Micronutrients
- Water soluble vitamins: RDAs, deficiency, toxicity
- Fat Soluble vitamins: RDAs, deficiency, toxicity
- Minerals: RDAs, deficiency, toxicity
- Metals: RDAs, deficiency, toxicity
- Phytonutrients
- Non-essential and conditionally essential nutrients
- Efficacy, safety, risks and benefits of glandular products and therapeutic enzymes

Catalysts and Sparkplugs
- Micronutrients
  - Vitamins
    - Water soluble – B, C
    - Fat soluble – A, E, D, K
  - Minerals
  - Antioxidants
  - Phytonutrients
  - Amino acids
  - Conditionally Essential Nutrients
Cannot be synthesized in sufficient quantities and must be obtained through diet
Classified by their biological and chemical activity, not their structure
Each "vitamin" refers to a number of vitamer compounds that all show the biological activity associated with a particular vitamin
Each set of compounds is grouped under an alphabetized vitamin "generic descriptor" title

- "Vitamin A" includes retinal, retinol, and four known carotenoids.
- Vitamers by definition are convertible to the active form of the vitamin in the body and are sometimes interconvertible to one another as well.
B Vitamins

- Vitamin B₁ – Thiamin
- Vitamin B₂ – Riboflavin
- Vitamin B₃ – Niacin
- Vitamin B₅ – Pantothenic Acid
- Vitamin B₆ – Pyridoxine
- Vitamin B₇ - Biotin
- Vitamin B₉ - Folic Acid
- Vitamin B₁₂ – Cobalamin

B-Complex: Cell Metabolism

- Energy metabolism
  - B₁ (Thiamin)
  - B₂ (Riboflavin)
  - B₃ (Niacin)
  - B₅ (Pantothenic acid)
  - B₆ (Pyridoxine)
  - B₇ (Biotin)
- Cell formation & division
  - B₅ (Pantothenic acid)
  - B₆ (Pyridoxine)
  - Folic acid
  - B₁₂ (Cobalamin)

Vitamin B₁ - Thiamin

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Thiamin B₁ mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>1.2</td>
<td>50-200 mg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Vitamin B1 – Thiamin: Functions

- Generation of energy from carbohydrates
- Necessary for conversion of pyruvate to acetyl coenzyme A (CoA)
- Necessary for several co-enzymes in Kreb's cycle to generate ATP
- RNA and DNA production
- Neuronal function
  - Formation of neurotransmitters (acetylcholine)
    - Assist with memory and cognition
  - Modulate chloride channels in nervous system

Vitamin B1 – Thiamin: Deficiency

- Beriberi – endemic in Asia due to eating polished white rice
- Affects cardiovascular, nervous, muscular and GI systems
  - Painful/tender muscles, numbness, wristfoot drop, loss of reflexes, weight loss, weakness, tachycardia, edema, confusion, edema, coma

Vitamin B1 – Thiamin: Food Sources

- Nutritional yeast
- Wheat germ
- Whole grains
- Sunflower seeds
- Brazil nuts
- Almonds
- Peanuts
- Legumes
- Garlic
- Dark leafy greens
**Vitamin B1 – Thiamin: Therapeutic Considerations**

- Consider if exhibit:
  - Dementia, neuropathy, fatigue, confusion, depression, muscle pain, memory loss
  - Excessive alcohol consumption (past or present)
  - Genetic SNPs that inhibit use of thiamin
  - Malabsorption (IBD, IBS, eating disorder)

---

**Vitamin B2 - Riboflavin**

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Riboflavin B2 mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children</td>
<td>4-6</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>1.3</td>
<td>50-200mg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-60</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>1.3</td>
<td></td>
<td>Toxic only through injection</td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Vitamin B2 – Riboflavin: Functions**

- Energy production
  - Kreb’s cycle
  - Electron Transport Chain
    - Flavin adenine dinucleotide (FAD)
  - Breakdown of glucose
  - Catabolism of fatty acids
    - Beta oxidation
    - Required for wide range of processes
Liver Detoxification
- Necessary for production of cytochrome P450 enzymes & glutathione conjugation

