Vitamins

Water Soluble Vitamin

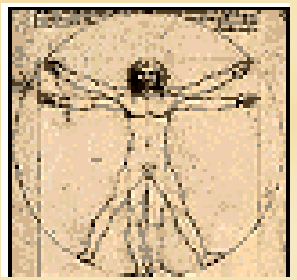
Amani Alghamdi

Water Soluble Vitamin Functions

Water Soluble Vitamins

- Vitamin C → Skin, bones, Infections, iron metabolism
- B Vitamins
  - Thiamin (B_1)
  - Riboflavin (B_2)
  - Niacin
  - Vitamin B_6
  - Folic Acid
  - Vitamin B_{12}
  - Pantothenic Acid
  - Biotin

→ Release energy from MACROnutrients:



Water soluble vitamins

- water-soluble vitamins found in the watery compartments of foods and distributed into the water compartment of the body.

- They can easily absorb into the blood-stream and are easily excreted if their blood concentration rise too high.

Water soluble vitamins

- These vitamins are less likely to reach toxic concentration in the body than the fat-soluble vitamins.

- Food never deliver excessive amount of the water-soluble vitamins, but large doses of supplement Can reach toxic levels

Vitamin C Functions

- Vitamin C → Co-factor: Stabilization of Collagen

Vitamin C roles

- Helps to form fibrous structural protein of connective tissues – collagen
  - Teeth
  - Bones
  - Wounds (scarring)
  - Arteries
- Enhances the immune system

Vitamin C - basics

- Antioxidant = Protectant
  - Protects tissue from oxidative stress
  - Enhances absorption of iron (protects it from oxidation) – tip: take vitamins with orange juice

- Essential nutrient – must get from diet
  - Animals can actually synthesize from glucose, but humans cannot

Vitamin C Sources

Orange juice: 62 mg per ½ c

Orange: 75 mg per 1 medium

Strawberries: 43 mg per ½ c

Cantaloupe: 113 mg per ½ melon

Kiwi: 74 mg per kiwi

Grapefruit: 36 mg per ½ c

Sweet red peppers, raw: 142 mg per ½ c

Green bell pepper, raw: 60 mg per ½ c

Mango: 57 mg per 1 medium

Tomato: 22 mg per tomato

Brussels sprouts, cooked: 48 mg per ½ c

Broccoli, cooked: 51 mg per ½ c

B Vitamins

1. Thiamin (B_1)
2. Riboflavin (B_2)
3. Niacin
4. Vitamin B_6
5. Folic Acid
6. Vitamin B_{12}
7. Pantothenic Acid
8. Biotin

Coenzymes:
Catalysts in
Biochemical Pathways

B vitamins

- The **B vitamins** are eight water-soluble vitamins that play important roles in cell metabolism.
- Supplements containing all eight are generally referred to as a **vitamin B complex**.
- Individual B vitamin supplements are referred to by the specific name of each vitamin (e.g. B_1, B_2, B_3 etc).

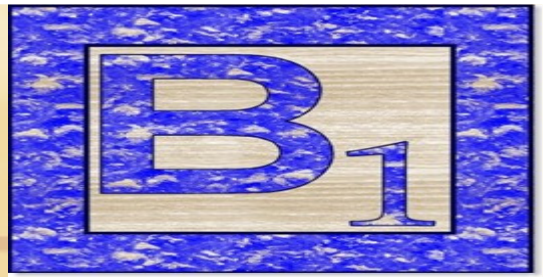
B vitamins

- B-vitamins do not give people energy like energy-yielding nutrients but help to burn this fuel or energy.

- This class contain 8 B vitamins each work as coenzyme. So these vitamins must be present in every cell continuously for the cells function properly.

