Plant Physiology (PLAG 521, Biol 511), CrHr 3

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Introduction

- Plant physiology is a study of the plant way of life
- ✓ Metabolism (life-sustaining chemical activity), Water relations, Mineral nutrition, Development, Movement, Stress responses
- ✓ Plant functions' in individual cellular organelles, cells, tissues, organs or in whole plants are the scopes of plant physiology

Intro. (cont.) Definitions

- **Structure:** a part of a body or an organism, e.g., an organ or tissue, identifiable by its shape and other properties
- **Function:** an organized systematic action of organelles, cells, tissue, organ, plant
- ➢ Anchorage, support, transport, synthesis
- **Process**: a series of sequential events operating under natural conditions
- ➢ water and mineral absorption, transpiration, photosynthesis, respiration,
- In living organisms, structures and functions/processes are intimately linked

Intro. (cont.) Basic postulates of plant physiology

i. Plant functions can be easily understood on the basis of the principles of physics and chemistry

ii. Plant physiology concerns with the study of 4 members of the 5 kingdoms of organisms, i.e., *monera, protista, fungi,* and *plantae*

Intro. (cont.) Basic postulates

iii. Cell Theory:

- Cell is the fundamental unit of life; all living organisms consist of cells which contain either membrane bound nuclei or comparable structures without membranes
- Life does not exist in unit smaller than cells
- Cells arise only from the division of pre-existing cells

Intro. (cont.) Basic postulates

iv. Eukaryotic cells contain membranes-bound organelles like chloroplast, mitochondria, vacuoles etc, whereas prokaryotic cells do not contain such membranes-bound organelles

v. Cells are characterized by special macro-molecules like starch, cellulose, proteins, lipids, DNA, RNA, amino acids, nucleotides and other metabolites

vi. In multi-cellular organisms, cells are organized into tissues and organs with specialized structures and functions

Intro. (cont.) Basic postulates

vii. Living organisms are self-generating structures

viii. Organisms grow and develop within environments and interact with these environmental factors and with each other in many ways; *Plant Ecology*

ix. In living organisms, structures and functions are intimately wedded

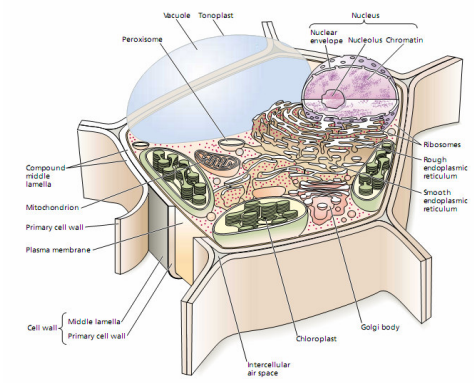
Intro. (cont.) **The Plant Cells Constituents**

- Plant cells contain a cell wall, cell membrane, cytoplasm and nucleus
- **Cell wall**

✓ It distinguishes plant cells from animal cells

✓ The major components of cell wall are cellulose, hemicellulose, pectin, protein and lignin (complex CHO2, provides rigidity to plant cells)

Intro. (cont.) **The Plant Cells Constituents**



Cell wall

- **Functions of cell wall:**

-provides rigidity and protection to the plant cell
-gives structural independence to individual cells
-involves in absorption and transport of water and dissolved minerals, in secretions, and in certain enzymatic activities
-plays an important role in disease resistance

The Plasma or Cell Membrane

- Present in all organisms. It is a complex barrier composed of lipid bilayers, and protein

- **The function of membrane:**
- regulates traffic;
- separates the internal from the external environment,
- serves as a platform (site, stru.) on which some reactions can occur,
- participates in some reactions (i.e., the membrane components are important intermediates or enzymes),
- provides some structural integrity for the cell

Cytoplasm (The interior substance)

- It refers to cell content between the cell membrane and the nucleus
- The two main components are cytosol and organelles
- Cytosol is a jellylike mixture that consists mostly of water, along with proteins, carbohydrates, salts, minerals and organic molecules
- About 20 % of the cytosol is made up of protein
- Suspended in the cytosol are tiny organelles

Mitochondria

- are called the “power house” of the cell
-are found scattered throughout the cytosol, and are relatively large organelles
-are surrounded by two membranes
-are the sites of chemical reactions that transfer energy from organic compound to energy-rich compound, adenosine triphosphate (ATP)

Ribosomes

- are not surrounded by a membrane
- are the most numerous organelles in almost all cells
- are the site of protein synthesis

• Plastids

- Are types of organelles, structures that carry out specialized functions in the cell
- Present in plant cell
- Make, and store food (carbohydrates, proteins, fats, etc)
-

Plastids (continued)

- Are bound by a double membrane and contain their own DNA (self propagating bodies in the cytoplasm).
- Are of three types:
- **1. Chromoplast** - variously pigmented and may or may not contain chlorophyll. It contains several types of fat soluble carotenoid pigments. They may be red, yellow, or orange which are sources of color of fruits, flowers and some leaves.

