Environmental Pollution and Oxidative stress in humans/ animals

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Introduction

- WHO has announced that more than one million deaths worldwide could be due to the effects of air pollution.
- Air pollution has long been recognized as being detrimental to health.
- In the past, attention was paid to the respiratory effects of pollution, as there is a clear link between higher air pollution and exacerbation of allergic diseases and lung infections, such as asthma.

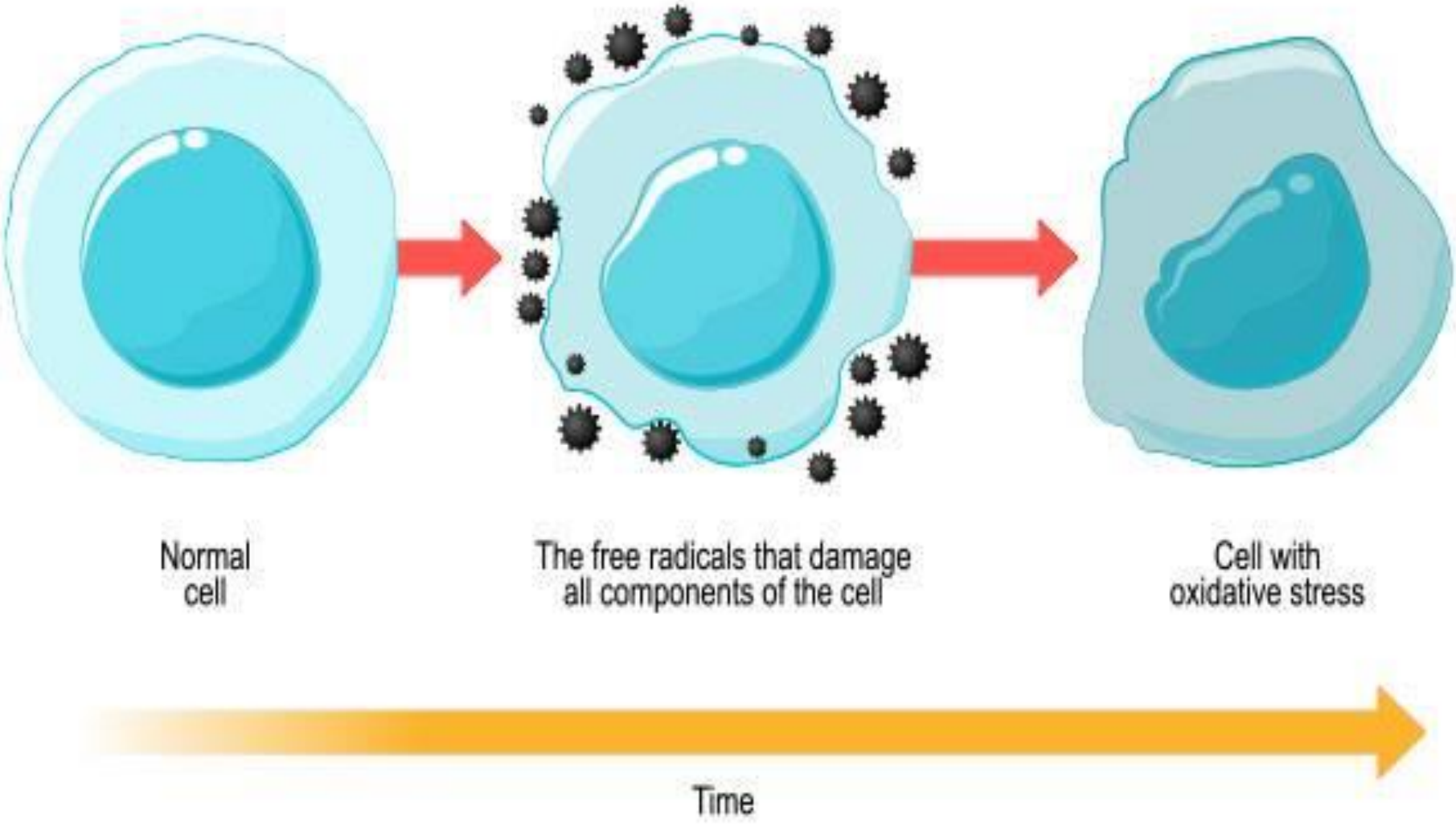
Oxidative Stress

- Our cells use almost all of the oxygen we breathe in for energy production. But around 2% doesn't get used. This "extra" oxygen splits into single atoms.
- Those molecules, called free radicals, contain an uneven number of electrons which makes them unbalanced and very reactive to other molecules they meet.
- These free radicals react with other molecules. The reaction that occurs is called oxidation. It's a perfectly normal process, and even essential for our bodies to function properly. But it can also be harmful.

Oxidative Stress

