

NUTRITION AND HEALTH

Abstract

Nutrition deals with study of dynamic process of utilization of ingested food for nourishment of the body to carry out various functions. In other words it deals with food assimilation. Foods can be classified as cereals, millets, pulses, vegetables, nuts and oil seeds, fruits, flesh and dairy foods, fats and oils, sugar and jaggery, condiments and spices, miscellaneous foods. All provide diverse nutrients. Functions, natural sources and daily requirement of these nutrients are important to know to maintain health and vitality. Some nutrients are “double edged swords”, i.e. their deficiency as well as excess results in diseases. Recognition of symptoms and signs of these diseases is first step of their management in practice.

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Author

Megha Luthra
Professor
Department of Community Medicine
Shri Guru Ram Rai Institute of Medical &
Health Sciences
Dehradun, Uttarakhand, India.
Email: drmeghaluthra9@gmail.com

I. DEFINITIONS

1. **Nutrition:** Deals with study of dynamic process of utilization of ingested food for nourishment of the body to carry out various functions. In other words it deals with food assimilation.
2. **Nutrient** is the active ingredient of food items, which determines food quality and health of the individual. For example: proteins, carbohydrates, fats, minerals and vitamins. All the nutrients together with water form the main bulk of food. The human body is made up of all the six constituents: 5 types of nutrients and water. An important additional part of food is dietary fibre.
3. **Food** includes substances consumed for maintenance of health, vitality and well-being and vitality of an individual excluding water and drugs. Foods are usually eaten after processes of washing, peeling, cutting, cooking, boiling, frying, baking, etc. After this food becomes '*diet*' (*meal*), sometimes it is consumed in the raw state.
4. **Dietetics** is the science dealing with study of nutrition in health and disease (i.e. meal planning for the healthy and diseased).
5. **Balanced Diet** is the diet consisting of appropriate foods in correct proportions, so that it provides optimum energy and proximate principles for maintenance of health, wellbeing and vitality. It provides for withstanding short duration of illness and lack of food.

II. CLASSIFICATION OF FOODS

1. **By Chemical Composition:** Proteins, fats, carbohydrates, vitamins and minerals.
2. **By Origin:** Foods of animal origin, foods of plant origin.
3. **By function:**
 - Body building foods (Foods rich in proteins e.g. meat, fish, milk, egg, pulses, etc.)
 - Energy yielding foods (Foods rich in fats and carbohydrates e.g. cereals, sugar, ghee, oil, etc.)
 - Protective foods (Foods rich in vitamins and minerals e.g. fruits, vegetables).
4. **By nutritive value:** Cereals, millets, pulses, vegetables, nuts and oil seeds, fruits, flesh and dairy foods, fats and oils, sugar and jaggery, condiments and spices, miscellaneous foods.

III. NUTRIENTS

1. **Macronutrients** are required in large quantities and constitute the main bulk of food and include proteins, carbohydrates, fats and fibre. As 'Proximate principles their contribution in the food is as follows:
 - Proteins—7 -15% of total energy intake
 - Fats—10-30% of total energy intake

- Carbohydrates—65-83% of total energy intake
2. **Micronutrients** are required in small quantities (micrograms to milligrams) e.g. vitamins and minerals and are essential for normal healthy living. Iodine, iron, zinc and vitamin A are important for immunity, intelligence, reproduction and work capacity. Since they cannot be synthesized endogenously, have to be supplied in diet. Micronutrient malnutrition (deficiencies) result from inadequate dietary intake, poor absorption from gastrointestinal tract, excessive losses, increased requirements or a combination of these factors.

Table 1

Nutrients	
Macronutrients	Micronutrients
Fats	Vitamins
Carbohydrates	Minerals
Proteins	
Water	
Fibre	

IV. PROTEINS

Proteins are of “first” importance. They are complex compounds that differ from carbohydrates and fats in that they contain nitrogen. *Amino acids* are the building blocks of proteins, linked by peptide chains. 22 amino acids are grouped into ‘*Essential*’ and ‘*Non-essential*’ groups. Essential ones (10 in number) are not synthesized in the body in required amounts and must be supplied from dietary proteins: leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine, histamine and arginine. Non-essential amino acids (arginine, asparaginic acid, serine, glutamic acid, proline, glycine etc) are synthesized in the body and needed for synthesis of tissue proteins.

A First class protein (‘*biologically complete protein*’ or ‘Protein of high biological value’) contains all essential amino acids in required quantities e.g. animal proteins such as egg, milk, fish, etc.

A Second class protein (‘*biologically incomplete protein*’ or ‘Protein of low biological value’) is deficient in one or more essential amino acids e.g. vegetable proteins such as cereals, pulses, etc.

Exceptions: Gelatine obtained from animals has low biological value while yeast and soyabean derived from vegetable sources have high biological value.

1. **Supplementary Actions of Proteins:** Cereals are deficient in lysine, maize in lysine and tryptophan. These are known as ‘Limiting amino acids’. When cereals and pulses are eaten together in combination, for example, ‘rice and dal’ or ‘dal and roti’, their deficient amino acids add up to provide a protein comparable to first class protein. This process of combining vegetable protein in diet to obtain dietary mix of protein of high biological value is known as supplementary action of proteins.

2. Functions of Proteins:

- Essential for growth and development of the body (Body building).
- Essential for the repair of the tissues (wear and tear)
- Provide energy (1 g provides 4 kcals of energy)
- Constituents of enzymes and hormones
- Make up antibodies, plasma and hemoglobin
- Maintain osmotic pressure and thus maintain fluid balance
- Maintain the hydrogen ion concentration of the body fluid thus maintain the acid-base balance.

3. Daily Requirement: Since proteins do not have bodily stores, daily supply is essential. The daily requirement of proteins is 0.83g/kg body weight for adults. It is more for growing children, during pregnancy, during lactation, during infections, infestations, stress and during recovery from diseases.

4. Sources of Proteins

- **Vegetable Sources:** These are cereals, pulses, beans, nuts, oil-seed cakes, etc. Although poorer in essential amino acids and second class proteins, they are the main sources of protein in India because of vegetarian nature of diet and low cost, easily availability and bulk consumption.
- **Animal Sources:** Egg-white, meat, milk, fish, cheese, etc. They are called First class proteins. Egg-proteins are considered to be “Reference Protein” because of its high biological value and digestibility.
- **Mixed Vegetable Proteins** (Vegetable Blends) utilize the supplementary action of the proteins of vegetable sources. Examples are:
 - Indian multipurpose food
 - Mysore food A & B
 - Balahar

Parameters of Evaluation (Assessment) of Proteins

Essential Amino Acid Score (Chemical Score) Essential amino acid concentration in test protein, expressed as its percentage in reference protein (i.e. egg-albumin).

$$\text{EAA score} = \frac{\text{mg of one essential amino acid in 1g of test protein}}{\text{mg of same amino acid in 1g of reference protein}} \times 100$$

The least score of an essential amino acid in a food indicates its limiting amino acid. EAA score is 50-60 for cereals and 70-80 for animal foods.