- **2. Leucoplast** - color less plastid, synthesize and store protein, oils, etc
- **3. Chloroplast** - Plastid containing pigment chlorophyll
- Chloroplasts contain a system of flattened, membranous sacs called thylakoids (site of photosynthesis)
- A stack of thylakoids forms granum (grana)
- The fluid compartment surrounding the thylakoids is called the stroma
- Adjacent grana are connected together by non-stacked thylakoids called stroma lamellae

Endoplasmic reticulum

- It is a system of membranous tubules and sacs
- It acts primarily as an intracellular highway, a path along which molecules moves from one part of the cell to another
- It forms storage and conducting system and concerned with the storage, secretion and transport of proteins synthesized by the cell to the exterior for extra cellular uses
- It is also concerned with lipids metabolism, their storage and export from the cell

Golgi apparatus (complex)

- Pancake- or pita bread-like stack of membranes
- Particularly important in cells that produce materials for export (secretion)
- It is the site of processing and packaging cellular components
- It is active in synthesizing many cell components, especially $(CH_2O)n$ and is involved in tagging proteins with $(CH_2O)n$ and other side chains for sorting them to their final destination

Vacuolar membrane or tonoplast

- Tonoplast controls the transport of solutes into and out of the vacuole and thus regulates the water potential of cells - especially of guard cells of stomata
- Tonoplast is also seat of *H+- ATPase* (ATP synthesis) and *PPase (pumps protons)* partaking in exit and entry of ions into vacuoles

Vacuole

- not present in animal cells
- large, central cavity containing fluid (cell sap)
- surrounded by a membrane (tonoplast)
- Functions for water storage, waste disposal, pH regulation, storage of essential ions, cell enlargement, facilitates diffusion, structural support

Nucleus

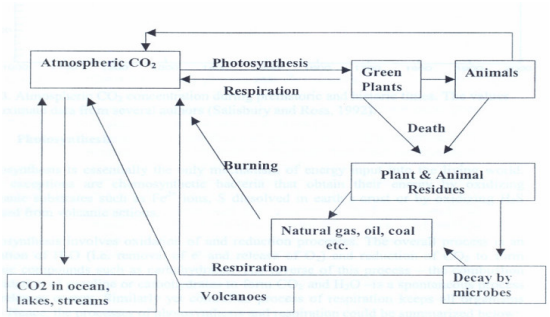
- is called the cell "brain"
- surrounded by a double membrane - the nuclear membrane
- Control cell's functions by determining (via mRNA) the types of enzymes to be synthesized and resultant biochemical reactions for different structures and functions
- Contains the genetic information

Chapter 2. CARBON METABOLISM

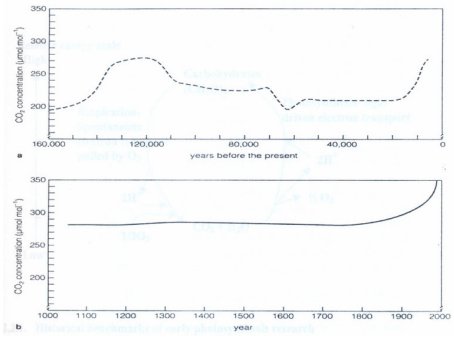
- **Carbon Cycle and CO2 Concentration in Atmosphere**
- CO2 [ ] was about 280 µmole/mol in atmosphere for about 150,000 years
- Since 1850, its [ ] rose exponentially
- This is due to:
- (i) burning of the fossil fuels and industrialization and
- (ii) burning of tropical forests and/or clearing of forest land in tropics for agricultural use.
- .

- Stable ecosystems (rain forests) add as much CO2 to atmosphere (by respiration) as they deplete during CO2 fixation (photosynthesis).
- In the process of forest clearing/burning, much more CO2 is transferred from biosphere to atmosphere
- Water bodies serve as greatest sink for CO2 controlling its excessive build-up in atmosphere. Typical C cycle is illustrated in Fig below

Carbon cycle showing the movement of C in different compartments in the nature



Atmospheric CO2 concentration during prehistoric (a) and historic (b) times. The values approximate data from several authors



Photosynthesis

- Photosynthesis is essentially the only mechanism of energy input into the living world.
- Only exceptions are chemosynthetic bacteria that obtain their energy by oxidizing inorganic substrates such as Fe2+ ions, S dissolved in earth's crust or by oxidizing H2S released from volcanic actions.
- Photosynthesis involves oxidation and reduction processes. The overall process is an oxidation of H2O (i.e. removal of e- and release of O2) and reduction of CO2 to form organic compounds such as carbohydrates.

- The reverse of this process - the combustion or oxidation of gasoline or carbohydrates to form CO2 and H2O - is a spontaneous process that releases energy.
- Similarly yet controlled process of respiration keeps all organisms alive.

Summary of the processes of photosynthesis and respiration