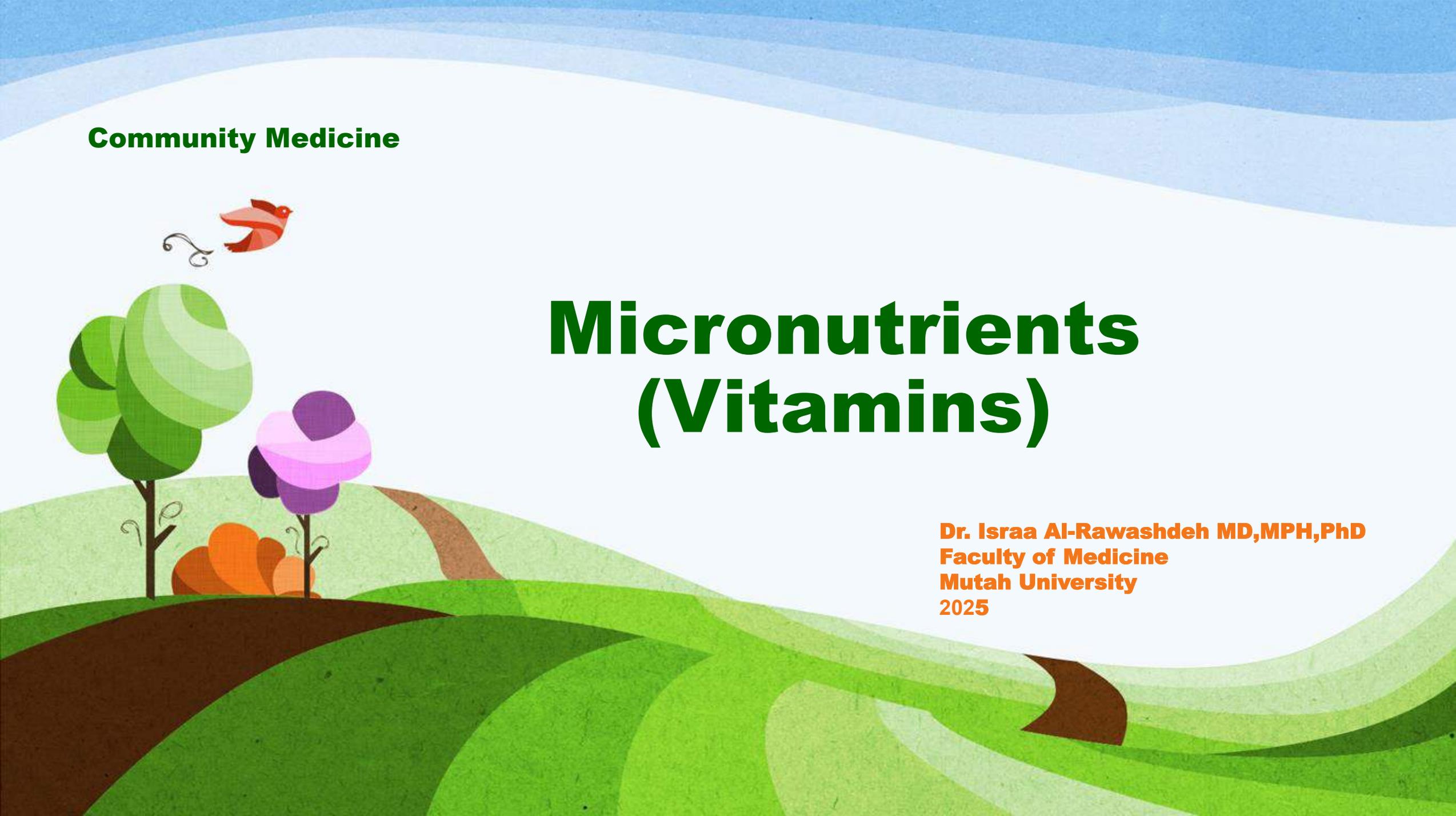


**Community Medicine**

# **Micronutrients (Vitamins)**

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**2025**



# Introduction

- **Micronutrients**: Chemical substances required in small quantities to regulate metabolic and biochemical processes in the body.
- They are essential dietary components.
- Critical for health in human body, especially in pregnant women and growing fetuses.
- Consequences of Imbalance:
- **Deficiency ("Hidden Hunger")**:
  - ✓ Growth retardation.
  - ✓ Impaired cognitive/physiological development.
  - ✓ Immunodeficiency.
- **Excess (Toxicity)**: Adverse health effects (e.g., hypervitaminosis).

# Introduction:

- **Micronutrients are classically divided into four groups:**

Organic

## Water-soluble vitamins

*B-complex (B1, B2, B3, B6, B9, B12) & Vitamin C.*

*Not stored; excess excreted in urine.*

## Fat-soluble vitamins

*A, D, E, K.*

*Stored in liver/adipose tissue; risk of toxicity.*

Inorganic

## Macro minerals

*Calcium, Potassium, Sodium, Magnesium, Phosphorus, Chlorine, Sulfur*

*Required in grams/day*

## Micro minerals

**Trace:** *Iron, Zinc, Copper, Iodine, Fluorine, Manganese, Cobalt (Required in mg/day)*

**Ultra trace elements:** *Selenium, Chromium, Molybdenum, Nickel, Lithium*

*Required in µg/day*

# Risk Factors for Micronutrient Malnutrition

## 1. Dietary & Nutritional Factors:

### Inadequate Diet:

**Monotonous diets (low micronutrient diversity).**

**Low intake of animal-source foods (reduces bioavailable iron, B12, zinc).**

**Seasonal food shortages → intermittent deficiencies.**

### Poor Absorption:

**Malabsorption (diarrhea, parasites like *Giardia* or hookworms).**

**Phytate-rich diets (reduce mineral bioavailability).**

## 2. Physiological & Medical Conditions

### High Demand:

**Pregnancy/lactation (↑ needs for iron, folate, vitamin A).**

**Infections (TB, HIV, malaria) → ↑ nutrient utilization/loss.**

**Cancer/chronic disease → cachexia/malabsorption.**

### Increased Loss:

**Schistosomiasis (blood loss → iron deficiency).**

**Protein-energy malnutrition (PEM) → compounded deficiencies.**

# Risk Factors for Micronutrient Malnutrition

## 3. Socioeconomic & Environmental Barriers

### Poverty:

**Limited access to diverse, nutrient-dense foods.**

**Food insecurity → reliance on staple crops (low micronutrients).**

### Education & Healthcare:

**Illiteracy/low education → lack of nutrition awareness.**

**Low breastfeeding rates → infant micronutrient gaps.**

Many of these deficiencies are preventable through nutrition education and consumption of a healthy diet containing diverse foods, as well as food fortification and supplementation, where needed.



