Topic 1.2 Ultrastructure of Cells

1.2.U1: Prokaryotes have a simple cell structure without compartmentalization

- **Outline the major differences between prokaryotic and eukaryotic cells.**
    - Prokaryotic Cells
        - Smaller (about 0.2 - 2 um)
        - DNA in nucleoid region (no nuclear membrane)
        - No membrane bound organelles
        - Cell wall of peptidoglycan
        - Smaller ribosomes (70s) in cytoplasm
        - DNA is circular and without histone proteins
        - Has plasmid DNA
        - Asexual cell division
    - Eukaryotic Cells
        - Bigger (10-100 um)
        - DNA in a true nucleus
        - Membrane bound organelles present
        - Cell wall of cellulose (plants) or chitin (fungus)
        - Larger ribosomes (80s) in cytoplasm and on ER
        - //also has 70s ribosomes within mitochondria and chloroplasts//
        - DNA is linear with histone proteins
        - Do not have plasmid DNA
        - Asexual or sexual cell division
- **List the functions of the following structures of a prokaryotic cell: cell membrane, nucleoid, plasmids, cytoplasm, ribosomes, cell wall, pili, capsule, and flagella.**
    - Cell membrane
        - Forms the boundary of the cell
        - acts as a selective barrier, allowing certain materials to pass into and out of the cell, but not others
    - Nucleoid
        - Location of the genetic material for inheritance and protein coding;

        - circular DNA
        - not associated with histone proteins
    - Plasmid
        - Smaller, circular DNA not associated with DNA in the nucleoid
        - Often contains genes for antibiotic resistance
    - Cytoplasm
        - Primarily water and dissolved molecules
        - the location of many metabolic reactions
    - Ribosome
        - Responsible for catalyzing the formation of polypeptides during protein synthesis.
        - Size is 70s
    - Cell wall
        - Found in most prokaryotic cells
        - Provides shape and protection to the cell
        - Composed of peptidoglycan
    - Pilus (singular)
        - Found in some (not all) prokaryotic cells
        - Hair-like structures t
        - Help the cell attach to surfaces
    - Capsule
        - Found in some (not all) prokaryotic cells
        - Helps the cell maintain moisture and adhere to surfaces.
        - Protects the cells from other organisms
    - Flagella
        - Found in some (not all) prokaryotic cells
        - Long extension used for cell locomotion
- **Contrast the size of eukaryotic and prokaryotic ribosomes.**
    - Prokaryotes have a smaller, 70s ribosome.
    - Eukaryotes have a larger, 80s ribosome.
    - The mitochondria and chloroplasts within eukaryotic cells have 70s ribosomes.
    - (The "s" stands for Svedberg unit, a measure of particle sedimentation rate)

1.2.U2: Eukaryotes have a compartmentalized cell structure

- **State the meaning and advantages of eukaryotic cells being "compartmentalized."**
    - Compartmentalization is the presence of membrane bound partitions (organelles) within the eukaryotic cell. The compartments allow for:
        - Specialization of regions within the cell for specific functions.
        - Molecules needed for a specific function to be concentrated in a region within the cell.
- **State structural differences between plant and animal cells.**
    - Animal Cells
        - No cell wall
        - No chloroplasts
        - No large vacuole
        - Not a fixed shape
        - Stores carbohydrates as glycogen
    - Plant Cells
        - Cell wall
        - Chloroplasts
        - Large vacuole
        - Fixed shape
        - Stores carbohydrates as starch

1.2.U3: Prokaryotes divide by binary fission

- **Define asexual reproduction.**
    - Asexual reproduction creates offspring from a single parent organism.
    - The offspring are genetic clones of that parent.
- **Outline the four steps of binary fission.**
    - 1. The nucleoid DNA replicates to create an exact duplicate copy.
    - 2. The nucleoid DNAs attach to the cell membrane.
    - 3. The cell membrane (and wall, if present) grow, causing the cell to elongate and the DNA molecules to move apart from each other.
    - 4. The cell membrane pinches inward, creating two genetically identical cells.

