1.1.5 WATER SOLUBLE VITAMINS

- Vitamins are micronutrients (organic.
- They are measured in milligrams (mg) or micrograms (µg)
- Vitamins may be classified into two groups
  - **Water Soluble Vitamins** : B Vitamins, Vitamin C.
  - **Fat Soluble Vitamins** : Vitamins A, D, E, K.
- Deficiency of vitamins results in diseases.

WATER SOLUBLE VITAMINS

- Vitamin B_1 – Thiamin
- Vitamin B_2 – Riboflavin
- Niacin – Nictonic Acid.
- Folate – Folic Acid.
- Vitamin B_6 – Pyridoxine.
- Vitamin B_{12} – Cobalamin.

- Originally B group vitamins were grouped together because they were found in liver and yeast and thought to be one vitamin – Vitamin B.
- In the 1920's, proof for the existence of more than one Vitamin B was solidified.
- Became known as **Vitamin B Complex**.
- Folate (Folic Acid) was discovered in 1945 and Cobalamin (Vitamin B12) was discovered in 1948.

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COMMON CHARACTERISTICS OF B COMPLEX VITAMINS

(1) : Most of these vitamins function as **co-enzymes** for the release of energy from food (particularly from carbohydrate)

(2) : These vitamins are **widely distributed** in most basic foods (except Vitamin B_{12} which is not usually found in foods of plant origin)

(3) : B vitamins are **readily destroyed** by heat, milling, canning, blanching, excessive processing and store. Some are even sensitive to light.

(4) : They are **water soluble**, therefore **not toxic** at high levels. They are readily excreted from the body.

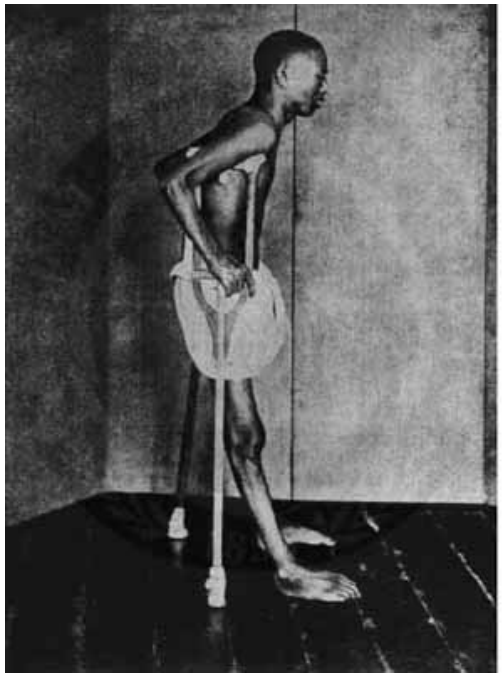
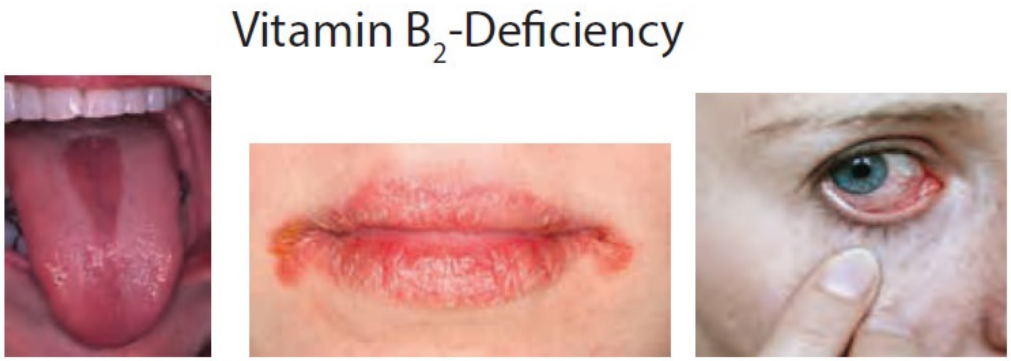
(5) : They supply **no energy**.

