VITAMINS: STRUCTURE AND FUNCTIONS

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LECTURE CONTENTS

- INTRODUCTION TO VITAMINS
- COMPOSITION OF VITAMINS
- CLASSIFICATION OF VITAMINS
- FAT SOLUBLE VITAMINS: STRUCTURE AND FUNCTIONS
- WATER SOLUBLE VITAMINS AND FUNCTIONS
- COENZYMES AND FUNCTIONS
- MINERALS AND FUNCTIONS
Vitamins are organic compounds required by the body in small amounts for metabolism, for protection, for maintenance of health and proper growth.

They cannot be synthesized by the body. Must be obtained by outside sources like diet, rumen of bacteria & sun.

Vitamins also assist in the formation of hormones, blood vessels, nervous system chemicals and genetic materials.

They generally act as catalysts, combining with proteins to create metabolically active enzymes that are essential for life reactions.

Without enzymes, many of the reactions essential to life would slow down or cease.
COMPOSITION OF VITAMINS

- Vitamins are of different chemical nature. These are alcohols, aldehydes, organic acids, their derivatives and nucleotide derivatives.
CLASSIFICATION OF VITAMINS

- Vitamins are classified according to their ability to be absorbed in fat or water
- 1. Fat Soluble Vitamins: these are oily and hydrophobic compounds, they are stored in the liver and not excreted out of the body. Bile salts and fats are needed for their absorption. Vitamins A, D, E and K are fat soluble
- 2. Water Soluble Vitamins: Vitamin B complex and Vitamin C are water soluble. They are not stored in the body, therefore are required daily in small amounts
CLASSIFICATION OF VITAMINS CONT’D

Fat Soluble Vitamins: *stored in tissues*

Examples
A
D
E
K

Water Soluble Vitamins: *not stored in tissues, must have constant supply*

Examples
B, B₁, B₂, B₆ & B₁₂
Niacin
Folic Acid
C
VITAMIN A
Vitamin A is a pale yellow primary alcohol derived from carotene. It includes Retinol (alcoholic form), Retinal (aldehyde form) and Retinoic acid (acidic form). Sources, physiological functions and deficiency: refer to notes.
VITAMIN D (Calciferol)
This comprises a group of fat soluble sterol founds naturally in few foods. The two major physiologically relevant forms of vitamin D are D2 (ergocalciferol) and D3 (cholecalciferol)
• Sources, physiological functions and deficiency: refer to notes
FAT SOLUBLE VITAMINS

VITAMIN E
also called Tocopherol or fertility hormone
Vitamin E is required in the human diet but its deficiency is rare except in pregnancy and the newborn, where it is associated with hemolytic anaemia

- It exists in the diet as a mixture of eight closely related compounds called tocopherols
- Sources, physiological functions and deficiency: refer to notes

STRUCTURE OF VITAMIN E

The vitamin E vitamers. In α-tocopherol and tocotrienol $R_1$, $R_2$, and $R_3$ are all —CH$_3$ groups. In the β-vitamers $R_2$ is H; in the γ-vitamers $R_1$ is H, and in the δ-vitamers $R_1$ and $R_2$ are both H.
VITAMIN K
Also called phylloquinone or anti-hemorrhagic vitamin or coagulation vitamin. Vitamin K is a complex unsaturated hydrocarbon found in two forms, vitamin K1(phylloquinone) and vitamin K2(Menaquinone)
Sources, physiological functions and deficiency:
Refer to notes
WATER SOLUBLE VITAMINS

- These include the B-vitamins and vitamin C
- They are soluble in water and can therefore be excreted in the urine
- They share few common properties besides their solubility characteristics
- Most of these vitamins act as coenzymes
- Examples include thiamine (Vit B₁), Riboflavin (B₂), Niacin, Pantothenic acid (Vit B₅), Vitamin B₆ (Pyridoxine), Biotin, Vitamin B₁₂ (Cobalamin) and folic acid
WATER SOLUBLE VITAMINS

VITAMIN B₁ (Thiamine)

- It is a colourless and crystalline substance
- It is readily soluble in water and slightly in ethyl alcohol
- Addition of a pyrophosphate (ppi) from ATP converts it to thiamine pyrophosphate (TPP), the coenzyme for all decarboxylation of alpha keto acids
- Source, physiological functions and deficiency: refer to notes

STRUCTURE OF VITAMIN B₁

(Chemical structure of thiamine pyrophosphate)
WATER SOLUBLE VITAMINS

VITAMIN B₂ (Riboflavin)

- It is a component of the flavin coenzymes, FAD and FMN.
- It is composed of an isoalloxazane ring system linked to ribitol.
- It is mainly used in energy metabolism of sugars and lipids.
- The activation of FMN and FAD is an ATP-dependent reaction.
- Source, physiological function and deficiency: refer to notes.

