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The Metabolism in the Course of Study Related to the Biological Science at Various Levels

Dr. Ashwani Kumar Gupta

Assistant Professor of Zoology, Regional Institute of Education, Capt. Ajmer, Rajastan-305004, India
Email: drash_kumar@yahoo.com

***Abstract* - Metabolism is the overall process through which living systems acquire and utilize the free energy they need to carry out their various functions. Metabolism is the essential for all types of living organisms and cells. The chemical changes that occur when animals consume plant or animal tissues as food, or when plants carry out photo synthesis are known as metabolism The free energy content of a substance play the role in the lives of organisms and cells. The metabolism is also essential in the course of study related to the biological sciences at various levels.**

Keywords: Metabolism, Free energy, Energy cycle, Vitamins and Coenzymes.

I. Introduction

Living organisms as require a continuous influx of free energy to maintain order in a universe bent on maximizing disorder. Metabolism is the overall process through which living systems acquire and utilize the free energy they need to carry out their various functions. They do so by coupling the exergonic processes required to maintain the living state such as the performance of mechanical work, the active transport of molecules against concentration gradients, and the biosynthesis of complex molecules.

Phototrophs acquire free energy from the sun through photosynthesis, a process in which light energy powers the endergonic reaction of CO_2 and H_2O to form carbohydrates and O_2. Chemotrophs obtain their free energy by oxidizing organic compounds obtained from other organisms, all ultimately phototrophs. This free energy is most often coupled to endergonic reactions through the intermediate synthesis of "high energy" phosphate compounds such as adenosine triphosphate (ATP). In addition to being completely oxidized, nutrients are broken down in a series of metabolic reactions to common intermediates that are used as precursors in the synthesis of other biological molecules.

The chemical changes that occur when animals consume plant or animal tissues as food, or when plants carry out photo synthesis are known as metabolism. Intermediary metabolism constitutes the sum of chemical reactions that the cell's constituents undergo, in the intact cell both synthetic (anabolic) and degradative (catabolise) processes go on simultaneously, and energy released from the degradation of some compounds may be utilized in the synthesis of other cellular components. Thus, the concept of an energy cycle has developed in biochemistry in which fuel molecules, representing a source of potential chemical energy, are degraded through known enzymatic reactions to produce a few different energy rich compounds.

Playing a key role in this energy cycle is the ATP-ADP system. ADP is able to accept a phosphate group from other energy - rich compounds produced during metabolism and thereby are converted into ATP. The ATP in turn, can be utilized to drive many biosynthetic reactions and, in addition, serve as a privacy source of energy for specific physiological activities such as movement, work, secretion, absorption and conduction. In doing so, it is generally converted back to ADP.

Metabolic pathways: Metabolic pathways are series of consecutive enzymatic reactions that produce specific products. Their reactants, inter mediates, and products are referred to as metabolites. The reactions of metabolic pathways that comprise metabolism are often divided into two categories.

(i) Catabolism (Degradation): Nutrients and cell constituents are broken down exergonically to Salvage their components and for generate free energy,

(ii) Anabolism (Biosynthesis): Bio-molecules are synthesized from simpler components.

The free energy released by catabolic processes is conserved through the synthesis of ATP from ADP and phosphate or through the reduction of the coenzyme $NADP^+$ to NADPH. ATP and NADPH are the major free energy sources for anabolic pathways.

A striking characteristic of degradative metabolism is that it converts large numbers of diverse substances to common intermediates. These intermediates then further metabolized in a few end products. The breakdown of various foodstuffs, first

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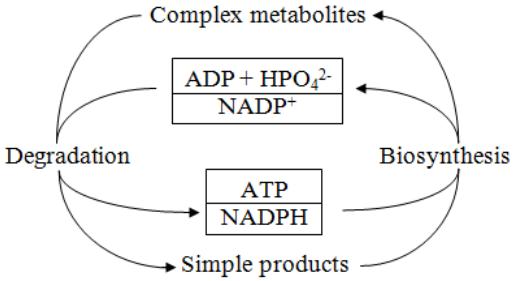
to their monomeric units and then to the common intermediate acetyl coenzyme A (acetyl-CoA).

Biosynthesis carries out the opposite process. Relatively few metabolites, mainly pyruvate, acetyl-CoA, and the citric acid cycle intermediates, serve as starting materials for a host of varied biosynthetic products.

