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Minnesota Nursery and Landscape Association (MNLA) Foundation

BOTANY, PLANT PHYSIOLOGY AND PLANT GROWTH

LESSON 2 – PLANT PARTS AND FUNCTIONS

CELLS: THE BUILDING BLOCKS OF LIFE

The Building Blocks of Life

All living things are composed of one or more cells – essentially tiny packages that initially contain all the stuff of life. First identified and named in 1665, the discovery and recognition of cells as the building blocks of life forever changed science and how we view living things. The discovery of cells was an incredible scientific milestone and the workings and mystery of cells remains a source of fascination and wonder to this day.

Single vs. Multicellular Organisms

Some life forms are composed of a single cell which contains all the machinery of life.

Such living things are called unicellular or single-celled organisms.

Examples include the amoeba, the paramecium, bacteria, and algae.

Single vs. Multicellular Organisms

Life forms can also be composed of multiple cells with specialized functions.

These life forms are called multicellular organisms.

In such cases, the individual cells cannot live independently; they are dependent upon other cells to survive as part of the larger organism of which they are an integral part.

Cell Anatomy

The Cell Membrane

- The cell membrane forms the interface between the interior of individual cells and the surrounding environment.
- The cell membrane is also called the cytoplasmic membrane, plasma membrane or plasmalemma.
- The cell membrane is primarily composed of approximately equal amounts of lipids (fats) arranged in a bilayer configuration and embedded proteins.

Cell Anatomy

The Cell Membrane

The cell membrane might be described as a sack that functions to compartmentalize the contents of individual cells and selectively controls the passage of materials (water, minerals, food, and a variety of other molecules involved in cellular metabolism and secretion) into and out of the cell.

Cell Anatomy

The Nucleus

- A membrane-bound structure that contains the genetic or hereditary material packaged in the form of chromosomes in a diffuse form called chromatin.
- The membrane that surrounds the nucleus is called the nuclear membrane or envelope; it has a double layer construction.
- The chromosomes are composed of DNA (deoxyribonucleic acid) and proteins.

Cell Anatomy

The Cytoplasm

- The cytoplasm includes everything contained within the cellular membrane except for the nucleus; the **protoplasm** includes the entire contents of the living cell including the nucleus.
- The cytoplasm is composed of a complex combination of materials and a variety of distinct structures with specific functions called **organelles**.
- The clear, jelly-like portion of the cytoplasm in which the organelles are suspended is called the ground substance or hyaloplasm.

Cell Anatomy

The Mitochondria

- Mitochondria – double membrane bound structures that contain the enzyme systems responsible for the oxidation of foodstuffs to release the energy needed by the cell to perform its functions.
- The oxidation process is called respiration and requires oxygen.
- Based on their function, mitochondria are sometimes described as the powerhouses of the cell.

Cell Anatomy

Chloroplasts

- Chloroplasts – membrane bound structures that contain the pigments and enzyme systems responsible for the process called photosynthesis.
- Photosynthesis is the process by which plants capture and store energy from the sun in the form of carbohydrates (sugars) synthesized from water and carbon dioxide with the release of oxygen.

Cell Anatomy

Chlorophyll

- The primary pigment involved in photosynthesis is called chlorophyll, a green pigment that captures light energy from the sun so it can be used to manufacture carbohydrates.
- Chloroplasts and chlorophyll are only found in plant cells and some algae and are responsible for their green coloration.

Cell Anatomy

Chloroplasts

- Without chloroplasts and chlorophyll, life as we know it would be impossible; the sunlight energy captured and stored by these organelles is the basis of the food chain and life on earth.

Cell Anatomy

Endoplasmic reticulum

- **Endoplasmic reticulum** (ER) – an elaborate system of membranes responsible for the synthesis of proteins and a variety of other materials.
- Two types – rough (RER) and smooth (SER) endoplasmic reticulum.
- The surface of RER is studded with **ribosomes** which are the sites of **protein synthesis**; free ribosomes are also found suspended within the cytoplasm.

Cell Anatomy

SER

- SER is not associated with ribosomes and is thought to be responsible for the synthesis of a variety of molecules involved in cellular structure and function including lipids, phospholipids, and steroids.
- Depending on their purpose, the materials synthesized by the endoplasmic reticulum may be used within the cell or ultimately secreted from the cell.

Cell Anatomy

Golgi Apparatus

- **Golgi Apparatus** – stacks of membrane-bound sacks responsible for the final stages in the synthesis of certain proteins and the synthesis of cellulose, lignin, pectins, and other polysaccharides destined for secretion from the cell.
- Materials synthesized by the enzyme systems in the ER are packaged in vesicles that pinch off from the ER for transport to the Golgi Apparatus where they are modified based on their ultimate function.

Cell Anatomy

Golgi Apparatus

- Once their modifications are complete, the materials produced by the Golgi Apparatus are similarly packaged in membrane-bound vesicles that are pinched off for transport within the cell or to the cell membrane in preparation for secretion from the cell.
- The Golgi Apparatus is ultimately responsible for the distribution of a variety of cellular constituents throughout the cell based on their function.