Protein Efficiency Ratio is the weight gain in a young growing animal per unit weight of protein consumed.

$$\frac{\text{Weight gain (g)}}{\text{Protein intake (g)}} \times 100$$

A high protein efficiency ratio (PER) (> 2.5) is assigned to proteins that are efficient in promoting growth. These are first class protein (animal proteins). The PER between 0.5 and 2.5 is assigned to proteins that are efficient in supporting life but not growth. These are vegetable proteins; found in pulses, nuts and cereals.

Protein energy (PE) is the percentage of the energy value obtained from the protein content of the food.

$$\text{PE percent} = \frac{\text{Energy obtained from protein}}{\text{Total energy in the diet}} \times 100$$

Proteins should provide 7-15 % of the total daily energy intake. All essential amino- acids (EAA) are required in the diet for tissue synthesis. Since EAA requirement decreases with age, the quality of diet for infants should be far superior for infants than for adults.

Digestibility Coefficient is the percentage of ingested proteins that is absorbed in the blood stream (i.e. ingested nitrogen minus fecal excreted nitrogen).

Biological Value (BV) is the percentage of nitrogen retained (after its excretion in the feces and urine) out of the nitrogen absorbed from the diet (i.e. absorbed nitrogen minus nitrogen excreted in urine).

$$\text{BV} = \frac{\text{Nitrogen Retained}}{\text{Nitrogen absorbed}} \times 100$$

Net Protein Utilization (NPU) is the proportion of ingested nitrogen from proteins retained in the body for tissue maintenance and growth. It is the product of biological value and digestibility coefficient divided by 100. It is indirectly related to the dietary intake of nitrogen. Low net protein utilization (NPU) indicates high protein requirement and vice-versa. A NPU value above 50 is considered satisfactory.

$$\text{NPU} = \text{DC} \times \text{BV}/100$$

1 g of protein is presumed to be equivalent to 6.25 g of nitrogen.

V. CARBOHYDRATES

Carbohydrates constitute the predominant bulk of our diet. Each unit of carbohydrate (CHO) consist of carbon, hydrogen and oxygen, hence the nomenclature. As per the number of units, carbohydrates can be monosaccharides (single unit, sweet, water soluble e.g. glucose, galactose, fructose, ribose), disaccharides (two carbohydrate units, sweet, water soluble e.g. lactose, maltose, sucrose) and polysaccharides (more than two units, usually tasteless, water insoluble e.g. starch, cellulose). Starch present in cereals, millets, roots and tubers is the main source of our energy. Cellulose is the dietary fiber present as lining in the cereals and pulses, fruits and vegetables.

1. Functions:

- Main source of energy 4 kcals/g of energy
- Oxidation of fat (Fats are burnt in the fire of carbohydrate)
- Storehouse of energy- as glycogen in the liver and muscles. The reserve is rapidly exhausted during starvation.
- Excess of carbohydrate is stored as fat in the body.
- Structural unit of nervous system, as cerebroside.
- Protein sparing action.
- Flavor and texture to food, increases palatability.

2. **Sources:** Cereals, pulses, roots and tubers, fruits. The carbohydrate (CHO) content of flesh foods is negligible. Sugar, jaggery and honey are 100 percent carbohydrates.

3. **Daily Requirement:** It is 400 to 500 g. CHO should constitute 65-83% of total energy requirement of the body.

4. **Carbohydrate and Disease:** High intake of sucrose rich foods causes sharp rise in blood glucose levels and predisposes for *obesity*. It also exerts beta-cells of islets of Langerhans in the pancreas eventually leading to exhaustion of beta-cells and consequent *diabetes*.

Sucrose promotes bacterial growth in the oral cavity which in turn produce acid corroding dental enamel and leading to the development of *dental caries*.

VI. DIETARY FIBER

This inert component of carbohydrate with little nutritive value is a non-starch polysaccharide. Found in vegetables, fibrous fruits (pineapple), brans and whole grains, it includes cellulose and non-cellulose polysaccharides such as hemicellulose, pectin, lignin, inulin. Majority of fibres are degraded by the microflora in the colon. Only a small part is digested by the bacterial flora to help themselves for multiplication and gas production. It makes the stool bulky and soft. The rectal distention stimulates the defecation reflex. Hence deficiency of fiber not only leads to constipation but also increases the hardness of the stool. Hard stool needs straining, which in turn increases the intra-abdominal pressure predisposing for the development of hemorrhoids, hernia, diverticulosis, and varicose veins.

Dietary fiber (soluble fiber) binds cholesterol of the food and prevents its absorption and eliminates it through stools, reduces serum cholesterol level. Thus it reduces risk of atherosclerosis. Low fiber diet is associated with less fecal volume and constipation, resulting in higher concentration of carcinogens ingested in the food. Bowel mucosa exposed to this higher concentration of carcinogens for an unduly long period, predisposes for cancer of colon. Fiber also acts as a scavenger-cum-vehicle to remove tissue debris and other unwanted materials from intestine through stools. Fiber facilitates, the normal peristaltic movements of the intestine. Soluble fiber prevents gallstones and obstructive jaundice. It also slows down the absorption of glucose, hence good for diabetics. Thus, fiber is an essential part of food, even though it is a non-nutrient. An average diet should include 40 g of fiber per day.

VII. FATS

Fats and oils are the richest source of energy, they are compounds of glycerol

(glycerin) and *fatty acids*. Latter are in turn made up of carbon, oxygen and hydrogen. Fats are the solid forms and oils are the liquid forms while *lipid* is a comprehensive term consisting of both fats and oils. Lipids include *simple lipids* (e.g. triglycerides), *compound lipids* (e.g. phospholipids) and *derived lipids* (e.g. cholesterol). About 99 percent of the body fat in the adipose tissue is in the form of *triglycerides*. The adipose tissue constitutes about 10 to 15 percent of body weight.

- 1. Saturated Fatty Acids** are derived primarily from animal sources (except coconut oil) e.g. lauric, palmitic and stearic acids. They can be synthesized in the body during the catabolism of proteins and carbohydrates.
- 2. Unsaturated Fatty Acids** are derived primarily from vegetable sources. These are further divided to monounsaturated (MUFA, e.g. Oleic acid) and polyunsaturated fatty acids (PUFA, e.g. Linoleic acid) former can be synthesized in the body but the latter cannot be synthesized in the body. *Trans fatty acids* are so named due to the presence of trans bonds in their molecular structure. Mainly found in Partially Hydrogenated Vegetable Oils (PVHOs), they are extremely detrimental to human health. They form deposits on vascular intima that takes decades to be eliminated from the human body and highly predisposes to plaque formation. Hence, they should be completely eliminated from human diet.