# Vitamins:



The word "vitamin" is derived from the Latin "vita," meaning life, and "amine," because vitamins were originally thought to contain amino acids.

Council for Responsible Nutrition

[www.crnusa.org](http://www.crnusa.org)

- In 1930s, commercially produced tablets of yeast-extract vitamin B complex and semi-synthetic vitamin C became available.
- *13 vitamins are known, 4 fat soluble (A, D, E, K) & 9 water soluble (C, the B group)*



Casimir Funk

# Vitamin A

- Two Primary Forms
  - **Preformed Vitamin A (Retinol):**
    - **Sources:** Liver, fish oils, dairy (cheese, milk), eggs.
    - **Directly usable by the body.**
  - **Provitamin A (Carotenoids, e.g., Beta-Carotene):**
    - **Sources:** Colorful plants (carrots, sweet potatoes, spinach, red peppers, mango, papaya and apricots).
    - **Metabolized to retinol in the intestinal mucosa and liver.**
- Notes:**
- **Carotenoid conversion is low (~12:1 ratio); fat intake boosts absorption.**
  - **Excess retinol is stored in the liver (risk of toxicity).**



# Key Functions of Vitamin A

## 1. Immunity

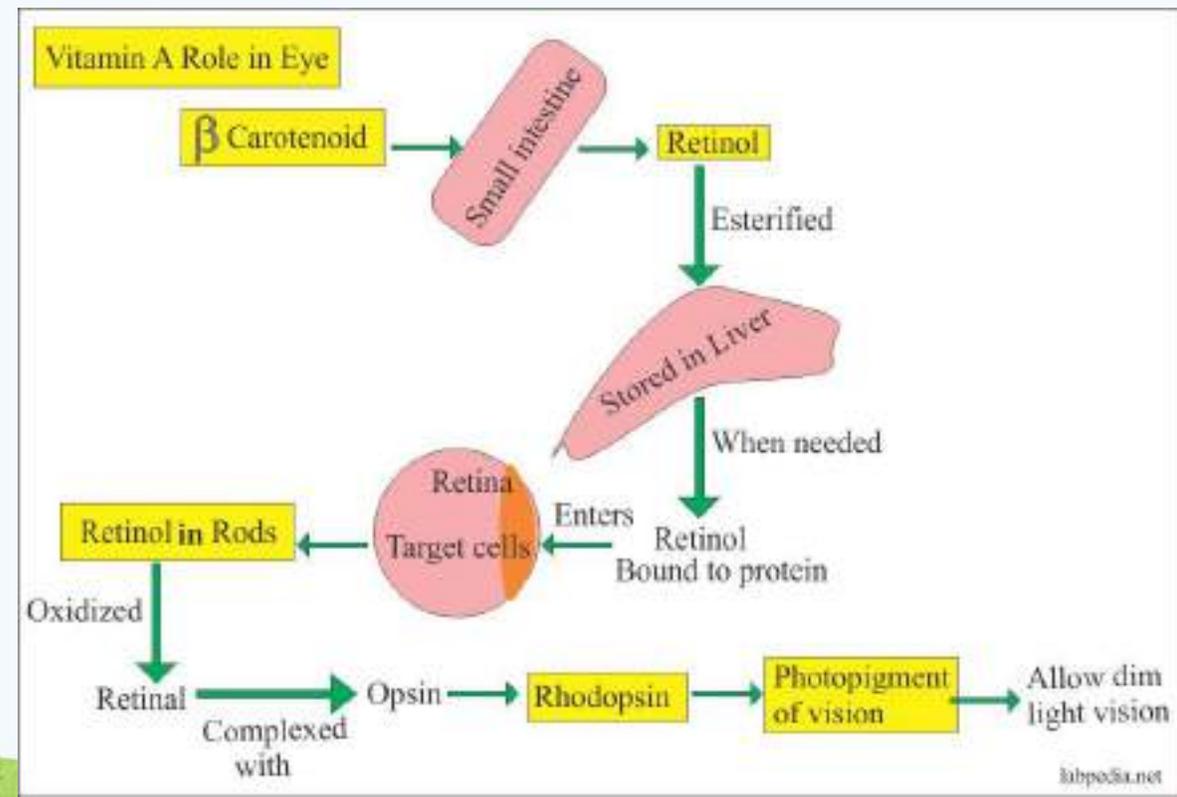
- ✓ **T-lymphocyte activation (critical for adaptive immunity).**
- ✓ **WBC maturation (supports neutrophil/macrophage function).**
- ✓ **Maintains epithelial barriers (skin, gut, respiratory tract).**

## 2. Vision

- ✓ **Rhodopsin synthesis (pigment for low-light vision).**
- ✓ **Corneal integrity (prevents xerophthalmia).**

## 3. Gene Regulation & Growth

- ✓ **Cell differentiation (e.g., embryonic development).**
- ✓ **Bone remodeling and reproductive health.**



# Vitamin A Deficiency

## 1. Ocular Changes

**Night Blindness:** Impaired dark adaptation (early sign).

### Xerophthalmia:

Dry conjunctiva → **Bitot's spots (foamy patches).**

**Corneal ulceration** → **Leading cause of childhood blindness.**

## 2. Extraocular Manifestations

**Immune Dysfunction:** ↑ Risk of infections (RTI, diarrhea).

### Epithelial Keratinization:

Respiratory/GI/Urinary tracts → Malabsorption, UTIs.

**Skin:** Follicular hyperkeratosis ("goosebumps" texture on arms/thighs).

**Growth Retardation:** Delayed bone development.

## Diagnosis

**Gold Standard:** Serum retinol < 0.7  $\mu\text{mol/L}$ .

**Clinical Signs:** Corneal lesions, skin changes.



*follicular hyperkeratosis, which manifests as small, rough, cone-shaped, raised papules on the posterior and lateral aspects of the arms and thighs.*

# Vitamin A – Daily Requirements & Storage

## Measuring Vitamin A

Unit: Retinol Activity Equivalents (RAE). Accounts for differences in bioavailability: 1 µg RAE = 1 µg retinol or 12 µg beta-carotene.

## Recommended Daily Intake (Adults 19–64 yrs):

Group	RAE/day
Men	900 µg
Women	700 µg
Pregnancy	770 µg
Breastfeeding	1,300 µg

*Liver Storage: Excess retinol is stored (↑ risk of toxicity).*

*No Daily Need: Consistent intake unnecessary due to reserves.*

- **Prevention:**
  - **Breastfeeding, fortified foods, supplementation.**

# Vitamin D – Synthesis, Activation & Function

## Vitamin D3 (Cholecalciferol):

Synthesized in humans/animals (from cholesterol).

Found in animal sources (fatty fish, egg yolks).

