MARUDHAR KESARI JAIN COLLEGE FOR WOMEN VANIYAMBADI

PG AND RESEARCH DEPARTMENT OF BIOCHEMISTRY

E-NOTES

SUBJECT NAME: CHEMISTYY OF BIOMOLECULES

SUBJECT CODE: GBC12

UNIT-Vitamins and Porphyrins

Water soluble - thiamine, riboflavin, niacin, pyridoxine, folic acid, ascorbic acid sources,
structure, biochemical functions, deficiency diseases, daily requirements. Fat soluble - vitamin A, vitamin D2, vitamin E and vitamin K - sources, structure, biochemical functions, deficiency diseases, daily requirements. Porphyrins the porphyrin ring
system, chlorophyll, hemoglobin, myoglobin and cytochrome.

Vitamins

Vitamins are essential nutrients found in foods. They perform specific and vital functions in a variety of body systems, and are crucial for maintaining optimal health.

The two different types of vitamins are **fat-soluble vitamins** and water-soluble vitamins. Fat-soluble vitamins — vitamins A, D, E and K — dissolve in fat before they are absorbed in the bloodstream to carry out their functions. Excesses of these vitamins are stored in the liver, and are not needed every day in the diet. For more information on fat-soluble vitamins.

In contrast, water-soluble vitamins dissolve in water and are not stored by the body. Since they are eliminated in urine, we require a continuous daily supply in our diet. The water-soluble vitamins include the vitamin B-complex group and vitamin C.

Water-soluble vitamins are easily destroyed or washed out during food storage or preparation. Proper storage and preparation of food can minimize vitamin loss. To reduce vitamin loss, always refrigerate fresh produce, keep milk and grains away from strong light, and avoid boiling vegetables with the exception of soups where the broth is eaten.

Water-Soluble Vitamins

B-complex Vitamins

Eight of the water-soluble vitamins are known as the vitamin B-complex group: thiamin (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3), vitamin B6 (pyridoxine), folate (folic acid), vitamin B12, biotin and pantothenic acid. The B vitamins are widely distributed in foods, and their influence is felt in many parts of the body. They function as coenzymes that help the body obtain energy from food. The B vitamins are also important

Thiamin: Vitamin B1

What is Thiamin. Thiamin, or vitamin B1, helps to release energy from foods, promotes normal appetite, and plays a role in muscle contraction and conduction of nerve signals.

Food Sources for Thiamin. Sources include pork, legumes, fish, peas, and liver. Most commonly, thiamin is found in whole grains and fortified grain products such as cereal, and enriched products like bread, pasta, rice, and tortillas. The process of enrichment adds back nutrients that are lost when grains are processed. Among the nutrients added during the enrichment process are thiamin (B1), niacin (B3), riboflavin (B2), folate and iron.

How much Thiamin. The Recommended Dietary Allowance (RDA) for thiamin is 1.2 mg/day for adult males and 1.1 mg/day for adult females (Table 1).

Thiamin Deficiency. Under-consumption of thiamin is rare in the United States due to wide availability of enriched grain products. However, certain groups may be at risk for thiamin deficiency including people with alcohol dependence, people with HIV/AIDS, people who have

undergone bariatric surgery, and those with low dietary intake, like older adults. Alcoholics are especially prone to thiamin deficiency because alcohol reduces thiamin absorption and storage, and excess alcohol consumption often replaces food or meals. Symptoms of thiamin deficiency include: mental confusion, muscle weakness, wasting, water retention (edema), enlarged heart, and the disease known as beriberi. Thiamin deficiency is currently not a problem in the United States.

Too much Thiamin. No problems with overconsumption are known for thiamin.

Riboflavin: Vitamin B2

What is Riboflavin. Riboflavin, or vitamin B2, helps to release energy from foods, and is also important for the growth, development and function of the cells in the body. It also helps to convert the amino acid tryptophan (which makes up protein) into niacin.

Food Sources for Riboflavin. Sources include eggs, organ meats (liver and kidney), dark green vegetables, milk, and whole and enriched grain products. Ultraviolet light is known to destroy riboflavin, which is why most milk is packaged in opaque containers instead of clear.

