

Lecture 8 – Water and Minerals



Overview

- Water's main functions
- How water and minerals mingle to form the body's fluids
- How cells regulate distribution of those fluids
- Roles of each of the minerals



Water

- You begins as a single cell bathed in a nourishing fluid
- As becoming air-breathing body of trillions of cells, each cell has to be close to water to survive
- Water makes up ~60% of adult person's weight



Human life begins in water

Why is water the most indispensable nutrient?

- ✓ Carries nutrients throughout body (without water cells quickly die)
- ✓ Solvent: it dissolves amino acids, glucose, minerals, etc. Fatty substances packaged with water-soluble proteins in blood and lymph
- ✓ Necessary to remove waste (blood, urine)
- ✓ Provides lubrication (joints) and shock protection (eyes, spinal cord, amniotic sac)
- ✓ Aids in maintaining the body's temperature

The body's water balance

- Imbalances between dehydration and overhydration can occur temporarily
- Amount of water can vary by pounds at a time (i.e. water retention with a meal high in salt or with hormonal fluctuations such as menstrual cycle). This does not reflect change in body fat.
- Fat weight takes days or weeks to change noticeably; water weight can change overnight.
- Balance regulated by brain and kidneys
- A 68-kg person contains 41 kg of water ($68 \text{ kg} \times 0.6$)

Water output:

- Kidneys (500 -1,400 mL)
- Skin (450-900 mL)
- Lungs (350 mL)
- Feces (150 mL)

Water input:

- Food (700 – 1,000 mL)
- Liquid (550- 1,500 mL)
- Water made by metabolism (200-300 mL)

Are some waters better for health than others?

- Hard water: high in calcium and magnesium
- Soft water: high in sodium and dissolves cadmium and lead from pipes
- Cadmium: can harm body, promotes bone fractures, kidney problems and hypertension
- Lead (from old plumbing): toxic metal- affects nervous system
- Filtered water: vary
- Bottled water
- Tap water: sediment is removed, chlorine added to remove hazards (microorganisms, heavy metals, chemicals), meets minimum standards
- https://youtu.be/0_ZcCqqpS2o

Bottled water – better than tap water?

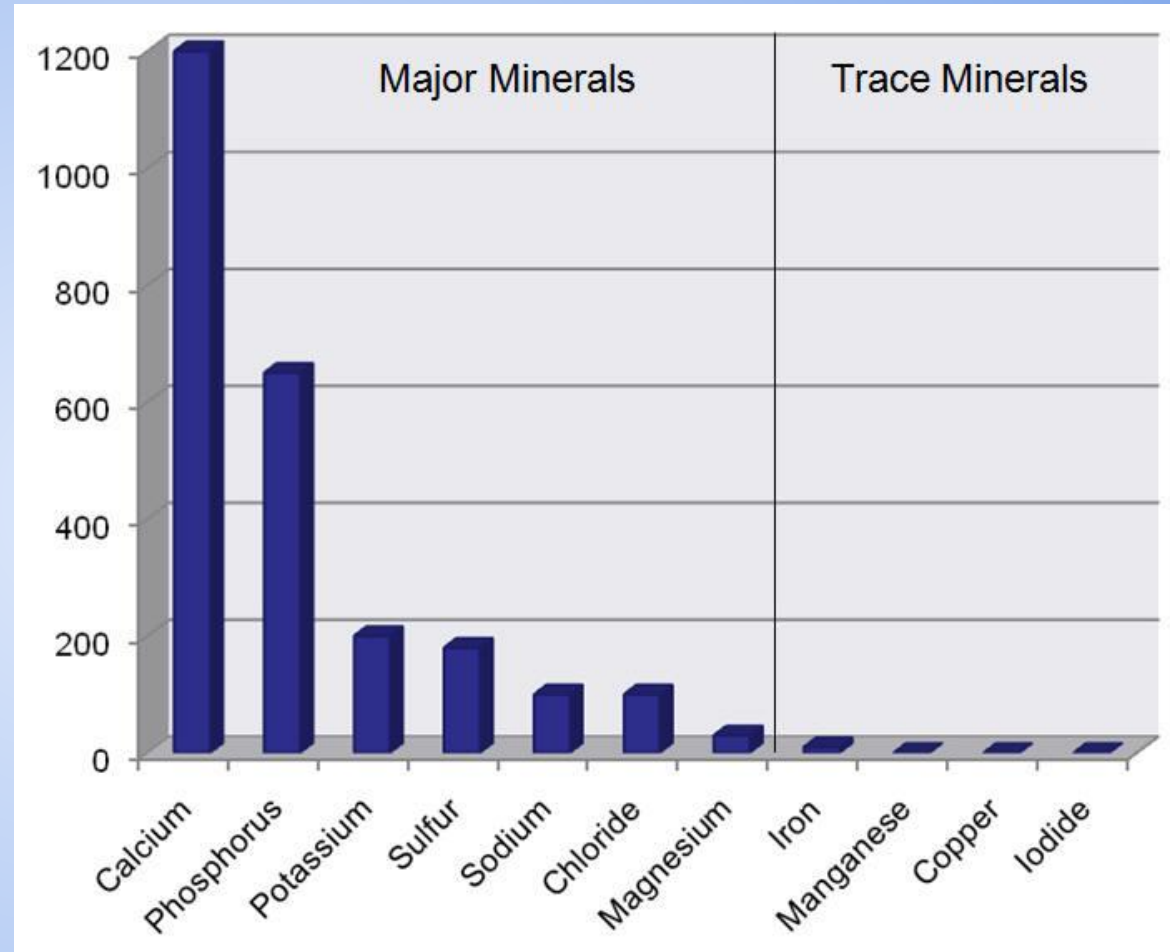
- Taste?
- Mineral content? Best choice is rich in calcium and magnesium but low in sodium
- Fluoride?
- Is it cleaner?
- Cost?
- Helps environment?
- <https://youtu.be/Se12y9hSOM0>

