

Vitamins

Organic compounds that:

- Are essential
- Naturally occur in food
- Deficiency occurs when the vitamin is missing from diet
- Good health is *restored*, if deficiency disorder is treated early
- Needed in **very** small amounts
 - mg = 1/1000 of a gram
 - mcg = 1/1,000,000 of a gram

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Vitamins

- Some have more than 1 form
 - Vitamin A = retinol, retinal, retinoic acid
- **Provitamins** = vitamin precursors that do not function until converted
 - Beta-carotene (plant pigment) precursor to vitamin A
 - Tryptophan (amino acid) precursor to B-vitamin niacin

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- **Enrichment**
 - Addition of thiamin, riboflavin, niacin, folic acid, and iron to refined flour and milled grains
- **Fortification**
 - Addition of one or more nutrients to processed foods

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The Vitamins



Vitamins fall into two classes—fat soluble and water soluble.

Fat Soluble Vitamins

- A, D, E, K
- Absorbed with dietary fat
- Stored in liver and fat
- Toxicity more likely (especially A and D)

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Water Soluble Vitamins

- C, the 8 B vitamins, choline
- Little stored (except B12)
- Less toxic, excess is excreted
- More fragile, easily destroyed by
 - Cooking
 - Alkaline
 - Processing
 - Light

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Vitamins

Natural Sources:

Plants, animals, fungi, and bacteria

Synthetic:

Made in labs

Most natural and synthetic forms have equal activity except:

Natural vitamin E: greater activity than synthetic

Synthetic folate: greater activity than natural

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Vitamin A

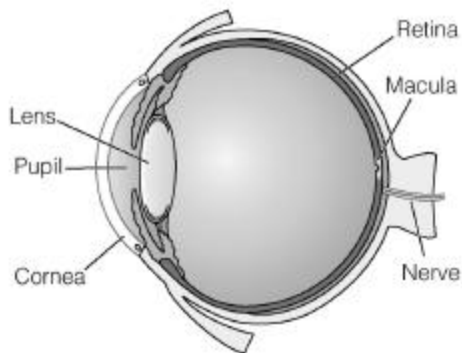
- Fat soluble
- Beta-carotene (and other carotenoids) are *provitamins*
 - Beta-carotene yields two molecules of vitamin A
- **Major functions**
 - Normal vision and reproduction
 - Cellular growth
 - Immune system function
 - Epithelial cell production and maintenance

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Functions of Vitamin A

- **Vision**
 - The retina, the light-sensitive area inside each eye, contains rods and cones which need vitamin A to function
 - Early deficiency causes night blindness
 - Later, keratin accumulates in cornea, leads to blindness
 - Xerophthalmia affects 3 to 10 million children

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An eye (sectioned).

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In dim light, you can make out the details of this room.

A flash of bright light momentarily blinds you as the pigment in the retina is bleached.

You quickly recover and can see the details again in a few seconds.

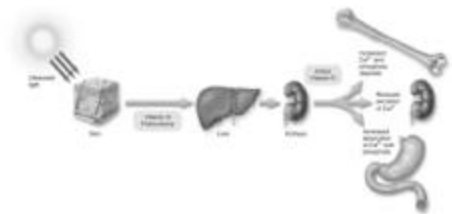
With xerophthalmia (vitamin A deficiency), you do not recover but remain blind for many minutes. This is night blindness.

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Vitamin D

- Fat soluble “sunshine vitamin”
 - When UV light hits skin, vitamin D prohormone formed



Functions of Vitamin D

- Aids calcium and phosphorus absorption
- Essential for bone development and growth
- Regulates blood calcium levels
- May have a role in cancer prevention

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Can we get enough D from sun?

