that is adapted to perform a specific function.

- Organelles may be enclosed by a single membrane or a double membrane.

No membrane	Single membrane	Double membrane
Ribosomes Nucleolus Centrioles	Vesicles and vacuoles rER, sER Golgi Apparatus Lysosomes	Nucleus Mitochondria Chloroplasts

Attention! The cell wall, cytoskeleton and cytoplasm are **not considered organelles**. *Why?*

- The cell wall is extracellular. (Located outside the cell; a structure produced by the cell but situated externally to the living boundary of the plasma membrane.)
- The cytoskeleton (microfilaments, intermediate filaments, and microtubules) is not a discrete structure: Discrete means having a clear shape or boundary. The cytoskeleton is a shifting network of proteins rather than a membrane-bound, solid unit.
- The cytoplasm is not specialized to perform a specific function

Advantages of compartmentalization in the cytoplasm of cells.

Membranes create a compartment with specific, controlled conditions inside.

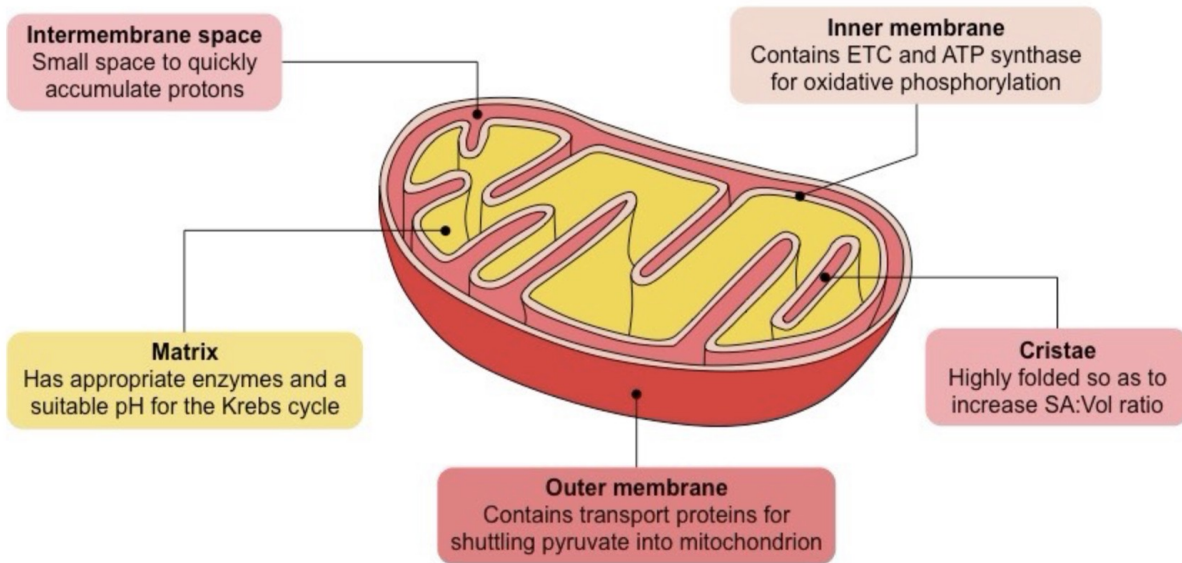
- Enzymes can be concentrated in a small space, increasing the chance for the binding of a substrate to the enzyme's active site.
- Substances that may damage cells are isolated within a membrane (e.g. in lysosomes or phagocytic vacuoles), protecting other structures.
- Conditions, such as pH, can be maintained at an optimal value for specific reactions.
- Large surfaces of membrane can become dense with proteins for specific processes.

Example: The DNA in the nucleus is compartmentalized from the cytoplasm.

- Keeping chromosomes inside the nucleus **protects** the DNA.
- In eukaryotes, translation can't begin if the mRNA hasn't passed out of the nucleus as opposed to prokaryotes where the DNA is 'free'. This allows for post-transcriptional **modification** of mRNA in eukaryotes as well as **regulation**! In prokaryotes, the mRNA immediately meets ribosomes.