THIAMIN : B_1

Sources	***Functions***	***Effects of Deficiency***	***Properties***	***Absorption***	***RDA's***
○ Meats ***(especially offal → liver, heart, kidney)*** ○ Leafy vegetables. ○ Grains/Cereals (wholegrains) ○ Nuts. ○ Yeast. ○ Wheatgerm. ○ Legumes. **NOTE** : Of our total Thiamin intake … **42%** comes from bread and cereals. **28%** comes from meats, fish and poultry. **5%** beans, nuts, legumes.	• Essential for the metabolism of carbohydrate (co-enzyme) • Essential for nerves. • Necessary for growth. • Necessary for appetite and general health.	• Mild cases the person may be 'run down', loss of appetite, appetite, apathy, depression. • Severe cases **'Beri Beri'** (nervous disease) where there is a build up of pyruvic acid in the body which affects transmission of nerve impulses, eventually paralysis → death. • Alcoholic neuritis. • Retarded growth.	• Extremely **water soluble**. • Very **unstable to heat**, destroyed by intense heat (eg) : canning. • **Sensitive to Alkalis** (eg) : bread soda and sulphur dioxide E220. • **Milling destroys** Thiamin.	Certain raw fish and seafood contain the enzyme **Thiaminase** which splits Thiamin into 2 chemical groups → making it inactive. **NB** : Heating fish destroys this enzyme.	**NO NEED TO LEARN**

RIBOFLAVIN : B_2

Sources	*Functions*	*Effects of Deficiency*	*Properties*	*RDA's*
○ Milk products (good source) ○ Offal (rich source) ○ Breakfast cereals (excellent source) **fortified!** ○ Yeast, yeast extract. ○ Salmon. ○ Poultry. ○ Wheat germ. ○ Green leafy veg (fair sources) ○ Citrus fruit, melon, tomatoes (poor sources)	• Growth. • Necessary for healthy skin. • Necessary for the metabolism of carbohydrate (ie) : release of energy from carbohydrate (co-enzyme) • Necessary for healthy nerves.	• Reddening of the mouth, sore red tongue **(glossitis)** • Cracks on lips mainly in the corner of the mouth **(cheilosis)** • Retarded growth. • Skin abnormalities (including scaly dermatitis) • Eye disorder (dimness of vision, burning of the eyes) • Anaemia (new symptom)	• Orange/Yellow substance. • **Water soluble**. • Stable **at normal cooking temperatures**. • Unstable at **high temperatures** (eg) : pressure cooking. • Unstable when cooking with bread soda. • **Affected by UV light**.	**NO NEED TO LEARN**

Thiamin B_1 Deficiency – 'Beri Beri'	***Riboflavin B_2 Deficiency***
 *Issues with nerve impulse transmission are evident (crutches present)*	 Fig 11.11: Symptoms of B_2 deficiency

NIACIN (NICOTINIC ACID) – Anti Pellagra Vitamin

Sources	*Functions*	*Effects of Deficiency*	*Properties*	*RDA's*
○ Meat (red) ○ Offal. ○ Fish. ○ Pulse veg. ○ Bread. ○ Yeast. ○ Bran. ○ Wheat germ. ○ Whole cereals. **NOTE** : Small amounts are manufactured in the gut by the essential amino acid **Tryptophan**.	• Necessary to help release energy from food (co-enzymes) • Necessary for healthy skin. • Necessary for healthy nervous and digestive systems. • Prevents the disease Pellagra.	• **Pellagra** – a reddish skin rash especially on the face, hands and feet when they are exposed to sunlight, which later makes the skin dark and rough. Italian word pell – agra → 'painful or rough skin' • **3D's** – Diarrhoea, Dementia, Dermatitis. • Depression. • Weakness and Weight loss.	• Water soluble. • Stable to heat. • 80% loss in milling of cereals. • Lost during thawing.	**NO NEED TO LEARN**

PYRIDOXINE : B_6

Sources	*Functions*	*Effects of Deficiency*	*Properties*	*RDA's*
Most basic foods. ○ Fish (eg) : Salmon. ○ Meat (eg) : Beef. ○ Eggs. ○ Liver. ○ Cereals. ○ Sweet potatoes. ○ Milk. ○ Fruit (other than citrus) (eg) : Bananas. **B_6 NOTE** : Vitamin B_6 may help relieve symptoms of PMT if taken one week before period date.	• Acts as a co-enzyme for protein (ie) : helps release energy from protein. • Necessary for healthy nervous system. • Necessary for the formation of structural proteins (eg) : Keratin in skin. • Necessary for growth. • Works with B_{12} and iron.	• Rare but may cause convulsions in infants. • Irritability. • Weak nails/hair and skin problems. • Insomnia. • Anaemia (Macrocytic)	• Water soluble. • Fairly heat stable. • May be lost in thawing. • Affected by oxygen.	**NO NEED TO LEARN**

