Riboflavin

Riboflavin derives its name from its yellow color (flavus=yellow) and is found in many substances. The suffix 'flavin' was added to the name of the source from which it was obtained, e.g. lactofalvin from milk, ovoflavin from egg, hepatoflavin from liver, and urofalvin from urine. When it was discovered that the molecule contained a group similar to the sugar ribose, the name 'riboflavin' was coined.

Chemistry: Riboflavin is dimethyl iso-alloxazine attached to d-ribitol, which is a pentose sugar. The empirical formula is $C_{17}H_{20}N_4O_6$.

Riboflavin is relatively stable to heat; ordinary cooking does not destroy it by more than 20%. However, cooking in excess water that is later thrown away entails considerable loss. Milk exposed to sunlight in a transparent glass bottle looses riboflavin.

Absorption: Riboflavin is absorbed from intestine; it also available as an injection.

Storage: Riboflavin is not stored in the body; Excess is excreted through the urine, to which it imparts a yellow color. It is also secreted in milk.

Action: Riboflavin acts as an enzyme that takes part in cell respiration.

Source: Riboflavin is found in milk, meat, cereals and pulses. Human intestinal bacterial flora probably synthesizes riboflavin.

[Please follow the source chart from the book, Nutrition Science; B.Srilakshmi**]**

Requirements: The daily requirement is 1-1.5mg. A well balanced diet supplies 1-2mg of riboflavin daily.

Deficiency: Riboflavin deficiency can be precipitated by:

1) Inadequate intake, particularly of milk which is a good source of riboflavin;
2) Poor absorption, as in diseases associated with chronic diarrhea;
3) Excessive demand, as with the raised metabolic rate in thyrotoxicosis, fever or pregnancy.

Deficiency of riboflavin also occurs with hypothyroidism and drugs such as phenothiazine, boric acid, and oral contraceptives. Galactoflavin is the riboflavin antagonist.

Manifestation of riboflavin deficiency may be overshadowed by the more prominent manifestation of pellagra or beriberi. The manifestations are:

1) Angular stomatitis and cheilosis;
2) Changes in the tongue;
3) Changes in the skin;
4) Corneal vascularisation.

The red blood cell is one of the active sites for conversion of pyridoxine to pyrodoxal phosphate through the action of riboflavin. In riboflavin deficiency this conversion rate is low.

Toxicity: Toxicity has not been noted following the therapeutic use of riboflavin, because of its rapid excretion by the kidneys.

Pyridoxine (Vitamin B_6, Adermin)

The word pyridoxine is derived from pyridine hydroxyl vitamin. It was also known as adermin, from anti-dermatitis vitamin.

Chemistry: Pyridoxine is a white crystalline substance, soluble in water and alcohol. Its empirical formula is $C_8H_{11}O_3N$.

Absorption: Absorption of vitamin B_6 from the intestine is rapid, and occurs by diffusion mainly from the jejunum. Enough is absorbed through the skin to relieve all sign of vitamin B_6 deficiency, if applied over a large area

Excretion: All the compounds are found in the urine after ingestion. On a vitamin B_6 deficient diet, the excretion can be higher than the intake.

Storage: The stores of vitamin B_6 in the body are usually sufficient to last for about eight weeks.
Action: Pyridoxal 5´-phosphate inhibits platelet aggregation and prolongs blood clotting time. In vitamin B_6 deficiency, the transamination activity decreases and more nitrogen is lost from the body as urea. Tryptophan is normally converted to kynurenine, with the aid of vitamin B_6 forms nicotinic acid. Deficiency of vitamin B_6 blocks the conversion and kynurenine accumulates. This is converted to xanthurenic acid and excreted by kidneys. Xanthuranic acid estimation in urine is a measure of vitamin B_6 deficiency.
Source: The foods richest in vitamin B_6 are egg yolk, meat, fish and milk among animal sources; vegetable sources are whole grains, cabbage and other green vegetables. The bioavailability of vitamin B_6 from animal sources is high than vegetables.

[Please follow the source chart from the book, Nutrition Science, B. Srilakshmi**]**

Requirements: Infants require 0.2-0.3mg and adults about 2-3mg vitamin B_6 per day. The requirement increases with a high protein diet.
Deficiency: Specific deficiency of vitamin B_6, when experimentally produced, was associated with loss of appetite, nausea, restlessness, lethargy, hyper pigmentation and pellagra-like skin changes.
Some deficiency conditions are:

a) *Convulsions in infants*: Vitamin B_6 is destroyed during the manufacture of milk powder. Infants fed on artificial feed or powdered milk may develop convulsions, which are easily controlled by the administration of vitamin B_6.
b) *Anemia*: Vitamin B_6 appears to be essential for red blood cell formation. Liver suggest that vitamin B_6 deficiency leads to failure of iron utilization for hemoglobin formation. Familial pyridoxine-responsive anemia requires 100-1000mg daily for correction of anemia and maintenance therapy.
c) *Xanthurenic Aciduria*: This condition results from a failure of conversion of tryptophan to nicotinic acid because of vitamin B_6 deficiency. Pregnant women and those on oral contraceptives have abnormal tryptophan metabolism, as seen by increased xanthurenic acid excretion. This abnormality is reversed by the oral administration of 5mg vitamin B_6. This vitamin is an essential co-factor in the developing nervous system, including the brain.
d) *Isoniazid*: Isoniazid, used for treatment of tuberculosis, is structurally related to pyridoxine. It interferes with vitamin B_6 metabolism and increases vitamin B_6 excretion through the urine. This produces pellagra-like rash, peripheral neuropathy and anemia, which can be prevented by vitamin B_6 supplementation. For the treatment of ioniazid overdose, intravenous pyridoxine hydrochloride is required.
e) *Cell mediated Immune Response*: Vitamin B_6 deficiency affects cell mediated immune response. Very high doses do not produce benefits beyond those observed with moderate supplements.

Treatment: For therapy, 10mg vitamin B_6 per day is administered, orally, intramuscularly or intravenously. Kidney stone formation is decreased with daily intake of magnesium oxide (200mg) and vitamin B_6 (10mg).
Toxicity: Extremely high doses (up to 6g daily) of vitamin B_6, when taken over several months for body-building, premenstrual tension, or unsteadiness if gait. These improve gradually the patient stops taking vitamin B_6.

Niacin (Nicotinic Acid, Nicotinamide)

Niacin includes nicotinic acid and its amide nicotinamide, as well as any derivative that can be biologically converted to active compounds.
Although nicotinic acid is refer to as a vitamin, this is strictly not correct science it can be synthesized by mammals, including humans, from the amino acid tryptophan.

It had been synthesized as early as 1867 by oxidation of nicotine, a well-known constituent of tobacco. The physiological activity of nicotinic acid bears no resemblance to that of nicotine. In order to allay fears that the vitamin might have some harmful effects of tobacco, it was renamed 'niacin' from 'nicotinic acid vitamin'.

Pellagra, a clinical condition due to deficiency of nicotinic acid, in the past assumes epidemic proportions among the blacks in the southern United States. *Elvehjem et al.* in 1937 found nicotinic acid and nicotinamide effects in curing black tongue in dogs (a condition similar to human pellagra), and suggested a clinical trial with these compounds in human pellagra. AS the niacin can prevent pellagra, the vitamin is also known as P-P factor (Pellagra Preventive factor).

Chemistry: It is a white crystalline compound, soluble in water. Its empirical formula is $C_6H_5o_2N$. Nicotinamide is formed from nicotinic acid. In animal tissues, nicotinic acid exists only as nicotinamide. Taken orally, nicotinic acid is rapidly converted into nicotinamide. Cooking does not destroy the nicotinamide in food, it can be lost if excessive water is used and drained off.