Conversion and activation of other vitamins
- Vitamin B6 – into active form
- Vitamin A – into active form
- Folic acid -> 5-MTHF
- Tryptophan -> Vitamin B3 (Niacin)

*Inflammation of tongue and throat (stomatitis)*
*Chapped cracked lips (cheilosis)*
*Inflammation of the corners of the mouth (angular stomatitis)*
*Oily, scaly skin rashes on scrotum, vulva, mouth*
*Eyes – itchy, watery, bloodshot and sensitive to light*
*Fatigue*
*Failure to thrive/grow*
*Anemia – normal RDW & Hgb*
*Pregnancy -> congenital heart defects & limb deformities*

Nutritional yeast
Milk, cheese
Leafy green vegetables
Liver, kidney
Eggs
Legumes
Mushrooms
Almonds
Consider if exhibit:
- Inflammation of tongue/throat, cracked lips/corners of mouth
- Poor diet (multiple deficiencies)
- Anemia – normal RDW & Hgb
- Women taking oral contraceptives
- Excessive alcohol consumption (past or present)
- Malabsorption (IBD, IBS, eating disorder)
- HIV
- Phototherapy to treat jaundice in infants

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Niacin B3 mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15-18</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15-18</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Two structures
- Nicotinic acid
- Nicotinamide
  - Does not have the same pharmacological and toxic effects as nicotinic acid
  - Does NOT reduce cholesterol or cause flushing

Two co-enzymes
- Nicotinamide adenine dinucleotide (NAD)
- Nicotinamide adenine dinucleotide phosphate (NADP)
  - Both play an important role in energy production & metabolism of glucose, fat and alcohol.
Liver can synthesize niacin from tryptophan. However, it is inefficient: 60 mg of tryptophan is needed to make 1 mg of niacin.

**Vitamin B3 – Niacin: Functions**

- Energy production
  - Kreb's cycle/ Electron Transport Chain
    - Nicotinamide Adenine Dinucleotide (NADH)
  - Catabolism of glucose, fat & protein
  - Breakdown of alcohol
- Required for wide range of processes

**Vitamin B3 – Niacin: Functions 🌟**

- Cell signaling (NAD)
- DNA repair (NAD)
- Production of steroid hormones in adrenals
- Vasodilation - flushing
- Fatty acid and cholesterol synthesis (NADP)
  - Lowers LDL, Lp(a), VLDL & triglycerides
  - Increases HDL
- Reduces inflammation
- Reduces oxidative stress
**Vitamin B3 – Niacin: Deficiency**

- Brain, gut, skin most susceptible
- Pellegra – the 4 Ds
  - Dermatitis, diarrhea, dementia and death
  - Hyperpigmentation, thickening of skin, inflammation of mouth & tongue, digestive disturbances, amnesia, delirium
- Psychiatric disturbances
  - Irritability, poor concentration, anxiety, fatigue, restlessness, apathy and depression

**Vitamin B3 – Niacin: Food Sources**

- Brewer’s yeast
- Organ meats
- Chicken
- Beef/venison
- Fish
- Whole grains
- Peanuts/PB
- Legumes

**Vitamin B3 – Niacin: Therapeutic Considerations**

- Consider if exhibit:
  - Poverty or malnutrition
  - Chronic use of alcohol
  - Eat corn/maize as staple food (only grain low in niacin)
  - High triglycerides, VLDL, LDL or Lp(a)
  - Low HDL
Vitamin B3 – Niacin: Toxicity

- Flushing is not a sign of toxicity
- Can occur at 500 mg – 6 grams/day
- Take with food and avoid alcohol & hot food/drink
- Liver toxicity possible – check liver enzymes
- Time-released form more likely to cause toxicity
- Can increase uric acid levels (gout)

Vitamin B5 – Pantothenic Acid

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Pantothenic Acid (B5) mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Derived from the Greek *pantothen*, meaning "from everywhere"

- Coenzyme A synthesis
- Starts the Kreb Cycle
- Oxidation of fats
- Carbohydrate metabolism
Vitamin B₅ – Pantothenic Acid: Functions