How much Riboflavin. The Recommended Dietary Allowance (RDA) for riboflavin is 1.3 mg/day for adult males and 1.1 mg/day for adult females (Table 1).

Riboflavin Deficiency. Under consumption of riboflavin is extremely rare in the United States. Groups at risk of riboflavin inadequacy include vegan athletes and pregnant and breastfeeding women and their babies. Symptoms of deficiency include skin disorders, cracks at the corners of the mouth, hair loss, itchy and red eyes, reproductive problems, and cataracts.

Too much Riboflavin. No problems with overconsumption are known for riboflavin.

Niacin: Vitamin B3, Nicotinamide, Nicotinic Acid.

What is Niacin. Niacin, or vitamin B3, is involved in energy production and critical cellular functions.

Food Sources for Niacin. Niacin is present in a wide variety of foods including animal and plant sources.

How much Niacin. The Recommended Dietary Allowance (RDA) for niacin is 16 mg/day for adult males and 14 mg/day for adult females (Table 1).

Niacin Deficiency. Niacin deficiency is not a problem in the United States and is mostly limited to people who eat very limited diets and diets low in protein. Pellagra is the disease state that occurs as a result of severe niacin deficiency. Symptoms include skin problems, digestive issues, and mental confusion.

Too much Niacin. Consuming large doses of niacin supplements beyond 35mg/day may cause flushed skin, rashes, hypotension symptoms, or liver damage (Table 2). Over-consumption of niacin is not a problem if it is obtained through food.

Vitamin B6: Pyridoxine, Pyridoxal, Pyridoxamine

What is Vitamin B6. Vitamin B6, otherwise known as pyridoxine, pyridoxal or pyridoxamine, aids in protein metabolism, red blood cell formation, and behaves as an antioxidant molecule. It is also involved in the body's production of chemicals such as neurotransmitters and hemoglobin.

Food Sources for Vitamin B6. Sources include legumes, organ meats, fish, meats, starchy vegetables, and whole grains and fortified cereals.

How much Vitamin B6. The Recommended Dietary Allowance (RDA) for vitamin B6 is 1.3 mg/day for adult males and females through age fifty (Table 1). The RDA for male and females over fifty years of age is 1.7 mg and 1.5 mg, respectively.

Vitamin B6 Deficiency. Vitamin B6 deficiency is uncommon and usually associated with low concentrations of other B-complex vitamins, like vitamin B12 and folic acid. Deficiency symptoms include dermatitis, swollen tongue, peripheral neuropathy, anemia, depression and confusion, and weakened immune function. A vitamin B6 deficiency in infants can cause irritability, acute hearing issues, and convulsive seizures.

Too much Vitamin B6. Over consumption from food sources have not been reported to cause adverse health effects, but chronic excess doses of vitamin B6 from supplements have been known to result in nerve damage (Table 2). The Food and Nutrition Board (FNB) has established an upper limit of 100 mg/day for adults.

Folate: Folic Acid, Folacin

What is Folate. Folate, also known as folic acid or folacin, aids in protein metabolism, promoting red blood cell formation, and lowering the risk for neural tube birth defects. Folate may also play a role in controlling homocysteine levels, thus reducing the risk for coronary heart disease.

Food Sources for Folate. Sources of folate include liver, kidney, dark green vegetables, meats, legumes, fish, whole grains, and fortified grains and cereals. Check the nutrition label to see if folic acid has been added.

How much Folate. The Recommended Dietary Allowance (RDA) for folate is 400 mcg/day for adult males and females. Pregnancy will increase the RDA for folate to 600 mcg/day (Table 1).

Folate Deficiency. Folate deficiency affects cell growth and protein production, which can lead to overall impaired growth. Anemia is the primary clinical sign of folate deficiency and includes symptoms like fatigue, headache, and heart palpitations. A folate deficiency in women who are

pregnant or of child bearing age may result in the delivery of a baby with neural tube defects, such as spina bifida. (Table 1).

Too much Folate. Over consumption of folate offers no known benefits, and may mask B12 deficiency as well as interfere with some medications (Table 2). For this reason, the FNB established an upper limit for folate from supplements or fortified foods of 1000 mcg/day.

