
جامعة الملك سعود
King Saud University

college of sciences
Zoology Department

# Cell Biology and Physiology

## ZOO (242)

# Cell organelles in term of structure and function

Lysosomes ,vacuoles and mitochondrion •

# Introduction

- In this lecture we are going to study about three endomembrane system organelles namely, Lysosome, Mitochondria and Vacuoles
- A lysosome (derived from the Greek words lysis, meaning "to loosen", and soma, "body") is a membrane-bound cell organelle found in most animal cells.
- The mitochondrion (plural mitochondria) is a double membrane-bound organelle found in most eukaryotic cells. The word mitochondrion comes from the Greek mitos, i.e. "thread", and chondrion, i.e. "granule" or "grain-like". It is the cellular energy producer.
- Vacuoles: vacuole is a membrane-bound organelle .Vacuoles are essentially enclosed compartments which are filled with water containing inorganic and organic molecules including enzymes.

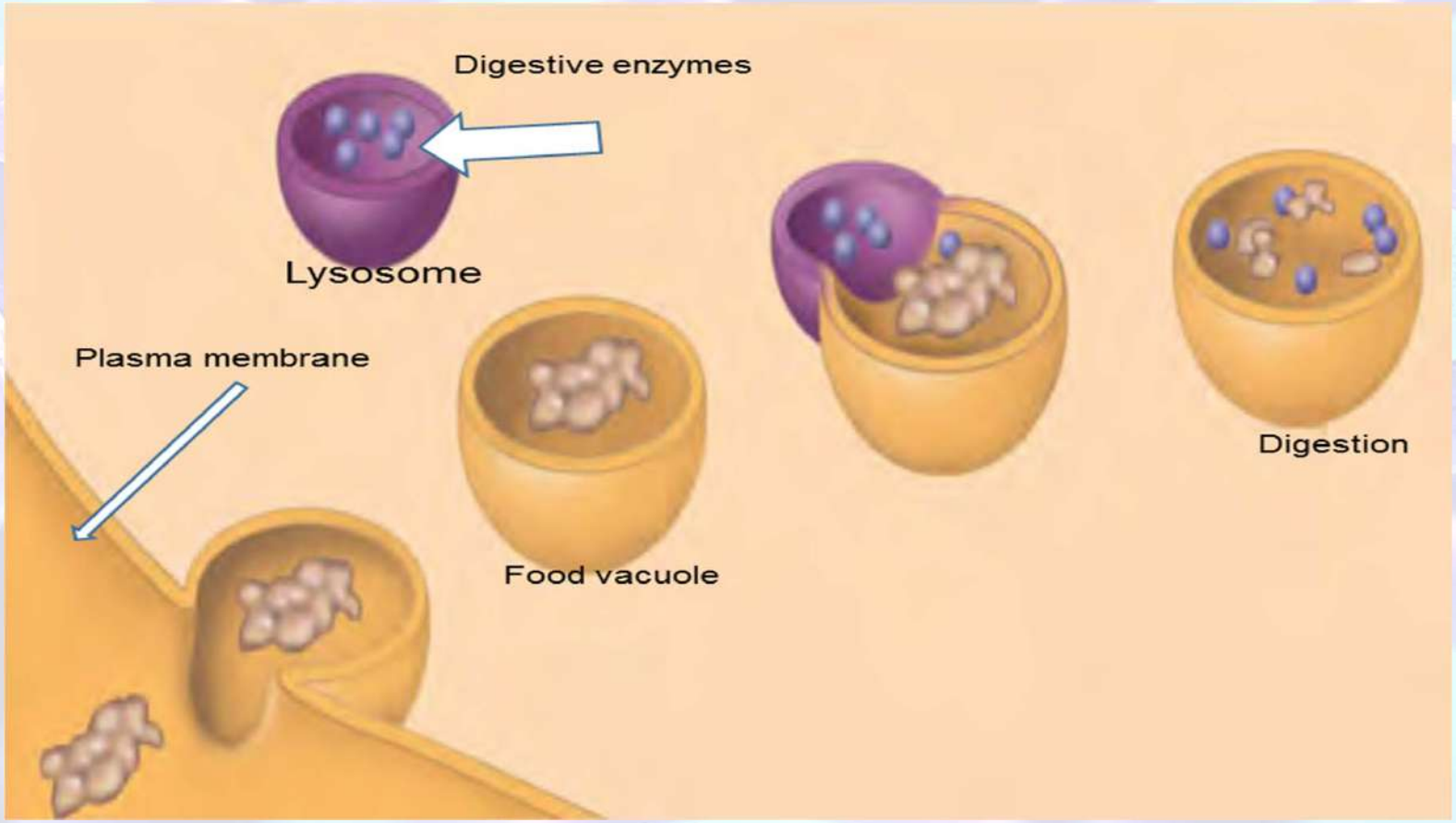
# Learning objectives

- Describe three examples of intracellular digestion by lysosomes.
- Name three different kinds of vacuoles, giving the function of each kind.
- Describe the structure of a mitochondrion and explain the importance of compartmentalization in mitochondrial function.