Sources of Fats

- Fats derived from animal Sources are ghee, butter, milk, cheese, egg yolk, meat and fish.
- Fats derived from vegetable Sources (Edible Oils) are groundnut oil, mustard oil, gingelly oil, linseed oil, safflower oil, rapeseed oil, coconut oil and palm oil.
- Certain amount of fat is also found among cereals (3-4%), pulses, and other vegetables that cannot be separated from the source. It is called *invisible fat*.

Functions

- Most concentrated source of energy (9 kcals/g): acts as a storehouse of energy in subcutaneous tissue
 - Main sources of vitamins A, D, E and K are animal fats
 - Subcutaneous fat acts as an insulator against cold
 - Cushioning to viscera like heart, kidney, intestines and support them
 - Structural unit of some tissues in the body like nervous tissue
 - Provides contour to the body
 - Provide palatability, taste and flavor of the food.
 - Prevent proteins from being used up for energy (Protein spacers).
- 3. Essential fatty acids** are essential to carry out functions and have to be derived only from the food (vegetable oils). EFAs are not synthesized in the body e.g. Linoleic acid, linolenic acid, arachidonic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).
 - **Functions of EFA**
 - Maintain the integrity of the skin (smoothness and healthiness)
 - Maintain enzyme system in the body

- Help in synthesis of prostaglandins
- EPA and DHA reduce the serum cholesterol in the blood by transportation
- DHA is especially active in retina and cerebral cortex.

Deficiency of omega-3 fatty acids (Linolenic acid, DHA and EPA) to visual and neurological symptoms. Deficiency of omega-6 fatty acids (Linoleic and arachidonic acids) leads to skin changes. Deficiency of all EFA in the diet may result in growth retardation, reproductive failure, skin disorders (like phrynoderma), increased susceptibility to infections, decreased myocardial contractility, renal hypertension and hemolysis. EFA are present mainly in vegetable oils and daily requirement is about 5 g. It is more in pregnant and lactating mothers, infants and growing children.

Saturated fatty acids are mainly obtained from animal fats and *unsaturated fatty acids* from the vegetable oils.

Exceptions: fish oil even though it is from animal source, it contains unsaturated fatty acids (i.e. 10%), coconut oil and palm oil are vegetable oils, still rich in saturated fatty acids (92 and 46% respectively).

Table 2: Fatty acids content of different fats (Percent)

Fats	Saturated Fatty Acids	Unsaturated Fatty Acids
Animal fats		
Butter	60	10-20
Meat	20.0	0.5
Egg	13.3	0.3
Buffalo milk	7.5	0.5
Cow's milk	3.8	0.5
Fish oil	2.0	10.0
Vegetable oils		
Groundnut oil	20	40
Mustard oil	08	15
Safflower oil	10	10
Sunflower oil	08	45
Coconut oil	92	04
Palm Oil	46	25

Source: ICMR, New Delhi

Refined Oils are vegetable oils treated with steam or alkali. The process brings about deodorization, removes free fatty acids, vitamin A and D and rancid materials. The taste is improved and unsaturated fatty acid content of the oil remains unchanged. Only drawback is the deficiency of vitamins A and D.

Hydrogenation of Oils (vegetable origin) is the process of converting liquid oils into semi-solid and solid fat called 'Vanaspati' or vegetable ghee. Hydrogenation removes color and odor making vanaspati a popular cooking medium.

Vegetable ghee has to be fortified with vitamin A and D as it is deficient in fat-soluble vitamins. Unsaturated fatty acids are converted into saturated fatty acids, EFA content is drastically reduced making it much less heart friendly. The only positive point is that keeping quality is better.

Daily Requirement (ICMR) 20 percent of total energy requirement should be met through fats (maximum 30%), i.e. about 40 g per day for an adult man, about 25 g from the visible fat (e.g. Rice Bran Oil) and remaining from the invisible form.

Fatty diet *excess* higher than 30% fats predisposes to obesity. Above 40% fats in diet containing high proportion of saturated fatty acids, is a major risk factor for Coronary Heart Disease (CHD), because it transiently increases blood cholesterol level (Post prandial hypercholesterolemia), which in turn predisposes for the development of atherosclerosis and coronary heart disease. 'High Density Lipoproteins' (HDL), a class of lipoproteins, transport cholesterol to liver from the peripheral tissues. Thus, HDL is called good cholesterol and protects against the development of atherosclerosis and CHD.

Another class of lipoproteins called 'Low Density Lipoproteins (LDL) and Very Low Density Lipoproteins (VLDL) are atherogenic and predispose for the development of CHD. The risk of CHD is doubled if LDL level is between 130 and 160 mg/dl and 3 times if it is more than 161 mg/dl. Thus, LDL is a real 'risk marker' of coronary artery disease. In case the LDL to HDL ratio is more than 5, it indicates the risk of coronary artery disease. Also EFA intake is inversely related to CHD mortality and there is a direct relationship between saturated fatty acids intake and CHD mortality. Therefore, to avoid CHD, not more than 30 percent of the calories required are obtained from fats and not more than 10 percent are derived from saturated fatty acids.

On the other hand, *deficiency* of essential fatty acids causes dry and rough skin called Phrynoderma, characterized by horny papular eruptions on the lateral and posterior aspects of arms and legs. Treatment is by administration of safflower oil, rich in EFA.

VIII. VITAMINS

Vitamins are so called because they enable the body to use other nutrients and carry out vital functions in the body. They have to be obtained from food. *Water soluble vitamins* are vitamin B complex and vitamin C. *Fat soluble vitamins* are vitamins A, D, E and K.

Vitamin B Complex includes Vitamins B1(Thiamine), B2 (riboflavin), B3 (niacin), B6 (pyridoxine), B12 (cyano- cobalamin), pantothenic acid, folic acid and para-amino benzoic acid. Due to lack of bodily stores these vitamins must be supplied in daily diet otherwise deficiencies occur. As they are water soluble, excess is eliminated via urine and toxicity is not known. Biotin, choline and carnitine also belong to this group but their role in human nutrition is being studied.