1.2.U4: Electron microscopes have a much higher resolution than light microscopes

- **Define resolution.**
    - The smallest interval distinguishable by the microscope, which then corresponds to the degree of detail visible in an image created by the instrument.
- **Compare the functionality of light and electron microscopes.**
    - *LIGHT MICROSCOPES*
        - Use lenses to bend light and magnify images.
        - Used to study dead or living cells in color.
        - Cell movement can be studied.
        - Larger field of view.
        - Objects can be magnified up to 2000X.
        - Can resolve objects 200 nm apart.
    - *ELECTRON MICROSCOPES*
        - Uses electron beams focused by electromagnets to magnify and resolve.
        - Requires cells to be killed and chemically treated before viewing.
        - No movement can be seen.
        - Without stain or dye, no color can be seen.
        - Smaller field of view.
        - Can magnify objects up to 250,000 times.
        - Can resolve objects that are 0.2 nm apart.

1.2.A1: Structure and function of organelles within exocrine gland cells of the pancreas

- **State the function of an exocrine gland cell.**
    - Exocrine gland cells synthesize molecules (often proteins) for secretion from the cell into an external space.
    - Exocrine gland cells of the pancreas secrete enzymes that function in digestion in the small intestine.
- **Describe the function of the following structures in an exocrine gland cell: plasma membrane, nucleus, mitochondria, Golgi apparatus, lysosomes, vesicles and endoplasmic reticulum.**
    - Plasma membrane: Forms the boundary of the cell, acts as a selective barrier allowing certain materials to pass into and out of the cell.

- Nucleus: contains most of the genes that control the eukaryotic cell, contains the nucleolus and chromatin.
- Mitochondria: The location of aerobic cellular respiration used to make ATP.
- Golgi apparatus: Consists of flattened membranous sacs; receives transport vesicles from the ER, modifies proteins produced in the ER, produces secretory vesicles
- Lysosome: Contains digestive enzymes that are used to break apart cellular debris and waste.
- Vesicles: Transport materials within the cell and out of the cell via exocytosis.
- Endoplasmic reticulum: Ribosomes on the ER synthesize proteins which are then moved through the ER and packaged into vesicles for transport.

1.2.A2: Structure and function of organelles within palisade mesophyll cells of the leaf

- **State the function of a palisade mesophyll cell.**
  - Palisade mesophyll cells are found on the upper surface of a leaf and have the primary job of performing photosynthesis.
- **Draw a labeled diagram of a palisade cell from the leaf mesophyll.**
  - Cell wall shown with two continuous lines to indicate the thickness.
  - Plasma membrane/cell membrane shown as a single continuous line (can be shown as the inner line of the cell wall if clearly labelled).
  - Nucleus shown with double membrane and nuclear pores.
  - Vacuole(s) drawn with a single continuous line.
  - Chloroplast shown with a double line to indicate the envelope and thylakoids.
  - Mitochondrion shown with double membrane and cristae.
- **Describe the function of the following structures in a palisade mesophyll cell: cell wall, plasma membrane, chloroplasts, vacuole, nucleus, and mitochondria.**
  - Cell wall: Provides structural rigidity and support.
  - Plasma membrane: Forms the boundary of the cell, acts as a selective barrier allowing certain materials to pass into and out of the cell.
  - Chloroplasts: Location of photosynthesis reactions. Produce carbohydrates using light energy, CO_2 and H_2O

- Vacuole: Membrane bound sacs, larger than vesicles, stores water and dissolved nutrients and helps maintain cell turgidity.
- Nucleus: Contains most of the genes that control the eukaryotic cell, contains the nucleolus and chromatin.
- Mitochondria: The location of aerobic cellular respiration used to make ATP.

1.2.S1: Drawings of the ultrastructure of prokaryotic cells based on electron micrographs

- **Explain why the ultrastructure of prokaryotic cells must be based on electron micrographs.**
  - "Ultrastructures" are small structures of/in a biological specimen that are too little to see with a light microscope.
- **Draw the ultrastructure of E.coli as seen in an electron micrograph.**
  - Cell wall drawn uniformly thick and outside the cell membrane
  - Capsule drawn outside the cell wall
  - Pili drawn as hair-like structures connected to cell wall
  - Flagellum drawn at one end only and longer than pili
  - Cell membrane represented by a continuous single line
  - 70S ribosomes drawn as small discrete dots (not circles)
  - Nucleoid DNA shown as a tangled line not enclosed in membrane
  - Plasmid drawn as a small circular ring of DNA
  - Cytoplasm labeled within the cell

1.2.S2: Drawings of the ultrastructure of eukaryotic cells based on electron micrographs

