

# VITAMIN C

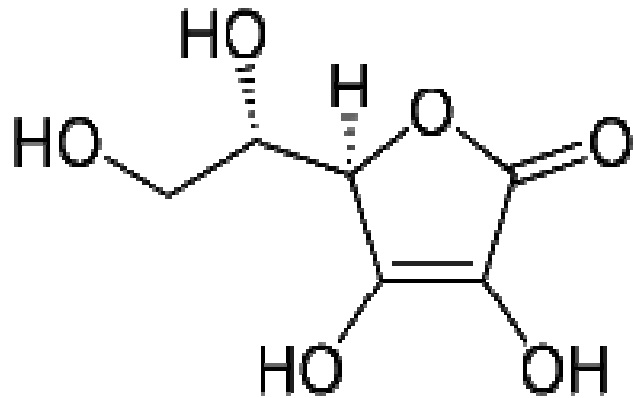


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# Vitamin C

- Vitamin C -**known as ascorbic acid** - is a water-soluble vitamin.
- Unlike most mammals, humans do not have the ability to make their own vitamin C. Therefore, we must obtain vitamin C through our diet.
- **Fun fact:** "**ascorbic acid**" comes from the New Latin "**scorbutus**" meaning **scurvy!**

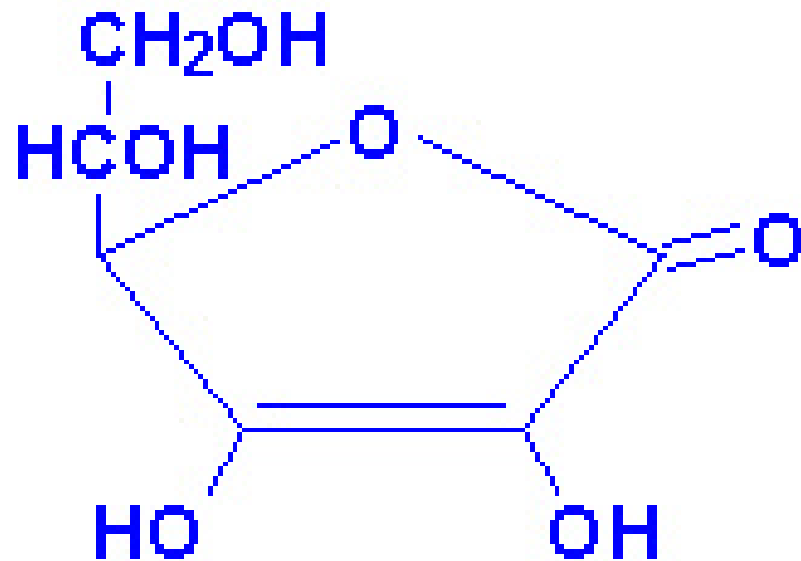


**FIGURE 1** Chemical structure of ascorbic acid.



# Vitamin C - Ascorbic Acid

- Structure
- Metabolism
  - oxidation/reduction
  - dehydroascorbic acid
  - dehydroascorbate reductase
  - glutathione (GSH)
    - glutamate-cysteine-glycine



# Functions of Vitamin C

- **Enhances absorption of iron**
- reduces iron to more absorbable ferrous form
- chelates with ferrous ion to make it more soluble

# Functions of Vitamin C

- **Hydroxylation of proline and lysine**
- post-translational reaction of procollagen
- hydroxylated collagen can be cross-linked to triple helix collagen
- Scurvy - weak collagen

# Functions of Vitamin C

- **Hydroxylation Reactions**
- Involves O<sub>2</sub> and metal coenzyme
  - (ferrous, cuprous)
- Carnitine synthesis
- Tyrosine synthesis & catabolism

# Functions of Vitamin C

- **Hydroxylation Reactions**
- **Synthesis of Neurotransmitters**
  - Dopamine
  - Norepinephrine
  - Serotonin
- **Bile acid synthesis**

# Functions of Vitamin C

- **Antioxidant Activity**
- Reacts and removes active oxygen species
- **Pro-oxidant Activity**
- Reduces metals to their pro-oxidant forms



# Functions

- Synthesis of collagen, an important structural component of blood vessels, scar tissues, tendons, ligaments, and bone.
- Synthesis of the neurotransmitters, **norepinephrine** critical to brain function and are known to affect mood.
- Highly effective antioxidant protects proteins, lipids (fats), carbohydrates, and nucleic acid (DNA and RNA) from damage by free radicals.
- Regenerates other antioxidants such as vitamin E.
- vitamin C is required for the synthesis of carnitine, a small molecule that is essential for the transport of fat to mitochondria, for conversion to energy.



