

Vitamins

I honestly have no idea what a vitamin is.
It's in a banana but it's also the sun? Sure.



What is a Vitamin?

- A substance needed by the body for growth, development, or metabolism that cannot be made by the body & must be obtained from the diet
 - **Non caloric**
 - **Organic** chemical compound
 - **Essential** to cell processes in the body
 - Needed in *small amounts* (in comparison to energy yielding macronutrients)
 - Often requirements are listed as **milligrams** (0.01g), **micrograms** (0.001g) or **international units** rather than grams
 - **International units** – not a measure of weight but a quantity that produces a particular biological effect agreed upon as an international standard. Used for fat-soluble vitamins primarily
 - **Precursors or Provitamins:** once inside body they are transformed chemically to one or more active vitamin forms ie. B-carotene to Retinol (Vit A) & Panthenol to Vitamin B5
- <https://youtu.be/ISZLTJH5lYg>

Vitamins – 2 categories

- 1) **Fat Soluble Vitamins: A, D, E, K**
- 2) **Water Soluble Vitamins: C and Bs**

Fat solubility determines:

- Absorption & transportation (through carrier proteins)
- Storage in liver and fatty tissues
- Potential to build up to toxic levels
- (because they can be stored)

Water-soluble vitamins:

- Absorbed directly into blood
- Excess are excreted in urine (lower risk of toxicity)



VITAMINS

WATER-SOLUBLE VITAMINS



Vit. B₁: Thiamine
B₂: Riboflavin
B₃: Niacin
B₅: Pantothenic Acid
B₆: Pyridoxine
B₇: Biotin
B₉: Folic Acid
B₁₂: Cobalamin
C: Ascorbic Acid

FAT-SOLUBLE VITAMINS



Vit. A: Retinol, -al, -oic Acid
D: Cholecalciferol
E: Tocopherol
K: Phylloquinone

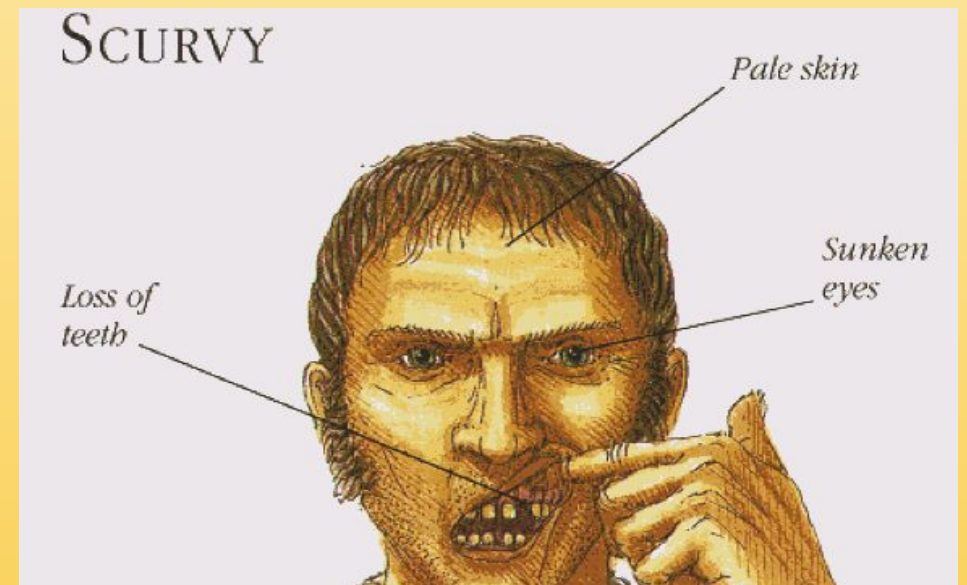
Vitamins in History

<https://youtu.be/jXH3TMYug0s>

1500 B.C. - Egyptians – feeding liver would cure night blindness (Vitamin A deficiency)

- 400 B.C. – Hippocrates – ox liver dipped in honey to prevent night blindness
- 1200 A.D. – Crusades – Crusaders afflicted by scurvy (deficiency Of Vit C)

- 1492-1600 – scurvy threatened
World exploration
 - Est. 2 million seamen
died of scurvy in this time period

