

Introduction

Definition : Vitamins are a group of organic nutrients required in small quantities for a variety of biochemical functions and which, *generally*, cannot be synthesized by the body and must therefore be supplied in the diet. *or*

(Ref. Harper's illustrated Biochemistry- 26th Edition, P-481)

Vitamin means vital amine. Vitamin may be defined as a potent organic compounds which is found in food in variable and minute quantity and must be supplied to the animal organisms from external sources, so that specific physiological functions, vital to life, may go on normally. *or*

Vitamins may be defined as organic compounds, other than any of the amino acids, fatty acids or carbohydrates, that are necessary in small amounts in the diet of higher animals for normal growth, maintenance of health, and reproduction.

(Ref. Bogert's Nutrition and Physical Fitness)

Antivitamins

The group of substances which are present in food and have antagonistic action to the vitamins. They are collectively known as antivitamins.

Example :

1. Dicoumarol are antagonistic to Vit-k.
2. Pyriothiamine, Oxy-thiamine to thiamine (Vit B) etc.

Provitamins

These are the precursor substances which can be converted into vitamin but do not possess any vitamin activity ie, alpha and beta carotenes are the provitamin of vit-A.

Hypervitaminosis

Occasionally, high therapeutic dose of certain vitamins when used for protracted period, tend to toxic symptom known as hypervitaminosis.

Water soluble vitamin rarely produce toxic symptom as their is a renal threshold for them; but fat soluble vitamins are more prone to toxic symptoms.

Classification of vitamin

Depending upon their solubility in water, fats and oils as well as fat solvents vitamins are divided into 2 groups :

A. **Fat soluble vitamins :** Those present in fats and soluble in fat solvents.

Example :

1. Vitamin A (*retinol, beta-carotenes*)
2. Vitamin D (*cholecalciferol/calciferol/1,25-dihydroxy cholecalciferol*)
3. Vitamin E (*tocopherols, tocotrienols*)
4. Vitamin K (*phyloquinone, menaquinones*).

B. **Water soluble vitamins :** These are water soluble and includes vitamin B-complexes and vitamin C. It does not stored in the body more than 48-72 hours except B₁₂.

i. **Non-B-complex :**

- a. Vitamin C (ascorbic acid)

ii. **B-complex :**

a. **Energy releasing :**

1. Vitamin B₁ (*thiamine*)
2. Vitamin B₂ (*riboflavin*)
3. Vitamin B₃ (*niacin, nicotinic acid, nicotinamide*)
4. Biotin
5. Pantothenic acid

b. **Hematopoietic :**

1. Folic acid
2. Vitamin B₁₂ (*cyanocobalamine*)

c. **Other :**

1. Vitamin B₆ (*pyridoxin*)
2. Pyridoxal
3. Pyridoxamine.

(Ref. Lippincott's Illustrated Reviews- Biochemistry, p-319;
Harper's illustrated Biochemistry- 26th Edition, P-482)

Amounts of daily required vitamins :

Vitamin A	5000 IU
Vitamin D	400 IU
Vitamin E	15 IU
Vitamin K	70 µg
Thiamine (B ₁)	1.5 mg
Riboflavin (B ₂)	1.8 mg
Pantothenic acid (B ₃)	Unknown
Niacin	20 mg
Folic acid	0.4 mg
Pyridoxine (B ₆)	2 mg
Vitamin B ₁₂	3 µg
Vitamin C or ascorbic acid	45 mg.

(Ref. Guyton 11th Edition: Page 875)

Causes of vitamin deficiency

1. Defective intake of vitamins or their precursors in food or as supplements. e.g Malnutrition, Unplanned diet etc.
2. Defect in absorption e.g Diarrhoea, Dysentery, Gastro-enteritis, Coeliac disease, sprue etc.
3. Defect in utilization e.g Wrong way of cooking.
4. Lack of knowledge about health.

Table 2-1. Vitamins essential or probably essential to human nutrition. (Choline is not listed because it is synthesized in the body in adequate amounts except in special circumstances.)