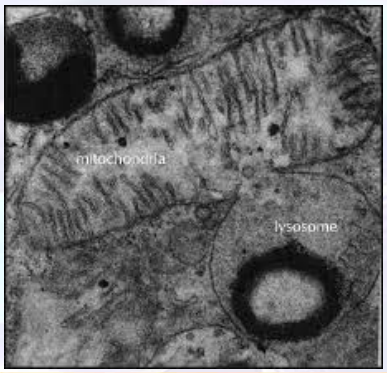
# Lysosome

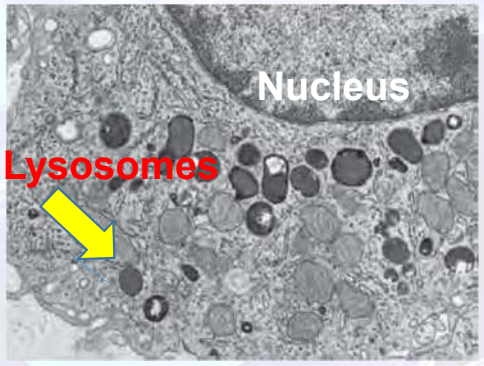
# Lysosomes

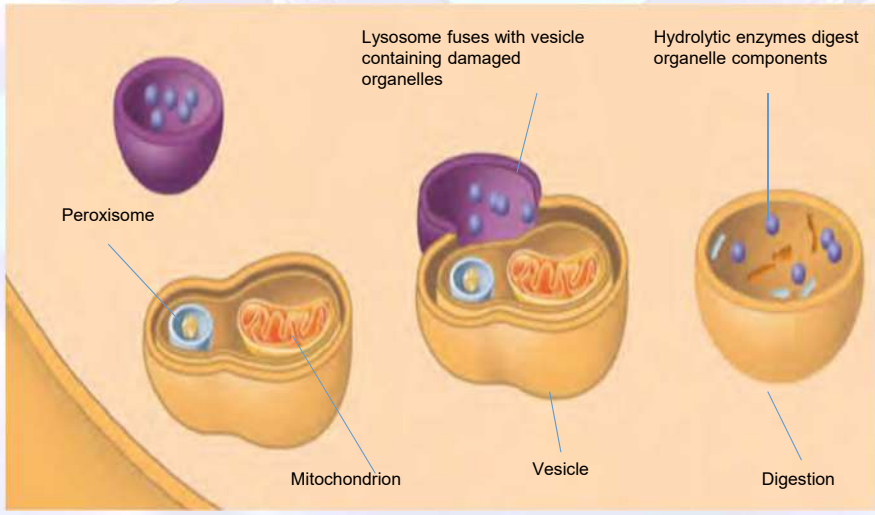
- Structurally and chemically, they are spherical vesicles containing hydrolytic enzymes capable of breaking down all kinds of biomolecules, including proteins, nucleic acids, carbohydrates, lipids, and cellular debris.
- They are known to contain more than 50 different enzymes, which are all optimally active at an acidic environment of about pH 4.5 .
- lysosomes work as the waste disposal system of the cell by digesting unwanted materials in the cytoplasm, both from outside of the cell and inside the cell. For this function they are popularly referred to as "suicide bags" or "suicide sacs" of the cell.


Digestive enzymes
Lysosome
Plasma membrane
Food vacuole
Digestion

- Lysosomes also use their hydrolytic enzymes to recycle the cell's own organic material, a process called autophagy.
- During autophagy, a damaged organelle or small amount of cytosol becomes surrounded by a double membrane (of unknown origin), and a lysosome fuses with the outer membrane of this vesicle.
- The lysosomal enzymes digest the enclosed material, and the organic monomers are returned to the cytosol for reuse.