- On the other hand, antioxidants are stable molecules.. they give free radicals an electron generously while remaining stable. This borrowing electron stabilizes free radicals and becomes less reactive.
- But sometimes there are far too many free radicals and far too few antioxidants in the crowd. Things are out of balance. This is when oxidative stress occurs.
- Without enough stabilizing antioxidants around to keep the crowd under control, the free radicals can turn into a raging mob. They begin to cause damage to DNA, proteins and fatty tissues in the body.

Oxidative stress

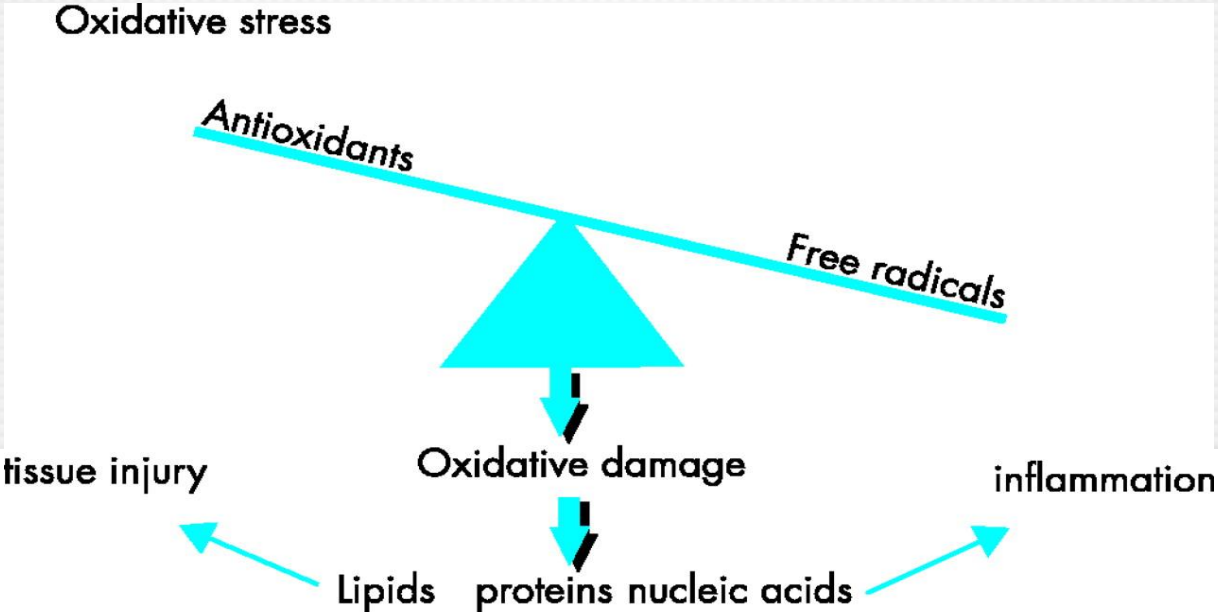


Pollution and oxidative stress

- Modern scientific research found a linkage between air pollution, especially airborne particulate matter (PM), and adverse effects of cardiovascular system.
- More than two thirds of the mortality attributed to air pollution arise from cardiovascular causes, in particular ischmic heart disease and cerebrovascular disease.
- According to Miller (2020), oxidative stress plays a key role in the cardiovascular effects of many air pollutants.

