Trace minerals

- iron
- zinc
- copper
- fluoride
- selenium
- iodine
- chromium
- manganese
- molybdenum

Trace minerals

• needed in tiny amounts (less than 100 mg/day)

• ESSENTIAL! General functions:
  • cofactors
  • hormone function
  • participate in chemical reactions

• good vs. toxic amounts sometimes not far apart
  • FDA cannot reg amounts of trace minerals in supplements
  • important not to habitually ingest >100% daily value

• interactions between trace minerals common, easily leads to imbalance
  • variety of foods good!

• TM content of foods varies with soil, water composition, processing

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Not covering all trace minerals- only iron, zinc and iodide
Iron has special property: transfers electrons very easily
ALL cells of body require iron!!
Factors listed are among most important - when iron imbalance problems more obvious in these areas

• **Oxygen transport**
  - iron is center of **heme molecule**: binds O\(_2\) in **hemoglobin & myoglobin**
  - most of iron in body in hemoglobin & myoglobin

• **Enzyme function**
  - can serve as **cofactors**: (inorganic components of enzymes)
  - help make up **cytochromes**
  - first step of Kreb’s cycle requires iron-containing enzyme [explains fatigue with deficiency!]

• **Immune Function**
  - enzymes in **WBCs** require iron

• **Brain function**
  - enzymes responsible for making **neurotransmitters** require iron
Iron Intake & Absorption

- Iron status
- GI function
- Iron in food
  - heme
  - non-heme

Iron absorption: in general, varies between 1% - 50%!

- Iron status
  - absorption more efficient when need higher

- GI function
  - MUST have enough HCl in stomach
  - HCl production decreases in elderly - decreases iron absorption
  - antacid use hinders iron absorption

- Iron in food comes in two forms
  - heme
    - found in hemoglobin or myoglobin
      - only present in animal tissue
    - much greater bioavailability
  - non-heme
    - found in plant foods, iron-fortified foods (example in book- spinach!!!)
      - less bioavailable

  - Ferrous iron (+2) Vs. Ferric iron (+3)
    - +2 is better absorbed
    - Acid in the stomach promotes the conversion of +3 to +2

Recommendations for iron intake:
  - men & postmenopausal women: 8 mg/day
  - premenopausal women: 18 mg/day

Sources of iron in diet
  - clams
  - beef
  - oysters
  - fortified cereals
  - cooking in an iron skillet
  - NOT GOOD: dairy
## Dietary factors that affect iron absorption

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<td>Vitamin C</td>
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<td>MFP factor</td>
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<tr>
<td>Tannins</td>
<td>HCl</td>
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<tr>
<td>Polyphenols</td>
<td>Citric, malic, &amp; lactic acid</td>
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<td>Oxalate</td>
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### Inhibitors
- **Fiber, phytate**
  - phytate = plant molecule, has lots of phosphate groups, responsible for binding positive ions
- **milk/dairy**
  - calcium, zinc compete with iron for absorption
- **phytochemicals**: tannins, polyphenols(catechins?) - found in tea
- **oxalate** (phytochemical)
  - organic acid found in leafy green veggies

### Enhancers
- **Vitamin C**
  - helps with non-heme
- **MFP factor**
  - protein found in meat, fish, poultry that promotes absorption of NON-HEME iron
- Some **acids** help
Iron transport and storage

- special proteins necessary for iron absorption into intestinal cells:
  - **mucosal ferritin** accepts iron into intestinal mucosa cells, stores
    - if needed by body, gives to **mucosal transferrin**
    - mucosal transferrin gives to **blood transferrin**
    - blood transferritin gives to tissues
  - **hemosiderin** another storage form

- **iron loss**: **feces** (intestinal lining shed every three days), nails, hair, skin cells, **bleeding**
Iron transport & storage

- Muscle
- Bone
- Liver
- Tissues

To form myoglobin
To form hemoglobin & RBCs
To be stored
To make heme enzymes or to store in ferritin & hemosiderin

Transferrin
Iron Deficiency & Toxicity

**• Anemia**

- [Image: Hemochromatic liver tissue]

- [Image: Microcytic anemia- RBC's]

**• Iron poisoning**

**• Hereditary hemochromatosis**

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**Stages of iron deficiency**
- **most common nutrient deficiency in world!**
  - frequently occurs between 6-24 months of age!
- **first stage**: depletion of **stores**
- **second stage**: depletion of functional iron
  - I.e. iron in blood transferrin low
  - heme production slows
- **third stage**: iron-deficiency anemia
  - RBC production slows
  - those that ARE made are microcytic, hypochromic
  - old RBCs die as usual

