

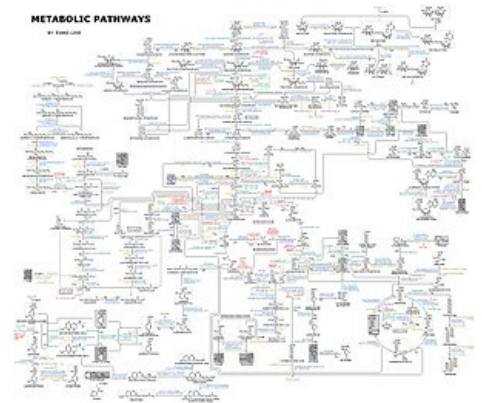
Metabolism

A summary of all enzyme-catalyzed reactions in the organism that transform essential nutrients, take place in an organized, integrated manner, with precise localization, transport and are regulated.

The processes by which living systems obtain free energy.

A set of **catabolic** (decomposing, degrading) and **anabolic** (storage, synthetic) processes. There are also *amphibolic pathways that are both anabolic and catabolic in nature. A special type are the anaplerotic reactions, which add intermediate products to the main metabolic processes.*

Synthetic processes require energy, which is obtained during the processing of nutrients from food (e.g. stored reserves of one's own body); the most important energy is that which the organism obtains through the oxidation of nutrients. The organism gradually unifies the variety of food compounds until only a few substances or only one of each type of nutrient remains.



Summary diagram of metabolic pathways

Basic Features

Energetic and Substance'

It provides energy and building material for the production of components of the organism and also produces these components. At its end, waste products are created, which are changed substances for easy elimination from the body.

1. phase: Polysaccharides are split into monosaccharides in the GIT

2. phase: The cell converts all monosaccharides to Template:D-glucose → glycolysis → pyruvate → acetyl-CoA. Conversion to acetyl-CoA results in the necessary unification (MK and AMK → acetyl-CoA), but the gain of free energy ΔG in the form of ATP is not so great that was enough for the needs of the body (only heat generation) => high energy gain necessary for endergonic (endothermic) reactions and for work is achieved by complete oxidation (burning) of the rest of acetic acid (acetyl) to CO_2 and H_2O , which are the end products of metabolism.

3. phase: Substances are burned through acetyl coenzyme A in the citrate cycle:

- CO_2 is produced during decarboxylation
- reduced cofactors NADH and FADH_2 are formed during redox reactions

Metabolism Strategy

- Maintaining a steady state – the flow of intermediates through the metabolic pathway is constant (fission – synthesis)
- Obtaining energy (production of ATP) – by oxidation of energy-rich molecules / nutrients → formation of NADH, FADH_2 → respiratory chain → oxidative phosphorylation
- Formation of NADH and NADPH – Main electron donors in reductive biosynthesis
- Gain of precursors for the synthesis of macromolecules
- Gain of special molecules – neurotransmitters, hormones and various factors
- Separate biosynthetic and degradation pathways – both pathways must be thermodynamically advantageous at all times
- The speed of metabolic pathways is rather influenced by the activity of key enzymes

Sources of free energy for the body

- Oxidation of NADH or FADH_2 formed in the citrate cycle
- Transfer of H^+ originating from nutrients and electrons + molecular oxygen → water (end metabolic product of all organic substances)
- Electron transfer from reduced cofactors → terminal respiratory chain
- Energy released along the chain bound into ATP (adenosine triphosphate) via *aerobic phosphorylation*

– The metabolism of AMK is different, as nitrogen is released from them in the form of toxic ammonia, which is processed in the urea cycle to the final non-toxic product, which is urea. Most AMK is converted to acetyl-CoA, or via rather complex pathways to components of the citrate cycle (ketogenic AMK to acetoacetate)

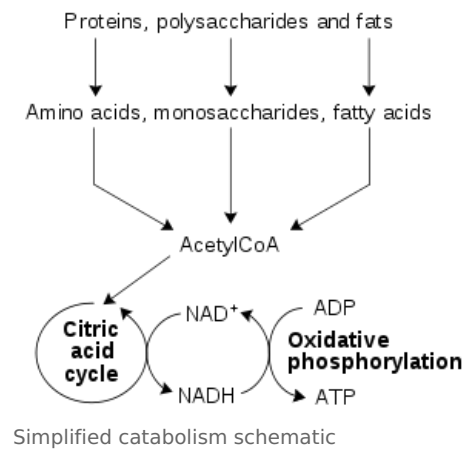
– The end product of purines (nucleic acids from food, body) is uric acid

Properties of metabolic pathways

- They are non-refundable
- They are regulated
- They take place in specific places = compartmentation.
- They contain a frequent determining degree