## Vitamin D2 (Ergosterol):

Plant/fungal origin (e.g., mushrooms).

Less bioavailable than D3.

- **Humans & animal utilize only vitamin D3 & they can produce it inside their bodies from cholesterol.**

## Synthesis & Activation:

**Precursor: 7-Dehydrocholesterol (7DC) in skin.**

**Sunlight Exposure: UVB converts 7DC → D3 (inactive).**

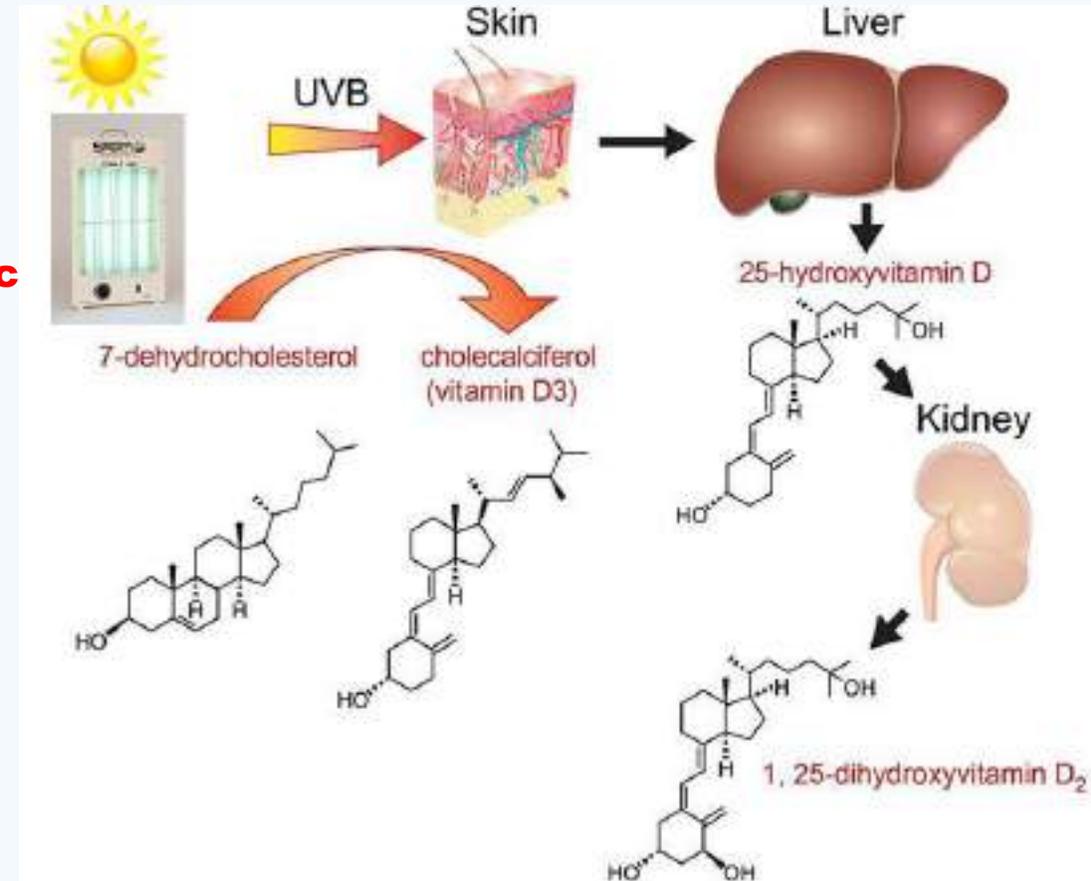
## Hydroxylation:

**Liver: D3 → 25-OH-D3 (storage form).**

**Kidneys: 25-OH-D3 → 1,25-(OH)<sub>2</sub>-D3 (active hormone).**

*Cholesterol → 7DC → Sunlight → D3 → Liver → Kidneys → Active D3.*

*Serum 25-OH-D3 reflects total vitamin D status (not 1,25-(OH)<sub>2</sub>-D3).*



# Sources of Vitamin D

**Primary Source: Sunlight (80-90% of needs)**

**Factors Affecting Synthesis:**

**Season/Latitude:** Weak UVB winter/winter months

**Sunscreen:** SPF 30 blocks 95% vitamin D production

**Skin Pigmentation:** Darker skin requires 3-6x longer exposure

**Age:** 🧓 70yo makes 25% of 20yo's vitamin D

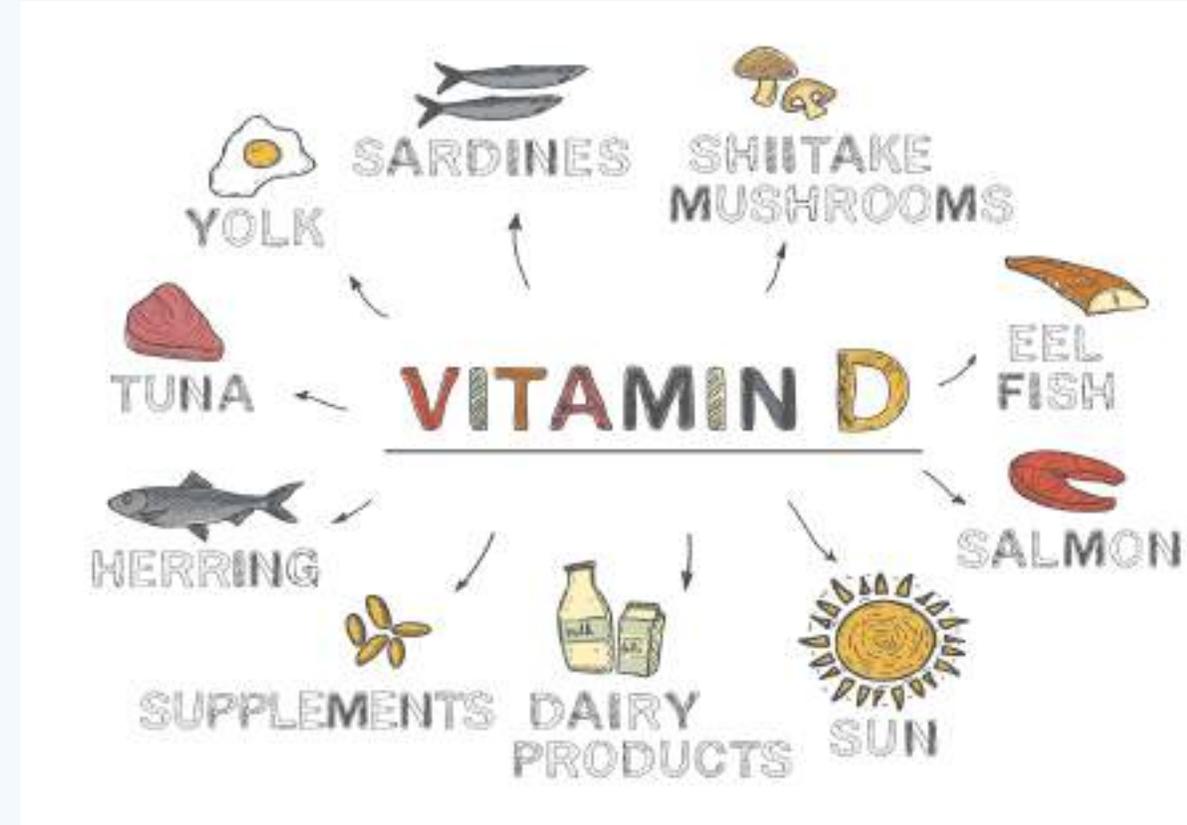
**Dietary Sources (D3):**

**Best:** Fatty fish 🐟 (salmon), cod liver oil

**Moderate:** Egg yolks

**Fortified:** Milk, plant milks

- Plants do not contain vitamin D3
- Human milk is deficient in vit. D



# FUNCTIONS

## 1. Calcium & Bone Metabolism

Gut: ↑ Absorption of dietary calcium (via calbindin protein).

Kidneys: ↓ Calcium excretion (reabsorption in renal tubules).

Bones: Maintains mineralization (prevents rickets/osteomalacia).

## 2. Cell Differentiation & Growth

Skin: Regulates keratinocyte proliferation (psoriasis treatment).

Collagen: Supports extracellular matrix integrity.

## 3. Immune System Modulation

Cell-Mediated Immunity: Activates macrophages, T-cells.

Autoimmunity: ↓ Risk of MS, RA (via cytokine regulation).

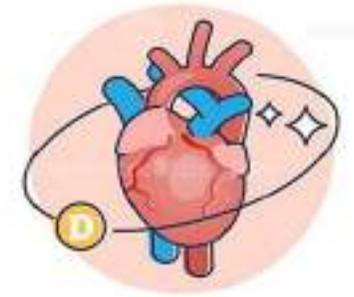
## FUNCTIONS OF VITAMIN D IN THE HUMAN BODY



CALCIUM AND PHOSPHORUS METABOLISM



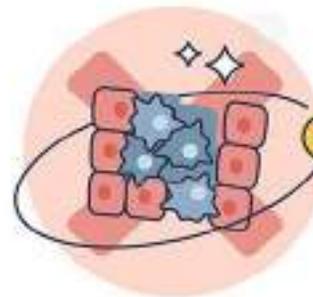
IMMUNE SYSTEM FUNCTION



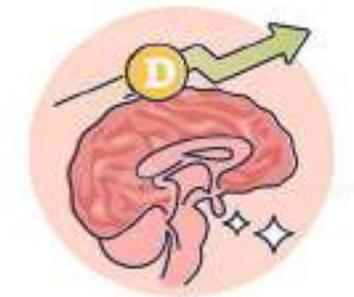
HEART HEALTH



MUSCULOSKELETAL HEALTH

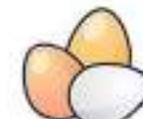


CANCER PREVENTION



COGNITIVE FUNCTION

### VITAMIN D SOURCES



LIGHT

EGGS

FORTIFIED FOODS

*50% of global population is vitamin D insufficient (serum <30 ng/mL)*

# Vitamin D Deficiency Disorders

## 1. Rickets (Children)

Failure of bone mineralization

Signs:

- Bowed legs • Rachitic rosary
- Delayed fontanelle closure • Craniotabes

## 2. Osteomalacia (Adults)

Incomplete bone matrix mineralization

Symptoms:

- Bone pain • Proximal myopathy
- Pathologic fractures

## 3. Osteoporosis Contribution

Mechanism: Secondary hyperparathyroidism → calcium leak



# Vitamin E

## Key Functions

### 1. Antioxidant:

Protects cell membranes from lipid peroxidation

Neutralizes free radicals (especially in RBCs, neurons)

### 2. Neurologic:

Maintains peripheral nerve integrity

Prevents axonal degeneration

### 3. Immune Enhancement:

Improves T-cell function

Reduces oxidative stress in macrophages)

## 2. Dietary Sources

### 🌿 Plant Oils:

Wheat germ oil, Sunflower oil,  
Nuts/Seeds: Almonds,  
Hazelnuts, Other: Spinach  
Avocado

# Vitamin E Deficiency:

Genetic : Primary deficiency = Ataxia with Vitamin E Deficiency (AVED), Autosomal recessive ( $\alpha$ -TTP gene mutation)

- Observed in low birth weight infants (*Hemolytic anemia (due to RBC fragility), Intraventricular hemorrhage (oxidant injury)*)

