

Basic Plant Biochemistry (Nabors – Chapter 7)

Biochemistry – study of how organic molecules (carbon based) form the basic structure of organisms

Molecular Components

- Carbohydrates
 - Supply and store energy
 - Serve as structural building blocks
 - Examples of carbohydrates
 - Monosaccharides – simple sugar (glucose, fructose, ribose)
 - Disaccharides – two monosaccharides linked together (sucrose = glucose + fructose); (maltose = glucose + glucose)
 - Polysaccharides – many monosaccharides linked together (e.g. starch and cellulose)
 - Sugars are linked together by dehydration synthesis
 - Starch – used for energy storage
 - Cellulose – chief component of plant cell walls
- Proteins (Fig 7.7)
 - Catalyze chemical reactions (e.g. Rubisco)
 - Structural building blocks
 - Chains of amino acids
 - Amino acid – amino group (NH₂), carboxyl group (COOH), H and variable side chain (R group)
 - R group – distinguishes each amino acid from each other
 - 20 types of amino acids are linked by peptide bonds – different combinations form different proteins
 - Proteins – also known as polypeptides
- Nucleic Acids (Fig 7.10)
 - DNA and RNA
 - Code and express genetic information
 - Nucleotides – composed of
 - bases (amino acids),
 - sugar (deoxyribose, ribose)
 - phosphates
 - are building blocks for DNA and RNA
 - DNA consists of two strands of nucleotides (double helix)
 - DNA – 4 bases (adenine, guanine, thymine, cytosine); deoxyribose
 - Nucleotides – building blocks for hormones
 - Modified nucleotide – ATP (stored energy)
- Lipids (Fig 7.11)

- Membrane components composed of C and H
 - Lipids – fats, phospholipids, steroids, terpenoids
 - Fats – fatty acid chains attached to glycerol
 - Phospholipids (Fig 7.12) – contain glycerol, two fatty acid chains, phosphate molecule; principal component of membranes
 - Steroids – occur in membranes; function as plant hormones

- Secondary Metabolites
 - Produced during metabolic reactions
 - Not essential for basic plant growth and development
 - Provide protection from herbivores and disease
 - Three main categories of secondary metabolites
 - Phenolics
 - Found in cell walls and vacuoles
 - Lignins – strengthen cell walls; repel herbivores
 - Flavonoids – deter herbivores; prevent bacterial decay; found in fruits & vegetables; include tannins (brown color in streams from decaying leaves), anthocyanin (attract pollinators)
 - Alkaloids
 - Protect plants from herbivores; affect animal nervous system
 - Includes caffeine, heroin, nicotine, cocaine, ephedrine
 - Terpenoids
 - Protect plants from herbivores
 - Pyrethrum (insecticide), peppermint (oil); resins, latex; released from plants (blue haze of mountains); protect plant from high temperature stress

Energy and Chemical Reactions

- Energy (Fig 7.16)
 - capacity to perform work
 - involved in chemical reactions
 - Potential energy – stored energy
 - Kinetic energy – energy involved with motion

- First Law of Thermodynamics
 - Energy can be used and transformed, but not created or destroyed

- Second Law of Thermodynamics
 - Every transfer of energy increases entropy (disorder) of matter in universe; order tends to disorder

- Chemical Reactions

- Involve input or output of energy
- All chemical reactions require “activation energy” (energy to get initial reaction started)

- Exergonic reaction – input of energy not required for reaction to occur
- Endergonic reaction – input of energy required for reaction to occur

- Involve oxidation and reduction (Redox) reactions (Fig 7.18)
 - Oxidation – loss of electron
 - Reduction – gain of electron
 - Oxidation and reduction reactions are paired in chemical reaction

- ATP is used to supply energy to reactions
 - Covalent bonds linking phosphates in ATP require energy to form (ADP + Pi → ATP)
 - Breaking these bonds releases energy to be used in chemical reactions (forms ADP + Pi)
 - ATP supplies activation energy for all reactions

 - Reactions requiring energy are coupled with reactions not requiring energy (known as “energy coupling”) Fig 7.20
 - Example – formation of glutamine requires energy (ATP); release of energy in adding P group to glutamine allows ammonia to bond to glutamic acid without additional energy

 - Important note – ATP supplies energy to reactions to support growth and development of plant; energy ultimately comes from photosynthetic products that are used in respiration to produce ATP

- Electron carriers are necessary for chemical reactions to proceed
 - NADH, NADPH, and FADH₂ donate electrons to reactions
 - These electrons catalyze enzymatic reactions
 - Important in all reactions – especially photosynthesis

Chemical Reactions and Enzymes

- Enzymes
 - Provide binding sites for reactions to occur (Fig 7.23a)
 - Reaction - substrates & enzymes form an enzyme-substrate complex
 - Result – products and enzyme after reaction (Fig 7.23b; Fig 7.24)
 - Co-factors (co-enzymes)
 - interact with enzymes to speed up reactions
 - can be inorganic minerals (Ca, Mg) or organic

- examples – hormones, vitamins, ATP, sugars, amino acids – all act to speed up reactions
- Competitive inhibition (Fig 7.25)
 - another substrate competes for binding site
 - blocks active site
 - increase in substrate concentration overcomes inhibition & reaction then occurs
 - Example – Rubisco (CO_2 competes with O_2); higher $[\text{CO}_2]$ increases likelihood of CO_2 binding
- Non-competitive inhibition
 - Inhibitor binds to non-active site
 - Results in change in shape of enzyme, so reaction is not likely to occur
- Feedback Inhibition (Fig 7.25)
 - End-product of reaction accumulates and inhibits the initial reaction
 - Example – too much sugar production reduces Rubisco activity, which reduces rate of photosynthesis, and hence sugar production
- Enzyme reactions are linked into metabolic pathways that produce the products that are needed for plant growth and survival