Vitamin	Action	Deficiency Symptoms	Source
A (A ₁ , A ₂)	Constituents of visual pigments; necessary for fetal development and for cell development throughout life	Night blindness, dry skin.	Yellow vegetables and fruit.
Thiamine (Vitamin B ₁)	Cofactor in decarboxylations	Beriberi, neuritis	Liver, unrefined cereal grains.
Riboflavin (vitamin B ₂)	Constituent of flavoproteins	Glossitis, cheilosis	Liver, milk
Niacin	Constituent of NAD ⁺ and NADP ⁺	Pellagra	Yeast, lean meat, liver.
Pyridoxine (Vitamin B ₆)	Forms prosthetic group of certain decarboxylases and transaminases. Converted in body into pyridoxal phosphate & pyridoxamine phosphate.	Convulsions, hyperirritability	Yeast, wheat, corn, liver.
Pantothenic acid	Constituent of CoA	Dermatitis, enteritis, alopecia, adrenal insufficiency.	Eggs, liver, yeast.
Biotin	Catalyzes CO ₂ "fixation" (in fatty acid synthesis, etc)	Dermatitis, enteritis	Egg yolk, liver, tomatoes.
Folates (folic acid) & related compounds	Coenzymes for "1-carbon" transfer; involved in methylating reactions	Sprue, anaemia, neural tube defects in children born to folate-deficient women.	Leafy green vegetables.
Cyanocobalamin (B ₁₂)	Coenzyme in amino acid metabolism. Stimulates erythropoiesis.	Pernicious anemia	Liver, meat, eggs, milk.
Vit-C	Maintains prosthetic metal ions in their reduced form; scavenges free radicles	Scurvy	Citrus fruits, leafy green vegetables.
Vit-D	Increase intestinal absorption of calcium and phosphate..	Rickets	Fish, liver.
Vit-E	Antioxidants ; cofactors in electron transport in cytochrome chain?	Ataxia and other symptoms and signs of spinocerebellar dysfunction	Milk, eggs, meat, leafy vegetables.
Vit-K	Catalyze gama carboxylation of glutamic acid residues on various proteins concerned with blood clotting.	Hemorrhagic phenomena	Leafy green vegetables.

Ref. Ganong 22th Edition, Page 313, 314, 315)

Characteristics of vitamins

The general characteristics of vitamins are-

- Distribution** : The vitamins are widely distributed in nature both in animal and plant kingdoms.
- Source** : All vitamins are manufactured in plants; only a few are manufactured in animals.
- Daily requirement** : Vitamins can perform their work in very low concentration. Hence, the total daily requirement is usually very small.
- Store** : Vitamins can be stored in the body to some extent.
- Fate** : Vitamins are partly destroyed & partly excreted.
- Vitamins are not destroyed by digestive process.
- Some of the vitamins are fat soluble and others are water soluble.

Table 2-2. Food and Nutrition Board, National Academy of Sciences- National Research Council recommended dietary allowances, revised 1989.¹²

Fat-Soluble Vitamins :

Category	Age (years) or Condition	Weight ³		Height ³		Protein (g)	Vitamin A (µg of RE) ⁴	Vitamin D (µg) ⁵	Vitamin E (mg of α-TE) ⁶	Vitamin K (µg)
		Kg	lb	Cm	Inch					
Infants	0.0-0.5	6	13	60	24	13	375	7.5	3	5
	0.5-1.0	9	20	71	28	14	375	10	4	10
Children	1-3	13	29	90	35	16	400	10	6	15
	4-6	20	44	112	44	24	500	10	7	20
	7-10	28	62	132	52	28	700	10	7	30
Males	11-14	45	99	157	62	45	1000	10	10	45
	15-18	66	145	176	69	59	1000	10	10	65
	19-24	72	160	177	70	58	1000	10	10	70
	25-50	79	174	176	70	63	1000	5	10	80
	51+	77	170	173	68	63	1000	5	10	80
Females	11-14	46	101	157	62	46	800	10	8	45
	15-18	55	120	163	64	44	800	10	8	55
	19-24	58	128	164	65	46	800	10	8	60
	25-50	63	138	163	64	50	800	5	8	65
	51+	65	143	160	63	50	800	5	8	65
Pregnant						60	800	10	10	65
Lactating	1st 6 months					65	1300	10	12	65
	2nd 6 months					62	1200	10	11	65

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² The allowances, expressed as average daily intakes over time, are intended to provide for individual variations among most normal persons as they live in the United States under usual environmental stresses. Diets should be based on a variety of common foods to provide other nutrients for which human requirements have been less well defined.