Catabolic reactions

1. Conversion of high-molecular substances from food into grafts – splitting of substances stored in the body
2. Unification of these fragments into simple basic products (mainly acetyl-CoA)
3. Use of basic intermediates in the citrate cycle to form CO_2 , NADH, FADH_2
4. Redox sequence. by reaction; protons from the hydrogenation cofactors NADH and FADH_2 are transferred to O_2 to form H_2O and a significant amount of usable energy in the form of ATP → end respiratory string



Anabolic reactions

1. Use of low-molecular structures to create substances with a higher molecular weight
2. Energy must be supplied for synthesis
3. Acetyl-CoA is often used as a substrate

Amphibolic reactions

They are both anabolic and catabolic in nature. E.g. Krebs cycle - running out to break down acetyl coenzyme A and at the same time provides input products for synthesis amino acids, heme and other compounds.

Anaplerotic reactions

They add products to the main metabolic processes. E.g. synthesis of oxaloacetate from pyruvate, intermediates of the citrate cycle

Basic methods of regulation

Regulation by amount of enzyme

- The amount of the enzyme depends on the rate of its synthesis (proteosynthesis) or degradation
- Setting the level of enzymes - induction or repression

Catalytic activity of enzymes

1. Reversible **allosteric** control
 1. Allosteric enzymes have multiple subunits
 2. The active and inactive form of the enzyme differ in 3D structure
 3. Substrate binding = active form
 4. Inhibitor binding = inactive form
 5. Inhibitor = negative effector
 6. Activator = positive effector
 7. An allosteric regulator can be a substrate of a reaction, a metabolite, a more distant or final product of the chain.
 8. The first reaction in many synthetic pathways is inhibited by the end product of that pathway.
2. Reversible **covalent** modification
 1. *Modulation by phosphorylation or dephosphorylation*
 1. Attachment (*kinases*) or detachment (*phosphatases*) of phosphate.
 2. Phosphorylation sites contain a free —OH group (important for phosphate uptake).
 3. Ex. Serine, Tyrosine, Threonine
 4. 50% by phosphorylation = activation
 5. 50% by phosphorylation = deactivation
 2. *Modulation by Adenylation*
 1. Attachment of AMP to enzyme molecule
 3. *Activation of zymogens*
 1. **NO** returnable
 2. Typical of protein digestion enzymes.
 3. An active enzyme is formed from an inactive proenzyme - the active site is uncovered by splicing.
 4. Important as a protection of producing cells - it acts as far as the lumen of the GIT

5. Proteolytic cleavage by enteropeptidases
6. Conversion of chymotrypsinogen to chymotrypsin
7. Activation of the hemocoagulation system

Substrate Availability

- Cell membrane:

It is not equally permeable to all molecules (e.g. Glc-6-P cannot pass through). Some molecules have special transport systems built into the membrane.

- Membranes of organelles inside the cell:

Different types have different permeability. Here, too, special transport systems appear (e.g. during MK degradation, MK must be transported into the mitochondria via a specific transport molecule carnitine)

Hormonal regulation

- Steroid hormones cause gene expression
- "First messengers" act extracellularly by binding to a membrane receptor. The response is the synthesis of the "second messenger"

Additional control mechanisms

- Department of metabolic pathways
- Compartmentation
- Organ specialization
- Enzyme inhibition

Thermodynamics of metabolic processes

- If ΔG is negative, reactions are spontaneous.
- $\Delta G < 0$ the reaction is exergonic (increasing the disorder of the universe) → The free energy of the starting substance is greater than the free energy of the product.
- $\Delta G > 0$ the reaction is endergonic (we supply energy to the system). If the reaction Product → Starting substance took place, ΔG would be greater than 0 and the universe would become more ordered. Therefore, this reaction can take place with another more energetically favorable reaction.

Explanatory notes

- NK = nucleic acids (DNA, RNA)
- MK = fatty acids
- AMK = amino acids

Links

- ws: Metabolismus

Related Articles

- Glycogen Metabolism
- Amino acid metabolism
- Pentose cycle, metabolism of fructose, galactose and glucuronic acid
- Lipid and lipoprotein metabolism

External links

- Metabolism (<https://en.wikipedia.org/wiki/Metabolism>)

Source

- WSÓL, Vladimír. *Thermodynamics of biochemical reactions* [lecture for subject General Biochemistry, specialization Pharmacy, Faculty of Pharmacy UK]. Hradec Králové. 2011-03-08.
- WSÓL, Vladimír. *Introduction to metabolism* [lecture for subject General Biochemistry, specialization Pharmacy, Faculty of Pharmacy UK]. Hradec Králové. 2011-03-09.
- WSÓL, Vladimír. *Regulation of metabolic events* [lecture for subject General Biochemistry, specialization Pharmacy, Faculty of Pharmacy UK]. Hradec Králové. 2011-05-03.