Five principal characteristics of metabolic pathways stem from their function of generating products for use by the cell:

1. Metabolic Pathways are irreversible.
2. Catabolic and anabolic pathways must differ.
3. Every metabolic pathway has a first committed step.
4. All metabolic pathways are regulated.
5. Metabolic pathways in eukaryotic cells occur in specific cellular locations.



ATP and NADPH are the sources of free energy for biosynthetic reactions. They are generated through the degradation of complex metabolites.

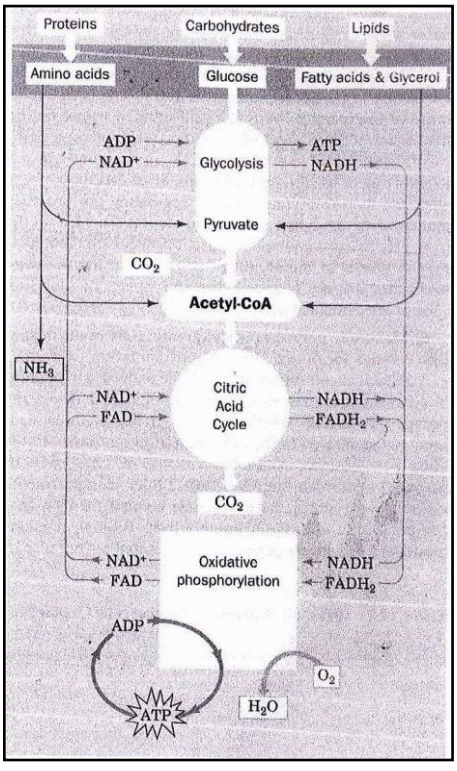


Figure: Overview of catabolism

Complex metabolites such as carbohydrates, proteins, and lipids are degraded first to their monomeric units, chiefly glucose, amino acids, fatty acids, and glycerol, and then to the common intermediate, acetyl-coenzyme A (acetyl-COA). The acetyl group is then oxidized to CO, via the citric acid cycle with the concomitant reduction of NAD and FAD. Reoxidation of these latter coenzymes by O, via the electron-transport chain and oxidative phosphorylation yields H_2O and ATP.

II. The Concept of Free Energy

One thermodynamic concept particularly useful to biochemists in free energy (G). The free energy content of a substance A, but this quantity cannot be measured experimentally If A is converted to B in a chemical reaction, however,

$$A \rightleftharpoons B$$

It is also known as the change in free energy (ΔG). This is the maximum amount of energy made available as A is converted to B. If the free energy content of the product B (G_B) is less than the free energy content of the reaction A (G_A), the ΔG will be a negative quantity. That is:-

$$\Delta G = G_B - G_A$$

$$= \text{ negative quantity when}$$

$$(G_A > G_B)$$

For a ΔG to be negative means that the reaction occurs with a decrease in free energy. Similarly, if B is converted back to A, the reaction will involve an increase in free energy, that is, ΔG will be positive.

Reactions having a negative ΔG are termed as exergonic; those that have a positive ΔG are called endergonic.

Experience has also shown that although the ΔG for a given process is negative, this fact has no relationship whatever to the rate at which the reaction proceeds. For example, glucose can be oxidized by O_2, (oxygen) to CO_2 (carbon-di-oxide) and water (H_2O).

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

$$\Delta = -686{,}000 \text{ cal/mole}$$

The ΔG for this reaction is a very large negative quantity, approximately -686,000 cal/mole of glucose. The large -ΔG has no relationship to the rate of the reaction, however, oxidation of glucose may occur in a matter of a few seconds in

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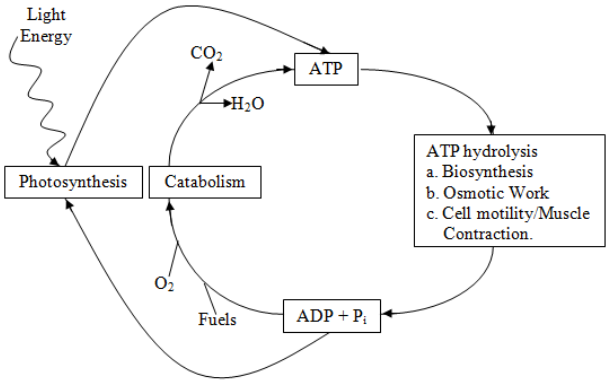
the presence of a catalyst in a bomb calorimeter. This reaction goes on in most living organisms at rate a varying from minutes to several Glucose e can nevertheless be kept in a bottle on the shelf for years in the presence of air without undergoing oxidation.