³ Weights and heights of Reference Adults are actual medians for the U.S. population of the designated age. The median weights and heights of those under 19 years of age are not necessarily the ideal values.

⁴ Retinol equivalents. 1 retinol equivalent = 1 µg of retinol or 6 µg of β-carotene.

⁵ As cholecalciferol. 10 µg of cholecalciferol = 400 IU of vitamin D.

⁶ α-Tocopherol equivalents. 1 mg of d-α tocopherol = 1 α-TE.

(Ref. Ganong 22th Edition; Page-312)

Vitamin A

Synonym : Retinol

Structure :

Vitamin A is often used as a collective term for several related biologically active molecules. The term *retinoids* includes both natural and synthetic forms of vitamin A that may or may not show vitamin A activity.

a. *Retinol* : A primary alcohol containing a beta-ionone ring with an unsaturated side chain. Retinol is found in animal tissues as a retinyl ester with long-chain fatty acids.

b. *Retinal* : The aldehyde derived from the oxidation of retinol. Retinal and retinol can readily be interconverted.

c. *Retinoic acid* : The acid derived from the oxidation of retinal. Retinoic acid cannot be reduced in the body and therefore cannot give rise to either retinal or retinol.

d. *Beta carotene* : Plant foods contain beta-carotene, which can be oxidatively cleaved in the intestine to yield two molecules of retinal. In human the conversion is inefficient, and vitamin A activity of beta-carotene is only about one sixth that of retinol.

(Ref. Lippincott's Illustrated Reviews- Biochemistry, p-331)

Table 2-3. Food and Nutrition Board, National Academy of Sciences- National Research Council recommended dietary allowances, revised 1989.^{1,2}

Water-Soluble Vitamins :

Category	Age (years) or Condition	Weight ³		Height ³		Vitamin C (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg NE) ⁷	Vitamin B6 (mg)	Folate (µg)	Vitamin B12 (µg)
		Kg	lb	Cm	Inch							
Infants	0.0-0.5	6	13	60	24	30	0.3	0.4	5	0.3	25	0.3
	0.5-1.0	9	20	71	28	35	0.4	0.5	6	0.6	35	0.5
Children	1-3	13	29	90	35	40	0.7	0.8	9	1.0	50	0.7
	4-6	20	44	112	44	45	0.9	1.1	12	1.1	75	1.0
	7-10	28	62	132	52	45	1.0	1.2	13	1.4	100	1.4
Males	11-14	45	99	157	62	50	1.3	1.5	17	1.7	150	2.0
	15-18	66	145	176	69	60	1.5	1.8	20	2.0	200	2.0
	19-24	72	160	177	70	60	1.5	1.7	19	2.0	200	2.0
	25-50	79	174	176	70	60	1.5	1.7	19	2.0	200	2.0
	51+	77	170	173	68	60	1.2	1.4	15	2.0	200	2.0
Females	11-14	46	101	157	62	50	1.1	1.3	15	1.4	150	2.0
	15-18	55	120	163	64	60	1.1	1.3	15	1.5	180	2.0
	19-24	58	128	164	65	60	1.1	1.3	15	1.6	180	2.0
	25-50	63	138	163	64	60	1.1	1.3	15	1.6	180	2.0
	51+	65	143	160	63	60	1.0	1.2	13	1.6	180	2.0
Pregnant						70	1.5	1.6	17	2.2	400	2.2
Lactating	1st 6 months					95	1.6	1.8	20	2.1	280	2.6
	2nd 6 months					90	1.6	1.7	20	2.1	260	2.6

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2 The allowances, expressed as average daily intakes over time, are intended to provide for individual variations among most normal persons as they live in the United States under usual environmental stresses. Diets should be based on a variety of common foods to provide other nutrients for which human requirements have been less well defined.

3 Weights and heights of Reference Adults are actual medians for the U.S. population of the designated age. The median weights and heights of those under 19 years of age are not necessarily the ideal values.

7 1 NE (niacin equivalent) is equal to 1 mg of niacin or 60 mg of dietary tryptophan.

(Ref. Ganong 22th Edition; Page-312)

Sources of vitamin A :

1. *Animal source* : Cod liver oil, halibut liver oil, liver, egg yolk, milk, milk products- butter, cream etc.
2. *Vegetable sources* : Green leafy vegetables, e.g carrots, pappyes, yellow mangoes, yellow bananas, spinach.