- Hydrolytic enzymes and lysosomal membrane are made by rough ER and then transferred to the Golgi apparatus
- Lysosomal enzymes work best in the acidic environment found in lysosomes. If a lysosome breaks open or leaks its contents, the released enzymes are not very active because the cytosol has a neutral pH.
- However, excessive leakage from a large number of lysosomes can destroy a cell by self-digestion

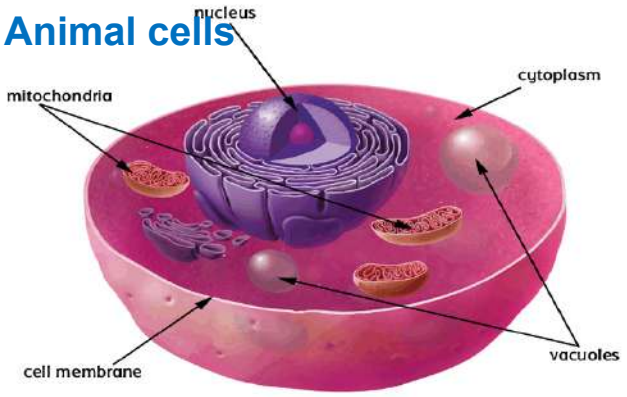
- Lysosomal enzymes digest the food. Digestion products, including simple sugars, amino acids, and other monomers, pass into the cytosol and become nutrients for the cell.

- Lysosomes carry out intracellular digestion in a variety of conditions.
- Amoebas and many other protists eat by engulfing smaller organisms or food particles, a process called phagocytosis.

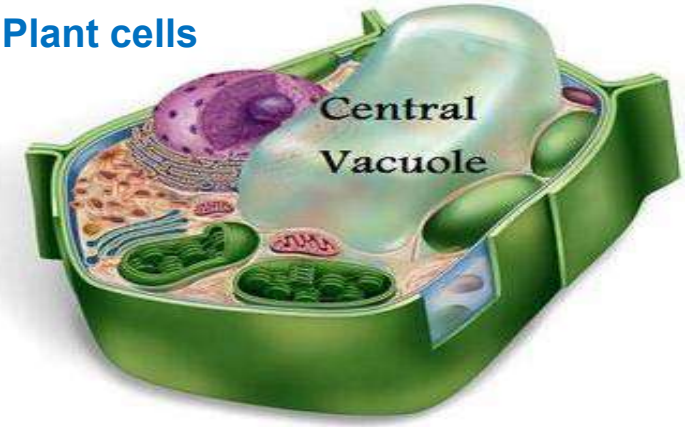
# Vacuoles: Diverse Maintenance Compartments

- Vacuoles are large vesicles derived from the endoplasmic reticulum and Golgi apparatus. Thus, vacuoles are an important part of a cell's endomembrane system.
- Like all cellular membranes, the vacuolar membrane is selective in transporting solutes; as a result, the solution inside a vacuole differs in composition from the cytosol.

