Mitochondria:
Structural and Functional Description

Course Outline

- History
- Overview of Mitochondria
  - ✓ Morphology
  - ✓ Localization
- Characteristics of the Double Membrane
- Functions of Mitochondria
  - ✓ Energy production
  - ✓ Other functions
- Mitochondrial Genome

Overview of Mitochondria:

Introduction
Every living organism requires a large amount of energy to perform its biological functions.

Source of energy:
•Photosynthesis
•Degradation of chemical compounds
  •*In prokaryotes*: Plasma membrane
  •*In eukaryotes*: Mitochondria

Mitochondrial DNA
Mitochondria have their own genome capable of replication. Mitochondrial DNA (mtDNA) consists of double-stranded, circular molecules, 5 µm in length. MtDNA has its own distinct characteristics.

RNA
Mitochondria synthesize RNA.
Ribosomes are present in all mitochondria.
The synthesis of mitochondrial RNA occurs independently of nuclear RNA synthesis.

Protein Synthesis
Mitochondria can autonomously synthesize proteins (Krebs cycle + Respiratory chain).

Introduction

Every living organism requires a large amount of energy to perform its biological functions.

Source of energy:

•Photosynthesis

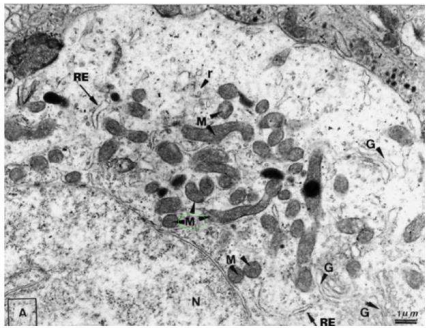
•Degradation of chemical compounds

- ➢ In prokaryotes: Plasma membrane
- ➢ In eukaryotes: **Mitochondria**

General Characteristics

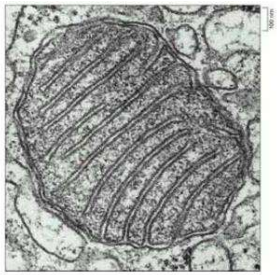
- Cytoplasmic organelles with a double membrane
- Found only in eukaryotes
- Present in all cell types except red blood cells
- Each cell contains 1,000 to 3,000 mitochondria depending on the cell type
- Responsible for the cell's energy production
- Contain their own genome
- Move through interactions with the cytoskeleton

Morphological Aspect in Optical Microscopy

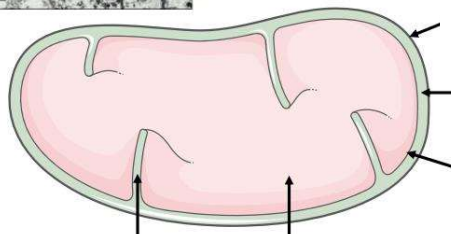


- **Variable shape**
  - **Globular**
  - **Filamentous**
- **Size and shape vary depending on the cell type**

Structure in Electron Microscopy



In a very schematic way...



- *Outer membrane (uniform and continuous)*
- *Intermembrane space (or outer chamber)*
- **Inner membrane (forms cristae)**
- **Crista**
- *Matrix or inner chamber*

General Characteristics

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1. Outer Membrane

- It is a *lipid bilayer*, 5 to 7 nm thick.
- Its *composition* is similar to that of the plasma membrane.
- Contains 50-60% proteins and 40-50% lipids.
- *Rich in porins*: large pores with a diameter of 2 to 3 nm.
- *Permeable* to ions and molecules with a molecular mass of less than 10 kDa.

2- Intermembrane Space

- It is a dense space, 4 to 7 nm thick.
- It contains:
  - ✓ H+ protons: involved in phosphorylation.
  - ✓ Cytochrome c molecules: involved in apoptosis.
  - ✓ Molecules smaller than 10 kDa.

3- Inner Membrane

- It is a lipid bilayer, 5 to 6 nm thick.
- Its organization is very different from that of the outer membrane.
- Contains 80% proteins and 20% lipids.
- Rich in cardiolipin (diphosphatidylglycerol).
- Features complex folds called mitochondrial cristae, projecting into the matrix.
- Rich in transporters and enzymatic protein complexes.
- Low fluidity (active transport).

