MACRO-MINERALS

What Are Minerals?

- Inorganic elements essential to the nutrition of humans
- 14 minerals are essential to body function
  - Play several key roles in overall health and well being
    - Help chemical reactions take place in cells
    - Help muscles contract
    - Keep the heart beating
- Two groups
  - Major minerals
  - Trace minerals

WHAT ARE MINERALS?

- Major minerals
  - Need to consume > 100 milligrams per day
  - At least 5 grams of the mineral in the body
  - Calcium, sodium, potassium, chloride, phosphorus, magnesium, and sulfur

Minerals

Very Important Roles in overall health and well-being

- Assist in **Chemical Reactions** in Cells
- Crucial to the **Immune System** Function
- **Fluid Balance**
- Nutrient **Transport** into Cells
- Help **Skeletal Muscle** Contract
- Maintain **Heart Beat**!

Two Groups:

Major and **Trace** Minerals

Major Minerals (macrominerals)

Need more than 100 mg/day.

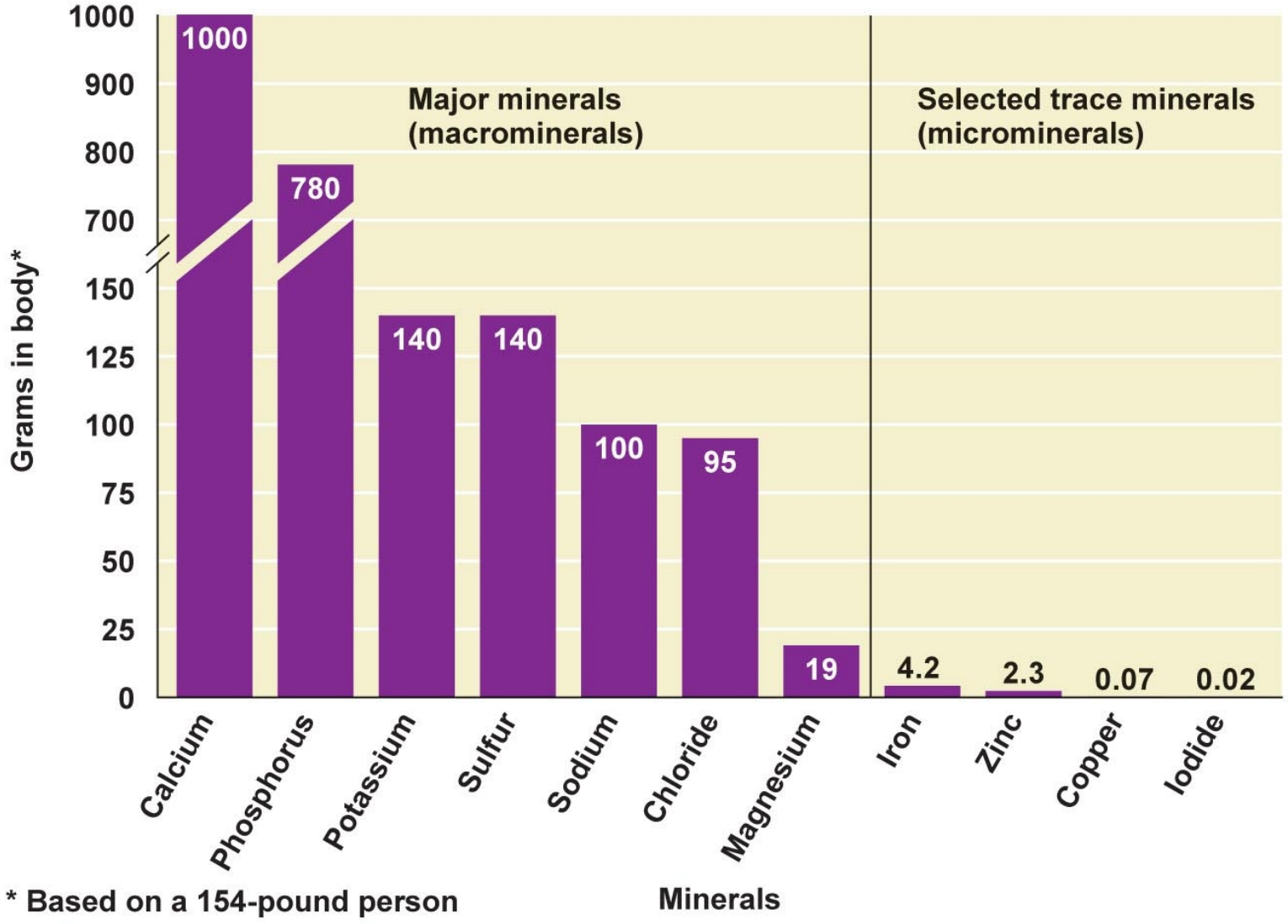
Min of 5 grams in the body.

The major minerals are the *6 dietary minerals* your body needs in the largest amounts.

These Include:

- **Calcium**
- **Phosphorus**
- **Potassium**
- **Sulfur**
- **Sodium**
- **Chloride**
- **Magnesium**

The Minerals in Your Body



Minerals

- Do not contain carbon
- Are most often found
  - As individual ions
  - Inorganic compounds

› Remain intact during digestion

› Generally do not change shape or structure when performing biological functions

› Most minerals absorbed from the diet are in the form of water-soluble salts

› Are not destroyed by heat, acid, oxygen, or ultraviolet light

› Mineral bioavailability: Degree to which a nutrient from food is absorbed and utilized in the body

Bioavailability

- Degree the nutrient from food is absorbed and utilized in the body
- Nutritional Status and Competing Minerals in GI tract. can affect absorption.

Other Nutrients can Improve Bioavailability.

- Vitamin **C** enhances **iron** absorption.
- Vitamin **D** enhances **calcium** absorption.
- **Animal Protein** enhances **zinc** absorption.

Mineral Bioavailability

Table 12.1

Factors That Affect the Bioavailability of Minerals

Factors That Increase Bioavailability	Factors That Reduce Bioavailability
Deficiency in a mineral increases absorption	Binders, such as oxalates found in some vegetables
Cooking increases the bioavailability of minerals in legumes	Phytates found in grains
Vitamin C increases the absorption of some minerals such as iron	Polyphenols in tea and coffee
Vitamin D increases the absorption of calcium, phosphorus, and magnesium	Supplementation of single minerals affects absorption of competing minerals

Mineral Functions

- Minerals work together to perform important functions in the body
  - Fluid and electrolyte balance
  - Blood formation
  - Building healthy bones
  - Maintaining a healthy immune system

Minerals Help Maintain Fluid Balance

› Minerals play a key role in fluid balance in the cells
  - Extracellular minerals – sodium and chloride
  - Intracellular mineral – potassium with the help of calcium, magnesium, and sulfur

Mineral Participate as Cofactors

- Cofactor – substance that helps catalyze a reaction
- Minerals serve as cofactors in
  - Antioxidant systems
  - Energy production
  - Muscle contraction
  - Nerve transmission

Minerals Make Up Bones and Teeth

- Minerals make up the crystalline structure (hydroxyapatite) that gives strength to bones and teeth
  - Major minerals
    - Calcium, phosphorus, and magnesium
  - Trace mineral
    - Flouride