Vitamin B1(Thiamine) Role of this vitamin is marked by it being indispensable for *carbohydrate metabolism*. Complete oxidation of pyruvic and lactic acids depends upon thiamine. Rich *sources* of thiamine are unmilled cereals, pulses, groundnuts, milk for infants. It is important to maintain supply of this vitamin in lactating mothers. Food for all should be

cooked in less water to minimize thiamine *losses* as it leaches into the water from outer pericarp of the cereal while cooking. Milling and polishing of rice, use of baking soda while cooking lead to further losses. It's required amount is 1 to 2 mg per day. Since the nervous system relies heavily upon carbohydrate for its energy needs, ill effects of thiamine *deficiency* are predominant in nervous tissue (i.e. neurological disturbances occur). Thiamine deficiency in adults presents as *Korsakoff's psychosis* and *Wernicke's encephalopathy*: the cerebral forms of thiamine deficiency. The former is characterized by memory defects and disorientation. Latter, common in alcoholics of Europe and North America, is characterized by ataxia, bilaterally symmetrical ophthalmoplegia, nystagmus, confusion progressing to stupor and coma. *Beriberi* (Dry, wet and infantile beriberi) is common among those who consume milled rice as staple cereal and its incidence has decreased with improvement in socio economic conditions. *Dry beriberi* is common among growing children with involvement of the nervous system (polyneuropathy). Symptoms also arise due to accumulation of pyruvic acid and lactic acid in the muscles. Calf muscles are tender, weak and wasted with sluggish reflexes. The child has difficulty in standing from sitting position. Children also have anorexia, dyspepsia, constipation, slow growth and emaciation. In *Wet beriberi* cardiovascular system is mainly involved with palpitation, tachycardia, dyspnea and edema feet. *Infantile beriberi* occurs among breastfed infants if the mothers are thiamine deficient. The child becomes restless, cries often, passes less urine and develops puffy face. *Daily requirement* is 1-2mg.

Vitamin B 2 (Riboflavin) is a cofactor of certain enzymes concerned with *cellular oxidation and growth*. Rich *sources of riboflavin* are green leafy vegetables, milk, liver. Fair sources are cereals and pulses except rice. Germination of pulses increases the riboflavin content. *Deficiency* is called '*Ariboflavinosis*' which is common among poor malnourished children and adults. Due to paucity of food its co-existence with deficiencies of other vitamins of the B-group is seen (*multiple vitamin deficiency syndrome*). Often there is impaired neuromotor function, characteristic involvement of skin and mucous membranes. Other features are sore, red, glazed, smooth tongue (glossitis), inflammation at angles of mouth (angular stomatitis), cracking at the angle of the mouth (cheilosis), scaly desquamation at nasolabial folds (nasolabial dyssebacia), scrotal dermatitis and watering of eyes, photophobia, and blurring of vision (due to vascularization of cornea and keratitis). *Daily requirement* is about 1 to 2.3 mg.

Vitamin B 3(Niacin/Nicotinic Acid) is an important component of co-enzymes required for *protein, fat and carbohydrate metabolism and tissue oxidation*. An essential amino acid tryptophan is its precursor (1:60 ratio). Although water soluble, it is metabolized and not excreted in urine. Good *sources* are foods rich in tryptophan like pulses, groundnuts, milk, liver, kidney, meat, fish and poultry. It occurs in a bound form in maize (niacytin) which is not available for use by the body. *Deficiency* of niacin results in anorexia, nausea, vomiting, dysphagia and dyspepsia. People subsisting on maize and jowar, (high leucine in these cereals interferes in the formation of niacin from tryptophan) have '*Pellagra*'. It is characterized by 3 D's-Dermatitis, Dementia and Diarrhea. Bilaterally symmetrical dermatitis is found on sun exposed body surfaces (face, hands and legs) with cracked, scaly and pigmented skin. Often there is itching and burning sensation. Diarrhea is scanty. Mental changes (dementia) include irritability, delirium and depression. *Daily requirement* is about 15 mg.

Vitamin B 6 (Pyridoxine) is necessary for *amino acid metabolism* and is abundant in *flesh foods*. Pyridoxine, pyridoxal and pyridoxamine are its three active forms. *Deficiency* results in loss of weight, edema, peripheral neuritis and morning sickness in pregnant females. It can also be caused by anti-tubercular drug INH and Vitamin B6 supplementation is a must for these patients. *Daily requirement* of vitamin B6 in adults is 2 mg 2.5 mg in pregnant and lactating women.

Folic Acid (Pteroylglutamic Acid; Folacin), derived from the latin word ‘Folia’ meaning ‘Leaf’ is an essential requirement for *DNA synthesis and cell maturation* in rapidly multiplying cells e.g. intestinal mucosal cells, bone marrow cells, RBCs. Rich sources are dark green leafy vegetables, pulses like soybean and liver. Free folates in these foods are rapidly absorbed. *Deficiency* results in abnormal cell division due to impaired DNA synthesis in tissues with rapidly dividing cells such as intestinal mucosa and bone-marrow. Hence, diarrhea and megaloblastic anemia (in children and pregnant mothers) and are predominant symptoms. Folic acid supplementation during pregnancy is a common practice to increase the birth weight of newborns. *Daily requirement* for adult man is 100 mcg and for adult woman 250 mcg. During pregnancy it increases to 500 mcg, during lactation to 350 mcg.

Vitamin B 12 (Cyanocobalamin) plays an important role in *DNA synthesis* of rapidly multiplying cells such as RBCs. It also helps in *amino acid metabolism and myelin formation* as a co-enzyme. This red crystal with cobalt atom combines with ‘intrinsic factor’ of gastric juices and ‘Vitamin B 12 intrinsic factor complex’ attaches itself to specific receptor sites on the brush border of ileal cells. Then the vitamin is absorbed to be stored in the liver, leaving behind intrinsic factor. Cobalamin synthesized by intestinal bacterial flora is not available for absorption. *Sources* of vitamin B 12 are foods of animal origin only. Plant foods are devoid of this vitamin and vegans are at risk of deficiency. Rich amounts are provided by liver while fish, egg and meat are fair sources. *Deficiency* is also common in vitamin B 12 malabsorption syndromes (blind loop syndrome, tropical sprue, Crohn's disease and intestinal tuberculosis) and breastfed infants of vitamin B 12 deficient mothers. Deficiency of Vitamin B12 impairs DNA synthesis and bone marrow erythropoiesis resulting in *megaloblastic anemia* (i.e. macrocytic normochromic anemia) and *demyelination* of large nerve fibers of spinal cord (long tracts of lateral and posterior columns). Paraesthesia of fingers and toes is the special feature. *Daily requirement* is 1 mcg per day for an average adult (man and woman) and 1.4 mcg during lactation, infants require 0.2 mcg.