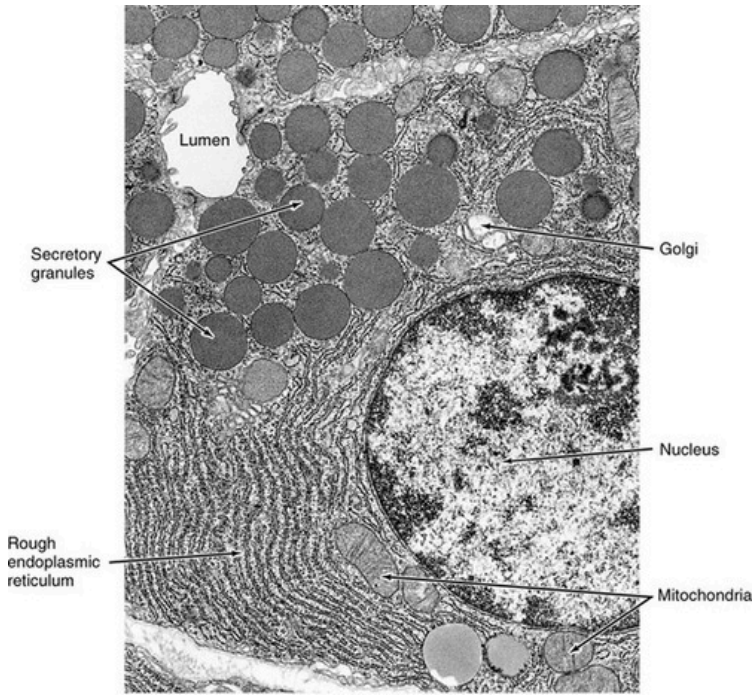
- **Draw and label a diagram of the ultrastructure of a generic animal cell.**
  - Cell membrane shown as a single continuous line
  - Nucleus drawn with double membrane and nuclear pores
  - Mitochondria with a double membrane, the inner one folded into internal projections, shown no larger than half the nucleus
  - Rough endoplasmic reticulum drawn as a multi-folded membrane with dots on surface
  - Golgi apparatus drawn as a series of enclosed sacs with evidence of vesicle formation
  - 80S ribosomes drawn as small discrete dots (not circles) in cytoplasm and on rER
  - lysosome and vesicles drawn as circles with single line

- **Draw and label a diagram of the ultrastructure of a generic plant cell.**
    - Cell wall drawn on outside perimeter with two continuous lines to indicate the thickness
    - Cell membrane shown as a single continuous line
    - Nucleus drawn with double membrane and nuclear pores
    - Vacuole drawn with a single continuous line
    - Chloroplast drawn with a double line and internal stacks of thylakoid
    - Mitochondria with a double membrane, the inner one folded into internal projections, shown no larger than half the nucleus
    - 80S ribosomes drawn as small discrete dots (not circles) in the cytoplasm and on rER

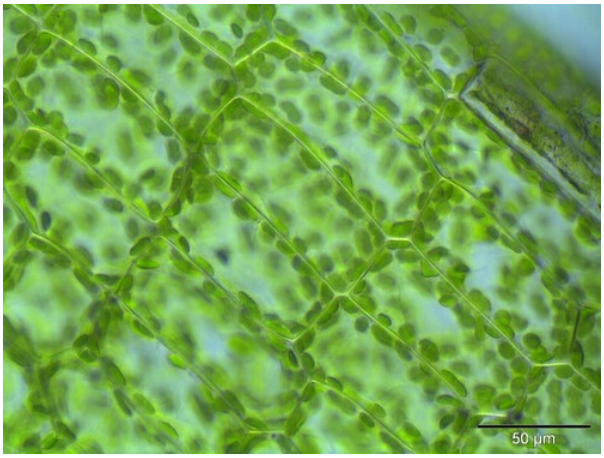
1.2.S3: Interpretations of electron micrographs to identify organelles and deduce the function of specialized cells

