

## The Endomembrane System

- Many of the internal membranes in a eukaryotic cell are part of the **endomembrane system**.
  - Series of intracellular membranes that compartmentalize the cell
- These membranes are either in direct contact with each other or connected by the transfer of **vesicles**, which are sacs made of membrane.
- In spite of these links, these membranes have diverse functions and structures – not identical in structure or function.
  - In fact, the membranes are even modified during life.  
(Thickness, composition, metabolic behavior)
- The endomembrane system includes the:
  - Nuclear envelope
  - Endoplasmic reticulum
  - Golgi apparatus
  - Lysosomes
  - Vacuoles
  - Plasma membrane.
- The smooth ER is rich in enzymes and plays a role in a variety of metabolic processes.
- Enzymes of smooth ER synthesize lipids, including oils, phospholipids, and steroids.
  - These includes the sex hormones of vertebrates and various steroid hormones secreted by adrenal glands.
- The smooth ER also catalyzes a key step in the movement of glucose from stored glycogen in the liver.
  - An enzyme removes the phosphate group from glucose phosphate, a product of glycogen hydrolysis, permitting glucose to exit the cell.
- Other enzymes in the smooth ER of the liver help detoxify drugs and poisons.
  - These include alcohol and barbiturates.
  - Frequent exposure leads to proliferation of smooth ER, increasing tolerance to the target and other drugs.
- Muscle cells are rich in enzymes that pump calcium ions from the cytosol to the cisternae (the sacs of the ER) .

- When a nerve impulse stimulates a muscle cell, calcium rushes from the ER into the cytosol, triggering contraction.
- These enzymes then pump the calcium back, readying the cell for the next stimulation.
- Rough ER is especially abundant in those cells that secrete proteins.
  - As a polypeptide is synthesized by the ribosome, it is threaded into the cisternal space through a pore formed by a protein in the ER membrane.
  - Many of these polypeptides are **glycoproteins**, a polypeptide to which an oligosaccharide is attached.
- These secretory proteins are packaged in **transport vesicles** that carry them to their next stage.
- Rough ER is also a membrane factory.
  - Membrane bound proteins are synthesized directly into the membrane.
  - Enzymes in the rough ER also synthesize phospholipids from precursors in the cytosol.
  - As the ER membrane expands, parts can be transferred as transport vesicles to other components of the endomembrane system.

### **The Golgi apparatus finishes, sorts, and ships cell products**

- Many transport vesicles from the ER travel to the **Golgi apparatus** for modification of their contents.
- The Golgi is a center of manufacturing, warehousing, sorting, and shipping.
- The Golgi apparatus is especially extensive in cells specialized for secretion.
- The Golgi apparatus consists of flattened membranous sacs - cisternae - looking like a sac of pita bread.
  - The membrane of each cisterna separates its internal space from the cytosol
  - One side of the Golgi, the *cis* side, receives material by fusing with vesicles, while the other side, the *trans* side, buds off vesicles that travel to other sites.
- During their transit from the cis to trans pole, products from the ER are modified to reach their final state.
  - This includes modifications of the oligosaccharide portion of glycoproteins.
- The Golgi can also manufacture its own macromolecules, including pectin and other noncellulose polysaccharides.

- During processing material is moved from cisterna to cisterna, each with its own set of enzymes.
- Finally, the Golgi tags, sorts, and packages materials into transport vesicles.

### **Lysosomes are digestive components**

- The **lysosome** is a membrane-bounded sac of hydrolytic enzymes that digests macromolecules.
- The lysosomal enzymes and membrane are synthesized by rough ER and then transferred to the Golgi.
- At least some lysosomes bud from the trans face of the Golgi.
- Lysosomes can fuse with food vacuoles, formed when a food item is brought into the cell by **phagocytosis**.
  - As the polymers are digested, their monomers pass out to the cytosol to become nutrients of the cell.
- Lysosomes can also fuse with another organelle or part of the cytosol.
- This allows the lysosome to recycle the cells own organic material
  - This recycling, or process of *autophagy* renews the cell.

### **Vacuoles have diverse functions in cell maintenance**

- Vesicles and vacuoles (larger versions) are membrane-bound sacs with varied functions.
  - **Food vacuoles**, from phagocytosis, fuse with lysosomes.
  - **Contractile vacuoles**, found in freshwater protists, pump excess water out of the cell.
  - **Central vacuoles** are found in many mature plant cells.
- The membrane surrounding the central vacuole, the **tonoplast**, is selective in its transport of solutes into the central vacuole.
- The functions of the central vacuole include stockpiling proteins or inorganic ions, depositing metabolic byproducts, storing pigments, and storing defensive compounds against herbivores.
- It also increases surface to volume ratio for the whole cell.
- The endomembrane system plays a key role in the synthesis (and hydrolysis) of macromolecules in the cell.
- The various components modify macromolecules for their various functions.