Animal cells



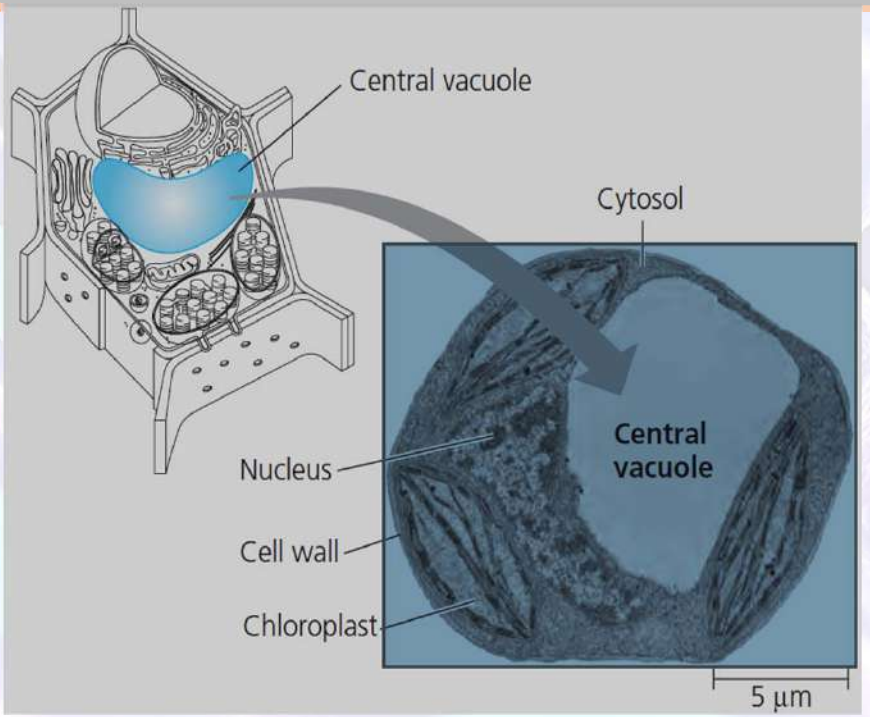

Plant cells

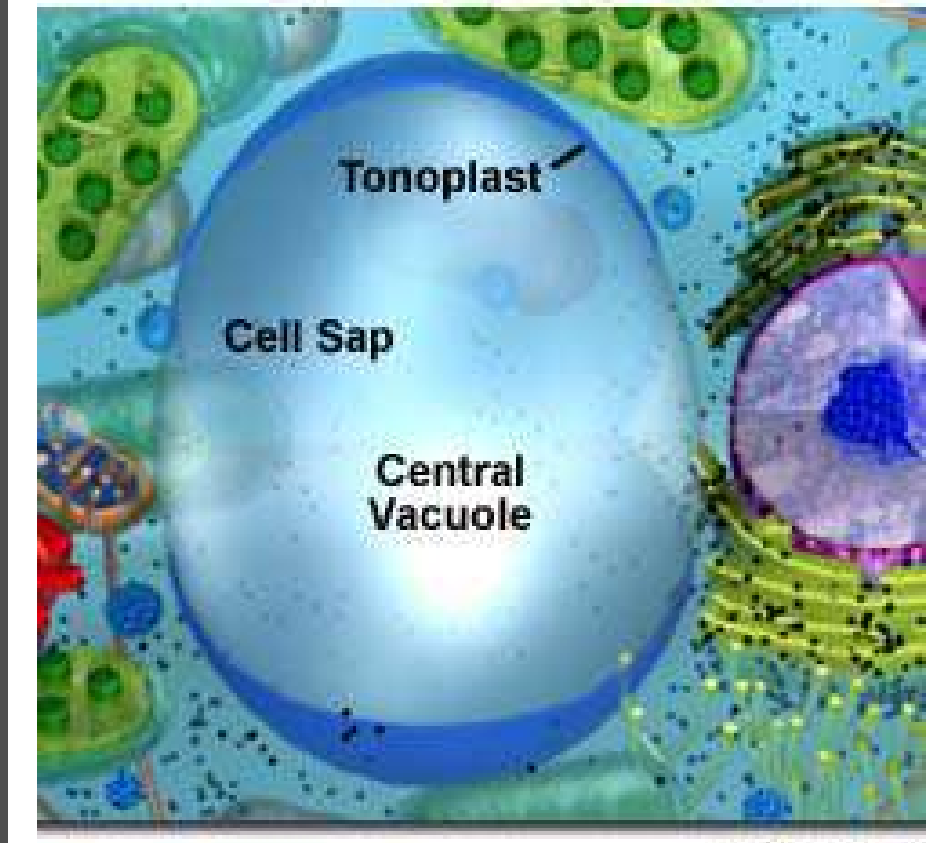


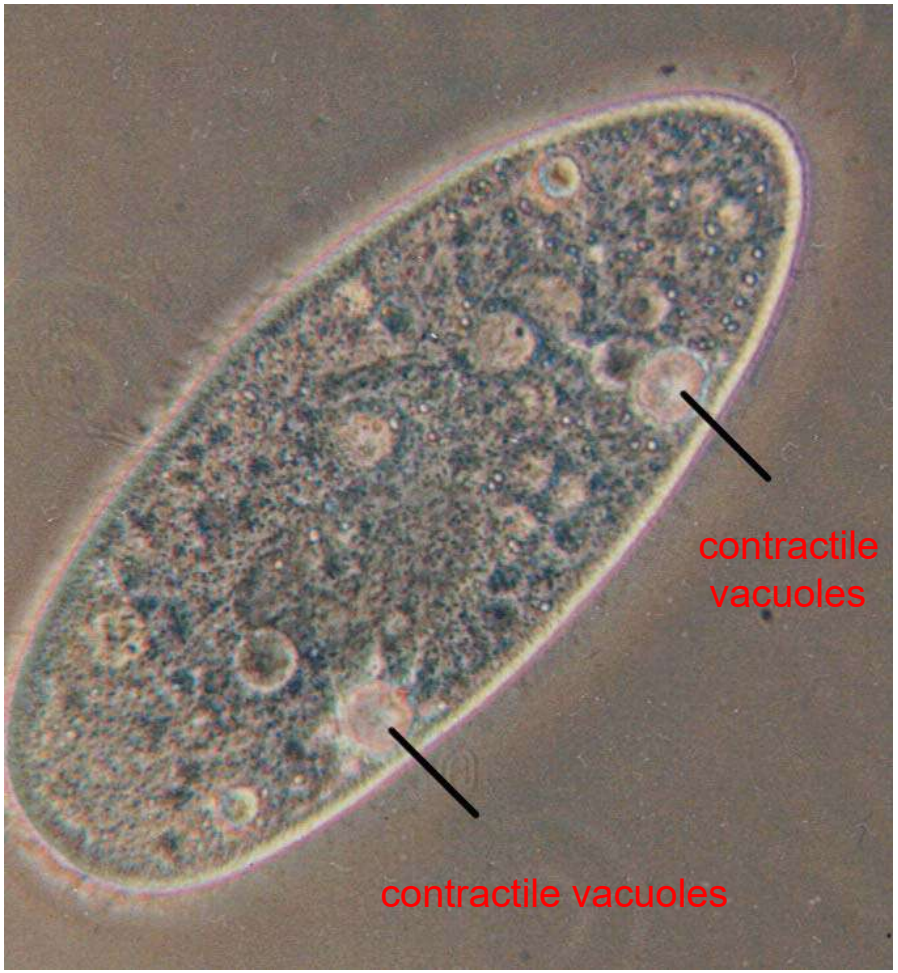
# Vacuoles Functions

- Vacuoles perform a variety of functions in different kinds of cells.
- Many freshwater protists have contractile vacuoles that pump excess water out of the cell, thereby maintaining a suitable concentration of ions and molecules inside the cell
- In plants and fungi, certain vacuoles carry out enzymatic hydrolysis, a function shared by lysosomes in animal cells
- Vacuoles may also help protect the plant against herbivores by storing compounds that are poisonous to animals. Some plant vacuoles contain pigments, such as the red and blue pigments of petals that help attract pollinating insects to flowers.

- Mature plant cells generally contain a large central vacuole is enclosed by a membrane termed the tonoplast, and developed by the combination of smaller vacuoles.
- The solution inside the central vacuole, called cell sap, is the plant cell's main repository of inorganic ions, including potassium and chloride.
- The central vacuole plays a major role in the growth of plant cells, which enlarge as the vacuole absorbs water, enabling the cell to become larger.