Daily requirement : 5000 IU (1 IU = 6 Micro gm.)

The RDA for adults is 1000 retinol equivalents (RE) for males and 800 RE for females. One RE = 1 µg of retinol, 6 µg of beta-carotene, or, 12 µg of other carotenoids.

(Ref. Lippincott's Illustrated Reviews- Biochemistry, p-333)

Absorption and transport of vitamin A :

- a. *Transport to liver* : Retinol ester present in the diet hydrolyzed in the intestinal mucosa, releasing retinol and

free fatty acids. Retinol derived from esters and from the cleavage and reduction of carotenes is reesterified to long-chain fatty acids in the intestinal mucosa and secreted as a component of chylomicrons into the lymphatic system. Retinol esters contained in chylomicrons are taken up by, and stored in, the liver.

- b. *Release from liver* : When needed, retinol is released from the liver and transported to extrahepatic tissues by the plasma retinol-binding protein (RBP). The retinol-RBP complex attaches to specific receptors on the surface of the cells of peripheral tissues, permitting retinol to enter. Many tissues contain a cellular retinol-binding protein that carries retinol to sites in the nucleus where the vitamin acts in a manner analogous to steroid hormones.

(Ref. Lippincott's Illustrated Reviews- Biochemistry, p-331)

Functions of vitamin A :

- a. **Visual cycle :** Vitamin A is a component of the visual pigments of rod and cone cells. Rhodopsin the visual pigment of the rod cells in the retina, consists of 11-cis retinal specifically bound to the protein opsin. When rhodopsin is exposed to light, a series of photochemical isomerizations occurs, resulting in the bleaching of the visual pigment and release of all trans retinal and opsin. Similar reactions are responsible for color vision in the cone cells.
- b. **Growth :** Animals deprived of vitamin A initially lose their appetites, possibly because of keratinization of the taste buds. Bone growth is slow and fails to keep pace with growth of the nervous system, leading to central nervous system damage.
- c. **Reproduction :** Retinol and retinal are essential for reproduction, supporting spermatogenesis in the male and preventing fetal resorption in the female. Retinoic acid is inactive in maintaining reproduction and in the visual cycle, but promotes growth and differentiation of epithelial cells; thus, animals given vitamin A only as retinoic acid from birth are blind and sterile.
- d. **Maintenance of epithelial cells :** Vitamin A is essential for normal differentiation of epithelial tissues and mucus secretion.

(Ref. Lippincott's Illustrated Reviews- Biochemistry, p-332)

Distribution of vitamin A :

Liver, kidney, cream, butter, and egg yolk are good sources of preformed vitamin A. Yellow and dark green vegetables and fruits are good dietary sources of the carotenes, which serve as precursors of vitamin A.

(Ref. Lippincott's Illustrated Reviews- Biochemistry, p-331)

Storage in the body : Vitamin A is stored in the liver. It may be sufficient to maintain a person without any intake of Vitamin A for upto ten months.

(Ref. Guyton, Wright's)

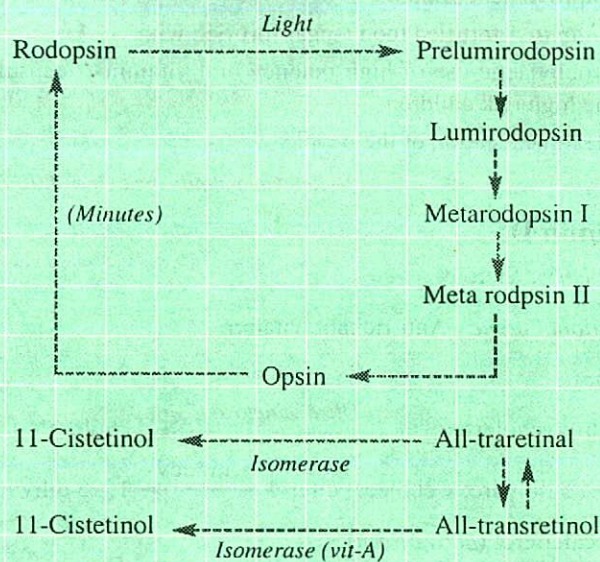
Table 2-1. Food combinations that provide the recommended daily allowance of total vitamin A activity for an adult.