Minerals Can Be Toxic

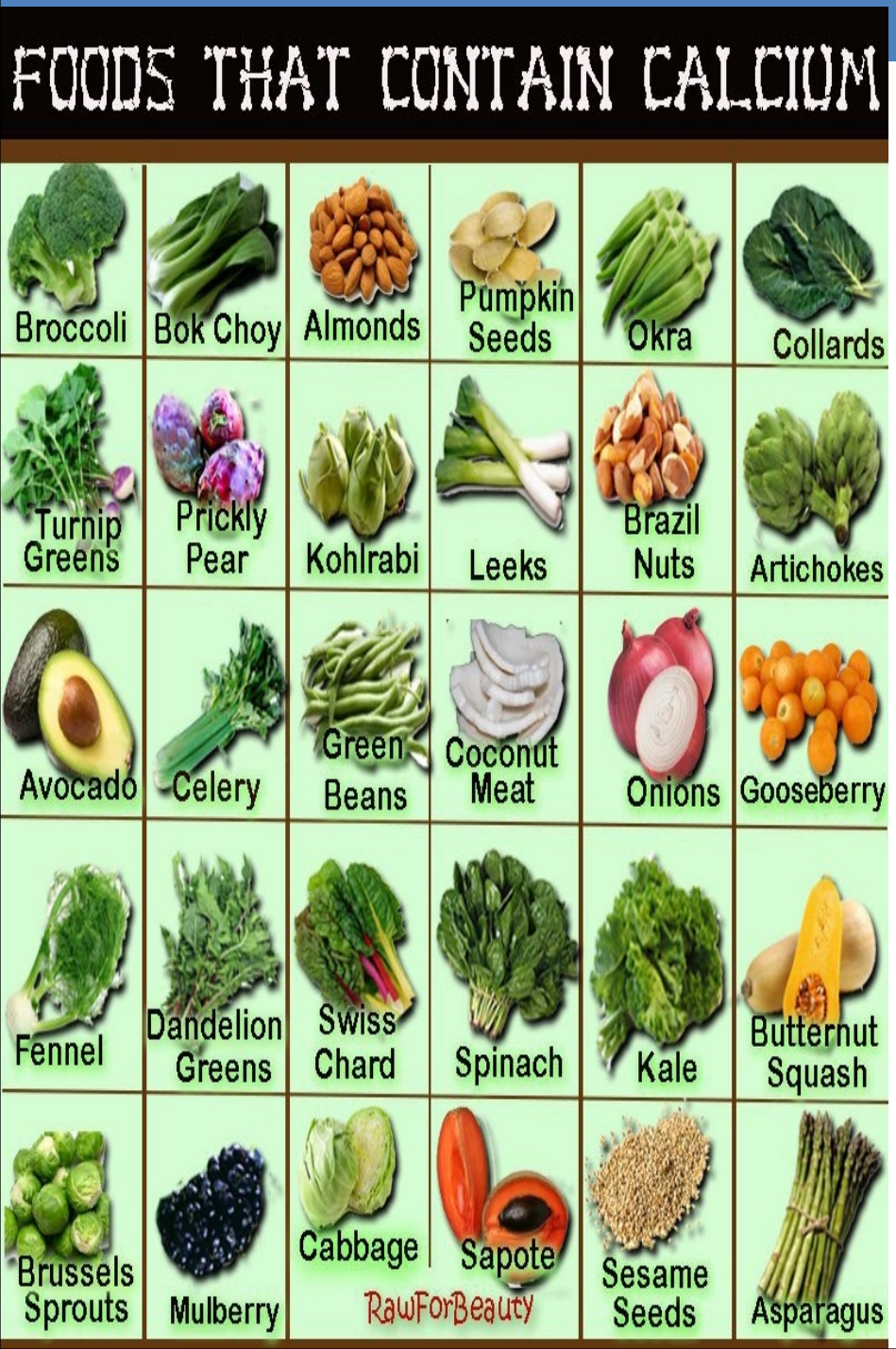
- If ingested in high amounts, minerals can be toxic; however, mineral toxicity is rare
- Toxicity most often seen with
  - Large amounts of supplements
  - Certain conditions that interfere with the body's adaptive abilities
- Toxicity not generally seen from excess dietary intake

1. Calcium (Ca^{2+})

- **Most abundant mineral** in body!
- Divalent **Cation** (has a + 2!)
- 99% of body's Ca^{2+} located in bones and teeth.

Some of the Top Foods for Calcium!

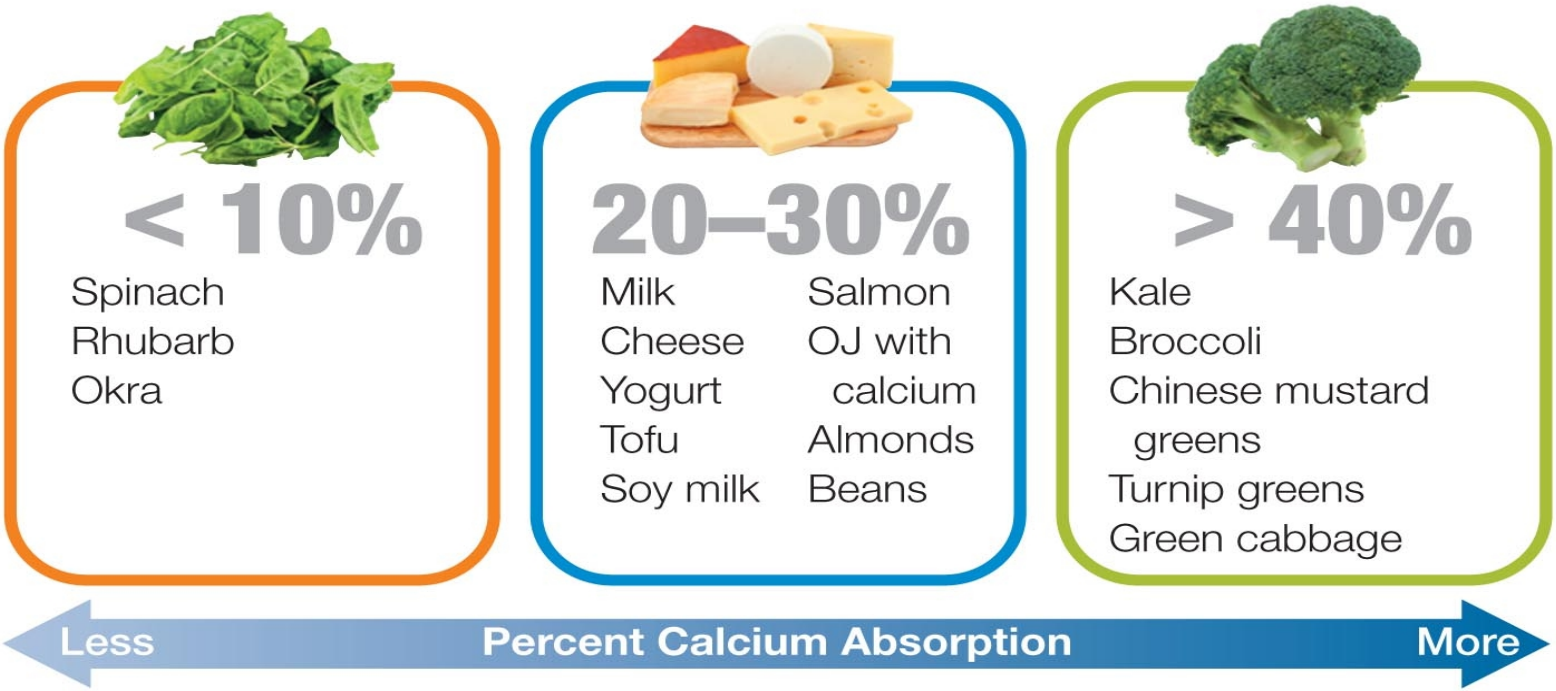
#1: **Cheese** (Mozzarella) - 961mg (95% DV)
#2: **Milk & Yogurt** - 125mg (13% and 49% DV)
#3: **Dark Leafy Greens** (Watercress, Kale) - 120mg (12% DV)
#4: **Cabbage** (Bok Choy) - 105mg (11% DV)
#5: **Okra** (Cooked) - 77mg (8% DV)
#6: **Broccoli** - 47mg (5% DV)
#7: **Green Beans** - 37mg (4% DV)
#8: **Almonds** - 264mg (26% DV)
#9: **Sardines** (in Oil with Bones) - 383mg (38% DV)
#10: **Pink Salmon** - (8%)



Bioavailability:

Vitamin D and lactose ↑ absorption.

Low **Protein** intake ↓ absorption.