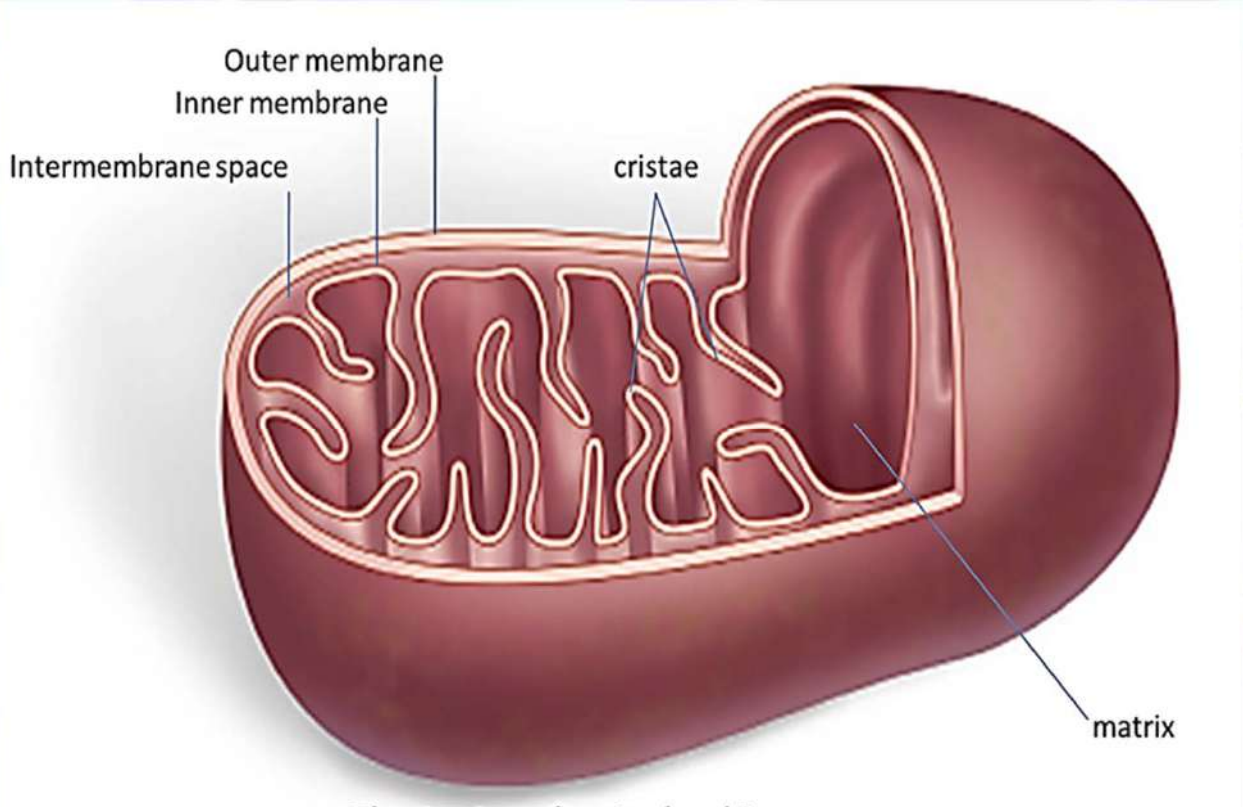



Plant Cell Central Vacuole
Tonoplast
Cell Sap
Central Vacuole
Figure 1


contractile vacuoles
contractile vacuoles

# Mitochondria

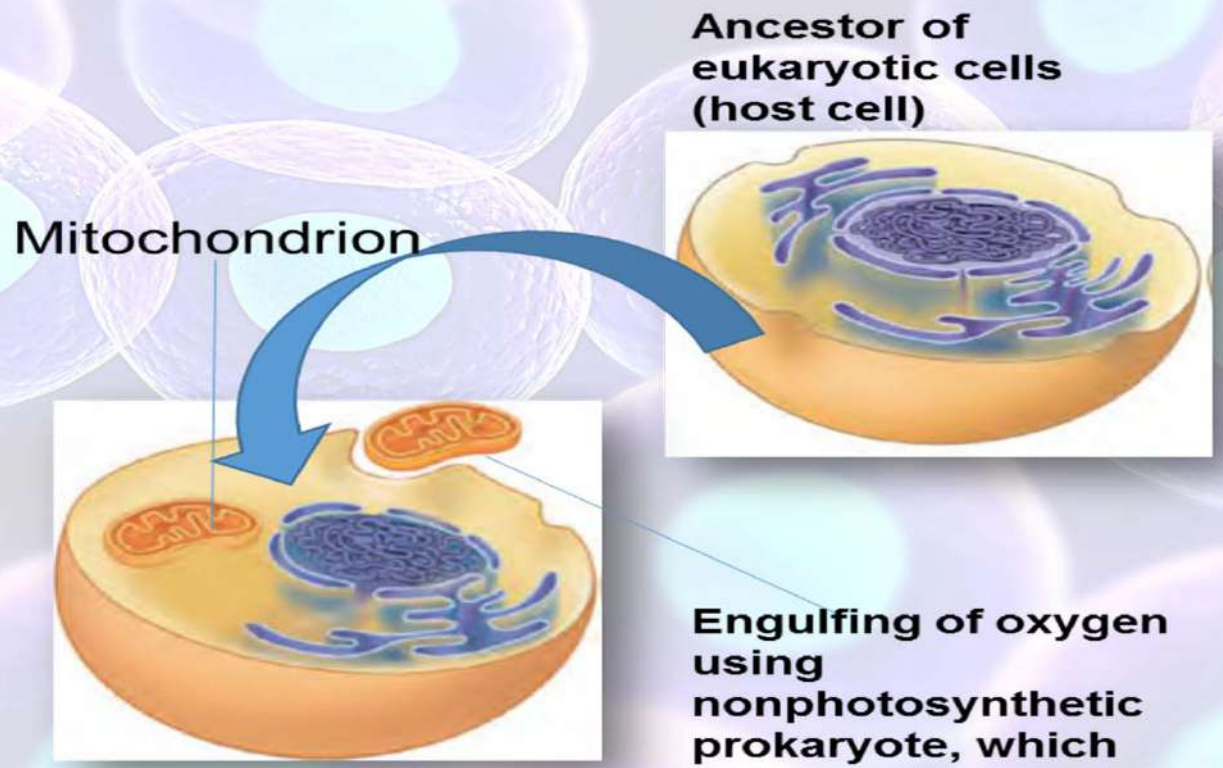
- Organisms transform the energy they obtain from their surroundings. In eukaryotic cells, mitochondria and chloroplasts are the organelles that convert energy to forms that cells can use for work
- Mitochondria (singular, mitochondrion) are the sites of cellular respiration, the metabolic process that uses oxygen to generate ATP by extracting energy from sugars, fats, and other fuels.
- Mitochondria are found in nearly all eukaryotic cells, including those of plants, animals, fungi, and most protists.
- Some cells have a single large mitochondrion, but more often a cell has hundreds or even thousands of mitochondria; the number correlates with the cell's level of metabolic activity.




