Lecture 11
Other functions

- Other functions include digesting foreign bacteria (or other forms of waste) that invade a cell.
- Helping repair damage to the plasma membrane by serving as a membrane patch, sealing the wound.
- In the past, lysosomes were thought to kill cells that were no longer wanted, such as those in the tails of tadpoles or in the web from the fingers of a 3- to 6-month-old fetus.
- While lysosomes digest some materials in this process, it is actually accomplished through programmed cell death, called apoptosis.
Cellular Digestion and the Secretory Pathway

Figure 1
The lysosome, has been shown to initiate a cell death pathway. Lysosomal membrane permeabilization (LMP) causes the release of cathepsins and other hydrolases from the lysosomal lumen to the cytosol. LMP is a potentially lethal event because the ectopic presence of lysosomal proteases in the cytosol causes digestion of vital proteins and the activation of additional hydrolases. Resulting in cytochrome c release and apoptosome-dependent caspase activation. Massive LMP often results in cell death without caspase activation; this cell death may adopt a subapoptotic or necrotic appearance.
Microbody

- A microbody is a cytoplasmic organelle of a more or less globular shape that comprises degradative enzymes bound within a single membrane.

- Microbodies are specialized as containers for metabolic activity. Types include peroxisomes, glyoxisomes, glycosomes and Woronin bodies.

- Peroxisomes contain enzymes of b-oxidation (break down fats and produce Acetyl-CoA), as well as enzymes of many other important pathways like amino acid and bile acid metabolism, oxidation/detoxification of various harmful compounds in the liver (ex. alcohol).
Microbody

- Glyoxysomes are found in germinating seeds of plants as well as in filamentous fungi.
- Glyoxysomes are peroxisomes with additional function - *glyoxylate cycle*.
- Glycosomes, besides peroxisomal enzymes, also possess glycolysis enzymes.
- Woronin bodies are special organelles found only in filamentous fungi.
- One established function of Woronin bodies is the plugging of the *septal pores* after *hyphal* wounding, which restricts the loss of cytoplasm to the sites of injury.
Peroxisomes are organelles from the microbody family and are present in almost all eukaryotic cells.

They participate in the metabolism of fatty acids and many other metabolites.

Peroxisomes harbor enzymes that rid the cell of toxic peroxides.

Peroxisomes are bound by a single membrane that separates their contents from the cytosol and contain membrane proteins critical for various functions, such as importing proteins into the organelles and aiding in proliferation. Peroxisomes can replicate by enlarging and then dividing.
Peroxisomes contain oxidative enzymes, such as catalase, D-amino acid oxidase, and uric acid oxidase. However the last enzyme is absent in humans, explaining the disease known as gout, caused by the accumulation of uric acid. Certain enzymes within the peroxisome, by using molecular oxygen, remove hydrogen atoms from specific organic substrates (labeled as R), in an oxidative reaction, producing hydrogen peroxide (H$_2$O$_2$, itself toxic):

\[ \text{RH}_2 + \text{O}_2 = \text{R} + \text{H}_2\text{O}_2 \]

Catalase, another enzyme in the peroxisome, in turn uses this H$_2$O$_2$ to oxidize other substrates, including phenols, formic acid, formaldehyde, and alcohol, by means of the peroxidation reaction:

\[ \text{H}_2\text{O}_2 + \text{R`H}_2 = \text{R`} + 2\text{H}_2\text{O} \]
Function

- Thus eliminating the poisonous hydrogen peroxide in the process.
- This reaction is important in liver and kidney cells, where the peroxisomes detoxify various toxic substances that enter the blood.
- In addition, when excess H$_2$O$_2$ accumulates in the cell, catalase converts it to H$_2$O through this reaction:
  
  $$2\text{H}_2\text{O}_2 = 2\text{H}_2\text{O} + \text{O}_2$$

- A major function of the peroxisome is the breakdown of fatty acid molecules, in a process called beta-oxidation.
- In this process, the fatty acids are broken down two carbons at a time, converted to Acetyl-CoA, which is then transported back to the cytosol for further use.
Glyoxysome

- **Glyoxysomes** are specialized peroxisomes found in plants (particularly in the fat storage tissues of germinating seeds) and also in filamentous fungi.
- As in all peroxisomes, in glyoxysomes the fatty acids are hydrolyzed to acetyl-CoA by peroxisomal β-oxidation enzymes.
- Besides peroxisomal functions, glyoxysomes possess additionally the key enzymes of glyoxylate cycle (isocitrate lyase and malate synthase) which accomplish the glyoxylate cycle bypass.
- Additionally, glyoxysomes possess the enzymes to produce intermediate products for the synthesis of sugars by gluconeogenesis.
- The seedling uses these sugars synthesized from fats until it is mature enough to produce them by photosynthesis.
The glyoxylate cycle is an anabolic metabolic pathway occurring in plants, and several microorganisms, such as *E. coli* and yeast. It has long been thought to be absent in most animals, such as vertebrates and insects. The glyoxylate cycle allows these organisms to use fats for the synthesis of carbohydrates.

Fatty acids from lipids are commonly used as an energy source by vertebrates via degradation by beta oxidation into acetate molecules. This acetate, bound to the active thiol group of coenzyme A, enters the citric acid cycle (TCA cycle) where it is fully oxidized to carbon dioxide.

To utilize acetate from fat for biosynthesis of carbohydrates, the glyoxylate cycle, whose initial reactions are identical to the TCA cycle, is used.
Glycosome

- The **glycosome** is a **membrane-enclosed organelle** that contains the **glycolytic enzymes**.
- It is found in a few species of **protozoa**, most notably in the human **pathogenic trypanosomes**, which can cause **sleeping sickness** and **Chagas's disease**, and **Leishmania**.
- The organelle is bounded by a single membrane and contains a dense **proteinaceous** matrix.
- It is believed to have evolved from the **peroxisome**.
- This has been verified by work done on Leishmania genetics.
A Woronin body (named after the Russian botanist Mikhail Stepanovich Woronin) is a peroxisome-derived, dense core microbody with a double membrane found near the septae that divide hyphal compartments in filamentous Ascomycota.

One established function of Woronin bodies is the plugging of the septal pores after hyphal wounding, which restricts the loss of cytoplasm to the sites of injury.