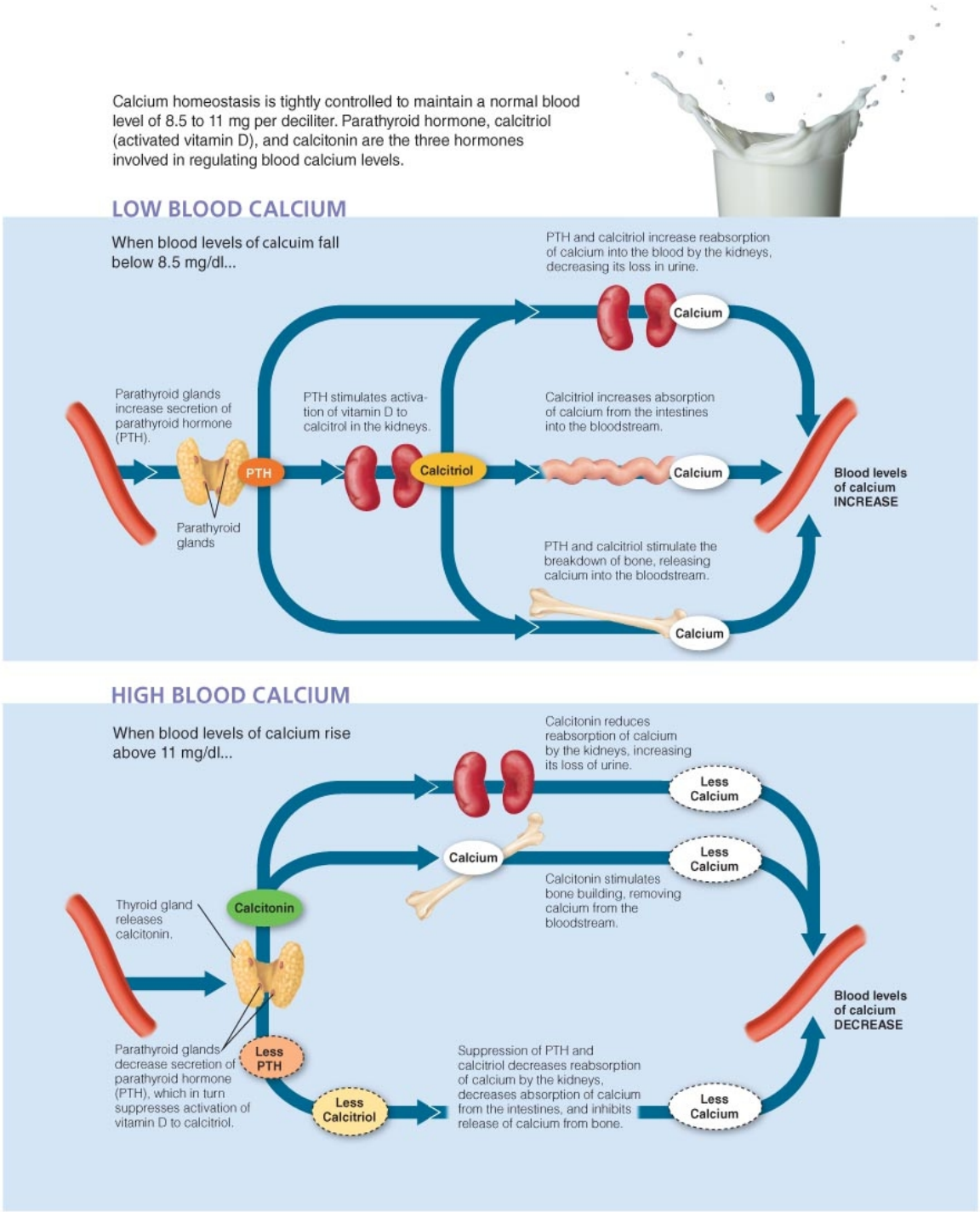
Absorption

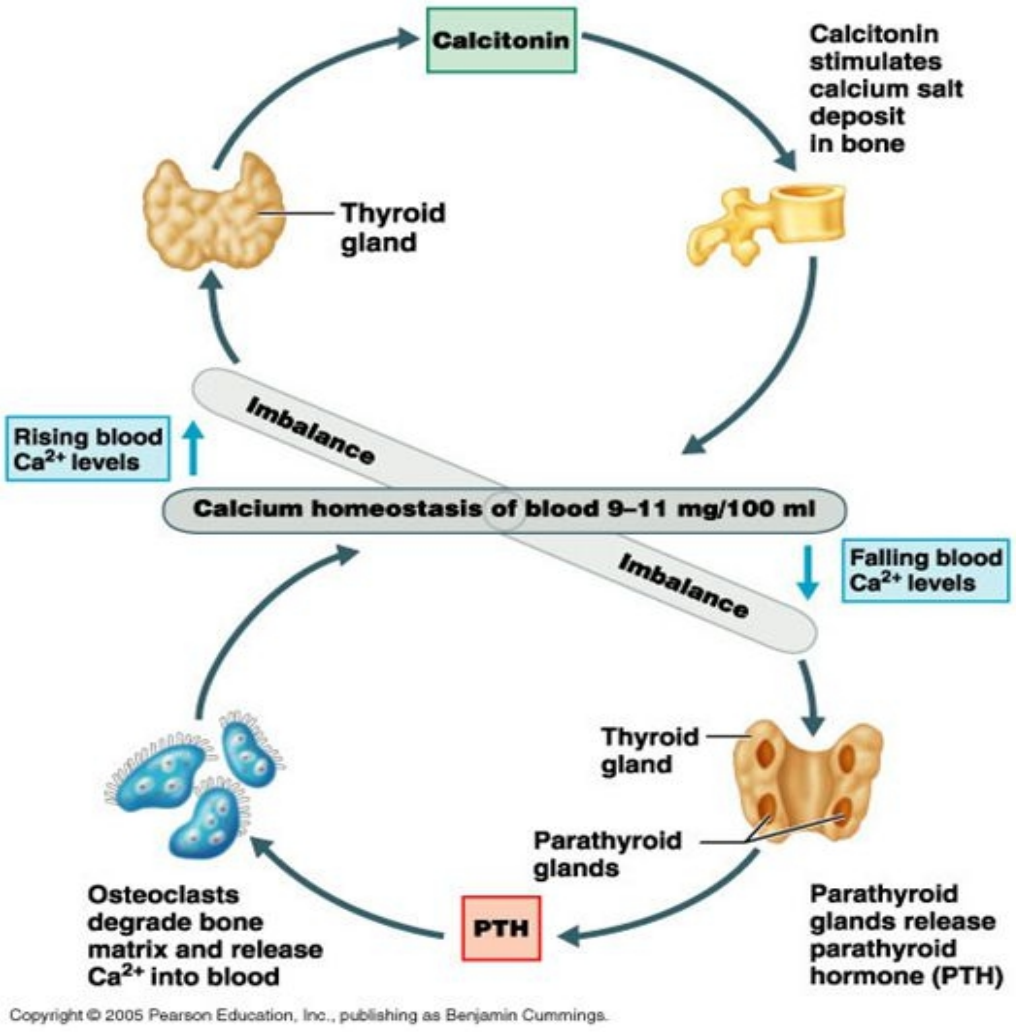
Low blood Ca^{2+} increases Ca^{2+} absorption.

The more Ca^{2+} consumed at once time, less absorbed.

Hormones Regulate Calcium Homeostasis (Balance)

Calcitriol (Vit. D_3)
Parathyroid Hormone
and
Calcitonin





- Regulation
  - Feedback loops (Whether and when)
    - Calcium homeostasis in the blood
    - Parathyroid hormone (PTH)
      - Elevates blood calcium concentration by increasing resorption
    - Calcitonin
      - Increase calcium deposition by osteoblasts

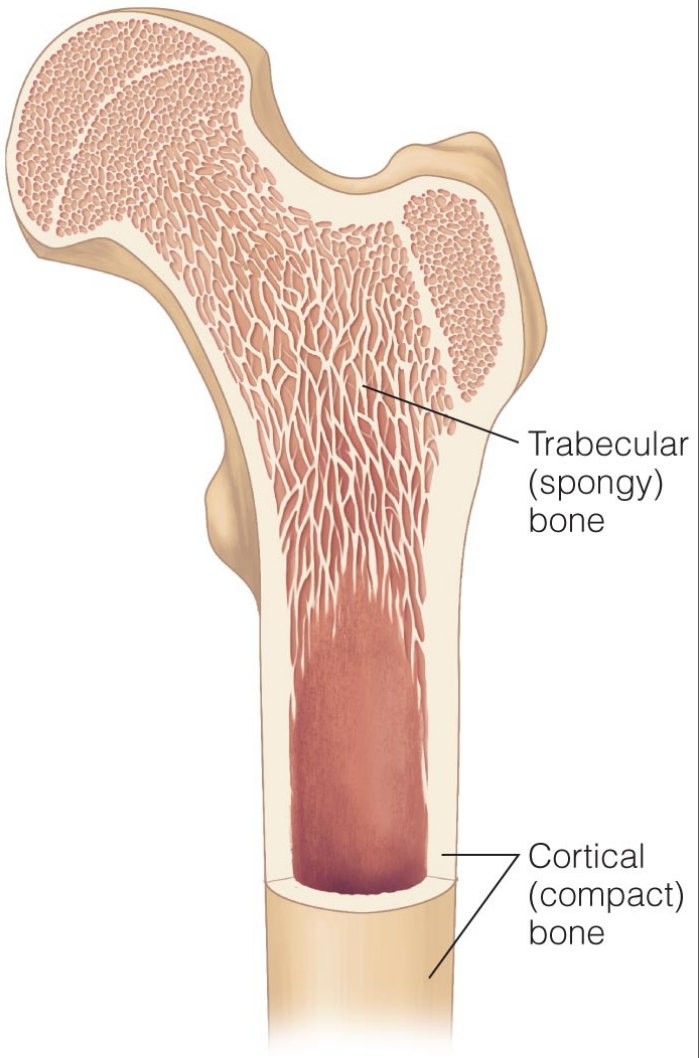
Functions of Calcium

Ca^{2+} helps build strong bones and teeth.

- Hard Outer Bone Surface

- Trabecular Bone:

Inside of bone; more sensitive to changes in dietary calcium



Calcium Functions: Many Important Roles:

- ❑ Muscle Contraction
- ❑ Nerve Transmission – release of Neurotransmitter!
- ❑ Regulating Hormones and Enzymes
- ❑ Blood Vessel Dilation/Constriction: Blood Pressure
- ❑ Blood Clotting

Calcium may:

a)Prevent **Colon Cancer** – by protecting lining of tract from caustic and abrasive substances.

b)Reduce the risk of **kidney stones** – Ca^{2+} binds to oxalates in foods.

c)Reduce the **risk of obesity** – by normalizing interactions between hormones.

Inadequate Ca^{2+} shifts hormonal response of PTH and calcitriol which may stimulate fat production and storage.