Absorption: Nicotinic acid and nicotinamide are both rapidly absorbed from the stomach, and the small& large bowels.

Storage: Nicotinamide is distributed throughout the body, being essential for tissue metabolism.

Excretion: The excretion of these two forms of this vitamin, is mainly through the urine.

Action: Like other members of vitamin B group, nicotinic acid is essential for tissue metabolism. Two active derivatives of nicotinamide are Nicotinamide Adenine Dinucleotide (NAD) and Nicotinamide Adenine Dinucleotide Phosphate (NADP). Nicotinic acid enhances stomach secretion significantly.

Source: Nicotinamide is found in the cells of all food stuffs, mainly in cereals and flesh foods.

[Please follow the source chart from the book, Nutrition Science, B. Srilakshmi**]**

- ***Tryptophan:*** Tryptophan is an amino acid that can prevent and cure pellagra. It is converted to nicotinic acid in the presence of vitamin B_6. Animal foods are rich in tryptophan. Milk though relatively poor in nicotinamide, is rich in tryptophan and so is a good pellagra preventive food. Approximately 60mg tryptophan is equivalent of 1mg of nicotinic acid; this is known as the niacin equivalent.
- ***Leucine:*** With the same intake of niacin and tryptophan, pellagra can be produced more easily in humans on a corn diet than on a wheat diet. Higher content of the amino acid leucine is responsible for the pellagra seen in people of southern India eating jowar, while consumption of rice with lower leucine content does not produce pellagra. It is not understood how leucine interferes with nicotinic acid and produces pellagra. Probably, because administration of 5g leucine metabolizes an additional 3.5mg nicotinic acid, as estimated by urinary excretion of N-methyl nicotinamide.

Requirements: The daily requirements of nicotinic acid vary with: **i)** physical excretion and metabolic rate; **ii)** the tryptophan content of diet.

Deficiency: The deficiency is caused by: **i)** defiant intake of nicotinic acid; **ii)** defective digestion as in diarrhea; **iii**) excessive demand during pregnancy, rapid growth or during increased metabolic rate, as in fever.

Deficiency of nicotinic acid in certain clinical conditions is described below:-

a) *Carcinoid tumors:* Normally a small amount of tryptophan is converted by the argentaffin cell of the gut into serotonin. With a carcinoid tumor of the small intestine or appendix, most of the available tryptophan is converted into serotonin and a clinical state resembling nicotinic acid deficiency is produced.
b) *Isoniazid therapy:* Isonicotinic acid hydrazide (isoniazid), a derivative of nicotinic acid, is extensively used in the treatment of tuberculosis. If the diet is not adequate during isoniazid administration, nicotinic acid deficiency can be precipitated.

c) *High Leucine Diet:* Pellagra is more common in communities eating maize (corn) and jowar (sorghum vulgare) than among those eating foods like rice, less in leucine.
d) *Bound Niacin:* Most food stuffs, especially cereals, have nicotinic acid compound in the bound form, which is not nutritionally available to animal and also not detected calorimetrically. However, this bound form is released in a dilute alkaline medium. Science coffee beans contain nicotinic acid; coffee is protective against pellagra for a population subsisting on a maize diet.

Deficiency of nicotinic acid may occur sub clinically or as pellagra. 'Subclinical' nicotinic acid deficiency manifests itself as weakness, irritability, burning tongue and constipation. The diagnosis can be established by dietetic history, and confirmed by clinical improvement noted within a fortnight of therapeutic administration of nicotinic acid.

PELLAGRA

Pellagra is classically characterized by three D's or four D's: Dermatitis, Diarrhea and Dementia followed by Death. The full-blown picture is not always seen.

1. Dermatitis: Pellagra derives its name from its skin manifestations (*pelle* = skin; *agra* = rough). Changes are marked on the areas exposed to the sun (back of hands, wrists, feet, ankles, neck, nose and cheeks—'Butterfly distribution'), and to friction (elbows, extensor surface of arms, knees, scrotum and perineal region). The affected parts are usually symmetrically distributed and well demarcated from the surrounding skin.

2. **D**iarrhea: The tongue appears raw, the papillae are lost, and the mucus membrane of the stomach is inflamed. Spiced and hoot food cannot be tolerated. Diarrhea accentuates the deficiency state. The small intestine may reveal structural and absorptive of fat and D-xylose.

3. **D**ementia: There is irritability, depression, poor concentration and loss of memory. Patients with pellagra dementia may be admitted to lunatic asylums, the mental symptoms being interpreted as primary psychosis and the skin pigmentation being ascribed to poor hygiene.

The psychiatric changes are probably related to serotonin, which is derived from tryptophan. Serotonin is a neurotransmitter and its metabolism is also disturbed in schizophrenia.

4, **D**eath: If previous conditions are not treated well, the patient may persuade the fourth and final stage 'D' i.e. death.

Treatment: Pellagra in human is always associated with other nutritional deficiencies; thus, a well balanced diet is of utmost importance. Milk and fresh meat are particularly needed. Oral nicotinic acid or nicotinamide are also advised.

Nicotinic acid is absorbed from the stomach. If given with food, absorption is gradual. Nicotinamide is also well absorbed but does not produce any symptoms like nicotinic acid, and so is preferred for treatment. Nikethamide (coramine), a diethyl amide of nicotinic acid, is commonly used as a cardiovascular stimulant. It, too, can alleviate the symptoms of pellagra.

For treatment of pellagra, 25-50mg nicotinamide is administered four to six times a day. With severe diarrhea, 25mg may be administered intravenously three times a day.

Hartnup's Disease (HERIDITARY PELLAGRA)

This is a hereditary disease characterized by intermittent attacks of rough, scaly, reddened skin on moderate exposure to sunlight; more severe exposure produces a rash similar like pellagra.

The disease gets its name from an afflicted family.

Other Uses of Nicotinic Acid:

- In doses of 500mg or more per day, nicotinic acid- i) decreases high blood cholesterol and triglycerides; ii) increases high density lipoproteins; iii) lowers mortality in heart disease.

- Nicotinic acid is used as therapy for dislipidemia in non-insulin dependent diabetes.
- Vascular disease: The vasodilator effect of nicotinic acid has prompted its use in angina pectoris and cerebral thrombosis, but no beneficial effect has been proved.
- Pain in coronary thrombosis: During an attack of angina pectoris, 50mg nicotinic acid subcutaneously has helped in the relief of pain and shock.
- Gilbert's syndrome: In this syndrome, slow intravenous injection of 50mg nicotinic acid over 30 minutes results in rise in serum bilirubin at 3 hours.

Toxicity: Side effects of nicotinic acid include flushing, itching, diarrhea, aggravation of acid-peptic pain, abnormal liver function tests, high uric acid and gout. Low blood pressure, arterial fibrillation, raised blood sugar, and even hepatic coma may ensure.
A physician who took 6g nicotinic acid daily for a year to reduce his serum cholesterol level developed bilateral amblyopia with paracentral scotomas.