**Iron toxicity**
- **UL set for level that causes stomach upset**
- **iron poisoning**
  - a leading cause of **poisoning death** in kids - OD on iron pills
  - their GI mucosa not as good at blocking
  - sx = N/V, diarrhea, tachycardia, dizziness, confusion, death
- **hereditary hemochromatosis**
  - genetic defect
  - **excessive iron absorption**, chronic iron overload
  - mild forms common! More common in men (don’t menstruate)
  - over time (years) can lead to severe organ damage
  - Good info at http://www.brown.edu/Courses/Digital_Path/Liver/hemochromatosis.html
Zinc functions

- Enzymes
- Cell membranes
- Gene regulation
- Immune system
- Other roles

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Zinc roles fall into 3 categories: catalytic, structural, regulatory

- **enzymes**
  - helps in both catalysis and structure roles
- **gene regulation**
  - zinc required by proteins that regulate gene expression
- **immune system**: immune cells require zinc for proper enzyme function
- **other functions**
  - tons!
  - interesting: necessary for taste perception
  - stabilize cell membranes (structural)
  - fertility
  - protein/alcohol metabolism

**regulation of zinc in body**

- similar to iron, a few differences

- **absorption**
  - depends on zinc status: need, current stores
  - animal sources better absorbed
  - fiber, phytate, calcium supplements in combo with phytate decrease absorption
  - very high dose iron supplements (non-heme) decrease absorption (fortification not likely to)

- **transport**
  - protein “metallothionein” binds/stores zinc in manner similar to ferritin (mucosal or hepatic)
  - if needed, mucosal metallothionein releases zinc to be carried in bloodstream by albumin and transferrin

- **distribution**
  - many pancreatic enzymes contain zinc: pancreas absorbs Zn from circulation
    - enzymes released into SI, Zn later absorbed by intestinal cells again = enteropancreatic circulation

- **excretion**
  - primarily lost in feces (shed in lining of intestine)
  - also lost in skin, nails, urine, sweat, etc.
Zinc recommendations & sources

men: 11 mg/day
women: 8 mg/day

• Recommendations for zinc intake
  • men: 11 mg.day
  • women (NOT pregnant): 8 mg/day
  • pregnant - 11 mg/day
  • nursing - 12 mg/day

• Food sources
  • meats, seafood, organ meats
  • fortified cereals but don’t tend to be well absorbed

• Deficiency
  • uncommon in US
  • more prevalent in populations that subsist on cereals (Egypt?)
    • CAN lead to severe growth retardation, delayed sexual maturation,
    hair loss, immune dysfunction

• Toxicity
  • rare from diet
  • can occur with chronic use of supplements
  • can interfere with iron, copper absorption
  • reduces HDL, Increases risk of heart disease
  • Diarrhea, cramps, Nausea, vomiting
Iodide (I) Functions

- I⁻ vs. I₂
- Thyroxine (T₄) → Triiodothyronine (T₃)

\[
\text{NH}_2
\]
\[
\text{CH}-\text{CH-C-OH}
\]

- Gene regulation, cell metabolism

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- in food as iodide (I⁻), others
- poisonous form = iodine (I₂)

Major Functions

- Thyroid hormone synthesis (T3 and T4)
- T₄ converted to T₃ in target cells
- T₃ controls metabolic rate of cell
- important for gene regulation - ESPECIALLY critical for nervous system development (1st 6 months in utero)
- also increases glucose use and protein synthesis
Iodide transport, storage

- Free/bound to albumin or thyroid binding globulin
- Thyroid gland

- [best absorbed in inorganic form]
- easily absorbed in several forms (I⁻, IO₃⁻ etc.)
- travels in blood
  - free
  - bound to protein (albumin or thyroid binding protein)
- 75% ends up in thyroid!
- when not enough in diet, thyroid enlarges in attempt to get more - goiter
- excretion: kidneys
Recommendations & sources

- 150 µg/day
- goitrogens

Iodized salt (1/2 tsp. meets RDA for iodide)
Saltwater fish, seafood, molasses
Sea salt is a poor source (loss during processing)
Plant source dependent on soil content
RDA for adult is 150 µg/day (1 gram salt = 76 µg)
Average intake exceeds RDA

goitrogens
- chemicals (natural) in raw veggies (destroyed by cooking)
- inhibit iodide metabolism in thyroid - I.e. inhibit thyroid hormone synthesis
- not major concern in developed countries
Iodide Deficiency/Toxicity

**Deficiency**
- Insufficient $T_4$ (continual release of TSH)
- Growth of the thyroid gland (goiter)
- Drop in the metabolic rate
- Harmful during pregnancy (esp. last 2 trimesters)
- Cretinism
  - stunted growth and mental development related to iodide deficiency during pregnancy
- Excessive consumption of goitrogens (staples of diet)

**Toxicity**
- Thyroid hormone synthesis is inhibited
- Consumption of seaweed
- Upper Level is 1.1 mg/day