Vitamin B12: Cobalamin

What is B12. Vitamin B12, also known as cobalamin, aids in the building of genetic material, production of normal red blood cells, and maintenance of the nervous system.

Food Sources for Vitamin B12. Vitamin B12 can only be found naturally in foods of animal origin such as meats, liver, kidney, fish, eggs, milk and milk products, oysters, shellfish. Some fortified foods, like breakfast cereals and nutritional yeast may also contain vitamin B12.

How much Vitamin B12. The Recommended Dietary Allowance (RDA) for vitamin B12 is 2.4 mcg/day for adult males and females (Table 1). Many adults over the age of fifty do not get enough vitamin B12, the dietary guidelines recommend consuming foods fortified with vitamin B12, such as fortified cereals.

Vitamin B12 Deficiency. Vitamin B12 deficiency most commonly affects vegans, infants of vegan mothers, and the elderly. Symptoms of deficiency include anemia and neurological changes, such as numbness and tingling in the hands and feet. In order to prevent vitamin B12 deficiency, a dietary supplement should be taken. Some people develop a B12 deficiency because they cannot absorb the vitamin through their stomach lining. This can be treated through vitamin B12 injections.

Too much Vitamin B12. No problems with overconsumption of vitamin B12 are known.

Biotin

What is Biotin. Biotin helps release energy from carbohydrates and aids in the metabolism of fats, proteins and carbohydrates from food.

Food Sources for Biotin. Sources of Biotin include liver, kidney, egg yolk, milk, most fresh vegetables, yeast breads and cereals.

How much Biotin. The Adequate Intake (AI) for Biotin is 30 mcg/day for adult males and females (Table 1).

Biotin Deficiency. Biotin deficiency is uncommon. A few of the symptoms of biotin deficiency include hair loss, skin rashes, and brittle nails, and for this reason biotin supplements are often promoted for hair, skin, and nail health. However, these claims are only a few case reports and small studies.

Too much Biotin. No problems with overconsumption are known for Biotin.

Pantothenic Acid: Vitamin B5

What is Pantothenic Acid. Pantothenic Acid, also known as vitamin B5, is involved in energy production, and aids in the formation of hormones and the metabolism of fats, proteins, and carbohydrates from food.

Food Sources for Pantothenic Acid. Almost all plant- and animal- based foods contain pantothenic acid in varying amounts. Richest dietary sources include fortified breakfast cereals, liver, kidney, meats, and seeds.

How much Pantothenic Acid. The Adequate Intake (AI) for Pantothenic Acid is 5 mg/day for both adult males and females (Table 1). Pregnancy will increase the AI for Pantothenic Acid to 6mg /day (Table 1).

Pantothenic Acid Deficiency. Pantothenic Acid deficiency is uncommon due to its wide availability in most foods.

Too much Pantothenic Acid. No problems with overconsumption are known for Pantothenic Acid. Rarely, diarrhea and gastrointestinal distress will occur with excessive amounts.

Vitamin C: Ascorbic Acid, Ascorbate

What is Vitamin C

The body needs vitamin C, also known as ascorbic acid or ascorbate, to remain in proper working condition. Vitamin C benefits the body by holding cells together through collagen synthesis; collagen is a connective tissue that holds muscles, bones, and other tissues together. Vitamin C also aids in wound healing, bone and tooth formation, strengthening blood vessel walls, improving immune system function, increasing absorption and utilization of iron, and acting as an antioxidant.

Vitamin C works with vitamin E as an antioxidant, and plays a crucial role in neutralizing free radicals throughout the body. Through its antioxidant activity, studies suggest vitamin C may help prevent or delay the development of certain cancers, heart disease, and other diseases in which oxidative stress plays a causal role. Research continues to document the degree of these effects.

Food Sources for Vitamin C. Many fruits and vegetables contain vitamin C, the best sources are citrus fruits, peppers, kiwi, strawberries, and broccoli. For example, one orange, one kiwi, 6 oz. (3/4 cup) of grapefruit juice, or 1/3 cup of chopped sweet red pepper each supply enough vitamin C for one day.