Folic Acid (Folate, Folacin, Pteroyglutamic acid)

The term Folic acid is derived from the Latin word *folium* (leaf), because folic acid is found extencively in green vegetables. *Lactobacillus casei* grows well only if folic acid is supplied. Folic acid was, therefore termed the Lactobacillus casei factor. Both the anti-anemia vitamins were originally discovered as essential factors for the growth of organisms—Folic acid as the *L. casei* factor and vitamin B_{12} as a factor for the growth of *L. lactis*.
Folacin and folate are generic names for compounds synthesized by plants and bacteria with the nutritional properties and chemical structure of folic acid.
Chemistry: Folates include glutamic acid radicals joined to a pteridine ring- either one or two or several (monoglutamate or diglutamate or olyglutamate). Folic acid is a monoglutamate joined to a pteridine ring, and is therefore called pteroylglutamic acid. Folates are sensitive to light, oxygen, extremes of pH and boiling. Between 50% and 95% of food folate can be destroyed by cooking, canning and other processing methods. Antioxidant agents in food such as ascorbic acid (vitamin C), prevent folate destruction during cooking. In the body, folic acid exists as tetrahydrofolic acid. Folic acid was first synthesized in 1954.

Folinic Acid (citrovorum factor) is a formyl derivative of tetrahydrofolic acid. Dihydroreductase is an enzyme that converts folic acid into a metabolically active, reduced form of folinic acid.
Absorption: Crystalline folic acid is primarily absorbed from the jejunum. Alkaline intestinal pH or simultaneous administration of sodium bicarbonate decreases folic acid absorption. The mean folate absorption from food is 50%.
Serum level: Serum folate is mainly in the form of 5-methyl tetrahydrofolic acid. The normal level of serum folate varies between 6 and 15 nanograms per ml.
Storage: The body store of 5-10mg is adequate to meet the requirements for three to four months. Storage occurs mainly in the liver as 5-methyl tetrahydrofolate.
Excretion: Folic acid excreted through the urine. The amount excreted depends upon the serum level is less than 10 nanogram per ml only 6% is excreted; but when it rises to 70nanogram per ml over 30% is excreted.
Action: Folic acid is itself inactive. It is converted in the body to the biologically active form, folinic acid. Folinic acid is essential for nucleoprotein synthesis and is therefore required for cell division and also for the maturation of red blood cells.
Source: Folates are derivative from vegetables, fruits, cereals, meat and liver, with varying availability.

[Please follow the source chart from the book Nutrition Science, B. Srilakshmi**]**

Folate synthesized by the colonic bacteria is not absorbed. Dietary folates exist as monoglutamates. Folate destruction occurs during cooking. The loss on steaming is 90% while that during frying in an open pan is 67-95%.

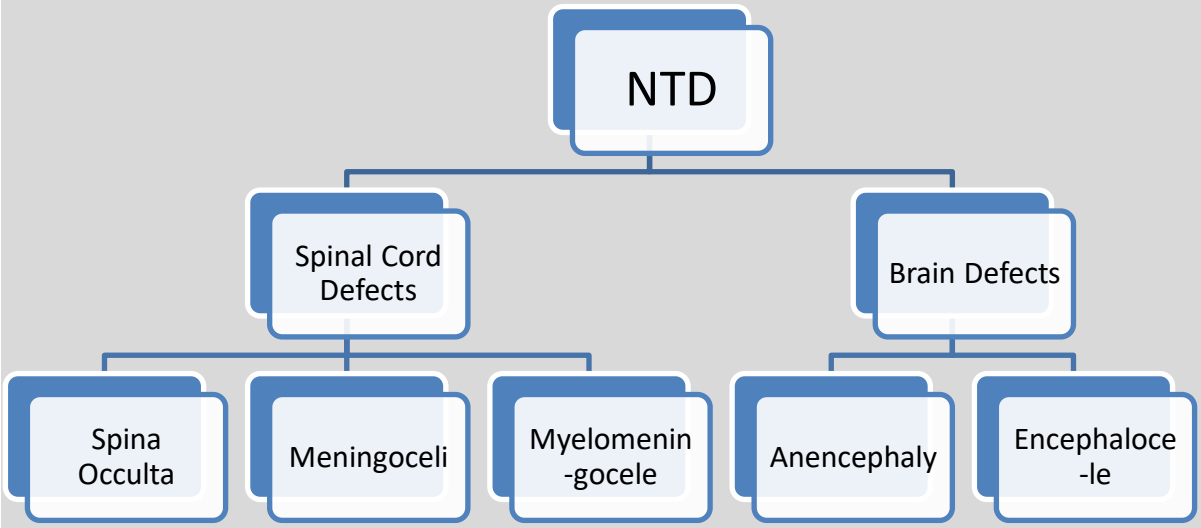
Requirements: The minimum supplement requires maintaining normal blood level in those deprived of dietary folate is 50-100 micrograms a day.
The average daily intake varies from 700-1500 micrograms, but only the fraction converted to monoglutamate may be absorbed.
Deficiency: The causes of folic acid deficiency are described below-

1. Deficient Intake: Folic acid, being both heat labile and water soluble, is easily destroyed by repeated boiling of food, or during cooking with excess water that is subsequently discarded.
2. Increased Demand: Increased demand is created by rapidly proliferated tissue.
3. Malabsorption: This is mainly due to the deficiency of the enzyme polyglutamate hydrolase following disease of jejunum. Goat's milk anemia occurs in infants fed on goat's milk, which contain only 10% as much folate as human milk.
4. Inhibition: Inhibition of absorption or metabolism of folic acid can cause deficiencies.

Deficient Intake	Increased Demand	Malabsorption	Inhibition of folate metabolism
• Poor dietary intake • Lengthy cooking • Alcoholism	• Pregnancy • Infancy • Hyperthyroidism • Hemolytic anemias • Leukemias • Carcinomas • Loss in dialysis	• Tropical sprue • Celiac disease • Stagnant loop syndrome • Small intestinal diseases • Jejunal resection • Congenital folate malabsorption • Drugs: phenytoin, contraceptives	• Folic acid antagonists (Antifols) • Alcoholism • Vitamin B deficiency • Liver diseases

Deficiency disease: Woman of child bearing age should be encouraged to include generous amounts of folic acid and sources in their diets- foods such as dark green leafy vegetables, legums, orange juice, soya, wheat germ, almonds and peanuts. Folic acid deficiency at the time of conception can cause ***"***neural tube defect" (NTD).

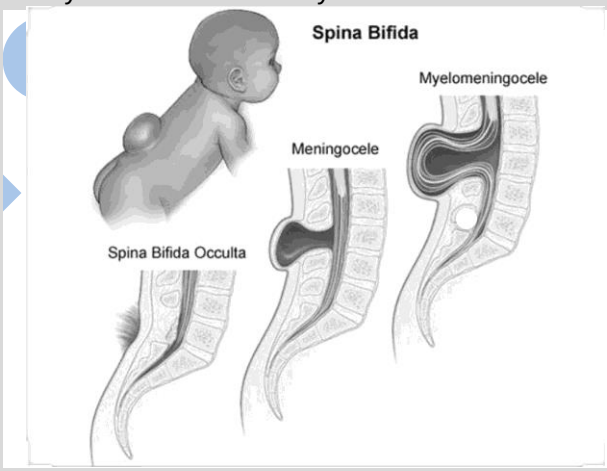
Neural Tube Defect
Neural tube defects are birth defects of the brain, spine or spinal cord. It happens in the first monthe of pregnancy, often before a woman even knows that she is pregnant.
The two most common NTD's are Spina Bifida and Anencephaly. In spina bifida, the fetal spinal column does not close completely and in anencephaly defect in brain development occur.
There are several types of neural tube defects as shown below.



Spinal Cord Defects *(Sipna Bifida- SB):*

Spina Occulta is the mildest form where there is small gap in the spine but the opening cannot be seen the back and it is accidentally found if the patient has a x-ray of lower back for any another reason.

Meningoceli is a sac of fluid not involving the spinal cord that comes out through an opening in the back and involved meninges also.