- 10 to 15 minutes per day, but depends on:
 - Time of day
 - Season (less UV in winter)
 - Latitude
 - Sunscreen
 - Clothing
 - Indoor living
 - Skin color
 - Pollution, smog

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North of 42 degrees latitude, sunlight is too weak to synthesize vitamin D from late October through early March. The same effect occurs during the winter in the southern hemisphere south of 42 degrees latitude



At 40 degrees latitude, sunlight is too weak to synthesize vitamin D during January and February

D Deficiency

- Adults – osteomalacia
 - E.g. Arab women who cover skin
 - Soft bones
- Children – rickets
 - Little sunlight exposure
 - Bowed legs
 - “beaded” ribs

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VITAMIN D

DRUG RECOMMENDED DOSE:
 Adults: 5 µg/day (17-20 µg)
 10 µg/day (37-40 µg)
 15 µg/day (52-70 µg)

TOLERABLE UPPER INTAKE LEVEL:
 Adults: 40 µg/day

CLINICAL FUNCTIONS: Mineralization of bone and teeth; bone; blood calcium and phosphorus; increasing absorption from digestive tract; enhancing calcium homeostasis; stimulating release by kidneys.

DEFICIENCY: Abnormal bone growth resulting in rickets in children; osteomalacia in adults; weakened teeth; muscle spasms.

TOXICITY: Hypocalcemia; calcification of soft tissue; blood vessel; kidney, heart, lungs; tissue of parathyroid gland; pancreas; prostate; testis.

Three foods provide 10 percent or more of the vitamin (200 IU) in a serving: 100 g sardines (100 IU), 100 g salmon (100 IU), 100 g cod liver oil (100 IU).

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WOOD SOURCES

MILK
3.6 - 3.6 µg





SALMON
9.0 - 9.0 µg

SARDINES
9.0 - 9.0 µg

SUNLIGHT
Synthesis in the skin

Vitamin D Sources

- Sun
- Fortified milk
- Cod liver oil
- Sardines, salmon, shrimp
- Fortified cereals

Vitamin E

- Major fat-soluble antioxidant in cells
 - Protects polyunsaturated fatty acids
- Improves vitamin A absorption
- Maintains nervous system and immune function
- Alpha tocopherol (also beta, gamma, delta)

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FIGURE 7-6 FREE-RADICAL DAMAGE AND ANTIOXIDANT PROTECTION

The radical formation occurs during metabolic processes, and it accelerates when tissues suffer stress or injury.

Free radicals cause chain reactions that damage cellular structures.

• Oxygen free radical
 • Susceptible molecules

Antioxidants quench free radicals and protect cellular structures.

• Antioxidant

- A chemically reactive oxygen free radical attacks fatty acids, DNA, proteins, or cholesterol molecules, which form other free radicals in turn.
- This initiates a rapid, self-amplifying chain reaction.
- The result is oxidative injury to lipids of cell membranes and cellular proteins; damage to DNA; or oxidation of cholesterol. These changes may initiate steps leading to disease such as heart disease, cancer, muscular degeneration, and others.
- Antioxidants, such as vitamin E, stop the chain reaction by changing the nature of the free radical.

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Vitamin E

- Deficiency
 - Hemolysis, rare
 - May occur with fat malabsorption
- Toxicity
 - Low toxicity (for fat soluble vitamin)
 - Supplements interfere with anti-coagulant medications (warfarin, coumadin)

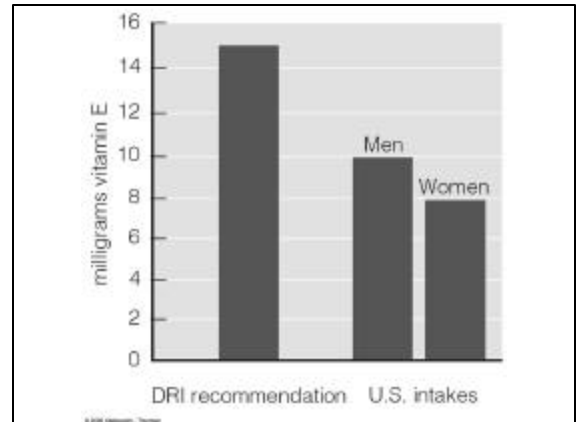
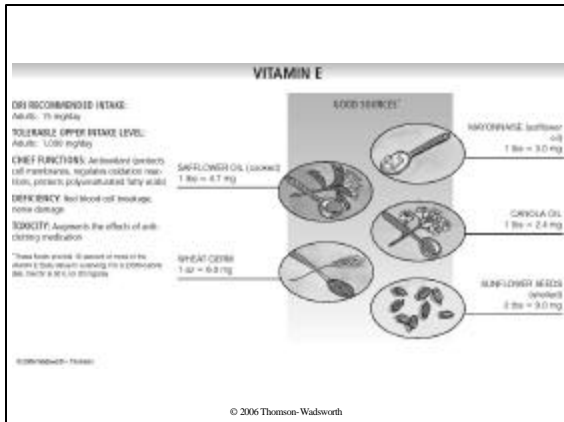
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Sources of Vitamin E

