DOWNLOAD PDF MEMBRANES, METABOLISM, AND DRY ORGANISMS

Chapter 1 : Membranes and Transport | Biology Biological Principles

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Received Apr 18; Accepted Jun This article has been cited by other articles in PMC. Over the past decade, metabolomics has developed into a major tool for studying the metabolism of organisms and cells, and through this approach much has been learned about metabolic networks and the reactions of organisms to various external conditions Lay et al. Most of this work involves a number of chemometric methods to identify markers in the metabolomic data for various events. But in fact, little work has been done on understanding the meaning of the metabolomic data itself and the role of the total of the compounds observed. Is there any logic in the studying the combination of compounds itself, instead of looking at the correlations between the compounds observed and any disease or applied experimental conditions? NMR-based metabolomics in particular give a clear view of the major compounds present in an organism or cell and enable the direct quantitative comparison of all major compounds. Considering all the information we have collected in recent years using our protocol for NMR-based metabolomics Kim et al. It seems that these compounds must serve some basic function in living cells and organisms. These compounds include sugars, some amino acids, choline, and some organic acids such as malic acid, citric acid, lactic acid, and succinic acid. With the exception of sugars, which may serve as storage products and a source of energy, the other compounds are present in such large amounts that it does not make sense to consider them as only intermediates in metabolic pathways. Here, we develop a novel theory about the role of these compounds, which may explain many questions in the biochemistry of cells and organisms. The theory is based on analogy with green chemistry, where in past years various synthetic ionic liquids ILs have been developed for chemical and enzymatic reactions as well as for the extraction of natural products. The field of ILs began in , when Paul Walden Plechkova and Seddon, reported on the physical properties of ethylammonium nitrate. But it is only in recent years that ILs and deep eutectic solvents DES have been revisited by chemical engineering, because such solvents can replace conventional organic solvents. Using the liquids made from synthetic chemicals, ILs and DES now have many different applications such as dissolving polymers and metals and as media for biotransformation Welton, ; Wasserscheid and Keim, ; Abbott et al. In fact, many of the synthetic ILs contain choline and in some cases also natural organic acids. In analogy with the synthetic ILs, we hypothesized that the metabolites that occur in large amounts in cells may form a third type of liquid, one separate from water and lipids. Taking the plant metabolomics data we have collected over recent years into consideration, we saw a clear parallel with the synthetic ILs. As the first step, we made various combinations of these candidates, thereby discovering more than 30 combinations that form viscous liquids Table I.