How much Vitamin C. The Recommended Dietary Allowance (RDA) for Vitamin C is 90 mg/day for adult males and 75 mg/day for adult females (Table 1). For those who smoke

cigarettes, the RDA for vitamin C increases by 35 mg/day, in order to counteract the oxidative effects of nicotine. Vitamin C recommendations also increase during pregnancy and lactation, see Table 1.

Vitamin C Deficiency. Although rare in the United States, severe vitamin C deficiency may result in the disease known as scurvy, causing fatigue and a loss of collagen strength throughout the body. Loss of collagen results in loose teeth, bleeding and swollen gums, and improper wound healing.

The following conditions have been shown to increase vitamin C requirements (Table 1):

- Environmental stress, such as air and noise pollution
- Tissue healing of wounds
- Growth (children from 0- 12 months, and pregnant women)
- Fever and infection
- Smoking

Too Much Vitamin C. Despite being a water-soluble vitamin that the body excretes when in excess, vitamin C overdoses an increase the risk of adverse health effects, like kidney stones, diarrhea, rebound scurvy, and increased oxidative damage. For this reason, the FNB has established an upper limit of 2000 mg/ day.

Can Vitamin C Prevent/Treat the Common Cold?

The controversy over using mega doses of vitamin C to prevent or treat the common cold and other infections remains a popular topic. Vitamin C appears to have the ability to enhance various immune cell functions, however, the precise dose and ideal timing of vitamin C intake has not been fully elucidated. Overall, the evidence suggests that adequate dietary vitamin C intake and possibly higher intake at plasma saturating levels (100-200 mg/day) may help prevent the common cold by optimizing cell and tissue levels. Regular intake at doses of 200- 1000 mg/day may be especially helpful in reducing cold incidence in people exposed to extreme physical exercise or cold environment and those with marginal vitamin C status, such as the elderly and chronic smokers. Among the general population, vitamin C intake at doses of 200 mg/day or more is moderately effective in improving the severity and duration of the common cold. In terms of treatment of established infections, some evidence indicates significantly higher doses (grams) may be beneficial in the recovery process by ameliorating the decline in leukocyte vitamin C levels; however, further research still needs to address safety concerns. Furthermore, this effect appears to have the most benefit on those with very low vitamin C levels.

Summary

- Water-soluble vitamins include the vitamin B-complex and vitamin C, and are essential nutrients needed daily by the body in very small quantities.

- The B-complex vitamins can be found in a variety of enriched foods like cereal grains and breads, as well as other foods such as meat, poultry, eggs, fish milk, legumes, and fresh vegetables. Vitamin C can be found in a many fruits and vegetables.
- Overall, in the United States deficiency is rare for B vitamins and vitamin C; with exceptions for alcoholics, those on very limited diets, and the elderly.
- Special attention should be paid to folate (folic acid) intake during pregnancy, in order to avoid birth defects.
- Vegans should be conscious of vitamin B12 intake because it is not present in plant foods.
- Some conditions warrant an increase in vitamin C intake, such as exposure to cigarette smoke, environmental stress, growth, and sickness.
- Over consumption of the water-soluble vitamins is generally not a problem in the United States, especially if the nutrients are obtained through food.
- Large amounts of vitamin B-complex and vitamin C supplements and multivitamins are not recommended.

Table 1. Recommended Dietary Intake (RDA) and Adequate Intake (AI) for Water-Soluble Vitamins

Life Stage Group	Thiamin B1 (mg/d)	Riboflavin B2 (mg/d)	Niacin B3[1] (mg/d)	Vitamin B6 (mg/d)	Folate (mcg/d)	Vitamin B12 (mcg/d)	Biotin (mcg/d)	Pantothenic Acid (mg/d)	Vitamin C (mg)
Infants[2]									
0 – 6mo	0.2*	0.3*	2*	0.1*	65*	0.4*	5*	1.7*	40*
7mo – 12mo	0.3*	0.4*	4*	0.3*	80*	0.5*	6*	1.8*	50*
Children (Boys and Girls)									
1 – 3y	0.5	0.5	6	0.5	150	0.9	8*	2*	15
4 – 8y	0.6	0.6	8	0.6	200	1.2	12*	3*	25
9 – 13y	0.9	0.9	12	1.0	300	1.8	20*	4*	45
Males									
14 – 18y	1.2	1.3	16	1.3	400	2.4	25*	5*	75
19 – 50y	1.2	1.3	16	1.3	400	2.4	30*	5*	90
51 +yrs	1.2	1.3	16	1.7	400	2.4	30*	5*	90
Females									
14 –	1.0	1.0	14	1.2	400	2.4	25*	5*	65