Cell Anatomy

Lysosomes

- **Lysosomes** – single-membrane-bound organelles produced by the Golgi Apparatus that contain enzymes responsible for the breakdown of a variety of molecules and cellular components; though present in nearly all animal cells, lysosomes may or may not occur in plant cells.

Cell Anatomy

Peroxisomes

- **Peroxisomes** – single-membrane-bound organelles manufactured by the endoplasmic reticulum and filled with the enzyme responsible for the breakdown of hydrogen peroxide, a byproduct of cell metabolism that can be dangerous to the cell.

Cell Anatomy

Vacuoles

- Vacuoles – membrane-bound, fluid-filled sacs that function in storage of food and wastes and a variety of other functions in cells.
- In contrast with animal cells, which may contain many small vacuoles, a large, central vacuole comprises a significant portion of the volume of plant cells.
- In plant cells, the vacuole stores nutrients, food molecules, waste products, pigments.

Cell Anatomy

Central Vacuole

- The central vacuole in plant cells also stores water and plays a key role in water management and cell **turgor** (water pressure).
- Together with the cell wall (discussed next), turgor pressure is the force responsible for firmness in non-woody tissues; wilting results when turgor pressure is lacking.

Cell Anatomy

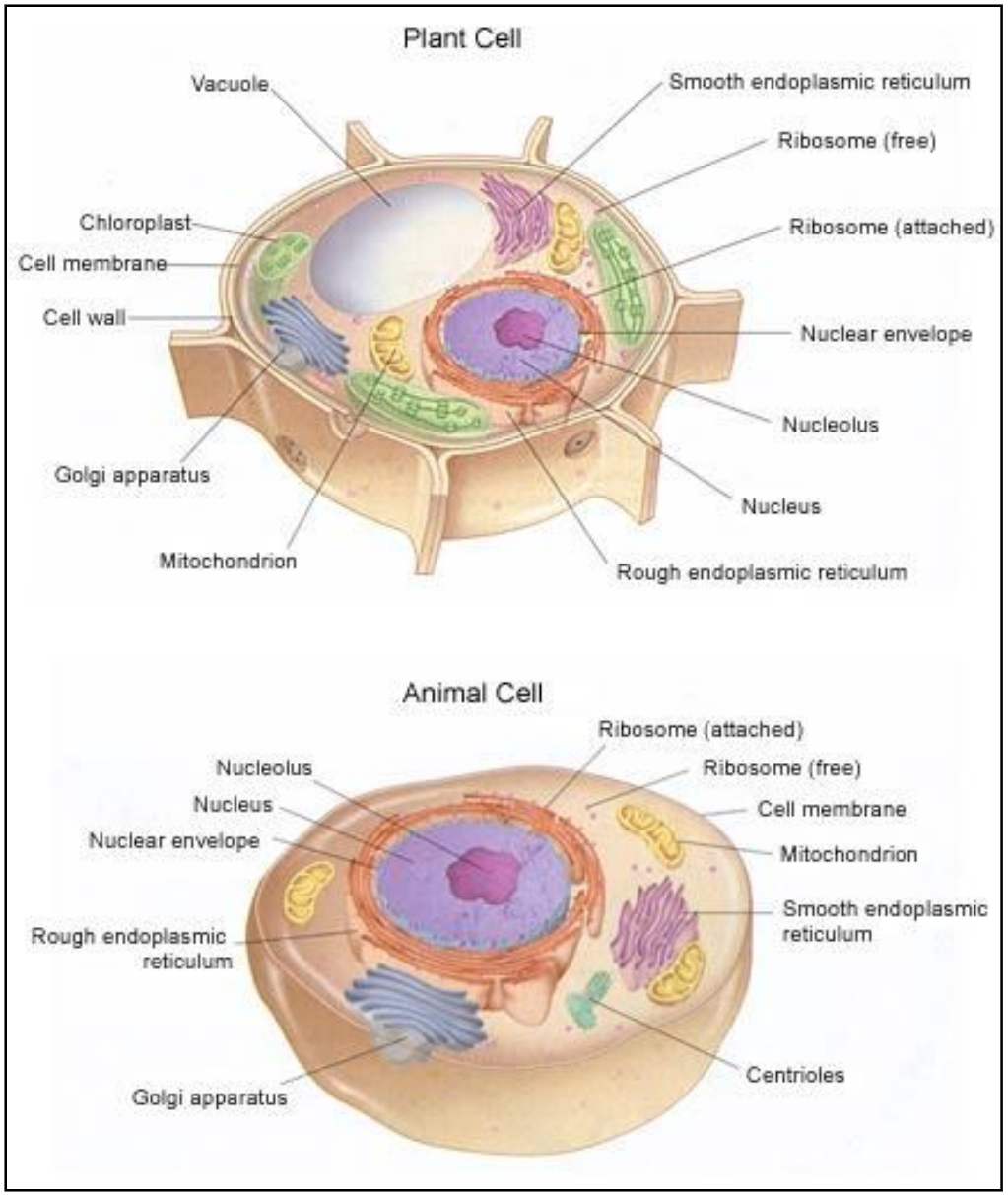
Central Vacuole

- A ridged structure that surrounds the protoplasm of plant cells.
- Cell wall materials are synthesized within the cell and secreted outside the cell.
- Initially the cell wall is composed of a thin layer of cellulose; this layer of cellulose is the primary cell wall.
- Over time, the cell wall may thicken with the addition of more cellulose and another substance called lignin which hardens the cell wall; these added materials comprise the secondary cell wall.