III. ATP (Adenosine Triphosphate) serves in a Cellular Energy Cycle

APT is the energy currency of cells in phototrophs, ATP is one of the two energy-rich-primary products resulting from the transformation of light energy into chemical energy. In heterotrophs, the pathways of catabolism have as their major purpose the release of free energy that can be captured in the form e energy-rich phosphoric con hydride bonds in ATP. In turn, ATP provides the energy that drives manifold activities of all living cells the synthesis of complex bio-molecules, the osmotic work involved in transporting substances into cells, the work of cell motility and the work of muscle contraction These diverse activities are all bowered by energy released in the hydrolysis of ATP to ADPL (Adenosine Diphosphate) and P_i. Thus, there is an energy cycle in cells where ATP serves as the vessel carrying energy from photosynthesis of catabolism to the energy - requiring processes unique to living cells.



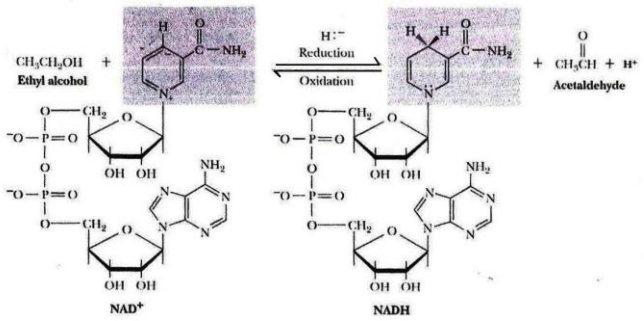
The ATP Cycle

The ATP cycle in cells, ATP is formed via photosynthesis in phototrophic cells or catabolism in heterotrophic cells. Energy requiring cellular activities are powered by AIP hydrolysis, liberating ADP and P.

IV. NAD^+ collects Electrons released in catabolism

The substrates of catabolism proteins, carbohydrates and lipids are good sources of chemical energy because the carbon atoms in these molecules are in a relatively reduced state. In the oxidative reactions of catabolism, reducing equivalents released from these substrates, often in the form of hydride ions. These hydride ions are transformed in enzymatic dehydrogenase reactions from the substrates to NAD^+ molecules, reducing them to NADH. A second proton accompanies these reactions appearing in the overall equation as H^+. In turn, NADH (Nicotinamide Adenine Dinucleotide - Hydrogen) is oxidized back to NAD+ when it transfers its reducing equivalents to electron acceptor systems that are part of the metabolic apparatus of the mitochondria. The ultimate oxidizing agent is O_2 (oxygen), becoming reduced to H_2O (water).

Oxidation reactions are exergonic, and the energy released is coupled with the formation of ATP in a process called oxidative phosphorylation. The NAD^+ - NADH system can be viewed as a shuttle that carries the electrons released from catabolic substrates to the mitochondria, where they are transferred to O_2, the ultimate electron acceptor in catabolism. In the process, the free energy released is traped in ATP. The NADH cycle is an important player in the transformation of the chemical energy of carbon compounds into the chemical Energy of phosphoric anhydride bonds. Such transformations of energy from one form to another are referred to as to as energy transductions, oxidative phosphorylation is one cellular mechanism for energy transduction.



Hydrogen and electrons released in the course of oxidative catabolism are transferred as hydride ions to the pyridine nucleotide, NAD to form NADH + H^+ in dehydrogenase reactions of the type

$$AH_2 + NAD^+ \longrightarrow A + NADH + H^+$$

The reaction shown is catalyzed by alcohol dehydrogenase.