- **Explain why cells with different functions will have different structures.**
    - Cells will have different types and/or quantities of organelles depending on the primary function of the cell type.
    - This allows for cells to specialize for a specific task.
- **Identify ultrastructures visible in a micrograph of a eukaryotic cell.**
    - Plasma membrane: Look for a thin line around the edge of the cell.
    - Ribosomes: Tiny dark dots, can be "free" in the cytoplasm or "bound" to the rough ER.
    - Nucleus: Often stained a darker color, look for a nuclear membrane and the nucleolus.
    - Rough endoplasmic reticulum: Look for stacks of lines, often with visible little dark dots attached. Typically closer to the nucleus than Golgi.
    - Golgi apparatus: Look for stacks of lines, without little dark dots attached. Typically further from the nucleus than ER.
    - Lysosome: Little sacs, often a light grey color. Hard to distinguish from vesicles.
    - Mitochondria: Often stain dark. Circular or kidney shapes with internal wavy lines.
    - Chloroplast: Typically an oval shape with stacks visible on the inside. If image is in color, the chloroplasts will be green.
    - Vacuole: Clear sac, typically larger in size than a vesicle or lysosome. More prevalent in plant cells than in animal cells.
    - Vesicle: Little roundish sacs. Often stain dark. Can be hard to distinguish from lysosome.
    - Flagella: Long tail-like structure emerging from the main cell body.

- Cell wall: Rigid outermost layer of a plant cell, external to the cell membrane. Thicker than the cell membrane.

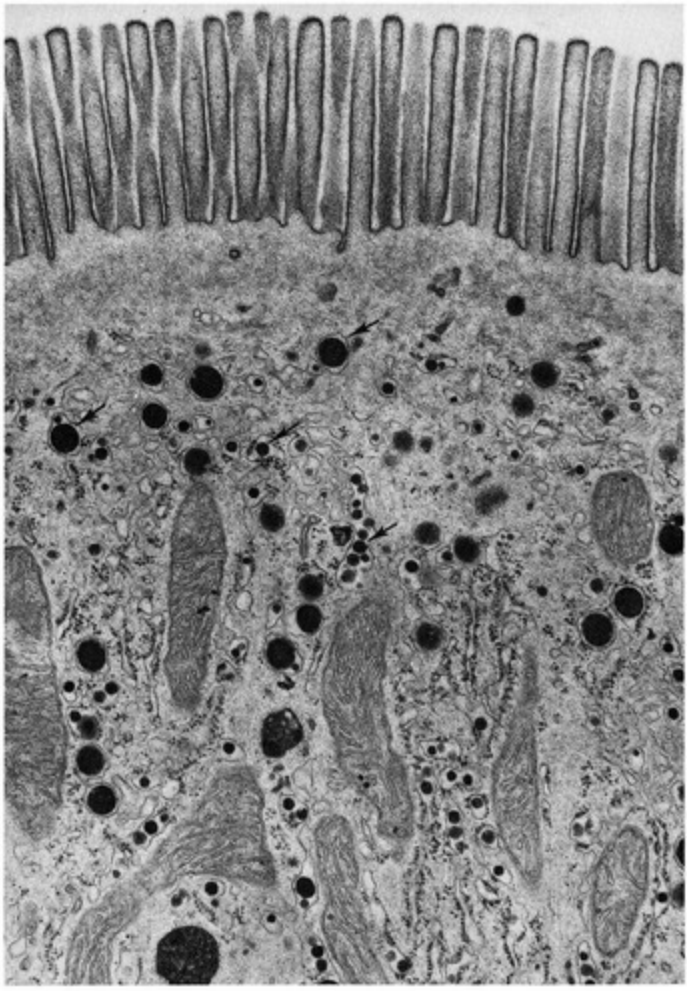
- **Given a micrograph of a cell, deduce the function of the cell based on the structures present.**
  - This is a cell from a pancreas exocrine gland.
    - 

    - It has a lot of rough endoplasmic reticulum, so it can be deduced that the cell secretes a protein.
    - There are vesicles concentrated near one edge of the cell containing the protein that will be excreted.

  - These are cells from an aquatic leaf.
    - 

        - There are many chloroplast present, so it can be deduced that the cells do photosynthesis.

    - This cell is from the small intestine. It is an epithelial cell of a villus.



        - This cell has many microvilli which increase the surface area for nutrient absorption.
        - There are many vesicles (dark stain) containing materials brought into the cell via endocytosis.

1.2.NOS: Developments in scientific research follows improvements in apparatus- the invention of the electron microscopes led to greater understanding of cell structure

- **With reference to a specific example, explain how an improvement in apparatus allowed for greater understanding of cell structure.**
    - *Technology* = machinery and equipment developed from the application of scientific knowledge.

- *Begets* = gives rise to; brings about.
- *Discovery* = the act of finding or learning something for the first time.