Chapter 2 : Membranes, metabolism, and dry organisms (edition) | Open Library

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Membranes and Transport Learning Objectives Explain the fluid mosaic model of cellular membranes, in terms of membrane structure, composition, and dynamics Identify the membrane lipids that are unique to each of the 3 domains of life Predict how variation in membrane lipid composition affects the fluidity and integrity of membranes Predict the direction of water transport across the membrane under different conditions of salt and osmolarity. Distinguish among the types of transport simple diffusion, facilitated diffusion, and active transport , based on their kinetics and energy requirements. Membrane Structure The cell membrane is a fundamental and defining feature of cells. Cell membranes also contain an approximately equal part, by mass, of integral membrane proteins; meaning proteins that are firmly embedded in the hydrophobic lipid bilayer. Some integral membrane proteins have alpha-helical domains that traverse the membrane transmembrane domains. Other proteins, called peripheral membrane proteins, are loosely and reversibly associated with membranes, interacting with the polar phosphate head groups. Cell membranes also have carbohydrates, in the form of oligosaccharides, covalently attached to membrane proteins glycoproteins or to lipids glycolipids. Eukaryotic cell membrane, showing a phospholipid bilayer composed of an outer leaflet layer with carbohydrates glycolipids and glycoproteins and a cytoplasmic leaflet. Integral membrane proteins have some part of the protein embedded in the hydrophobic lipid bilayer. However, because of the hydrophobic inner core, phospholipids and integral membrane proteins do not spontaneously cross the lipid bilayer or flip across it from one side to the other. Bacteria, Archaea and Eukarya, have distinct membrane lipids that pose challenges and offer hints to reconstructing the evolutionary history of life on Earth. Bacteria and Eukarya both have membrane phospholipids with fatty acid chains ester-linked to D-glycerol. Archaea, however, have utterly different membrane phospholipids, with branched isoprene chains instead of fatty acids, L-glycerol instead of D-glycerol, and ether linkages instead of ester linkages see http: The ether linkages and isoprene chains make Archaeal membranes more resistant to heat and pH extremes. Ether-linked phospholipids in Archaea, compared with ester-linked phospholipids. Based on DNA sequence similarities, eukaryotic information processing genes are descended from archaea Allers and Mevarech , Cotton and McInerney , whereas eukaryotic membrane phospholipids synthesis genes and energy metabolism genes appear to have descended from bacteria. Eukaryotes also have membrane lipid innovations that are not found in either Archaea or Bacteria: Sterols are essential in all eukaryotic cell membranes. Sterols reduce membrane fluidity and permeability, and increase membrane rigidity and strength. Together with sphingolipids they help organize regions of the membrane into lipid rafts , microdomains in the plasma membrane with increased rigidity, that organize cell signaling proteins into functional complexes see review by Lingwood and Simons, Generic sterol structure, from Wikipedia Cholesterol structure, from Wikipedia Sterol biosynthesis is a complex pathway that requires molecular oxygen O2 ; 11 molecules of oxygen are required to synthesize just one molecule of cholesterol Desmond and Gribaldo, Therefore, steroid biosynthesis could not have evolved before the Great Oxygenation Event , circa 2. Significantly, this time coincides with the origin of eukaryotes in the fossil record. Evolution of steroid biosynthesis pathways thus looks like one of the keys to evolution of eukaryotes. Not to be left out, bacteria have their own special membrane adaptations in the form of hopanoids , the bacterial equivalent of membrane sterols. Hopanoids have 5 rings, and do not require oxygen for their biosynthesis. At higher temperatures, lipid bilayers become more fluid think about butter melting on a hot day , and more permeable or leaky. At lower temperatures, lipid bilayers become rigid like butter in the refrigerator. For cell membranes to function properly, they must maintain a balance between fluidity, to allow movement of proteins and lipids within the membrane, along with membrane curvature, bending, budding and fusion, without compromising membrane integrity and allowing substances to leak into or out of the cell. Sterols such as cholesterol in mammals, ergosterol in fungi, and phytosterols in plants, buffer membrane fluidity and permeability over a broad temperature range. In mammals, cholesterol increases membrane packing to reduce membrane fluidity and permeability. The fatty acids tails of phospholipids also affect

membrane fluidity. Fatty acids can vary in length, and the number of double bonds in the hydrocarbon chain. Naturally-occurring unsaturated fatty acids are cis-unsaturated, meaning the remaining hydrogens are on the same side of the molecule, and results in a bend in the hydrocarbon chain. Trans-unsaturated fatty acids , with the hydrogens on opposite sides, still result in a nearly straight hydrocarbon chain. Trans-unsaturated fatty acids are rare in nature, but are produced when vegetable oils are partially hydrogenated in food processing. Elaidic acid is the principal trans unsaturated fatty acid often found in partially hydrogenated vegetable oils. Stearic acid is neither cis nor trans because it has no carbon-carbon double bonds. Cis-polyunsaturated 2 or more double bonds fatty acids are even more bent and disruptive. Anything that disrupts close packing of lipids, such as higher temperatures or unsaturated fatty acids with kinks or bends, make membranes more fluid. Even water molecules diffuse only slowly across cell membranes, because water molecules are highly polar. Diffusion results in net movement of molecules down their concentration gradient, from an area of high concentration to an area of low concentration. In the case of osmosis, water molecules move from the side with low solute concentration to the side with higher solute concentration. If there is a difference in solute concentrations across the membrane, then solute molecules will try to diffuse across the membrane to equalize solute concentrations. But if the membrane is impermeable to the solute molecules, then water will move to try to equalize the solute concentrations. Cells are adapted to their aqueous environment in terms of their cytoplasmic solute concentrations. Mammalian cells have cytoplasmic solute concentrations that balance the physiological salt concentrations. In physiological saline solutions, mammalian cells are in an isotonic environment, meaning the solute concentrations inside the cell and outside the cell are in balance, so there is no net movement of water across the cell membrane. In a hypotonic solution, the solute concentration outside the cell is lower than inside the cell, so water will enter the cell to try to reduce the internal solute concentration. In a hypertonic solution, the solute concentration outside is higher than inside the cell, so water will exit the cell and the cell will shrivel up. Membrane Proteins and Transport How do cells transport molecules like glucose across the membrane? Membranes have dedicated transport proteins with transmembrane domains. Water transport is mediated by highly conserved proteins called aquaporins, which are present in all 3 domains of life. Click the link to download and view the molecular movie showing transport of a labeled water molecule through an aquaporin channel. The movie encompasses about 12 nanoseconds: The protein channels are highly specific for the molecule, and again results in net transport down a concentration gradient, from a region of high concentration to a region of low concentration. What if the cell wants to move molecules against a concentration gradient? Even when phosphate concentrations outside the cell are very low, cells can transport phosphate into the cell, where the cytoplasmic concentration of phosphate may be much higher. Active transport of molecules against their concentration gradient requires expenditure of energy, often in the form of hydrolysis of ATP. Kinetics of Transport Active transport is easy to identify because it requires energy, and transports against the concentration gradient. But is it possible to distinguish facilitated diffusion from simple diffusion? Because facilitated diffusion is mediated by protein channels, and because the number of protein channels in a cell membrane is limited, facilitated diffusion shows saturation kinetics. The kinetics of simple diffusion and facilitated diffusion. The rate of transport v is plotted against the concentration of solute [S] for simple diffusion of a solute shown in red and facilitated diffusion of a solute by a carrier protein shown in green. However, facilitated diffusion through protein channels will reach a limit, when molecules are passing through all available protein channels as fast as they can. Further increases in the concentration of molecules cannot cause faster diffusion, because every channel is busy and molecules have to wait for openings. Active transport will also display saturation kinetics, for the same reason. Simple diffusion will rarely reach such a limit, because the entire area of the membrane is available. To summarize membranes and transport, check out this animation: To test your understanding of transport processes, look at this teaching tidbit on Cell Membrane Permeability. Put it all together.