Daily Needs for Ca^{2+}

AI for Adults: 1,000 to 1,100 mg/day

UL: 2,500 mg/day

Ca^{2+} Toxicity

Hypercalcemia: Too much Ca^{2+} in blood

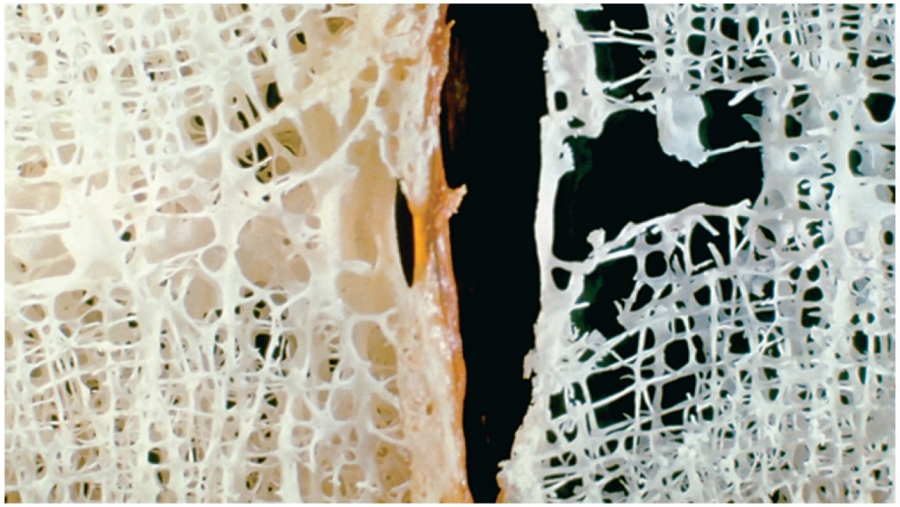
Symptoms:

- **Constipation**
- **Bone pain**
- **Muscle weakness**
- **Mental confusion**
- **Impairs absorption of Fe, Zn, Mg and P.**

Ca^{2+} Deficiency

Hypocalcemia: Blood Ca^{2+} levels below normal

- Bones less dense, weakened and brittle.
- ↑risk of **Osteoporosis** and **Bone Fractures**



Do not take a calcium supplement at the same time of day as an iron supplement!

2. Phosphorus (PO_4^{3-})

2nd most abundant Mineral in Body

Most (85%) in **Bone Tissue**
the rest in muscle, cell membrane, ECF

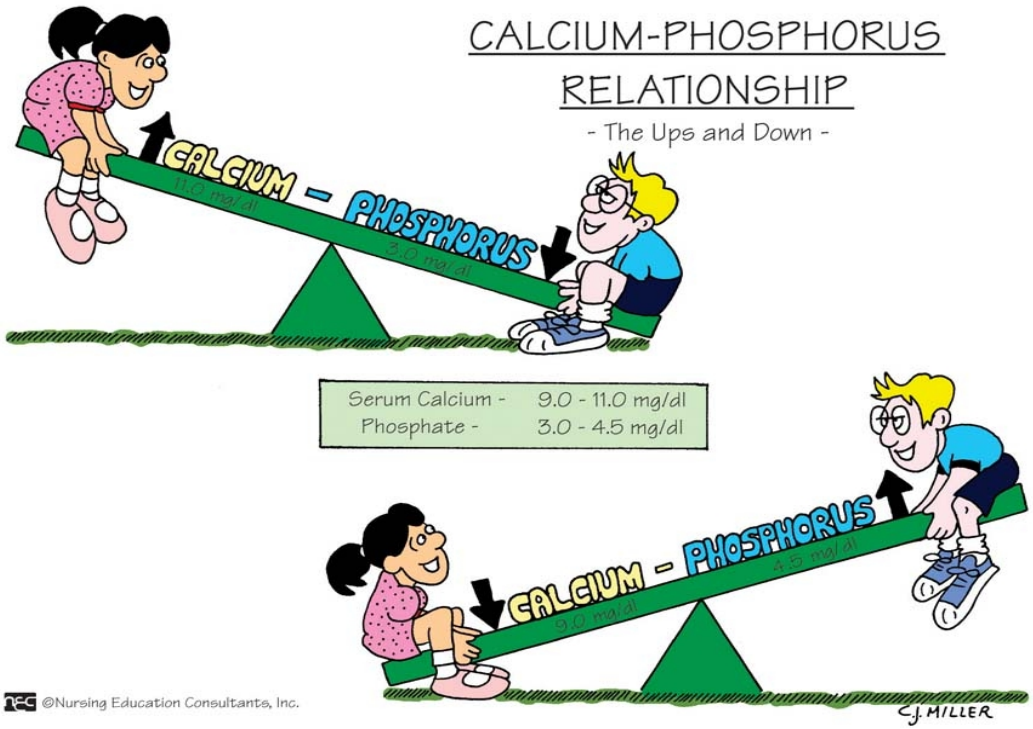
Absorbed in the Small Intestine
Vitamin D enhances **bioavailability**.

Parathyroid Hormone (PTH)

This hormones regulates **P** homeostasis.

- Stimulates resorption of **P** from bone
- Stimulates **P** excretion from kidney

Excretion – most **P** lost in **Urine**, some in **Feces**



Phosphorus Needs in the Body!

- Formation of Bones and Teeth
- Integral part of cell membrane
  Phospholipids
- Required for ATP and Creatine Phosphate

"Phosphate Backbone" is part of **DNA** and **RNA** in every cell!

RDA Adult: 700 mg/day

UL: 4,000 mg/day

Americans consume 1,000 mg/day.

Food Sources of Phosphorus

- Foods from animal sources
- Plant seeds – 50% of P is bioavailable due to ***phytates***.
- Soft drinks and colas contain phosphoric acid.

P Toxicity

Hyperphosphatemia - Only with kidney disease

High intake of **P** with low Ca^{2+} intake can decrease bone mass.

P Deficiency is rare.

Hypophosphatemia

Muscle weakness, bone pain, **rickets**, confusion, and death in extreme cases!

3. Potassium (K^+)

- **Major Cation** in intracellular fluid (**ICF**)
- Absorbed in **Small Intestine** and **Colon**
- Kidneys regulate balance ***excreting excess***.

- **Muscle Contraction** and **Nerve Impulse**.
- Rhythmic Heart Beats.
- Regulate Blood Pressure when excreted.
- Acts as a **Buffer** in Blood.
- Preserves Ca^{2+} and PO_4^{3-} in bones.

Minor amounts are lost in sweat.

Daily Needs

Adults: 4,700mg/day.
May ↓ Hypertension.

May ↓ bone losses and risk of kidney stones.

The Fabulous Fifteen

Nutrient Rating for K

Food Source	DV
Beet Greens	37%
Lima Beans	27%
Swiss Chard	27%
Sweet Potato	27%
Potatoes	26%
Spinach	24%
Avocado	21%
Pinto Beans	21%
Bananas	10%

Most Americans fall short.
F ~2,200 and M~3,300mg/day.

K Toxicity

Hyperkalemia: Too much K^+ in blood!

Cannot occur from food intake – but with supplementation or salt substitutes!

This can lead to:

- **Irregular heart beat**
- **Heart damage**
- **Death**

If kidneys impaired or taking medications for heart disease or diuretics ↑ risk and need to be cautious.

K^+ Deficiency

Hypokalemia: Too little K^+ in blood.

- ↑risk of **hypertension**, kidney stones, and loss of bone mass.
- Caused by prolonged **vomiting** or **diarrhea**

Can lead to:

- Muscle Weakness and Cramps
- Irregular Heart Beat and Paralysis

4. Sodium (Na)

- **Major Mineral** => Na^+ Electrolyte
- **Cation** usually combined with chloride (NaCl)

- Primarily in Blood and extracellular fluid (ECF)
- Regulates Blood Volume

Table salt – *a*ccounts for 90% of our Na - part of our problem? Please, use **Sea Salt**!

40% wt table salt = Na; 60% wt table salt = Cl

Absorption, Transport, and Excretion of Na

- 95-100% absorbed in Small Intestine!
- About 5% Excreted in Feces.
- Blood levels Maintained by **Kidneys**.

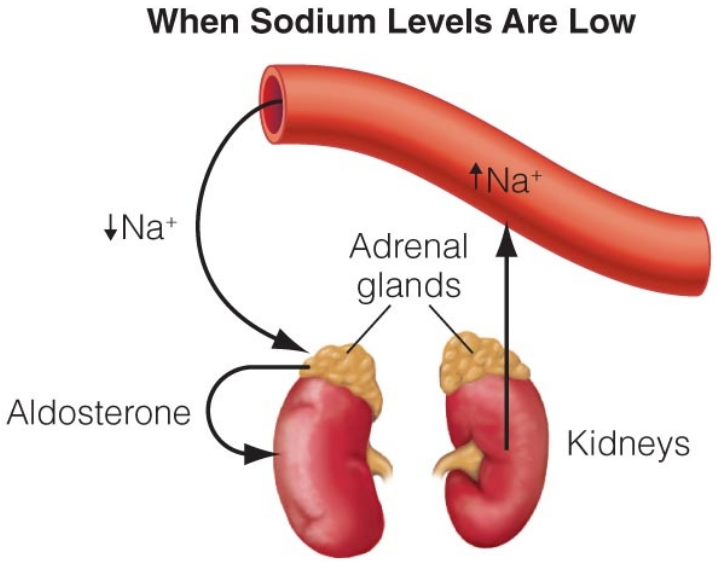
Na Regulates Fluid Volumes:

High [Na^+] signals need to **Conserve Water**.

Hypertonic ('salty') blood triggers **Thirst** mechanism in Hypothalamus – signals drinking!