STRUCURE OF VITAMIN B₂
WATER SOLUBLE VITAMINS

VITAMIN B₃ (NIACIN OR NICOTINIC ACID)

- Niacin can be synthesized from tryptophan
- Niacin contains a substituted pyridine ring and when NAD⁺ activated forms NAD⁺ and its phosphorylated derivative NADP⁺, which are coenzymes of many dehydrogenases
- Sources, physiological functions and deficiency: refer to notes
WATER SOLUBLE VITAMINS

PANTOTHENIC ACID (VIT.B5)

- Also called coenzyme, pantothenic acid is a vitamin that forms an essential part of acyl groups in general, including the acetyl group derived from pyruvate.
- The coenzyme is derived metabolically from ATP, the vitamin pantothenic acid and β-mercaptoethylamine.
- Sources, physiological functions and deficiency: refer to notes.
WATER SOLUBLE VITAMINS

VITAMIN B6 (PYRIDOXINE)

- Vit.B6 exists in three forms: Pyridoxine, Pyridoxal and Pyridoxamine and their corresponding phosphates.
- Pyridoxal phosphate participates in transaminations, decarboxylations, racemizations and numerous modification of amino acid sequence side chains.
- Sources, physiological functions and deficiency: Refer to notes.

STRUCTURE OF VIT. B6
WATER SOLUBLE VITAMINS

VITAMIN B₇ (BIOTIN)

- Biotin is a vitamin and a coenzyme commonly associated with enzyme performing carboxylation reactions
- Biotin is also known as “anti-egg white injury factor” or as H-factor
- Sources, physiological functions and deficiency: refer to notes
WATER SOLUBLE VITAMINS

VITAMIN B9 or M or Bc (folic acid)

- The active form acid is tetrahydrofolate (THF)
- Coenzymes derived from the vitamin folic acid participates in the generation and utilization of single–carbon functional groups, methyl, methylene and formyl
- Sources, physiological functions and deficiency: Refer to notes
WATER SOLUBLE VITAMINS

VITAMIN B12 (Cyanocobalamin)

- The metal cobalt in vitamin B12 is coordinated with a tetrapyrrole ring system, called a corin ring, which is similar to the porphyrin ring of heme compounds.
- B12 requiring reactions involve methyl group transfer and adenosylcobalamin-dependent isomerizations.
- Sources, physiological functions and deficiency:
- Refer to notes
WATER SOLUBLE VITAMINS

VITAMIN C (Ascorbic acid)

- It is a water soluble vitamin
- It is essential for the hydroxylation of proline and lysine in the formation of collagen
- Collagen is a fibrous protein with myriad connective and supportive functions
- Sources, physiological functions and deficiency:
- Refer to notes
COENZYMES AND COFACTORS

- Cofactors essentially act as enzymes’ CHEMICAL TEETH

**Cofactors**

- Essential ions
  - Activator ions (loosely bound)
  - Metal ions of metalloenzymes (tightly bound)

- Coenzymes
  - Cosubstrates (loosely bound)
  - Prosthetic groups (tightly bound)
MANY VITAMINS ARE COENZYME PRECURSORS