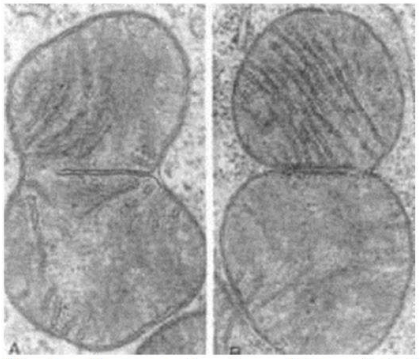
4- Mitochondrial Matrix

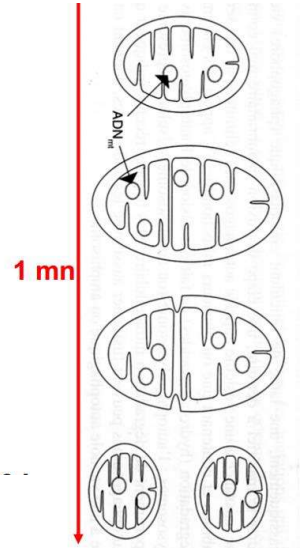
❑ Finely granular.

❑ Contains:

- Mitoribosomes resembling bacterial ribosomes.
- Circular DNA (mtDNA).
- Messenger RNA (mRNA) and transfer RNA (tRNA).
- Dense and irregular granulations.
- Numerous enzymatic systems:
  - ✓ Enzymes for pyruvate oxidation.
  - ✓ Enzymes for fatty acid β-oxidation.
  - ✓ Enzymes involved in the citric acid cycle (Krebs cycle).

Mitochondrial division

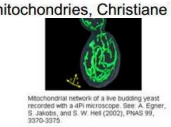




½ vie d'une mitochondrie 6 à 10

Les mitochondries, Christiane Delbart, Editions Tec & Doc

Mitochondrial fusion



- **Fusion into larger mitochondria or more branched structures.**

4-1 Mitochondrial DNA

- Mitochondria have their own genome, capable of replication.
- mtDNA consists of double-stranded, circular molecules, 5 µm in length.
- mtDNA has its own distinct characteristics.

4-2 RNA

- Mitochondria synthesize RNA.
- Ribosomes are present in all mitochondria.
- The synthesis of mitochondrial RNA occurs independently of nuclear RNA synthesis.

4-3 Protein Synthesis

- Mitochondria are capable of autonomously synthesizing proteins.

Fonctions des mitochondries

- ➢ Cellular respiration (Krebs cycle + Respiratory chain)
- ➢ Synthetic functions
- ➢ Thermogenesis
- ➢ Calcium regulation
- ➢ Mitochondria and aging

1. The Mitochondrial Respiratory Chain or Oxidative Phosphorylation

2. Synthetic Functions

•2.1. Mitochondria and Steroid Hormone Synthesis

Mitochondria, in collaboration with the endoplasmic reticulum, participate in the biosynthesis of steroid hormones from cholesterol, facilitated by mitochondrial cytochromes P450.

•2.2. Production of Precursors for Non-Essential Amino Acids

3. Mitochondria and Calcium Homeostasis

•Mitochondria, along with the endoplasmic reticulum, are the primary calcium reservoir.

•Regulation of intracellular calcium concentration, although the mechanisms remain poorly understood.

•Transport occurs through ion channels (Na+/Ca++ exchangers).

Conclusion

- La mitochondrie est le générateur unique d'énergie de nos cellules. Ces organites jouent un rôle essentiel en produisant, stockant et distribuant l'énergie nécessaire à la survie cellulaire.
- Les cellules humaines contiennent en moyenne 1 500 mitochondries, réparties dans le cytoplasme en fonction des besoins énergétiques.
- Mobiles, elles se déplacent pour répondre aux exigences spécifiques des différentes régions de la cellule.
- Dotées de leur propre ADN, les mitochondries possèdent la capacité de se diviser de manière indépendante et même de s'autodétruire lorsque cela est nécessaire pour le bon fonctionnement de la cellule.
- Sans mitochondries, aucune cellule ne peut fonctionner, et par conséquent, la vie devient impossible.