- Involved in synthesis of:
  - Amino acids
  - Fatty acids
  - Cholesterol
  - Phospholipids
  - Steroid hormones
  - Neurotransmitters
  - Antibodies

Vitamin B₅ – Pantothenic Acid: Deficiency & Toxicity

- Deficiency extremely rare in humans
- Toxicity very unlikely
  - No Tolerable Upper Level Intake (UL) has been established
  - No reported side effects at 10 grams/day

Vitamin B₅ – Pantothenic Acid: Therapeutic Considerations

- Blood lipid imbalances
  - Pantethine (derivative of B₅) can lower LDL and triglyceride levels
- Poor cellular energy production or need for cellular energy support
  - Wound healing, adrenal fatigue, autoimmunity, chronic fatigue
- Poor hair growth
- Diabetic neuropathy
  - Studies show that 85% of people treated with alpha-lipoic acid report further improvement with B₅

Münchener Medizinische Wochenschrift (Germany), 1997, 139/12 (34-37)
**Vitamin B₅ – Pantothenic Acid:**
**Food Sources**
- Chicken liver
- Avocado
- Sunflower seeds
- Whole grains
- Legumes
- Eggs
- Meat/Salmon
- Yogurt
- Cauliflower/Broccoli

---

**Vitamin B₆ - Pyridoxine**

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Pyridoxine (B₆) mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Children</strong></td>
<td>4-6</td>
<td>.6</td>
<td>20mg-50mg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td>15-18</td>
<td>1.3</td>
<td>250 to 500mg</td>
<td>long-term may be excessive</td>
</tr>
<tr>
<td>(SCoA = 25 mg)</td>
<td>19-24</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>1.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td>15-18</td>
<td>1.3</td>
<td>40mg-150mg</td>
<td></td>
</tr>
<tr>
<td>(SCoA = 20 mg)</td>
<td>19-24</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Vitamin B₆ - Pyridoxine**

- Many forms:
  - Pyridoxine (most common in supplements)
  - Pyridoxal
  - Pyridoxal-5-phosphate (PLP) – metabolically active form (sold as P-5-P)
  - Pyridoxamine
- All forms can be interconverted (theoretically)
  - Conversion dependent on FMN – need B₂
  - Some people need to be given PLP/P₅P
Active form pyridoxal-5-phosphate (PLP) serves as cofactor in many reactions:
- Amino acid metabolism
- Synthesis of neurotransmitters
  - Serotonin, dopamine, epinephrine, norepinephrine, GABA and histamine
- Glucose metabolism
- Lipid metabolism
- Hemoglobin synthesis

Required for methylation
- Converts homocysteine to cysteine

Modulates steroid hormones
- Can bind to receptor sites for estrogen, testosterone, glucocorticosteroids, etc.
- Useful for morning sickness, PMS and estrogen-dominant disorders
Seborrhoeic dermatitis-like eruption
Sore/inflamed tongue
Angular cheilitis
 Conjunctivitis
 Somnolence
 Confusion
Neuropathy
Elevated homocysteine

> 1,000 mg/day can cause neuropathy
  Pain and numbness in extremities
 > Doses over 200 mg not considered safe for pregnancy or lactation

Morning sickness during pregnancy
Neurotransmitter-related disorders
  Depression, anxiety, ADD, Parkinson’s disease
Carpal tunnel
PMS
Elevated homocysteine
  Take along with Folic acid, B12 and trimethylglycine (TMG)
**Vitamin B6 – Pyridoxine: Food Sources**
- Avocado
- Brewer’s yeast
- Organ meats
- Blackstrap molasses
- Most vegetables/leafy greens
- Eggs
- Beef
- Whole grains
- Nuts
- Bananas

---

**Vitamin B7 - Biotin**

<table>
<thead>
<tr>
<th></th>
<th>RDA</th>
<th>Age</th>
<th>Biotin mcg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td></td>
<td>4-6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-10</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td>15-18</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>19-24</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-50</td>
<td>25</td>
<td>30-500 mcg per day</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>50+</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td>15-18</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>19-24</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25-50</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>50+</td>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Up to 10 mg daily for over six months used with no signs of toxicity

