Chapter 4

Cell Structure and Function
What is a cell?

- Cell - smallest unit of life
- Two fundamental categories of cells in nature
  - Prokaryotic and Eukaryotic
  - Eukaryotic Cells
    - Large nucleus
    - DNA is present inside the nucleus
  - Prokaryotic
    - Does not have a prominent nucleus
Prokaryotic and Eukaryotic Cells
Cell components

- **Plasma membrane** – Cells outer membrane
  - It separates metabolic activities from events outside the cell
- **Nucleus**
  - Double layered membrane sac that holds eukaryotic cell DNA
- **Prokaryotic cell - Nucleoid**
Cell components

Cytoplasm

- Semi fluid mixture of water, ions, sugar and proteins between plasma membrane and DNA

Ribosomes

- Site of protein synthesis
Cell Membrane

- Lipid bilayer is the foundation of all cell membrane
- Hydrophobic tails are sandwiched between their hydrophilic heads
- Phospholipids are the most abundant type of lipid in a cell membrane
Components of Cell Membranes

- Lipid bilayer

  Two hydrophobic tails

<table>
<thead>
<tr>
<th>Hydrophilic head</th>
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<tbody>
<tr>
<td>Lipid bilayer</td>
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<tr>
<td>fluid</td>
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Cell sizes and shapes

- Surface to volume ratio strongly influence the cells size and shape
- Volume increases with cube of its diameter but its surface area increases with square
How do we see cells?

Cell Theory

- All organisms consist of one or more cells
- Cell is the smallest unit that retains the properties of life

Microscopes

Light microscopes
- Use visible light to illuminate the object
Microscopes

- All light passes in waves
- Wave length of visible light is 400nm
- Structures smaller than one – half of the wave length are too small to be visible
- Structures less than 200nm appear blurry

Electron Microscopes

- Electrons are used to illuminate cells
Microscopes

- Electrons travel in much shorter wave length
- Can resolve structures as small as 0.2nm

Scanning electron microscopes

- Specimen is coated with thin layer of gold or other metal
- Metal emit both electrons and x-rays, that are converted into image
Ocular lens enlarges primary image formed by objective lenses.

Objective lenses (those closest to specimen) form the primary image. Most compound light microscopes have several.

Stage supports microscope slide

Condenser lenses focus light rays through specimen.

Illuminator

Light source (in base)
Membrane Structure and Function

- Cell membrane is organized as a lipid bilayer with many proteins in it.
- Basic framework of all cell membranes.

**Fluid Mosaic model**

- Cell membrane is a mosaic composed of phospholipids, sterols, proteins and other components
Membrane Structure and Function

Membrane Proteins

- **Transporters** – helps to move specific solutes across the bilayer
- **Receptors** – initiate change in a cell activity by responding to an outside signal
- **Recognition proteins** – identify cell as self (belonging to one’s body) or as non-self (foreign body)
- **Adhesion proteins** – helps cells stick to one another and to protein matrix
Plasma membrane of animal cells

- **EXTRACELLULAR FLUID**
  - A glucose transporter allows glucose to cross the membrane through a channel in its interior.
  - An ATP synthase, which makes ATP when H+ crosses a membrane through its interior.
  - A calcium pump moves calcium ions across the membrane; requires ATP energy.

- **LIPID BILAYER**
  - Phospholipid
  - B cell receptor. It binds to bacteria, other foreign agents.
  - Recognition protein that identifies a cell as belonging to one's own body.
  - Protein filaments of the cytoskeleton

- **CYTOPLASM**
  - Plasma membrane of animal cells
Introducing Prokaryotic Cells

- They are single-celled organisms
- Prokaryotic cells are grouped into domains – bacteria and archaea
- **Structure**
  - Capsule – A thick protective jelly like polysaccharide in the outer most layer
  - Cell wall - rigid porous structure surrounds the plasma membrane
  - Flagella – slender cellular structure used for motion
Prokaryotic Cells

- **Pili** – protein filament that projects from the surface, used for attachment
- “Sex” pilus – transfers genetic material
- Cytoplasm – contains many ribosomes
Prokaryote Structure

Most prokaryotic cells have a cell wall outside the plasma membrane, and many have a thick, jellylike capsule around the wall.