18y									
19 – 50y	**1.1**	**1.1**	**14**	**1.3**	**400**	**2.4**	**30***	**5***	**75**
51 + yrs	**1.1**	**1.1**	**14**	**1.5**	**400**	**2.4**	**30***	**5***	**75**
Pregnant									
14 – 18y	**1.4**	**1.4**	**18**	**1.9**	**600**	**2.6**	**30***	**6***	**80**
19 – 50y	**1.4**	**1.4**	**18**	**1.9**	**600**	**2.6**	**30***	**6***	**85**
Lactation									
14 – 18y	**1.4**	**1.6**	**17**	**2.0**	**500**	**2.8**	**35***	**7***	**115**
19 – 50y	**1.4**	**1.6**	**17**	**2.0**	**500**	**2.8**	**35***	**7***	**120**

Table 1 is a summarization of the standards for nutrient recommendations of water-soluble vitamins: The Dietary Reference Intake (DRI). These recommendations meet the average daily nutritional needs of all healthy people. To ensure the needs of all in the population, the DRI usually exceeds the requirements for most people. They do not cover requirements for illness and special health disorders.

Fat-soluble vitamins

Fat-soluble vitamins are vitamins A, D, E, and K. They are present in foods containing fats. The body absorbs these vitamins as it does dietary fats. They do not dissolve in water.

Vitamins help the body function effectively. There are two types: water-soluble and fat-soluble vitamins. The water-soluble vitamins are vitamins B and C.

Most vitamins come from food, but sunshine contributes to vitamin D. Some people need or choose to take supplements that provide extra vitamins.

The body absorbs fat-soluble vitamins best when a person eats them with higher-fat foods.

This article looks at the types, functions, and sources of fat-soluble vitamins, and what can happen if a person has too much or too little.

Vitamin A

Carrots are a dietary source of vitamin A.

Vitamin A helps maintain healthy vision. Without vitamin A, a person could experience vision problems and possibly vision loss.

Types

Vitamin A is not a single vitamin but a collection of compounds known as retinoids. Retinoids occur naturally in the human body, and they are present in some dietary sources.

Some foods provide retinols, which the body can use directly as vitamin A. Others provide provitamin A, compounds that the body converts into vitamin A.

Function

Vitamin A supports several functions throughout the body, including:

- vision
- the immune system

Learn more here about why we need vitamin A.

Dietary sources

People can obtain vitamin A through dietary sources.

Animal sources provide preformed vitamin A, or retinols. This type is ready for the body to use.

Plant sources provide carotenoids, such as beta-carotene, which is a powerful antioxidant. The body can convert these into vitamin A.

For this reason, lists of ingredients often show vitamin A content as “vitamin A RAE.” RAE means “retinol activity equivalents.”

Animal sources of vitamin A include:

- fish liver oil
- beef liver
- cheese, milk, and other dairy products
- Sources of beta carotene include:
- sweet potato
- kale, spinach, and other green, leafy vegetables
- carrots
- cantaloupe

- black-eyed peas
- fortified breakfast cereals

Find out more here about dietary sources of vitamin A.

Recommended intake

Nutritionists measure some vitamins in two ways:

- micrograms (mcg) RAE
- international units (IU)

Food packages usually show the amounts in IU. A diet that contains 900 mcg RAE of vitamin A, which is the recommended intake for males over 14 years of age, would provide around 3,000–36,000 IU of vitamin A, according to the Office of Dietary Supplements (ODS).

Anyone who has concerns about their vitamin A intake should seek advice from a health professional, who will help them understand these measures.

The recommended intake of vitamin A varies by age and sex.

The *2015–2020 Dietary Guidelines for Americans* recommend consuming the following amounts each day. Amounts are in mcg RAE.

