Vitamins
Fat Soluble

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Vitamins

- Structure
  - Individual Units
  - NOT linked together – i.e. NOT building blocks like for glucose, fatty acids, amino acids

- Function
  - Do NOT yield energy when broken down
  - Assist enzymes and other biological factors that release energy from CHO, Pro, Fats = coenzymes

- Amounts needed
  - Measured in micrograms or milligrams, not grams
# Two Classes of Vitamins

## Water Soluble
- **Vitamin C**
- **B Vitamins**
  - Thiamin
  - Riboflavin
  - Niacin
  - Pantothenic Acid
  - Biotin
  - Vitamin B$_6$
  - Folic Acid
  - Vitamin B$_{12}$

## Fat Soluble
- **Vitamin A**
- **Vitamin D**
- **Vitamin E**
- **Vitamin K**
# Vitamin Comparison

<table>
<thead>
<tr>
<th></th>
<th>Fat Soluble</th>
<th>Water Soluble</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Absorption</strong></td>
<td>Lymph then</td>
<td>Directly into blood</td>
</tr>
<tr>
<td></td>
<td>blood/protein carrier</td>
<td></td>
</tr>
<tr>
<td><strong>Storage</strong></td>
<td>Long term</td>
<td>Short term</td>
</tr>
<tr>
<td><strong>Excretion</strong></td>
<td>Less readily excreted – remain in fat storage sites</td>
<td>Kidneys detect and remove in urine</td>
</tr>
</tbody>
</table>
Fat soluble Vitamins – the functions

- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K
Fat soluble Vitamins – digestion

- Digestion and absorption follow a similar pathway to dietary fats
- Insoluble in water – packaged into chylomicrons
- Taken up by liver – can be stored
- Transported to other tissues via proteins

Condition which alters/hinders function of intestine or fat absorption will limit the absorption
Vitamin A

SOURCES OF VITAMIN A AND BETA CAROTENE

Adult DRI (RDA) is 700 to 900 μg RAE.

- Carrots, cooked: 671 μg† per ½ c
- Sweet potato, cooked: 961 μg† per ½ c
- Fortified milk: 150 μg* per c
- Mango: 78 μg† per mango
- Cantaloupe: 444 μg† per half melon
- Spinach, cooked: 472 μg† per ½ c
- Apricots, dried: 60 μg† per ½ c

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Essential Nutrient
Vitamin A

FUNCTION: Versatile

- Best known function is in vision.
  - Night Blindness
    (is the inability to see well at night or in poor light)

- Helps to maintain healthy epithelial tissue.
- Reproduction & Development
- Immunity
- Growth
Vitamin A

Too much? HIGHLY TOXIC

- Birth defects
- Permanent damage to the liver and eyes
- Reduced bone density

Overdose is usually from taking supplements not from eating food.
Vitamin A

VITAMIN A EXCESS

From Abu-Abed et al., 2001
Vitamin A

Too little?

- Hardening of skin cells
- Night blindness or total blindness
- Increased risk of infection
Vitamin D

- Vitamin D is different from all other vitamins in that body can synthesize it with the help of sunlight.

Therefore, vitamin D is not an essential nutrient. Given enough sun, people need no vitamin from good.
Vitamin D – aka Calciferol

**FUNCTION:**
- Bone making and maintenance
- Assists in the absorption of dietary calcium.
- Helps to make calcium and phosphorus available in the blood.
- The body can synthesize it with the help of sunlight.
Vitamin D sources

- Cholecalciferol is produced in the skin by U.V. radiation of 7-dehydrocholesterol (vitamin D precursor, that is synthesized by the liver).

- Performed vitamin D from fish-liver oil, flesh of oily fish, egg yolk, and liver (milk is poor source of vitamin D).

_Flesh_ is the biological tissue of a person or animal located between the skin and the bones.
Absorption and activation:

- It is absorbed in the intestine.
- Activation of vitamin D, start in the liver cell, where it is hydroxylated on the 25\textsuperscript{th} position by 25-hydroxycholecalciferol.
- 25-hydroxy D\textsubscript{3} is further hydroxylated in kidney by 1-\(\alpha\) hydroxylase \(\rightarrow\) 1,25 dihydroxy D\textsubscript{3} (Calcitriol) which is the metabolically the active form of the vitamin.
Absorption and activation