- bacterial flagellum
- cell wall
- plasma membrane
- DNA in nucleoid
- cytoplasm, with ribosomes
Microbial Mobs

**Biofilm** – a population of microorganisms (bacteria, algae, yeast, fungi) that is growing attached to a surface
Eukaryotic Cells

- Eukaryotic cells – contain nucleus and organelles
- Organelles – a structure that carries out a specialized function inside a cell. E.g. a nucleus in Eukaryotic cell
Nucleus and Nuclear Envelope

**Function** – nucleus keeps that eukaryotic DNA separated from the cytoplasm

**Nuclear Envelope / Outer boundary** – consist of two lipid bilayer
- It encloses a semi-fluid matrix called nucleoplasm

**Nucleolus** – an irregularly shaped region within the nucleus that manufactures ribosomes
Nucleus and Nuclear Envelope

- nucleus
- pore across the nuclear envelope
- nucleoplasm
- nucleolus
- chromatin
- nuclear envelope’s outer lipid bilayer merging with an ER membrane
Nucleus and Nuclear Envelope

- **chromosome** – A double stranded molecule of DNA with attached proteins
- **Chromatin** – dense string like fiber in which chromosomal DNA and proteins are arranged
Endomembrane System

Endomembrane system – a set of organelles in the cytoplasm of eukaryotic cell

Endoplasmic Reticulum (ER)

- an extension of the nuclear envelope
- consists of continuous compartments of tubes and saes
- site where many new polypeptides are modified
Endomembrane System

Two kinds of Endoplasmic Reticulum (ER)

- Smooth ER
- Rough ER

**Smooth ER**

- does not have ribosomes
- Functions include synthesis of lipids, metabolism of carbohydrates, detoxification of drugs and poisons

**Rough ER**

- many ribosomes are attached
- Polypeptide modification
Endomembrane System

Golgi bodies – organelle of endomembrane system
  - Vesicles – small sacs made of membrane
  - Enzymes inside a Golgi body modifies polypeptide and synthesizes lipids

Other vesicles
  - Lysosomes – take part in intracellular digestion
  - Peroxisomes – digests fatty acids and amino acids, breaks down toxins and metabolic byproducts
Endomembrane System

- nucleus
- rough ER
- smooth ER
- Golgi body
- vesicles
Plant Cell

**CELL WALL**
- Protects, structurally supports cell

**CHLOROPLAST**
- Specializes in photosynthesis

**CENTRAL VACUOLE**
- Increases cell surface area; stores metabolic wastes

**CYTOSKELETON**
- Structurally supports, imparts shape to cell; moves cell and its components

**MITOCHONDRIUM**
- Energy powerhouse; produces many ATP by aerobic respiration

**PLASMODESMA**
- Communication junction between adjoining cells

**PLASMA MEMBRANE**
- Selectively controls the kinds and amounts of substances moving into and out of cell; helps maintain cytoplasmic volume, composition

**NUCLEUS**
- Keeps DNA and its transcription into RNA away from potentially damaging reactions in cytoplasm

**RIBOSOMES**
- (attached to rough ER and free in cytoplasm)
- Sites of protein synthesis

**ROUGH ER**
- Modifies new polypeptide chains

**SMOOTH ER**
- Diverse roles; e.g., makes lipids, degrades fats, inactivates toxins

**GOLGI BODY**
- Modifies, sorts, ships proteins and lipids for export or for insertion into cell membranes

**LYSOSOME-LIKE VESICLE**
- Digests, recycles materials

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\( a \) Typical plant cell components.

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Animal Cell

- **NUCLEUS**: Keeps DNA and its transcription into RNA away from potentially damaging reactions in cytoplasm.
- **RIBOSOMES** (attached to rough ER and free in cytoplasm): Sites of protein synthesis.
- **ROUGH ER**: Modifies new polypeptide chains.
- **SMOOTH ER**: Diverse roles; e.g., makes lipids, degrades fats, inactivates toxins.
- **GOLGI BODY**: Modifies, sorts, ships proteins and lipids for export or for insertion into cell membranes.
- **LYSOSOME**: Digests, recycles materials.