# Sources <sup>[4]</sup>

<b>Food</b>	<b>Serving</b>	<b>(Vitamin C (mg</b>
<b>Orange juice</b>	<b>¾ cup (6 ounces)</b>	<b>75</b>
<b>Grapefruit juice</b>	<b>¾ cup (6 ounces)</b>	<b>60</b>
<b>Orange</b>	<b>1 medium</b>	<b>70</b>
<b>Grapefruit</b>	<b>½ medium</b>	<b>44</b>
<b>Strawberries</b>	<b>1 cup, whole</b>	<b>82</b>
<b>Tomato</b>	<b>1 medium</b>	<b>23</b>
<b>Sweet red pepper</b>	<b>½ cup, raw chopped</b>	<b>141</b>
<b>Broccoli</b>	<b>½ cup, cooked</b>	<b>58</b>
<b>Potato</b>	<b>1 medium, baked</b>	<b>26</b>

# RDA for Vitamin C

- 10 mg/day prevents scurvy
- historic RDA's 45-70 mg (60mg in 1989), 75mg in 2000
- prevention of scurvy vs antioxidant effect with supplements?

# Vitamin C Deficiency

- Disease result from severe vitamin C deficiency

## Scurvy

Cardiovascular Disease

*Stroke*

Cataracts

Lead toxicity



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# Scurvy

- Bleeding gums
- petechiae
- easy bruising
- impaired wound healing and bone repair
- joint pain
- anemia

# Scurvy

- It has been known for many centuries as the potentially fatal disease.
- By the late 1700's the British navy was aware that scurvy could be cured by eating oranges or lemons, even though vitamin C would not be isolated until the early 1930's.



# History of Vitamin C



- 17<sup>th</sup> century – sailors got scurvy on ships and ship surgeon, James Lind, prescribed lemon juice as preventative. Performed an experiment that proved that lemon juice prevents scurvy.
- We now know today that it is because of the Vitamin C in the lemon that prevents scurvy or a vitamin C deficiency.

# Cool Scurvy Dudes:

## Captain James Cook



**James Lind, a pioneer in  
the field of scurvy prevention**





**James Lind, a surgeon in the Royal Navy, conducted clinical tests that proved that citrus fruits and their juices would cure and prevent scurvy, the disease which killed a million seamen between 1600 and 1800. In this painting he is shown aboard HMS Salisbury in 1747. Lind published his paper, *A Treatise on the Scurvy* was published in 1751. He later became Chief Surgeon of the Royal Naval Hospital and published many more papers on how to safeguard the health of sailors.**

**Image from *A History of Medicine in Pictures*, published by Parke, Davis & Co. in 1960; Artist: Robert A.Thom**

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# People at risk of scurvy include:

- People with chronic malnutrition or those that eat less than 2 servings of fruits/vegetables per day
- Alcoholics
- Elderly
- Men who live alone (bachelor or widower scurvy)
- Children
- People on peculiar diets or food fads
- People with other medical conditions that may prevent the intake and/or absorption of vitamin C
- Dialysis patients
- Malabsorption disorders
- Severe dyspepsia



# Diagnosis

The diagnosis of scurvy is primarily a clinical one, based on a dietary history of inadequate vitamin C intake and the signs and symptoms described here.



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# Signs & Symptoms

- Symptoms of scurvy generally develop after at least 3 months of severe or total vitamin C deficiency, they includes:
- Weakness & fatigue
- Bruising easily & bleeding from weakening blood vessel, connective tissue & bones due to collagen loss.
- Hair, teeth loss & gingivitis .
- Infants may be irritable, have pain when they move, and lose their appetite. Infants do not gain weight as they normally do. In infants and children, bone growth is impaired, and bleeding and anemia may occur. [1]+[2]