---

**Vitamin B7 – Biotin: Functions**

- Metabolism of:
  - Fatty acids
  - Proteins and amino acids
    - Especially isoleucine and valine
  - Carbohydrates
  - Helps maintain blood sugar
  - Gluconeogenesis
Vitamin B7 – Biotin: Deficiency

- Not typical
- Alopecia (hair loss)
- Conjunctivitis
- Scaly dermatitis
  - Especially around eyes, nose, mouth and genitals
- Dry skin, nails
- Depression, lethargy
- Impaired growth

Vitamin B7 – Biotin: Therapeutic Considerations

- Dermatitis
- Alopecia
- Pregnancy
- Depression
- If consume egg whites (raw) for years

Vitamin B7 – Biotin: Food Sources

- Swiss chard
- Leafy greens
- Peanuts
- Raw/runny egg yolk
- Small amount synthesized by gut bacteria
### Vitamin B9 – Folic Acid

<table>
<thead>
<tr>
<th>RDA</th>
<th>Folic Acid mcg</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-6</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>7-10</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-18</td>
<td>400</td>
<td>~400 – 1000 mcg</td>
</tr>
<tr>
<td>19-24</td>
<td>400</td>
<td>&gt;400 mcg if not taking with B12</td>
</tr>
<tr>
<td>25-50</td>
<td>400</td>
<td>10mg daily for 5 years have been used in adults with no adverse effects</td>
</tr>
<tr>
<td>50+</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-18</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>25-50</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>400</td>
<td></td>
</tr>
</tbody>
</table>

- **Many forms:**
  - Folate → dihydrofolate (DHF) → tetrahydrofolate (THF) → methylene-THF → methyl-THF (MTHF)
  - All biological reactions are dependent upon THF/MTHF
    - DHFR is the key
    - Conversion very slow and variable in humans
    - May require MTHF supplementation

### Vitamin B9 – Folic Acid: Functions

- Cell division, DNA synthesis and repair
  - Very important during pregnancy and infancy
- Red blood cell formation
  - Deficiency results in macrocytic anemia
- Homocysteine metabolism
**Vitamin B9 – Folic Acid: Deficiency**

- Neural tube defects
  - Spina bifida
- Macrocytic anemia
- Peripheral neuropathy
- Confusion, forgetfulness
- Depression
- Heart palpitations
- Elevated homocysteine
- Rx: Trimethoprim, Pyrimethamine, Methotrexate, Sulfonamides, Valproic acid

**Vitamin B9 – Folic Acid: Therapeutic Considerations**

- Pregnancy
- Macrocytic anemia – take with B12
- Elevated homocysteine
- Chronic alcohol consumption
- When use/have used:
  - Trimethoprim (Primsol, Trimpe, Proloprim)
  - Pyrimethamine (Daraprim)
  - Methotrexate
  - Sulfonamides (Sulfa drugs, thiazide)
  - Valproic acid (Convulex, Depakote, Epilim, Valparin, Valpro, Viapro, Stavzor)

  *Use MTHF/5-MTHF not folic acid/folate*

**Vitamin B9 – Folic Acid: Food Sources**

- Dark green leafy vegetables
- Avocado
- Brewer’s yeast
- Asparagus
- Brussel sprouts
- Legumes/peas
- Poultry and meat
- Eggs
- Whole grains
Vitamin B12 - Cobalamin

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Cobalamin (B12) mcg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>2.4</td>
<td>No dose recorded</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cobalamin may refer to several chemical forms of B12:
- Cyanocobalamin (most common; must be converted in the body into active form)
- Hydroxycobalamin
- Methylcobalamin (active form of B12)
- Adenosylcobalamin (active form of B12)

Need Intrinsic Factor for absorption
- Parietal cells of stomach secrete HCL and Intrinsic Factor
- Antacids inhibit Intrinsic Factor
- Pernicious anemia
**Vitamin B₁₂ – Cobalamin: Functions**

- Homocysteine metabolism

![Homocysteine metabolism diagram]