Myelomeningocele is one of the common and most severe forms of SB. In this the unfused portion of spinal column allows the spinal cord to protrude through an opening, forming a sac enclosing the spinal elements such as meninges, cerebrospinal fluid, parts of the spinal cord and nerve routes.

Sign & Symptoms: The symptoms of SB are: i) loss of bladder or bowel control; ii) partial or concrete lack of sensation; iii) paralysis of the legs; iv) weakness of hips, legs or feet of a new born; v) abnormal feet or leg, i.e., clubfoot; vi) build up of fluid inside the skull (hydrocephalus); vii) hair present act sacral region; viii) dimpling of the sacral area.

Treatment: Experts recommended that all women of childbearing age take a daily supplement of 400 micrigrams of folic acid. Women already had first pregnancy with NTD should take a daily 4 mg tablet of folic acid for atleast one month before conception and then throughout the first twelve weeks of pregnancy.

Clinical Manifestations: Clinically, folate deficiency results in- **i)** megaloblastic anemia; **ii)** tropical sprue-like symptoms; **iii)** neurological disorders.

Treatment: There is no evidence that more than 1 mg folic acid is needed daily. A once- daily helping of fresh fruits or vegetables is a good prophylaxis.

Expectant mothers should be given an oral supplement of 400 micrograms folic acid per day. Folic acid supplement, 400 microgram daily, prior to and during early pregnancy may prevent *neural tube defect* in the fetus.

When it is established that microcytic anemia in an adult is due to folic acid deficiency, 0.5-1.0 mg folic acid administered orally until the hemoglobin level is normal. There is a drop in serum in 24 hours, and

peak reticulocyte response appears in 7-10 days. Folic acid is usually effective when given orally, but injection may be necessary when it is not absorbed.

Epilepsy Diphenylhydantoin and barbiturates used over prolonged period as anticonvulsant therapy for epilepsy, produce microcytic anemia, megaloblastic bone marrow, reduced serum folate and caused deterioration in mental condition. Therapy consists of the administration of 10-15 mg folic acid daily initially and 1000 microgram vitamin B_{12} weekly.

Folic acid antagonists: Folate anti-metabolites (trimethoprim, anticancer drug mithotraxate, aminopterin) inhibit dihydrofolate reductase activity.

Folic acid- vitamin B_{12} antagonism is seen in: i) pernicious anemia, ii) anticonvulsant therapy. Folic acid also provides fuel to malignant cells in leukemia, myeloma and Hodgkin's disease; in such cases folic acid should not be administered except to correct anemia or leucopenia.

Toxicity: Oral folic acid (pteroylglutamic acid) is generally regarded as not toxic for normal humans but it may cause neurological injury when given to patients with undiagnosed pernicious anemia. Te vitamin should be given with caution to drug-treated epileptic patients because seizure control may be affected.

Vitamin B_{12} (Cobalamine)

The name cyanocobalamine is given because vitamin B_{12} contains a cyanide group and cobalt.

Adenosylcobalamin is the main cobalamine of red blood cell and tissues, while in the liver 70% of B_{12} is methylcobalamine.

Vitamin B_{12} is interesting because of the reasons listed below:

1) It was discovered almost simultaneously in the US and England, in 1948.
2) It is extensively produced by fungi and bacteria.
3) Even a millionth of a gram of it is active (there is no drug in clinical medicine which has comparable purity and potency).
4) It is unusual for marked deficiency to occur from deficient intake. Such a state is usually due to malabsorption, secondary to deficient secretion of intrinsic factor by the stomach.
5) It is the only vitamin containing the element cobalt.

Chemistry: The empirical formula is $C_{63}H_{90}O_{14}N_{14}PCo$. It is a red crystalline substance, the color being due to cobalt. It is slightly soluble in water.

Vitamin B_{12} is produced only by microorganisms. Many bacteria produced it for their own grown growth even with infinitely small supply of cobalt. Some organisms produce vitamin B_{12} far in excess of their requirement; these bacteria are used for commercial production. The human intestinal bacteria also produce appreciable amounts of vitamin B_{12}; this is excreted in the feces. Fertilizers made from dried sludge may contain as much as 7 microgram of vitamin B_{12} per gram.

Absorption: Two factors, namely, intrinsic factor and extrinsic factor, were necessary for the relief of pernicious anemia. The intrinsic factor (IF) is produced by the stomach; the extrinsic factor (EF) is vitamin B_{12}. In the treatment of pernicious anemia, feeding liver together with human gastric juice produced remarkable improvement, while feeding liver alone was not effective.

Absorption from the intestine: Active absorption of B_{12} (after dissociation from IF) occurs in the distal part of the small intestine.

Passive absorption by diffusion occurs throughout the length of the small intestine when large therapeutic oral doses (100micrograms) are administered.

Absorption varies inversely with the dose administered: with a dose of 0.1 microgram of crystalline vitamin B_{12} the absorption is 77% but with a dose of 50 micrograms it is 3%. Absorption decreases with age.

Cyanocobalamin is not an active vitamin for humans until the cyanide is removed within the body.

Gastric acid suppressing medications used for peptic ulcer therapy also inhibit cobalamin absorption.

Serum vitamin B_{12}: The normal serum vitamin B_{12} level is 200-1000 picograms /ml. In pernicious anemia, values are always below 170 and frequently below 100 picograms /ml [1 picogram= 1×10^{-6} microgram].

Storage: The bulk of body stores of vitamin B_{12} are in the form of coenzyme B_{12}. The total body store of 2000 micrograms (2mg) is adequate for years. The liver stores about half the total; 1.0(0.7-1.2) microgram/g of wet liver.

Excretion: The excretion occurs mainly through the urine, feces and milk.

Urine: A normal person excretes about 30 picograms vitamin B_{12} per day through the urine. Well over 95% of a dose of over 50 micrograms is quickly excreted in a normal person, but in a person, whose liver store is depleted, more is retained and the urinary excretion is lower.

Faeces: The faecal vitamin B_{12} primarily that produced by bacteria in the large intestine, which is not absorbed by body.

Milk: vitamin B_{12} is secreted in the human milk, the concentration being nearly equal to that in blood. Infants breast-fed by mothers with deficiency of vitamin B_{12} may develop vitamin B_{12} deficiency.

Action: Adenosylcobalamin is required for the conversion of homocysteine into methioninine. When the conversion is deficient, folate metabolism is deranged, causing defect in DNA synthesis and failure in maturation of blood cells. Vitamin B_{12} also plays a role in converting the body store of methyl folate into its active form, folacin.

Source: Vitamin B_{12} is synthesized by bacteria in the soil, water, human & animal intestines. Vitamin B_{12} in animal foods is available as methylcobalamine, adenosylcobalamin and hydroxycobalamin. Those who live on a pure vegetarian diet in which even milk is excluded are in danger of developing deficiency. Gross vitamin B_{12} deficiency also develops in infants breast feed by strict vegetarian mothers.

Human colonic bacteria produce large amounts of vitamin B_{12} but this is not absorbed. The normal 24-hour stool contains about 10 microgram of total vitamin B_{12}, of which about 5 micrograms are cobalamin. Stool vitamin B_{12} may be an important source vitamin B_{12} in some situations: Iranian vegetarians do not develop vitamin B_{12} deficiency because they grow their vegetables in night soil (human manure) and consume them without careful washing.