The structure of a mitochondrion.

# The Evolutionary Origins of Mitochondria

- Mitochondria and chloroplasts display similarities with bacteria that led to the a widely accepted endosymbiont theory.
- This theory states that an early ancestor of eukaryotic cells engulfed an oxygen-using non-photosynthetic prokaryotic cell.
- Eventually, the engulfed cell formed a relationship with the host cell in which it was enclosed, becoming an endosymbiont (a cell living within an-other cell).
- The model it proposes is consistent with many structural features of mitochondria.
- First, rather than being bounded by a single membrane like organelles of the endomembrane system, mitochondria have two membranes surrounding it. There is evidence that the ancestral engulfed prokaryotes had two outer membranes, which became the double membranes of mitochondria and chloroplasts.

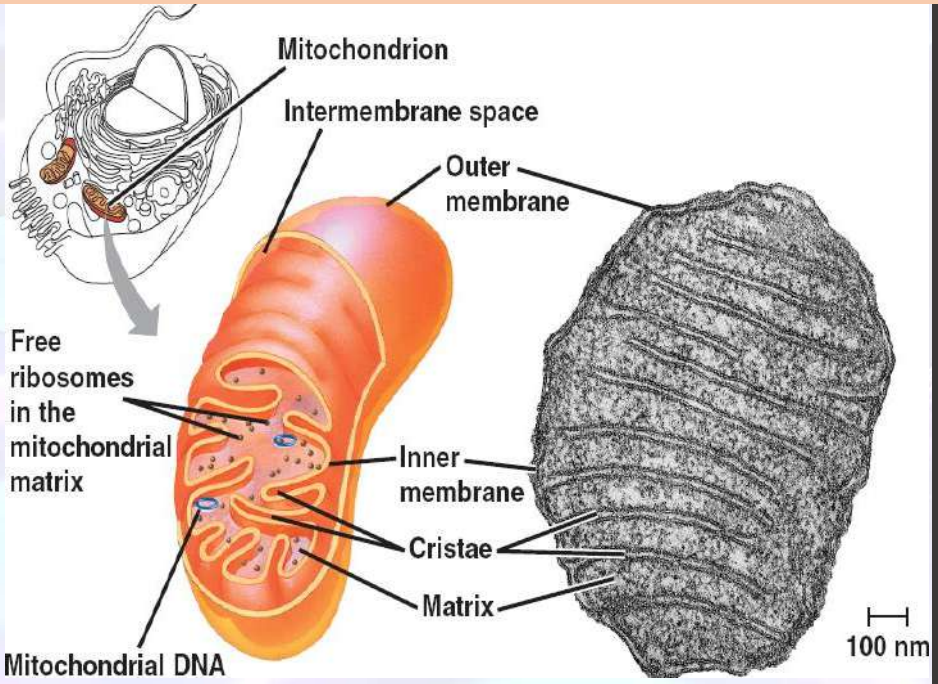

Ancestor of eukaryotic cells (host cell)
Mitochondrion
Engulfing of oxygen using nonphotosynthetic prokaryote, which becomes a mitochondrion