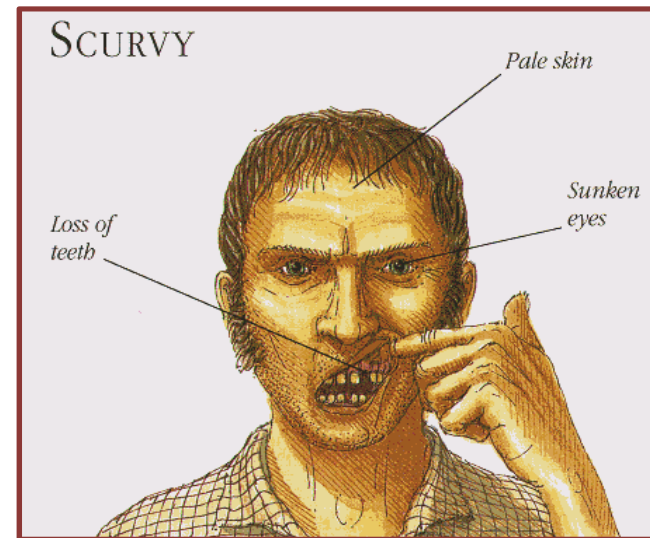


# Complications

- **Skin problems:** one of the first signs of scurvy is the development of perifollicular hyperkeratotic papules, These appear as reddish/bluish bruise-like spots surrounding hair follicles. The central hairs are twisted like corkscrews that may break easily. The papules may join together to form large areas of palpable purpura or ecchymoses (bruises).
- **Oral problems:** gums may swell and become red, soft and spongy. Any slight friction may cause the gums to bleed. Often this results in poor oral hygiene and dental diseases.
- **Musculoskeletal problems:** bleeding in the joints causes extreme discomfort and pain. Joints may be swollen and tender and the pain can be so severe that patients cannot walk.
- **Heart and lung problems:** shortness of breath, low blood pressure, and chest pain leading to shock and death. [2]



**Figure 2 : Corkscrew hair [3]**



**Figure3: Gingivitis**

# Treatment & Prevention

- Treatment is simply with vitamin C supplements taken orally.
- The adult dose is 800-1000mg/day for at least 1 week, then 400mg/day until complete recovery.
- In the U.S., the recommended dietary allowance (**RDA**) for vitamin C was recently revised upward from 60 mg daily for men and women. The RDA continues to be based primarily on the prevention of deficiency disease, rather than the prevention of chronic disease and the promotion of optimum health.
- Infants who are being weaned from breast milk to cow's milk need a supplement containing vitamin C. [5]+[2]



# Toxicity of Vitamin C

- UL adults: 2000mg/d
- Osmotic diarrhea
- Oxalate kidney stones
- Decreases uric acid reabsorption resulting in increased risk of gout
- Affects diagnostic tests in feces and gout
  - fecal blood
  - urinary glucose

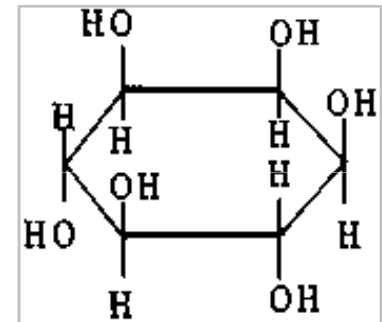


# Vitamin B-complex

Vitamin	Chemical name
<b>B<sub>1</sub></b>	<b>Thiamine</b>
<b>B<sub>2</sub></b>	<b>Riboflavin</b>
<b>B<sub>3</sub></b>	<b>Nicotinamide (niacin)</b>
<b>B<sub>4</sub></b>	<b>Adenine (no longer considered a vitamin)</b>
<b>B<sub>5</sub></b>	<b>Pantothenic acid</b>
<b>B<sub>6</sub></b>	<b>Pyridoxine</b>
<b>B<sub>7</sub></b>	<b>Biotin</b>
<b>B<sub>8</sub></b>	<b>Inositol</b>
<b>B<sub>9</sub></b>	<b>Folacin (folic acid)</b>
<b>B<sub>10</sub></b>	<b><i>p</i>-aminobenzoic acid (PABA) / H1</b>
<b>B<sub>11</sub></b>	<b>L-carnitine / <i>b</i>-hydroxy-<i>g</i>-trimethylammonium butyrate (or choline)</b>
<b>B<sub>12</sub></b>	<b>Cyanocobalamin</b>