[Please follow the source chart from the book, Nutrition Science, B. Srilakshmi**]**

Requirements: The daily dietary intake is 3-30 micrograms from milk, cheese, eggs etc. The daily requirement of vitamin B_{12} if difficult to assess, and appears to vary from person to person. Only 1 microgram is needed for formation of red blood cells, while as little as 0.1 microgram is effective in producing improvement in pernicious anemia.

Deficiency: The causes of the deficiency are listed below:

1) *Lack of intake:* A deficient intake of vitamin B_{12} occurs in pure vegetarians who refuse to take even milk or milk products, and in infants breast-fed by deficient mothers.
2) *Lack of intrinsic factor:* This occurs- i) in pernicious anemia, ii) after stomach resection, iii) congenitally as an isolated defect in infants and children.
3) *Deficiency of intestinal absorption:* The terminal small intestine is the site of absorption of vitamin B_{12}. Diseases of the ileum such as tuberculosis, sprue and resection; result in lack of absorption of vitamin B_{12}. Administration of broad-spectrum antibiotics inhibits the growth of these bacteria and the anemia improves. Vitamin B_{12} deficiency itself decreses the ideal capacity for B_{12} absorption.

Absorption is also impaired by drugs: neomycin, colchicines, para aminosalicyclic acid, methotrexate, oral contraceptives and alchohol.

4) *Excessive demand :* Hematological manifestations are: **i)** macrocytic anemia, in which the blood smear shows variation in the size and shape of red blood cells; **ii)** megaloblasts in the bone marrow; and **iii)** reduction in the average survival time of red blood cells from the normal 120 days to 60 days.

Neurological manifestations of some changes are described here: **i)** changes in the lateral columns of the spinal cord, producing weakness, spasticity and extensor plantar response. **ii)** changes in the peripheral nerves giving bilateral and symmetrical tingling, numbness, paresthesiae and diminished or absent sensation involving the distal parts of the limbs. **iii)** mental changes, manifested as loss of mental energy, depression, paranoia and psychosis.

Serum Cobalamine Level: A serum cobalamine level of less than 170 picograms per ml is highly suggestive, but less than 100 picograms per ml are diagnostic of cobalamin deficiency.

Treatment:

Pernicious anemia: The vitamin B_{12} dosage schedule for pernicious anemia is variable. Three factors guide the schedule:- **i)** a vitamin B_{12} – deficient person can accumulate a store in the liver to last for a long time if a sufficiently large dose is given; **ii)** very high doses lead to considerable loss in the urine; and **iii)** individual requirements for producing remission as well as for maintenance are variable.

Injection therapy: Intramuscular injection of hydroxycobalamin is preferred to cyanocobalamin as the former is better retained. When vitamin B_{12} was first discovered, the administration of even 1 microgram a day was found sufficient to produce remission in pernicious anemia. Interruption of therapy in these patients results in relapses.

Oral therapy: Oral therapy of vitamin B_{12} is not conventionally advised for pernicious anemia, but it can be given. Vitamin B_{12} is administered with intrinsic factor to facilitate absorption.

Nutritional vitamin B_{12} deficiency: those with dietary deficiency of vitamin B_{12} (without pernicious anemia) respond to 1 microgram vitamin B_{12} administered orally.

Prophylaxis: Deficiency of vitamin B_{12} has been described after partial gestrectomy and resection of the ileum; therefore, prophylactic monthly injections of 100 micrograms vitamin B_{12} are advised.

Tobacco Amblyopia: Tobacco amblyopia is related to cyanide metabolism, and hydroxycobalamin is a powerful cyanide antagonist in patients with these condition only hydroxycobalamin should be administered (not cyanocobalamin).

Use of Folic acid*:* Though folic acid alone may improve the blood picture in pernicious anemia, it may precipitate neurological complications. On the other hand, though the blood picture improves with vitamin B_{12}, in cases of sprue and idiopathic steatorrhea, fatty diarrhea response only to injections of folic acid.

Toxicity: Even with high doses of vitamin B_{12} no toxicity has been noted, but anaphylactic reaction may occur.

Pantothenic acid (Filtrate Factor)

Pantothenic acid was first isolated in 1938 and synthesized in 1940. Pantothenic acid derives its name from its distribution in all food stuffs (*pantothen* = everywhere).

It was also known as 'Filtration Factor' because all the B-vitamins were all absorbed on fuller's earth; Pantothenic acid was not absorbed but passed into the filtrate.

This factor was observed that it prevented graying of far in rats. The absence of this factor was known to produce changes in the skins of chicks that superficially resembled human pellagra; hence, it was also known as 'chick pellagra factor'.

Chemistry: Pantothenic acid is a peptide derivative; d-pantothenic acid is a viscous oil but its calcium salt, calcium pantothenate, is a crystalline substance soluble in water; this salt is the commercial preparation.

Action: Pantothenic acid is known as coenzyme A (for acetylation) within living cell. It also plays a part in: **i)** amino acid metabolism; **ii)** synthesis of fatty acids and cholesterol; **iii)** formation of sterols.

Absorption: Pantothenic acid is absorbed from the alimentary tract.

Excretion: The usual urinary excretion is 3mg a day. About 6.7 micrograms/ml is secreted in human milk.

Blood level: The normal blood level of Pantothenic acid is 0.225 micrograms/ml.
Source: This coenzyme is distributed throughout all animal tissues, the highest concentration being in the liver, kidneys, spleen, heart and adrenals.

[Please follow the source chart from the book, Nutrition Science, B. Srilakshmi**]**

Requirements: No clear data exist on the daily requirement. An average diet contains 6-10mg pantothenic acid, and this is evidently adequate.
Deficiency: The deficiencies are:
Burning Feet Syndrome: This condition is seen among the poor and during conditions of war. There are sensations of 'pins & needles', tingling and numbness and burning in the feet especially during the night. This condition was believed to be relieved by intramuscular calcium pantothenate, 20-40mg daily, but this has not been confirmed.
Burning feet syndrome is also known to occurring poly neuropathy, diabetes, sub-acute combined degeneration of the spinal cord and polycythemia.
Grey hair: Pantothenic acid was proved to be an anti grey fur factor for rats, but large doses over a prolonged period have failed to affect human hair.
Burns: Encouraging results have been reported from topic application of Pantothenic acid for burns.
Paralytic ileus: Pantothenic acid has been advocated for the treatment of paralytic ileus but correction of the cause seems more logical.
Toxicity: It is likely safe for most people when taken by mouth in appropriate amounts. The recommended amount for adults is 5mg /day. Even larger amounts (up to 10g) seem to be safe for some people. But taking larger amounts increases the chance of having side effects such as diarrhea.

Biotin (B_7, Vitamin-H, Biotina, Apprarex, Coenzyme-R)

Biotin was originally called vitamin H (for the german word *Haut* = skin) because it protected rats from dermatitis. It is a component of human tissues and is necessary for bacterial growth in culture media.
Action: Biotin works by breaking down food into sugar that your can use for energy. Biotin is important for healthy skin and nails and it also keeps your eyes, liver and nervous system working properly. During pregnancy, biotin is important for normal fetal development.
Storage: Biotin is not stored in the body. Because of this, you can become low on biotin if you do not get enough in your diet.
Uses of Biotin: Many people take supplements in hopes of treating hair loss, cradle cap in infants, and brittle nails. Some people also take biotin supplements to treat diabetes and nerve pain associated with diabetes, although there is not much evidence to support this type of use. Some research also suggests that a deficiency in nutrients that include biotin could contribute to the development of type II diabetes. Two 2012 studies found that biotin improved the blood sugar and insulin levels of people with type II diabetes when they took it along with chromium supplements. The researchers concluded that taking biotin supplements may be beneficial for both people with diabetes and those who are obese.
Deficiency: Although biotin deficiency is rare, it can develop during pregnancy or in people who poor nutrition of experience rapid weight loss. Symptoms of biotin deficiency include hair loss, dry skin, a scaly rash around the eyes or mouth, dry eyes fatigue and depression. Some of the deficiencies are:
Egg White Injury: The study of biotin was stimulated by the dermatitis and spasticity of the hind legs that developed in chicks and rats kept on a diet which contains uncooked egg white. The damage is not due to any toxic substance but the presence of a protein in egg white called Avidin (*avid* = hungry+ albumin). Avidin combines with biotin and this complex is excreted in the stool. Hence excess avidin prevents the absorption of biotin. Heat destroys avidin and so cooked eggs do not produce biotin deficiency.
Alopecia: Alopecia (baldness) occurs in biotin deficiency. Intravenous biotin (200micrograms) helps the re-growth of healthy hair.