**Vitamin B₁₂ – Cobalamin: Functions**

- DNA methylation/repair
  - Helps prevent cancer and autoimmune diseases
- Hemoglobin formation
  - Lack of Intrinsic Factor -> Pernicious anemia
  - Lack of B₁₂ -> Macrocytic anemia
- Nerve function
  - Needed for myelin production

**Vitamin B₁₂ – Cobalamin: Deficiency**

- Macrocytic anemia
- Elevated homocysteine
- Peripheral neuropathy
- Memory loss/cognitive deficits
- Mania (long term)
- Psychosis (long term)
**Vitamin B12 – Cobalamin: Therapeutic Considerations**

- Macrocytic anemia
- Elevated homocysteine – use with MTHF
- Peripheral neuropathy
- Memory loss/cognitive deficits
- Elderly
- Long-term antacid use (PPI/H2 Antagonists)
- Mania (long term)
- Psychosis (long term)
- Cyanide poisoning

**Vitamin B12 – Cobalamin: Food Sources**

- Meat
- Fish
- Poultry
- Eggs
- Dairy

**Vitamin C – Ascorbate**

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Vitamin C mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15-18</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>75</td>
<td>1000 mg daily</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>90</td>
<td>10-20 grams daily</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>90</td>
<td>daily have shown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>90</td>
<td>benefits</td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Vitamin C – Ascorbate: Functions

- Made internally by almost all organisms
- Except guinea pigs, most bats, monkeys and HUMANS
- Required in the diet
  - Can only store a small amount
  - Can develop deficiency symptoms in 1-6 months

- Collagen synthesis
- Antioxidant
  - Protects proteins, fats, carbohydrates, DNA & RNA from free radical damage
  - Can regenerate other antioxidants and increase glutathione production

- Immune support
  - Enhances lymphocyte proliferation and phagocytosis
  - Increases natural killer (NK) cell activity up to 10x
  - Helps increase interferon
    - Increases detection/recognition of potential threats
  - Protects against oxidizing agents released by immune cells
  - Enhances iron absorption
**Vitamin C – Ascorbate: Deficiency**

- Scurvy
  - Brown spots on skin (esp. thighs/legs), spongy gums, bleeding from all mucus membranes

**Vitamin C – Ascorbate: Deficiency ★**

- Easy bruising
- Impaired wound healing
- Vascular fragility
  - Bleeding hemorrhoids, varicose veins
- Bleeding gums
- Impaired immune function
- Iron deficient anemia

**Vitamin C – Ascorbate: Therapeutic Considerations**

- Easy bruising
- Impaired wound healing
- Vascular fragility
  - Bleeding hemorrhoids, varicose veins
- Bleeding gums
- Impaired immune function
- Iron deficient anemia
- Detoxification support
  - Vitamin C Calibration/Flush
Vitamin C – Ascorbate: Food Sources
- Cherries
- Plums
- Peppers
- Kiwi
- Broccoli
- Berries
- Papaya
- Citrus
- Pineapple
- Leafy greens...

Fat Soluble Vitamins
- Vitamins A, D, E and K (KADE)
- Soluble in lipids/oil
- Stored in fatty tissues and the liver
- Excessive use may lead to toxic accumulation
- Eliminated slowly from the body

Vitamin A
Retinyl palmitate -> Retinol, Retinal, Retinoic acid

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Vitamin A IU</th>
<th>Therapeutic dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-6</td>
<td>2,500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-10</td>
<td>3,500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-18</td>
<td>5,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>5,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-50</td>
<td>5,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>5,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-18</td>
<td>4,000</td>
<td></td>
<td>10,000 IU per day</td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>4,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-50</td>
<td>4,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>4,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-18</td>
<td>4,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>4,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-50</td>
<td>4,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>4,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Vitamin A is a group of compounds
- Retinol
- Retinal
- Retinoic acid
- Provitamin A carotenoids
  - Alpha-carotene
  - Beta-carotene
  - Gamma-carotene