- Nuts and seeds
- Unprocessed grain products
- Wheat germ
- Oils (sunflower, safflower)
- Peanut butter

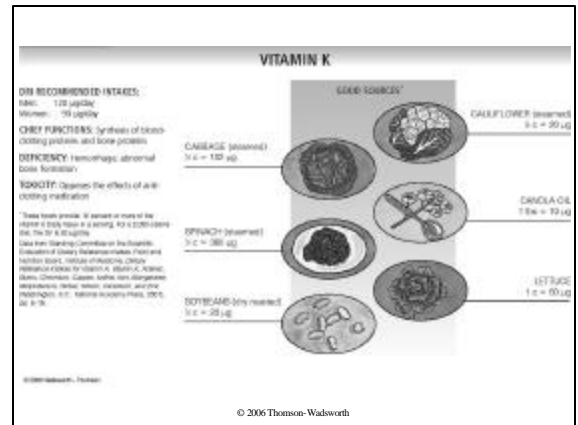
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Vitamin K



- Fat soluble
- Functions:
 - Synthesis of blood clotting proteins
 - Interferes with Warfarin, Coumadin
 - Synthesis of bone proteins

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Sources of Vitamin K


- Leafy greens
- Canola
- Soy beans, soy oil
- Intestinal bacteria

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Vitamin K

- Newborns given a dose of vitamin K to hold them until vitamin K-producing bacteria establish in the intestinal tract



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Vitamin K

- Deficiency is rare
 - “Hemorrhagic disease of the newborn”
 - Sterile intestine
- Toxicity unknown

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Water Soluble Vitamins

- C and Bs and choline
- More easily destroyed by heat and light
- Excess excreted in urine
 - Less toxic than fat soluble (except B6)
- Little stored (about 1 month supply)
 - Except B12
- Need to eat sources more often

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Vitamin C

- Water soluble
- Ascorbic acid
- Functions:
 - Collagen synthesis
 - Antioxidant
 - Immune system functioning
 - Increases iron absorption
- Higher DRI for smokers

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Vitamin C

- **Scurvy**
 - Vitamin C deficiency
 - Long sea journeys
 - Magellan lost 80% of crew in 1520
 - British sailors - “limeys”



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Scurvy

- Symptoms:
 - Breakdown of collagen, connective tissue
 - Loose teeth
 - Gum bleeding
 - Bruising
 - Anemia

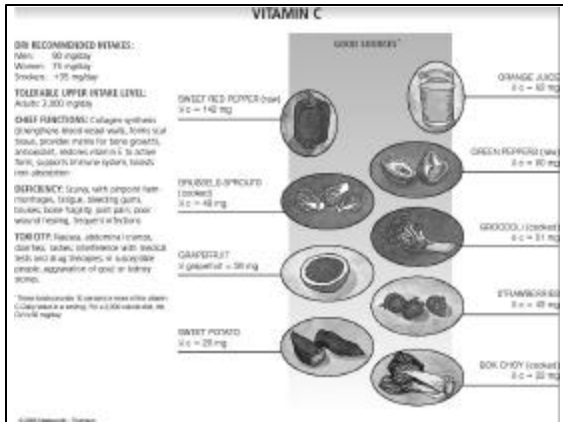


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Scurvy

- Poor diets, little fresh fruit or vegetables
 - Elderly
 - Alcoholics
 - In 2003, a collage student who lived on processed food

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Sources of Vitamin C

- Citrus fruit
- Strawberries, berries
- Potatoes
- Cabbage
- Tomatoes
- Peppers

Does C prevent colds?