Requirements: There is no recommended dietary allowance (RDA) for biotin, only suggested adequate intake levels are described below:

AGE	REQUIREMENT (mcg/day)
1-12months	7
1-3 years	8
4-8 years	12
9-13 years	20
14-18 years	25
18 above	30
During pregnancy	30
Breastfeeding	35

Toxicity: Biotin is a safe and non-toxic vitamin. It has not been associated with any serious side effects, even in large doses. The FDA reports that biotin is safe and well tolerated when taken by mouth in recommended doses.

Choline

Choline was identified in the last century. It is a component of the phospholipids lecithin and in combination with alcohol forms acetylcholine and supplies a labile methyl group for transmethylation.
Source: Egg yolk, wheat germ, liver, brain, kidney, heart, lean meat, yeast, soyabeans, peanuts and skimmed milk are good sources of choline. The amino acid methionine can act as a donor of labile methyl groups to convert ethanolamine to choline. For this reason the requirements of choline cannot be assessed.
Uses of Choline: *Asthma:* Taking choline by mouth seems to lessen symptoms and the number of days that asthma is a problem for some people. It also seems to reduce the need to use bronchodilators.
Birth defects of the brain & spine (neural tube birth defects): Early research suggests that women who consume a lot of choline in their diet have a lower risk of having babies with neural tube birth defects.
Prevention of fatty liver: Phospholipids are concerned with the metabolism of fat. In the absence of choline, neutral fat and to some extent cholesterol esters accumulate in the liver, producing fatty liver. As choline prevents fatty liver it is called a lipotropic factor.

Requirements: An average diet supplies 200-600mg of choline daily. Adequate intake (AL), as established by the Food and Nutrition Board of the National Institute of Medicine is:

AGE	REQUIREMENTS (mg/day)
Adult men	550
Adult women	425
Pregnant women	450
Breastfeeding women	550
Children-1-3years	200
Children 4-8 years	250
Children 9-13 years	375
Infants <6 moths	125
Infants 7-12months	150

Toxicity: Taking high doses of choline by mouth is possibly unsafe for adults. Doses over the daily upper intake levels are more likely to cause side effects such as sweating, a fishy body odor, gastrointestinal distress, diarrhea and vomiting. There is some concern that increasing dietary choline intake might increase the risk of cancer of the colon and rectum. One study found that women eating a diet that contains a lot of choline have an increased the risk colon cancer.

Inositol (Vitamin B_8)

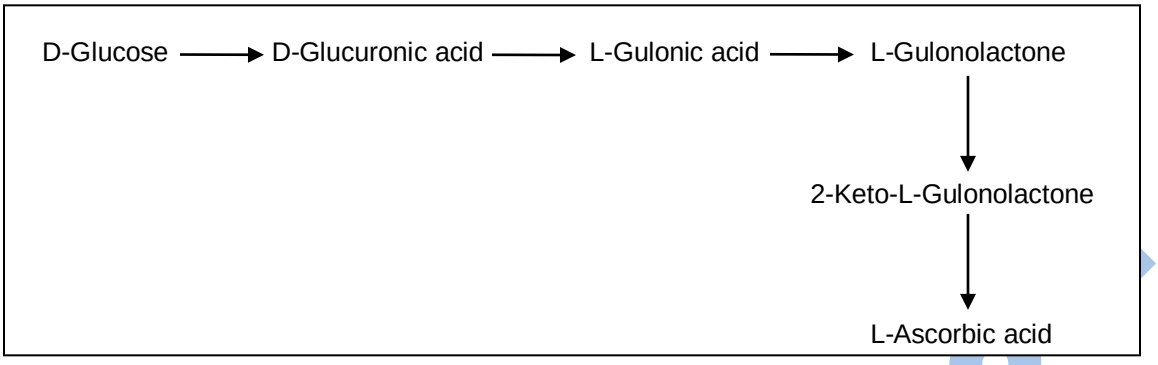
It is a component of membrane phospholipids. It is lipotropic agent that removes fat from the liver. It is a type of sugar that helps provide structure to your cells. It also affects the hormone insulin and the function of chemical messengers in your brain.
Chemistry: Inositol is a 6-carbon sugar alcohol present primarily as myo-inositol.
Source: Inositol sometimes referred to as vitamin B_8, naturally occurs in foods such as fruits, beans, grains and nuts. Fresh vegetables and fruits contain more myo-inositol than frozen, canned or salt free products. Inositol is present in phytic acid of plant tissue. Human body can also produce inositol from the carbohydrates.
Requirements: There are two main forms of inositol used in supplements, namely myo-inositol (MYO) and D-chiro-inositol (DCI).There is no demonstrable requirement of inositol in man. An adult is believed to consume 1g inositol per day.

Use of Inositol: i) Though more research is needed, inositol shows potential as an alternative treatment option for mental health conditions, including panic disorder, depression and bipolar disorder.
ii) Inositol may help reduce blood triglyceride levels, improve insulin function, lower blood pressure and promote ovulation in women with polycystic ovary syndrome (PCOS) when administered with folic acid.
iii) Inositol is potential treatment option for preterm infants with respiratory distress syndrome. This syndrome showed better survival rate upon receiving intravenous myo-inositol during the first week of life.
Toxicity: Inositol supplements seem to be well tolerated by most people. However, mild side effects have been reported with doses of 12 g per day or higher. These include nausea, gas, difficulty sleeping, headache, dizziness and tiredness.

Vitamin C (Ascorbic acid, Anti-Scorbutic Vitamin)

The chemical name of vitamin C is ascorbic and it is also known as hexuronic acid and anti-scorbutic nutrient. Scurvy was classically a disease of sailors. In 1747, the British naval surgeon James Lind demonstrated that oranges and lemons could cure scurvy. The experimental study of vitamin C started with the production of scurvy in guinea pigs by Holst and Frolich. It was fortunate that they worked on guinea pig because it is now known that these animals and primates do not synthesize their own vitamin C. Vitamin C was first synthesized in1933 by Reichstein et al.
Chemistry: Ascorbic acid is a simple compound containing 6-carbon atoms, related to the monosaccharide glucose. It is stable to acid, readily soluble in water but easily destroyed by oxidation, light, alkali and heat especially in the presence of iron or copper. Its empirical formula is $C_6H_8O_6$. Levo-ascorbic acid is an active anti scorbutic substance, while Dextro-ascorbic acid is not.
Synthesis: Vitamin C is synthesized by animals (except guinea pigs and primates) and plants, from simple sugars stuffs. The failure of guinea pigs and primates to synthesize their own ascorbic acid from is due to deficiency of the enzymes in the liver that convert L-gulonic acid to ascorbic acid.

