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 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

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

**1960 | 1974**

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

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 if they leak into cytosol = don’t want to digest yourself!

When things go wrong...

- What if a lysosome digestive enzyme doesn’t function?
  - don’t digest a biomolecule
    - instead biomolecule GM2 ganglioside 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 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

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Fetal development

**syndactyly**

6 weeks

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Vacuoles

- 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

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Putting it all together…