Vision
- The retinol is oxidized to its aldehyde, retinal, which complexes with a molecule in the eye called opsin found in the rod cell. When a photon of light hits the complex, the retinal changes from the 11-cis form to the all-trans form, initiating a chain of events which results in the transmission of an impulse up the optic nerve.
- Vitamin A is important for vision/night vision

Immune function
- Reduces infections
- Maintains mucosal surface integrity (respiratory and GI tracts) which act as natural barrier to pathogens
- Improves antibody response
- Increases WBC proliferation
**Vitamin A: Functions**

- Skin and cellular health
  - Maintains normal skin health by switching on genes and differentiating keratinocytes (immature skin cells) into mature epidermal cells

- Growth
  - Regulates genetic growth hormone expression

- Fetal Development
  - Promotes proper cellular differentiation and development of the limbs, heart, eyes and ears

- Gene expression
- Bone metabolism
- Blood cell formation (hematopoiesis)
- Antioxidant
Dry eyes
Impaired vision
Night blindness
Impaired immunity
• Ear infections, UTIs
• Hyperkeratosis (white lumps at hair follicles)

Acute toxicity > 25,000 IU/kg of body weight
Chronic toxicity > 4000 IU/kg daily for 6-15 months
Liver toxicity can occur as low as 15,000 IU/day
People with kidney failure: 4000 IU/day
Children can reach toxic levels at 1500 IU/kg body weight

Toxicity only occurs with preformed (retinoid) vitamin A, NOT carotenoid forms
Nausea, irritability, reduced appetite, vomiting, blurry vision, headache, hair loss, diarrhea, fatigue, hair loss, dry skin, bone fractures, osteoporosis, systemic itchy skin
Pregnancy: doses used for acne treatment have been shown to disrupt normal fetal development
Vitamin A: Therapeutic Considerations

- Early weaning from breastmilk
- Removal of gall bladder/impaired bile production or release
- Chronic alcohol use
- Low-fat diets

Vitamin A: Therapeutic Considerations

- Oral contraceptive use
  - Oral contraceptives can significantly increase vitamin A plasma levels. Oral contraceptives that contain estrogen and progestin increase retinol binding protein (RBP) synthesis by the liver, increasing the export of RBP-retinol complex in the blood. Whether this increases the dietary requirement of vitamin A is not known.

Vitamin A: Food Sources

- Cod liver oil
- Liver
- Sweet potato/pumpkin/squash
- Carrot
- Broccoli
- Butter/cheese
- Kale/spinach/collards
### Vitamin D3

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Vitamin D IU</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>400</td>
<td></td>
<td>Toddlers 2500 – 6000 IU daily for 4 months upper limit</td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>400</td>
<td></td>
<td>Toddlers 2500 – 6000 IU daily for 4 months upper limit</td>
</tr>
<tr>
<td></td>
<td>15-18</td>
<td>400</td>
<td></td>
<td>400 IU – 10,000 IU</td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>400</td>
<td></td>
<td>Adults 5000 – 10,000 IU daily for 6 months upper limit</td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>400</td>
<td></td>
<td>Consider sunlight exposure</td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>400</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Vitamin D – Calciferol

- Two Major Forms
  - Vitamin D2: Ergocalciferol
  - Vitamin D3: Cholecalciferol

Liver hydroxylation of cholecalciferol to calcidiol

Kidney hydroxylation of calcidiol to calcitriol

### Vitamin D: Sources

- Hormone-like in action
- D3 results from
  - UV irradiation (sunlight) of 7-dehydrocholesterol, which is then converted in the liver and kidneys to active form
  - 10 minutes of sun exposure to face and hands = 400 IU
- Supplementation with D3
Researchers at University of Wisconsin investigated vitamin D status of healthy males living in Hawaii:
- Mean of 11.1 hours/week of total body sun exposure with no sunscreen
- 51% had low vitamin D levels
- Ability to convert vitamin D in the skin becomes significantly diminished with age

Vitamin D: Functions
- Bone health
  - Helps with calcium absorption from small intestine in ileum
- Immune Function
  - Regulates proteins that up- and down-regulate immune functions
  - Anti-Inflammatory: ≥ 80 ng/ml
Vitamin D: Functions

Vitamin D Inhibits Inflammatory Cytokines & Acts as an Immune System Brake

Vitamin D plays a direct role in balancing inflammation cascade.

