Free radicals

Free radicals are atoms or groups of atoms with an odd (unpaired) number of electrons and can be formed when oxygen interacts with certain molecules. Once formed these highly reactive radicals can start a chain reaction. Their chief danger comes from the damage they can do when they react with important cellular components such as DNA, or the cell membrane. Cells may function poorly or die if this occurs. To prevent free radical damage the body has a defense system of *antioxidants.*

Oxidative stress

Oxidative stress is essentially an imbalance between the production of free radicals and the ability of the body to counteract or detoxify their harmful effects through neutralization by antioxidants.

Oxidative stress occurs when excess oxygen radicals are produced in cells, which could overwhelm the normal antioxidant capacity. When the concentration of reactive species is not controlled by internal defense mechanisms such as antioxidants (tocopherols, ascorbic acid, and glutathione) or enzymes involved in oxygen radical scavenging (catalase, peroxidase, and superoxide dismutase, SOD), oxidative damage occurs to proteins, lipids, and DNA, which could lead to cytotoxicity, genotoxicity, and even carcinogenesis when damaged (mutated) cells can proliferate. Oxidative stress could results from the following: (1) the presence of xenobiotics, (2) the activation of the immune system in response to invading microorganisms (inflammation), and (3) radiation, which makes oxidative stress a common denominator of toxicity or stress.

Generation of Free radicals in the body

The human body produces oxygen free radicals and other reactive oxygen species as by products through numerous physiological and biochemical processes. Oxygen-related free radicals (superoxide and hydroxyl radicals) and reactive species (hydrogen peroxide, nitric oxide, peroxynitrile, and hypochlorous acid), are produced in the body, primarily as a result of aerobic metabolism. At the same time, compounds such as glutathione, arginine, citrulline, taurine, creatine, selenium, zinc, vitamin E, vitamin C, vitamin A, and polyphenols routinely found in the food supply help to regulate the reactive oxidative species generated.

Major antioxidants

Antioxidants are compounds that inhibit oxidation.

Antioxidants are classified into two broad divisions, depending on whether they are soluble in water (hydrophilic) or in lipids (lipophilic). In general, water-soluble antioxidants react with oxidants in the cell cytosol and the blood plasma, while lipid-soluble antioxidants protect cell membranes from lipid peroxidation. These compounds may be synthesized in the body or obtained from the diet. The different antioxidants are present at a wide range of concentrations in body fluids and tissues, with some such as glutathione or ubiquinone mostly present within cells, while others such as uric acid are more evenly distributed.

Antioxidants are found in certain foods and may prevent some of the damage caused by free radicals by neutralising them. These include the nutrient antioxidants, vitamins A, C and E, and the minerals copper, zinc and selenium.

The three major antioxidant vitamins are beta-carotene, vitamin C, and vitamin E.

Vitamin C

Ascorbic acid or "vitamin C" is a monosaccharide oxidation-reduction (redox) catalyst found in both animals and plants. Ascorbic acid is a redox catalyst which can reduce, and thereby neutralize, reactive oxygen species such as

hydrogen peroxide. ascorbic acid is also a substrate for the redox enzyme ascorbate peroxidase, a function that is particularly important in stress resistance in plants.

Vitamin E

Vitamin E is the collective name for a set of eight related tocopherols and tocotrienols, which are fat-soluble vitamins with antioxidant properties. α-tocopherol is the most studied as it has the highest bioavailability, with the body preferentially absorbing and metabolising this form.

α-tocopherol form is the most important lipid-soluble antioxidant, and it protects membranes from oxidation by reacting with lipid radicals produced in the lipid peroxidation chain reaction. This removes the free radical intermediates and prevents the propagation reaction from continuing. This reaction produces oxidised α-tocopheroxyl radicals that can be recycled back to the active reduced form through reduction by other antioxidants, such as ascorbate, retinol or ubiquinol.

B- carotene

Beta carotene, like all carotenoids, is an antioxidant. Beta carotene is a red/orange pigment found in many fresh fruits and vegetables. Beta carotene is converted into vitamin A, an essential vitamin. Vitamin A is toxic at high levels. Beta carotene is a carotenoid and an antioxidant

Vitamins/mineral	Location in the cell	Functions
Vitamin C	Ascorbic acid (cytosol)	Reacts with several types of ROS/RNS
Vitamin E	α-tocopherol (membranes)	Breaks fatty acid peroxidation chain reactions
β-carotene	β-carotene (membranes)	Prevents initiation of fatty acids peroxidation chain reaction
Selenium	Glutathione peroxidase (cytosol)	An enzyme that converts hydrogen peroxide to water
Copper and zinc	Superoxide dismutase (cytosol)	An enzyme that converts superoxide to hydrogen peroxide
Manganese and zinc	Superoxide dismutase (mitochondria)	An enzyme that converts superoxide to hydrogen peroxide
Copper	Ceruloplasmin (water phase)	An antioxidant protein, may prevent copper and iron from participating in oxidation reactions
Iron	Catalase (cytosol)	An enzyme (primarily in liver) that converts hydrogen peroxide to water