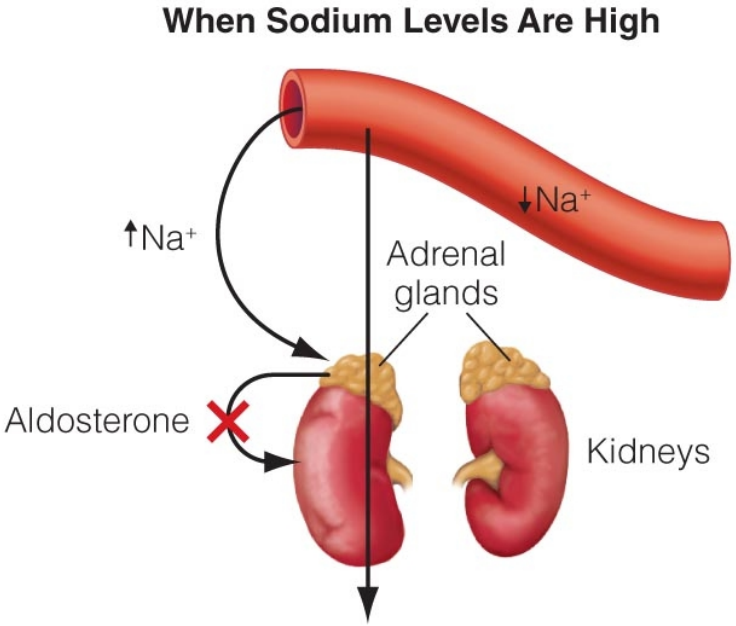
Na loss through perspiration!

Sodium Balance Maintained by Kidneys



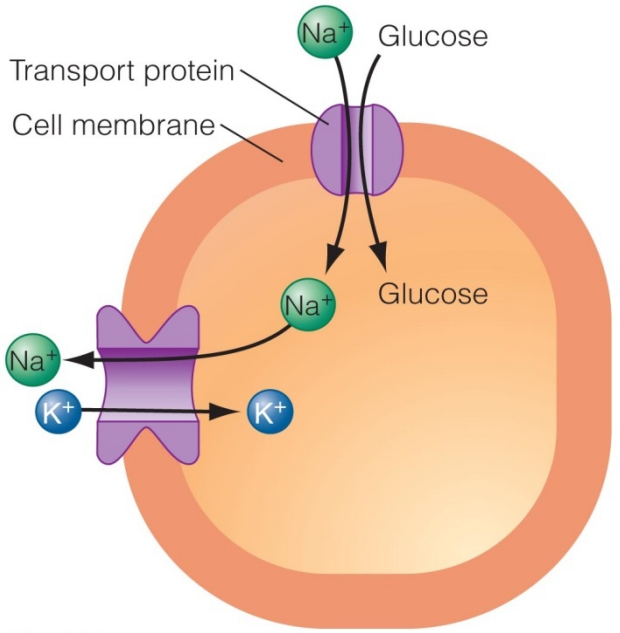
a When sodium levels in the blood are low, aldosterone is released from the adrenal glands, which triggers the kidneys to reabsorb sodium into the blood.

Aldosterone causes kidney to **retain** sodium!



b When sodium levels in the blood are high, the adrenal glands stop secreting aldosterone, and the kidneys excrete the excess sodium through the urine. This lowers the levels of sodium in the blood.

Na plays a role in nerve **impulse transmission** and participates in muscle contraction



- Helps transport some nutrients

- Preserves and enhances food flavor!

Food Sources of Sodium

Some Facts and Figures about Na use:

- About **70%** of Na is from processed foods.

  Canned, processed meats, frozen or pre-packaged meals

- Only **12%** comes from natural food sources

- About **5%** added during cooking.

- About **6%** added at the table.

Hypernatremia (excess Na in blood) – when fluids not replenished as water is lost (e.g. vomiting or diarrhea)

* Or, from ingesting too much Na^+

Sodium deficiency is rare.

Hyponatremia - from consuming too much water in a short time, e.g. endurance athletes.

Symptoms: Headache, muscle weakness, fatigue, seizures, as we have seen, can cause death.

5. Chloride (Cl^-)

- A **Major** Electrolyte
- An **Anion** bound to Na (NaCl in foods)
- Primarily in **blood** (**88**%), the other **12**% is:
  - in intracellular fluid (**ICF**)
  - part of **HCl** (hydrochloric acid) in stomach
- After ingestion, **dissociates** in the stomach.
- **Absorbed** in Small Intestine - **Excreted** in Urine

Not to be confused with chlorine, a powerful disinfectant, poisonous if inhaled or ingested.

Metabolic Functions of Chloride

- Maintains Fluid Balance.
- Assists in the removal of **CO_2** from blood.
- Maintains normal pH range of blood.
- Part hydrochloric acid (**HCl**).

Chloride Daily Needs and Food Sources

- Daily needs: Adults >50 is 2,300 mg/day.

  In general, Americans currently consume 3,400 mg/day to >7,000 mg/day.

Food Sources:

- **Table salt**
- **Processed foods**
- **Seaweed, tomatoes, olives, lettuce, celery, and rye**
- ***Salt substitutes***

Daily Needs of Cl

UL = 3,600 mg. Toxicity is very rare.

*Can occur with severe dehydration (**hyperchloremia**)

- **Deficiency -** Rare

  From prolonged **diarrhea** or **vomiting**.

  Diuretics can increase urinary losses.

  Symptoms: shallow breathing, muscle weakness, muscle spasms, and twitching

MICRO-MINERALS (TRACE ELEMENTS)

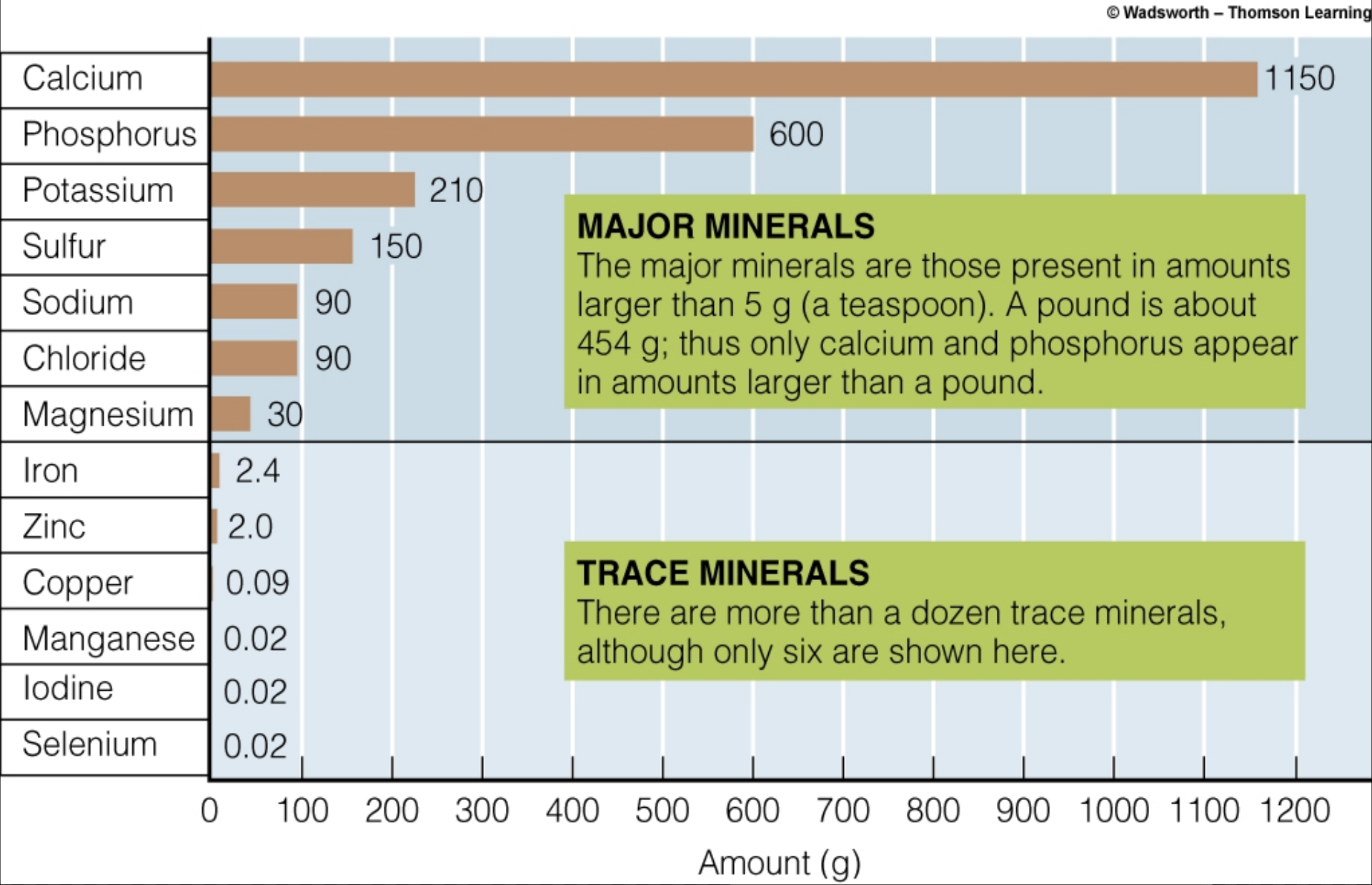
Minerals

- Two categories:
  - macrominerals > 0.005%
  - microminerals < 0.005%
- macrominerals are essential at levels of 100mg or more per day for human adults
- microminerals are often referred to as trace elements

Trace minerals

- Need to consume > 20 milligrams per day
- The body contains less than 5 grams total
- Iron, zinc, copper, selenium, chromium, iodide, manganese, molybdenum, and fluoride