Coenzyme: a small molecule that works with an enzyme to promote the enzymes activity. Many coenzymes have vitamin B as part of their structure. (CO=with)

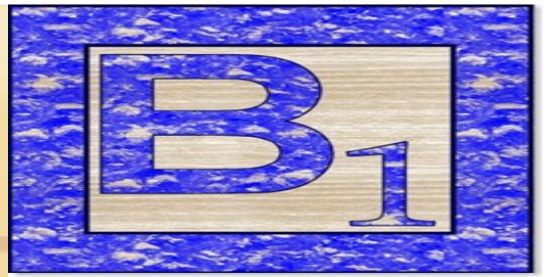
Thiamin (Vitamin B1)



- Acts primarily as a coenzyme in reactions that release energy from carbohydrate
- Thiamin functions in the body as thiamin pyrophosphate (TPP)
- Thiamine $\xrightarrow{\text{(Brain- Liver)}}$ TPP

Thiamine Diphosphotransferase

Thiamin (Vitamin B1)

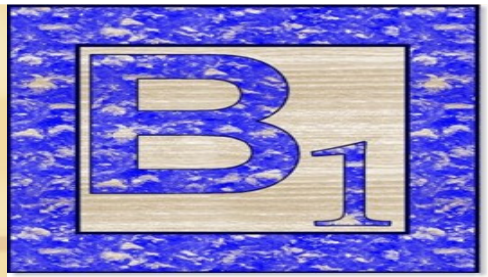


- TPP is incorporated into 2 important enzymes:

1. pyruvate dehydrogenase

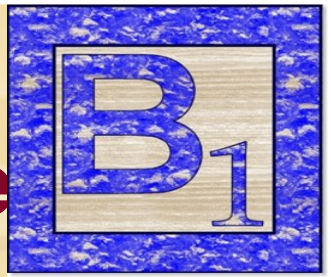
2. ketoglutarate dehydrogenase.

Pyruvate dehydrogenase



- Pyruvate dehydrogenase is part of a multi-enzyme complex that acts to convert pyruvate generated in glycolysis into acetyl-CoA for entry into the tricarboxylic acid (TCA) cycle.

Ketoglutarate dehydrogenase

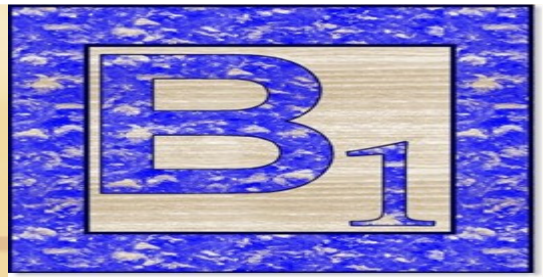


- ketoglutarate dehydrogenase is a key point of regulation in the TCA cycle.

- Ketoglutarate dehydrogenase is involved in the conversion of ketoglutarate to succinyl CoA.

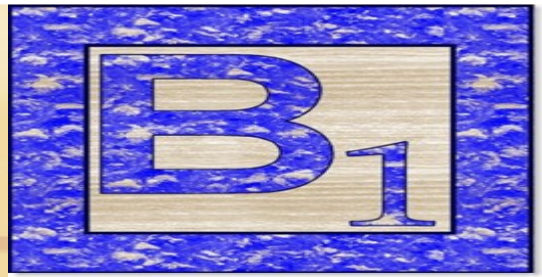
In the case of both enzymes, TPP assists in decarboxylation of a small ketoacid

Functions of thiamine



- All cells use thiamine in their **energy metabolism**, specially nerve cell membranes.
- TPP serves as coenzyme for pyruvate and α-keto glutarate dehydrogenases catalyzed **oxidative decarboxylation reaction**
- Coenzyme in transketolase catalyzed reactions of **pentose phosphate pathway**

Thiamin (Vitamin B1) sources

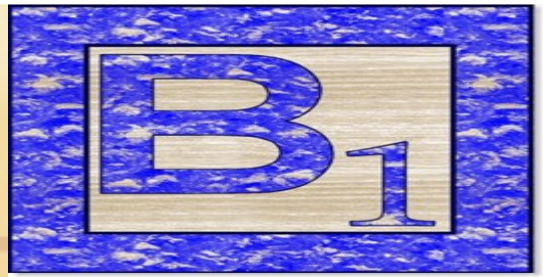


Plant: whole grains (unrefined cereal grain), yeast, beans, peas.

Animal: liver, heart, kidney and milk.

Recommended intake: 1-1½ mg/day

Deficiency



- Beri Beri is thiamine deficiency in the hands, feet and and muscular weakness and abnormal heart action.