Table 3: Recommended allowances of B-complex vitamins for Indians

Groups	Category	B1 (mg/d)	B 2 (mg/d)	B 6 (mg/d)
Sedentary work	Man	1.2	1.4	1.9
Moderate work		1.4	1.6	2.2
Heavy work		2.1	1.7	2.8
Sedentary work	Woman	1.0	1.1	1.5
Moderate work		1.1	1.3	1.8
Heavy work		1.4	1.7	2.3
	Pregnant woman	+0.2	+0.2	2.5
	Lactating woman	+0.3	+0.4	2.5

Infants				
0-12 months		0.3	0.3	0.4
0-6 months		0.3	0.4	0.5
6-12 months		0.5	0.6	0.8
Children				
1-3 years		0.7	0.8	1.1
4-6 years		0.8	1.0	1.4
7-9 years		1.1	1.3	1.8
10-12 years	Boys	1.1	1.3	1.8
	Girls	1.0	1.2	1.6
13-15 years	Boys	1.4	1.6	2.2
	Girls	1.2	1.4	1.9
16-18 years	Boys	1.5	1.0	1.8
	Girls	1.2	2.4	1.7

Source: ICMR, New Delhi

Table 4: Recommended intake of folic acid and Vit B 12

Groups	Folic acid (mcg/d)	Vitamin B 12 (mcg/d)
Adults		
Man	1.0	100
Woman	1.0	250
Pregnant woman	1.2	500
Lactating woman	1.4	350
Infants		
0-12 months	0.4	25
Children	0.6	80-100
1-6 years	0.8	120-140
7-9 years		120-140
Adolescents		
10-12 years	0.8	150-250
13-15 years	0.8	
16-18 years	1.0	150-250

Source: nipccd.nic.in

Vitamin C (Ascorbic Acid) is necessary for the *collagen formation and maintenance* which acts as intercellular cement supporting as a matrix for the blood vessels, bones and cartilage, connective tissues. It also helps in *tissue oxidation and absorption of iron*. This water-soluble vitamin is very sensitive to heat and 50 percent of vitamin C is lost in cooking. *Sources:* Amla (Indian gooseberry) is very rich source of this vitamin which remains present in fresh and dried/preserved forms of this berry. Others are fresh fruits, particularly citrus fruits. Tomato, orange, germinating pulses, guavas, fresh green leafy vegetables, cabbage also contain good amounts of this vitamin. Animal foods are poor in vitamin C. *Deficiency of Vitamin C* causes 'Scurvy' with childhood features of painful swelling and epiphyseal

separation at ends of long bones due to bleeding in periosteum, 'scorbutic rosary' (angular prominence of costochondral junction in contrast to dome shaped and semi-circular rickety rosary). There is delayed healing of the wounds, joint pains, anemia and weakness, hemorrhages from the mucous membranes, subcutaneous petechial hemorrhage, bleeding gums (due to loss of vascular integrity). Daily requirement for adults is 40 mg and for infants is 25 mg.

1. **Vitamin A:** Beta-carotene found in plant foods is the main precursor of Vitamin A. Carotene is converted into retinol in the intestine, which is then absorbed and stored in the liver as retinol-palmitate. Plant foods contain readymade retinol

Functions

- Maintenance of integrity of the skin and mucous membranes of various physiological systems.
- Immune response generation: anti-infective vitamin.
- Skeletal growth.
- Synthesis of 'Rhodopsin' pigment in the retina of the eye, which is necessary for the normal vision, especially in the dim-light for dark adaptation. Thus, vitamin A is essential for normal vision
- Protection from some epithelial cancers such as carcinoma of bronchus.

Sources: *Animal Sources* are meat, liver, fish, egg-yolk, milk, cheese, butter, ghee. Richest source is fish liver oil (Cod liver oil and shark liver oil). Green leafy vegetables are the cheapest *Vegetable Sources* of vitamin A, e.g. spinach, amaranth. Darker green color of the vegetables indicates higher carotene content. *Richest source* is red palm oil. Other sources are yellow fruits like mango and papaya. Some roots like carrots are also rich in beta carotene.

Table 5: Vitamin A content of some common foods (micrograms of carotene per 100g of edible portion)

Food	Vitamin A content
Plant foods	
Green leafy vegetables	5500
Carrot	1890
Tomato ripe	350
Mango	2743
Papaya	666
Coriander	6918
Animal Foods	
Milk	160
Butter	3200
Ghee (cow)	2000
Ghee (buffalo)	900
Egg-yolk	600
Cod liver oil	10,000

Source: ICMR, New Delhi

IX. DEFICIENCY

An adequately nourished person has sufficient reserve of vitamin A to meet 6 to 9 months of Vitamin A requirement as the human liver has huge capacity to store vitamin A as retinol palmitate. But a newborn child needs vitamin A everyday and children are always at risk of deficiency.

Active, toxic, free retinol is always transported along with a binding protein called 'Retinol binding protein,' produced by the liver. Its production is decreased in severe protein deficiency and liver diseases resulting in decreased mobilization of liver retinol reserves leading to following deficiency signs and symptoms:

1. Ocular Manifestations (*'Xerophthalmia'; dry eye*): Dryness of conjunctiva and decreased synthesis of rhodopsin in the retina lead to following consequences

- Night blindness (Nyctalopia): Inability to find mother in the dim light/evening by a young child due to failure in the dark adaptation. Classical complaint by the mother is that her child cannot find her or dashes against the wall as the dark sets in. Nyctalopia is the earliest symptom.
- Conjunctival xerosis: Normal, smooth, shiny conjunctiva over the sclera becomes dry, dull and wrinkled (smoky appearance) in childhood
- Bitot's Spots: Triangular, foamy, yellowish/pearly-white spots develop usually on lateral bulbar conjunctiva and are often bilateral (characteristic of vitamin A deficiency).
- Corneal xerosis: Smooth, shiny, transparent cornea becomes dull and dry, eventually opaque. Lack of treatment leads to corneal ulceration (medical emergency).
- Corneal ulcer: Of varying sizes, which after healing leaves behind a permanent scar affecting vision.
- Keratomalacia: In later stages cornea softens and liquefied partly or completely, constituting a grave medical emergency because if the eye collapses, vision is lost. This is one of the major causes of preventable blindness in India and is often associated with PEM.

2. Extraocular Manifestations

- Retardation of growth
- Follicular hyperkeratosis (Phrynoderma)
- Anorexia
- Increased incidence of respiratory and alimentary infections
- Development of urinary calculi.

3. Assessment of Vitamin A Deficiency: *Hypervitaminoses A* Excess intake of retinol causes anorexia, vomiting followed by sleep disorders and skin desquamation. Other features are hepatomegaly, papilledema, bony exostoses (swelling over the long bones), brittleness of the bones and often fractures. Attention has also been drawn to the teratogenic effects of massive doses of vitamin A.

Table 6: Criteria of vitamin A Deficiency

Criteria	Prevalence (among children 6 months to 6 years)
Night blindness	> 1%
Bitot's spots	> 0.5%
Corneal xerosis	>0.01%
Corneal ulcer/keratomalacia	> 0.05%

Source: WHO. TRS. No. 672,1982.