How to make filthy water drinkable

- https://www.ted.com/talks/michael_pritchard_invents_a_water_filter?language=en
(~10 min)

Major Minerals and Trace Minerals

- **Minerals:** naturally occurring, inorganic, chemical elements
- **Major minerals:** found in body in amounts larger than 5 g
- **Trace minerals:** in small amounts (less than 5 g)
- Both equally important



Body fluids and Minerals

- Major minerals form salts that dissolve in body fluids
- **Salts** are compounds: composed of charged particles (ions). Ex: K^+Cl^-
- **Ions**: electrically charged particles. Ex: Na^+ and Cl^-
- **Electrolytes**: compounds that dissociate in water to form ions. Ex: K^+Cl^-
- Electrolytes help conduct electricity in the body
- Cells direct where salts go, this determines where fluids flow (*water follows salt*)
- Mineral salts help keep fluids in proper compartments in body

Calcium – 99% in bones and teeth

- **Function:** makes structure of bone and tooth; role in nerve transmission, muscle contraction, blood clotting. Absorption rises when dietary deficiency or increased need (i.e. growth)
- Most abundant mineral in body

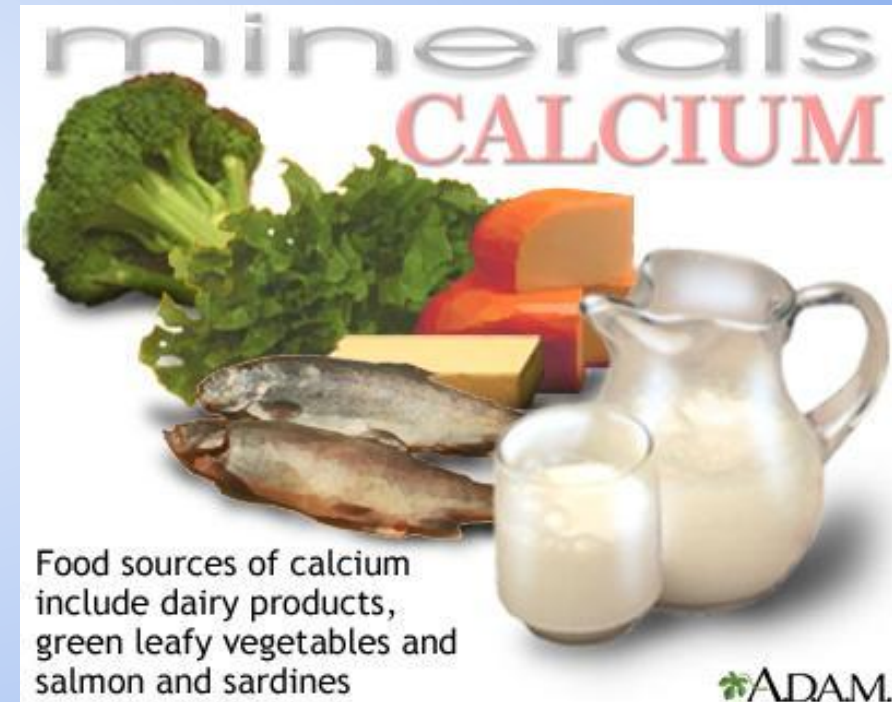
RDA 1000 mg/day

1200 mg/day in women over 50

1300 mg/day in pregnancy & teens

NHASE Studies have shown many people eat insufficient calcium to meet the RDA

Deficiency: leads to poor bone density and ultimately, osteoporosis. *Very common* around the world



Calcium Cont.

- Absorption is decreased by high phosphorus intake, caffeine, & low Vit D
- Toxicity can occur starting at 2500 mg/day – nausea & vomiting, headache, thirst
- Calcium levels in the blood do not reflect nut. status because of tight homeostatic control
- Adequate Calcium intake seems to be protective against fractures, osteoporosis, cancers, heart disease, and weight management.