The Trace Minerals



ZINC

ZINC

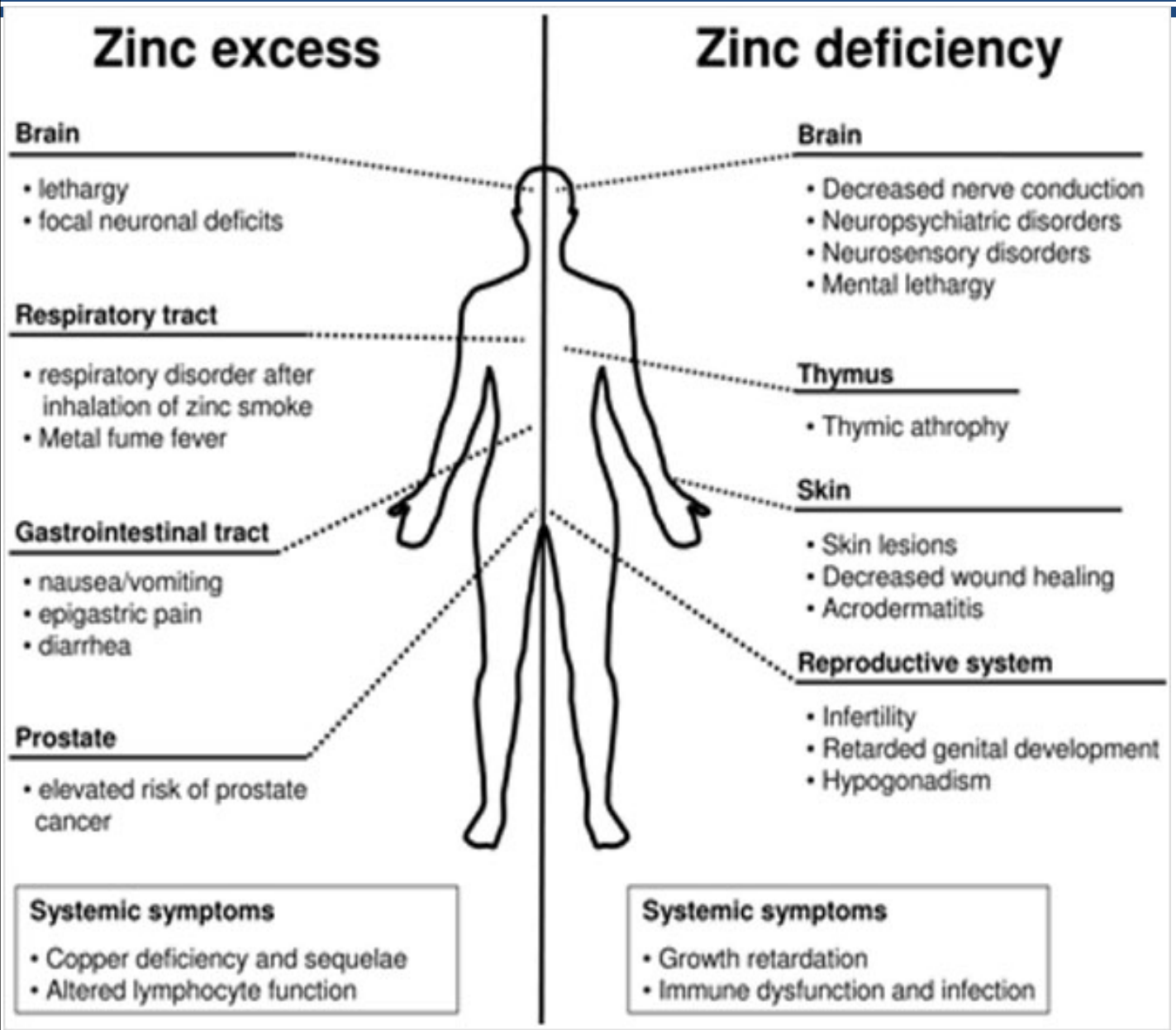
- Biological roles
  - Involved in many enzymes (over 20 metalloenzymes)
    - Carbonic anhydrase
    - Carboxypeptidase A
      - Four types of proteases
        - Serine
        - Cysteine
        - Aspartic acid
        - Zinc

ZINC

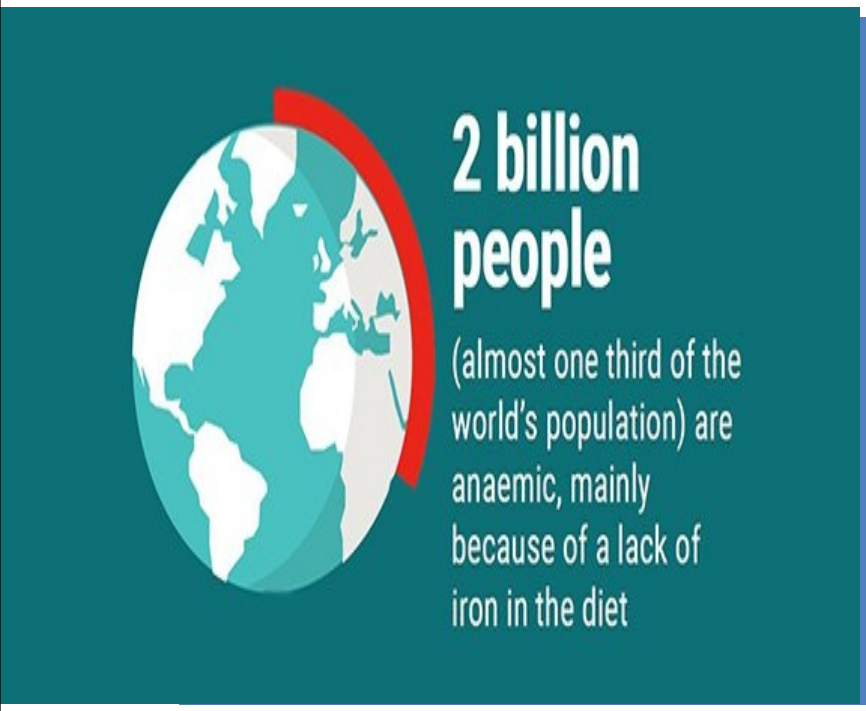
- Zinc absorption appears to be dependent on a transport protein, metallothionein
- Deficiencies include poor growth, delayed wound healing, impairment of sexual development and decreased taste acuity
- Zinc is present in gustin, a salivary polypeptide that is necessary for the development of taste buds

ZINC

- Severe zinc deficiency is seen primarily in alcoholics (especially if they have developed cirrhosis), patients with chronic renal disease or severe malabsorption diseases
- Occasionally seen in patients on long term total parenteral nutrition (TPN) –patient develop a dermatitis
- Zinc is occasionally used therapeutically to promote wound healing and may be of some use in treating gastric ulcers



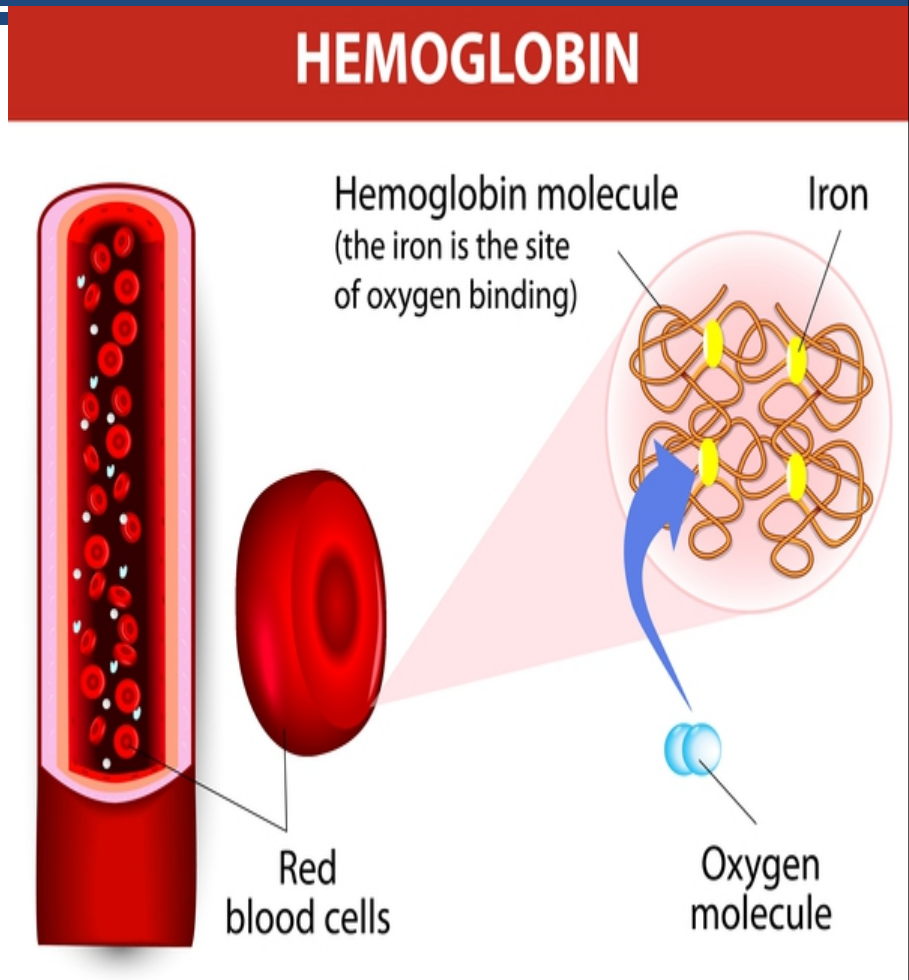
IMBALANCE OF ZINC AMOUNT


2 billion
people
(almost one third of the world's population) are anaemic, mainly because of a lack of iron in the diet