Table 7: Recommended Intake of Vitamin A

Groups	RDA 2009 (Retinol Equivalents mcg/d) Retinol	Beta carotene*
Adults		
Man	600	4800
Woman	600	4800
Pregnant woman	800	6400
Lactating woman	950	7600
Infants		
0-6 months	350	-
6-12 months	2100	-
Children		
1 -3 years	400	3200
4-6 years	600	4800
7-9 years	600	4800
Adolescents		
10-12 years	600	4800
13-15 years	600	4800
16-18 years	600	4800

Source: ICMR, New Delhi

* Beta Carotene = 8 times retinol

X. VITAMIN D

This steroid molecule occurs in two forms namely vitamin D 2, (calciferol) and D 3 (cholecalciferol). Former is made by the conversion of ergosterol in plants by ultra violet rays in sunlight and is not available for humans. Vitamin D 3 occurs naturally in fats of animal origin and fish liver oils. It can also be naturally synthesized in the body, on exposure of ultraviolet rays of sun to dehydro-cholesterol (provitamin D present under the skin). It is then transported to liver and fat depots for storage.

1. Functions

- Required for absorption of calcium and phosphorus from intestines
- Calcification and hardening of bones.

2. **Sources:** Vegetable foods do not contain this vitamin but vitamin D is naturally synthesized in the body adequately upon exposure of skin to ultra violet rays of sunlight. Animal foods rich in vitamin D are fish liver oil, butter, milk, ghee and egg-yolk.

Table 8: Food Sources of Vitamin D

Food	Vitamin D 3 content (mcg per 100 g)
Shark liver oil	30-100
Cod liver oil	200-500
Halibut liver oil	500-10,000
Egg-yolk	1.5
Butter	1.0
Fish	05-30

Source: ICMR, New Delhi

Deficiency causes *Rickets* among children and *Osteomalacia* among adults. In rickets laying down of cartilage cells is incomplete and calcification is also irregular. Bone becomes soft and predisposed for deformation and fractures due to body weight itself with growth of child. The earliest sign is Craniotabes (soft membranous occipital or posterior part of parietal bones of the skull can be felt like a ping-pong ball when pressure is applied and released). Frontal and parietal bossing becomes evident later. Rickety- rosary (bead like look of costochondral junctions over the chest) has been described. Pigeon chest (forward projecting sternum), Harrison's sulcus (horizontal depression along the line of insertion of diaphragm), delayed eruption of primary teeth, spinal deformities (scoliosis, kyphosis or lordosis), widening of wrist (due to widened epiphyses of long bones seen as a cup shaped depression and widening of epiphyseal plate on x-ray), genu valgum, genu and coxa-vera (bending of long bones upon weight bearing), (protuberant abdomen due to hypotonia resulting in flabbiness of abdominal muscles) are the other typical clinical features. Bilateral lamellar cataracts are seen in deficiency of vitamin D in early infancy. On radiological investigation large gap is seen between epiphyses and metaphyses. Serum phosphorus low and alkaline phosphatase is high.

Osteomalacia is common among pregnant and lactating women due to higher requirements of vitamin D. Usual activities like standing, climbing stairs etc become difficult and gait becomes waddling. There is rarefaction of bones with typical Looser's zones on X ray. *Daily Requirement* is obtained from exposure to sunlight hence rickets is rare in India. Dietary Vitamin D is essential only when exposure is inadequate. One mcg of cholecalciferol = 40 IU (To convert mcg to IU, multiply by 40).

Table 9: Daily requirement amount of Vitamin D

Infants	5.0 mcg (200 IU)
Children	10.0 mcg (400 IU)
Adult	2.5 mcg (100 IU)
Pregnancy/Lactation	10.0 mcg (400 IU)

Source: ICMR, New Delhi

Hypervitaminosis D Since there is narrow margin between the daily requirement and toxic dose, overdose can occur resulting in anorexia, thirst, nausea, vomiting, drowsiness. Resulting hypercalcaemia can cause cardiac arrhythmias, calcification of tissues and renal failure.

Vitamin E (Tocopherol) is an anti-oxidant and free radical scavenger (due to its anti-oxidant property it protects membrane phospholipid from free radical induced peroxidase damage). Although its role in humans is not understood completely, miscarriage and sterility has been shown to be associated with its deficiency in experimental animals. There are possible beneficial effects on wound healing, ischemic heart disease and coronary thrombosis, menopausal symptoms.

Dietary sources are foods rich in polyunsaturated fatty acids (green leafy vegetables, safflower, cotton seed, sunflower, wheat germ, soybean and corn oils, egg-yolk and butter). Infants require 3 mcg (5 IU) of alpha-tocopherol per day, normal adults require 10 mcg (15 IU) of vitamin E per day.

Vitamin K has two active forms vitamin K1 and K 2. Vitamin K 1 plays an important role in synthesis of coagulation factor prothrombin and its deficiency results in hemorrhages by prolonging the blood clotting time. Dietary sources are green leafy vegetables, fruits, cheese, egg-yolk and liver. Cow's milk has more vitamin K1 (60 mcg/L) than milk of humans (15 mcg/L). Vitamin K2 is synthesized by intestinal bacterial flora. Vitamin K is stored in the liver. Its deficiency in adults is rare and caused by decreased intake or by the long-term antibiotic usage leading to suppressed normal intestinal flora. Newborns may show deficiency of vitamin K due to lack of intestinal flora and non existent hepatic stores and bleed more from the umbilical cord. For prevention 1 mg of aqueous vitamin K is given immediately at birth. Adult daily requirement of 0.03 mg per kg is from a combination of dietary intake and gut synthesis.

XI. Minerals

Minerals are required for repair, growth, and metabolic functionality as inorganic salts of elements. They can be 'Major minerals' like calcium, sodium, potassium, magnesium and phosphorus which are required in appreciable amounts. 'Trace elements' like iron, iodine, fluorine, zinc, copper, cobalt, chromium and manganese are required in minute amounts.

Calcium is required *bones and teeth formation, blood coagulation of blood, muscular contraction* (by controlling neuromuscular excitation) and *membrane permeability*. Stores in bones and teeth exist on dynamic equilibrium with blood levels of 10 to 11 mg/dl with the aid of vitamin D, parathyroid hormone and calcitonin. Among *sources* richest are milk (120 mg/100 ml cow's milk and of 30 mg /100 ml human milk) and milk-products, eggs and fish. Green leafy vegetables and millets like ragi are very good sources of calcium. Calcium-cesinogenate of milk is easily assimilated by the body. Calcium absorption from plant sources is impaired because of oxalic acid and phytic acid that form insoluble complexes. Drinking water is additional source of calcium.