Food	Amounts
Whole milk	1 pt (480 gm)
1. Pumpkin pie	4 in wedge (150 gm)
Vegetable beef soup	1 C
Margarine or butter	2 t bsp
2. Broccoli	2/3 C
Nectarines	2
Eggs	2
3. Apricots	2-4
Tomato juice	6 oz

* Each of these food combination furnishes somewhat more than 5000 IU of total vitamin A activity.

(Ref: Bogert's Nutrition & physical Fitness)

Table 2-2. Diagram of visual cycle



(Ref. Guyton 11th edition)

Hypervitaminosis A :

Excessive intake of vitamin A produces a toxic syndrome called *hypervitaminosis A*. Amount exceeding 7.5 mg of retinol per day should be avoided.

Early signs of chronic hypervitaminosis A are reflected in the skin, which becomes dry and pruritic, the liver, which becomes enlarged and become cirrhotic, and in the nervous system, where a rise in intracranial pressure may mimic the symptoms of a brain tumour.

Pregnant women particularly should not ingest excessive quantities of vitamin A because of its potential for causing congenital malformations in the developing fetus.

(Ref. Lippincott's Illustrated Reviews- Biochemistry, p-331)

Deficiency Signs (consequences of vitamin A deficiency) :

In a word vitamin A deficiency produce 'infection'.

1. **Eye changes :** Deficiency causes disintrigation of epithelium of cornea and lacrimal gland causes--
 - a. **Night blindness (nyctalopia) :** This is the earliest change and is due to les formation of rhodopsin.
 - b. **Xerophthalmia :** Coconjunctival kertinization.
 - c. **Keratomalacia :** Corneal softening and ulceration.
 - d. **Bitot's sports :** Triangular, shiny, gray (white plaques) spots on the conjunctiva.
 - e. **Corneal scarring and blindness.**
2. **Squamous metaplasia :** Squamous metaplasia of columnar mucus-secreting surfaces and transitional epithelium.
Common sites are : Cornea, conjunctiva, upper respiratory tract, urinary tract, salivary gland, pancrease, sebaceous gland and sweat gland.
3. **Impaired immunity and increased susceptibility** to infections in childhood.

Prevention of Vitamin A deficiency

1. Improvement of diet.
2. Vitamin A fortified food (sugar fortified with vit-A)
3. Prophylactic use of high potency oral vitamin-A capsule in the high risk children.
4. Health education of the people.

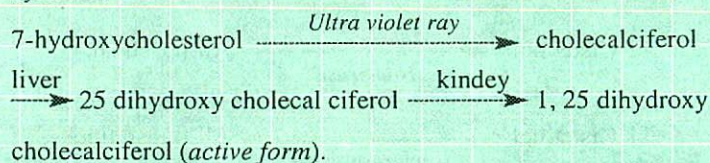
(Ref. Community medicine; J, E. Park)

Vitamin D

Chemistry : Steroid

Functional name : Anti-ricketic vitamin.

Synthesis :



Sources :

1. **Animal :** Exposure to sunlight, cod-liver oil, halibut liver oil, liver, egg yolk.
2. **Vegetable :** Ergot, yeast etc.

Daily requirement : 400 – 800 IU.

Functions :

- i. It helps in absorption of calcium and phosphorus from the intestine.
- ii. It helps in the calcification of new bones.
- iii. It leads to proper growth of bone and skeleton.

Deficiency effects :

- i. In children : Rickets.
- ii. In adult : Osteomalacia : (softening of mature bone)

Toxicosity :

Anorexia, nausea, vomiting, thirst, drowsiness.

Rickets

Features of Rickets : This occurs in children who are not exposed to sunlight and whose diet is deficient in vit D as well. Typically, this was (it is no longer common in the western world) thus a disease of the poor European children. Poor children of Bangladesh (a sun bathed country), where the custom is to remain bare bodied, are thus free from rickets.

The changes in rickets are as follows :

- i. In the bones, the calcium content is low and the bones become therefore soft. Such bones bow when they bear weight, as in femur and tibia.
- ii. The process of ossification, in cartilagenous bone is retarded. Normally, the cartilage is first calcified, then removed and then new bones are deposited. In rickets, the calcification of the cartilage is poor, the cartilage cells continue to proliferate and the shaft becomes broad and irregular.

Rarely, the rickets may be due to disease (destruction) of the kidney (renal rickets).