Chapter 3 : Energy and enzymes | Biology Biological Principles

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Explain how the 2nd Law of Thermodynamics applies to living organisms Predict the direction of reactions from Gibbs free energy changes, and vice versa Distinguish between steady-state homeostasis and chemical equilibrium Use energy diagrams to explain how catalysts increase rates of reaction Plot enzyme kinetics: The First Law says that energy cannot be created or destroyed. The Second Law says that in any energy conversion, some energy is wasted as heat; moreover, the entropy of any closed system always increases. One way we can see the Second Law at work is in our daily diet. We eat food each day, without gaining that same amount of body weight! The food we eat is largely expended as carbon dioxide and heat energy, plus some work done in repairing and rebuilding bodily cells and tissues, physical movement, and neuronal activity. Although living organisms appear to reduce entropy, by assembling small molecules into polymers and higher order structures, this work releases waste heat that increases the entropy of the environment. Gibbs Free Energy Gibbs free energy is a measure of the amount of work that is potentially obtainable. Instead of absolute quantities, what is usually measured is the change in free energy: This figure from Wikipedia illustrates that reactions will proceed spontaneously towards equilibrium, in either direction, and that the equilibrium point is the minimum free energy state of the reaction mixture. Cells couple exergonic reactions to endergonic reactions so that the net free energy change is negative ATP is the primary energy currency of the cell; cells accomplish endergonic reactions such as active transport, cell movement or protein synthesis by tapping the energy of ATP hydrolysis: The rate of the reaction is determined by the activation energy the energy required to attain the transition state barrier Ea: Energy diagram of enzyme-catalyzed and uncatalyzed reactions, from Wikipedia The peak of this energy diagram represents the transition state: Reactions with a high activation energy will proceed very slowly, because only a few molecules will obtain enough energy to reach the transition state â€" even if they are highly exergonic. Starting with equal amounts of X and Y, the reaction will go in reverse. The addition of a catalyst definition: As a result, in the presence of the catalyst, a much higher percentage of molecules X or Y can acquire enough energy to attain the transition state, so the reaction can go faster, in either direction. Note that the catalyst does not affect the overall free energy change of the reaction. Starting with equal amounts of X and Y, the reaction diagrammed above will still go in reverse, only faster, in the presence of the catalyst. Most enzymes are proteins, but several key enzymes are RNA molecules ribozymes. Enzymes are highly specific for their substrates. Only molecules with a particular shape and chemical groups in the right positions can interact with amino acid side chains at the active site the substrate-binding site of the enzyme. Enzyme-catalyzed reactions have saturation kinetics The velocity of enzyme-catalyzed reactions increases with the concentration of substrate. However, at high substrate concentrations, the quantity of enzyme molecules becomes limiting as every enzyme molecule is working as fast as it can. At saturation, further increases in substrate concentrations have no effect; the only way to increase reaction rates is to increase the amount of enzyme. Enzyme inhibitors Enzymes are subject to regulation, and are the targets of many pharmaceutical drugs, such as non-steroidal pain relievers. Many enzymes are regulated by allosteric regulators which bind at a site distinct from the active site. Noncompetitive inhibitors act allosterically bind at a site different from the active site. When the noncompetitive inhibitor binds allosterically, it often changes the overall shape of the enzyme, including the active site, so that substrates can no longer bind to active site. Competitive inhibitors compete with the substrate for binding to the active site; the enzyme cannot carry out its normal reaction with the inhibitor, because the inhibitor physically blocks the substrate from binding the active site. My lecture videos on thermodynamics and enzymes have audio lag, plan to re-do in shorter segments Powerpoint file used in the videos:

Chapter 4 : Trehalose: an intriguing disaccharide with potential for medical application in ophthalmology

In contrast, we do not understand well even basic physiological behavior in these organisms. This includes the widespread phenomenon of organic acid excretion. One strong hurdle to fully exploit the metabolic capacity of these organisms is the enormous, highly environment sensitive phenotypic plasticity. In this work we explored organic acid excretion in Penicillium ochrochloron from a new point of view by simultaneously investigating three essential metabolic levels: This was done in strictly standardized chemostat culture with different nutrient limitations glucose, ammonium, nitrate, and phosphate. These different nutrient limitations led to various quantitative phenotypes as represented by organic acid excretion, oxygen consumption, glucose consumption, and biomass formation. Glucose-limited grown mycelia were used as the reference point very low organic acid excretion. Both ammonium and phosphate grown mycelia showed increased organic acid excretion, although the patterns of excreted acids were different. Introduction The global demand for organic acids and their derivatives as source for chemical building blocks Sauer et al. Albeit filamentous fungi are biotechnologically widely used to meet this market, their ability to produce these metabolites is far from being exploited. One reason is a lack of understanding of even basic physiological aspects of these organisms e. For example, the reason why filamentous fungi excrete organic acids at all is still debated controversially Neijssel et al. For most organic acidsâ€”if not allâ€”it is still unclear what exactly triggers or impedes their production and excretion Krull et al. However, concepts of systems biology brought the increasing awareness that understanding organisms and their physiology needs to go a few steps further than to search for a single decisive factor in the cause and effect relationship, which isâ€”due to the high complexity of cellular metabolismâ€”rather unlikely Chubukov et al. Indeed, systems biology highlighted the need for a quantitative analysis of dynamic interactions between the components of a physiological network. Unfortunately, this is specially difficult with filamentous fungi, because of their enormous, highly environment-sensitive phenotypic plasticity Foster, ; McGetrick and Bull, ; Bridge et al. This strong phenotypic plasticity of filamentous fungi poses high demands on the standardization of cultivation conditions and the characterization of physiological states and growth phases in submerged culture. Thus, to be successful, an unusual high degree of standardization is necessary. In this work we aimed at exploring organic acid excretion in a filamentous fungusâ€”Penicillium ochrochloronâ€”from a new point of view by investigating three essential metabolic levels simultaneously. The targeted levels were: As all three levels are intertwined and connected via intermediary metabolites and energetics Figure 1 , a change in one level will cause consequences on the other levels. The respiratory chain is physically connected with the tricarboxylic cycle via the succinate dehydrogenase and indirectly via the NADH turnover. A main consumer of the ATP produced by oxidative phosphorylation is the plasma membrane ATPase, which in turn provides the cell with a proton motive force for nutrient uptake. Last but not least, all excreted metabolites have to pass the plasma membrane. Of course, in the past all three target levels PM-M-R have been connected in one way or another with organic acid excretion in filamentous fungi: So far, these levels have not been explored simultaneously, quantitatively, related to each other and in chemostat culture. Additionally, it is unknown, if and how organic acid excretion and its relation to the PM-M-R dynamics shifts in dependence of the nutrient limitation. Unfortunately, systemic approaches as these are highly challenging. They require not only an extensive standardization of cultivation methods to ensure comparability between different physiological states, but also the application of different sophisticated experimental methods adjusted for each targeted level. Therefore, in this study the PM-M-R dynamics were explored in rigorously standardized chemostat cultivations Bull, under energetically different conditions i. This elaborate task was only possible because we could rely on three decades of experimental experience with our model organism P. The resulting data not only provides a unique new point of view for organic acid excretion in filamentous fungi but also highlight the need for the scientific community to focus more on the phenomenon of phenotypic plasticity in these organisms. Especially, as it is