Pollution and oxidative stress

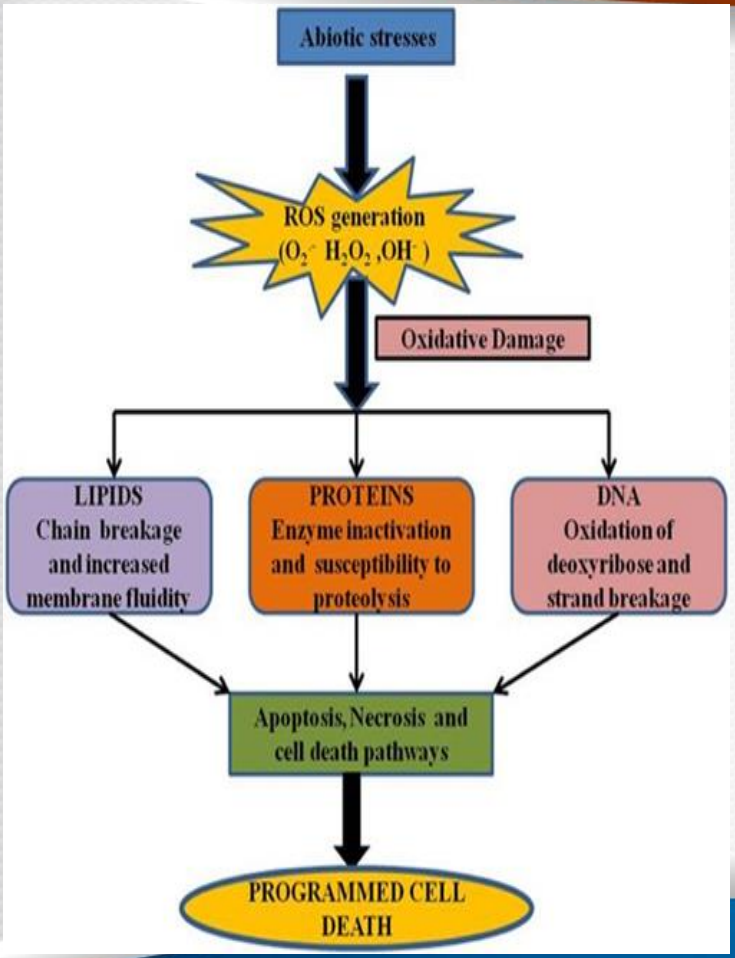
- There is a fine balance between free radicals and a variety of endogenous antioxidants.
- Oxidative stress exists when there is an excess of free radicals over antioxidant defences. As a consequence, free radicals attack and oxidise other cell components such as lipids (particularly polyunsaturated lipids), proteins, and nucleic acids. This leads to tissue injury and in some cases, the influx of inflammatory cells to the sites of injury.