Age (years)	**1–3**	**4–8**	**9–13**	**14 and over**
Female	300	400	600	700
Male	300	400	600	900

Deficiency

Vitamin A deficiency is rare in the United States, but it can affect a person who:

- follows a plant-based diet
- has cystic fibrosis

A long-term deficiency can lead to a loss of night vision and possibly a total loss of vision.

Overdose

Too much vitamin A can be toxic.

It can affect:

- people who take vitamin A supplements
- those with a high intake of fish liver oil

- people who take medications that contain retinoids, such as acitretin (Soriatane), a treatment for psoriasis

During pregnancy, high levels of vitamin A can harm a growing fetus.

Symptoms of an overdose include:

- headaches
- fatigue
- nausea
- dizziness

In severe cases, coma and death can result.

Vitamin A supplements are available for purchase online. However, people should speak to a doctor before taking these or other supplements.

The time a person takes a vitamin can affect its impact. Find out more here about when to take different vitamins.

For more in-depth resources about vitamins, minerals, and supplements, visit our dedicated hub.

Vitamin D

People obtain vitamin D:

- naturally through exposure to sunlight or in the diet
- through fortified foods
- as supplements

The body obtains the compounds it needs to make vitamin D from food. It also produces vitamin D when ultraviolet (UV) light meets the skin.

Types

Vitamin D is not a single substance but a group of compounds collectively known as calciferol.

The body absorbs calciferol into the bloodstream and then converts it to calcitriol.

Two types occur naturally:

- vitamin D-3, found in animal fats
- vitamin D-2, found in plants, such as mushrooms

Function

Vitamin D has two main roles in the body:

- It maintains bone health.
- It supports the immune system.

Find out more about the health benefits of vitamin D.

Dietary sources

A person can obtain some vitamin D from the sun, but most people will also need to use other sources, too. The main alternative is food.

Dietary sources include:

- oily fish and fish oils
- fortified dairy products, plant-based milks, and cereals
- beef liver
- eggs

How can you get more vitamin D from the sun? Click here to find out.

Recommended intake

Experts measure vitamin D in international units (IU).

Current guidelines recommend that people of all ages intake of 600 IU of vitamin D daily. This is hard to measure, however, as it is not easy for a person to know how much vitamin D they obtain from sunlight.

Deficiency

A vitamin D deficiency can affect:

- older adults and children who do not spend much time out of doors
- people with darker skin
- some people with chronic health conditions
- those who live far from the Equator, where winter days are short
- those with obesity

The main effects of vitamin D deficiency include:

- osteoporosis, or loss of bone mass

- osteomalacia, when bones become soft

- rickets, when a child's bones do not develop as they should
- increased risk of infection and autoimmunity

Learn more about vitamin D deficiency.

Overdose

It is rare for a person to have too much vitamin D, but using supplements could trigger this.

Having too much vitamin D could lead to high levels of calcium in the blood.

This can lead to:

- nausea
- headaches
- low appetite and weight loss
- a buildup of calcium in tissues and blood vessels
- heart or kidney damage
- high blood pressure

Vitamin D supplements are available for purchase in pharmacies and online. A person should speak to their doctor before using these supplements, however.

Vitamin E

Vitamin E is an antioxidant that can help the body destroy free radicals. Free radicals are unstable atoms that can cause oxidative stress. Oxidative stress can lead to cell damage, and this can result in cancer and other diseases. Vitamin E may help protect the body from a range of health issues.

Types

There are eight forms of vitamin E, but only alpha-tocopherol meets humans' needs, according to the ODS.

Function

Some reasons why the body needs vitamin E are:

- as an antioxidant
- to boost the immune system
- to dilate blood vessels and help prevent clotting

Dietary sources

Good sources of vitamin E include:

- wheat germ oil
- sunflower seeds and oil
- almonds, hazelnuts, and peanuts
- spinach and broccoli
- kiwi fruit and mango

Which foods are good sources of vitamin E? Find out here.

Recommended intake

Current guidelines recommend people consume the following amounts of vitamin E. Experts measure vitamin E intake in milligrams (mg) AT, but packaging currently uses international units (IU).