<table>
<thead>
<tr>
<th>Coenzyme</th>
<th>Examples of chemical groups transferred</th>
<th>Dietary precursor in mammals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biocytin</td>
<td>CO₂</td>
<td>Biotin</td>
</tr>
<tr>
<td>Coenzyme A</td>
<td>Acyl groups</td>
<td>Pantothenic acid and other compounds</td>
</tr>
<tr>
<td>5’-Deoxyadenosylcobalamin (coenzyme B₁₂)</td>
<td>H atoms and alkyl groups</td>
<td>Vitamin B₁₂</td>
</tr>
<tr>
<td>Flavin adenine dinucleotide</td>
<td>Electrons</td>
<td>Riboflavin (vitamin B₂)</td>
</tr>
<tr>
<td>Lipoate</td>
<td>Electrons and acyl groups</td>
<td>Not required in diet</td>
</tr>
<tr>
<td>Nicotinamide adenine dinucleotide</td>
<td>Hydride ion (:H⁻)</td>
<td>Nicotinic acid (niacin)</td>
</tr>
<tr>
<td>Pyridoxal phosphate</td>
<td>Amino groups</td>
<td>Pyridoxine (vitamin B₆)</td>
</tr>
<tr>
<td>Tetrahydrofolate</td>
<td>One-carbon groups</td>
<td>Folate</td>
</tr>
<tr>
<td>Thiamine pyrophosphate</td>
<td>Aldehydes</td>
<td>Thiamine (vitamin B₁)</td>
</tr>
</tbody>
</table>
Minerals are inorganic elements needed for the functioning of the body. They make up about 4% of body weight of adults, they cannot be changed or broken down. Some which are needed in high quantities are referred to as macro-elements, examples include Na, K, Mg, Cl etc. Others are needed in smaller quantities and are termed microelements, they include Fe, Cu, F, I etc.
MACRO-ELEMENTS

- The body requires relatively large amounts of about 7 minerals (macro-elements)

1. Calcium (Ca)
2. Phosphorus (P)
3. Sulphur
4. Magnesium
5. Potassium
6. Chlorine
7. Sodium
MACRO-ELEMENTS

- **Calcium (Ca)**

**Functions:** Calcium plays myriad of functions that includes

- Bones and teeth formation, membrane transport, nerve transmission, muscle contraction, hearth rhythm, blood clotting and enzyme cofactor

**Sources:** milk, milk products and leafy vegetables

**Deficiencies:** Osteoporosis and Bone fractures

**Excesses:** Nausea, vomiting, loss of appetite, kidney toxicity, irregular heart beat, reduced absorption of iron and zinc
MACRO-ELEMENTS

• Phosphorus (P)

Functions: in bone and teeth formation, ATP formation, creatine phosphate, DNA and RNA, phospholipids and active transport

Source: Cheese, milk, nuts and eggs

Deficiencies: hypophosphatemia with symptoms similar to calcium deficiency

Excesses: Reduce body stores of calcium
MACRO-ELEMENTS

3. Sulphur (S): needed by most proteins

4 Magnesium (Mg): it acts as coenzymes for enzymes

Sources: vegetables, cereals, beans, potatoes, cheese and animal tissues

Deficiencies: can result in poor calcium absorption

Excesses: Heart problems and difficulty in breathing

5 Potassium (K), 6 Chlorine (Cl) and 7 Sodium (Na)

Functions: Osmotic Balance, Nerve impulse, Muscle contractions
The body requires only trace amounts of others (micro-elements). These includes

1. Flouride (F)
Functions: it strengthens bones
Excesses: Browning of teeth, brittle bones, fatigue and muscle weakness

2. Iodine (I)
Functions: Synthesis of thyroid hormones
Deficiencies: Goiter, mental and physical retardation (cretinism)
3. Iron (Fe)
Functions: **Heamoglobin synthesis**
Excesses: *has been linked to arthritis, heart disease, diabetes, infectious disease and cancer*

Functions: **Cofactors for enzymes**

7. Copper
Functions: **Cofactors for enzymes**
Deficiency: **Anemia, impaired immunity, altered iron metabolism**
MICRO-ELEMENTS

- **8 Zinc**
  
  **Functions:** Cofactors for enzymes, synthesis of testosterone and sperm development
  
  **Deficiencies:** Reduced immune functions, Vomiting, gastric upset and slow absorption of copper

- **9 Molybdenum:**
  
  **Functions:** Cofactors for enzymes
  
  **Excesses:** Increased secretion of copper

- **10 Selenium**
  
  **Functions:** Cofactors for enzymes
  
  **Deficiencies:** muscle pain or weakness and impaired immunity
  
  **Excesses:** Fragile nails, hair loss, fatigue, abdominal pain, nausea and nerve damage