Chapter 4: Cell Structure and Function

Animacules and Cells Fill'd with Juices

A. Early observations revealed an unseen world:

1. Galileo saw the facets of an insect's eyes.

2. Robert Hooke saw small compartments in cork, which he named cells.

3. Van Leeuwenhoek observed several types of living cells, including sperm.

4. Schleiden and Schwann proposed the idea that all living things were composed of cells.

5. Virchow concluded that all cells come from cells.

B. These observations and many others led to the cell theory:

1. All organisms are composed of one or more cells

2. The cell is the smallest unit having the properties of life.

3. The continuity of life arises directly from the growth and division of single cells.

I. Basic Aspects of Cell Structure and Function

A. Structural Organization of Cells

1. A plasma membrane separates each cell from the environment, permits the flow of molecules across the membrane, and contains receptors that can affect the cell’s activities.

2. A nucleus or nucleoid region localizes the hereditary material, which can be copied and read.

3. The cytoplasm contains membrane systems, particles (including ribosomes), filaments (the cytoskeleton), and a semifluid substance.

4. There are basically two kinds of cells in nature:

a. Eukaryotic cells contain distinctive arrays of organelles, including a membrane-bound nucleus.

b. Prokaryotic cells (bacteria) have no nucleus.

B. The Lipid Bilayer of Cell Membranes

1. The lipid bilayer of plasma membranes forms a boundary between inside and outside of the cell, subdivides the cytoplasm into compartments, and regulates the entry/exit of substances.

2. Proteins positioned in the plasma membrane serve as channels, pumps, or receptors.

C. Cell Size and Cell Shape

1. Most cells are too small to be seen without a microscope.

2 The small size of cells permits efficient diffusion across the plasma membrane and within the cell.

3. As the surface area of a cell increases by the square of the diameter, the volume increases by the cube of the diameter.

II. Focus on Science: Microscopes—Gateways Cells

III. Defining Features of Eukaryotic Cells

A. Major Cellular Components

1. The nucleus controls access to DNA and permits easier packing of DNA during cell division.

2. The endoplasmic reticulum (ER) modifies proteins and is also involved with lipid synthesis.

3 Golgi bodies also modify proteins, sort and ship proteins, and play a role in the biology of lipids for secretion or internal use.

4. Various vesicles transport, store, and digest various materials within the cell.

5. Mitochondria have enzymes responsible for ATP formation.

6. Ribosomes , either "free" or attached to membranes are the assembly sites of polypeptide chains.

7. The cytoskeleton determines cell shape and internal organization; it also provides for motility.

B. Organelles form compartmentalized portions within the cytoplasm allowing reactions to be separated with respect to time (allowing proper sequencing) and space (allowing incompatible reactions to occur in close proximity).

C. What Organelles Are Typical of Plants? (see Figure 4.8a and 4.9).

D. What Organelles Are Typical of Animals? (see Figure 4.8b and 4.10).

IV. The Nucleus

A. The nucleus isolates DNA–which contains the code for protein assembly, from the sites–ribosomes in cytoplasm, where proteins will be assembled.

B. Nuclear Envelope

1. The nuclear envelope consists of <u>two</u> lipid bilayers with pores..

2. The inner surface has attachment sites for protein filaments, which anchor the DNA molecules and keep them organized.

3. The outer surface is studded with ribosomes.

C. Nucleolus

1. The nucleolus appears as a dense, globular mass of material within the nucleus.

2. It is a region where RNA subunits of ribosomes are prefabricated before shipment out of the nucleus.

D. Chromosomes

1. Chromatin refers to the total collection of DNA and proteins.

2. Each chromosome is a single molecule of DNA and its associated proteins; it may take on different appearances depending on the events currently happening within the cell.

E. What Happens to the Proteins Specified by DNA?

1. Within the cytoplasm, newly formed polypeptide chains may be stockpiled in solution or may enter the cytomembrane system (ER, Golgi bodies, and vesicles).

2. Some of the proteins will be used within the cell in which they were made, other will be exported for use elsewhere.

V. The Cytomembrane System

A. The cytomembrane system is a series of organelles in which lipids are assembled and new polypeptide chains are modified into final proteins.

B. Endoplasmic Reticulum

1. The endoplasmic reticulum is a collection of interconnected tubes and flattened sacs that begins at the nucleus and winds its way through the cytoplasm.

2. Two kinds of ER may be found in a cell:

a. Rough ER consists of stacked, flattened sacs with many ribosomes attached; oligosaccharide groups are attached to polypeptides as they pass through on their way to other organelles or to secretory vesicles.

b. Smooth ER has no ribosomes; it is the area from which vesicles carrying proteins and lipids are budded; it also inactivates harmful chemicals.

C. Golgi Bodies

1. A Golgi body consists of flattened sacs–resembling a stack of pancakes–whose edges break away as secretory vesicles.

2. Here proteins and lipids undergo final processing, sorting, and packaging.

D. A Variety of Vesicles

1. Lysosomes are vesicles that bud from Golgi bodies; they carry powerful enzymes that can digest the contents of other vesicles, worn-out cell parts, or bacteria and foreign particles.

2. Peroxisomes are small vesicles that contain enzymes using oxygen to degrade fatty acids and amino acids, forming a harmful byproduct, hydrogen peroxide, which is then converted to water.

VI. Mitochondria

A. Mitochondria are the primary organelles for transferring the energy in carbohydrates to ATP under oxygen-plentiful conditions.