Osteomalacia

If there is lack of vit D in adult life, the condition is called osteomalacia (softness of the bone). It is thus, the counterpart of rickets in adult life. The calcium concentration of the bones is poor, the bones become soft and bow under pressure. Deformed pelvic bones (deformed, because of the load of the body weight) may ultimately result in obstetrical problems.

Hypervitaminosis D

Gross intake of vit-D above 10, 000 units usually lead to toxic manifestations characterized by :

- i. Nausea, vomiting, diarrhoea with loss of appetite.
- ii. Hypercalcaemia leads to-
 - a. Deposition of Ca in joint soft tissues.
 - b. Deposition of Ca in kidney leads to nephro calcinosis, urinary calculi ultimately renal failure and death.
 - c. Deposition of Ca in vessels leads to vascular symptoms.

Vitamin E

Synonym : Anti-sterility vitamin.

Chemistry : Tocopherol (alpha, beta, gamma, delta; alpha is most active).

Sources :

1. **Animal :** Eggs, meats, liver, fish, chicken, milk.
2. **Vegetable :** Soya bean, seed oil especially corn, wheat etc.

Daily requirement : 15-20 IU.

Functions :

- i. Prevents sterility.
- ii. Exerts anti-oxidative effect to protect other vitamins in foods.
- iii. Essential for normal function of muscle.
- iv. Essential for normal foetal development.
- v. Necessary for normal reproduction in lower animal.

Deficiency effect :

- i. Sterility (loss of reproductive capacity)
- ii. Habitual abortion.
- iii. Testicular degeneration.
- iv. Muscular dystrophy.

Vitamin K

Synonym : Anti-haemorrhagic factor (*phylloquinone, menaquinones*).

Chemistry : 2- methyl -3 phenyl -1, 4-naphthoquinone.

Sources :

1. **Animal sources :** Are poor, but cheese, egg yolk, liver are good sources. It is also synthesized by intestinal flora.

2. *Vegetable sources* : Green vegetables as spinach, cabbage, peas, cereals, soyabean.

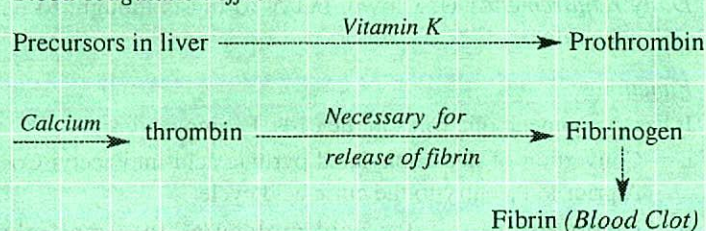
Daily requirement : 70 µg

In haemorrhagic diseases 5 mg orally or in injection form.

Functions :

- It helps in the formation of prothrombin, factor vii, ix, & x by the liver which takes part in normal coagulation.
- It shortens the prothrombin time.
- It prevents haemorrhage.
- It plays an important role in oxidative phosphorylation in the mitochondria.

Blood coagulation effects :



Deficiency sign :

- Hypo-prothrombinemia with resultant prolonged clotting time.
- Uncontrollable haemorrhage in new born.
 - * Large amount of vitamin K is synthesized by intestinal flora, so dietary deficiency usually does not occur.
 - * An important use of vitamin K is as an antidote to the anticoagulant drugs such as dicumerol.

Vitamin B complexes

Vitamin B Complexes :

The members of vitamin-B Complexes are :

- Thiamin (B₁)
- Riboflavin (B₂)
- Pantothenic acid (B₃)
- Niacin
- Pyridoxine (B₆)
- Lipoic acid
- Biotin
- Folic acid
- Cyanocobalamin (B₁₂).

Thiamin (B₁)

Synonym : Antiberiberi or anti-neurotic vitamin.

Sources :

- Vegetables* : Middle coat of cereal grains, peas, pulses, beans, nuts, unpolished rice, is rich in vitamin B₁.
- Animal sources* : Generally poor but liver, heart, kidney, egg yolk contains less amount.

Daily requirement : 1.5 mg (average).

	Age	Allowance mg/day
Male	11 - 18 yrs	1.4
	19 - 22 yrs	1.5
	23 - 50 yrs	1.4
	51 yrs & over	1.2
Female	11 - 22 yrs	1.1
	23 yrs & older	1.0
	Pregnant	+ 0.4
	Lactating	+ 0.5

(Ref: Bogert's Nutrition & physical Fitness)

Functions :

- Plays an important role in carbohydrate metabolism.
- Essential for maintenance of normal appetite and digestion.
- Essential for normal function of nervous tissue.

