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## What Are Antioxidants?

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All living organisms utilize oxygen to metabolize and use the dietary nutrients in order to produce energy for survival. Oxygen thus is a vital component for living. Oxygen mediates chemical reactions that metabolize fats, proteins, and carbohydrates to produce energy.



## Dark side of oxygen

While oxygen is one of the most essential components for living, it is also a double edged sword. Oxygen is a highly reactive atom that is

capable of becoming part of potentially damaging molecules commonly called “free radicals.”



## **Free radicals**

These free radicals are capable of attacking the healthy cells of the body. This may lead to damage, disease and severe disorders. Cell damage caused by free radicals appears to be a major contributor to aging and diseases like:

- cancer
- heart disease
- decline in brain function
- decline in immune system etc.

Overall, free radicals have been implicated in the ***pathogenesis*** of at least 50 diseases.

Since free radicals contain an unpaired electron, they are unstable and reach out and capture

electrons from other substances in order to neutralize themselves. This initially stabilizes the free radical but generates another in the process. Soon, a chain reaction begins and thousands of free radical reactions can occur within a few seconds on the primary reaction.



## **Reactive oxygen species (ROS)**

ROS is a term which comprises of all highly reactive, oxygen-containing molecules, including free radicals. Types of ROS include the hydrogen peroxide, nitric oxide radical, singlet oxygen, and various lipid peroxides. These can react with **membrane lipids**, nucleic acids, proteins and enzymes, and other small molecules.

## **Oxidative stress**

Oxidative stress means an unbalance between pro-oxidants and antioxidant mechanisms. This results in excessive oxidative metabolism. This stress can be due to several environmental factors such as



exposure to pollutants, alcohol, medications, infections, poor diet, toxins, radiation and etc. Oxidative damage to DNA, proteins, and other macromolecules may lead to a wide range of human diseases most notably, heart disease and cancer.



## **Control of free radicals**

***Novel genetic mutations*** may explain link between high HDL cholesterol and reduced heart disease risk.

Normally, free radical formation is controlled naturally by various beneficial compounds known as antioxidants.

When there is deficiency of these antioxidants, damage due to free radicals can become cumulative and ***debilitating***. Antioxidants are capable of stabilizing, or deactivating, free radicals before they attack cells.



## **Antioxidants from food**

There are several nutrients in food that contain antioxidants. Vitamin C, vitamin E, and beta carotene are among the most commonly studied dietary antioxidants.

Vitamin C is the most important water-soluble antioxidant in extracellular fluids. Vitamin C helps to neutralize Reactive Oxygen Species (ROS) in the water or aqueous phase before it can attack the lipids.

Vitamin E is the most important lipid soluble antioxidant. It is important as the chain-breaking antioxidant within the cell membrane. It can protect the membrane fatty acids from lipid peroxidation. Vitamin C in addition is capable of regenerating vitamin E.

Beta carotene and other carotenoids also have antioxidant properties. Carotenoids work in **synergy** with vitamin E.

## **Antioxidant deficiencies**

A diet low in fats may impair absorption of beta carotene and vitamin E and other fat-soluble nutrients. Fruits and vegetables are important sources of vitamin C and carotenoids. Whole grains and high quality vegetable oils are major sources of vitamin E.



The antioxidant networks in the body are complex and are composed of several components. These may be **endogenous** factors such as glutathione, thiols, haem proteins, coenzymes Q, bilirubin and urates. These may also be endogenous enzymes like GSH reductase, GSH transferase, GSH peroxidises, superoxide dismutase and catalases.



## Dietary factors

Some nutritional and dietary factors also function as antioxidant **metabolites** or parts of the antioxidant metabolic pathways. These include ascorbic acid or vitamin C, tocopherols or vitamin E, beta carotenes and retinoids, selenium and etc.

Antioxidant metabolite	Solubility	Concentration in human serum ( $\mu\text{M}$ )	Concentration in liver tissue ( $\mu\text{mol/kg}$ )
Ascorbic acid (vitamin C)	Water	50 – 60	260 (human)
Glutathione	Water	4	6,400 (human)
Uric acid	Water	200 – 400	1,600 (human)retinol (vitamin A): 1 – 3
$\alpha$ -Tocopherol (vitamin E)	Lipid	10 – 40	200 (human)

Apart from diet, the body also has several antioxidant mechanisms that can protect itself from **ROS mediated damage**. The antioxidant enzymes – glutathione peroxidase, catalase, and superoxide dismutase (SOD) are such enzymes. They require micronutrient cofactors such as selenium, iron, copper, zinc, and manganese for their activity. It has been suggested that an inadequate dietary intake of these trace minerals may also lead to low antioxidant activity.

# Power Words

**pathogenesis** - the manner of development of a disease

**membrane lipids** – compound which belongs to a group of (structurally similar to fats and oils) which form the double-layered surface of all cells (lipid bilayer).

**novel genetic mutations** – new type of change in the genes which can be spontaneous or caused by other environmental factors

**debilitating** – making someone very weak and infirm

**synergy** – interaction of two or more agents or forces so that their combined effect is greater than the sum of their individual effects

**carotenoids** – any of a class of mainly yellow, orange, or red fat-soluble pigments, including carotene, which give colour to plant parts such as ripe tomatoes

**endogenous** – having an internal cause or origin

**metabolites** – a substance formed in or necessary for metabolism

**ROS mediated damage** – cell damage caused by reactive oxygen species