- Cannot prevent colds
- May shorten length and/or decrease the severity of a cold
- Large doses (1000 mg or more) may cause nausea, diarrhea
 - Increase oxalate kidney stones

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B vitamins

- 4 B vitamins must be added to enriched grain products
 - Thiamin
 - Riboflavin
 - Niacin
 - Folate

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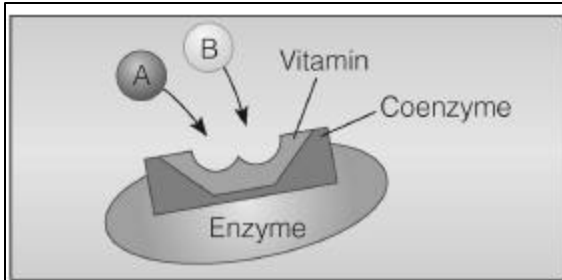
B vitamins

- Enzymes – regulate chemical reactions in the body
- Coenzymes – necessary for many enzymes to work
- B vitamins are coenzymes (especially in energy metabolism)

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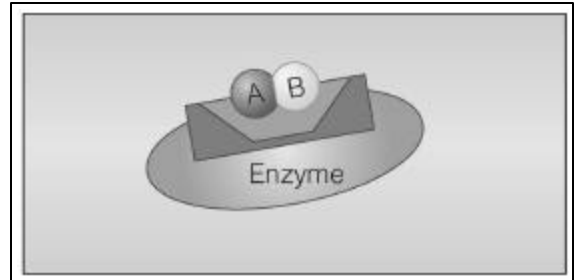
Without the coenzyme, compounds A and B don't respond to the enzyme.

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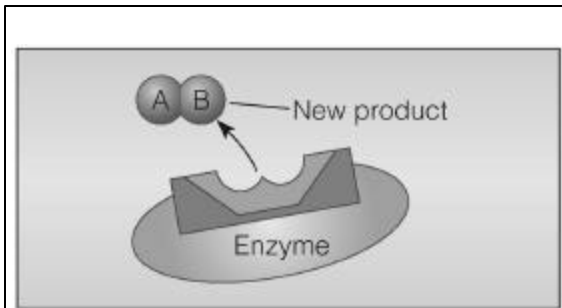
With the coenzyme in place, compounds A and B are attracted to the active site on the enzyme, and they react.

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The reaction is completed with the formation of a new product. In this case the product is AB.

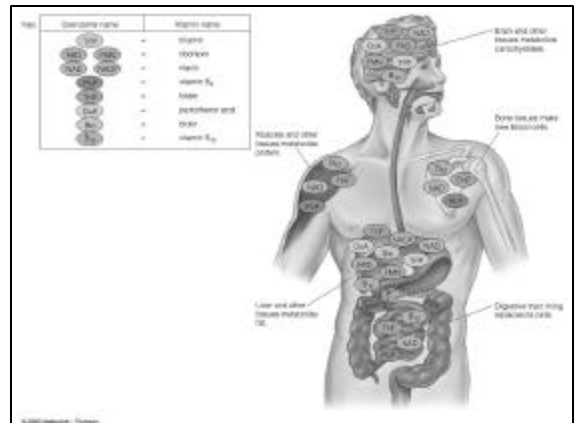
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The product AB is released.

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Thiamin (vitamin B1)

- Functions
 - Energy metabolism
 - Nerve function
- Deficiency = Beri beri
 - Symptoms: weakness, poor muscular coordination, cardiovascular problems, edema.

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Beri beri

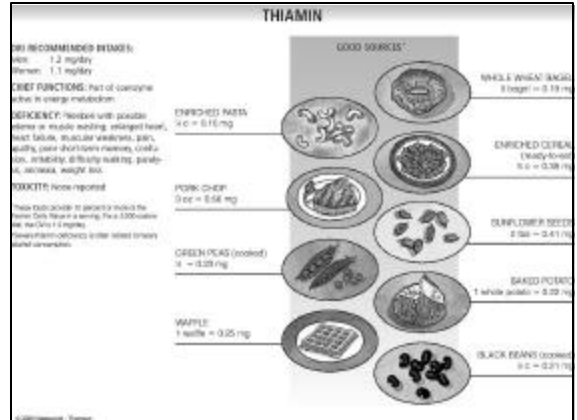
- Asia in 1800s when rice began to be refined
 - Most calories from rice
- In US, alcoholics: poor diet, alcohol decreases thiamin absorption