connected inevitably with many aspects of experimental methodology and thus the quality of the gained data sets. The wild type strain originated from a soil which was strongly contaminated with heavy metals and was initially identified as the closely related species Penicillium simplicissimum Franz et al. For both strains a re-identification revealed P. The media as well as detailed procedures for pre-culture and chemostat cultivations are described in Schinagl et al. In addition, an overview for growth media is given in the supplementary information, section growth media and chemicals. In chemostat cultivations the limiting nutrients were mM in reservoir: For chemostat cultivations the following bioreactors were used Schinagl et al. The medium components in total 1. After blending the medium components and transfer into the bioreactor under sterile conditions, the medium was inoculated with mL of pre-culture 72 h, ammonium exhausted at c. Two hours after the inoculation the feed pump was started. Cultures reached a steady state after four hydraulic residence times. Analytics of main nutrients glucose, ammonium, and phosphate as well as determination of biomass and extracellular organic acids were done as specified in Vrabl et al. Nitrate was determined according to Doblander and Lackner We aimed at keeping the pH at above 7. However, the shift in pH caused by the elevated extraction temperatures was so far neglected. In consequence we pursued the following strategy in choosing the appropriate buffer additive: First, the buffer range should guarantee that the pH at extraction conditions is 7. Second, the buffer should not negatively interfere with the analytical assay or the HPLC column in any way. Although borate, TAPS and CAPS buffers would meet at least the first criteria, preliminary experiments demonstrated that they did not meet the second criteria unpublished results. To ensure that the pH stayed above 7. Further sample processing, e. Nucleoside and Nucleotide Analysis As part of an extensive rework of our whole sample processing, also the former analytical method Ganzera et al. To determine the intracellular nucleoside and nucleotide content, a new analytical method was established. For elution the gradient started with The wavelength for diode array detection DAD was set to nm, the excitation and emission wavelengths for fluorescent detection FLD were set to nm and nm, respectively. For the separation of the analytes within 15 min the optimum buffer was 60 mM citric acid and 0. The injection was done hydro dynamically at 35 mbar for 6 s. Before each run the capillary was re-conditioned with 0. All required solutions were membrane filtered and replaced periodically. Details on method validation e. Respiration R Sample preparation for high resolution respirometry was done as described in Schinagl et al. Modifications of this respirometric assay concerning i the time regime, and ii the applied inhibitors and uncouplers were mandatory, because mycelium of P. Phosphate-limited mycelium started to clog the overflow pipe between 24 and 48 h of steady state cultivation, which limited the time for sampling and therefore the time regime for the respirometric assay was shortened accordingly, i. For example, cyanide was clearly the better choice for inhibiting complex IV of glucose-limited grown mycelia Schinagl et al. Immediately after injection of cyanide to the hyphae in the respirometer chamber a strong oxidative burst was observable, which was also noticed if cyanide was added to the respiration medium without biomass. On the other hand, azide exerted a complete inhibition of complex iV in these mycelia, which was not the case for glucose-limited mycelium as mentioned before. Also the uncoupling agents for the mitochondrial proton gradient were tested for applicability, e. Here an outline of the method is given. For further details concerning optimizations, assay set up and conditions, as well as the composition of reagents see supplementary information, section plasma membrane. Because this part is less well-documented than the sections Energy Metabolism Vrabl et al. Harvest of the Biomass The culture broth from the bioreactor was poured into a 2 L graduated beaker and the volume noted. The cold fermentation broth was filtered through a cotton cloth and the filtrate checked for bacterial infection. Air bubbles were removed by gentle stirring with a glass rod and the chamber was filled with homogenization medium to the brim. The hyphae were disintegrated for 2 min at 20, rpm. The main part of the MF was re-suspended by means of an all glass Potter-Elvehjem homogenizer in resuspension medium 1 RM 1 for further treatment with the aqueous polymer two phase system, an aliquot was re-suspended in resuspension medium 2 RM 2 for determination of protein and vanadate sensitive ATPase activity. For the tests, changes and improvements made in the meantime to this method see supplementary information, section plasma membrane. Here only the final procedure is reported. A general description of the method can be found in Larsson and Widell A two phase system 27 g necessary for a 36 g partitioning system Larsson and Widell,

