Vitamin C (ascorbic acid)

Ascorbic Acid (Vitamin C)

King and Waugh in 1933, isolated from orange, an antiscurvy substance having strong reducing nature. Its structure was established in 1938 by Howarth and it was named as ascorbic acid. Its reducing nature was due to its strong tendency to donate reducing equivalents.

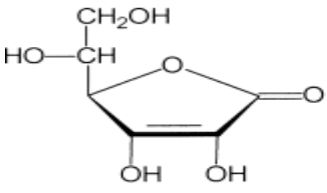
Absorption and Storage of Vitamin C

Vitamin C is absorbed from the small intestine by a carriermediated process at the luminal surface that requires a sodium gradient. The transport resembles the sodium-dependent transport of sugars and amino acids (Chapter 7). The effi - ciency of absorption is high (80–90%). Following absorption, the vitamin circulates in plasma, red cells and leukocytes. It is found in highest concentrations in the adrenals, the pituitary and the retina, in that order.

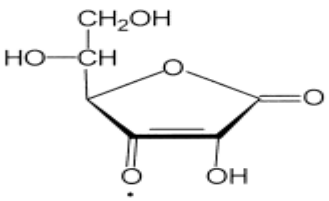
Structure and Synthesis of Vitamin C

The structure of ascorbic acid resembles monosaccharides (hexoses) and it can exist as L- and D-isomers. Only the L form possesses the vitamin activity.

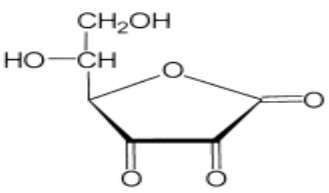
Vitamin C is synthesized by most of the plant and the animal kingdom in uronic acid pathway (Chapter 10). Only humans, higher primates, guinea pigs, and fruit-eating bats have lost the ability to synthesize the vitamin because of lack of the enzyme L-gluconolactone oxidase, that converts gluconolactone to ascorbic acid. Therefore, vitamin C is an essential nutrient in these animals.



ascorbate



monodehydroascorbate
(semidehydroascorbate)



dehydroascorbate

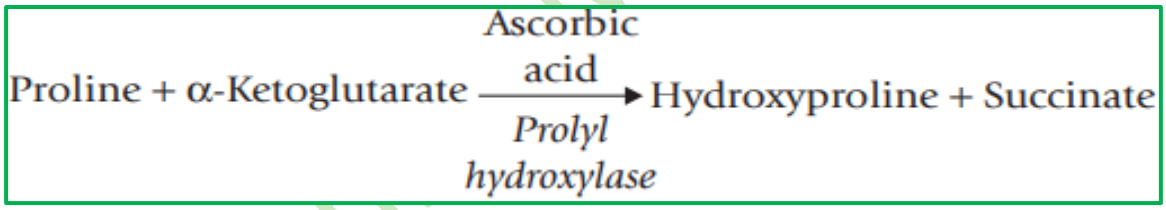
Functions of Vitamin C (Ascorbic acid)

Vitamin C (Ascorbic acid) functions as a reducing agent and a scavenger of free radicals (antioxidant).

1- As a reducing agent: Ascorbic acid is promptly oxidized to its biological equivalent dehydroascorbic acid, which can be readily reduced to re-form ascorbic acid. Mechanism of action of ascorbic acid relative to its many activities is explained by its ability to undergo such reversible oxidation and reduction reactions. In a large proportion of reactions, the prime function of this vitamin is to maintain metal co-factors in their lower valence state, e.g. Fe2and Cu.

Some of the important ascorbate-dependent reactions are as below:

(a) During collagen biosynthesis, the hydroxylases causing post-translational hydroxylation of prolyl and lysyl residues require ascorbate.



Thus, vitamin C plays a role in the formation of matrix of bones, cartilages, and connective tissue. In absence of vitamin C, newly synthesized collagen cannot form fi bres properly, which accounts for the prominent connective tissue abnormalities of scurvy.

(b) Synthesis of norepinephrine from dopamine by the enzyme dopamine b-monooxygenase depends on vitamin C (Fig. 13.23).

(c) Carnitine synthesis requires two Fe2-containing ascorbate-dependent dioxygenases. Carnitine deficiency decreases mitochondrial fatty acid oxidation and thereby contributes to the fatigue, characteristic of scurvy.