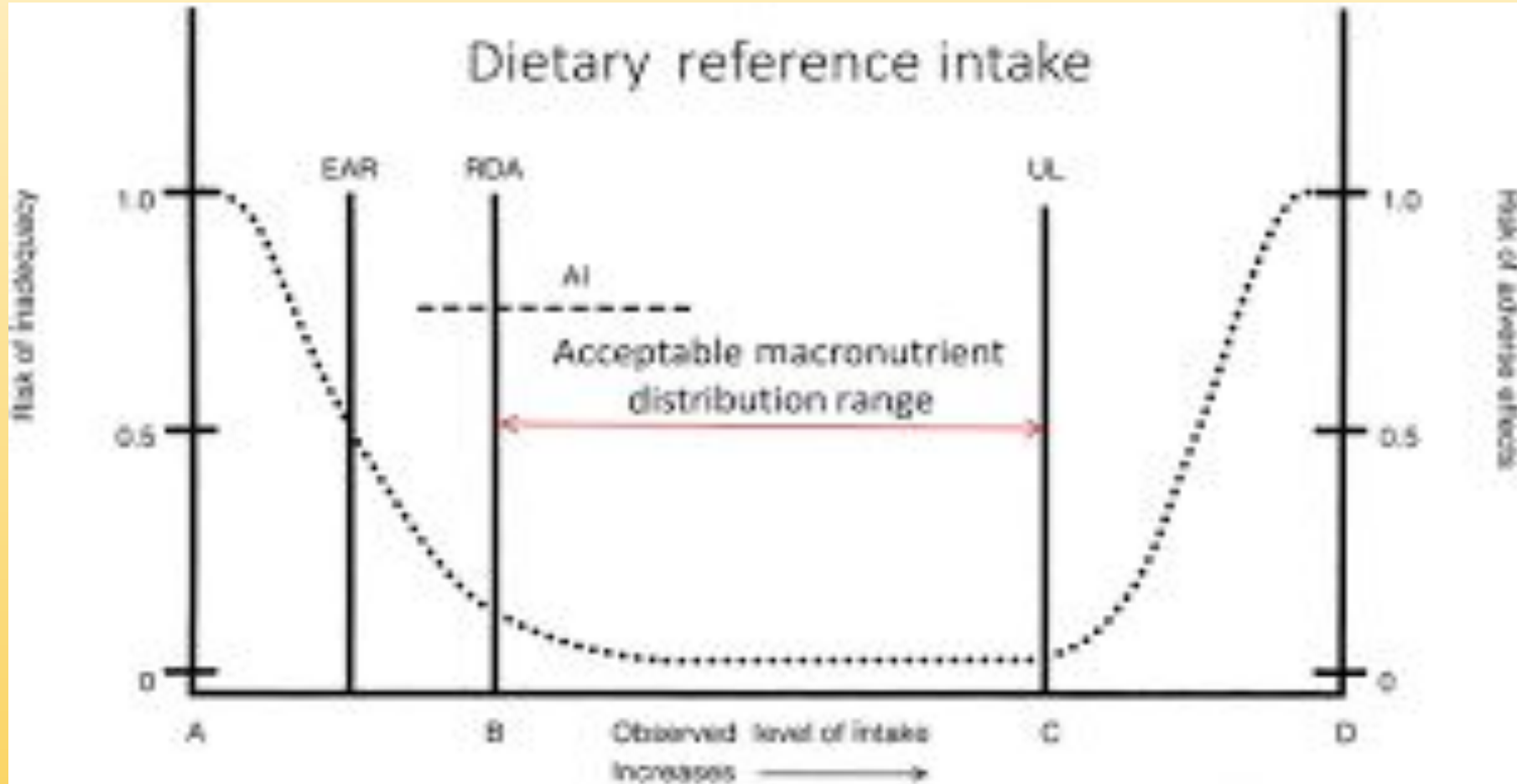


Vitamins History

- 1747 – Scottish surgeon James Lind discovered citrus fruits prevent/cure scurvy. (This theory was not accepted until 20th century.)
- 1884 – Japanese Navy Takaki Kanehiro – lower ranking officers who ate only polished rice got beriberi (vitamin B1 deficiency) – linked diet to disease but thought protein deficiency caused beriberi
- 1897 - Christiaan Eijkman – discovered that unpolished rice fed to chickens prevented beriberi
- Frederick Hopkins + Christiaan Eijkman 1929 – Nobel Prize for discovery of several vitamins
- 1930 – beta-carotene (vitamin A precursor) and 1931 – vitamin C discovered

Remember how we define the AMDR?

We use the same concept for micronutrients (vitamins and minerals)
Acceptable ranges are known, but *optimal* intake levels are often still unknown.



The fat-soluble Vitamins

- **A, D, E, and K:** found in fats and oils of foods and require bile & fat digesting enzymes in order to be absorbed
- Once absorbed, they are stored in liver and fatty tissue until needed.
- Body can survive weeks w/o these vitamins as long as diet provides average minimum amounts
- Deficiencies of fat-soluble vitamins occur when diet is consistently low in them
- Fat malabsorption (liver disease, low bile production) can impair absorption of vitamins

Fat-soluble Vitamins: Vitamin A

- First vitamin to be recognized
- **Retinols** are found in *animal sources*, **Beta-carotene** is its *plant precursor*
- Roles in gene expression, **vision**, maintenance of body linings and **skin**, immune defenses, growth of bones and of body, reproduction
- Recommended daily dose: 700 mcg RAE for women (approx 2333 IU) &
 - 900 mcg RAE/day for men (approx 3000 IU)
- **Deficiency can cause: xerophthalmia:** dry eyes & night blindness
As well as: dry skin, sickness, death
- Overdoses can cause serious problems, esp birth defects in pregnant women
- **Upper Limit (UL):** 3000 ug/10 000 IU/day of retinol form.