## AVED Patients:

**Progressive ataxia (onset age 5-15 years)**

Loss of deep tendon reflexes

**Neurologic Manifestations**

**Motor Signs:**

Limb ataxia

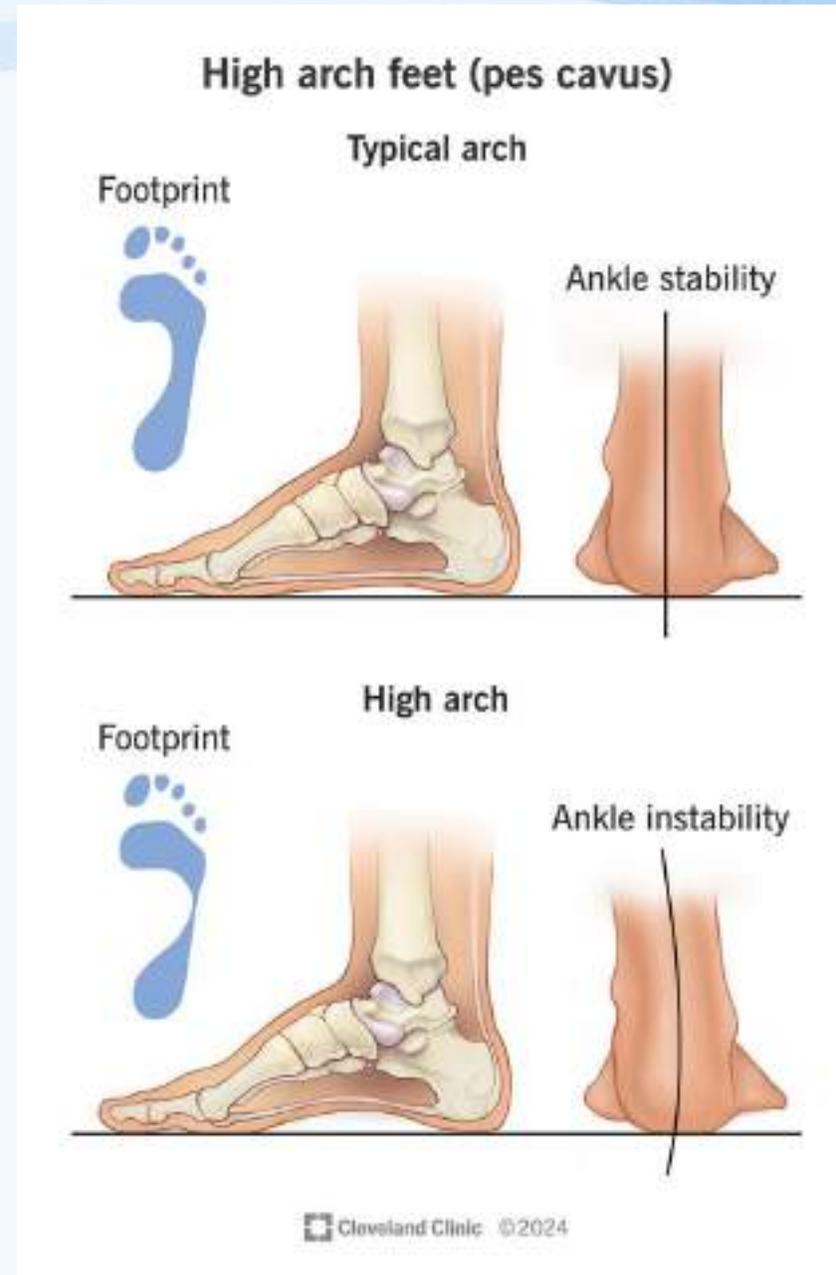
Dysarthria

Muscle weakness

**👣 Foot Deformities:**

Pes cavus (high arches)

Scoliosis (chronic imbalance)



# Vitamin K

It is a cofactor of the enzyme that catalyzes one step in the formation of prothrombin.

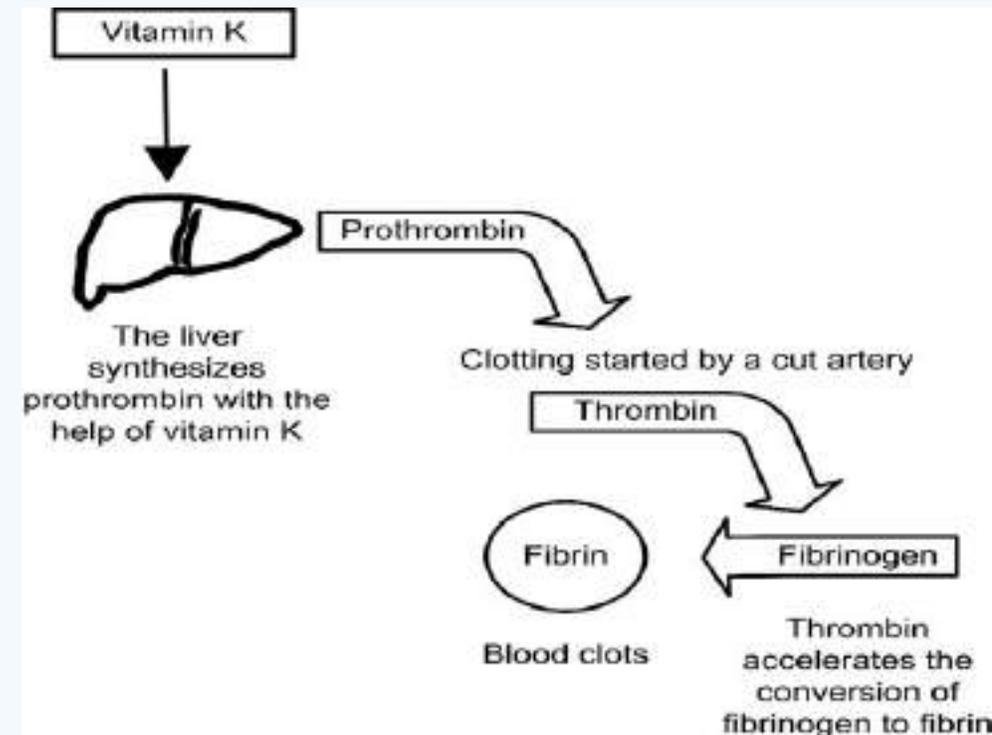
Needed for the generation of several clotting factors in the liver. (*helping wounds to heal*)

Source- green leafy vegetables.

Deficiency-coagulation defect due to hypoprothrombinemia and deficiency of factor VII resulting in hemorrhagic disease of the newborn.

1mg IM –newborn.

*In severe deficiency-2.5 to 5 mg parenterally.*



# The B Vitamins

Vitamin B1 -- Thiamine

Vitamin B2 -- Riboflavin

Vitamin B3 -- Niacin

Vitamin B5 -- Pantothenic acid

Vitamin B6 -- Pyridoxine

Vitamin B7 -- Biotin

Vitamin B9 -- Folic Acid

Vitamin B12 -- Cobalamin/  
Cyanocobalamin

# Vitamin B1

- *Active Form: Thiamine pyrophosphate (TPP)*
- *Function – Coenzyme for PDH complex (TCA cycle)*
- *ATP production from carbs/proteins*
- *Sources – meats, whole grains, legumes, tuna, soy milk*
- *RDA –1 mg/day*
- **Deficiency** – decreased ATP production – impaired cellular function – **Beriberi**



Two major types of Beriberi:

- **Wet Beriberi** which affects the **cardiovascular system** *Cardiomegaly, HF*
- **Dry Beriberi** which affects the **nervous system**. *Peripheral neuropathy, Wernicke-Korsakoff*

# Riboflavin B2

- Vitamin B2
- Biologically active forms – Flavin mononucleotide (FMN) – Flavin adenine dinucleotide (FAD)
- Function –involved in the conversion of nutrients into energy. **It is also required in the conversion of vitamin B6 to its active form, and in the conversion of tryptophan to niacin (vitamin B3).**
- Sources – Milk, mushrooms, tomatoes, liver, green leafy vegetables
- RDA – 1.1-1.3 mg/day
- Deficiency – Growth retardation – **Ariboflavinosis**
  - Glossitis (soreness of the tongue).
  - Stomatitis (Stomatitis is inflammation of the mouth and lips)

## Riboflavin deficiency



Fig. 14.1: Angular stomatitis and cheilosis from riboflavin (vitamin B<sub>2</sub>) deficiency. Note the lesions at the corners of the mouth (angular stomatitis) along with fissuring of the adjoining lips (cheilosis). Most such patients are pure vegetarians.



