

Chapter 10

The Plant Cell and Physiological Processes

1. The cell itself

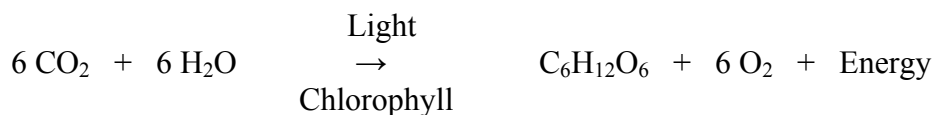
- definition - a cell is a living unit of the plant; without the proper functioning of cells, a plant cannot survive
- role in respect to herbicides - when a weed is injured or killed by a herbicide, the herbicide is affecting some event that occurs in the cell function

2. Cell organelles - parts of the cell that are important to plant survival; normal plant processes occur in organelles within the cell (See Figure 4.2 - Parts of a plant cell; page 79)

- nucleus - contains the genetic information for the plant (DNA); it's proper functioning is essential to the synthesis of ribonucleic acids and proteins; nuclear division is called mitosis
- chloroplast - site of photosynthesis; water and CO₂ are converted to sugars with light acting as the energy source and chlorophyll pigments acting as energy trapping agents (see discussion below)
- mitochondria - site of respiration; in respiration, sugars are metabolized to produce CO₂, water, and chemical energy in the form of adenosine triphosphate (ATP). ATP is used in numerous synthetic and metabolic processes in the cell (see discussion below)
- golgi bodies - involved in excretory functions and in cell wall formation
- vacuoles - water-filled area surrounded by a membrane known as the tonoplast; involved in water economy of the cell and storage of waste materials
- endoplasmic reticulum - involved in synthesis of membrane proteins and lipid synthesis
- ribosomes - involved in protein synthesis

3. Plant physiological systems

- cell division (mitosis) - process by which plant growth is made possible; is initiated and largely controlled by the nucleus of the cell
- When cell division occurs each daughter cell contains a duplicate of the mother cell
- photosynthesis - the process by which light energy is used to produce energy in the form of glucose



Photosynthesis includes both a light dependent phase (light reaction), which occurs in lamellae of the chloroplast and a light independent phase (dark reaction) which occurs in either light or darkness in the stroma of the chloroplast.

The light reaction includes:

Photo System I (PS I)

Photo System II (PS II)

Photo System II precedes Photo System I only because PS I was discovered first

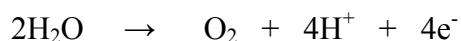
PS I and PS II are referred to as the "Z scheme"

- see Figure 7.1 (The electron transport chain in photosynthesis; page 80)

In the light reaction:

Biological energy is derived from light energy, chlorophyll, and splitting of water. Energy is stored in high energy phosphate bonds, NADPH (nicotinamide adenine dinucleotide phosphate) and ATP (adenosine triphosphate)

Splitting water into oxygen and hydrogen ions occurs.



Using the e⁻, a transfer of energy occurs through a series of protein electron acceptors (electron transport system) with energy as ATP and NADPH produced. See Figure 7.1 - The electron transport chain in photosynthesis; page 80)

In the dark reaction:

Biological energy (ATP/NADPH) derived from light reaction is used to convert CO₂ and water into carbohydrate (CO₂ fixation)

CO₂ Fixation



- see Figure 7.1 (The electron transport chain in photosynthesis; page 80)
- respiration - the reverse of photosynthesis; the process whereby cells utilize glucose produced in photosynthesis for energy and cell function



- amino acid synthesis - amino acids are the building blocks of proteins; when synthesis of amino acids is inhibited protein synthesis is also affected
 - pigment synthesis - pigments include chlorophyll and carotenoids; chlorophyll is essential for photosynthesis
 - lipid metabolism - lipids serve numerous functions in the plant and are components of cell and cell organelle membranes and the “surface” lipids in waxes and cutin in the cuticle, and in suberin, which surrounds the casparian strip of endodermal cells in the root
 - cell wall synthesis - the primary component of cell walls in cellulose
 - disruption of transport systems - this would include movement of photosynthate in the phloem
4. Herbicide mode of action
- definition - biochemical responses of plants to herbicides; detailed description of the physical and molecular fate of the herbicide in the plant as well as the metabolic and structural changes it induces
 - mode vs. mechanism - terms are used interchangeably
 - site of action - location at which the herbicide exerts toxicity at the cellular level