Fat-soluble Vitamins: Vitamin A (cont.)

- **Beta-carotene:** antioxidant, precursor vitamin found in *plants*
- 12 ug = 1 ug of retinol (Vit A) to body
- Present in:

Deep orange

Dark green vegetables

Are rich in b-carotene

Food Sources of Retinols: (Animal Sources)

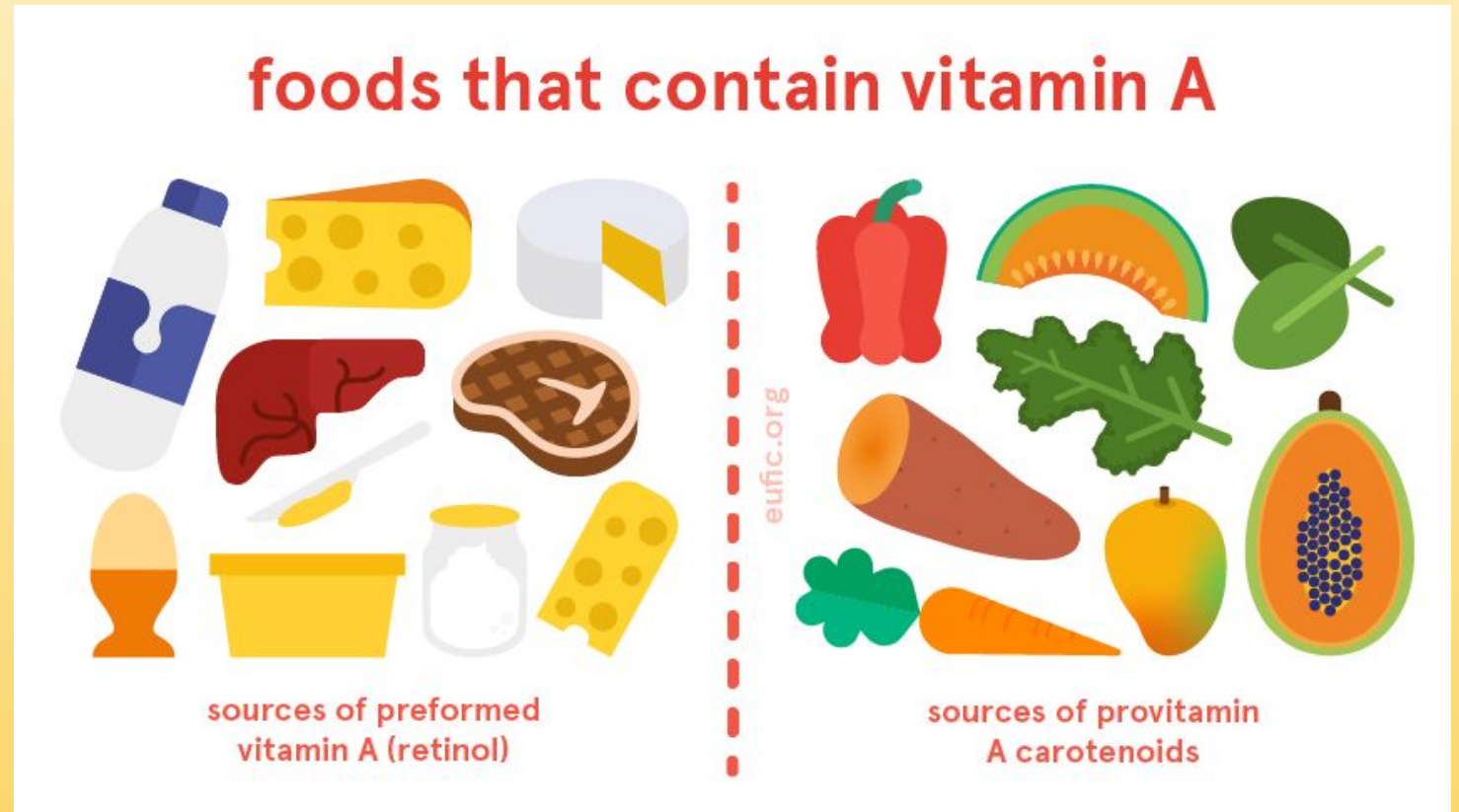
Dairy Products, Eggs

Animal Liver & Liver Oils (such as Cod Liver Oil)

Don't eat Polar Bear Liver! It contains toxic levels of Vit A

FYI: Vit A can be tested in the blood, but is rarely done.

Normal range is 15 – 60 mcg/dL (Labs will vary somewhat)



Fat-soluble Vitamins: **Vitamin D**

- Both Vitamin A and D act like hormones, activate gene expression

Roles

- It **regulates blood calcium and phosphorus levels**, maintaining bone integrity
- Actions in bones, intestines, kidneys, brain, heart, stomach, pancreas, skin, reproductive organs.
- Many inflammatory conditions show low serum Vit D – causal or correlation?