(d) During bile acid synthesis in liver mitochondria, the 7-a-hydroxylase reaction requires ascorbic acid.

(e) Absorption of iron is aided by vitamin C by converting ferric to ferrous ions (Fig. 19.2).

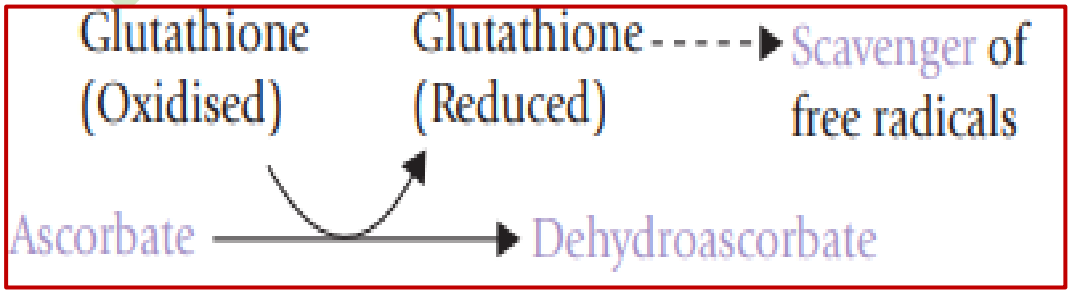
(f) During steroidogenesis, ascorbic acid is thought to participate in several oxidation-reduction reactions. This may explain highest tissue concentrations of ascorbate in the adrenal cortex.

(g) Ascorbate participates in tyrosine catabolism by serving as coenzyme for 4-hydroxyphenylpyruvate dioxygenase.

(h) Vitamin C also participates in bone mineral metabolism.

NOTE: Vitamin C deficiency (scurvy) results in connective tissue problems because of impaired collagen synthesis.

2. As an antioxidant: Ascorbic acid is not only one of the strongest naturally occurring reducing agents known, but it can also serve as an antioxidant in several nonenzymatic reactions. It decreases oxidation of DNA and arrests protein damage, reduces lipid peroxidation and oxidation of low-density lipoproteins, and decreases production of extracellular oxidants from neutrophils. Because of these actions it provides several health benefi ts, especially in prevention of atherosclerosis and coronary heart disease.



An important area associated with its antioxidant properties is in the prevention and treatment of cancer. For example, it may suppress the formation of potentially carcinogenic nitrosamines from dietary nitrite and nitrate in the stomach, which may explain its protective effect in cancer. Epidemiological studies suggest that vitamin C exerts a synergistic effect with other dietary antioxidants, vitamin E and carotenoids, and this may have a signifi cant role in the prevention of cancer, cardiovascular disease and cataract formation. The quantitative contributions of these components to the overall effect are not known.

NOTE: Vitamin C (water-soluble antioxidant), acts together with membrane antioxidants (vitamins A and E) to limit the extent of free radical-mediated oxidative reactions. They prevent lipid peroxidation, and may have antimutagenic properties

Clinical Deficiency of Vitamin C (Ascorbic acid), Scurvy,

Scurvy, the vitamin C deficiency disease, first became prominent during the 15th century among sailors on long voyages whose diets were devoid of fresh foods. The introduction of limes to the diet of the British navy alleviated scurvy and led to the nickname ”limey” for the British sailors.

The disease is characterized by reduced crosslinking of collagen fibres, resulting in fragile blood vessels and haemorrhagic diathesis, which manifests in various forms. There is tendency to bleeding, especially in joints and under the skin.

Gums become soft and spongy, teeth become loose and there is poor wound healing. Bones become weakened and anaemia and infections develop. If untreated, these infections may prove fatal.

Vitamin C requirements

Vitamin C illustrates extremely well how different criteria of adequacy, and different interpretations of experimental evidence (section 11.1), can lead to different estimates 404 Vitamins and minerals of requirements, and to reference intakes ranging between 30 and 90 mg/day for adults. The requirement for vitamin C to prevent clinical scurvy is less than 10 mg/day.

Note: Though RDA for vitamin C is 45 mg/day, a daily intake of 10 mg is sufficient to prevent scurvy.

Toxicity of vitamin C

There is little evidence of any significant toxicity from these high intakes. Once the plasma concentration of ascorbate reaches the renal threshold, it is excreted more or less quantitatively with increasing intake, and there is no evidence that higher intakes increase the body pool above about 1500 mg per kg body weight.