Biosynthesis of Vitamin C

The vast majority of animals and plants are able to synthesize vitamin C, through a sequence of enzyme-driven steps, which convert monosaccharides to vitamin C. In plants, this is accomplished through the conversion of mannose or galactose to ascorbic acid. In some animals, glucose needed to produce ascorbate in the liver (in mammals and perching birds) is extracted from glycogen; ascorbate synthesis is a glycogenolysis-dependent process. In reptiles and birds the biosynthesis is carried out in the kidneys.

Among the animals that have lost the ability to synthesize vitamin C are simians and tarsiers, which together make up one of two major primate suborders, Haplorrhini. This group includes humans. The other more primitive primates (Strepsirrhini) have the ability to make vitamin C. Synthesis does not occur in a number of species (perhaps all species) in the small rodent family Caviidae that includes guinea pigs and capybaras, but occurs in other rodents (rats and mice do not need vitamin C in their diet, for example).

A number of species of passerine birds also do not synthesize, but not all of them, and those that do are not clearly related; there is a theory that the ability was lost separately a number of times in birds. In particular, the ability to synthesize vitamin C is presumed to have been lost and then later re-acquired in at least two cases.

All tested families of bats, including major insect and fruit-eating bat families, cannot synthesize vitamin C. A trace of gulonolactone oxidase (GULO) was detected in only 1 of 34 bat species tested, across the range of 6 families of bats tested. However, recent results show that there are at least two species of bats, frugivorous bat (Rousettus leschenaultii) and insectivorous bat (Hipposideros armiger), that retain their ability of vitamin C production. The ability to synthesize vitamin C has also been lost in teleost fish.

These animals all lack the L-gulonolactone oxidase (GULO) enzyme, which is required in the last step of vitamin C synthesis, because they have a differing non-synthesizing gene for the enzyme (Pseudogene ΨGULO). A similar non-functional gene is present in the genome of the guinea pigs and in primates, including humans. Some of these species (including humans) are able to make do with the lower levels available from their diets by recycling oxidised vitamin C.

Most simians consume the vitamin in amounts 10 to 20 times higher than that recommended by governments for humans. This discrepancy constitutes much of the basis of the controversy on current recommended dietary allowances. It is countered by arguments that humans are very good at conserving dietary vitamin C, and are able to maintain blood levels of vitamin C comparable with other simians, on a far smaller dietary intake.

Like plants and animals, some microorganisms such as the yeast Saccharomyces cerevisiae have been shown to be able to synthesize vitamin C from simple sugars.