- Supplements come in various forms – carbonate, citrate, bisglycinate, microcrystalline hydroxyapatite etc., with different pros & cons
- Calcium should never be supplemented alone – linked to increased atherosclerosis & kidney stones. Always use with Mag, Vit D &/or K

Highest **CALCIUM** FOODS CHART

Calcium Sources - Not *just* Dairy products

High Calcium Foods are found in a few categories:

Dairy Foods, Dark Green Leafy Vegetables, Soy Foods like edamame and tofu, Beans and lentils, seeds, canned fish with the bones, and fortified foods.

Foods commonly fortified with calcium include: Orange & Grapefruit juice, plant milks, and cereals.

Dairy	SERVING SIZE	CALCIUM (MG)
MILK	1 CUP	300
HIGH PROTEIN MILK	1 CUP	380
CHOCOLATE MILK	1 CUP	280
BUTTERMILK	1 CUP	300
EGGNOG	1 CUP	330
DRY MILK	1/4 CUP	330
YOGURT, PLAIN, NONFAT	8 OZ	488
YOGURT, PLAIN, LOW FAT	8 OZ	448
LOW FAT GREEK YOGURT	8 OZ	260
NON FAT GREEK YOGURT	8 OZ	250
KEFIR, PLAIN, LOW FAT	1 CUP	317
COTTAGE CHEESE	1 CUP	130
CHEDDAR, MUENSTER	1 OZ	200
PARMESAN, FETA	1 OZ	300
CHEESE (RICOTTA)	1/2 CUP	340
SOUR CREAM	1/2 CUP	120
ICE CREAM OR FROZEN YOGURT	1/2 CUP	100
PUDDING OR CUSTARD	1/2 CUP	150
WHEY PROTEIN ISOLATE	1.2 OZ	160

Non Dairy Milk	SERVING SIZE	CALCIUM (MG)
SOY MILK, CALCIUM FORTIFIED	1 CUP	200 TO 400
SOY MILK YOGURT, PLAIN	8 OZ	300
ALMOND MILK, FORTIFIED	1 CUP	300-450
OAT MILK, FORTIFIED	1 CUP	350
RICE MILK, FORTIFIED	1 CUP	284

Seafood	SERVING SIZE	CALCIUM (MG)
SARDINES (WITH BONES)	3 OZ	325
SALMON (WITH BONES)	3 OZ	180
SHRIMP	3 OZ	125
OYSTERS	3 OZ	80

Vegetables	SERVING SIZE	CALCIUM (MG)
KALE	1 CUP (COOKED)	180
COLLARD GREENS	1 CUP (COOKED)	260
SPINACH	1 CUP (COOKED)	240
BOK CHOY	1 CUP (COOKED)	160
BROCCOLI	1/2 CUP	90