was prepared to give final concentrations of 6. The concentration of the dextran stock solution was checked twice with two different polarimeters. The 27 g two phase system in a 50 mL polycarbonate centrifugation tube; tube 1 was loaded with microsomal fraction approximately 20 mg of protein; 72 mg of protein at maximum and completed with RM 1 to a total weight of 6 g. The separation system tube 1 was incubated on ice for 5 min and then mixed by 40 inversions of the tube by hand. To increase yield and purity of the plasma membranes two further phase partitioning steps were applied for an illustration of the procedure see Figure 1 of Larsson and Widell, The lower phase from tube 1 was diluted 1: Membranes were spun down at 10, g for 1 h. Here only the final methods are given. The assay was carried out either in polystyrene semi-micro cuvettes or in polystyrene flat bottom microplates. For phosphate determination we now used a modified method of Lanzetta et al. The main reason for this change was that the method of Lanzetta et al. On one microplate six different assays could be performed, each in triplicate, together with five phosphate standards pipetting regime see supplementary information, section plasma membrane. The different assays were: For each sample c. The gels were run at RT, thereupon proteins were visualized with a coomassie brilliant blue stain Dyballa and Metzger, The linear ion trap and the orbitrap were operated in sequence, i. Only tryptic peptides with up to two missed cleavages were accepted. No fixed modifications were considered. The mass tolerance for precursor ions was set to 10 ppm; the mass tolerance for fragment ions was set to 0.

Chapter 5 : MEMBRANES METABOLISM AND DRY ORGANISMS | www.nxgvision.com

Membranes, Metabolism and Dry Organisms (Comstock Book) by Editor-A. Carl Leopold. Comstock Pub Assoc, Hardcover. Good.

Oxidative phosphorylation , Chemiosmosis , and Mitochondrion In oxidative phosphorylation, the electrons removed from organic molecules in areas such as the protagon acid cycle are transferred to oxygen and the energy released is used to make ATP. This is done in eukaryotes by a series of proteins in the membranes of mitochondria called the electron transport chain. Pumping protons out of the mitochondria creates a proton concentration difference across the membrane and generates an electrochemical gradient. These organisms can use hydrogen , [45] reduced sulfur compounds such as sulfide , hydrogen sulfide and thiosulfate , [1] ferrous iron FeII [46] or ammonia [47] as sources of reducing power and they gain energy from the oxidation of these compounds with electron acceptors such as oxygen or nitrite. Phototroph , Photophosphorylation , and Chloroplast The energy in sunlight is captured by plants , cyanobacteria , purple bacteria , green sulfur bacteria and some protists. This process is often coupled to the conversion of carbon dioxide into organic compounds, as part of photosynthesis, which is discussed below. The energy capture and carbon fixation systems can however operate separately in prokaryotes, as purple bacteria and green sulfur bacteria can use sunlight as a source of energy, while switching between carbon fixation and the fermentation of organic compounds. This proton motive force then drives ATP synthesis. Reaction centers are classed into two types depending on the type of photosynthetic pigment present, with most photosynthetic bacteria only having one type, while plants and cyanobacteria have two. The electrons then flow to the cytochrome b6f complex , which uses their energy to pump protons across the thylakoid membrane in the chloroplast. Anabolism Anabolism is the set of constructive metabolic processes where the energy released by catabolism is used to synthesize complex molecules. In general, the complex molecules that make up cellular structures are constructed step-by-step from small and simple precursors. Anabolism involves three basic stages. First, the production of precursors such as amino acids , monosaccharides , isoprenoids and nucleotides , secondly, their activation into reactive forms using energy from ATP, and thirdly, the assembly of these precursors into complex molecules such as proteins , polysaccharides , lipids and nucleic acids. Organisms differ according to the number of constructed molecules in their cells. Autotrophs such as plants can construct the complex organic molecules in cells such as polysaccharides and proteins from simple molecules like carbon dioxide and water. Heterotrophs , on the other hand, require a source of more complex substances, such as monosaccharides and amino acids, to produce these complex molecules. Organisms can be further classified by ultimate source of their energy: Photosynthesis , Carbon fixation , and Chemosynthesis Plant cells bounded by purple walls filled with chloroplasts green , which are the site of photosynthesis Photosynthesis is the synthesis of carbohydrates from sunlight and carbon dioxide CO2. In plants, cyanobacteria and algae, oxygenic photosynthesis splits water, with oxygen produced as a waste product. This process uses the ATP and NADPH produced by the photosynthetic reaction centres , as described above, to convert CO2 into glycerate 3-phosphate , which can then be converted into glucose. These differ by the route that carbon dioxide takes to the Calvin cycle, with C3 plants fixing CO2 directly, while C4 and CAM photosynthesis incorporate the CO2 into other compounds first, as adaptations to deal with intense sunlight and dry conditions. Gluconeogenesis , Glyoxylate cycle , Glycogenesis , and Glycosylation In carbohydrate anabolism, simple organic acids can be converted into monosaccharides such as glucose and then used to assemble polysaccharides such as starch. The generation of glucose from compounds like pyruvate , lactate , glycerol , glycerate 3-phosphate and amino acids is called gluconeogenesis. Gluconeogenesis converts pyruvate to glucosephosphate through a series of intermediates, many of which are shared with glycolysis. This is important as it allows the formation and breakdown of glucose to be regulated separately, and prevents both pathways from running simultaneously in a futile cycle. As any of the hydroxyl groups on the ring of the substrate can be acceptors, the polysaccharides produced can have straight or branched structures. Some intermediates are omitted for clarity. Fatty acids are made by fatty acid synthases that polymerize and then reduce acetyl-CoA units. The acyl chains in the fatty acids are