V. NADPHC (Nicotinamide adenine dinucleotide Phosphate-Hydrogen)

Whereas catabolism is fundamentally an oxidative process, anabolism is, by its contracting nature, reductive. The biosynthesis of the complex constituents of the cell begins at the level of intermediates derived from the degradative pathways of catabolism; or, less commonly bio-synthesis begins with oxidized substances available in the inaminate environment, such as carbon dioxide (CO_2). When the hydrocarbon chain of fatty acids are assembled from acetyl-CoA into a $-CH_2-$ at every other position along the chain,

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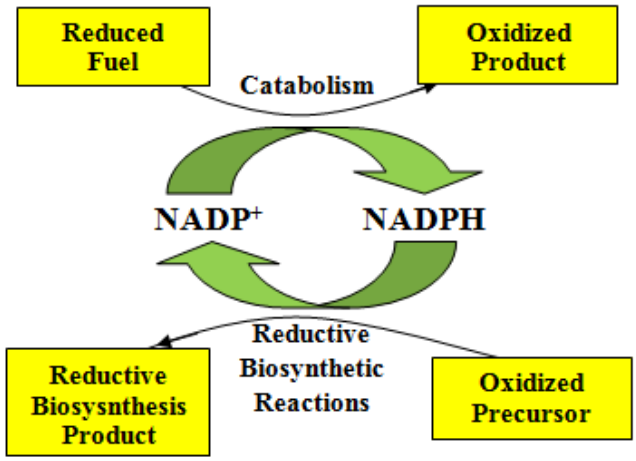
then when glucose is synthesized from CO_2 (carbon dioxide) during photosynthesis in plants, reducing power is required. These reducing equivalents are provided by NADPH, the usual source of high-energy hydrogenase for reducing biosynthesis, NADPH is generated when $NADP^+$ is reduced with electrons in the form of hydride ions. In heterotrophy organisms, these electrons care removed from fuel molecules by $NADP^+$ specific dehydrogenases. In these organisms, NADPH can be viewed as the Carrier of electrons from catabolic reactions to aerobic reactions. In photo synthetic organisms the energy of light is used to pull electrons. From water and transfer them to $NADP^+$, O_2 (oxygen) is a by - product of this process. Transfer of reducing equivalents from catabolism to anabolism via the NADPH cycle.



VI. Coenzymes and vitamins Provide Unique chemistry and Essential Nutrients to Path ways

In addition to NAD^+ and NADPH, a variety of other small molecules are essential to metabolism. Some of these are started essential nutrients called vitamins. Vitamins are required in the diet, usually in trace amounts, because they cannot be synthesized by the organism itself. The requirement for any given vitamin depends on the organism.

Except for vitamin C (ascorbic acid), the water-soluble vitamins are all components or precursors of important biological substances known as Coenzymes. These are low molecular-weight molecules that bring unique chemical functionality to certain enzyme reactions.

Coenzymes may also act as carriers of specific functional groups, such as methyl groups and acyl groups. The side chains of the common amino acids provide only a limited range of chemical reactivities and carrier properties. Coenzymes, acting in concert with appropriate enzymes provided a broader range of catalytic properties for the reactions of metabolism; coenzymes are typically modified by these reactions and at are then converted back to their original forms by other enzymes, so small amounts of these substances can be a used repeatedly. The fat-soluble vitamins are not directly related to coenzymes, but they play essential roles in a variety of critical biological processes, including vision, maintenance of bone structure, and blood coagulation.

VI. Conclusion and Recommendation

The metabolism applies to the assembly of biochemical reactions which are employed by the organisms for the synthesis of cell materials and for the utilization of energy from their environments. The metabolism of an organism or of cell may be defined as the sum total of all the enzyme - catalyzed reactions that occur in an organism (or in a cell). The metabolic reactions are essential for all living organisms and all living cells. The various activities powered by metabolism (Catabolism) include mechanical movement, growth, reproduction, accumulation of foods, elimination of wastes, generation of electricity, maintenance of temperature etc. The various activities and anabolic exemplified by food manufacture, protein synthesis, fat synthesis etc. some processes can be either catabolic of anabolic depending on the energy conditions in the cell. These referred to as amphibolism.

Since the life sciences along with the physical sciences have received much more attention to revise and refresh course there is an urgent need now to lay emphasis on the protection of environment all over the world and thence to provide a better life to the living beings of this planet in order to maintain a proper balance between the environment and human survival it becomes imperative to incorporate concepts of immediate concern that have direct implications not only to theory but practical work and their subsequent application for environmental protection and human survival This is also significant with the view point to bring out social awareness towards the protection of environment, human survival and then to maintain the ecological and biochemical balance.

The study of such concept as metabolism should be specifically introduced in the course of study related to the biological sciences at various levels.

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