Vitamin D Status Implicated in Multiple Conditions Related to Inflammation
**Vitamin D: Functions**

- May be involved in:
  - Depression and mood
  - Cognition and dementia
  - Pregnancy – deficiency associated with:
    - Gestational diabetes, pre-eclampsia and small birth weight
  - Testosterone production
  - Improving body composition
  - Decreasing VAT
  - Better overall health and mortality

**Vitamin D: Deficiency**

- Rickets
  - Impeded growth and soft, weak deformed long bones that bend and bow
- Osteomalacia
  - Softening of bones
  - Bending of spine, bowing of legs
  - Bone fragility
  - Increased risk of fractures
  - 25-OH Vit D ≤ 10 ng/ml

- Compromised Immune Function
  - Auto-immune disorders
    - MS, Diabetes, Lupus, RA, IBD, etc.
  - Frequent upper respiratory infections
    - Cold/flu
  - Cancer
  - Inflammation
    - Cardiovascular disease, fibromyalgia, chronic pain
Vitamin D: Toxicity

- Rare without high-dose supplementation
- Hypercalcemia
- Anorexia, nausea, vomiting
- Increased urination and thirst
- Weakness, insomnia
- Kidney damage (chronic)

Vitamin D: Therapeutic Considerations

- Ideal levels: 50-65 ng/ml
- Autoimmunity – raise levels to 80-90 ng/ml
- SAD/Depression
- Fractures, Osteoporosis/Osteopenia
- Dark skin
  - Research shows that dark-skinned people living in temperate climates have lower vitamin D levels
  - Melanin hinders vitamin D synthesis
  - Sunscreen – blocks vitamin D synthesis

How Much Vitamin D Do You Need?

- Have blood tested: 25-hydroxyvitamin D
- Optimal levels 50-80 ng/ml

<table>
<thead>
<tr>
<th>Daily Vitamin D Dose</th>
<th>Increases blood levels by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,000 IU</td>
<td>11.6 ng/ml</td>
</tr>
<tr>
<td>10,000 IU</td>
<td>58.5 ng/ml</td>
</tr>
<tr>
<td>50,000 IU</td>
<td>257.6 ng/ml</td>
</tr>
</tbody>
</table>

- BMI important – larger people need more D
- Example: target 60 ng/ml
  - 154 lb person, baseline level: 20 ng/ml
  - Need ~5,000 IU/day

Liver, cod liver oil
- 3 Tbsp cod liver oil provides ~ 4000 IU
Fatty fish – salmon, mackerel, tuna, sardines
Butter
Supplements
Sunshine
- 10 minutes of sun exposure to face and hands = 400 IU

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Vitamin E IU</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;400 IU for extended periods of time can interfere with blood clotting, and can elevate blood pressure in hypertensive individuals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;1500 IU for extended periods of time can result in diarrhea, nausea, flatulence</td>
</tr>
<tr>
<td>Children</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-6</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>15</td>
<td>200 IU-800 IU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tocopherols
- α-tocopherol
- β-tocopherol
- γ-tocopherol
- δ-tocopherol
- ε-tocopherol

Tocotrienols
- α-tocotrienol
- β-tocotrienol
- γ-tocotrienol
- δ-tocotrienol
- ε-tocotrienol

d-α-tocopherol most biologically active
"dl" forms are synthetically derived
Vitamin E: Functions

- Antioxidant
  - Protects cell membranes from oxidation
    - Inhibits lipid peroxidation
  - Reduces inflammation
    - Inhibits cyclooxygenase (COX) enzymes
  - Can be recycled by other antioxidants
    - Vitamin C, vitamin A
    - Alpha-Lipoic acid

Vitamin E: Functions

- Cardiovascular disease
  - Gene expression
    - Down-regulates CD36 scavenger receptor gene
      - Inhibits atherogenetic plaque formation
    - Up-regulates CTGF gene
      - Helps repair and regenerate tissue damaged during atherosclerosis
      - Inhibits platelet aggregation