Plant-Based	SERVING SIZE	CALCIUM (MG)
SOYBEANS (COOKED)	1 CUP	260
TOFU (PREPARED WITH CALCIUM)	1/2 CUP	430
TEMPEH	1/2 CUP	95
TAHINI (SESAME SEED BUTTER)	1 TBSP	154
EDAMAME (GREEN SOYBEANS)	1/2 CUP	50
NAVY BEANS (COOKED)	1 CUP	125
BLACK BEANS (COOKED)	1 CUP	100
KIDNEY BEANS (COOKED)	1 CUP	75
CHICKPEAS (COOKED)	1 CUP	80
LENTILS (COOKED)	1 CUP	40
HUMMUS	1/4 CUP	60

Fruits	SERVING SIZE	CALCIUM (MG)
DRIED FIGS	1/2 CUP	120
ORANGES	1 MEDIUM	60
KIWIFRUIT	1 MEDIUM	30
BLACKBERRIES	1 CUP	40
GRAPEFRUIT JUICE, 100%, FORTIFIED	1 CUP	350
ORANGE JUICE, 100%, FORTIFIED	1 CUP	350

Fortified Foods	SERVING SIZE	CALCIUM (MG)
COLD BREAKFAST CEREAL	1 CUP	250 TO 1000
BREAD	1 SLICE	150-200
GRANOLA BAR	1 BAR	50 TO 200
ENERGY BAR	1 BAR	100 TO 300
CRACKERS	5 CRACKERS	50 TO 150
COOKIES	2 COOKIES	50 TO 100
PRETZELS	10 PRETZELS	50 TO 100

Osteoporosis- can lifestyle choices reduce the risks?

- Insufficient Ca⁺ and vitamin D intake is a cause of osteoporosis but not the only one!
- Physical activity (sedentary lifestyle increases risk) - Resistance training can prevent/reduce risk
- Genetics
- Estrogen deficiency
- Being underweight/small frame
- Use of tobacco and alcohol
- Excess protein, sodium, caffeine, soft drinks
- Long term corticosteroid use
- Hyperthyroidism /Hyperparathyroidism

Phosphorus

- **Function:** important for bones and teeth structure.
- Helps maintain acid-base balance, part of DNA, energy metabolism, part of cell membranes (phospholipids)
- **RDA:** Ages 9 -18 & in pregnancy 1250 mg/day
- Ages 19+ 700 mg/day

• **Best sources:** yogurt, milk, salmon, scallops, Chicken, lentils, beef, cashews, potatoes

Deficiencies are rare in the developed world & usually associated with kidney or parathyroid Problems rather than insufficient intake