**CYTOSKELETON**: Structurally supports, imparts shape to cell; moves cell and its components.

- microtubules
- microfilaments
- intermediate filaments

**MITOCHONDRION**: Energy powerhouse; produces many ATP by aerobic respiration.

**CENTROLES**: Special centers that produce and organize microtubules.

**PLASMA MEMBRANE**: Selectively controls the kinds and amounts of substances moving into and out of cell; helps maintain cytoplasmic volume, composition.

b Typical animal cell components.

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Mitochondria and Chloroplast

Mitochondria
- break down organic compounds by aerobic respiration (oxygen required)
- produce ATP

Chloroplast
- Produce sugars by photosynthesis
- Contain a pigment chlorophyll, responsible for green coloration of most plants
Structure of chloroplast

- Two outer membrane
- Semifluid interior is known as stroma
- Thylakoids – inner membrane system folded into flattened disks
Cell Surface Specializations

Eukaryotic Cell Wall

- Plants, many protists and fungal cells have cell wall around their plasma membrane
  - Protects, supports, maintains cell shape
  - Primary and secondary cell walls

Plasmodesmata - Channels across cell walls that connect plant cells
**Plant Cell Walls**

**a** Plant cell secretions form the middle lamella, a layer that cements adjoining cells together.

**b** In many plant tissues, cells also secrete materials that are deposited in layers on the inner surface of their primary wall. These layers strengthen the wall and maintain its shape. They remain after the cells die, and become part of pipelines that carry water through the plant.
Plasmodesmata are channels across the cell walls and the plasma membranes of living cells that are pressed against one another in tissues.
Plant cuticle

- Protective body covering made of cell secretions
Matrix between animal cells

Most cells of multicellded organisms are surrounded by extracellular matrix
E.g Chitin in fungus
Cell Junctions

Structure that connects a cell to other cells

Three types of cell junctions common in animal tissues are

**Tight junctions** - Seals cells together tightly

**Adhering junctions** – Anchors cells to one another

**Gap junctions** – Connect cytoplasm of adjacent cells
adhering junction
free surface of epithelial tissue
different kinds of tight junctions
gap junction
basement membrane (extracellular matrix)
adhering junction
Cytoskeleton

- Present in eukaryotic cells
- Dynamic frame of diverse protein filaments
- Reinforces cell shape

Components of cytoskeleton

- Microtubules
- Microfilaments
- Intermediate proteins
Components of cytoskeleton

Microtubules
- They are long
- Composed of subunits of protein tubulin
- Form a dynamic framework for many activities

Microfilaments
- Consist of protein filament actin
- They strength or change the shape of eukaryotic cells
Components of cytoskeleton

Intermediate filaments
- Forms the stable parts of cytoskeleton
- They strengthen and maintain cell and tissue structure

Motor Protein
- A type of protein, interacts with elements in cytoskeleton to move cell structures
Components of cytoskeleton

- **Microtubules**
- **Microfilaments**
- **Intermediate filaments**
Celia and Flagella

- They are structures for cell motility
- They are whip like structures that propels the cells through the fluid
- It has 9+2 array of internal structure

False feet

- Amoebas and some other types of eukaryotic cells form temporary irregular lobes called pseudopods or “false feet”
- They help to move the cell and engulf prey
a Sketch and micrograph of one eukaryotic flagellum, cross-section. Like a cilium, it contains a 9 + 2 array: a ring of nine pairs of microtubules plus one pair at its core. Stabilizing spokes and linking elements that connect to the microtubules keep them aligned in this radial pattern.
b Projecting from each pair of microtubules in the outer ring are “arms” of dynein, a motor protein that has ATPase activity. Phosphate-group transfers from ATP cause the dynein arms to repeatedly bind the adjacent pair of microtubules, bend, and then disengage. The dynein arms “walk” along the microtubules. Their motion causes adjacent microtubule pairs to slide past one another.

c Short, sliding strokes occur in a coordinated sequence around the ring, down the length of each microtubule pair. The flagellum bends as the array inside bends:

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basal body, a microtubule organizing center that gives rise to the 9 + 2 array and then remains beneath it, inside the cytoplasm
Flagellum and Pseudopods