Deficiency sign :

Thiamin (vitamin B₁) deficiency affects predominantly the peripheral nervous system, cardiovascular system and the gastro-intestinal tract. The clinical manifestation is known as **beriberi**.

The main symptoms of beriberi are as follows :

- Loss of appetite (anorexia), impaired digestion, severe constipation, gastric atony.
- Weakness.
- Polyneuritis.
- Cardiac failure.

Types of beriberi :

There are three types of beriberi :

- Dry (*neuritic*)
- Wet (*cardiac*)
- Cerebral.

(Ref. wright's)

Riboflavin (B₂)

Synonym : Lactoflavin.

Sources :

- Animal sources* : Egg yolk, liver, kidney, milk, meat, heart muscles etc.
- Vegetable sources* : Green leafy vegetables, peas, beans, cereal grains.

Daily requirement : 1.8 mg (average).

	Age	Allowance mg/day
Male	11 - 14 yrs	1.6
	15 - 22 yrs	1.7
	25 - 50 yrs	1.6
	51 yrs & over	1.4

Functions :

- i. It acts as co-enzyme in tissue oxidation and respiration.
- ii. It helps in protein, fat and carbohydrate metabolism.
- iii. Essential for normal growth.

Deficiency sign :

- i. Glositis : Inflammation of tongue.
- ii. Angular-stomatitis : Cracking at the angle of the mouth.
- iii. Cheilosis : Cracking at the line of closure of lips.
- iv. Scrotal and vulval dermatitis.
- v. Burning sensation of skin, eyes, vascularisation of cornea, mental depression, headache, anorexia, vomiting, forgetfulness.

Niacin

Synonym : Nicotinic acid and pellagra preventing factor.

Sources :

1. *Animal sources* : Milk, milk products, fish, liver, meat, egg, yeast.
2. *Vegetable sources* : Peas, tomato, nuts, maize, vegetables.

Daily requirement : 15 - 20 mg (average).

	Age	Allowance mg/day
Male	11 - 14 yrs	18
	15 - 22 yrs	19
	25 - 50 yrs	18
	51 yrs & over	16
Female	11 - 22 yrs	15
	23 - 50yrs	14
	51 yrs & over	13
	Pregnant	+2
	Lactating	+5

(Ref : Bogert's Nutrition & physical Fitness)

Functions :

- i. Prevent pellagra.
- ii. Acts as co-enzyme in the form of NAD and NADP.
- iii. Essential for the normal functioning of the skin, intestinal tract and nervous system.
- v. Essential for growth.

Deficiency sign :

- i. Pellagra is characterized by three 'D'- *Dermatitis, Diarrhoea and Dementia*.
- ii. Glossitis.
- iii. Mental depression.
- iv. Stomatitis.

Pellagra : Pellagra means rough skin. At first the skin is red, itchy then becomes swollen and tense and finally desquamation

occurs. Here also GI tract disorders occur including irritation and inflammation of mucous membrane of mouth, tongue, gum and other parts of GI tract. Mental changes occur including depression, irritability and delirium.

Pantothenic Acid (B₅)

Pantothenic acid is mainly incorporated in the body into co-enzyme A.

Sources :

1. *Animal sources* : Liver, kidney, egg-yolk, skimmed milk.
2. *Vegetable sources* : Whole grains, cereals, peas, wheat, molasses, sweet potato.

Daily requirement : Unknown, but 5-10 mg is thought to be adequate.

Functions :

It has many metabolic roles in the cells. Example are :

- i. Conversion of decarboxylated pyruvic acid into acetyl Co-A prior to its entry to the citric acid cycle.
- ii. Degradation of fatty acid molecules into multiple molecules of acetyl Co-A.

Deficiency sign : Deficiency of pantothenic acid in lower animals can cause -

- i. Retarded growth
- ii. Failure of reproduction
- iii. Grawing of hair
- iv. Dermatitis
- v. Fatty liver
- vi. Haemorrhagic adrenal cortical necrosis.

In human being no definite deficiency syndrome occurs, because of-

- i. The wide occurrence of this vitamin in almost all foods.
- ii. It probably be synthesized in the body.