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Edema from wet beriberi



Sources of Thiamin



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Riboflavin

- Yellow vitamin in milk
 - Destroyed by light
- Functions: Energy metabolism
- Deficiency
 - Uncommon
 - Inflammation of tongue
 - Cracks at corners of mouth

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Niacin

- Nicotinic acid, nicotinamide
- Can be made from amino acid tryptophan
- Functions: Energy metabolism

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Niacin

- Deficiency – widespread in rural South in early 1900s
 - Diet primarily corn (low niacin, low protein)
 - **Pellagra**
 - Diarrhea
 - Dermatitis
 - Dementia
 - Death



Treating corn with lime (calcium hydroxide), as in masa or tortillas, releases bound niacin

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Sources of niacin

- Adequate protein (tryptophan) = adequate niacin
- Milk, eggs, meat, fish, nuts, whole grains, legumes



NIACIN

DRI RECOMMENDED INTAKES:

Infant – 4 mg/day*

Childhood – 12 mg/day

WOMEN'S UPPER RANGE LEVEL:

16 mg, 15 mg/day

CHILD FUNCTIONS: Part of coenzyme

needed in energy metabolism

DEFICIENCY: Pellagra, characterized by

flaky skin rash (dermatitis) when exposed

to sunlight, mental depression, apathy,

fatigue, loss of memory, headache, diar-

rhea, delirium or pain, vomiting, swollen

gums, bright red or dark tongue

SYMPTOM: painful, flaky, itchy, and rash

("black, flaky") exfoliate, swelling,

swollen gums, hair loss, impaired

gumline tolerance

*RDA: 20 mg (recommended intake for women aged

18-24 years is 12 mg; for women aged 25-50

years is 14 mg; for women aged 51-70 years

is 16 mg; for women aged 71 years and older

is 18 mg. For a 2000-calorie diet, the

DRI is 16 mg/day. For a 2500-calorie diet, the

DRI is 18 mg/day. For a 3000-calorie diet, the

DRI is 20 mg/day.

*Source: National Academies Press

GOOD SOURCES*

CHICKEN BREAST

3 oz = 8.9 mg

PORK CHOP

3 oz = 3.8 mg

BAKED POTATO

1 white potato = 3.9 mg



TUNA (in water)

3 oz = 11.2 mg

ENRICHED CEREAL

1/2 cup (1/2 oz)

3.8 = 6.6 mg

MUSHROOMS (cooked)

3/4 c = 3.2 mg

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Niacin

- Supplements can lower cholesterol
 - May cause flushing
 - Too much – liver damage

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Biotin

- Functions: Energy metabolism
- Widespread in food
 - Deficiency rare
 - Low toxicity
- Protein in **raw** eggs (avidin) binds biotin

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Vitamin B6

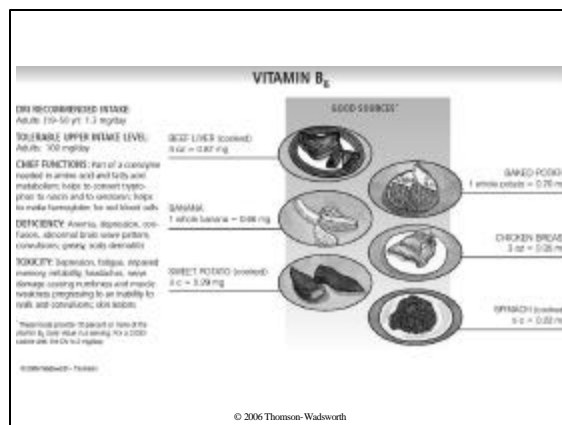
- Pyridoxine
- Most toxic of water soluble vitamins
 - Supplements
- Functions:
 - Energy metabolism, esp. protein metabolism

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Vitamin B6

- Deficiency symptoms
 - Dermatitis, anemia, convulsions, depression, and confusion
- Deficiency rare, except in alcoholics
- ? Reduces symptoms of PMS?

