

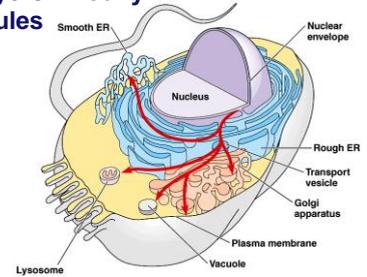
## Chapter 5

### The Cell's Endomembrane System: Endoplasmic Reticulum, Golgi Apparatus, Lysosomes, Vacuoles



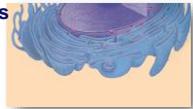
## Overview

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

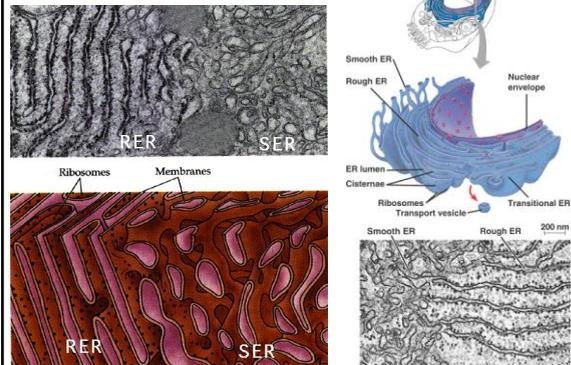


## Endoplasmic Reticulum

- **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

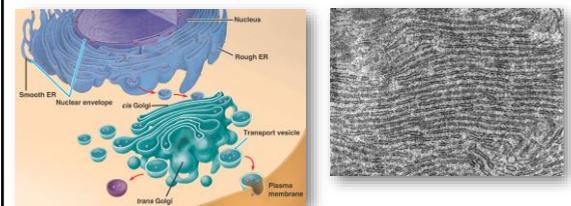


## Smooth ER function

- **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

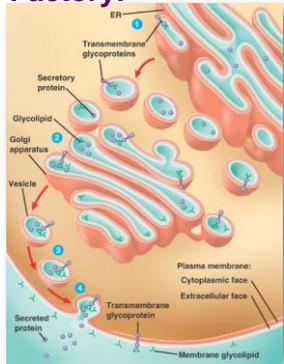
## Rough ER function

- **Produce proteins for export out of cell/membrane proteins**
  - ♦ protein secreting cells
  - ♦ packaged into transport vesicles for export



### ER is a 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

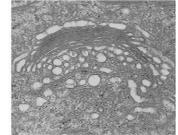
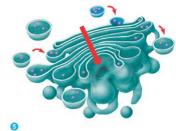


### Golgi Apparatus

#### Function

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

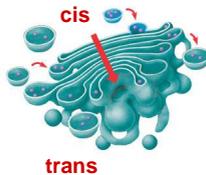
Which cells have a lot of Golgi?



### Golgi Apparatus

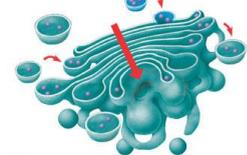
#### Structure

- ◆ 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)

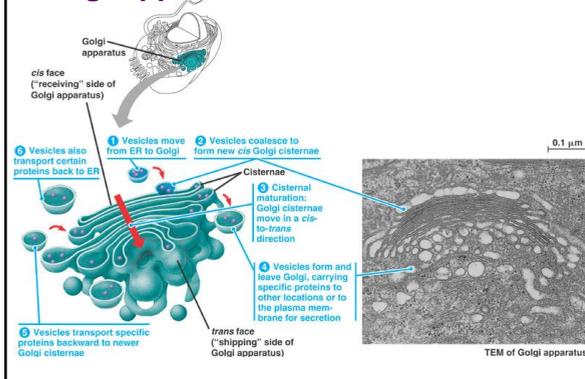


### Golgi processing

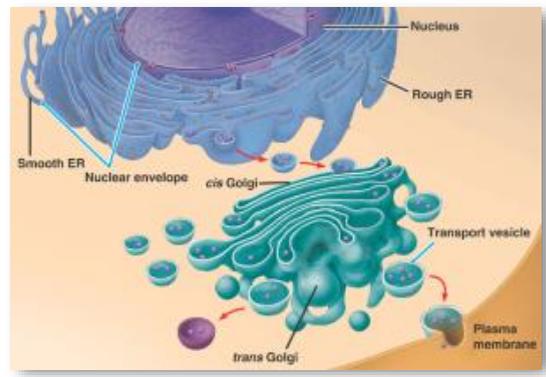
- During path from cis to trans, products from ER are modified into final form
- tags, sorts, & packages materials into transport vesicles
  - ◆ Golgi = “UPS headquarters”
  - ◆ Transport vesicles = “UPS trucks”
    - delivering packages that have been tagged with their own barcodes



### Golgi Apparatus

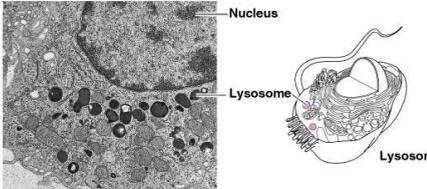


### Putting it together...



## 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

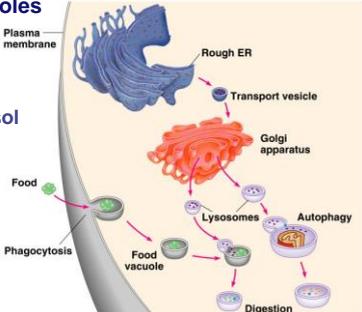
- Function
  - a little “stomach” for the cell
    - lyso- = breaking things apart
    - some = body
  - also the “clean up crew” of the cell



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

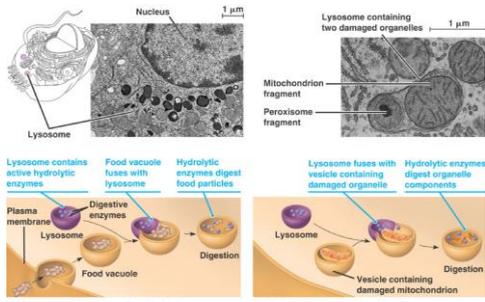
## Cellular digestion

- 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<sup>+</sup> 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 if they 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 GM2 ganglioside collects in lysosomes...
    - ...so 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 lysosomes are supposed to “leak”...

- **Apoptosis = programmed cell death**
  - ◆ **critical 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

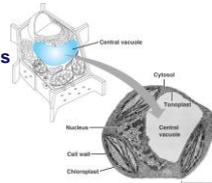
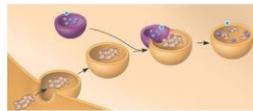
#### syndactyly



### Vacuoles

#### Function

- ◆ **little “transfer ships”**
- **Food vacuoles**
  - ◆ **phagocytosis, fuse with lysosomes**
- **Contractile vacuoles**
  - ◆ **in freshwater protists, pump excess H<sub>2</sub>O out of cell**
- **Central vacuoles**
  - ◆ **in many mature plant cells**



### Putting it all together...