Age (years)	**1–3**	**4–8**	**9–13**	**14 and over**
Female	6 mg (9IU)	7 mg (10.4 IU)	11 mg (16.4 IU)	15 mg (22.4 IU)
Male	6 mg (9IU)	7 mg (10.4 IU)	11 mg (16.4 IU)	15 mg (22.4 IU)

The ODS note that, during breastfeeding, a female should consume 19 mg (28.4 IU) each day.

Deficiency

Vitamin E deficiency is rare, but it can affect people with Crohn's disease or cystic fibrosis. These conditions affect the liver's ability to absorb vitamin E.

A deficiency can result in:

- nerve and muscle damage that affects movement and coordination
- vision problems
- a weakened immune system

As vitamin E is an antioxidant, a long-term deficiency could increase the overall risk of various diseases.

Click here to find out how to recognize a vitamin E deficiency.

Overdose

Obtaining vitamin E through natural sources is unlikely to lead to an overdose, although supplement use can increase this risk.

People who use blood-thinning medication, such as warfarin (Coumadin) should ask their doctor before taking vitamin E supplements, as these may interfere with blood clotting.

Vitamin E supplements are available for purchase in pharmacies and online.

Vitamin K

Vitamin K helps the body form blood clots. Blood clotting is essential to prevent excessive bleeding.

Types

There are several types of vitamin K.

The two most common groups are:

- Vitamin K-1 (phylloquinone), present in green, leafy vegetables and some other plant sources
- Vitamin K-2 (menaquinones), present in animal sources and fermented foods

There are also synthetic forms and other forms that the body makes.

Function

Apart from blood clotting, vitamin K may also:

- lower the risk of heart disease
- enhance bone health
- reduce the buildup of calcium in the blood

Learn more here about why we need vitamin K and where to get it.

Dietary sources

Food sources of vitamin K-1 and K-2 include:

- kale
- liver
- spinach
- parsley
- butter
- egg yolks

Learn about 40 foods that provide vitamin K.

Recommended intake

Experts do not have enough evidence to recommend a specific intake of vitamin K suitable to meet the needs of 97-98% of healthy individuals.

Instead, they recommend an adequate intake (AI), an amount assumed to provide nutritional adequacy, as follows:

Age (years)	**1–3**	**4–8**	**9–13**	**14–18**	**19 and over**
Female	30	55	60	75	90
Male	30	55	60	75	120

Deficiency

The body is not able to store as much vitamin K as it does vitamin A or D. This means a person needs a regular intake of vitamin K, and there is a higher chance of a deficiency.

A vitamin K deficiency may result in:

- excess bleeding
- lower bone density, in the long term

Learn more about a vitamin K deficiency here.

Overdose

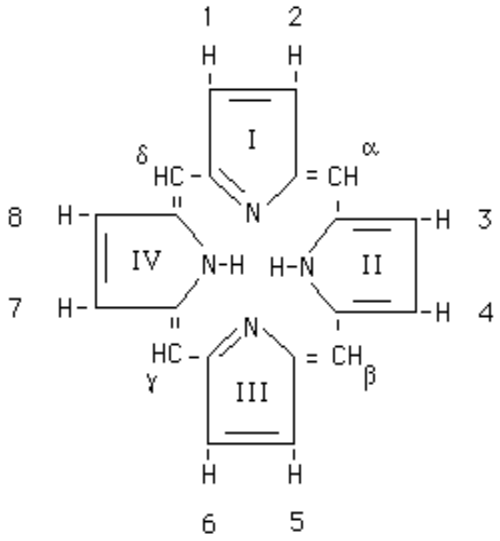
Taking high quantities of vitamin K does not appear to lead to adverse effects. However, it can interfere with the use of blood-thinning medications, such as warfarin (Coumadin).

Vitamin K supplements are available for purchase in pharmacies and online. However, people should speak to a doctor before using them, especially if they use blood thinners or have a condition that affects blood clotting.