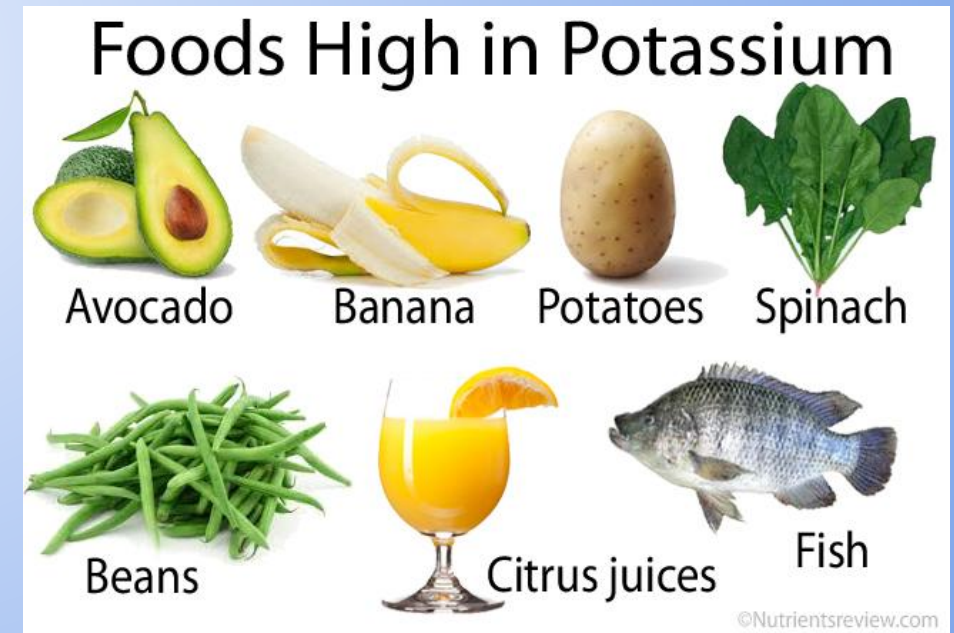
Potassium

- **Function:** most abundant positive ion inside cells, is important in many metabolic functions. It has a strong relationship with sodium via the Na^+/K^+ pump
- Assessing K^+ in the body is difficult, because it is mostly intracellular. Abnormal blood potassium levels therefore reflect kidney disease, dehydration, or certain medication use, NOT dietary intake.

-Adequate intake (AI)

{insufficient evidence for RDA}

- : Male 3000 – 3400 mg
- Female 2300 – 2600 mg/day
- NHANES study found that average daily intake is below the recommended AI



Potassium

Food Sources: Apricots, lentils, prunes, acorn squash, raisins, potato

Groups that are at risk of K deficiency: people with inflammatory bowel disease, those using thiazide diuretics or large doses of laxatives, people with pica (persistent eating of non-nutritious foods such as clay)

People with K deficiency are at risk of: high blood pressure, kidney stones, bone problems, blood sugar control & diabetes

Hyperkalemia: usually a result of kidney disease or medication overdoses can cause potentially fatal cardiac arrhythmias



Magnesium

- **Function:** important to build protein and using energy. Magnesium is a cofactor in more than 300 enzyme systems. It plays a role in active transport of Ca & K ions across the cell membrane, which is important to nerve conduction, muscle contraction & normal heart rhythm.
- Blood levels are kept under tight homeostatic control. Better testing option include Mg in the RBC, salivary or a magnesium loading test.
- **RDA:** Males 400 – 420 mg
- Females: 310 – 400 mg
- NHANES study showed average intake was around 50-100 mg deficient of RDA

Magnesium

Food Sources: pumpkin seeds, chia seeds, almonds, spinach, cashews, peanuts
Black beans, edamame

Laxative effect: some forms of supplemental magnesium exert an osmotic laxative effect by drawing more water into the bowel

Milk of Magnesia (Mag. Hydroxide)

Magnesium Citrate

Roloids contains mag. hydroxide



Magnesium

- **Deficiency** can occur with chronic under intake. Symptoms include: fatigue, weakness, muscle contractions and cramps, numbness, tingling, heart palpitations, migraine headaches
- Groups at greater risk of deficiency are: people with inflammatory GI diseases, Type 2 diabetics, older adults
- Magnesium **toxicity** generally only occurs in cases of very large doses (>5000 mg/day) of Mag. Containing laxatives +/- antacids.

Medication interactions: PPI (Nexium, Prevacid) use for >1 year can result in hypomagnesemia

Loop diuretics (Lasix) & thiazide diuretics (hydrochlorothiazide) can cause hypomagnesium through increased excretion

Sodium

- **Function:** main positively charged ion *outside* body's cells. Sodium attracts water. Major role in keeping fluid and electrolyte balance. Too much sodium raises blood pressure and aggravates hypertension
- BUT salt is not the only cause of hypertension...<https://youtu.be/4QXmTqpqVJY>
- **Recommended amounts:**
1,300-1,500 mg/day

Tolerable Upper Limits: >2300 mg/day

A 2004 survey found that 60 -85% of Canadians were consuming more than the TUL for sodium.

Sodium

Foods to REDUCE/AVOID



Major dietary sources of sodium are in: Processed meats, packaged bread products, shrimp, soups, ham, instant pudding, salad dressings

