

Chapter 4 Lecture Notes: Eukaryotic Cell Structure and Function

- I. Overview: What is a eukaryote?
 - A. Organisms whose cell/cells have a membrane-enclosed nucleus
 - B. Have numerous other intracellular membranes that allow partitioning of the cell for various tasks
 - C. Have organelles: structures within or on a cell that perform a specific task

- II. The cytoplasmic matrix
 - A. Composition
 1. 70 – 85% water (both bulk and bound to other molecules)
 2. 20% protein – favors protein-protein interactions
 3. pH = neutral

 - B. Function
 1. location of many metabolic processes
 2. contains the cytoskeleton - intricate intracellular network of interconnected filaments including microfilaments, microtubules, and intermediate filaments (see below) that provides:
 - a) strength and rigidity to the cell
 - b) means to control movement of components within the cell
 - c) anchoring point for organelles
 3. contains organelles (see below)

- III. Components of the cytoskeleton
 - A. Microfilaments
 1. Specific functions: cell motion and shape changes - *i.e.* amoeboid movement and cytoplasmic streaming, cytokinesis
 2. Structure
 - a) 4-7 nm in diameter
 - b) composed of actin protein filaments which can be either scattered or organized
 3. Evidence for function
 - a) location
 - b) cytochalasin B blocks the polymerization of actin filaments by binding to end of filament and disrupts corresponding function
 - c) actin-based → actin is known to be involved in movement

 - B. Microtubules
 1. Specific functions
 - a) cell shape
 - b) movement - *i.e.* present in cilia and flagella
 - c) intracellular transport – *i.e.* microtubules move chromosomes during mitosis; movement of Golgi vesicles
 2. Structure

- a) 25 nm in diameter
 - b) composed of tubulin proteins (alpha and beta) which assemble into a helical arrangement to form a cylinder
3. Evidence for function
- a) intracellular distribution
 - b) colchicine disrupts polymerization of tubulin and corresponding functions

C. Intermediate filaments

- 1. Function: cell shape
- 2. Structure:
 - a) 8-10 nm in diameter
 - b) various types defined by protein subunits

IV. Eukaryotic ribosomes

A. Function: protein synthesis

B. Structure: Macromolecular complex of proteins and RNA

C. Types:

- 1. attached to RER – synthesize membrane, secreted, or organelle proteins
- 2. free in cytoplasm – synthesize other proteins for cytoplasm or other organelles

V. The endoplasmic reticulum (ER)

A. Function: packages and transports proteins and lipids

B. Structure

- 1. Network of interconnected membrane sacs (cisternae) and tubules
- 2. Membrane is connected to nuclear membrane

C. Types

- 1. Rough ER = RER
 - a) ER that has ribosomes associated with it
 - b) proteins are synthesized and inserted either into the ER membrane or through ER membrane into lumen
 - c) site of synthesis of proteins that are secreted from the cell or destined to be membrane proteins or organelle proteins
- 2. Smooth ER = SER
 - a) no ribosomes
 - b) site of synthesis and metabolism of fatty acids and phospholipids

VI. Golgi apparatus

A. Function: "Traffic police officer of cell"; modifies, sorts, and transports proteins and membrane components to appropriate cellular location

B. Structure:

1. Series of flattened, membranous sacs (cisternae) that are grouped in stacks (dictyosomes) of 4-8 sacs
2. Vesicles bud off the cisternal edges and carry material from one sac to the next (cis to trans)
3. Polarity: stacks have polarity that is defined by:
 - a) cis = closest to and associated with the ER
 - b) trans = furthest from the ER
 - c) sacs vary in enzyme content and degree of vesicle formation

C. Mechanism

1. Vesicles that are carrying cellular components bud off ER, travel to the Golgi, and then fuse with cis cisternae →
2. various modifications as vesicles bud of one cisterna and carry it to a trans cisterna →
3. modifications include adding functional group tags (frequently sugars) that help sort cell components →
4. at the trans face of the Golgi, vesicles bud off and either:
 - a) deliver membrane proteins to various organelles via membrane fusion
 - b) fuse with the plasma membrane, thereby delivering contents outside of the cell
 - c) fuses with other organelle membranes, thereby delivering contents into organelle lumen

VII. Endosomes

A. Function

1. Uptake of compounds (nutrients) from external environment
2. Phagocytic immune cells are defenses against bacteria

B. Structure: membranous vacuole/vesicle formed when the cell invaginates its plasma membrane to take up solutes/particles