Deficiency linked to cancers – colorectal, breast,
Prostate, ovarian, multiple myeloma

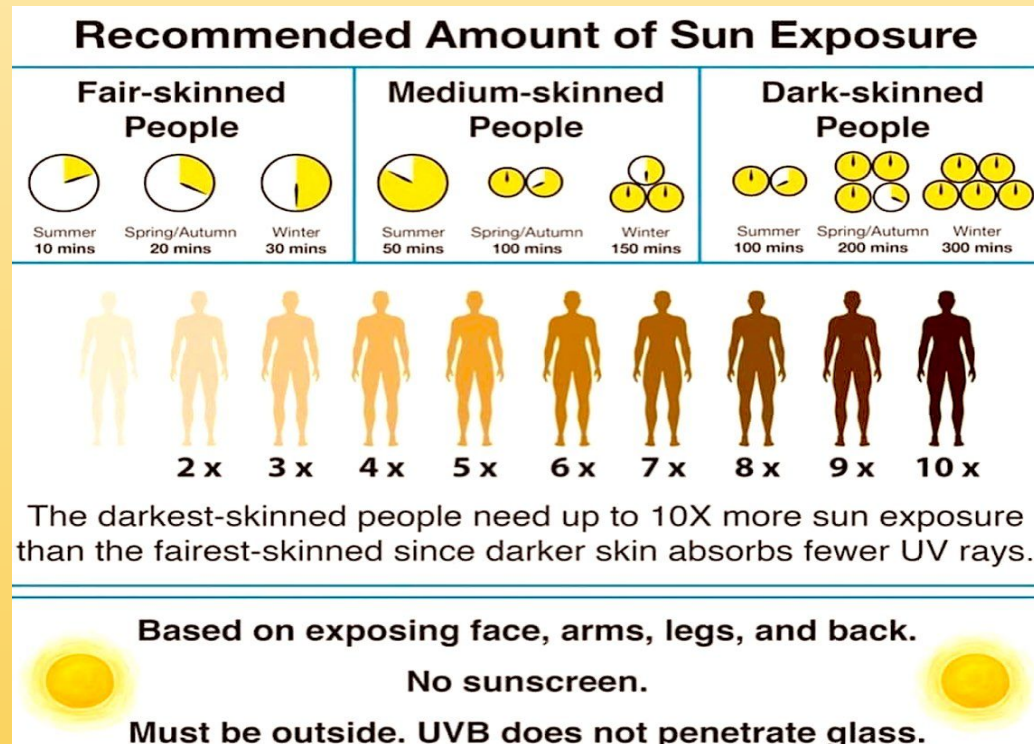
<https://youtu.be/OKOVydqPmTw>



Is Vitamin D really “essential”?

Theoretically, the body can *synthesize all it needs of vitamin D with help of sunlight*
(So Vit D is not always an “essential” nutrient, as long as there is enough sun exposure each day)

But - As you will see from the graphs below, there are many circumstances where we may not get enough sun exposure to make ALL of our required Vitamin D



Fat-soluble Vitamins: Vitamin D

Too little Vitamin D= Danger to bones!

Diseases of deficiency:

Rickets (in children): unable to mineralize newly forming bone material: legs bow, knock-kneed, beaded ribs, protruding (pigeon) chest in children

Although not common in Canada, many children worldwide suffer from rickets due to inadequate food combined with lack of sunlight