In plans Vitamin C accumulates during the ripening process and is presumably synthesized within the plant cells from naturally occurring glucose.



Destruction: Vegetables cells contain an enzyme called ascorbic oxidase. When vegetables are cut fine, a greater quantity of the enzyme is released and more vitamin C is destroyed. The rate of enzymic oxidation increases as the temperature is raised and therefore hitting of graded vegetables destroys vitamin C. Ascorbic oxidase is destroyed on boiling. If vegetables are immersed directly in boiling water, the enzyme is destroyed immediately, and hence no loss of vitamin C occurs.
vitamin C is more easily destroyed than other vitamin. During cooking loss of vitamin C occurs due to: i) cutting the vegetables fine; ii) Using excess water that is later thrown away; iii) gradually heating the vegetables, rather than putting them into boiling water.; iv) overcooking; v) keeping vegetables hot for a long time before they are served; and vi) adding Sodium bicarbonate in order to preserve the color of vegetables, as alkalinity destroys vitamin C. Modern methods of dehydration, freezing and canning preserve the vitamin C content of food to a considerable extent.

Absorption: Ascorbic acid is absorbed from the intestine. Natural citrus extract is more slowly but better absorbed than synthetic ascorbic acid.

Blood level: The plasma level of ascorbic acid in normal person is 1mg per 100ml, with lower values found in deficiency states. The plasma vitamin C values in normal pregnancy are 0.35-0.4mg per 100ml as compared to 1.2mg per 100ml in non-pregnant women.

Storage: The total body pool is about 2-3g. When the body content exceeds 4g, the excess is quickly excreted.

Excretion: Ascorbic acid excreted in the urine when the plasma level exceeds 1.4mg per 100ml.Normally very little is excreted in faeces, but the loss is appreciable in diarrhea.

Action: Ascorbic acid is a reducing substance and it is beneficial to many conditions, such as:

1) *Collagen synthesis:* vitamin C helps conversion of proline to hydroxyproline; the latter helps the formation of collagen. If the collagen is defective, they are not bound together; tissues such as bone matrix, teeth and the lining of blood vessels are not properly formed.
2) *Iron metabolism:* Ascorbic acid is also necessary for the formation of osteoblast and red blood cells. It assists the transfer of iron from blood plasma into ferritin for storage in the liver as well as the release of iron from ferritin when required. The role of ascorbate in iron metabolism is related not only to enhance absorption but also to intracellular metabolism of iron binding protein.
3) *Carnitine synthesis:* vitamin C is required for the synthesis of carnitine. Carnitine is a small nitrogen containing organic compound involved in the transport fatty acids into mitochondria to be oxidized to release energy for use by cells.
4) *Neurotransmitter synthesis:* vitamin C is required to sustain the activity of the copper containing enzyme dopamine oxygenase, which catalases the oxidation of dopamine to form the neurotransmitter nor-epinephrine. Vitamin C also appears to be involved in the hydroxylation of tryptophan during the biosynthesis of serotonin (5-hydroxy tryptamine). The involvement of

vitamin C in the synthesis of neurotransmitters probably explains the presence of high concentration of vitamin C in brain and adrenal tissues.

5) *Activation of hormones:* Many peptide hormones and hormone releasing factors are synthesized as precursor molecules that are enzymatically modified into their active forms. Vitamin C is essential for the activation of bombesin (human gastrin-releasing peptide) calsitonin, gastrin, oxytocin, thyrotropin, cordicotropin, vasopressin, growth hormone-releasing factor.
6) *Drug detoxification:* vitamin C is required for the optimal activity of various drug- detoxifying metabolic systems within the body.
7) *Antioxidant activity:* A range of enzymes and antioxidant reducing agents (including vitamin E, -β Carotene, vitamins C) are able to convert these oxidizing agents too harmless substances that can be excreted. Vitamin C can combine with and so ''Scavenge'' many types of oxidizing free radicals. It can also regenerate the reduced form of vitamin E converting that vitamin back into the form in which it can act as an antioxidant.
The free radicals in cigarette smoke are scavenged by ascorbate in fluids lining the respiratory tract. Smoking one cigarette consumes 0.8mg ascorbic acid. The RDA for smokers is therefore 100mg, and for non-smokers, 60mg.
Vitamin C also aids calcium absorption by preventing the incorporation of calcium into insoluble complexes. Vitamin C converts inactive form of folic acid into its active form dihydrofolic acid and tetrahydrofolic acid.

ANTIOXIDANTS

Antioxidants are molecules that fight or scavenge free radicals of any living organism. Thus they are also known as ''scavengers of free radicals''. The USDA (United States Department of Agriculture) definition of an antioxidant can be extended in nutritional context to include 'compounds that protect biological system against the potentially harmful effects of processes or reactions that can cause excessive oxidation'.

Free radicals are chemical species with one or more unpair electrons. Paired electron spin in opposite directions and their energy is neutralized, while a molecule or radical with an unpair electron has unbalanced energy and becomes unstable and highly reactive. It can either lose an electron and get 'oxidized' or lose an electron and get 'reduced'.

The normal functioning of cells is dependent on a proper balance of pro-oxidants and antioxidants. The former promote the release of oxygen to provide energy needed for the cell functioning. In this process different biochemical process takes place, which continuously produce various free radicals. If these free radicals are not quenched by antioxidants, they cause damage to cells, proteins, DNA and RNA.

Source:

Antioxidant nutrients	Foods containing antioxidant nutrients
β-carotene	Yellowish to orangish fruits & vegetables and eggs.
Vitamin C	Fresh or frozen fruits and vegetables.
Vitamin E	Vegetables oils, nuts and seeds.
Selenium	Brazil nuts, eggs, sunflower seed, chicken breast, mushroom, halibut and oysters.

Action: antioxidant defence system of the body consists of endogenous and exogenous antioxidants which work together at molecular level to protect cell membrane, lipoproteins, DNA and RNA from the damaging effects of free radicals. Exogenous antioxidants are nutrients such as ascorbic acid, tocopherols and β-carotene and non-nutrients obtained through intake of different diets. Compound regarded as a first line of defence, i.e. primary a antioxidant or

secondary antioxidant are synthesized by cells(endogenous), and others need to be provided by the diet.
For example, a number of enzymes with antioxidant function require trace elements from the diet as cofactors. Cytoplasmic and mitochondrial super oxide dismutases require copper, zinc and manganese to catalise the removal of super oxide radicals (O_2^-) produced by the cell. Hydrogen peroxide (H_2O_2) is removed by catalase which requires iron and also by cytosolic glutathione peroxidase ($GSHP_x$). This enzyme also removes potentially toxic lipid hydroperoxides from the cell and is dependent on selenium for optimal function.
Non-enzymic antioxidants are small molecular weight compounds. Endogenously produced examples include glutathione and uric acid. Micro nutrients of dietary origin with antioxidant functions include vitamin E is an example of a phenolic antioxidant. Such molecules readily donate the hydrogen from the hydroxyl (HO) group on the ring structure to free radicals which then become unreactive.
Uses: It has so many beneficial effects on too many diseased conditions. Such as-

Nutrient	Beneficial effect
β-carotene	Reduced risk of various cancers and cardiovascular disease especially smokers.
Vitamin C	Reduced risk of upper gastrointestinal tract, cervix cancer, cardiovascular disease.
Vitamin E	Significant decrease in the risk of oral and pharyngeal cancer, cardiovascular disease.
Selenium	Reduced risk of esophageal and stomach cancers.