Fig. 14.2: Glossitis with stomatitis from riboflavin deficiency. Note the typical smooth and magenta tongue. There is also an evidence of angular stomatitis.

# Niacin B3 : Niacin

- *Active Forms: NAD<sup>+</sup>/NADP*
- Both are needed for Redox reactions (ATP production) DNA repair and cholesterol synthesis.
- Sources – *Meat, mushrooms, fortified cereals*

RDA – 14-16 NE/day (NE = niacin equivalents = 1 mg niacin or 60 mg tryptophan)

- Deficiency – Pellagra = “rough skin”

Pellagra is characterized by “the 3 Ds”: dementia, diarrhea, and dermatitis.

*Casal necklace (collar)*



# Pyridoxine B6

- **Active Form:** PLP pyridoxal phosphate

Function – *Coenzyme for transamination reactions – AA metabolism (neurotransmitters), Heme synthesis*

- **Sources:** Bananas, chickpeas, liver

- RDA – 1.3-1.7 mg

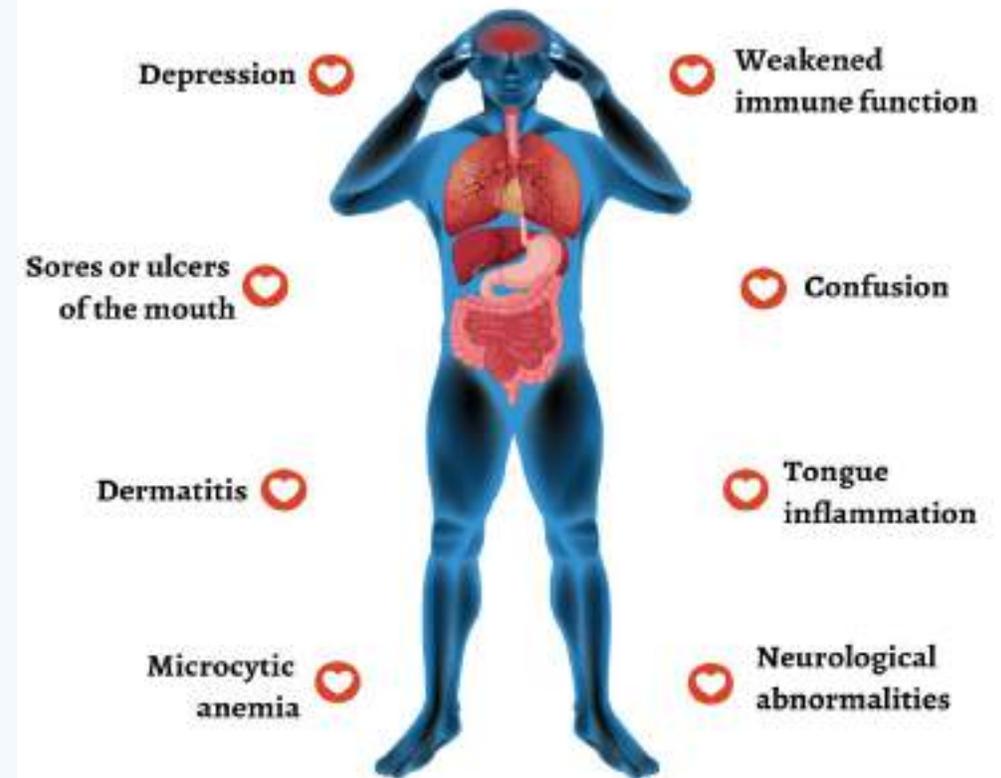
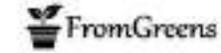
- **Deficiency** – Induced by TB drug isoniazid (supplement should be given)

Pyridoxine deficiency is commonly associated with other B vitamin deficiencies, such as folic acid and vitamin B12, and is rare in isolation.

- **Microcytic hypochromic anemia**

Deficiency of active pyridoxine is found in chronic alcohol dependence, chronic renal failure or autoimmune disorders, obesity, pregnancy, preeclampsia, eclampsia, and malabsorptive states such as celiac disease, inflammatory bowel disease, and bariatric surgery.

## VITAMIN B6 DEFICIENCY SYMPTOMS



Evidence based content

# Biotin B7

- *Role: Lysine-bound cofactor*
- *Function – Carboxylation reactions (e.g., acetyl-CoA → malonyl-CoA)*
- *Sources – Eggs, nuts, gut microbiota **Also synthesized by intestinal bacteria***
- *RDA – At least 30 mg/day*
- *Deficiency – **Rare** except in high-risk populations, such as those who experience biotinides deficiency, **alcoholism**, chronic use of **epileptic medications**, **and pregnant or breastfeeding women.***

Biotin deficiency is associated with hair thinning, a scaly rash around the eyes, nose, mouth, and perineum, nail changes, skin infections

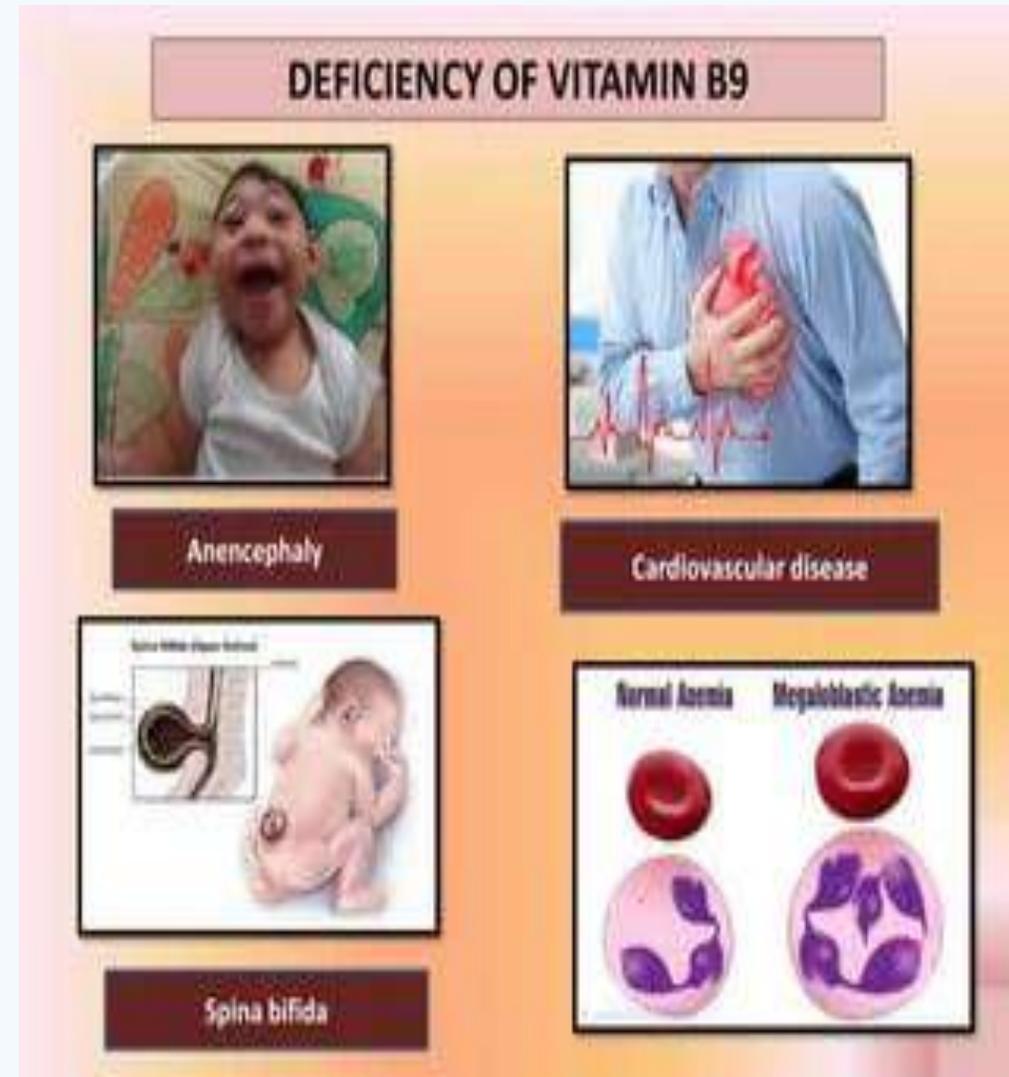
Excessive biotin levels have no known toxic effects