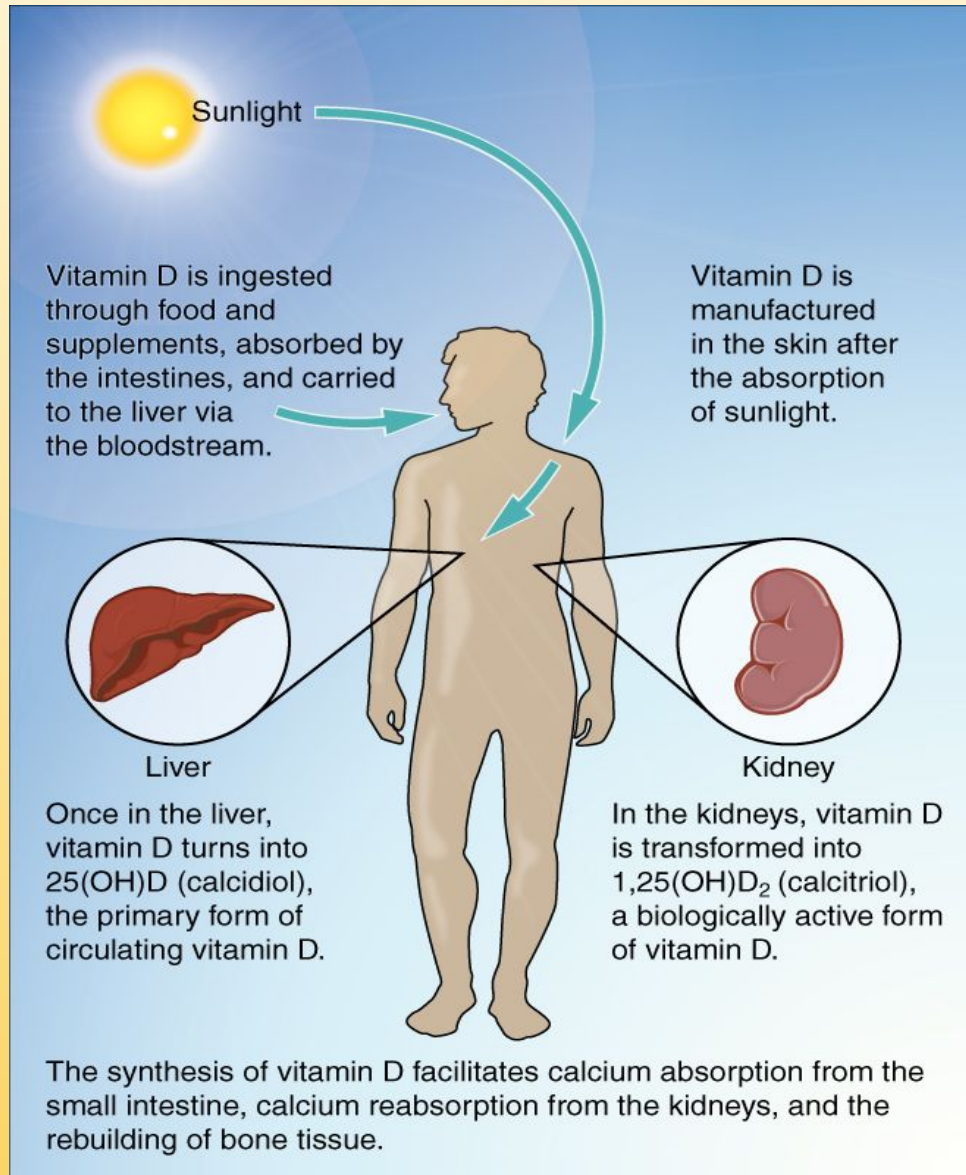
Osteomalacia (adulthood): common in women who have low calcium intakes and little exposure to sun, repeated pregnancies and periods of lactation

[SciShow Vit D](#)

Too much Vitamin D: danger to soft tissues

- Vitamin D is potentially toxic – if toxic doses are ingested hypercalcemia can result in symptoms of: nausea & vomiting, weakness, & frequent urination. Over time hypercalcemia can progress to kidney problems and bone pain.
- If overdose continues, it forces calcium to be deposited in soft tissues
- Vit D fortification needs to be monitored: In the 1990s, 2 people died and others became ill after drinking milk that had mistakenly over fortified with up to 500 times the usual dosage of vitamin D
- **DRI** (dietary reference intake): upper intake level of vitamin D = 100 micrograms/day (1,000 IU)
- **UL** is 4000 IU/day. However, there was an extensive research boom on Vit D in the 2000s & studies found dosages of 5000- 10 000 IUs to be well tolerated. UL is likely to be revised in the next few years.
- **Toxic Doses:** 60 000 IUs/day for months – almost impossible to ingest by mistake.
- OTC Vit D is available in 400 - 2500 IU dosages.

How can people make a vitamin from sunlight?



- UV from sunlight transform a cholesterol compound in human skin into a vitamin D precursor, which is absorbed into blood
- Pigments of dark skin protect from UV but reduce Vitamin D synthesis
- Dark-skinned people require longer exposure to sun (~ 3 hs) for several days (vs. 20 min for light-skinned people)

FYI: Blood Testing to determine levels:

Less than 30 nmol/L = risk of rickets/osteomalacia

More than 50 nmol/L = usually adequate for bone health

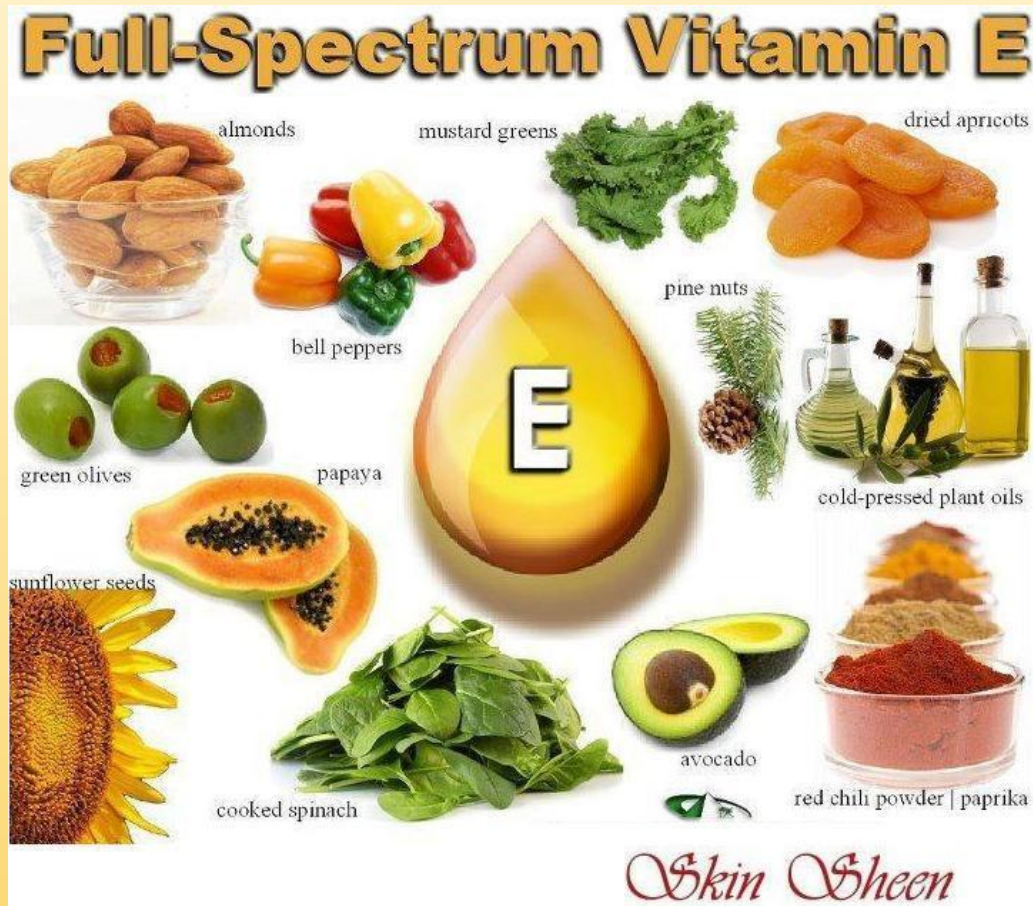
More than 125 nmol/L = risk of toxicity

Vitamin E

- **Powerful antioxidant** (quench free radicals), main defender against oxidative damage
- Free radicals: formed during normal cell metabolism, they disrupt cell membranes, DNA and proteins that perform cellular work. If unchecked, free radicals may lead to cancer, heart disease or other diseases
- Especially important for cells constantly exposed to high oxygen concentrations (lung, skin and blood)
- Deficiency: rare in humans but occur in newborn premature infants
- Vitamin E is widely distributed in plant foods; it is destroyed by high heat; toxicity is rare

<https://youtu.be/HtF61dxP1zs>

- Vitamin E is widespread in foods (although animal fat has almost none)



Recommended daily intake is 15 mg/day
(approx 22- 33 IUs)

UL: 1000 mg/ 1500 IUs/day.

Toxicity is very rare. May cause blood thinning/delayed clotting.

FYI: Blood testing can be done, but is rare.

Normal range for alpha-tocopherol is 5.5 mg/L

Vitamin K

- *Necessary for blood clotting*
- **Deficiency** causes uncontrolled bleeding
- **Toxicity** causes jaundice (bilirubin released into blood instead of into bile)
- **DRI:** 90- 120 mg/day (for adults)

VITAMIN K

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- Vitamin K helps blood clotting, essential to stop bleeding from wounds.
- People with vitamin K deficiency may experience easy bruising, nosebleeds, etc., although the deficit of this vitamin is rare to occur.
- The sources of vitamin K are animal fats (egg yolks, whole milk, red meat, ...) and dark green vegetables (spinach, asparagus, ...)



Vitamin K

Two forms : Vit K1 found in plant foods

Vit K2 found in fermented foods & animal foods

In a healthy gut, probiotic bacteria can convert K1 to the active form of K2.

Toxicity: rare. No **UL** has been established.

<https://youtu.be/vILC0pUtmTA>

Fat-Soluble Vitamins

Vitamins	Good Sources	Main Functions
A	Liver; eggs; cheese, milk; yellow, orange, and dark green vegetables & fruit	Maintains healthy skin, bones, teeth, & hair. Aids in vision in dim light
D	Milk; eggs; liver; exposure of skin to sunlight	Maintains bones and teeth; helps in the use of calcium and phosphorus
E	Margarine; vegetable oils; wheat germ; whole grains; legumes; green vegetables	Aids in maintenance of red blood cells, vitamin A, and fats
K	Green, leafy vegetables; potatoes; liver	Aids in blood clotting

Water–Soluble: Vitamins C and B

- They require special consideration in food preparation to avoid losing or destroying them
- Body absorbs them easily and just as easily excretes them in the urine

Water-Soluble Vitamins

Vitamin	Good Sources	Main Functions
B1 (Thiamin)	Port products; liver, whole grain; legumes	Aids in carbohydrate use and nervous system function
B2 (Riboflavin)	Milk; eggs; meat; whole grains; dark green vegs.	Aids in metabolism of carbs, proteins, fats
B3 (Niacin)	Poultry; meat; fish; nuts	Aids in metabolism
B6 (Pyridoxine)	Meat; fish; poultry; fish; whole grain; vegetables	Aids in metabolism of carbs, proteins, & fats
B12 (Cobalamin)	Meat; fish; poultry; eggs; grains	Maintains healthy nervous system and red blood cells
Pantothenic acid	Organ meats; poultry; fish; eggs; grains	Aids in metabolism
C (Ascorbic acid)	Citrus fruits; green vegetables; melons;	Aids in bone, teeth, & sin formation; resistance to

