

Endosomes, Lysosomes and Peroxisomes

General Introduction

Eukaryotic cells contain specialized intracellular compartments known as **organelles**, which are delimited by biological membranes. These organelles ensure the spatial and functional organization of cellular activities. Among them, **endosomes, lysosomes and peroxisomes** play a crucial role in **intracellular trafficking, digestion, detoxification and cellular recycling**. Their coordinated activity is essential for the maintenance of **cellular homeostasis**.

I. Endosomes

1. Definition

Endosomes are **membrane-bound intracellular compartments** involved in the **internalization, transport, sorting and maturation** of molecules taken up by the cell through **endocytosis**.

2. Origin and formation of endosomes

Endosomes originate from:

- the **plasma membrane** during endocytosis,
- **endocytic vesicles** formed after membrane invagination.

They represent an **intermediate compartment** between the plasma membrane and lysosomes, allowing either the **recycling of molecules** back to the cell surface or their **targeting for degradation**.

3. Functional role of endosomes

Endosomes ensure:

- sorting of receptors and ligands,
- recycling of membrane components,
- transport of molecules toward lysosomes,
- regulation of cellular signaling pathways.

II. Lysosomes

1. Definition

Lysosomes are **digestive organelles** containing a wide range of **hydrolytic enzymes**, which allow the degradation of macromolecules within the cell.

2. Structure and composition

Lysosomes are characterized by:

- a **single limiting membrane**,
- an **acidic internal pH** (4.5–5.0), optimal for enzymatic activity,
- a lumen rich in hydrolytic enzymes, including:
 - proteases,
 - nucleases,
 - lipases,
 - glycosidases,
 - phosphatases.

3. Biogenesis of lysosomes

Lysosomal enzymes are:

1. **Synthesized in the rough endoplasmic reticulum (RER)**,
2. **Modified and sorted in the Golgi apparatus**,
3. Transported to endosomes, which progressively mature into functional lysosomes.

4. Functions of lysosomes

a. Heterophagy

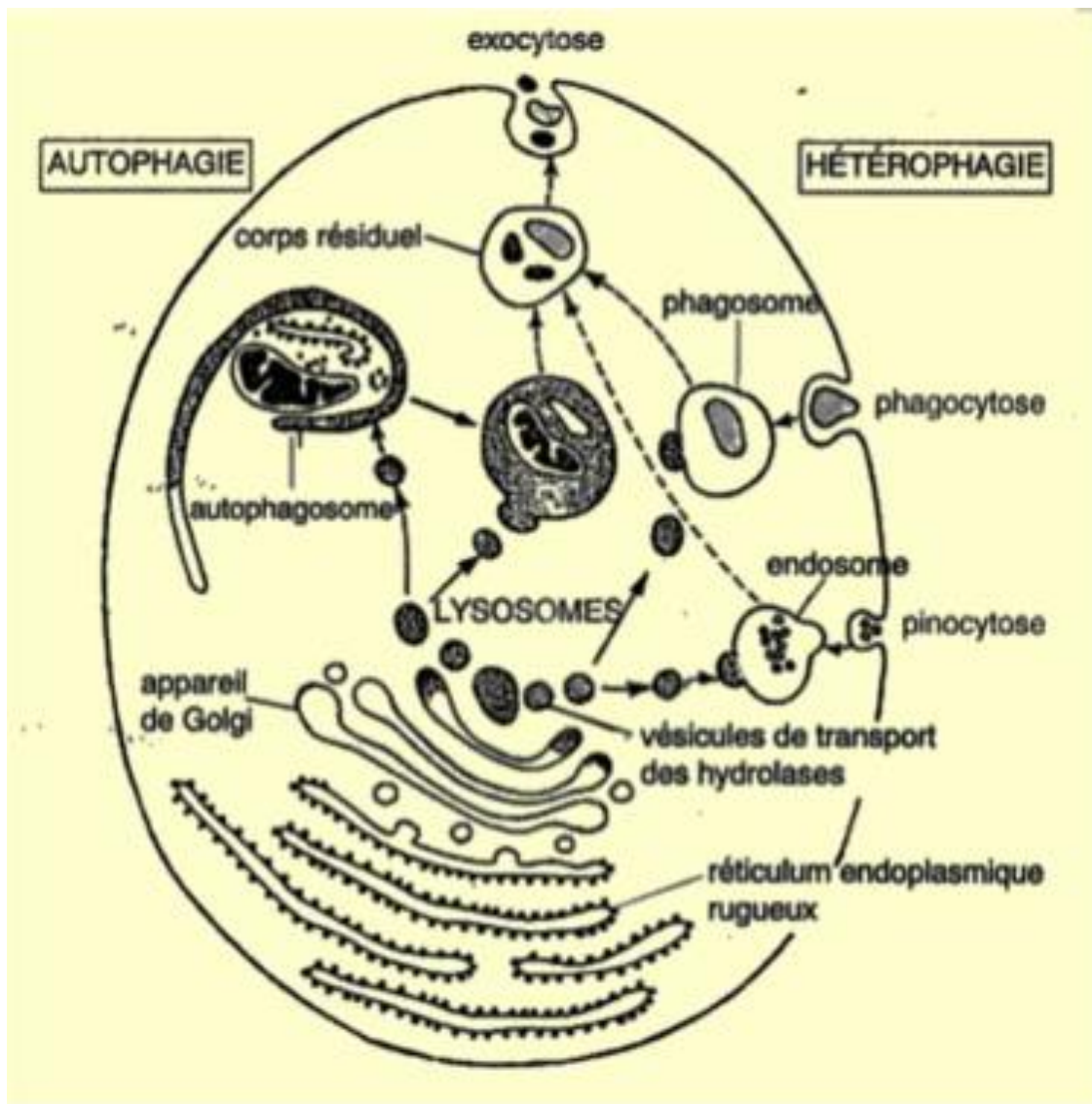
Lysosomes digest **extracellular material** internalized by phagocytosis or endocytosis.

b. Autophagy

They degrade **aged or damaged organelles**, allowing the **recycling of cellular constituents**.

c. Autolysis

Lysosomes participate in **programmed cell death (apoptosis)** through controlled enzymatic release.



III. Peroxisomes

1. Definition

Peroxisomes are metabolic organelles involved in **oxidative reactions**, **cellular detoxification**, and **lipid metabolism**.

2. Structure

Peroxisomes are characterized by:

- a **single membrane**,
- a **dense matrix** rich in oxidative enzymes,
- the **absence of DNA and ribosomes**.

3. Peroxisomal enzymes

The peroxisomal matrix contains enzymes such as:

- **oxidases**, which generate hydrogen peroxide (H_2O_2),
- **catalase**, which decomposes hydrogen peroxide.

4. Biogenesis and replication

Peroxisomes are formed by **self-replication** through growth and division. Unlike lysosomes, they **do not originate from the Golgi apparatus**. Their enzymatic proteins are synthesized in the cytosol and imported into the peroxisome via specific targeting signals.

5. Functions of peroxisomes

Peroxisomes contain enzymes that catalyze both the **production and degradation of hydrogen peroxide (H_2O_2)**:

- **Oxidases** oxidize a substrate (R) using molecular oxygen, producing H_2O_2 .
- **Catalase** decomposes H_2O_2 (toxic for the cell) into water (H_2O) and oxygen (O_2), or uses H_2O_2 to oxidize another toxic substrate (R').

The **main function of peroxisomes** is the **elimination of reactive oxygen species (free radicals)** generated during cellular metabolism, thereby protecting the cell from oxidative damage.