Source: The vitamin C content of food items varies considerably depending on: i) growing conditions; ii) state of maturity; **iii)** regional differences; and **iv)** seasons. The main sources of vitamin C are green vegetables and fruits and fresh crop potatoes. Guava has a high content of vitamin C (212mg/100g). Cereals and pulses do not contain vitamin C in the dry state, but if soaked in water for about 48 hours and allowed to germinate, they form a good source of vitamin C.
Requirements: The recommended requirements vary from 30-100 mg a day.
Deficiency: The main deficiency disease is known as ''Scurvy''. Breast fed infants are not susceptible to scurvy as it contains adequate amount of vitamin C. Infants do not show manifestations of scurvy unless the mother's diet is very low in vitamin C. Boiling fresh milk destroys a considerable amount of vitamin C. The main deficiency symptoms of vitamin C are as follows:

- *Tender bones*: There is evidence of general tenderness especially noticeable in the legs. The legs assume the typical frog like position.
- *Petechial haemorrhage*: The capillaries become brittle and burst thus giving rise to red and purple spots over the body.
- *Gingivitis*: This is known as bleeding gums. There are spongy swellings of the mucous membrane.
- *Delayed wound healing*: The wound healing is delayed due to failure of the cells to deposit collagen fibrils.
- *Cessasation of bone growth*: The bones cease growth. The cells of growing epiphyses continue to proliferate but no matrix is laid down between the cells. Consequently, bones fracture easily at the point of growth because they fail to ossify.

SCURVY
The time required to produce scurvy experimentally depends upon the original vitamin C pool size. Symptoms of scurvy appear when the pool is about 0.5g. Volunteers deprived of vitamin C showed no

clinical manifestations for 17 weeks. The first signs noted were hyperkeratotic hair follicles at 17-21 weeks, followed by perifollicular haemorrhages at 26-34 weeks.

Pathology: The basic pathological change is defective formation of collagen. The lining of blood vessels and the bony matrix are poorly formed.

Clinical features: Before the development of clinical signs, vague general symptoms such as lassitude, fatigue, weakness, irritability, a tendency to recurrent infections, and aching of bones are noted.

The related changes in scurvy are:

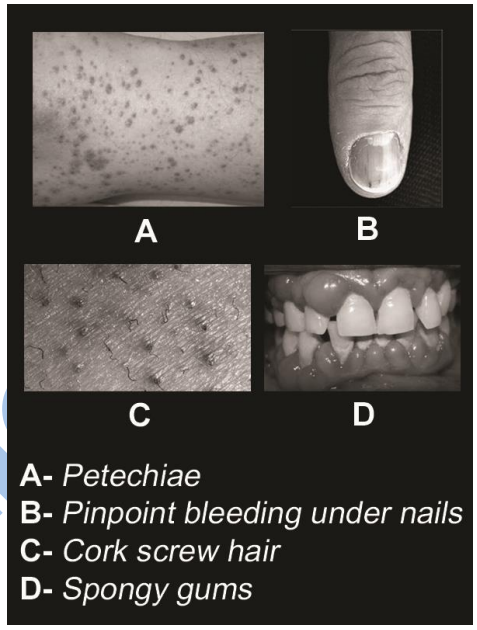
» *Blood vessels*: Blood vessels become fragile and porous due to defective formation of the lining of the walls. This leads to spongy gums and haemorrhage into skin and alimentary & urinary tracts.

» *Skin*: The skin becomes become rough and dry. Early changes are seen in the hair follicles, and are most marked on legs & buttocks.

» *Bones*: During the normal growth, cartilage cells at the growing ends of bones proliferate. In the absence of vitamin C bone formation is retarded. This gives rise to osteoporosis and spontaneous fractures.

» *Teeth & Gums*: Deficiency of vitamin C in children leads to defective formation of teeth. The gums become spongy and bleed easily if slight pressure is applied.

» *Anemia*: Microcytic hypochromic anemia is a common feature, partly due to blood loss from haemorrhage and partly due to deficient absorption of iron.



General manifestations: General signs of scurvy are fever, rapid pulse, and susceptibility to infection. Wound healing is delayed.

Infantile Scurvy

Pregnant women taking excess of vitamin C increase the metabolizing enzyme in the fetus, producing scurvy in the new born. Infantile scurvy also occurs in babies fed on powdered milk.

The symptoms of infantile scurvy are loss of appetite, failure of gain weight, irritability, pallor, defective growth of bones, and haemorrhages in the subperiosteum and viscera.

Treatment: Two types of treatments are done for two conditions.

Scurvy

1. *Prophylaxis*: One hundred grams of germinated pulses provide 10mg vitamin C. About 10mg vitamin C per day is adequate to prevent clinical manifestations of scurvy.
2. *Curative*: Two or four intravenous injection of vitamin C (100ml), at intervals of six hours, will control the haemorrhagic tendency. These should be followed by 100mg orally, three or four times a day.

Infantile Scurvy

1. *Prophylaxis*: The best prevention is one teaspoonful of fresh orange juice, starting in the second week of life, and gradually increasing the amount till the juice of one whole fruit is given daily.

2. Curative: 50mg vitamin C with food, or preferably in orange juice, is administered three or four times a day. As vitamin C is a reducing agent, it is inadvisable to mix it with substances during intravenous therapy.
3. *After-care*: General instructions on dietetic requirements and methods of cooking are necessary. A diet insufficient to prevent deficiency will also lack other nutritional components.

Other Uses: Vitamin C has many useful effects such as:

Wound healing: In the absence of vitamin C, wound healing is defective and formation of scar tissue is delayed.

Common cold: Vitamin C has gained reputation for being useful in reducing the severity of the common cold.

Rheumatic fever: In the controlled clinical study, the morbidity caused by streptococcal infection was higher in patients with vitamin C deficiency and acute rheumatism was noted only in them.

Haemorrhagic disease of newborn: If the cord blood values are very low, marked deficiency in the maternal blood is presumed. Such infants are likely to develop haemorrhagic disease of the newborn.

Fever and Diarrhea: Patients with high fever and diarrhea require increased amount of vitamin C; oral administration of vitamin C, 100mg three times a day, is adequate.

Post-race Respiratory Tract infection: *Ultra marathon runners* have significantly higher incidence of upper respiratory tract infection in the immediate post-race period. The infection reduced by prophylactic use of 600mg vitamin C daily.

Pressure sores: Among elderly people with femoral neck fractures, low concentration of vitamin C appears to favor the development of pressure sores.

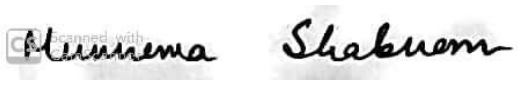
Cancer: A relationship between low vitamin C and cancer of esophagus, oral cavity, stomach, pancreas, rectum, breast and cervix has been noted.

Cataracts: Free radicals of oxygen tend to lead the cataracts in the eyes. The antioxidant vitamin C and E reduce the risk.

Toxicity: High doses of vitamins (megavitamin therapy) may prove harmful. Vitamin C is probably is one of the most overused nutrients, owing mainly to false claim as to its efficiency in the common cold. Daily administration of 200mg vitamin C saturates the body stores. After saturation, the excess is excreted through the urine. With higher doses even the absorption rate is considerably reduced.

Large doses of vitamin C destroy vitamin B_{12} in food, and increase blood estrogen levels in women undergoing estrogen therapy.

Oxalic acid is a breakdown product of vitamin C. High vitamin C intake tends to lead to low blood sugar, highly acid urine, and calcium oxalate and uric acid kidney stones. Gastrointestinal disturbances and changes in the blood coagulation time also occur.



Munnema Shabnom
Department of Food & Nutrition
Mankar College