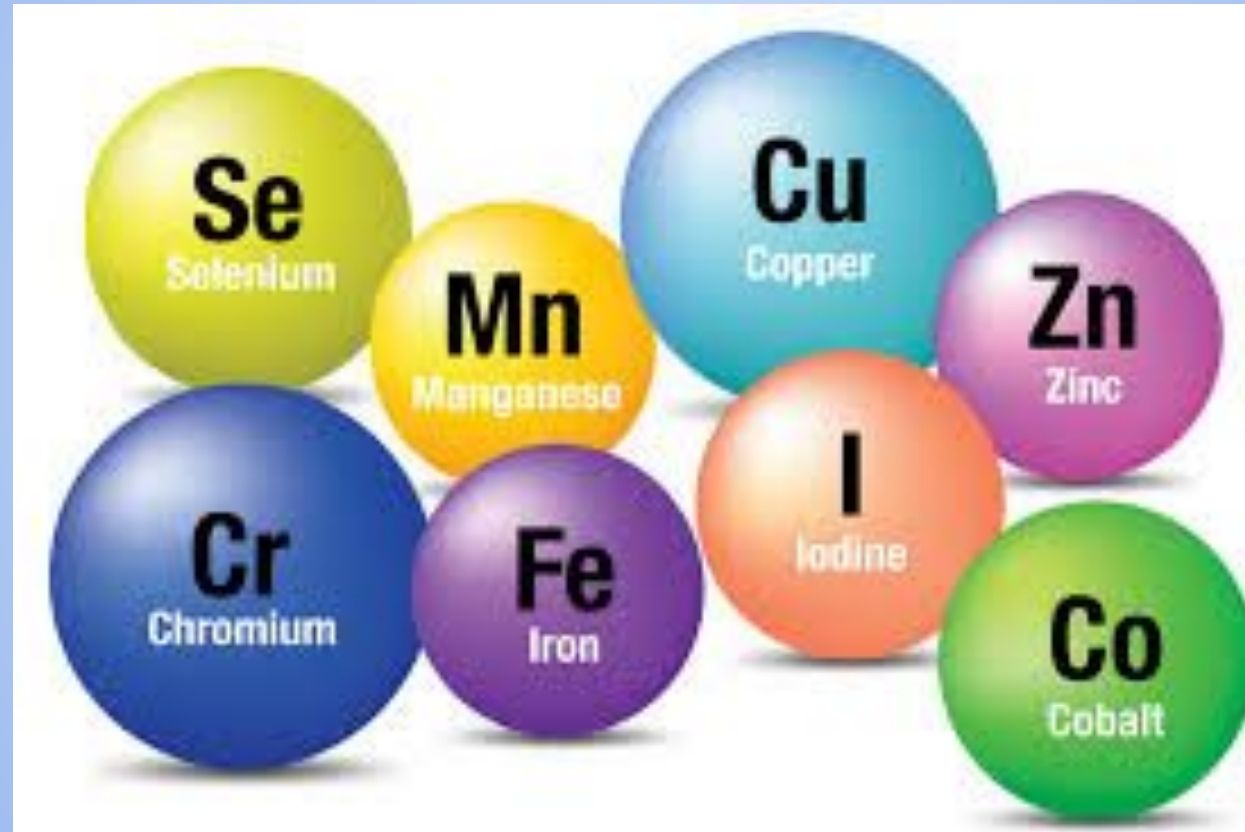
Hypernatremia – high blood sodium. Can be caused by dehydration, loss of body fluids, certain medications such as steroids

Hyponatremia – low blood sodium. (Often caused by too much water) Usually caused by heart, lung, kidney or adrenal problems.

<https://youtu.be/72Ncvlr6GQk>



Trace Minerals



Iodine

- Part of **thyroid** hormones, critical for metabolism
- Causes **goiter** (enlargement of thyroid gland) if iodine is deficient (simple goitre) or in excess (toxic goiter)
- **Cretinism:** mental and physical retardation caused by iodine deficiency during pregnancy

https://youtu.be/keE_ed7xCm4

RDA 150 mcgs/day, 220 mcgs in pregnancy

Food sources: seaweeds, enriched breads, cod, yogurt,
Oysters, *iodized salt*



Iodine

- **Groups at risk of deficiency:** People who live in the Goiter belt (poor soil iodine), vegans, pregnant women, people not using iodized salt, people eating a lot of goitrogenic foods
- **Goitrogens:** foods that interfere with the body's uptake of iodine. Includes soy, cassava, and cruciferous vegetables (cabbage, broccoli, cauliflower, brussel sprouts)
- Insufficient iodine has also been linked to fibrocystic breast disease. Potassium iodide has been approved to reduce cancer risks from radiation exposure.
- **Tolerable upper limits:** 900 – 1100 mcg/day
- Toxicity symptoms are similar to deficiency: goiter, hypothyroidism but also thyroiditis & hyperthyroidism.