Riboflavin (B_2)

Riboflavin is the precursor for the coenzymes, flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD)

Functions

- FMN and FAD serve as prosthetic groups of oxidoreductase enzymes

1. Oxidative degradation of fatty acids (FAD is the prosthetic group of acyl CoA dehydrogenase.

2. Oxidative deamination of α-amino acids:
    1. FMN: Prosthetic group of L-a.a.oxidase.
    2. FAD: Prosthetic group of D-a.a. oxidase

Functions

- Riboflavin is also needed to help the body convert vitamin B6 and folate into active forms

Sources and Requirement

Sources

The major source is leafy vegetables. Other good sources are yeast, cauliflower, liver and kidney.

Requirement

1.2-1.7 mg/day

Deficiency:

- Cause riboflavinosis.

The main symptom are:

skin rash,

dermatitis, 

cheilosis: fissures at the corner of the mouth 

Glossitis: tongue smooth and purplish 

Niacin (Vitamin B3)

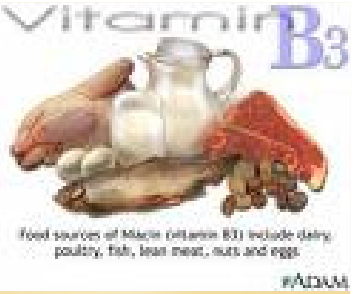
- Like other vitamins, is participating in the energy metabolism of the body.
- Niacin is unique among the B vitamins in that the body can make it from protein. The amino acid tryptophan can be converted to niacin in the body.

Niacin (Vitamin B3)

- Part of coenzyme for energy
- Deficiency disease: **Pellagra**
- Can be made from the amino acid tryptophan in the body
- 60 mg tryptophan synthesize $\xrightarrow{\text{(PLP)}}$ 1mg Niacin

Synthesize of niacin from tryptophan requires pyridoxal phosphate (PLP).

Recommended intakes



- Recommended intakes are therefore, stated in niacin equivalent (NE) reflecting the body's ability to convert tryptophan to Niacin.

- N.B.: the conversion is inefficient and most people required dietary sources of both tryptophan and niacin.

Niacin (Vitamin B3)

- Vitamin B3 (niacin) is a component of NAD+ (or NADH) which is the major transporter of electrons from glycolysis and the Krebs cycle to the electron transport chain.

- NAD is nicotinamide dinucleotide and the nicotinamide part is derived from niacin (also known as vitamin B3 or nicotinic acid).

Function

- NAD^+ and $NADP^+$ are coenzymes of many oxidoreductase enzymes in both cytosol and mitochondria.

- NAD^+ linked dehydrogenases catalyze oxidoreduction reaction in oxidative pathways in citric acid cycle and glycolysis

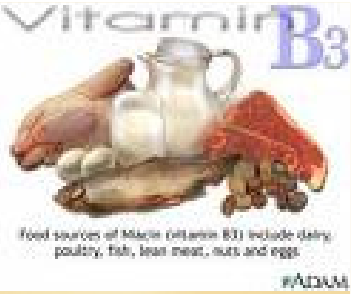
$AH_2 + NAD^+ \rightarrow A + NADH + H^+$

1. Glyceraldehydes 3-P dehydrogenase
2. Malate dehydrogenases
3. Lactate dehydrogenases

Sources:

- Food stuff containing Niacin as B_1.
- Tryptophan containing protein such as meat

Deficiency:



- Pellagra= niacin deficiency disease

Pellagra is classically described by "the four D's":

- **Diarrhea:**
- **Dermatitis**: **Dermatitis** is a blanket term meaning any "inflammation of the skin" (e.g. rashes, etc.)

- **Dementia**:

- **Death:**

Pantothenic acid (vitamin B_5) function

- Sources as B_1
- Function: is also important in energy metabolism.

- Pantothenic acid is recognized as a substance that **stimulates growth**.
- Pantothenic acid is involved in more than **100 different steps in the synthesis of lipids, steroid hormones and Hb.**
- Active pantothenic acid **is coenzyme A (CoA) and acyl carrier protein of fatty acid synthesis**.

Pantothenic acid (vitamin B_5) function

- The SH group of both CoA and ACP acts as a carrier of acyl group (R-COL$^-$) in enzymatic reaction involved in:

1. Fatty acid oxidation and synthesis.
2. Oxidative decarboxylation of α-keto acids.
3. Formation of citric acid in citric acid cycle.