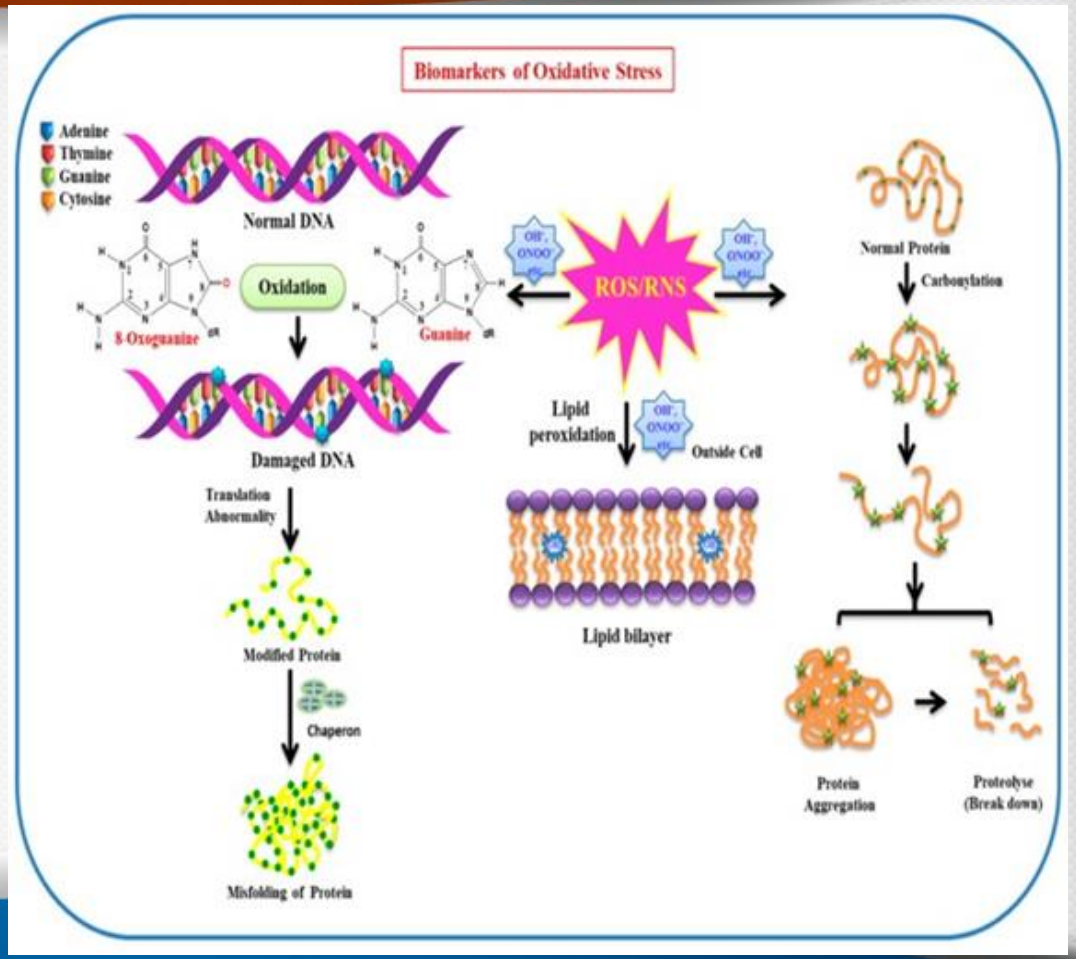


ROS causing oxidation of Proteins, Lipids and Nucleic acids.

- Reactive oxygen species (ROS) induced oxidative damage to lipids, proteins and nucleic acids. Oxidative stress, induced by the accumulation of reactive oxygen species (ROS) such as O▪−2, H2O2 and OH▪, which can bring out a range of stress responses. Exposure of cells to severe oxidative stress can elicit lethal response pathways such as apoptosis, necrosis, and possibly other forms of cell death pathways which can ultimately lead to programmed cell death

ROS causing oxidation of Proteins, Lipids and Nucleic acids.





Environmental pollutant that causes oxidative stress; heavy metals, EDCs, microplastics

- The exponential growth of pollutaant discharges into the environment due to increasing industrial and agricultural activities is a rising threat for human health and a biggest concern for environmental health globally. Several synthetic chemicals, categorized as potential environmental endocrine-disrupting chemicals (EDCs), are evident to affect the health of not only livestock and wildlife but also humankind

Environmental pollutant that causes oxidative stress; heavy metals, EDCs microplastics