# Vitamin B9 (Folate)

- **Function:** nucleic acid synthesis and red blood cell production. involved in converting homocysteine to methionine, which is essential for hematopoiesis and prevention of megaloblastic anemia
- **Sources:** *Leafy greens, fortified grains*
- **Deficiency** is associated with poor diet, alcoholism, and malabsorptive disorders.
- **Folate deficiency :** **megaloblastic anemia**, characterized by large erythrocytes with abnormal nuclei. Patients may report weakness, fatigue, poor concentration, irritability, headaches, and palpitations. Deficiency can also cause oral ulcerations and changes in skin, hair, and fingernails.
- **Maternal low folate levels during pregnancy increase the chance of congenital birth defects, including fetal neural tube defects**, and congenital heart defects, in addition to low birth weight, preterm labor, and delayed fetal growth

The dosage for women of childbearing age : 400-800 µg/day pre-conception



# Vitamin B12 (Cobalamin, Cyanocobalamin, Methylcobalamin)

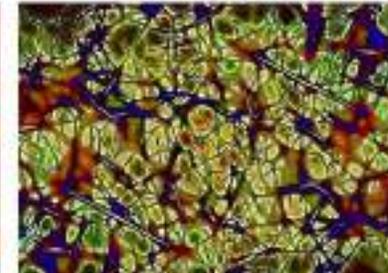
- FOOD SOURCES: Animal products only and fortified foods.
- BIOCHEMICAL FUNCTION: Gastric acid helps to release cobalamin from animal protein. Cobalamin combines with an intrinsic factor to absorb in the **distal ileum**.
- Important for **red blood cell production, neurologic function, and myelin synthesis**.
- Deficiency: **Patients using proton pump inhibitors PPIs, H2 receptor antagonists, colchicine, and metformin are more likely to have cobalamin malabsorption.**
- **Megaloblastic anemia, fatigue, low appetite, and neuropsychiatric symptoms. If not treated, neuropsychiatric illness and irreversible neurologic damage occur.**
- *Cobalamin deficiency is treated with IM injections of 1000 mcg 3 times weekly for 2 weeks followed by weekly injections for 1 month to replenish stores. Patients can then receive monthly cobalamin 1000 mcg injections or oral cobalamin 1000–2000 mcg daily for maintenance*

## Vitamin B12 is essential for

Red blood cell  
formation



Neurological  
function



DNA  
synthesis



*one third of Jordanian adults have vitamin B12 deficiency with no gender differences.*

<https://doi.org/10.1159/000355440>

# Vitamin C – Multifunctional Micronutrient

**BIOCHEMICAL FUNCTION:** One of the main Antioxidant in blood and cells • Augments functional activity of immune cells • Assists collagen, carnitine, serotonin, and adrenaline production

As a result, deficiency affects the skin, tendons, ligaments and bones.

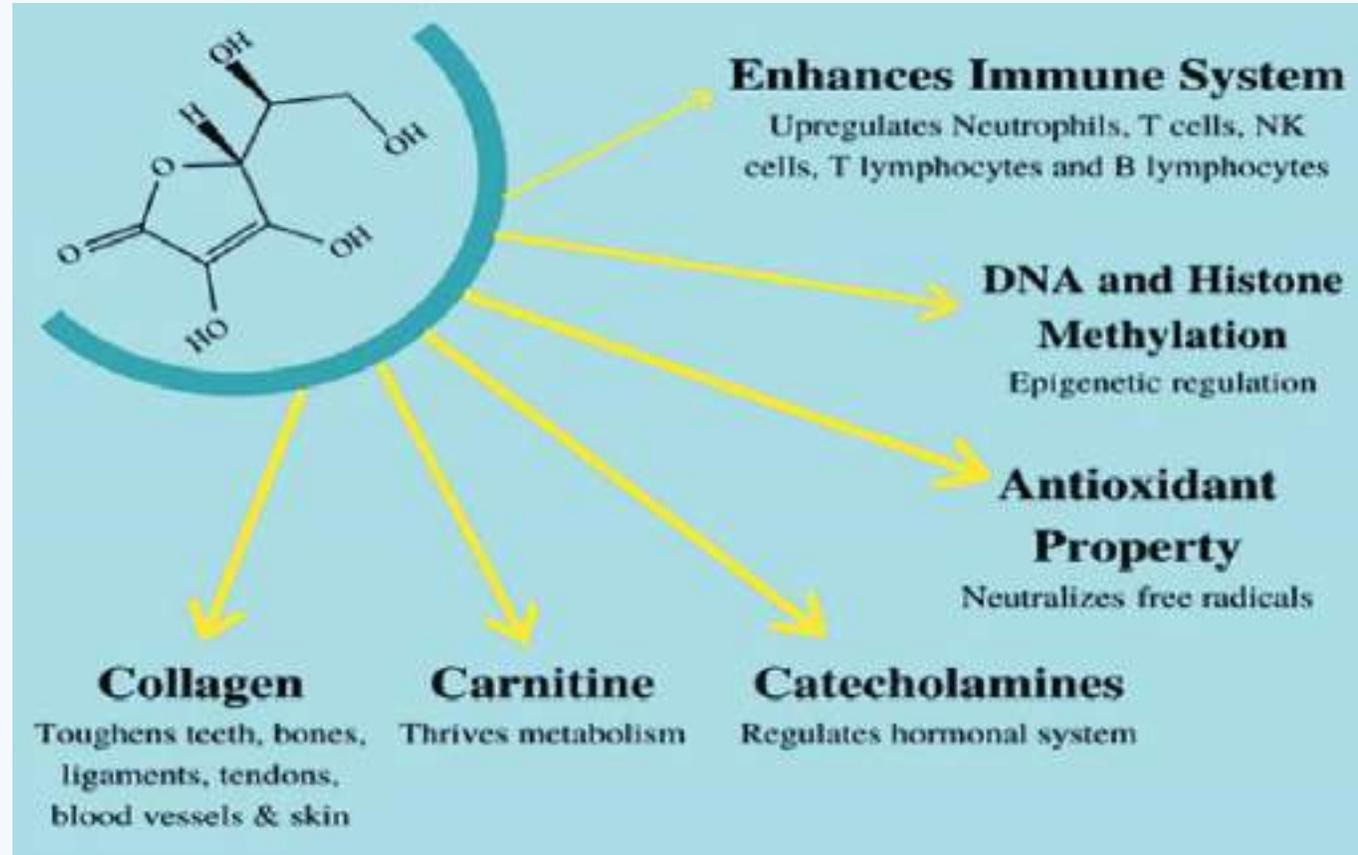
Immune function: Immune cells contain high levels of vitamin C. During an infection, its levels are quickly depleted.