Acetyl CoA + Oxaloacetate $\longrightarrow$ Citrate,

4. Cholesterol synthesis

Deficiency:

- There is no evidence of pantothenic acid deficiency disease because it is very widespread in natural food.

Biotin:

- It is also important in energy metabolism
- sources as B_1. The active form of biotin is biocytin.
- Function:
- Involved in carboxylation reactions i.e. carrier CO_2.
  - ➢ acetyl CoA carboxylase in FA synthesis
  - ➢ pyruvate carboxylase in gluconeagesis
  - ➢ propionyl-CoA carboxylase

Propionyl CoA→succinate→citric acid cycle

Deficiency of biotin

- Deficiency: is rare because it is found in numerous foods and is synthesized by intestinal bacteria.

- Deficiency of biotin is generally seen only:
  - After long antibiotic therapy which deplete intestinal flora.
  - Following excessive consumption of raw eggs, due to the affinity of the egg white protein, avidin, for biotin preventing intestinal absorption of biotin

Vitamin B_6

- Vitamin B_6 consists of 3 closely related pyridine derivatives:

  pyridoxine,

  pyridoxal

  pyridoxamine.

- All three compounds are efficiently converted to the biologically active form of vitamin B_6 pyridoxal phosphate

Pyridoxal Pyridoxal Kinase → **Pyridoxal Phosphate PLP**

Role of Vitamin B_6

- Pyridoxal phosphate (PLP) is the active form and is a cofactor in many reactions of amino acid metabolism, including:
  - transamination,
  - deamination,
  - decarboxylation.
- PLP also is necessary for the enzymatic reaction governing the release of glucose from glycogen.
- PLP Converts tryptophan into niacin.

Vitamin B_6 deficiency:

- impair immune response by impaired antibody production.
- (skin lesions resembles those of B_2 and niacin deficiency).
- A microcytic anaemia

Vitamin B9 Folic acid

- **Folic acid** (also known as **Vitamin B9** or **Folacin**) and **Folate** (the naturally occurring form)
- Vitamin B9 (Folic acid and Folate inclusive) is essential to numerous bodily functions ranging from **nucleotide synthesis** to the **remethylation of homocysteine**.
- It is especially important during periods of **rapid cell division and growth**.
- Both children and adults require folic acid to produce healthy red blood cells and prevent anemia.

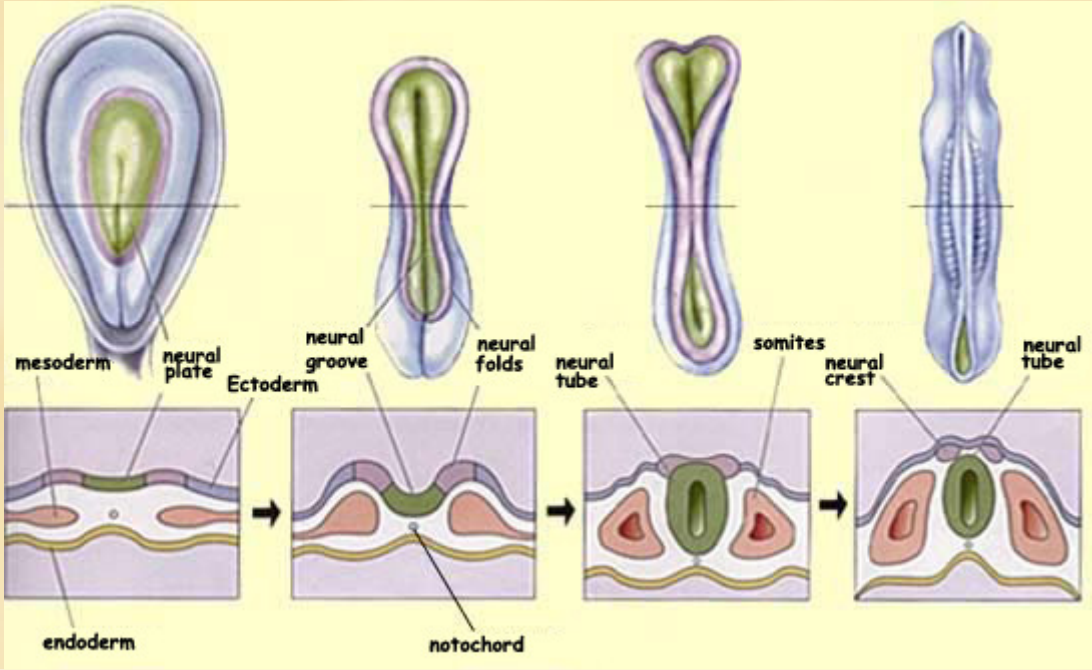
Folic acid deficiency

Folic acid deficiency reduces the capacity of the body to make **dTMP** which affects the rapidly dividing bone marrow cells associated with red blood cell production.