- Parathyroid hormone is essential for the hydroxylation step in the kidney.
- 24,25 dihydroxy D₃ is another active form. However, it is less active than 1,25 dihydroxy D₃.
- The level of the two active forms is reciprocally related, but they are nearly equal in normal calcium level.
- Disease affect liver or kidney may impair the transformation of precursor vitamin D active form therefore; produce symptoms of vitamin D deficiency.
Vitamin D

Skin → Cholesterol derivative → Cholecalciferol (in blood)

blood → Calcidiol (inactive) → Calcitriol (Active hormone form of vitamin D)

5-15 min Sunlight/week
Vitamin D

Deficiency:
- Children = Ricket’s Disease
- Adults = Osteomalacia
  - Calcium absorption; Blood Calcium = bone deficiency

Toxicity:
- 10x RDA
  - Calcium absorption; Blood Calcium = Calcium deposits on soft tissue
    - eg kidney stones

5 µg/dl (19-30 yrs)
Vitamin D from sun

- Prolonged exposure to sunlight degrades the vitamin D precursor in the skin, preventing its conversion to the active vitamin.

- Prolonged exposure to sunlight causes skin cancer.
Vitamin E (Tocopherols):

- Vitamin E is a fat-soluble antioxidant. It protects other substances from oxidation by being oxidized itself.

- Therefore naturally occurring tocopherols.

- \( \alpha \)-tocopherol (5,7,8 trimethyl tocol) is the most active and abundant one.

- Vitamin E as an antioxidant:
Vitamin E as an antioxidant

- Vitamin E is specially effective in preventing the oxidation of polyunsaturated fatty acids (PUFA), but it protects all other lipids e.g. vitamin A from oxidation by molecular oxygen and free radicals (N.B.: if O₂ attach PUFA → FA peroxides).
Vitamin E as an antioxidant

- Vitamin E exerts an especially important antioxidant effect in the lungs, where the cell are exposed to high concentration of O$_2$.

- It is also prevent heart disease by protecting LDL from oxidation which encourages development of atherosclerosis (oxidized LDL).
Vitamin E Deficiency: Rare

Premature infants

Those who cannot absorb fats

These include disease of the liver, gallbladder and pancreas
Vitamin E deficiency

When blood concentration of vitamin E falls below a critical level, the RBCs tend to break, open, spell their contents (hemolysis) due to increased fragility of the red blood cell membrane because of the peroxidation of their membrane PUFAs.

this is known as erythrocyte hemolysis which is seen in premature infants born before the transfer of vitamin E from the mother to the fetus that takes place in the last weeks of pregnancy.
Vitamin E toxicity

- Vitamin E toxicity effects are not serious as vitamin A or vitamin D toxicity.

- High dose of vitamin E interfere with blood-clotting action of vitamin K is enhancing the action of anti-coagulant medication leading to haemorrhage (blood fails to clot).
Vitamin E sources:

- Cotton seed oil, corn oil, peanut oil and wheat germ oil are good sources.
- Green lettuce leaves have high content.
- Other good sources: eggs, muscle meat, liver and fish.
Vitamin K

FUNCTION:
Blood clotting
- Synthesis of proteins involved in clotting
- Koagulation = Danish word = coagulation

Bone health
- Works with vitamin D to regulate calcium

Stored in liver
Vitamin K

• Blood clotting:
  • At least 13 different proteins and the mineral Ca$^{2+}$ are involved in making blood clotting.
  • Vitamin K is essential for the activation of one of these proteins, among of them prothrombin, the precursor of thrombin.
  • When any of the blood-clotting factor is lacking $\Rightarrow$ haemorrhage disease.
Intestinal synthesis

• Like vitamin D, vitamin K can be obtained from a non food source, bacteria in the intestinal track (intestinal flora) synthesize vitamin K that body can absorb, but people cannot depend on this source alone.
Deficiency:

- Manifested by remarkable tendency to bleed profusely from minor wounds and easy brushing.

- Diagnosed by prolonged blood coagulation time.
Deficiency

- Is rare, but may occur in 2 cases:

1. Fat malabsorption conditions.

2. Medication interfere with vitamin K’s synthesized its action in the body, e.g. antibiotics kill the bacteria that produce vitamin K.

People take these medication should eat vitamin K-rich food.
Toxicity:

- The symptoms include RBC hemolysis, jaundice and brain damage.
- N.B.:
- High intake of vitamin K can reduce the effectiveness of anti coagulant medication used to prevent the blood from clotting.

- In food: green vegetables e.g. spinach, fruit, peas, vegetable oil, tomatoes, egg yolk liver, etc.