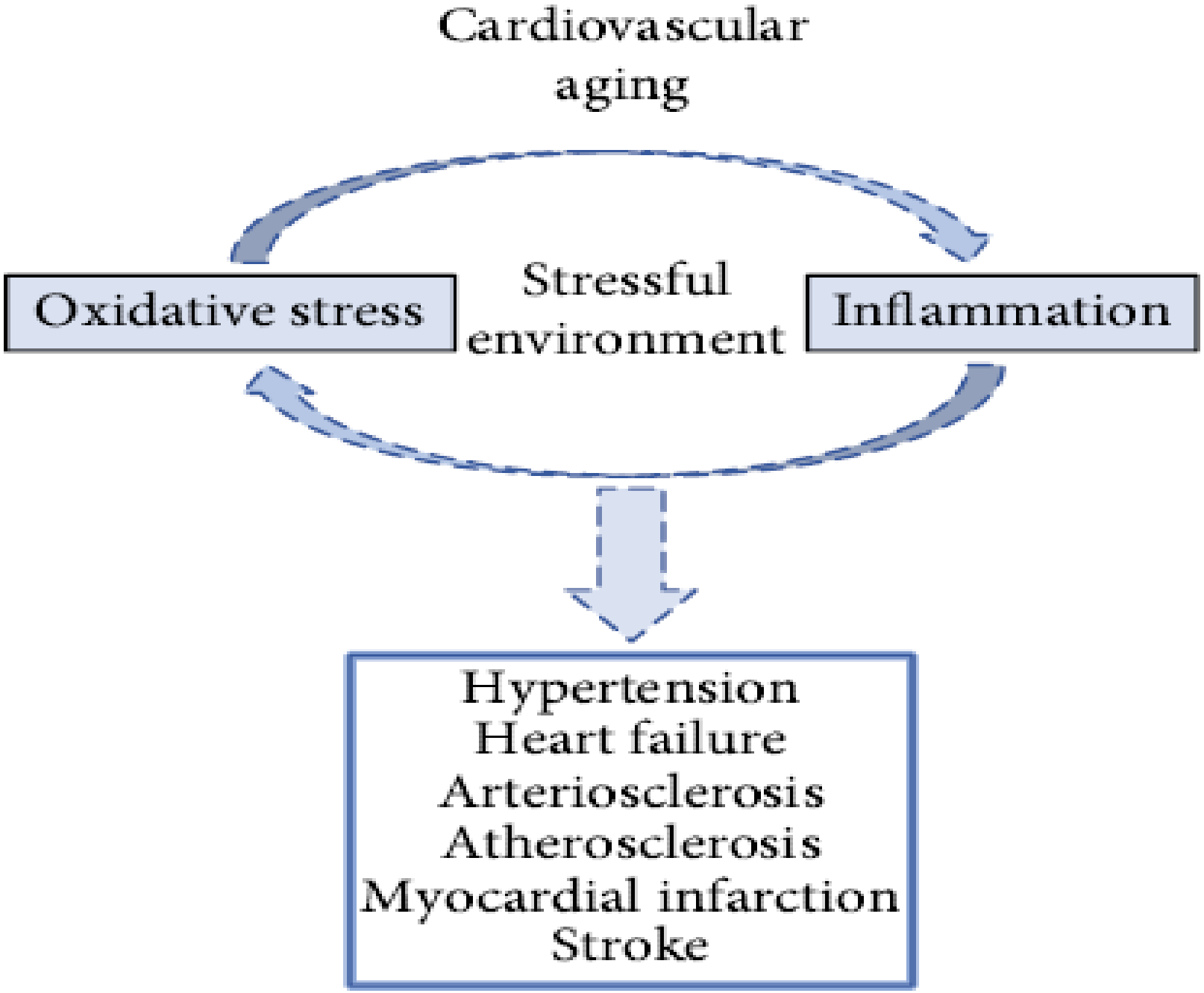
- Exposure of plastics to high temperature can
- lead to leaching or migration of toxic components in environment in the form of microplastics or nanoplastic.
- Drinking water particularly is thought to be a source of significant exposure through leaching, industrial waste discharge and inadequate treatment of water supply for chemicals.
- EDCs can also be transferred from mother to child through trans-placental route as well as through breast milk.

Environmental pollutant that causes oxidative stress; heavy metals, EDCs, microplastics

- Microplastic has been reported to act as vectors by sorbing pollutants and contributing to the bioaccumulation of pollutants, particularly in marine ecosystems, organisms, and subsequently food webs.

Affect on humans

- In humans, oxidative stress is thought to be involved in the development of ADHD, cancer, Parkinson's disease, Lafora disease, Alzheimer's disease, atherosclerosis, heart failure, myocardial infarction, fragile X syndrome, sickle- cell disease, autism, and depression and seems to be characteristic of individuals with Asperger syndrome.


