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Plant biochemistry notes pdf

mono- & oligosaccharides, glycosides, ascorbic acid storage polysaccharidesPage 2 Introduction and reviews the importance of PhotosynthesisPrimary Photosynthetic carbon assimilation mechanism 2)C2 carbon metabolism a.k.a. photorespiration Secondary Photosynthetic pathways as evolutionary pathways to accelerate carbon assimilation and reduce oxygenase activity a)distinguish features 4)The limitations of Chemical thermodynamics are basically the manufacture and breakdown of bonds between atoms and/or molecules. Biochemistry (or biological chemistry) is the manufacture and breakdown of bonds between molecules in biological systems. Plant biochemistry covers most biochemistry because plants are able to synthesize most of the molecules known in nature. Since you have all taken a general biochemical course, this course will focus on the formation of important molecules that are mostly ultimately derived from plants and the synthesis of molecules that are unique to plants but important to the natural world or the human type. In biochemistry, we are primarily concerned with the chemistry of the three main atoms of the biosphere, H, C and O (accounting for ~90-95% of the mass of most plants) plus N, P and S and some ions such as Fe+2/+3, Cu+1/+2, Na+, K+, Ca+2 and Cl-. Other constituents of plant elements that are very small but necessary include Zn+2, B+3, Mn+3/+4, Mo+4/+6. Abundance (relative to 1000 atoms C) the main elements in plants and animals are illustrated in the following table: Zea mays element (corn) Homo sapiens (human) Hydrogen 1705 2038 Carbon 1000 1000 Oxygen 765 252 Nitrogen 29 143 Potassium 6.5 6 Calcium 1.6 25 Phosphorus 1.8 22 Magnesium 2.0 1.4 Sulfur 1.5 5.2 Chlorine 1.1 2.8 Iron 0.4 0.05 It is important to note that atoms such as C, H, O and N need electrons to fill their outer shells and can share electrons to form valen bonds. H - 1 bond C - 4 bonds O - 2 bonds N - 3 bonds Atom carbon can bond each other and form a long chain. The lower the atomic weight, the stronger the valen bond. Why? Can you name a very strong carbon polymer? What is important in biochemistry is the water of the main solvent molecules. The shape and function of most biological molecules includes their interaction with water. As you learned in previous biochemistry courses water has unique chemical properties. Some of these will be briefly reviewed here. Based on its molecular weight, water will be expected to be a gas at temperatures of >-100°C. Even the temperature at which water is in a liquid state sets limits on most biological processes. By comparison, H2S is a gas at a temperature of >-59° C. Water 2 pairs of electrons that are not shared from electrons excess oxygen around the appeal of oxygen electronegativity (S-) atoms or molecules for electronOxygen is the most electronegative atom in the biological world. Attraction H-bonding H to the electronegative group (e.g. O, N, S) H2O exists as a polymer should be viscous, but the bonds weak (4.5 cal/mol for H-bonding turnover of 10-11 seconds H2O state low ionization Heat Vaporization - calories needed to increase 1 g of liquid at boiling point to 1 g of steam. H2O 540 cal. CH2CH2OH 262 cal. H2O has a great cooling effect when it evaporates. When sunlight hits the leaves, H2O evaporates and the leaves do not become hot. Many biological molecules exist as isoomers. Geometric isomers: Fatty acids are usually cis although trans shapes are more stable. Stereoisomers: Sugars and amino acids are D or L (mirror image) e.g. D- and L-glucose Natural sugars are D-isomers. Only L-isomers of amino acids are contained in proteins, although some amino acid D can be tied up in antibiotics and small peptides. The enzyme cataract reaction usually gives one or the other stereoisomeres. Mixed races have the same proportion of possible isoders. Most chemical synthesis provides a mixture of breeds. Therefore engineering plants have tremendous potential in the future for the production of certain isobas needed in medicine or industry. Metabolism catabolism anabolism builds for example protein synthesis, photosynthesis is damaged e.g. respiratory, protein hydrolysis The state of molecular reduction is an indication of the energy level of molecules. The less energy that can be released when oxidized. Classification of life based on nutritional requirements: Autotrophs Heterotrophs Use inorganic carbon (CO2, HCO3-, CO32-) Use of inorganic nitrogen (NO3, NH4+) Use inorganic sulfur (SO42-) synthesizes all necessary growth factors Reducing carbon Requires reduction of sulfur requiring reduction of essential amino acids, fatty acids, vitamins, etc. Autotrophs can be further divided into photosynthetic andmosynthetic organisms. As you might expect, atmospheric organisms use chemical energy, for example: Almost all life on earth (with the possible exception of some deep-sea vents) and basically all the reduced carbon including fossil fuels is the result of photosynthesis. The Earth is estimated to be ~4.9 billion years old and the plant is estimated to have first evolved ~3 billion years ago. At this time it is estimated that ~2 x 