The most common form is known as ascorbic acid.

Unlike the B vitamins, vitamin C doesn't act as a coenzyme,

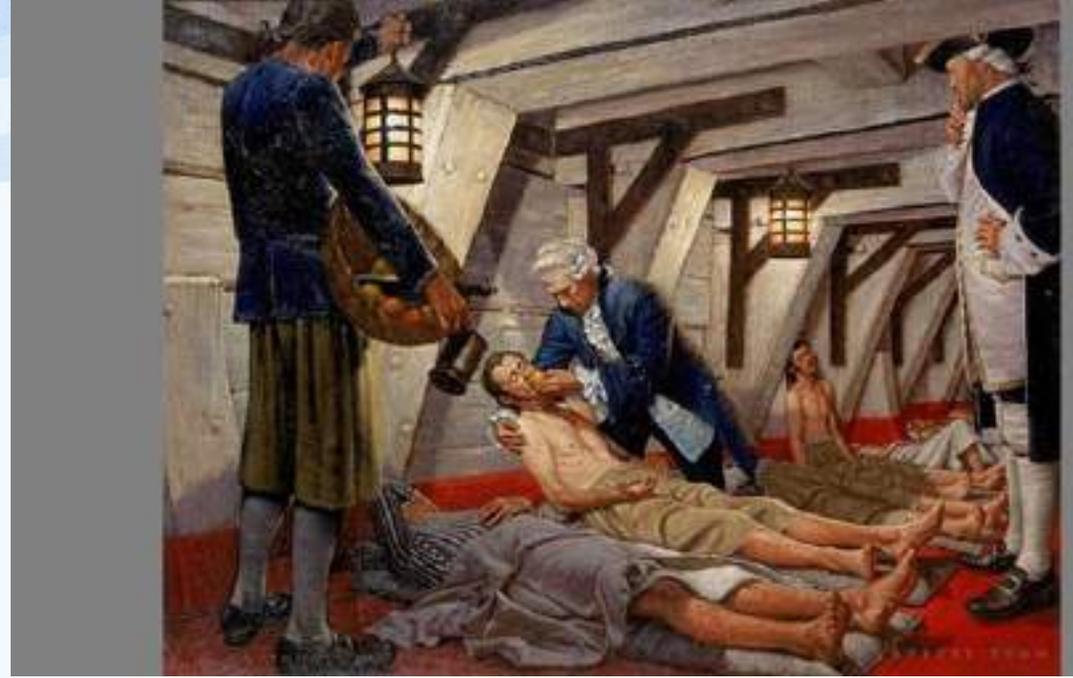
Source: Chili peppers, sweet peppers, guavas, kiwifruits, strawberries, oranges, kale, spinach, broccoli, grapefruit, potatoes, tomatoes

Supplement: Men: 90 mg (125 mg\*) Women: 75 mg (110 mg\*) \* Smokers



# Vitamin C deficiency

- **SCURVY : Rare nowadays especially severe forms.**
- *Characterized by the breakdown of connective tissue.*
- **Deficiency is usually a result of:**
  - **low consumption of fresh fruits and vegetables**
  - **Displaced populations who rely on cooked, fortified rations and who do not have access to fresh fruits and vegetables are at a high risk for deficiency. Outbreaks have been repeatedly reported from refugee camps.**
  - **Chronic alcoholics, institutionalized elderly**
  - **vitamin C is low in cow's milk, infants can be at high risk for vitamin C deficiency.**



## Vitamin C Deficiency

Deficiency disease: **Scurvy**

Deficiency symptoms:

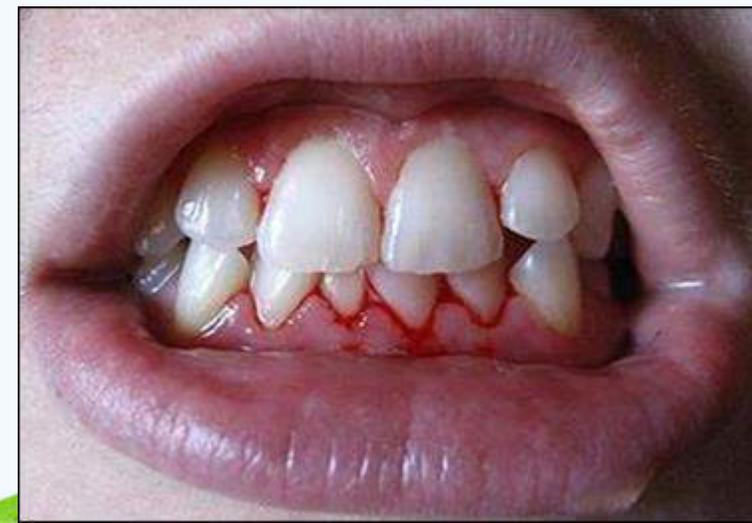
- **S**kin discoloration & bruising
- **H**emorrhaging
- **A**naemia
- **D**ental issues
- **E**xhaustion / fatigue
- **S**welling of joints (edema)

Mnemonic: **SHADES**





Perifollicular  
haemorrhage  
AND corkscrew  
hair





THANK YOU