Cardiovascular
aging
Oxidative stress
Stressful
environment
Inflammation
Hypertension
Heart failure
Arteriosclerosis
Atherosclerosis
Myocardial infarction
Stroke

The antioxidant system of the body; role of enzymes

- An antioxidant is a molecule which has the ability to prevent or slow the oxidation of macromolecules.
- The role of antioxidants is to lower or terminate these chain reactions by removing free radicals or inhibiting other oxidation reactions by being oxidized themselves. So, antioxidants are often reducing agents such as polyphenols or thiols

The antioxidant system of the body; role of enzymes

- In order to maintain proper cell signaling, it is likely that a number of radical scavenging enzymes maintain a threshold level of ROS inside the cell. When the level of ROS exceeds this threshold, the increase in ROS production may lead to excessive cell signaling, as well as damage to key components of the signaling pathways

- Oxidative stress occurs when the balance between formation of reactive oxygen species and detoxification leads to increased levels of reactive oxygen species, resulting in a disturbance of cellular function.

- (R O S) can also damage DNA, protein, and lipids, which may lead to the initiation of carcinogenesis.
- Concentrations of reactive oxygen species must be controlled by several defense mechanisms, including a number of antioxidants and detoxifying enzymes

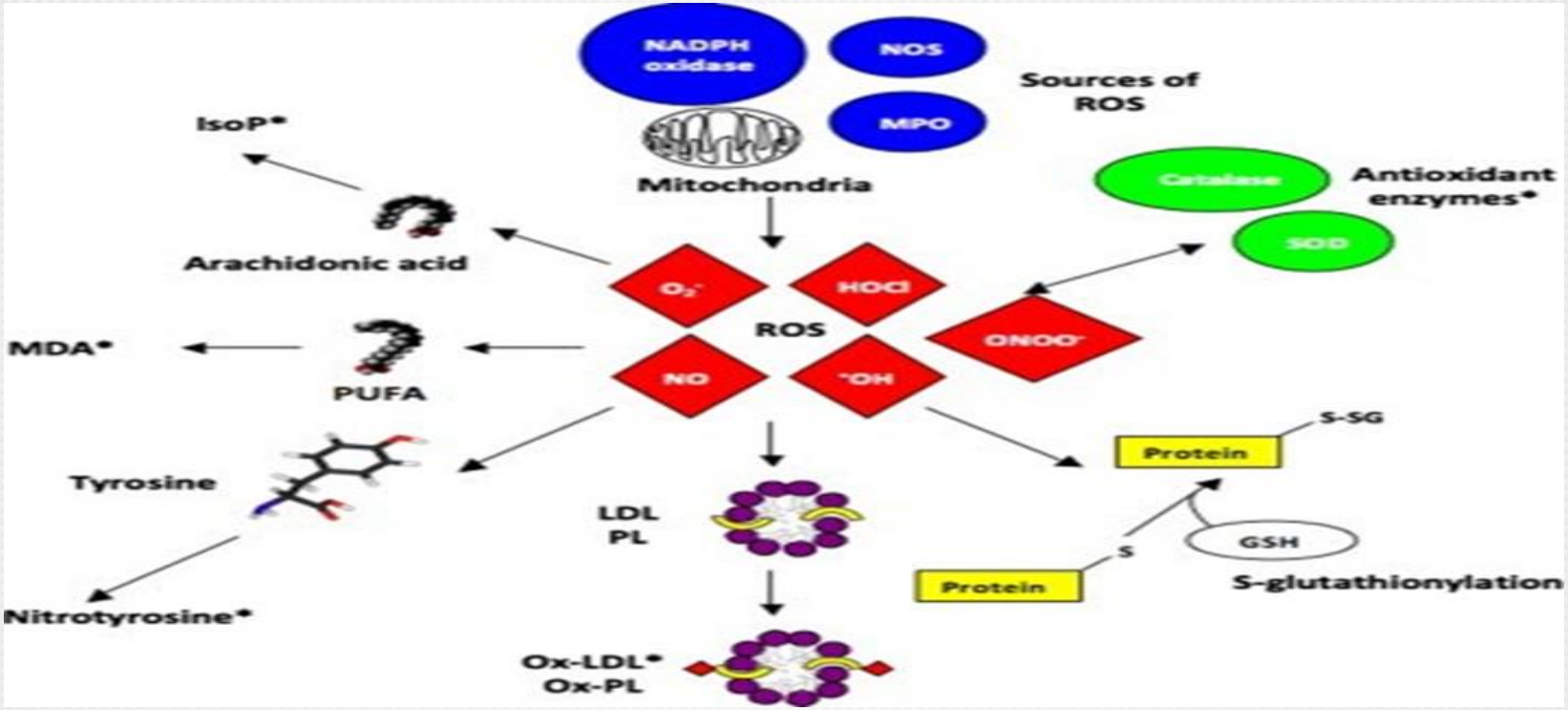
The antioxidant system of the body; role of enzymes