1011 tons of CO2 is repaired annually from photosynthesis. ~ 1/2 co2 in perennial ends up as cellulose or other wall components. In certain environments hydrocarbons made by plants are not consumed by heterotrophs and accumulate. In what environment and in what form does fixed carbon usually accumulate? Heterotrophs can be classified as: Saprophytes: living from dead organic matter Parasites: living and growing on compulsory living cells: growing only on living organisms faculty: functions on living or dead matter Symbionts: benefits to host greater than any danger, for example: lichen: blue green algae + mycorrhizae fungus: growing on plant roots and supplying (especially P) for plant Bioenergetics Energy is the capacity to do the work and overcome resistance. Molecules tend to look for at least the highest energetic or enthalpy state, H. The balance in the biological system is death - that is, the organism needs regular energy input. Energy in biological systems is provided by certain forms of chemical energy (see review) such as greatly reduced molecules or high energy structures. Chemical energy has traditionally been measured in calories, abbreviated as cal, but si units, joules, are now recommended. Gibbs free energy, G, (named for J. Willard Gibbs, co-founder of thermodynamics) = H - TS where T is the temperature (° K) and S is entropy. DG is part of the total energy available to perform the work and can be transferred to other systems. energy is released as the reaction continues towards balance under constant temperature and pressure conditions. dg balance = 0. R = gas constant 1,987 cal/mol. T = temperature in degrees Kelvin, 273.15 + °C Standard free energy is designated DG° compares reactions with standard reactants and products are stored at 1 M, T = 25 ° C & pressure = 1 atmosphere DG ° ' = standard free energy changes in which the pH is maintained at 7. DG° = -RTlnKeq with a strong -DG° on balance there will be a higher molar concentration of C+ D than A + B. For the following reaction series free energy changes given for each energetic step will support the formation of glucose + Pi over G-6-P. The reaction can be combined with the exergonic reaction kinase has two glucose substrates and ATP and binds both. Gibbs Free Energy for overall reaction is DG° = -4 (+3.3 - 7.3). Therefore this reaction will tend towards the G-6-P and ADP. Another example: DG° = 7.7 - 7.6 - 8.0 = -7.9 There are 4 main classes or groups of molecules in the cell. Three of them can be used as energy sources although only two of them are used except in poor conditions. Why is so much energy present in oils rather than carbohydrates? Enzymes analyze most biochemical reactions. Most enzymes are proteins; some are ribonucleic acid. Like other catalyst enzymes increase reaction levels They do this by reducing reaction activation energy It allows biochemical reactions to occur at physiological temperatures (e.g. 4-40 °C in plants) Increasing reaction levels at physiological temperatures by as much as 1017, but not affecting reaction balance or Keq Usually very stereotypical for substrates and enzyme products binding substrates form intermediate structures that reduce the need for energy to activate and impose conditions on the molecular substrates that support the reaction. The rate of chemical reactions, including those confirmed by enzymes, increases as temperature increases. Q10 = _____ Q10 for chemical reactions ~= _____ Q10 for reactions physical (e.g. mild reaction of photosynthesis) ~= _____ High Energy Structure 1. Phosphoric Acid Anhiddrides 2. Mixed Oxidation Anhiddrides / Oxidation is Reduction is _____semakin easily lose e-, so it will be easier to oxidize. The less negative the redox potential, the less easily it loses e-, so it will be easier to reduce. Electrons are transferred from molecules with more negativity to those with less negative redox potential. What is the usual final e-acceptor in a redox reaction? DG° = -nFDE'o n = # electron transferred F = Faraday Constant (equivalent to 23,063 cal/volts) DE'o = redox potential -- E'o reduced - DE'o oxidized In breathing, NADH + H + + 1/2O2 + H2O DG° = -nFDE'o = -(1/2O2 + H2O DG° = -nFDE'o = -(1/2O2 + H2O DG° = -nFDE'o = -(1/2O2 + H2O DG° = -nFDE'o = -(1/2O2 + H2O DG° = -nFDE'o = -(1/2O2 + H2O DG° = -nFDE'o = -(1/2O2 + H2O DG° = -nFDE'o = -(1/2O2 + H2O DG° = -nFDE'o =2)*(23,063)*[0.817 -(-0.32)] = -52.5 kcal make up 3 ATP for each NADH ATP oxidation for each NADH = 21.9/52.5 * 100 = 42% of energy trapped in the ATP; The other 58% is lost as heat – very high efficiency compared to industrial processes! Respiratory Quotient, RQ=CO2 produced ÷ O2 consumed –- gives an idea of what the main substrate is being inspired RQ Substrate Carbohydrates 1 Protein 0.8-0.9 Fat or Oil 0.7 requires a lot of O2 to oxidize proteins or fats and oils compared to CO 2 produced Aerobic C6H12O6 + 6O2 6CO2 + 6H2O DG° = -686 kcal Anaerobic C6H12O6 2CH3CHOHCOOH DG° = -47 kcal Lactic acid produced can still be oxidized. Please email us if you have any questions or comments regarding the class or web page. This page was last modified February 7, 2001. 2001.

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