- types of toxicity -

acute toxicity implies rapid kill, usually within minutes or a few hours after contact is made with the plant

translocation is short distance; sometimes referred to as contact herbicides on the basis of their rapid kill examples: bromoxynil, paraquat, diquat, and diphenyl ethers

chronic toxicity implies slow acting a few days or longer; visual symptoms may be observed several hours after application but death is slow

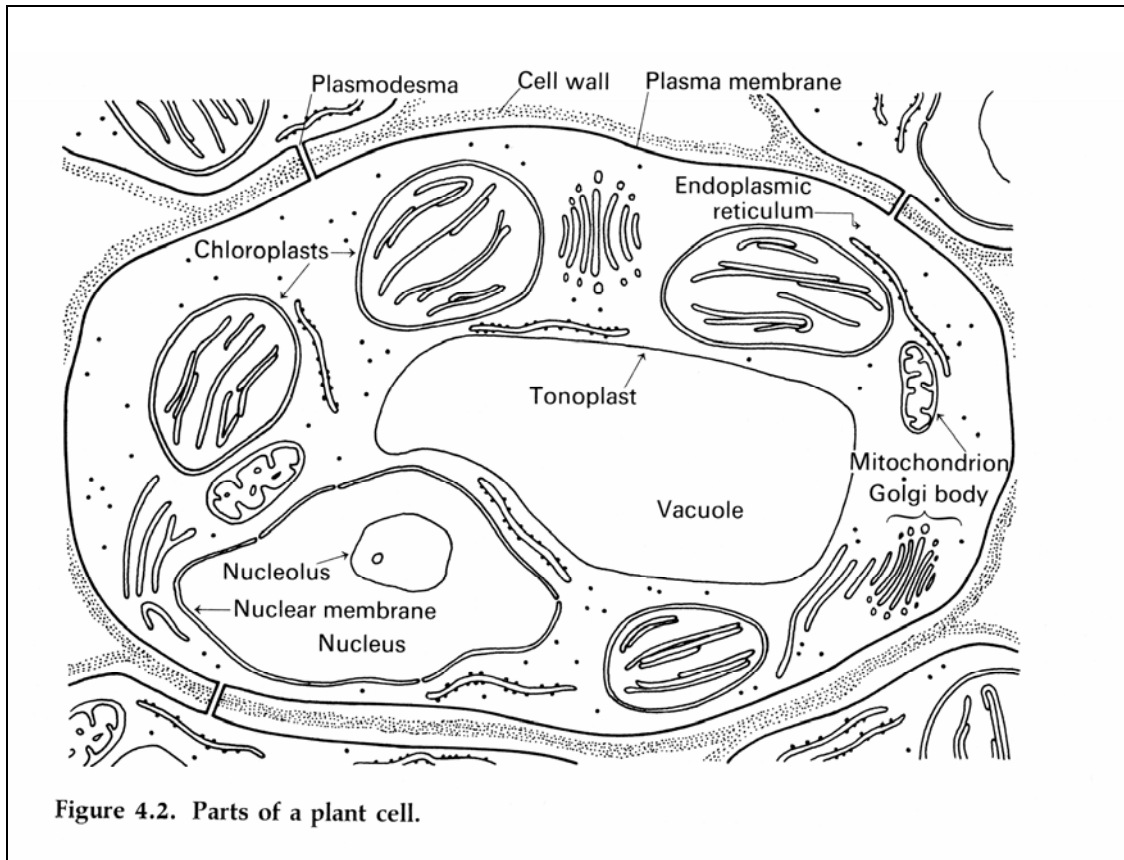
translocation is long distance; sometimes referred to as systemic herbicides; biological function is embedded in molecular structure

Herbicide must get into the cell and exert its action on some process going on in the cell, e.g., cell division, protein synthesis, photosynthesis, fat synthesis, pigment synthesis, etc.