B. Each mitochondrion has an outer membrane and an inner folded membrane (cristae).

1. Two compartments are formed by the membranes.

2. Hydrogen ions and electrons move between the compartments during ATP formation.

C. Mitochondria have their own DNA and ribosomes, a fact which points to their origination from ancient bacteria engulfed by predatory cells.

VII. Specialized Plant Organelles

A. Chloroplasts and Other Plastids

1. Chloroplasts are oval or disk shaped, bounded by a double membrane, and are critical to the process of photosynthesis.

a. In the stacked disks (grana), pigments and enzymes trap sunlight energy to form ATP.

b. Sugars are formed in the fluid substance (stroma) surrounding the stacks.

c. Pigments such as chlorophyll (green) confer distinctive colors to the chloroplasts.

2. Chromoplasts store red and brown pigments that give color to petals, fruits, and roots.

3. Colorless amyloplasts store starch granules.

B. Central Vacuole

1. In a mature plant, the central vacuole may occupy 50 to 90 percent of the cell interior.

a. Central vacuoles store amino acids, sugars, ions, and wastes.

b. The vacuole enlarges during growth and greatly increases the cell's outer surface area.

2. The enlarged cell, with more surface area, has an enhanced ability to absorb nutrients.

VIII. Components of the Cytoskeleton

A. The cytoskeleton gives cells their internal organization, shape, and capacity to move.

1. It forms an interconnected system of bundled fibers, slender threads, and lattices that extends from the nucleus to the plasma membrane.

2. The main components are microtubules, microfilaments, and intermediate filaments–all assembled from protein subunits.

3. Some portions are transient, such as the "spindle" microtubules used in chromosome movement during cell division; others are permanent, such as filaments operational in muscle contraction.

B. Microtubules

1. Microtubules, the largest structural elements in the cytoskeleton, are composed of tubulin subunits which compose a cylinder.

2. Microtubule organizing centers (MTOCs) are small masses of proteins in the cytoplasm that give rise to microtubules.

3. Microtubules govern the division of cells and some aspects of their shape as well as many cell movements.

C. Microfilaments

1. Microfilaments, the thinnest elements, consist of two helically twisted polypeptide chains assembled from actin monomers.

2. Microfilaments are particularly important in movements that take place at the cell surface; they also contribute to the shapes of animal cells.

D. Myosin and Other Accessory Proteins

1. Extending from the microfilaments of muscle cells, myosin plays a vital role in contraction.

2. Other proteins attach microfilaments to the inner surface of the plasma membrane (spectrin) or span the plasma membrane to connect microfilaments to outside proteins (integrins).

E. Intermediate Filaments

1. Intermediate filaments, the most stable of the cytoskeleton elements, occur only in animal cells of specific tissues.

2. Examples include desmins and vimentins (support machinery by which muscle cells contract) and lamins (form a scaffold that reinforces the nucleus).

IX. The Structural Basis of Cell Motility

A. Mechanisms of Cell Movements

1. Through controlled assembly and disassembly of their subunits, microtubules, and microfilaments grow or diminish in length, thereby the structures attached to them are thereby pushed or dragged through the cytoplasm (example: pseudopod movement in Amoeba.

2. Parallel arrays of microfilaments or microtubules actively slide past one another to bring about contraction, as in muscle.

3. Microtubules or microfilaments shunt organelles from one location to another as in cytoplasmic streaming.

B. Flagella and Cilia

1. Microtubular extensions of the plasma membrane have a 9 + 2 cross-sectional array that arises from a centriole (a type of MTOC) and are useful in propulsion.

2. Flagella are quite long, not usually numerous, and found on one-celled protistans and animal sperm cells.

3. Cilia are shorter and more numerous and can provide locomotion for free-living cells or may move surrounding water and particles if the ciliated cell is anchored.

X. Cell Surface Specializations

A. Eukaryotic Cell Walls

1. Cell walls are carbohydrate frameworks for mechanical support in bacteria, protistans, fungi, and plants; cell walls are not found in animals.

2. In growing plant parts, bundles of cellulose strands form a primary cell wall that is pliable enough to allow enlargement under pressure.

3. Later, more layers are deposited on the inside of the primary wall to form the secondary wall.

4. Lignin composes up to 25 percent of the secondary wall in woody plants; it makes plant parts stronger, more waterproof, and less inviting to insects.

B. Matrixes Between Animal Cells

1. The matrix between animal cells includes cell secretions and materials drawn from the surroundings between cells.

2. For example, cartilage consists of scattered cells and collagen embedded in a "ground substance" of modified polysaccharides; bone is similarly constructed.

C. Cell-to-Cell Junctions

1. In plants tiny channels called plasmodesmata cross the adjacent primary walls and connect the cytoplasm

2. Animal cells display three types of junctions:

a. Tight junctions occur between cells of epithelial tissues in which cytoskeletal strands of one cell fuse with strands of neighboring cells causing an effective seal.

b. Adhering junctions are like spot welds at the plasma membranes of two adjacent cells that need to be held together during stretching as in the skin and heart.

c. Gap junctions are small, open channels that directly link the cytoplasm of adjacent cells.

XI. Prokaryotic Cells–The Bacteria

A. The term prokaryotic ("before the nucleus") indicates existence of bacteria before evolution of cells with a nucleus; bacterial DNA is clustered in a distinct region of the cytoplasm (nucleoid).

B. Bacteria are some of the smallest and simplest cells.

1. Bacterial flagella project from the membrane and permit rapid movement.

2. A somewhat rigid cell wall supports the cell and surrounds the plasma membrane, which regulates transport into and out of the cell.

3. Ribosomes, protein assembly sites, are dispersed throughout the cytoplasm.