FOLATE (FOLIC ACID)

Name	*Sources*	*Functions*	*Effects of Deficiency*	*Properties*	*RDA's*
FOLATE (FOLIC ACID) **Folate** = Natural form of the vitamin (present in food) **Folic Acid** = Supplement form of this B vitamin (eg) : fortified breakfast cereal.	○ Liver. ○ Green leafy veg – spinach, kale. ○ Dried beans. ○ Oranges. ○ Avocadoes. ○ Whole wheat products. ○ Cauliflower. **NOTE** : Breakfast cereals are fortified with folic acid.	• Necessary for the synthesis of DNA and RNA, the genetic material of cells. • It works with B_6, B_{12} and iron to make red blood cells. • Folic acid is thought to help reduce the risk of heart attacks, strokes and some cancers. • It is necessary to help form the neural tube in the early stages of foetal development.	• Deficiency of folic acid affects the growth and repair of cells. • May cause macrocytic anaemia (red blood cells are reduced in number, larger in size and carry less haemoglobin) • Low levels of folic acid are linked with atherosclerosis, constipation, osteoporosis and infertility. • Spina bifida in babies.	• Easily destroyed during cooking. • Water soluble. • Bread soda (alkali) increases loss of folic acid if added to cooking water. • Sensitive to oxidation and cooking.	**Children over 11 years.** 200 µg **Adults** 300 µg **Pregnant and Lactating Mothers** 400 µg

COBALAMIN : B_{12}

Name	*Sources*	*Functions*	*Effects of Deficiency*	*Properties*	*RDA's*
Cobalamin, Deep red crystalline substance. Most complex structure of all vitamins. A cobalt atom is present in the molecule.	Cobalamin is found in small amounts in all animal tissue but it is absent from foods of plant origin. ○ Eggs. ○ Milk. ○ Cheese. ○ Meat. ○ Fish. ○ Yoghurt. **NOTE** : Cobalamin can be made from a mould used to produce antibiotic Streptomycin.	• Cobalamin works with Vitamin B6, Folic acid and iron to make red blood cells. • Necessary to help the formation of the myelin sheath on nerve fibres. • It plays a part in the production of nucleic acids during cell division. • Helps treat Pernicious Anaemia. • Helps fat and carbohydrate metabolism.	• Pernicious Anaemia, Tiredness, Paleness of Skin, Headaches, Shortness of breath, Irritability, Red sore tongue. • Reduced number of white blood cells could lead to susceptibility of infection. • May lead to mental confusion, memory loss, moodiness. • Loss of appetite.	• Water soluble. • Sensitive to light. • Destroyed by strong Acids and Alkalis. • Heat stable to 100 °	**Children** 0.7 – 1.0 µg **Teenager** 1 – 1.4 µg **Adult** 1.4 µg **Pregnant and Lactating Mothers** 1.6 – 1.9 µg

VITAMIN C (ASCORBIC ACID)

Name	*Sources*	*Functions*	*Deficiency*	*Properties*	*RDA's*
Vitamin C (Ascorbic Acid) **NOTE** : Vitamin C is the most unstable of all the vitamins. As it is water soluble, a regular supply is needed (easily excreted)	○ Green leafy veg (Kale) ○ Blackcurrants. ○ Kiwis. ○ Citrus fruits (Oranges) ○ Strawberries. ○ Pineapple. ○ Fresh peas.	• Necessary for the **manufacture of connective tissue**. • Essential for **healthy gums and skin**. • Essential for **strong bones and teeth**. • Builds **strong blood vessels**. • Prevents bruising. • Necessary for the **absorption of iron** (Non-Haem → Ferrous) • Necessary for **cell metabolism**. • Prevents scurvy.	• Incomplete absorption of iron (Iron Deficiency), Anaemia, Listlessness, Weakness. • Susceptibility to infection. • Weakness of blood vessels therefore susceptibility to bleeding. • Delayed healing of wounds. • **Scurvy** : Bleeding gums, Loose teeth, Pains in limbs, Tiredness.	• Acid crystalline substance. • Water soluble. • Acts as an Antioxidant E300. • Unstable to heat. • Oxygen in the air destroys it. • Destroyed by Alkalis. • Freezing (little effect) • Canning (some loss)	**Children** 45mg **Teenager** 50-60mg **Adults** 60mg **Pregnant and Lactating Mothers** 80mg → Necessary to cope with the absorption of increased iron intake

Niacin Deficiency – 'Pellagra'

Description of Vitamin C

Vitamin C is set apart from the other vitamins by a number of distinguishing characteristics.