IRON

Iron

- Iron deficiency is the most widespread vitamin or mineral deficiency in the world.
  - 70% of your body's iron is in your hemoglobin.
  - Too little iron = too little oxygen

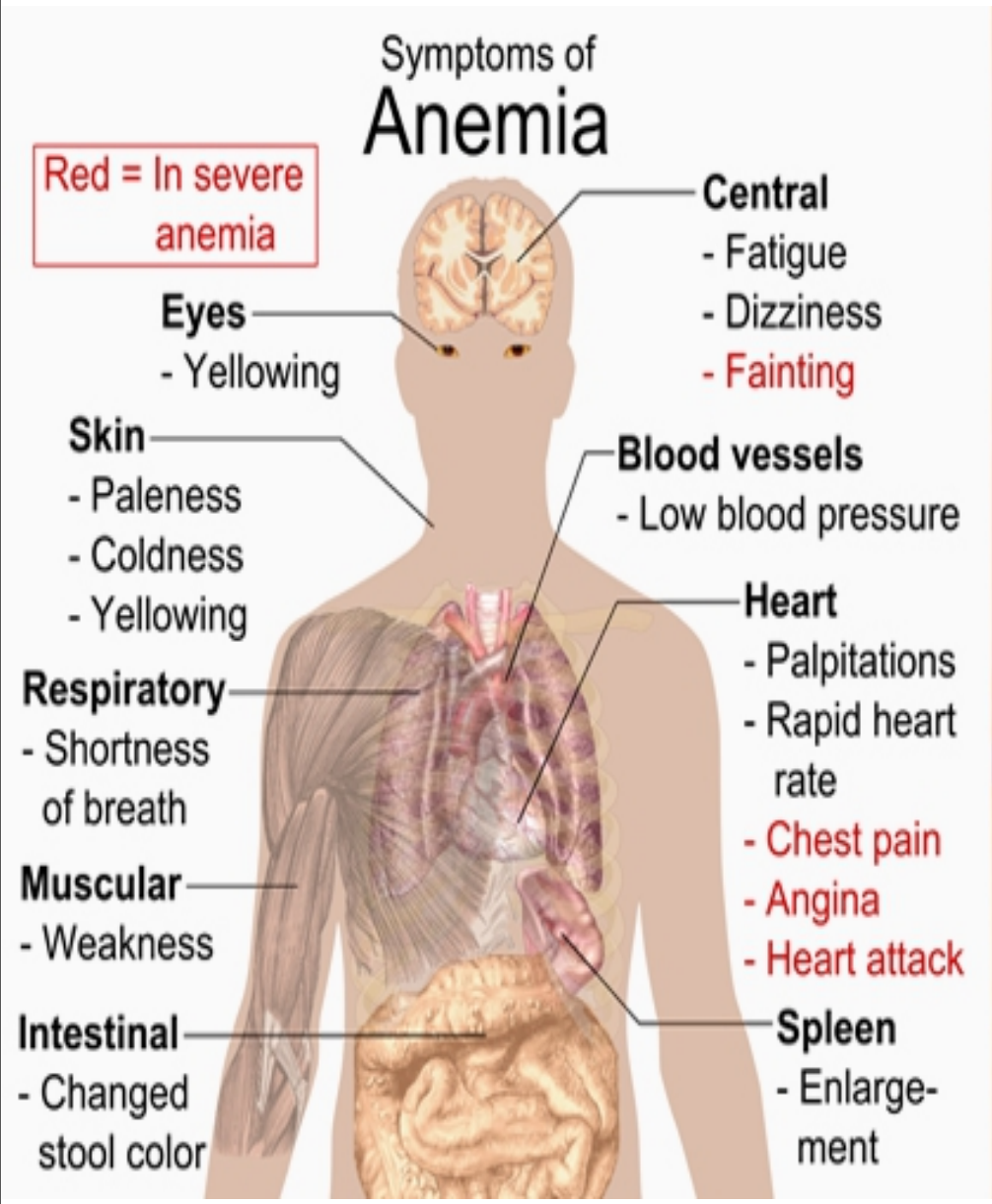


IRON & FOODS

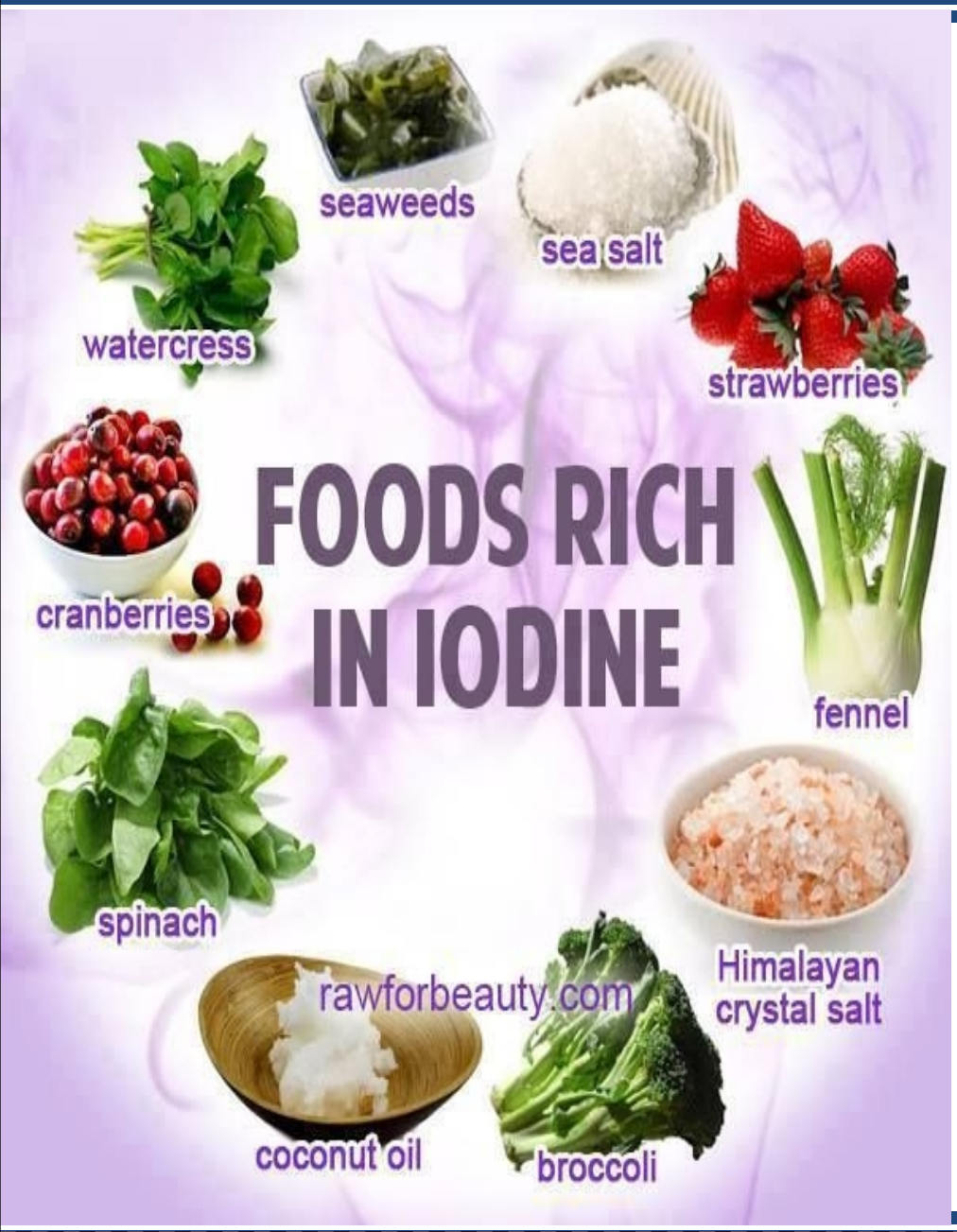
- Heme iron:
  - Found in animal products
    - Red meats, liver, poultry and eggs
- Non-heme iron:
  - Found in plant products
    - Beans, nuts, seeds, dried fruits, fortified breads and cereals

Symptoms of iron deficiency

Fatigue	Poor cognitive function
Tachycardia	Reduced exercise tolerance
Palpitations	Inability to maintain proper body temperature
Rapid breathing on exertion	Brittle & spoon-shaped nails
Restless leg	Sores at corner of mouth
Infections	Pica


Symptoms of
Anemia
Red = In severe anemia
Central
- Fatigue
- Dizziness
- Fainting
Eyes
- Yellowing
Skin
- Paleness
- Coldness
- Yellowing
Blood vessels
- Low blood pressure
Heart
- Palpitations
- Rapid heart rate
- Chest pain
- Angina
- Heart attack
Respiratory
- Shortness of breath
Muscular
- Weakness
Intestinal
- Changed stool color
Spleen
- Enlarge-ment

IODINE



- Iodine is an element that is needed for the production of thyroid hormone.
- If you do not have enough iodine in your body, you cannot make enough thyroid hormone.