For some herbicides the specific cellular mode of action is unknown (not uncommon for some pharmaceuticals as well)

In most cases, herbicides in the same chemical family will have the same mode of action (there are a few exceptions)

For most of the remainder of the semester, material will be presented by specific mode of action with general information, a discussion if known of the specific site of action, symptoms, specific family(s) and chemistry represented to include specific herbicides with discussion of metabolism, translocation, selectivity, and use.



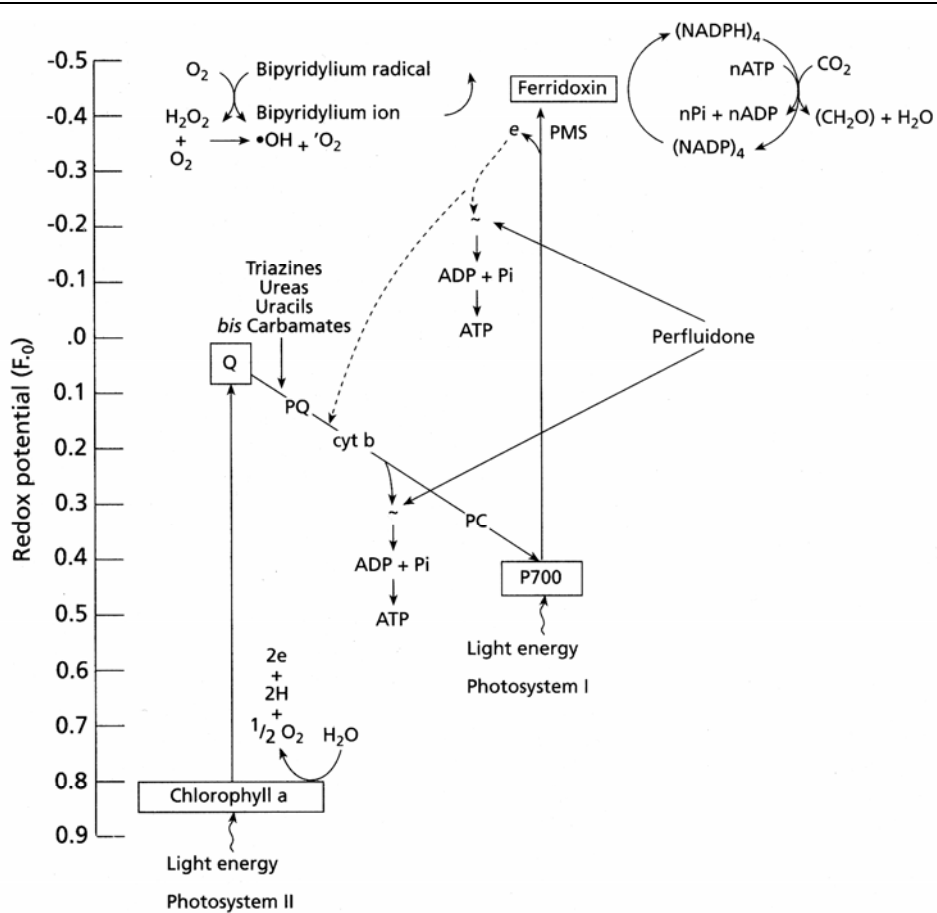


FIGURE 7.1 ■ The electron transport chain in photosynthesis and the sites of action of herbicides that interfere with electron transfer in this chain (Q = electron acceptor; PG = plastoquinone).
 SOURCE: F. M. Ashton and A. S. Crafts. 1981. *Mode of action of herbicides*, 2nd ed., p. 55. New York: John Wiley & Sons, Inc. Reprinted with permission of John Wiley & Sons, Inc.