- Oxidation reactions are important for cells,
- but they have harmful effects; Thus, plants and animals contain many antioxidants, such as vitamins C and E and glutathione, as well as various enzymatic systems that catalyze antioxidant reactions such as catalase, superoxide dismutase (SOD) and peroxidase. Defects or inhibition of these antioxidant enzymes lead to oxidative stress and cells may be damaged and destroyed.

Biomarkers of oxidative stress; biochemical and molecular

- Biomarkers of oxidative stress can be classified as molecules that are modified by interactions with ROS in the microenvironment; and molecules of the antioxidant system that change in response to increased redox stress. DNA, lipids (including phospholipids), proteins and carbohydrates are examples of molecules that can be modified by excessive ROS in vivo

Biomarkers of oxidative stress; biochemical and molecular.



Biomarkers of oxidative stress; biochemical and molecular.

- Two of the most well studied markers of lipid peroxidation are isoprostanes (IsoPs) and malondialdehyde (MDA).
- Other lipid oxidation products that have been explored as biomarkers include lipid hydroperoxides, fluorescent products of lipid peroxidation, oxidation resistance assays and oxysterols

Biomarkers of oxidative stress; biochemical and molecular

ROS-induced changes in gene expression

ROS levels affect key expression Genes involved in the regulation of cellular and systemic oxidative stress.