Higher Level

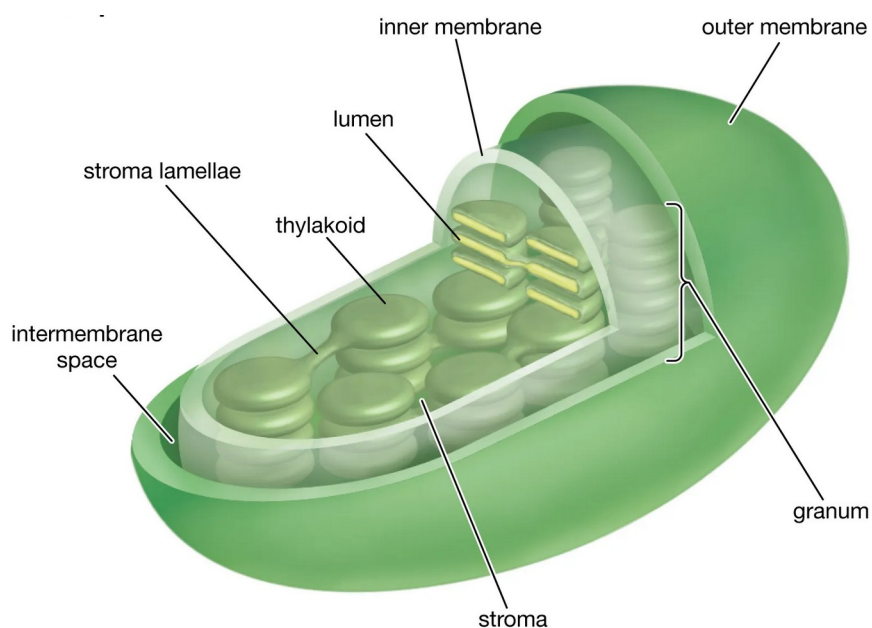
Structure and function of a **mitochondrion**



The structure of the mitochondrion is adapted to the function it performs:

- *Outer membrane* – contains transport proteins that enable the shuttling of pyruvate from the cytosol
- *Inner membrane* – performs *electron transport chain* and *oxidative phosphorylation* (ATP synthase)
- *Cristae* – [inner membrane] is arranged into folds that increase the **Surface Area : Volume ratio**
- *Intermembrane space* – maximizes hydrogen gradient upon proton accumulation
- *Matrix* – central cavity, contains appropriate **enzymes** and suitable **pH** for *Krebs cycle* to occur
- They have their own DNA (circular and naked) and 70S ribosomes

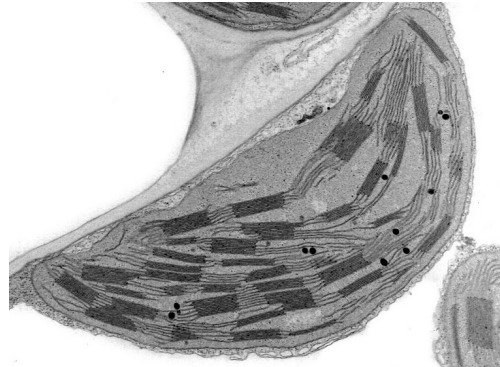
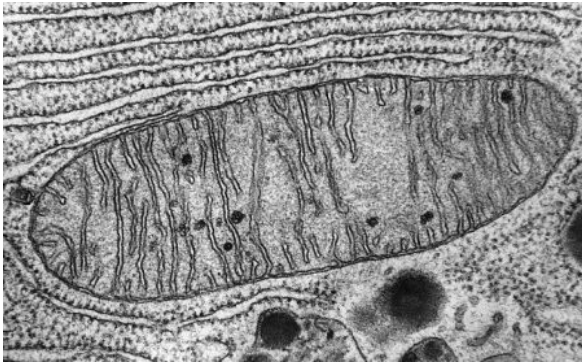
Structure and function of a **chloroplast**



The structure of the chloroplast is adapted to the function it performs:

- *Thylakoids* – flat discs with **small volume** to maximize H gradient upon proton accumulation
- *Grana* – stacks of thylakoids, to increase **SA:Vol ratio** of the thylakoid membranes
- Pigments are organized into *photosystems* in thylakoid membrane to maximize light absorption
- *Stroma* – central cavity, contains appropriate **enzymes** and a suitable **pH** for the *Calvin cycle*
- *Lamellae* – connects and separates grana, maximizing photosynthetic efficiency
- Chloroplasts have their own DNA (circular and naked) and 70S ribosomes

Electron micrographs of the mitochondrion and chloroplast



Functional benefits of the double membrane of the nucleus

The nuclear membrane, or 'nuclear envelope', is a double membrane with pores (holes) that envelopes the genetic material of *eukaryotic* cells, forming what we call the nucleus.