extended by a cycle of reactions that add the acyl group, reduce it to an alcohol, dehydrate it to an alkene group and then reduce it again to an alkane group. The enzymes of fatty acid biosynthesis are divided into two groups: In animals and archaea, the mevalonate pathway produces these compounds from acetyl-CoA, [74] while in plants and bacteria the non-mevalonate pathway uses pyruvate and glyceraldehyde 3-phosphate as substrates. Here, the isoprene units are joined together to make squalene and then folded up and formed into a set of rings to make lanosterol. Protein biosynthesis and Amino acid synthesis Organisms vary in their ability to synthesize the 20 common amino acids. Most bacteria and plants can synthesize all twenty, but mammals can only synthesize eleven nonessential amino acids, so nine essential amino acids must be obtained from food. Nitrogen is provided by glutamate and glutamine. Amino acid synthesis depends on the formation of the appropriate alpha-keto acid, which is then transaminated to form an amino acid. Each different protein has a unique sequence of amino acid residues: Just as the letters of the alphabet can be combined to form an almost endless variety of words, amino acids can be linked in varying sequences to form a huge variety of proteins. Proteins are made from amino acids that have been activated by attachment to a transfer RNA molecule through an ester bond. Pyrimidines , on the other hand, are synthesized from the base orotate , which is formed from glutamine and aspartate. Xenobiotic metabolism , Drug metabolism , Alcohol metabolism , and Antioxidant All organisms are constantly exposed to compounds that they cannot use as foods and would be harmful if they accumulated in cells, as they have no metabolic function. These potentially damaging compounds are called xenobiotics. In humans, these include cytochrome P oxidases , [87] UDP-glucuronosyltransferases , [88] and glutathione S-transferases. The modified water-soluble xenobiotic can then be pumped out of cells and in multicellular organisms may be further metabolized before being excreted phase III. In ecology , these reactions are particularly important in microbial biodegradation of pollutants and the bioremediation of contaminated land and oil spills. Biological thermodynamics Living organisms must obey the laws of thermodynamics , which describe the transfer of heat and work. The second law of thermodynamics states that in any closed system , the amount of entropy disorder cannot decrease. Thus living systems are not in equilibrium , but instead are dissipative systems that maintain their state of high complexity by causing a larger increase in the entropy of their environments. In thermodynamic terms, metabolism maintains order by creating disorder.

Chapter 6 : - Membranes, Metabolism and Dry Organisms (Comstock Book) by A. Carl Leopold

Trehalose is a naturally occurring disaccharide comprised of two molecules of glucose. The sugar is widespread in many species of plants and animals, where its function appears to be to protect cells against desiccation, but is not found in mammals. Trehalose has the ability to protect cellular.