Water-soluble vitamins: Vitamin C

- **Sources:** citrus fruit, cabbage, leafy greens, cantaloupe, strawberries, peppers, tomatoes, potatoes, mangoes, papaya, kiwi
- **Functions:**
 - *Collagen synthesis* – blood vessel walls, scar tissue, bone matrix
 - Anti-oxidant
 - Restores vitamin E to active form
 - Hormone synthesis
 - Immune function and *increase absorption of iron*
- **Deficiencies: Scurvy** (anemia, frequent infections, bleeding gums, muscle/bone pain, bruising, slow healing) <https://youtu.be/9BdDJV0z-Y4>
- **Toxicities:** nausea/digestive cramps, diarrhea, headache, rashes
- **RDA** 75 - 90 mg/day (extra 35 mg/day for smokers)
- **UL** 2000 mg/day - VERY conservative - many people can take up to 10 000 mg/day without any digestive symptoms

Vitamin C

FYI: Testing in blood is possible, but rarely done

Normal range is 0.4 - 2.0 mg/dL

- Certain medications including aspirin, tetracycline & oral contraception may increase the need for Vit C

SCURVY

During the age of discovery, scurvy was a huge problem for sailors who were out at sea for weeks to years at a time, subsisting on dried meat and fish, biscuits and "pease" - dried peas or lentils, sometimes mixed with oats. Scurvy was a mystery to the sailors and a huge source of shame. Some tried 'earth bathing' when they sighted land, thinking that the sickness was caused by being surrounded by too much water.

James Lind was a British Naval Surgeon who first connected fresh fruits, limes in particular, with preventing the symptoms of scurvy. <https://youtu.be/rb5knx92oww>

Scurvy is now rare, found mostly in malnourished people, and chronic alcoholics.

Water–Soluble: Vitamins B

- B vitamins act as coenzymes
- **Coenzyme:** small molecule that activates enzyme
- B vitamins help body metabolize carbohydrates, lipids and amino acids.
- Several B vitamins, each with special qualities
 - Thiamin (B1)
 - Riboflavin (B2)
 - Niacin (B3)
 - Pantothenic Acid (B5)
 - Vitamin B6 (pyridoxal -5- phosphate)
 - Biotin
 - Folate
 - Vitamin B12

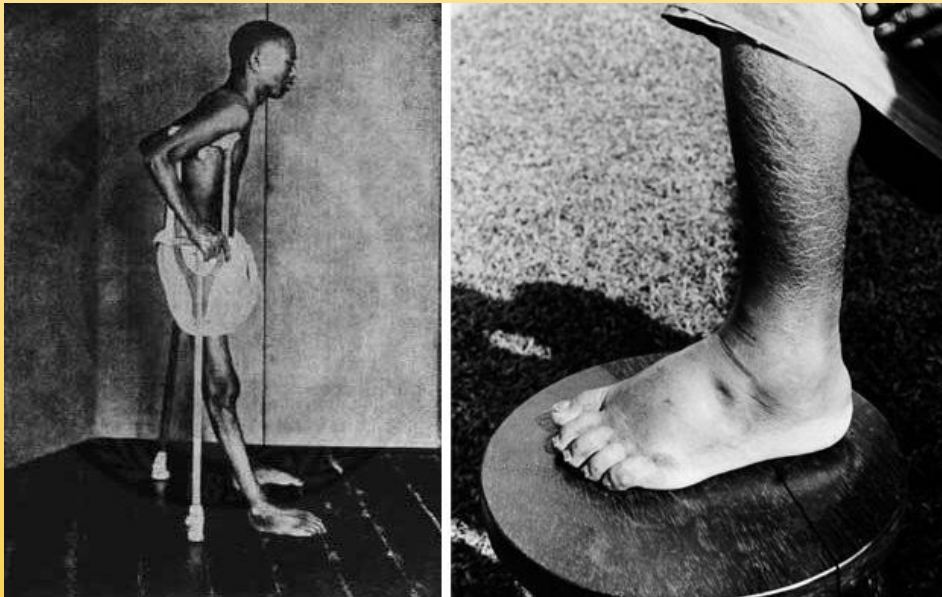
Thiamine - B1

1st B vitamin discovered

- **Functions:** Metabolism – help release nutrients from food; helps body make ATP for energy at the cellular level. Conduction of nerve signals.
- Do NOT directly supply body with energy (no calories) but allow the energy reactions in the body to take place
- **Sources:** pork, fish, nuts, beans, brown rice, whole grains, seafood
- **Deficiencies:** now pretty rare but can occur in anorexia, malnutrition, & Crohn's disease. Dialysis & Loop diuretics such as furosemide (Lasix) may impair B1 absorption.
- In **chronic alcoholics**, "**wet brain**" or **Wernicke-Korsakoff syndrome** is related to thiamine deficiency. Symptoms include confusion, difficulty with muscle coordination, and hallucinations.
-