- Pores allow molecules to diffuse between the nucleus (nucleoplasm), and the cytoplasm. They also control the passage of mRNA out the nucleus.
- The outer membrane of the nuclear envelope is continuous with the ER of the cytoplasm.
- The nuclear membrane breaks into vesicles during mitosis and meiosis: Once the DNA is correctly positioned at the conclusion of mitosis or meiosis, the vesicles reform the nuclear envelope.

Structure and function of free and bound ribosomes.

Ribosomes are cytoplasmic organelles found in both prokaryotic and eukaryotic cells. They are made of protein and ribosomal RNA (rRNA). Prokaryotic ribosomes (70S) are smaller than eukaryotic ones (80S).

Eukaryotic ribosomes may be found in **two locations** within cells. They may be attached to the ER (making it rough ER), or they may be free in the cytoplasm of the cell. They differ in function:

- **Free ribosomes** produce proteins that are used within the cell, in the nucleus, by mitochondria, and in other organelles not derived from the cell's inner membrane system.
- **Ribosomes** that are **bound** to membranes produce proteins that are transported through the ER and exported from the cell (aka secretory proteins, e.g. hormones and enzymes). These proteins are sent to the **Golgi apparatus**, where they are properly packaged for cellular exit.

Structure and function of the Golgi apparatus

The Golgi apparatus consists of flattened sacs (cisternae). Its role is to **process** products from the rough ER for **exit** from the cell (secretory proteins, e.g. hormones and enzymes). These sacs are numerous in cells engaged in producing and secreting substances (e.g. glands). As a protein or lipid moves through the cisternae, they are modified, the final product is then packaged into vesicles. The modification of the substance includes the attachment of a signal chemical, which directs it to the desired destination.

Transport **vesicles** may become lysosomes within the cell, while others may return to the ER. Many will combine with the plasma membrane and go through the process of exocytosis.

Structure and function of vesicles in cells

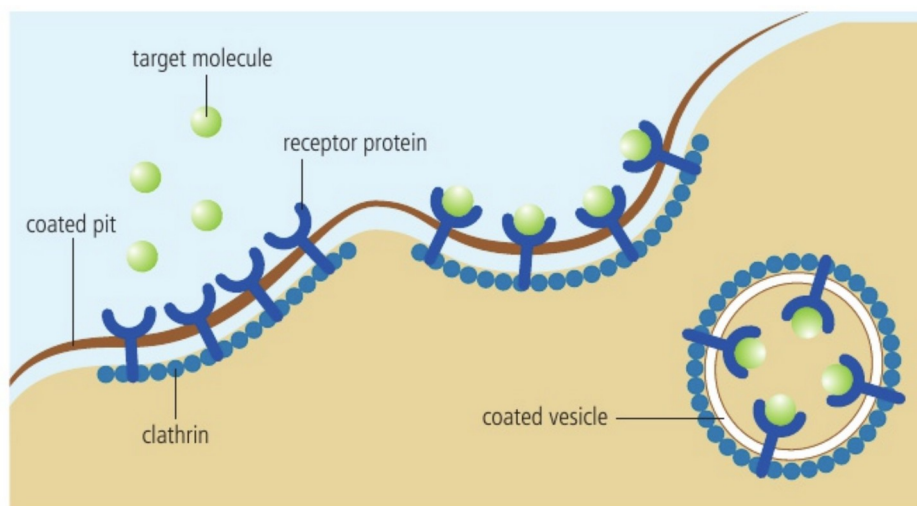
→ **Vesicles** are small membrane-bound sacs in which substances are transported or stored in the cell.

Do **not** confuse these with vacuoles, which are larger and more permanent structures...

→ **Clathrins** are anchor proteins that function in the process of endocytosis.

Clathrins are located specifically on the exterior of plasma membranes. Their function is to enhance vesicle formation in something we call *receptor-mediated endocytosis* (*more on this later*). Because different cells need to take in different molecules, they have specific receptors on their surface to bind to specific molecules. They also drive the membrane's physical inward curvature.

The advantage of *receptor-mediated* is that it is selective and efficient compared to ordinary endocytosis.



▲ A diagram of receptor-mediated endocytosis. Note the anchoring clathrin proteins allowing the receptors to bind to specific molecules.