HEALTH BENEFITS OF IODINE

Organic Facts
www.organicfacts.net

- Controls body's base metabolic rate
- Stimulates hormonal activity
- Maintains optimal energy levels
- Prevents dangerous forms of cancer
- Forms healthy & shiny skin
- Flushes out chemical toxins
- Boosts immune system
- Cures enlarged thyroid gland

TOP 10 IODINE FOODS

DrAxe.com
FOOD IS MEDICINE

1 Dried Seaweed

4500 mcg
(100% DV)
1/4 OZ

2 Cod Fish

99 mcg
(66% DV)
3 OZ

3 Cranberries

90 mcg
(60% DV)
1 OZ

4 Yogurt

87 mcg
(58% DV)
1 CUP

5 Baked Potato

60 mcg
(40% DV)
1 MEDIUM

6 Turkey Breast

34 mcg
(23% DV)
3 OZ

7 Navy Beans

32 mcg
(21% DV)
1/2 CUP

8 Tuna

17 mcg
(11% DV)
3 OZ

9 Strawberries

13 mcg
(8.6% DV)
1 CUP

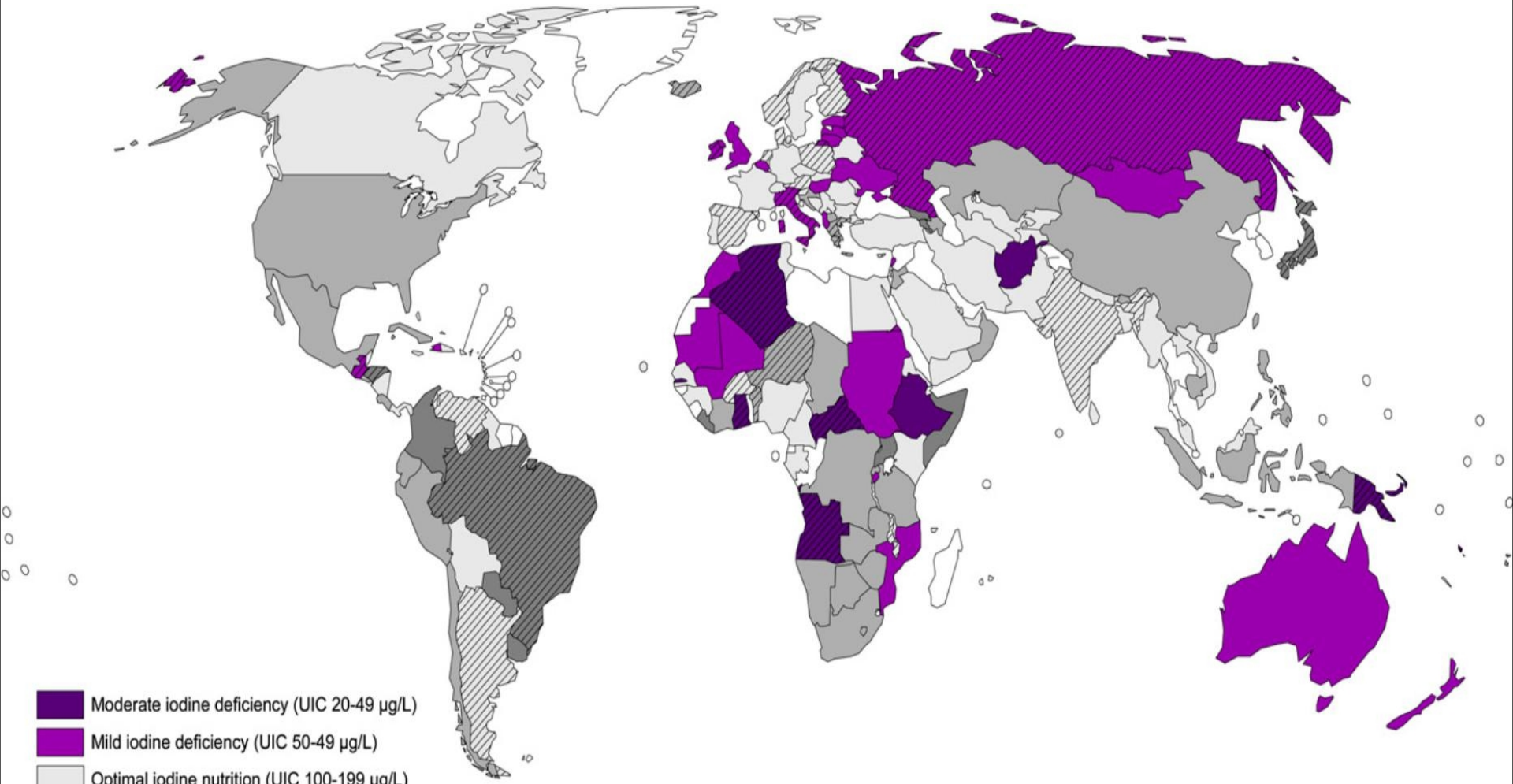
10 Eggs

12 mcg
(8% DV)
1 LARGE

IODINE DEFICIENCY

- Thus, iodine deficiency can lead to enlargement of the thyroid, hypothyroidism and mental retardation in infants and children whose mothers were iodine deficient during pregnancy.
- Iodine deficiency and the resulting low levels of thyroid hormone can cause women to stop ovulating, leading to infertility.
- Iodine deficiency can also lead to an autoimmune disease of the thyroid and may increase the risk of getting thyroid cancer.
- Iodine plays an important role in development of the central nervous system.
- In extreme cases, iodine deficiency can lead to cretinism, a disorder that involves severely stunted physical and mental growth.

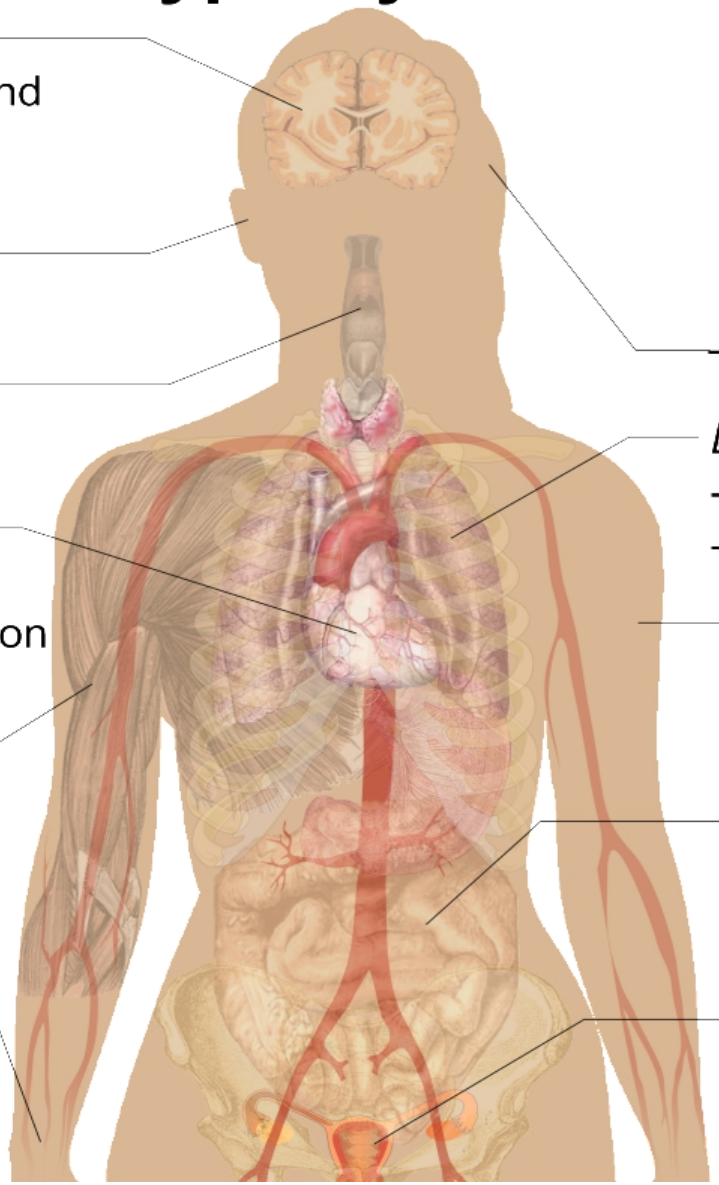
IRON DEFICIENCY



[a] The country estimates in the cross-hatched countries are based on subnational data. The national coverage of iodized salt in these countries is incomplete, there are large variations in the iodine intake and some regions likely remain deficient.

Signs and symptoms of

Hypothyroidism



Psychological
- Poor memory and concentration

- Poor hearing

Pharynx
- Hoarseness

Heart
- Slow pulse rate
- Pericardial effusion

Muscular
- Delayed reflex relaxation

Extremities
- Coldness
- Carpal tunnel syndrome

General
- Fatigue
- Feeling cold
- Weight gain with poor appetite

- Hair loss

Lungs
- Sortness of breath
- Pleural effusion

Skin
- Paresthesia
- Myxedema

Intestines
- Constipation
- Ascites

Reproductive system
- Menorrhagia