Beri-beri

- Vitamin B1 (thiamine) is critical for **cell metabolism** and **nerve cell membranes**
- B1 was discovered in 1910 in Japan after observing Beri-beri symptoms in sailors eating white rice for an extended period of time. Brown rice was found to reverse the symptoms. <https://youtu.be/lzIBpFDRr5g>
- **Beriberi** – deficiency of thiamine (eating polishing rice, without brown coat)
- DRI = 1.1 to 1.2 mg/day
- UL = None established



Riboflavin (B2)

- **Sources:** cabbage, cauliflower, spinach, lettuce, leafy greens, breads, pasta, milk, meats
- **Functions:** role in metabolism of all cells
- **Deficiencies:**
 - Cracks at corners of mouth, sore throat, hypersensitivity to light, reddening of cornea, skin rash
- **Toxicities:**
 - No toxicity symptoms reported
- RDA = 1.1 - 1.3 mg/day
- UL = None established



Niacin - B3

- **Sources:** liver, chicken, beef, tuna, brown rice, avocados, nutritional yeast, peanuts
- **Functions:** energy metabolism of every cell of body
- **RDI:** 14 –16 mg/day
- **UL:** 35 mg/day
- **Deficiencies:**
 - **Pellagra:** “4 D symptoms”: diarrhea, dermatitis, dementia, death
- **Toxicities:**
 - Large doses (3000 mg/day +) can cause nausea, vomiting, liver damage
 - Therapeutic Dose for high cholesterol is 1000 – 3000mg/day
 - Therapeutic use for some schizophrenics 3 000 - 18 000 mg/day - MOA seems to be promoting conversion of norepinephrine to epinephrine
 - These high doses MUST be monitored by a physician

Pantothenic Acid - B5

Functions in the body: converting food into glucose, synthesizing cholesterol, forming red blood cells

- helps synthesize Coenzyme A which the liver uses to metabolize some drugs & toxins

Deficiency: fatigue, depression, hypoglycemia, burning feet

Food Sources: meats, fish, whole grains (not milled), dairy products, legumes

RDI Adults: 5 mg/day

UL : None established

Toxicity: very low. Stomach upset & diarrhea have been reported at doses of 10 000mg/day



Pyridoxine - B6

RDA: 1.3 - 2.0 mg/day

UL: 100 mg/day

Treatment for: Pregnancy induced nausea (under doctor's supervision)

Food sources: beef liver, tuna, salmon, chickpeas, poultry, fortified grains, dark green leafy vegetables

Toxicity: can occur with large doses (1000 mg/day +) over the long-term . Symptoms are neuropathy of hands & feet, nausea, and ataxia (lack of control of body movements)

Deficiency: rare. Associated with deficiencies of other B vitamins such B12 & folic acid. Can lead to microcytic anemia.

<https://youtu.be/UrocSQqC0qU>



Folate (folic acid) - B9

- **Sources:** asparagus, avocado, leafy green vegetables, beets, seeds, liver, enriched breads, cereal, pasta, grains
 - **Functions:** cell metabolism, DNA & RNA synthesis, neural tube development, neurotransmitter production
 - **Deficiencies:**
 - Megaloblastic Anemia, Neuropathies, birth defects esp. Spina Bifida, suppression of immune system, frequent infections, depression, headache
 - **Toxicities:**
 - Masks vitamin B12 deficiency
- RDA = 400 -600 mcg/day
UL= 1000 mcg/day

<https://youtu.be/nvss-sVIRw8>



Vitamin B12

- **Sources:** animal products (meat, fish, poultry, milk, cheese, eggs)
- **Functions:** new RBC synthesis, helps maintain nerve cells, DNA & RNA synthesis
- **Deficiency AKA Pernicious anemia:**
- Take a long period of deficient intake (years) before showing signs & symptoms OR a deficiency of intrinsic factor in the stomach (needed to absorb B12) - genetic link
 - Megaloblastic Anemia, fatigue, depression, long term constipation, sore/red tongue and nerve degeneration (d/t effects on the myelin sheath) progressing to paralysis, tingling or numbness
 - Vegans – will need supplementation or to be very mindful of taking in fortified foods (plant milks, cereals). Plant foods are NOT a good source of B12 on their own

RDA : 4 - 6 mcg/day

UL: Not established

- **Toxicities:**
 - unknown

Vitamin B12

Supplements can be in two forms:

- Cyanocobalamin which is synthetic & not found in nature but is stable and cost effective
- Methylcobalamin which is a naturally occurring form found in food sources like fish, meat & eggs

B12 is regularly tested in your blood. Normal ranges may vary between labs but are usually between 170 - 600 pmol/L. This range varies between countries - Japan's normal range is 550 - 1300 pmol/L.

https://youtu.be/1u_XVBwjEyK

