

Chapter 5

The Cell's Endomembrane System—
 Endoplasmic Reticulum,
 Golgi Apparatus,
 Lysosomes, Peroxisomes,
 Vacuoles, Vesicles

Overview

- Play key role in synthesis (& hydrolysis) of macromolecules in cell
- Various “players” modify macromolecules for various functions

Endoplasmic Reticulum

- Function**
 - manufactures membranes & performs many bio-synthesis functions
- Structure**
 - membrane connected to nuclear envelope & extends throughout cell
 - accounts for 50% membranes in eukaryotic cell
 - rough ER = bound ribosomes
 - smooth ER = no ribosomes

Types of ER

Smooth ER function

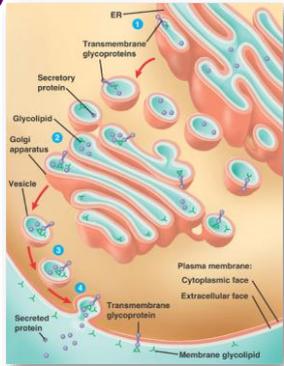
- Factory processing operations**
 - many metabolic processes
 - synthesis & hydrolysis
 - enzymes of smooth ER...
 - synthesize lipids, oils, phospholipids, steroids & sex hormones
 - hydrolysis (breakdown) of glycogen (in liver) into glucose
 - detoxify drugs & poisons (in liver)
 - ex. alcohol & barbiturates

Rough ER function

- Produce proteins for export out of cell
 - protein secreting cells
 - packaged into transport vesicles for export

Membrane Factory

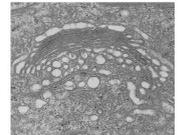
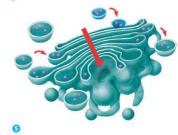
- Synthesize membrane phospholipids
 - ◆ build new membrane
 - ◆ as ER membrane expands, bud off & transfer to other parts of cell that need membranes
- Synthesize membrane proteins
 - ◆ membrane bound proteins synthesized directly into membrane
 - ◆ processing to make glycoproteins



Golgi Apparatus

Function

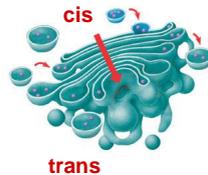
- ◆ finishes, sorts, & ships cell products
 - “shipping & receiving department”
- ◆ center of manufacturing, warehousing, sorting & shipping
- ◆ extensive in cells specialized for secretion



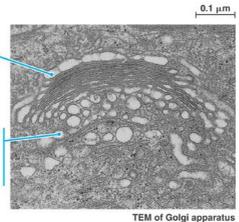
Golgi Apparatus

Structure

- ◆ flattened membranous sacs = cisternae
 - look like stack of pita bread
- ◆ 2 sides = 2 functions
 - cis = receives material by fusing with vesicles = “receiving”
 - trans buds off vesicles that travel to other sites = “shipping” (transport)

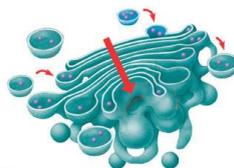


Golgi Apparatus

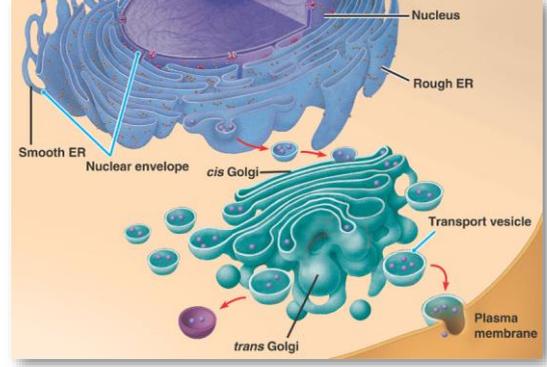


Golgi processing

- During path from cis to trans, products from ER are modified into final form
- tags, sorts, & packages materials into transport vesicles
 - ◆ Golgi = “UPS headquarters”
 - ◆ Transport vesicles = “UPS trucks”
 - delivering packages that have been tagged with their own barcodes

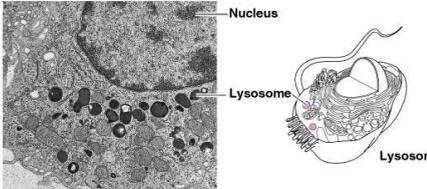


Putting it together...



Lysosomes

- Structure
 - membrane-bounded sac of hydrolytic enzymes that digests macromolecules
 - enzymes & membrane of lysosomes are synthesized by rough ER & transferred to the Golgi



only in animal cells

Lysosomes

1960 | 1974

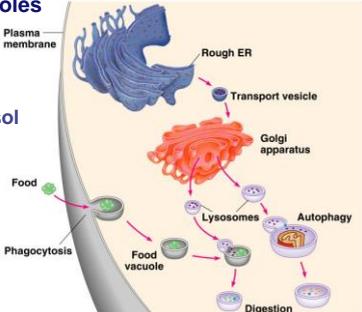
- Function
 - a little “stomach” for the cell
 - lyso- = breaking things apart
 - some = body
 - also the “clean up crew” of the cell