# Inositol (Vitamin Bh)

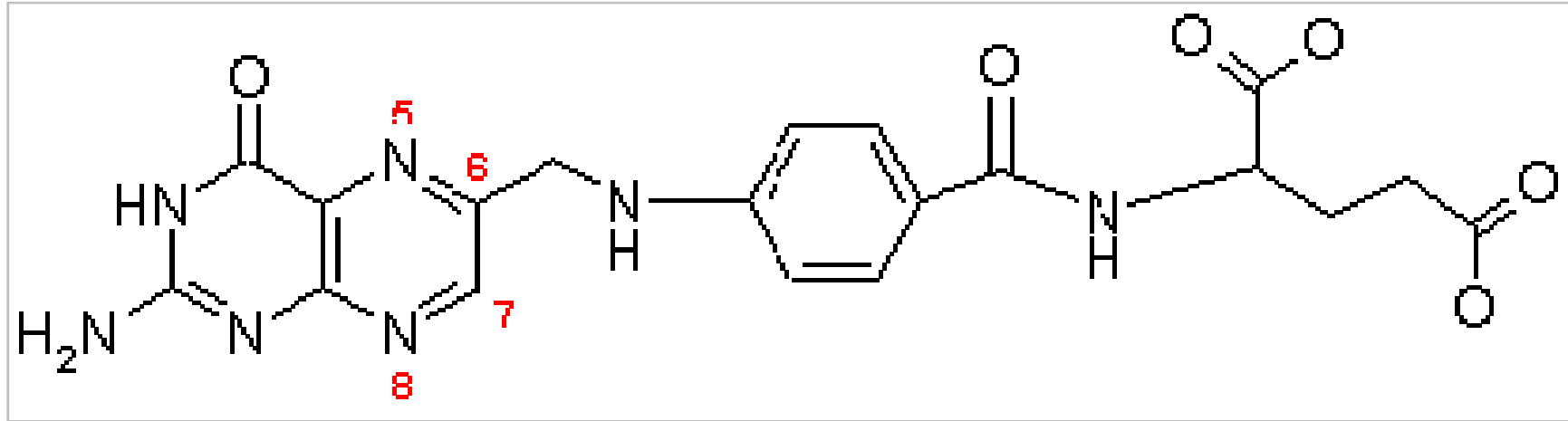
- Inositol is part of the vitamin B-complex.
- Since it is not essential in the human diet, it cannot be considered a vitamin.
- Inositol is naturally present in foods high in fiber (wheat, legumes, bran, etc).
- It is required for:
  - For proper formation of cell membranes.
  - For formation of lecithin
  - It is not a vitamin per se, but it works synergistically with many vitamins and nutrients.
    - functions closely with a B complex vitamins, Choline, folacin, Vitamins B-6 and B-12.
  - Inositol is necessary for proper function of nerves, brain, and muscles in the body.
  - This nutrient is also often used to counter depression; indeed, serotonin needs inositol for proper functioning.
  - Exists in all human cells, where it plays an important role in cell proliferation and differentiation.
- Low levels of this nutrient may result in depression and some research has shown that increased levels of Inositol appear to be a promising treatment for depression.



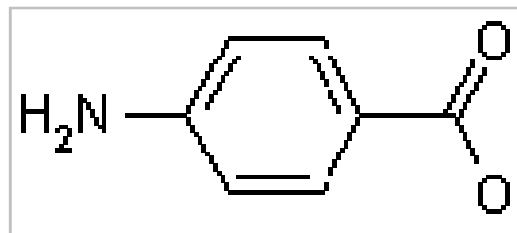
# P-amino benzoic acid ( $B_x$ )

- A substance required for the synthesis of folic acid by many organisms.
- PABA is an essential nutrient for some **bacteria** and is sometimes called **Vitamin  $B_x$** .
- **Para-aminobenzoic** acid is included in the B-vitamin complex, although it is not an essential nutrient for humans and it varies in its activity from other B vitamins.
- Although humans lack the ability to synthesize **folate** from PABA, it is sometimes marketed as an essential nutrient under the premise that it can stimulate intestinal bacteria.
- It also absorbs ultraviolet light and is used as **aminobenzoic acid**, as a topical sunscreen. Abbreviated PAB or PABA.
- The potassium salt is used as drug against fibrotic skin disorders.

# Structure



**Folic acid**



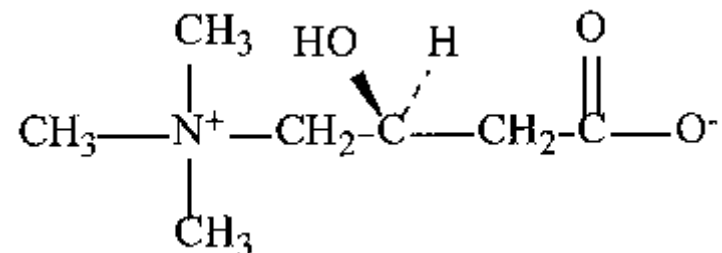
**PABA (vitamin Bx)**

# L-CARNITINE (B11)

- L-carnitine
  - Is made in the body from the amino acids **lysine** and **methionine**,
  - Is needed to release energy from **fat**.
  - It transports fatty acids into mitochondria, the powerhouses of cells.
  - In infancy, and in situations of high energy needs, such as **pregnancy** and breast-feeding, the need for L-carnitine can exceed production by the body.
- Therefore, L-carnitine is considered a "**conditionally essential**" nutrient.

# L-carnitine

- L-carnitine's actions appear to be particularly important in the heart.
- As an example, patients with **diabetes** and **high blood pressure** were given 4 grams of L-carnitine per day in a preliminary study.
- After 45 weeks, **irregular heartbeat** and abnormal heart functioning decreased significantly compared with nonsupplemented patients.



# Sources of L-carnitine

- Dairy and red meat contain the greatest amounts of carnitine. Therefore, people who have a limited intake of meat and dairy products tend to have lower L-carnitine intakes.
- Carnitine deficiencies are rare, even in strict vegetarians, because the body produces carnitine relatively easily.
- Rare genetic diseases can cause a carnitine deficiency.
- Also, deficiencies are occasionally associated with other diseases, such as diabetes and cirrhosis.
- Most people do not need carnitine supplements. For therapeutic use, typical amounts are 1–3 grams per day.