Pyridoxin (B₆)

Vitamin B₆ exists in 3 forms- pyridoxine, pyridoxal and pyridoxamine & remains in the cells in the form of pyridoxal phosphate.

Sources :

1. *Animal sources* : Egg yolk, liver, milk, meat, yeast, fish, etc.
2. *Vegetable sources* : Leafy vegetables, corn, wheat, cabbage, legumes.

Daily requirement : 2 mg (average).

	Age	Allowance mg/day
Male	11 - 14 yrs	1.8
	15 - 18 yrs	2.0
	19 yrs & over	2.2

Female	11 - 22 yrs	1.3
	23 - 50yrs	1.2
	51 yrs & over	1.2
	Pregnant	+0.3
	Lactating	+0.5
Female	11 - 14 yrs	1.8
	15 yrs & over	2.0
	Pregnant	+0.6
	Lactating	+0.5

(Ref: Bogert's Nutrition & physical Fitness)

Function :

- It acts as a co-enzyme and involves in trans-amination for the synthesis of aminoacid.
- Essential for metabolism of tryptophan.

Deficiency effects :

- Dermatitis around mouth & eye
- Anorexia
- Nausea
- Vomiting
- Neuritis
- Gastro-intestinal disorders
- Convulsion.

Folic Acid

Sources :

- Animal sources : Liver, kidney, milk, egg.
- Vegetable sources : Leafy vegetables, beans, nuts and cabbage.

Daily requirement :

Unknown but 50 microgram is thought to be adequate.

Functions :

- Necessary for maturation of RBC.
- Necessary for the synthesis of purines and thymine, which is required for the formation of DNA.

Deficiency effects :

- Megaloblastic anaemia.
 - Gastro-intestinal disorders.
 - Glossitis.
- * Severe folate deficiency may cause infertility or even complete sterility.

Recommended allowance for folic acid & vitamin B₁₂.

	Age	Folic activity mcg /day	Vitamin B ₁₂ activity mcg/day
Male	11 yrs & over	400	3
Female	11 yrs & over	400	3
	Pregant	800	4
	Lactating	500	4

Cyanocobalamin (B₁₂)

Synonym : Antipernicious anaemia factor.

Sources : Liver, egg yolk, kidney, milk, cheese & meat.

Daily requirement : 2 micro-gram.

Functions :

- Essential for maturation and formation of RBC.
- Necessary for the synthesis of DNA.

Deficiency effects :

- Pernicious or magaloblastic anaemia.
- Demyelination of the large nerve fibers of the spinal cord specially of the lateral columns.

Storage of vitamin-B complexes in the body : The storage of vitamin-B complexes are relatively slight (48-72 hours). When a person's diet is deficient in vitamin-B compounds, clinical symptoms of the deficiency can some times be recognized within a few days (except for vitamin B₁₂ which can last in the liver for a year or longer).

Vitamin C

Synonym : Ascorbic acid, antiscorbutic.

Sources :

- Vegetable sources : Fresh citrus fruits, e. g. Amlaki, orange, lemon, guava, pineapple, papay etc. Fresh vegetables e. g. cabbage, cauliflower, green peppers, spinach, lettuce, tomato etc.
- Animal sources : Generally poor but milk contains small amount.

Daily requirement : 50-100 mg (average).

	Age	Allowance mg/day
Male	1 - 10 yrs	45
	11 - 14 yrs	50
	15 yrs & over	60
Female	1 - 10 yrs	45
	11 - 14 yrs	50
	15 yrs & over	60
	Pregnant	+20
	Lactating	+40

(Ref: Bogert's Nutrition & physical Fitness)

Functions :

- It maintain normal intercellular material of cartilage, dentine and bone.
- It takes part in wound healing.some metabolic action.
- It has some metabolic action.
- It prevents scurvy.
- Large doses protect against infection.
- It is essential for maturation of RBC.

Deficiency effect :

- Scurvy.
- Anaemia.

Scurvy

A deficiency (vit C) disease characterized by haemorrhagic manifestation and abnormal formation of bones and teeth.

Symptoms : Preceded by period of ill health, characterizd by

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2.10 Physiology

shallow complexion; loss of energy, pains in leg, limbs, and joints. Anaemia, great weakness, bleeding gums, looseing of

teeth, subcutaneous haemorrhages and haemorrhages from mucus membrane etc.