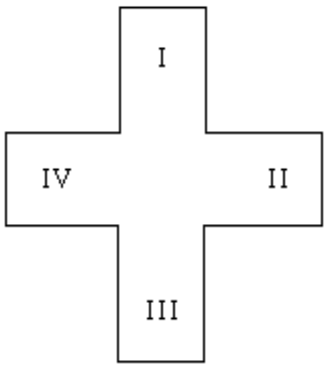
Porphyrin

Porphyrin, any of a class of water-soluble, nitrogenous biological pigments (biochromes), derivatives of which include the hemoproteins (porphyrins combined with metals and protein). Examples of hemoproteins are the green, photosynthetic chlorophylls of higher plants; the hemoglobins in the blood of many animals; the cytochromes, enzymes that occur in minute quantities in most cells and are involved in oxidative processes; and catalase, also a widely distributed enzyme that accelerates the breakdown of hydrogen peroxide.

Porphyrins have complex cyclic structures. All porphyrin compounds absorb light intensely at or close to 410 nanometres. Structurally, porphyrin consists of four pyrrole rings (five-membered closed structures containing one nitrogen and four carbon atoms) linked to each other by methine groups (—CH=). The iron atom is kept in the centre of the porphyrin ring by interaction with the four nitrogen atoms. The iron atom can combine with two other substituents; in oxyhemoglobin, one substituent is a histidine of the protein carrier, and the other is an oxygen molecule. In some heme proteins, the protein is also bound covalently to the side chains of porphyrin.



Porphin, showing the four pyrrole rings and the Roman numerals which designate them. Arabic numbers indicate positions at which substituents may be attached. Greek letters denote the methene bridges.



Schematic representation of porphin.

Properties

Porphyrins are strongly colored compounds. The variety of available colors is apparently unlimitedalthough there is an observable inclination towards red and purple. The color is a consequence of the complicated electronic spectra of porphyrins, which contain intense absorptions in the visible region (called **Q bands**). Even more intense (ten times and more) is the **Soret band** found in the near UV, so named after its discoverer (Another conspicuous characteristic of porphyrins, directly associated with their optical properties,is the **aromaticity** of the macrocycle. It is most evidently manifested in the ^{1}H NMR spectra by the downfield shifts of peripheral protons and the strongly upfield shifts of the inner NH's(usually negative on the scale).

Porphyrin aromaticity is most frequently described in terms of the **[18]annulene model**, proposed by E. Vogel. According to that model, a delocalization pathway is distinguished in the

macrocycle, as shown in Figure 4, which is aromatic in the traditional Hückel sense. The porphyrin is thus viewed as a bridged diaza[18]annulene.

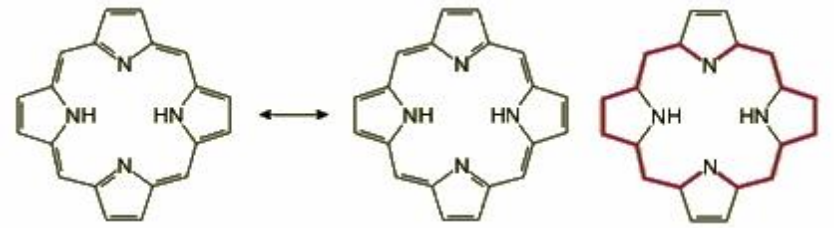


Fig. 4. Delocalization pathway in porphyrin according to Vogel's [18]annulene model.

Porphyrins are weak bases and can be protonated to form dications. In the unprotonated porphyrin (called *free base*) the two inner protons are mobile and jump freely among the four nitrogens. The *trans* (21,23-H) tautomer, shown in all schemes, is energetically preferred to the *cis* form (21,22-H).

Porphyrins form a great number of complexes with metal ions and some nonmetals (Figure 5).The coordinating environment provided by porphyrins is very flexible and can be fine-tuned to particular oxidation and spin states by varying peripheral substitution and axial ligands. This tunability was probably Nature's reason to choose porphyrin as its "workhorse macrocycle."

Of the naturally ocurring metalloporphyrins the iron complexes, called *hemes*, are by far the most important. They make the reactive centers of numerous heme proteins, responsible for oxygen transport and storage (hemo- and myoglobin), electron transfer (cytochromes), and oxidation of organic substrates (oxygenases of the P450 family).