Physiological Ecology Photo by: This diversity of living conditions is reflected in the intriguing physiological adaptations developed by animals that live in these environments. Adaptions to Cold Temperature has a widespread impact on design. Two basic approaches to dealing with the challenge of temperature are to either maintain a constant and relatively high body temperature independent of ambient temperature endothermy or to let body temperature fluctuate with environmental temperature ectothermy. Endotherms maintain a high internal temperature through metabolic heat generation. Most of this heat comes from metabolism in the gut and brain. In cold weather, increased muscular activity through shivering or simply exercising provides a mechanism to increase metabolic heat production. Some endotherms, like the arctic fox, are cold-weather specialists. Their most obvious strategy against the cold is insulation provided by a thick layer of fur. Aquatic animals rely predominantly on blubber for insulation as fur loses much of its insulation value upon immersion in water. Another cold weather strategy is to temporarily decrease metabolic rate and body temperature. This regulated decrease in body temperature decreases the temperature difference between the animal and the air and therefore minimizes heat loss. Furthermore, having a lower metabolic rate is less energetically expensive. Many animals survive cold frosty nights through torpor, a short-term temporary drop in body temperature. Other animals such as marmots take a much more drastic approach: They hibernate through the cold months, letting their body temperature fall to a few degrees above ambient temperature. Contrary to popular belief, bears are not true hibernators as they undergo only a slight drop in body temperature and this activity can only be considered a deep sleep. Ectotherms, which rely mostly on external sources of heat, adopt much different strategies to the cold. Ectotherms have little or no insulation. This is helpful to gain heat from the environment but ectotherms have difficulty coping with cold temperatures. Without the ability to prevent heat loss, cold-weather ectotherms either must be able to tolerate freezing or to be able to live in sub-freezing environments without ice formation in their bodies. Freeze-tolerant animals like the wood frog can survive the freezing crystallization of up to 65 percent of their body water. Freeze-intolerant animals, including many antarctic fish, avoid freezing by having antifreeze compounds in their plasma to lower the freezing and supercooling point of their tissues. Adaptations to Heat and Dryness A major challenge in hot and dry environments is the balance of water and temperature regulation. For endotherms, the main cooling mechanism is An African dromedary. Animals adapted to hot and dry environments have mechanisms for minimizing water loss while surviving the heat. Animals with a body covered by fur have limited ability to sweat, and rely heavily on panting to increase evaporation of water across the moist surface of the tongue and mouth. Birds have no sweat glands and therefore all birds pant. Interestingly, dense fur on desert inhabitants may also help to insulate the animal from heat gain. Long loops of Henle of the kidney are another adaptation to arid environments. These long tubes are capable of super-concentrating urine, and enabling desert dwellers such as the kangaroo rat to conserve water. Big noses also help in the heat. Camels also are known to let their body temperature rise during the day and dissipate the extra heat load during the cool night through conduction contact with a cool surface , which does not require water. Small animals, with their high surface area-to-volume ratio, are in great danger of heat overload in hot environments. Most small animals therefore remain in burrows during the day and come out at night when the temperature is lower. The nocturnal lifestyle of desert-adapted rodents explains why gerbils keep their owners up at night. Adaptations to Marine Environments Marine environments pose a similar problem to an arid environment, the lack of fresh water. Bony fish osmoregulate control salt regulations in this high-salt environment by drinking seawater and eliminating salt through pumps in the gills. Similarly, marine birds drink seawater and eliminate salt through glands located in their eye orbit. Sharks have the curious arrangement of salt glands in the rectum. The ocean floor provides the strange environment of high ambient pressure and little or no light. One adaptation to lack

of light has been the loss of eyes and pigmentation in some deep-sea fish. Other organisms have adapted to low light levels by possessing bioluminescent systems, either by having luminous organs or carrying bioluminescent bacteria. Such a system is useful for species recognition, luring prey, startling predators and mating. Deep-sea life also requires an adaptation to the extremely high pressure found at depths. Barophilic, or pressure-loving, organisms have adapted ways to avoid problems caused by high pressure. One adaptation is the modification of the set of lipids in cell membranes, designed to maintain fluidity despite the high pressure. Relatively pressure-insensitive enzymes are also found in organisms that live at great depths. Adaptations to Low Oxygen Concentration Just as high pressure influences organismal design, the low barometric pressure and thus low oxygen availability of the skies also presents an evolutionary force on physiology. A dramatic example of high altitude adaptation is seen in the bar-headed goose, a bird whose migration path between India and Tibet requires flight over Mount Everest. Research suggests that these birds maintain a phenomenal blood supply to flight muscles, and their blood has a unique hemoglobin structure, which optimizes oxygen transport in high-altitude conditions. Warm, stagnant bodies of water also present a low-oxygen environment and fish inhabiting these waters survive by managing to breathe both air and water. Lungfish, as the name suggests, possess both gills to breathe water and lungs to breathe air. It is likely that an organism similar to this air-breathing fish gave rise to terrestrial vertebrates millions of years ago. Every organism on Earth represents a successful path to adapting to a specific environment, which helps to explain the impressive biodiversity of life present today.

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