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Sources of B6

- Meat, poultry, fish
- Whole grains
- Nuts, seeds
- NOT refined grains, not added back
- Easily lost in food processing

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Folate

- Folic acid (synthetic, supplement form)
 - Folate, folacin (natural food form)
- Functions:
 - DNA synthesis, tissue synthesis
 - Protein metabolism

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Folate Deficiency

- Affects cells that rapidly divide, such as RBCs
 - Bone marrow releases large, immature, abnormal RBCs (megaloblasts)
- Anemia – insufficient functional red blood cells

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Folate Deficiency

- In first few weeks after conception, the neural tube forms
 - Develops into brain and spinal cord
 - Neural tube defects
 - Spina Bifida
 - Anencephaly



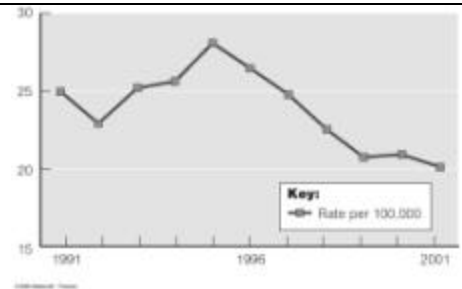
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Spina Bifida



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In 1990s, folic acid added to enriched grains in US. Neural tube defects have decreased by 25%

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FOLATE

DAILY RECOMMENDED INTAKE:
Adults: 400 µg/day

WOMEN OF REPRODUCTIVE AGE:
Pregnant: 600 µg/day
Lactating: 500 µg/day

CHIEF FUNCTIONS: part of a coenzyme needed for new cell synthesis

DEFICIENCY: anemia, smooth, red tongue, depression, mental confusion, weakness, fatigue, irritability, headache; a low intake increases the risk of neural tube birth defects

TOXICITY: masks vitamin B₁₂ deficiency symptoms

These foods provide 10 percent or more of the daily value. Daily values are based on a diet of 2,000 calories. *Other recommendations are available for children, pregnant women (600 µg), lactating women (500 µg), and men (400 µg). †U.S. Food and Drug Administration. ‡U.S. Department of Health and Human Services.

| FOOD SOURCE | AMOUNT | % DAILY VALUE |
|----------------------------------|---------------|---------------|
| BEET LISTS (cooked) | 3 oz = 207 µg | 52% |
| LENTILS (cooked) | 3 oz = 179 µg | 45% |
| SPINACH (raw) | 1 oz = 95 µg | 24% |
| ENRICHED CORNMEAL (ready-to-eat) | 3 oz = 82 µg | 21% |
| BEETS | 3 oz = 80 µg | 20% |
| ASPARAGUS | 3 oz = 57 µg | 14% |
| PEAS (cooked) | 3 oz = 18 µg | 5% |
| AVOCADO | 3 oz = 45 µg | 11% |

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Sources of Folate

- “Foliage” – leafy greens, fruits and vegetables, oranges, legumes, enriched grain products



Folate / Folic Acid

- DRI 400 mcg/day for adults
 - Women of childbearing age 400 mcg synthetic folic acid (better absorbed) plus food folate
- Folate toxicity
 - Too much can mask a vitamin B12 deficiency

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Vitamin B12

- Cobalamin
- Functions:
 - Part of coenzymes for:
 - Folate metabolism
 - Maintenance of *myelin sheaths*

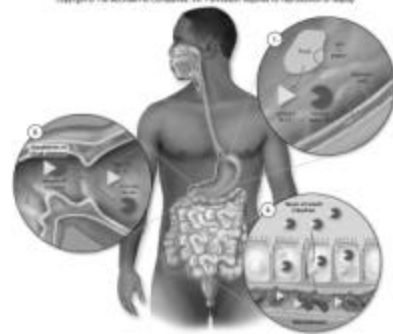
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Vitamin B12

- **Absorption of B12**
 - HCL and pepsin required to release B12 from proteins
 - B12 must bind to intrinsic factor for absorption.