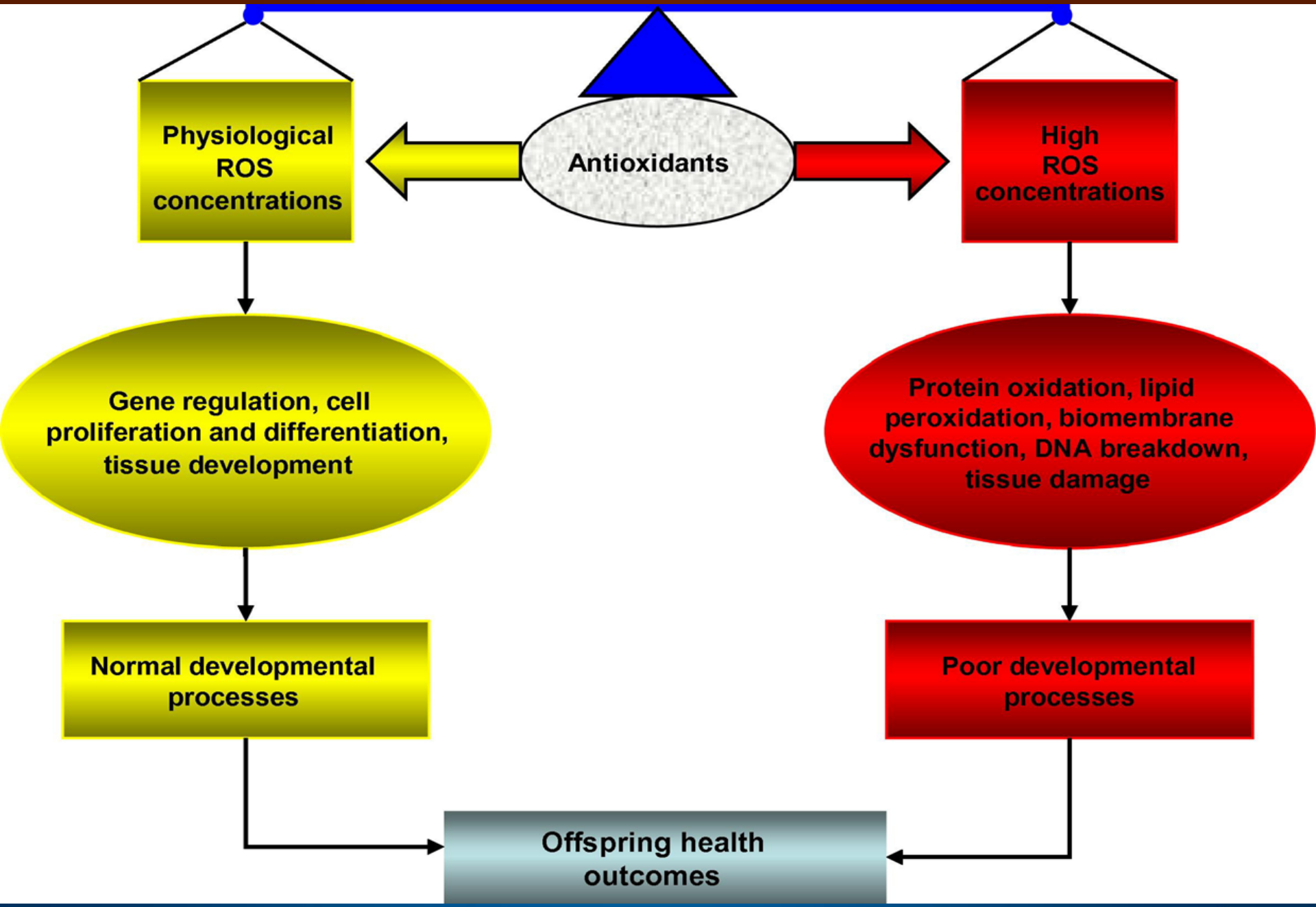
Example: nuclear factor (derived from erythrocytes 2) -like 2Nrf-2, a transcription factor that is upregulated in response to Oxidative stress leads to increased expression of cellular antioxidant enzymes Additional examples include

Peroxisome proliferator-activated receptor gamma activator

1-alpha (PGC-1α) and thioredoxin .

Biomarkers of oxidative stress; biochemical and molecular

- Clinical and epidemiological data show an association of typical oxidative stress markers such as lipid peroxidation products, 3-nitrotyrosine or oxidized DNA/RNA bases with all major cardiovascular diseases, which supports the concept that the formation of reactive oxygen and nitrogen species by various sources represents a hallmark of the leading cardiovascular comorbidities such as hyperlipidemia, hypertension and diabetes


Physiological ROS concentrations
Antioxidants
High ROS concentrations
Gene regulation, cell proliferation and differentiation, tissue development
Protein oxidation, lipid peroxidation, biomembrane dysfunction, DNA breakdown, tissue damage
Normal developmental processes
Poor developmental processes
Offspring health outcomes

studies

Exposure to nano-BCs in the aquatic environment. The results showed that all carbon nanocomposites inhibit algal growth and that nano-BC causes both oxidative stress, which is attributed to the overproduction of intercellular reactive oxygen species (ROS). Nutrient uptake in nano-BC compounds could be a major factor in their distinctive biological effects on algae. These results provide useful information about the biological effects of carbon nanocomposites on aquatic organisms *(Hauang, et al., 2021).*

studies

2- This study reports that the toxicity of microbeads was size dependent and that smaller microbeads were more toxic. Examinations revealed that antioxidant-related enzymes and MAPK signaling pathways were significantly activated in response to microplastic exposure in a size-dependent manner(

Jeong ,et all..2016)

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