Antioxidants and Herbs

Presented at the ACHS 3rd Annual Herb Day Celebration 2008

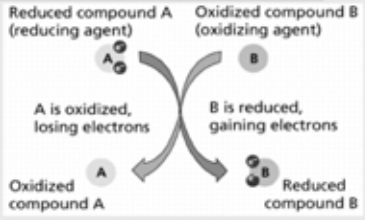
- What are antioxidants?
- Why are they useful in our bodies and herbal medicine?
- Where are they found in herbs?

Antioxidants?

- The word seems to be everywhere!
- Diet books, supplement labels, cancer cures, skin care, tea – the list goes on.
- Do we know what they are exactly and what they actually do?
- Free radical fighters – but, what are free radicals and where do they come from?
- Immune system boosters and infection fighters – but, how?
- We must start with a bit of chemistry.

Oxidation Reduction Reactions - Redox

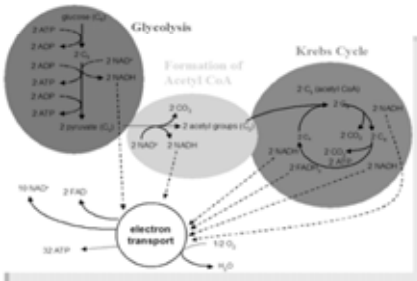
- Oxidation describes the loss of electrons by a molecule, atom or ion.
- Substances that have the ability to remove electrons from another substances, or oxidize, are called oxidants or oxidizers.
- Reduction describes the gain of electrons by a molecule, atom, or ion.
- Substances that have the ability to transfer electrons to another substance, or reduce, are called reductants or reducers.
- Oxidation was named after oxygen because this molecule is the most common and one of the strongest oxidizers on earth.
- The rusting or oxidizing of iron is an example of this type of reaction.
- $Fe^{+2} \rightarrow Fe^{+3} + e^-$
- $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

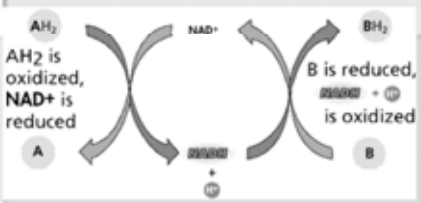


Reduction
Oxidant + e^- → Product
(Gain of Electrons) (Oxidation Number Decreases)

Oxidation
Reductant → Product + e^-
(Loss of Electrons) (Oxidation Number Increases)

Redox Reactions in the Body and Biology

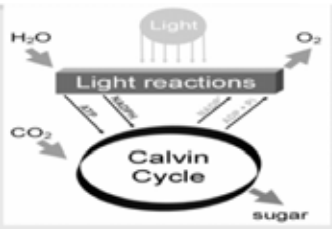


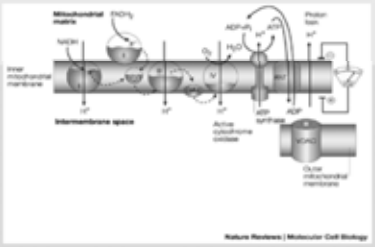


- Our first basic definition of "antioxidant" is a substance that prevents oxidation.
- But where does oxidation happen in the body?
- Would we want to prevent oxidation in the body?
- Actually many of the important biological processes in both our bodies and plants are driven by redox reactions.
- Cellular respiration for example is the oxidation of glucose $C_6H_{12}O_6$ to CO_2 and the reduction of oxygen O_2 to water H_2O.
- Even the intermediate steps of this process depend heavily on two redox rxns – the reduction of NAD^+ to NADH and the reverse the oxidation of NADH to NAD^+

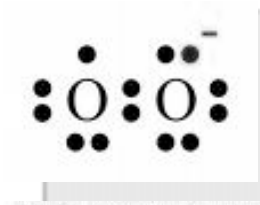
Redox Reactions in the Body and Biology

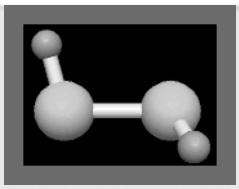
- In plants, photosynthesis is also driven by redox reactions.
- Photosynthesis produces the glucose needed for fuel through the reduction of carbon dioxide into sugars and the oxidation of water into molecular oxygen.
- The reason both photosynthesis and cellular respiration can be continually generated via redox reactions is because of the large amount of energy released when electrons are transferred from reductants to oxidants.
- This energy can be harnessed to produce ATP, the molecule that truly supplies the energy for metabolism.
- However, nature cannot completely manage the outcome of every redox exchange. It is the intermediate steps that can create dangerous by-products.