Cell Anatomy

The Cell Wall

- A third layer of material called **pectin** is deposited between the cell walls of neighboring cells; this layer is called the **middle lamella** and functions to cement the cells together.
- Collectively the cell walls provide structural support to plants.



Diagrams of plant and animal cells showing structure and primary organelles.

http://www.teachersdomain.org/asset/tdc02_img_animplant/

Cell Multiplication

- Relatively young cells are able to replicate themselves through a process of DNA replication and cytokinesis (division of the cytoplasm) wherein one cell divides to become two cells each with a copy of the hereditary DNA.
- The process is called mitosis and primarily occurs in clusters of actively dividing cells called meristems located at the growing tips of roots and shoots and just under the bark of woody plants.

Cell Multiplication

- Cell division and the resulting creation of new cells is the primary process responsible for plant growth.
- Root and shoot (height) growth results from cell division in the apical meristems located in the growing tips of roots and shoots.
- The annual increase in diameter of woody stems results from cell division in a circular meristem called the cambium or vascular cambium which is located just under the bark of trees and shrubs. In woody plants, the cambium produces phloem (food conducting tissue) to the outside and xylem (water conducting tissue, wood).

Cell Differentiation & Cell Types

In addition to meristematic cells, these primary types of cells and generally found in plants:

- **Parenchyma Cells**
- **Collenchyma Cells**
- **Sclerenchyma Cells**

Newly formed cells produced by the dividing cells in meristems are called parenchyma cells; they are undifferentiated and have thin cell walls. At maturity, they also have large vacuoles.

Cell Differentiation & Cell Types

- As parenchyma cells mature, they evolve to become specialized cell types and serve specific functions within the plant; they perform a variety of cell functions and are living at maturity.
- Parenchyma cells form the pith and cortex in herbaceous (non-woody) stems, the palisade and mesophyll tissue in leaves, the pulp of fruits, and storage tissues in roots, tubers, and seeds (endosperm and cotyledons).

Cell Differentiation & Cell Types

- Parenchyma cells retain the ability to revert and become meristematic cells and are important in wound healing and the production of adventitious (adventive, new) root and shoot meristems and successful graft unions when propagating plants.
- As parenchyma cells continue to mature they may ultimately develop into the second primary cell type found in plants called collenchyma cells.

Cell Differentiation & Cell Types

- Collenchyma cells have variously thickened cell walls and are responsible for structural support. They are living at maturity and are found in growing shoots and leaves, leaf petioles, outer tissues in herbaceous stems, the thickened rinds of some fleshy fruits, and in association with young vascular tissues.
- Collenchyma cells can differentiate further and become the third primary cell type found in plants called sclerenchyma cells.

Cell Differentiation & Cell Types

- Sclerenchyma cells have extremely thick secondary cell walls composed of cellulose and varying amounts of lignin and are primarily involved with water transport (xylem) and support.
- Sclerenchyma cells can be divided into two types – fibers and sclereids. Fibers tend to be long and narrow and fairly flexible; plant fibers are important in the production of rope, baskets, brushes, fabrics, and paper.

Cell Differentiation & Cell Types

- Sclerenchyma cells are dead at maturity and are found in the vascular tissues (xylem and phloem), the shells of nuts and seeds, the tough layers in apple cores and the grit in the flesh of pears.
- The woody stems and roots of trees and shrubs are primarily composed of old, xylem tissue and, thus, sclerenchyma cells.

Meiosis

- Meiosis is a process that is similar to mitosis, yet different in that it reduces the chromosome number in the new cells by half; diploid (2n; two copies of each chromosome pair/cell) to haploid (1n; one copy of each chromosome pair/cell).
- In general, the cells produced by meiosis are gametes – egg and sperm cells - and each carries half of the genetic information needed for a new individual and are ultimately involved in sexual reproduction.

Meiosis

- Upon fertilization, half of the genetic information required for the new individual comes from the female male parent and half comes from the male parent and we are back to the diploid (2n) chromosome content.
- The joining of the male and female gametes results in the formation of a zygote which then undergoes mitosis and develops into an embryo within a seed and upon germination a new plant.

Cells: The Building Blocks of Life

- As we have seen, cells are, indeed, the building blocks of life.
- All living things, simple and complex, unicellular and multicellular, and including plants and animals, are made up of one or more cells.
- The primary differences between plant and animal cells include the cell walls of plant cells and the presence of chloroplasts and chlorophyll in some plants cells which are both lacking in animal cells.

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