1974 Nobel prize: Christian de Duve
Lysosomes discovery in 1960s

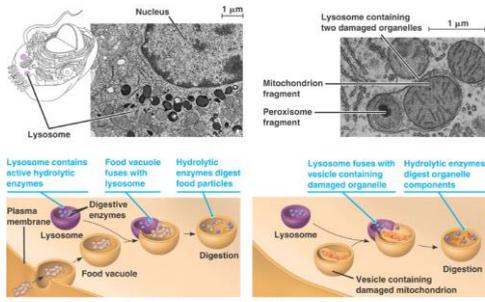
Cellular digestion

- Lysosomes fuse with food vacuoles
- Polymers are digested into monomers
 - pass to cytosol to become nutrients of cell



The Recycler

Fuse with organelles or macromolecules in cytosol to recycle materials



(a) Phagocytosis: lysosome digesting food
(b) Autophagy: lysosome breaking down damaged organelle

Lysosomal enzymes

- Lysosomal enzymes work best at pH 5
 - organelle creates custom pH
 - how?
 - proteins in lysosomal membrane pump H⁺ ions from the cytosol into lysosome
 - why?
 - enzymes are very sensitive to pH
 - so?
 - enzymes are proteins — pH affects structure
 - why evolve digestive enzymes which function at pH different from cytosol?
 - digestive enzymes won't function well if leak into cytosol = don't want to digest yourself!

When things go wrong...

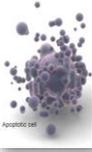
Tay-Sachs

- What if a lysosome digestive enzyme doesn't function?
 - don't digest a biomolecule
 - instead biomolecule collects in lysosomes
 - lysosomes fill up with undigested material
 - lysosomes grow larger & larger
 - eventually disrupt cell & organ function
- “Lysosomal storage diseases” are usually fatal
 - Tay-Sachs disease
 - lipids build up in brain cells
 - child dies before age 5



Sometimes its supposed to work that way...

- Apoptosis = cell death
 - little role in programmed destruction of cells in multicellular organisms
 - auto-destruct mechanism
 - "cell suicide"
 - some cells have to die in an organized fashion, especially during development
 - ex: development of space between your fingers during embryonic development
 - ex: if cell grows improperly this self-destruct mechanism is triggered to remove damaged cell
 - cancer over-rides this to enable tumor growth



Fetal development

syndactyly

Before After

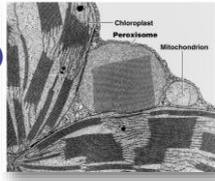


6 weeks

15 weeks

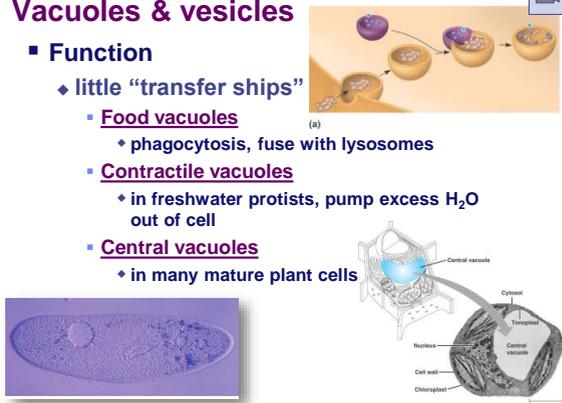
Peroxisomes

- Other digestive enzyme sacs
 - in both animals & plants
 - breakdown fatty acids to sugars
 - easier to transport & use as energy source
 - detoxify cell
 - detoxifies alcohol & other poisons
 - produce peroxide (H₂O₂)
 - must breakdown
H₂O₂ → H₂O



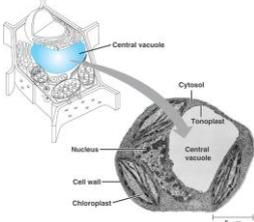
Vacuoles & vesicles

- Function
 - little "transfer ships"
 - Food vacuoles**
 - phagocytosis, fuse with lysosomes
 - Contractile vacuoles**
 - in freshwater protists, pump excess H₂O out of cell
 - Central vacuoles**
 - in many mature plant cells

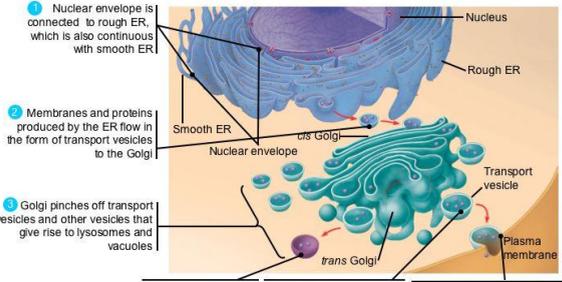


Vacuoles in plants

- Functions
 - storage
 - stockpiling proteins or inorganic ions
 - depositing metabolic byproducts
 - storing pigments
 - storing defensive compounds against herbivores
 - selective membrane
 - control what comes in or goes out



Putting it all together...



- Nuclear envelope is connected to rough ER, which is also continuous with smooth ER
- Membranes and proteins produced by the ER flow in the form of transport vesicles to the Golgi
- Golgi pinches off transport vesicles and other vesicles that give rise to lysosomes and vacuoles
- Lysosome available for fusion with another vesicle for digestion
- Transport vesicle carries proteins to plasma membrane for secretion
- Plasma membrane expands by fusion of vesicles; proteins are secreted from cell