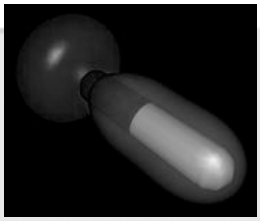




Free Radicals and the Electron Transport Chain







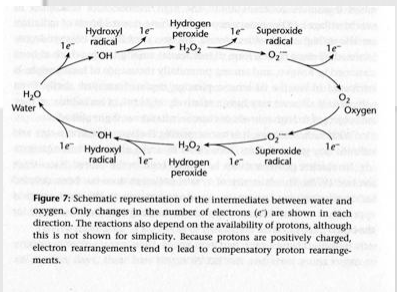


Figure 7: Schematic representation of the intermediates between water and oxygen. Only changes in the number of electrons (e^-) are shown in each direction. The reactions also depend on the availability of protons, although this is not shown for simplicity. Because protons are positively charged, electron rearrangements tend to lead to compensatory proton rearrangements.

A free radical is an atom or molecule that contains a single unpaired electron. This makes them highly reactive.

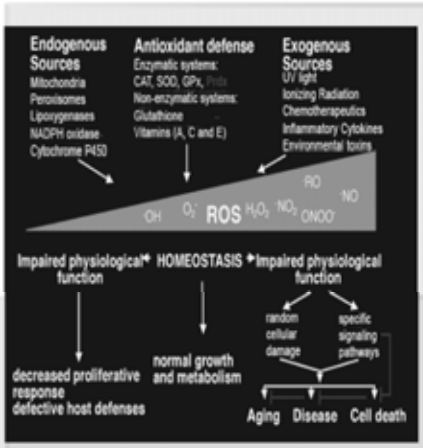
The three main free radicals produced in the body are:

The superoxide radical – $O_2^{\cdot-}$

Hydrogen peroxide – H_2O_2

The Hydroxyl radical – $^{\cdot}OH$

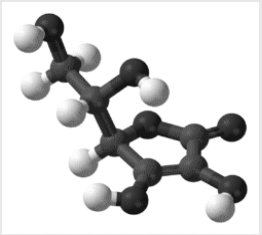
Reactive Oxygen Species – Oxidative Stress



- Our bodies are constantly harnessing the power of oxidation and working to neutralized the damage it can cause to cells.
- When there are more free radicals than antioxidants, oxidative stress can occur on many levels.
- The main defense and buffer for Reactive Oxygen Species or ROS is antioxidants.
- We produce enzymes and specific antioxidant molecules that are designed to neutralize the common free radicals produced during cellular respiration and other cell processes.
- However, we do have to supplement this defense with antioxidants that come from outside the body – i.e. from the diet. In doing so we are able to also utilize the molecules that plants use to fight this same problem

How Antioxidants Help

- React with free radicals and ROS to neutralize them without starting a chain reaction.
- Help return other oxidized anti-oxidants to their neutral state. This prevents cell damage such as DNA damage, lipid or cell membrane oxidation which can lead to loss of intracellular K^+ ions.
- Chelate metals to prevent reactions which can form even more free radicals.
- Protect macrophages and other phagocytic white blood cells during infection.
- In these ways, anti-oxidants fill the gap when our cells and even our body is under oxidative stress. This leads to more optimal cell function and perhaps overall health.
- Vitamin C and Vitamin E work separately and together as antioxidants

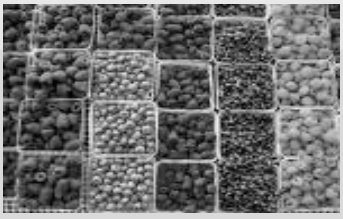


Herbal Sources for Antioxidants

- There are several common antioxidants found in herbs.
- Vitamin C – reducing agent, chelates metals, protects other antioxidants such as Vitamin A and E and essential fatty acids from oxidative damage
- Polyphenols, especially flavonoids – reducing agents, metal chelators, ROS scavengers, chain- breaking antioxidants, can stop formation of oxygen singlets. Work while protecting Vit.C and increase Vit.C absorption. Often yellow in color – relates to the tonic herbs.
- Beta-carotene and carotenoids – effective free radical scavengers. Usually orange and red in color.

Herbal Sources of Antioxidants

- Calendula – Lycopene, carotenoids
- Capsicum, Dandelion – Vit. A and C
- Vitamin C – Shepherd's Purse, Plantain, Meadowsweet, Juniper, Bilberry, Agrimony, Horehound, Burnet, Yellow dock, Nettle
- Ginkgo, Licorice, Astragalus, Garlic, Ginger, Turmeric
- Alfalfa, Artichoke, Cat's Claw, Chiretta, Hawthorne, Marjoram, Milk Thistle, Red Sage, Rosemary, Tarragon, Thyme, Witch Hazel
- Of course, the best source of antioxidants is plenty of fresh, organic fruits and vegetables in the daily diet



Further Reading

- Oxygen, The Molecule That Made the World by Nick Lane
- Medical Herbalism The Science and Practice of Herbal Medicine by David Hoffman
- Planetary Herbology by Michael Tierra
- Principles and Practice of Phytotherapy by Simon Mills and Kerry Bone
- Wikipedia articles on antioxidants, free radicals, redox, cellular respiration, and photosynthesis