1. The vitamin C-active compounds are relatively simple organic acids with a structure similar to the 6 carbon sugars (see formula in the Appendix). They are composed only of carbon, hydrogen, and oxygen and, unlike the B-complex vitamins, have no nitrogen.
2. Only a few animal species require vitamin C. They lack an enzyme (to be described) that, if present, allows the liver, or kidney in some species, to make ascorbic acid from glucose. It has therefore been argued that vitamin C is not a vitamin but a hormone, which a few species are genetically unable to manufacture. In humans, however, vitamin C fulfills all the requirements of a vitamin.
3. Vitamin C is one of the most unstable of all vitamins, readily destroyed in processing, cooking, drying, or overheating.
4. There are only a few good dietary sources of vitamin C,—certain fruits and green vegetables. Grains, nuts, beans, and most foods of animal origin, except for liver and fresh milk, are devoid of vitamin C.
5. Humans need more vitamin C than any other vitamin. The requirement is about 20,000 times the requirement for vitamin B-12, for example. This difference has little or no nutritional significance and the recommended intake, 60 milligrams (mg) a day is still a very small amount, relative to the total amount of foods we eat.

60mg

PAST QUESTIONS

RULE : The marking scheme for questions on Vitamins is **NEVER CONSISTENT**, but a good rule to remember is to always give ..

- 6 Food sources.
- 4 Biological functions.
- 4 Properties.
- 4 Deficiency symptoms.

2004 Q1(B) HIGHER LEVEL (24 MARKS)

(d) Oily fish is a good source of Vitamin D.
Give an account of Vitamin D and refer to (i) properties, (ii) biological functions and (iii) recommended dietary allowance (RDA). (24)

- **PROPERTIES** : 3 @ 3M.
- **FUNCTIONS** : 3 @ 3M.
- **RDA** : 6M.

2007 Q1(B) HIGHER LEVEL (28 MARKS)

(c) Give an account of ***folic acid/folate*** and refer to:

(i) sources in the diet
(ii) properties
(iii) biological functions
(iv) recommended dietary allowance (RDA). (28)

- **SOURCES** : 2 @ 4M.
- **PROPERTIES** : 2 @ 4M.
- **BIOLOGICAL FUNCTIONS** : 2 @ 4M.
- **RDA** : 1 @ 4M.

2009 Q1(B) HIGHER LEVEL (21 MARKS)

(c) Vitamin B12 is sometimes lacking in the diet of vegetarians.
Give an account of ***vitamin B12 (cobalamin)*** and refer to:

- sources in the diet
- properties
- biological functions. **(21)**

- **SOURCES** : 3 @ 3M.
- **PROPERTIES** : 2 @ 3M.
- **BIOLOGICAL FUNCTIONS** : 2 @3M.

2012 Q2(B) HIGHER LEVEL (18 MARKS)

(c) Give an account of Vitamin A under **each** of the following headings:

- biological functions
- effects of deficiency
- properties. **(18)**

- **FUNCTIONS** : 3 @ 2M.
- **EFFECTS OF DEFICIENCY** : 3 @ 2M.
- **BIOLOGICAL FUNCTIONS** : 3 @2M.

2016 Q2(B) HIGHER LEVEL (15 MARKS)

(c) **Oily fish and fish liver oils can make a significant contribution to a persons' intake of vitamin D.**
Give an account of vitamin D and refer to:

- type / form
- properties
- effects of deficiency. (15)

- **TYPE/FORM** : 1 @ 3M.
- **PROPERTIES** : 3 @ 2M.
- **BIOLOGICAL FUNCTIONS** : 2 @3M.

2016 Q2(B) HIGHER LEVEL (15 MARKS)

(c) Give an account of Vitamin C (ascorbic acid) under each of the following headings:

- properties
- sources
- biological functions. (15)

- **PROPERTIES** : 3 @ 1M.
- **SOURCES**: 3 @ 1M.
- **BIOLOGICAL FUNCTIONS** : 3 @ 3M.

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