Table 10: Calcium content of common sources (mg/100 g)

Leafy vegetables	200
Ragi	344
Sitaphal	3500
Fish	150
Cheese	790

Table 11: Calcium requirements for Indians

Groups	Calcium (mg/d)
Adults	
Man	600
Woman	600
Pregnant woman	1200
Lactating woman	1200
Infants	
0-12 months	500
Children	
1 -9 years	600
Adolescents	
10-12 years	
Boys	600
Girls	700
13-15 years	
Boys	800
Girls	700
16-18 years	
Boys	600
Girls	600

Source: nipccd.nic.in

Dietary deficiency of calcium leads to loss of calcium from bones and consequent osteoporosis. *Daily requirement* is tabulated above.

Iron is required for *brain functioning and development, body temperature maintenance*. Iron is mainly necessary for *hemoglobin synthesis* (oxygen transport and cell respiration), *myoglobin, cytochrome, catalase and antibody formation*. 75% of 4 g of total body iron is present in the blood as hemoglobin and 25% as storage iron. Haem iron found in animal *sources* (liver, meat, fish and poultry) is better absorbed and nonhaem in vegetable sources (ragi, green leafy vegetables, dried fruit and jaggery) is poorly absorbed due to presence of intestinal phytates, oxalates etc. Tea and eggs decrease iron absorption because of tannin and phosphate respectively. Only 3-4% of iron present in food is absorbed. It is then stored in the spleen, liver, bone marrow and kidney after being transported as plasma ferritin. Although iron from broken down red cells reutilized for the formation of new red cells daily loss of 1 mg in an adult man and 2 mg in a menstruating woman occur. *Deficiency* of iron

(iron deficiency anemia-IDA) is either due to decreased intake (dietary imbalances leading to low iron diet) or due to social factors like poverty and lack of food. It can also be due to increased demand (pregnancy and infections) and excessive losses during physiological (menstruation, puberty menorrhagia, childbirth) or pathological hemorrhages (ankylostomiasis, peptic ulcers, bleeding hemorrhoids, ulcerative colitis). Other factors like dietary interfering substabces, repeated pregnancies, chronic infections also contribute to IDA. Clinically evident as decreased haemoglobin after bone marrow and blood reserves are severely depleted, there may be grave consequences as decreased work capacity (tiredness, easy fatiguability and exhaustion) leading to decreased efficiency and production, increased accident proneness in the industries etc is invariably detrimental to the economy. Anemia also results in adverse pregnancy outcome (abortions, premature births, LBW, still births, hemorrhages), increased maternal and infant mortality rates, infections (due to impaired immunity), growth failure, decreased physical activity due to decreased motor development and impaired learning process.

Iodine is indispensable for the *adequate well-being, metabolism, growth and development of all human beings* as it helps in T 3 (Triiodothyronine) and T 4 (Thyroxine) synthesis. Human body has 15-20 g of this crystalline solid that is always found in free inorganic state in nature. After being easily and completely absorbed from intestines it is transported and stored in thyroid gland by concentration. *Chief human source* is iodine of soil that determines its level in food and water. Thus, dietary sources are cereals, vegetables, fruits and pulses of soil rich in iodine and sea-foods (shrimps, sea-fish, crab, prawn, lobster-fish). Since fresh water also contains 1-50 mg/liter of this essential trace element, 10 % of our iodine requirement is met by water we drink. *Deficiency* of iodine is geo-chemical in nature: soil of mountains is leached by snow-fall, landslide, heavy rain fall, flooding and eco-degrading activities i.e. iodine of upper layer of soil is flushed out. *Iodine Cycle* maintains iodine level in soil of plain areas to some extent i.e. iodine from surface soil leaches by rain, snow and glaciation and is also carried by rivers, floods and wind to sea. This makes the ocean the richest reservoir of iodine from where the iodine is returned to the soil by rain fall to complete the iodine cycle.

Deep layers of soil also contain iodine making deep wells a potential good source of iodine. When diet is deficient in iodine, T 3 and T 4 hormone levels become low thus stimulating anterior pituitary gland to synthesize Thyroid Stimulating Hormone (TSH). This leads to '*Goitre*' - a compensatory cellular hyperplasia of thyroid gland to entrap all available blood iodine in order to maintain balance of iodine in the body. It is a non-toxic, non-neoplastic and non-inflammatory swelling of the thyroid gland. A condition recognized as early as 500 BC by ancient Indian doctors Sushruta and Charaka , goiter has been described in ancient texts as 'Galganda'.Goitrogens like cyanoglycosides and thiocynates in cauliflower, cabbage, turnip, radish, etc interfere with iodine uptake and promote iodine deficiency. Iodine deficiency also results in '*Iodine Deficiency Disorders*' (IDD). This is a spectrum of clinical features that does not spare any age group or sex, but hits mothers and children the hardest. Pregnant mothers experience abortions and still-births; neonates have congenital anomalies, mental retardation and cretinism; growing children have speech and hearing defects, dwarfism and impaired mental abilities (retarded physical and psychomotor development); adults have hypothyroidism (goiter and myxedema)

Table 12: Grading of Goiter

Grade 0:	No palpable or visible goiter (no goiter)
Grade 1:	Goiter palpable but not visible in the normal position of the neck.
Grade 2:	Visible and palpable goiter.

(WHO 1994)

**Table 13: Requirement of iodine is less than one tea spoonful for entire human life.
Daily requirement (in mcg)**

Adult	150
Pregnant woman	200
0-11 months	50
12-59 months	90
School children	120

(authorstream.com)

Fluorine is required for *bone mineralization* and *dental enamel formation* and also *prevents dental caries* by protecting enamel from acids produced by oral microflora. This highly highly reactive, abundant element is always found in fluoride (combined) form. *Main source* is drinking water and foods. Tea (consumed black), cheese and sea fish are rich in flourides while tinned food and juices, areca nut and black salt are good sources. *Recommended level* of fluorides in drinking water is 0.5 to 0.8 mg per liter. *Both deficiency and excess* of this trace element result in disease, hence it is called a ‘double edged sword’. Inadequate intake (e.g. in areas with fluoride level below 0.5 mg/L of water) results in *dental caries*. ‘DMF-Index’ (D = Decayed; M = Mottled, F = Fallen) is used to identify extent of dental caries in the community. Excess (prolonged ingestion of drinking water with higher than 1 mg/L) results in *fluorosis* which is of dental and skeletal types. Teeth lose their shine followed by mottling (appearance of chalky-white patches) in *dental fluorosis* which is usual in incisors and molars but not in milk teeth. These patches progress to brownish/black colour. With increasing severity teeth look corroded due to pitting which may be permanent. In *skeletal fluorosis* there is calcification of ligaments and tendons leading to pain in limb joints followed by stiffness and pain of back. On clinical examination deformities like genu valgum are common due to osteoporosis. Laboratory investigations reveal high levels of fluoride in urine and blood, anemia with structural anomalies of RBCs. Calcified ligaments and tendons, exostosis (new bone formation) and increased density, thickness and girth of bones are evident on X ray. Huge numbers are affected by fluorosis in states of Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan, Kerala and Punjab as it is endemic in India. High-risk groups include pregnant and lactating mothers, children, patients with renal and cardiovascular diseases and elderly people. Early stages of fluorosis result in reversible non-skeletal changes that are treated by nutritional intervention and safe drinking water. Unmanaged early stages progress into crippling skeletal fluorosis and irreversible dental changes.