Importance of folic acid during early pregnancy:

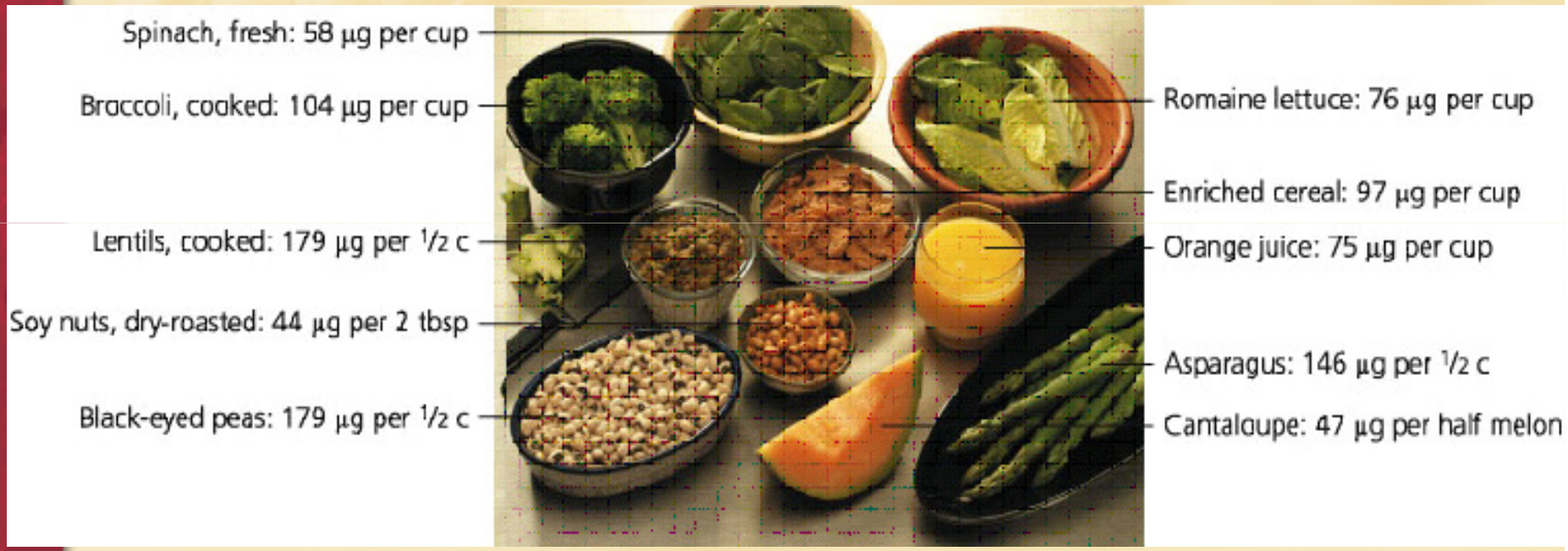
Closure of the neural tube occurs around the 28th day of pregnancy

neural tube defects is reduced by 400µg folic acid supplement/day before conception and during the first month of pregnancy.



Folic Acid Sources

Adult DRI (RDA)=400µg



Vitamin B_{12} (Cobalamin)

- Vitamin B_{12} is composed of complex tetrapyrrol ring structure a cobalt ion in the center (cobalamin).

Sources:

- The only source of cobalamin in nature is through synthesis **by microorganisms in liver of animals**. Neither animals nor plants can synthesize it.
- Not present in vegetable goods.
- Only sources of this vitamin are goods of animal origin as liver, meat, milk and eggs, negligible amounts are provided by intestinal flora.

Functions

- Vitamin B_{12} assists folate in cell division and each performs a specific role that other cannot do.