Oxidative stress theory

Oxidative stress theory (also free radical theory) describes the importance of free radicals and oxidative reactions that are involved in the aging of the body. It was formulated in 1965, when living cells were already known to form reactive free radicals as a by-product of normal metabolic reactions.

Free radicals and ROS

Free radicals are atoms or groups of atoms that have an unpaired electron , and this electron tends to form a nonradical particle through a chemical bond between the unpaired electrons. In addition to free radicals, oxidative damage can also be caused by substances called **reactive** (https://www.wikiskripta.eu/index.php?curid=44793) oxygen species (**ROS**). Characteristic representatives of ROS are **superoxide anions** or **hydrogen peroxide** . They arise in the body through various processes such as. aerobic phosphorylation, but also by ionizing and UV radiation.

Mechanism

Free radicals, resp. ROS react with cellular proteins, nucleic acids or membrane phospholipids and cause their **oxidative damage** , which can lead to changes in their biological activity:

- **to the loss of natural protein functions ;**
- **to cause mutations in DNA ;**
- **to changes in membrane functions ;**
- **to cell damage and death .**

Across the body, the **accumulation of such changes accelerates the degenerative processes associated with aging** . Thus, according to free radical theory, the cause of aging is oxidative damage to macromolecules by free radicals, which arise as by-products of metabolism. Today, this theory is more commonly referred to as oxidative stress theory, because non-radical substances (ROS) also make a significant contribution to oxidative damage.

ROS routes

In the aging process, the action of ROS is affected by two main types of pathways:

- **pathways that affect the resulting amount of ROS throughout the body ;**
- **pathways that repair or de novo synthesize ROS-damaged structures, i. DNA, proteins and lipids .**

In group I, we can distinguish **between pathways leading to the production of ROS and pathways that eliminate the resulting amount of ROS** . Most of the oxygen in the cell is consumed by the **respiratory chain** located in the mitochondria , **and the by-products it produces (superoxide and hydroxyl radicals, hydrogen peroxide)** are a potential source of oxidative damage to the mitochondria itself and other cellular structures.

ROS-destroying pathways form a **complex antioxidant defense system *including*** *small molecules (tocopherols, vitamin C, glutathione , etc.) and* **antioxidant enzymes (superoxide dismutase - SOD, glutathione peroxidase , catalase , etc.)** The balance between ROS production and disposal determines the absolute oxidative stress levels.

Summary

Free radicals cause a high number of mutations in the cell, which depletes the capacity of repair systems (their capacity decreases with age). Mutations accumulate not only in nuclear DNA but also in mt-DNA. It is assumed that 2-3% of the oxygen atoms processed in the mitochondria are inefficiently reduced to form ROS. As a result, the mitochondrial genome has a mutation rate 10–20 times higher than the nuclear genome.

As a result, oxidative stress, as a result of both ROS and free radicals, causes a reduction in the biological activity of proteins, damage to biological membranes and mutations at the DNA level. All these changes lead to cell death and thus accelerate the aging process.

Links

Related Articles

- Basic reactive forms of oxygen and nitrogen
- Oxidative stress
- Examination of antioxidant capacity parameters

External Links

- Diseases caused by oxidative stress (oxidativestressresource.org) (http://www.oxidativestressresource.org/)
- Oxidative Stress Shortens Telomeres (PubMed.gov) (https://pubmed.ncbi.nlm.nih.gov/12114022/)

References

- NOVOTNÁ, Božena and Jaroslav MAREŠ. Developmental biology for medics. 1st edition Prague: Karolinum, 2005, 99 pp. ISBN 80-246-1023-X.