C. Types

1. Phagosome = vacuole that forms from plasma membrane during phagocytosis, in which large particles from outside the cell are engulfed
2. Receptor-mediated endosome = vesicle that forms when a specific molecule binds to its receptor in the plasma membrane; very important for entry of some viruses into cells
3. Pinosome = vesicle that forms from plasma membrane during pinocytosis, in which small amounts of liquid from outside the cell are engulfed

VIII. Lysosomes

A. Function

1. intracellular digestion of macromolecules brought in by endocytosis
2. intracellular digestion of old cell component that were engulfed by lysosome or by ER membrane = autophagy

B. Structure

1. Spherical, single membranous organelles
2. Bud off of the ER and Golgi
3. Maintain acidic environment by pumping in protons
4. Contain acid hydrolases (degrade polymers into monomers)

C. Mechanism

1. New lysosomes (called primary lysosomes) fuse with endosomes to generate a secondary lysosome →
2. Digestion of the material occurs in the secondary lysosome →
3. Secretion of monomers into the cytoplasm →
4. When large amounts of undigested materials have accumulated = residual body

IX. The vacuome = term used to emphasize the functional and physical unity of the ER, Golgi, endosomes, and lysosomes

X. Mitochondria

A. Function: "The powerhouse of the cell"; organelle that contains the enzymes that generates energy for the cell via respiration

B. Structure

1. Two membranes
 - a) Outer
 - b) Inner membrane is extensively folded (cristae); generates an electrical chemical gradient; and contains enzymes for generation of ATP (ATPase) and for electron transport
2. Mitochondrial matrix contains ribosomes, DNA, enzymes for TCA cycle

C. "Reproduce" by binary fission

D. Numbers can be 1 large or up to 1000 smaller ones

E. Origin may have been bacterial

1. rRNA similar to purple photosynthetic bacteria
2. circular DNA encoding some but not all mitochondrial proteins
3. bacterial-like ribosomes
4. antibiotics that inhibit bacterial protein synthesis in bacteria, also inhibit mitochondrial protein synthesis

XI. Chloroplasts

A. Function: Carries out photosynthesis

B. Structure

1. Outer and inner membranes
2. Thylakoids – internal membrane sacs which contains chlorophyll and electron transport chain enzymes; form stacks called grana;
3. Matrix called the stroma contains
 - a) ribosomes
 - b) DNA
 - c) starch granules
 - d) thylakoids
 - e) dark reaction enzymes for formation of carbohydrates

C. Most have numerous oval chloroplasts, but some algae have one large one

D. Like mitochondria, the origin may have been bacterial (see above).

XII. Nucleus

A. Function:

1. Contains the genetic material (DNA) in the form of linear molecules
2. DNA replication and transcription occur here

B. Structure

1. Enclosed by outer and inner membranes that have numerous pores that are a result of the fusion of the two membranes
2. Chromatin – dense, fibrous material that contains DNA and proteins
3. Nucleolus – location of rRNA synthesis and the beginning of the assembly of immature ribosomal subunits

XIII. Plasma membrane

A. Function

1. Retain cytoplasm
2. Semi-permeable membrane
3. Mediate cell-cell interactions
4. Mediate adherence to surfaces

B. Structure

1. Phospholipid bilayer (generally similar to prokaryotes)
2. Many types of phospholipids
3. Contain cholesterol
4. Glycoproteins

XIV. Cell coverings

A. Cell walls

1. Many eukaryotes lack cell walls – How do they survive without? sterols
2. cell walls
 - a) simpler than prokaryotes
 - b) contain layers of polysaccharides (cellulose, pectin, chitin, glucan) and inorganic components such as silica, calcium carbonate

B. Pellicle – rigid layer of proteinaceous elements under the plasma membrane of some protozoa and algae

XV. Cilia and flagella

A. Function: Motility

B. Similarities in structure

1. membrane bound cylinders
2. 9 doublets microtubules around 2 central microtubules (9 + 2 organization)
3. basal body = 9 triplet microtubules (9 + 0 organization) that lie in the cytoplasm at the base of the organelles - directs synthesis of organelles

C. Differences in size: cilia are shorter and more numerous

D. Differences in macroscopic patterns of movement: flagellum move in a whip-like pattern while cilium moves like an oar in the water

E. Molecular mechanism of movement

XVI. Comparison of prokaryotes and eukaryotes

Table 4-2