# The Evolutionary Origins of Mitochondria

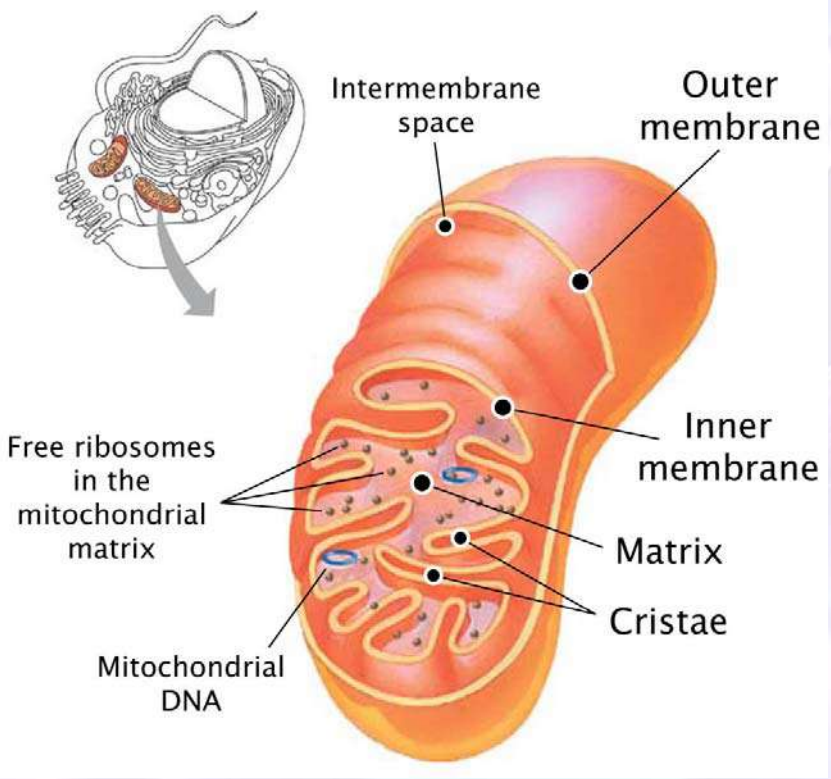
- Second, like prokaryotes, mitochondria contains ribosomes, as well as circular DNA molecules attached to their inner membranes.
- The DNA in these organelles programs the synthesis of some of their own proteins, which are made on the ribosomes inside the organelles.
- Third, also consistent with their probable evolutionary origins as cells, mitochondria are autonomous (somewhat independent) organelles that grow and reproduce within the cell.

# Structure

- The mitochondrion is enclosed by two membranes, each a phospholipid bilayer with a unique collection of embedded proteins
- The outer membrane is smooth, but the inner membrane is convoluted (wavy in shape), with infoldings called cristae. As highly folded surfaces, the cristae give the inner mitochondrial membrane a large surface area, thus enhancing the productivity of cellular respiration.



- The inner membrane divides the mitochondrion into two internal compartments.
- The first is the intermembrane space, the narrow region between the inner and outer membranes.
- The second compartment, the mitochondrial matrix, is enclosed by the inner membrane. The matrix contains many different enzymes as well as the mitochondrial DNA and ribosomes



# Summary

- **Lysosome:** Membranous sac of hydrolytic enzymes (in animal cells). Breakdown of ingested substances, cell macromolecules, and damaged organelles for recycling.
- **Mitochondria:** Bounded by double membrane; inner membrane has in-foldings (cristae). The function of mitochondrion is cellular respiration.
- **Vacuole:** Large membrane-bounded vesicle. Digestion, storage, waste disposal, water balance, cell growth, and protection.

# References


- **Biology by Jane B Reece; Neil A Campbell; et al** Boston : Benjamin Cummings / Pearson, ©2011. English : 9th ed. chapter 06
- **https://en.wikipedia.org**