Prevention and Control: Although a variety of methods are available for testing fluoride content of water (ion-selective, photometric and calorimetric), ion- selective method using ion-meter is most sensitive. According to the result, fluoridation of water can be done to prevent and control dental caries problem or defluoridation by ‘Nalgonda technique’

(National Environmental Engineering Research Institute, Nagpur) can be suggested at domestic level to prevent and control fluorosis. Nowadays Reverse osmosis technique removes sulfates, nitrates and fluoride from drinking water. Domestic filters based on activated alumina technology also serve the purpose. *Daily requirement* of fluoride is 0.5 to 0.8 mg/L of drinking water.

XII. NALGONDA TECHNIQUE

Take 40 l of raw water in a bucket with tap 3 to 5 cm above the bottom. Slowly add 500 mg/l of alum, followed by 30 mg/l sodium carbonate (lime) and 120 mg/40 l bleaching powder. Stir slowly for 10 to 20 minutes and allow to remain for approximately one hour so that sludge settles below the tap level. Supernatant water is defluoridated to permissible limit of fluoride and can be consumed through the tap. Discard the settled sludge.

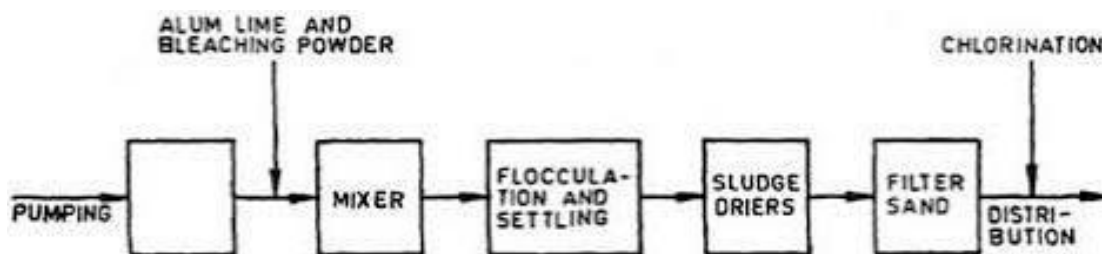


Figure: Flow Diagram for Nalgonda Technique

Zinc as a component enzymes like carbonic anhydrase is necessary for *DNA, ribosome and RNA stabilization, biomembrane functioning, immunity*. Of 1.4 to 2.3 g of zinc in adult body 96 mcg per 100 ml is found in plasma. Low levels of zinc in plasma are seen in pernicious anemia, chronic diarrhea, immune deficiency, thalassemia, dermatitis and myocardial infarction. *Sources* are wheat, pulses and nuts for vegetarians, fish and meat for flesh eaters. Zinc absorption is promoted by cysteine, histidine and retarded by phytates. *Deficiency* is characterized by anemia, growth failure, hypogonadism, hepatomegaly, neural tube defects in developing fetus and intrauterine growth retardation.

Copper helps in *myelin synthesis, iron metabolism and connective tissue formation* by forming enzymes such as cytochrome co-oxidases, amine-oxidases, ferroxidases. Some genetic defects of copper metabolism cause Hepatolenticular degeneration (Wilson's disease), Kinky hair syndrome (Menke's Syndrome). Good *sources* in diet are dried legumes, nuts, shellfish, liver and kidney. *Deficiency* is characterized by neutropenia. Other features are anemia, osteoporosis leading to fractures and metaphyseal fraying, hypocupremia. *Daily requirements* are 30 mcg per kg for adults, 40 mcg per kg for children and 80 mcg per kg for infants.

Cobalt helps in *haemoglobin and myelin synthesis* as an ingredient of cyanocobalamin (vitamin B 12). It is abundant in foods but an important *non nutrient source* is anti foaming agent which when added to beer/beverages and consumed in large amounts is known to cause epidemics of pericardial effusion and cardiomyopathy. Its *deficiency* is not reported but *poisoning* in human beings causes tinnitus, diarrhea and loss of hearing if acute and goiter, polycythemia if chronic.

Chromium has indirect role in *protein, carbohydrate, lipid metabolisms* due to its enhancing effect on action of insulin. *Deficiency* may lead to insulin refractoriness, impaired glucose tolerance, glycosuria and hyperglycemia.

Selenium is an *antioxidant* when it functions in conjunction with vitamin E as it produces a red cell enzyme called glutathione peroxidase. Rich *sources* are sea food and meat. *Deficiency* is found in protein energy malnutrition and significant weight increase occurs when this mineral is replaced in diet. Endemics of osteoarthritis of adolescents (Kashin-Beck disease) and cardiomyopathy endemic (Keshan disease) are reported from China due its deficiency. *Adults require 70 mcg and infants require 10-15 mcg* daily. Poisoning is called selenosis and is associated with loss of nails and hair.

Ultratrace Minerals are boron, arsenic, bromide, cadmium, nickel, molybdenum, silicon, vanadium and tin as they are required in amounts less than 1 mcg/day.

Antioxidants boost immunity, fight diseases and ageing by *conversion of free radicals* (highly reactive atoms or molecules with an unpaired electron released during normal metabolism that destroy cells/tissues resulting in disease and rapid ageing) *to neutral forms*. They include *minerals* iron, selenium, copper, zinc and *vitamins* A, C, E. Anti-oxidants can be *cellular*: superoxide dismutase, Vitamin E, glutathione and *plasmalar*: are ceruloplasmin, bilirubin, albumin.

Table 14: Requirements for iron and zinc for Indians

Groups	Iron(mg/d)	Zinc (mg/d)
Adults		
Man	17	12
Woman	21	10
Pregnant Woman	35	12
Lactating Woman	25	12
Children		
1-3 years	9	5
4-6 years	13	7
7-9 years	16	8
Adolescents		
10-12 years		
Boys	21	9
Girls	27	9
13-15 years		
Boys	27	11
Girls	32	11
16-18 years		
Boys	26	12
Girls	28	12

Source: ICMR (New Delhi)