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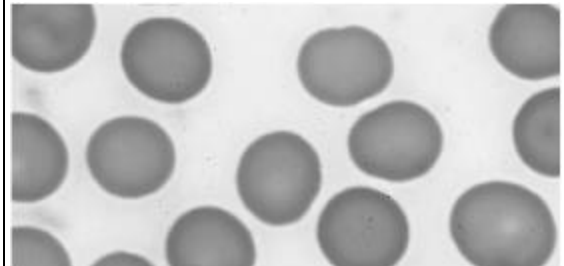
Vitamin B12



Vitamin B12

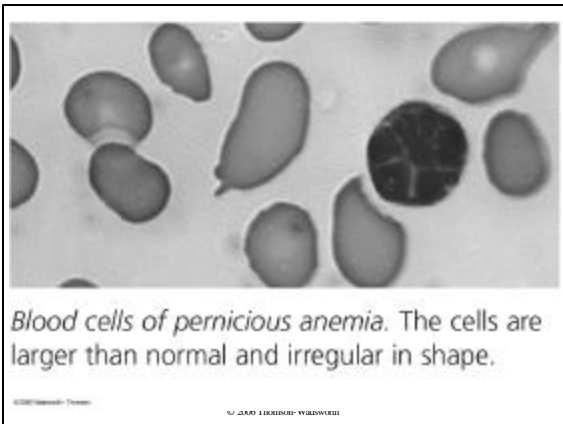
- Deficiency:
 - **Pernicious Anemia**
 - Symptoms:
 - megaloblastic anemia, nerve damage, weakness, memory loss, confusion,

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B12 deficiency

- Elderly produce less HCl and “intrinsic factor”
 - B12 injections
- Vegans
 - Nutritional yeast, fortified products
- Up to 2 years worth of B12 stored in liver

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VITAMIN B₁₂

DRI RECOMMENDED INTAKE:
 Adults: 2.4 µg/day

CHIEF FUNCTIONS: part of coenzyme needed to make cell synthesis, helps to maintain nerve cells

DEFICIENCY: neurological anomalies, anemia, large red blood cells, tongue tingling or numbness, fatigue, memory loss, depression, degeneration of nerve impulses and paralysis

TOXICITY: None reported

*These foods provide 10 percent more of the vitamin B₁₂ they contain at a serving than a 100 percent daily DRI of 2.4 µg/day.
 †This non-dairy food may help to maintain B₁₂ deficiency caused by a lack of intrinsic factor, but is not a source from which to obtain vitamin B₁₂. To get the full amount of vitamin B₁₂ from this source, it is important to eat it.

| GOOD SOURCE* | |
|---|----------------------------------|
| CHICKEN LIVER 2 oz = 14.0 µg | SMOKED SALMON 3 oz = 7.5 µg |
| TRIPLE-CHEESE OMELETTE 3 oz = 2.0 µg | TUNA (in water) 3 oz = 3.0 µg |
| COOTAGE CHEESE 1 oz = 2.8 µg | SWISS CHEESE 1 oz = 1.9 µg |
| POUR-OVER OMELETTE 3 oz = 1.0 µg | |

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Sources of B12

- ONLY animal products: meat, milk, fish, poultry
- Red Star T-6635+ nutritional yeast
- Fortified products: soy milk, etc

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Supplements

- 40% of Americans take vitamin/mineral supplements
- If some is good, is more better?
- Are they beneficial?
- Are they safe?

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Supplements

- Are they safe?
 - High doses of vitamin A increase bone fractures, cause birth defects, cause liver damage
 - D is the most toxic vitamin. Toxicity causes calcium deposits in soft tissue.

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Some people benefit from vitamin/mineral supplements

- Deficiency diseases
- People who don't eat whole food groups (vegans, children?)
- Pregnancy (folate, iron)
- Newborns (vitamin K)
- Infants (D if not exposed to sun and BF)

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Some people benefit from vitamin/mineral supplements

- Elderly (trouble chewing, poor abs B12)
- AIDS (lose nutrients, malabsorption)
- Alcoholics
- Surgery, burns, wounds

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