Iron

- Present in all living cells
- Most iron in hemoglobin (red blood cells) and myoglobin (muscle cells), helping hold and carry oxygen
- Plants & Iron fortified foods contain **Non-heme iron**. Animal sources contain **heme iron** which has higher bioavailability.
- **Food sources:** Oysters, white beans, chocolate, liver, lentils, tofu, sardines, beef
- Iron levels can be measured in the blood through several tests: ferritin (Normal 30 mcg/L +) to measure iron stores, hemoglobin (N 12 g/dL +) & hematocrit (N 36-50%) to identify Iron Deficiency anemia.
- <https://youtu.be/vXNhGmv8fXA>

Iron

- **RDA** Males 8 – 11 mg, Females 8 – 18 mg, in pregnancy 27 mg
- **Groups at risk of deficiency:** pregnant women, young children (first suggested solid foods are those high in iron), women with heavy periods, people with GI diseases, People with cancer
- **Toxicity:** supplementation can lead to stomach pain, constipation. Different forms can reduce that likelihood. Iron can interfere with Zinc absorption.
- Severe overdose > 60 mg/kg can be fatal.
- **Hemochromatosis:** excessive buildup of iron in the body due to a genetic mutation. Treatment is blood donation, monitoring iron & liver function.
- Vitamin C increases Iron absorption.
- Tea, coffee, calcium, phosphorous, tannins, phytates and fiber can affect iron absorption

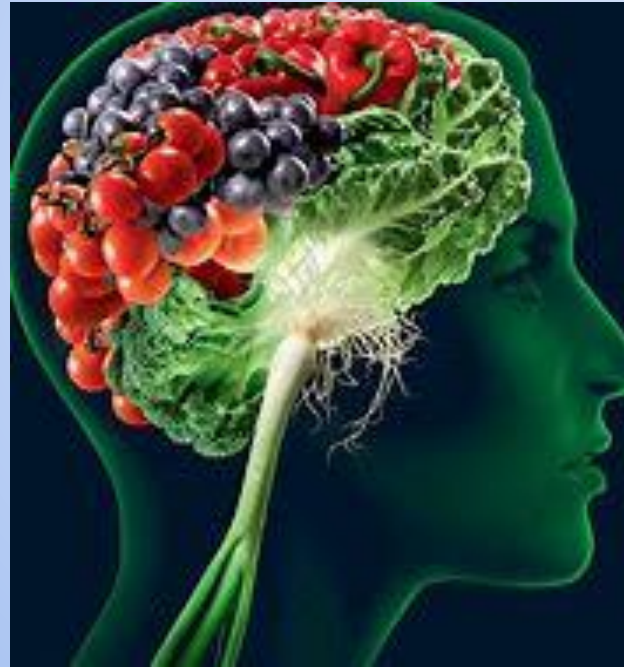
Other Trace Minerals

- **Zinc:** deficiencies cause growth retardation with sexual immaturity.
- **Selenium:** protects from oxidation. Deficiency causes heart disease
- **Fluoride:** stabilizes bones and makes teeth resistant to decay
- **Chromium:** works with insulin to control blood glucose concentrations
- **Copper:** needed to form hemoglobin and collagen
- **Boron :** Affects body's use of bone building minerals such as calcium, magnesium & Phosphorus.

All trace elements play important roles in body. All trace minerals are toxic in excess.

The surprisingly dramatic role of nutrition in mental health

- <https://www.youtu.be/3dqXHHCc5IA> (17 min)



Reviewing Water and Mineral content...

1. Water balance is governed by the:

- a. Liver
- b. Kidneys
- c. Brain
- d. b and c

2. Which two minerals are major constituents of bone?

- a. Calcium and zinc
- b. Phosphorus and calcium
- c. Sodium and magnesium
- d. Magnesium and calcium

Reviewing water and minerals content... (cont.)

3. The best way to control salt intake is to cut down on processed and fast food

- a. T
- b. F

4. The most abundant mineral in the body is iron:

- a. T
- b. F