Vitamin E: Deficiency

- Neuromuscular problems
  - Spinocerebellar ataxia
  - Myopathies
- Neurological problems
  - Dysarthria
  - Loss of deep tendon reflexes
  - Male infertility
  - Retinopathy
  - Impairment of immune response
Vitamin E: Toxicity

- Toxicity is rare
- Can act as anticoagulant
  - Increased risk of bleeding
  - Caution/monitor when use with aspirin, anticoagulants (Warfarin, Coumadin) or surgery

Vitamin E: Therapeutic Considerations

- Male infertility
- Cardiovascular disease
- Fat malabsorption – often have greasy stools
  - Gastric bypass
  - IBD (Crohn’s disease, Ulcerative colitis)
  - Liver disease
  - Pancreatic insufficiency

Vitamin E: Food Sources

- Wheat germ oil
- Sunflower oil/seeds
- Almonds/Almond oil
- Flax oil
- Pecans and walnuts
- Avocado
- Dark leafy greens
**Vitamin K**

- **Vitamin K1**
  - Phylloquinone
  - Synthesized by plants
  - Found in green leafy vegetables
  - Can be converted to K2 in the body
    - Bacteria in colon

- **Vitamin K2**
  - Main storage in animals
  - Several subtypes
    - Menaquiones
    - "MK-n"
  - MK-4 most common in animals/humans
  - Can be made from K1

**Vitamin K: Functions**

- "K" is for "Koagulation"
- Protein Formation
  - Blood coagulation
    - 7 vitamin K-dependent clotting factors in the coagulation cascade
    - Prothrombin and other factors/proteins
  - Bone metabolism
    - Osteocalcin and bone matrix proteins
    - Helps bind calcium in the bones
Anemia
Bruising
Bleeding gums/nose
Heavy menses
Osteoporosis (K2)
Coronary heart disease (K2)
Aortic calcification (MK-7)

No known toxicity – no UL set
Studies done at 45 mg – 135 mg/day of K2 (MK-4) show no increase risk of blood clotting
Doses as high as 250 mg/kg body weight in rats did not alter blood clot formation
Unlike safe natural forms of vitamin K1 and K2, a synthetic form – Vitamin K3 (menadione) – can be toxic

- Those at risk of deficiency:
  - Liver damage/disease (alcoholics)
  - IBD (Crohn’s, UC, Celiac)
  - Bulimics
  - Anticoagulant meds
  - Long-term aspirin use
  - Hemorrhagic disease
    - Newborns, spontaneous nose bleeds
  - Osteoporosis/fractures
  - CVD & elevated diastolic blood pressure
  - Kidney stones (calcium based)
Vitamin K: Food Sources

- Vitamin K₁
  - Dark leafy greens
  - Broccoli
  - Brussel sprouts
  - Cabbage
  - Parsley

- Vitamin K₂
  - Natto
  - Fermented/aged cheese
  - Eggs, chicken, beef
  - Liver/organ meats
  - Sauerkraut
  - Kefir

Vitamins: Questions??

Minerals

<table>
<thead>
<tr>
<th>Major Minerals</th>
<th>Trace Minerals</th>
<th>Metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>Chromium</td>
<td>Boron</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Copper</td>
<td>Lithium</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Cobalt</td>
<td>Nickel</td>
</tr>
<tr>
<td>Potassium</td>
<td>Iodine</td>
<td>Silicon</td>
</tr>
<tr>
<td>Sodium</td>
<td>Iron</td>
<td>Strontium</td>
</tr>
<tr>
<td></td>
<td>Manganese</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Molybdenum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Selenium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vanadium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zinc</td>
<td>Tin</td>
</tr>
</tbody>
</table>
Minerals – Why So Important?

- Act as co-enzymes
- Regulate fluid balance
- Help muscle function
  - Muscle contraction
- Help nerve function – alter electrical currents
  - Nerve conduction
  - Transport channels
- Keep bones healthy

Mineral Facts

- Can be stored in the body
- Are NOT affected by cooking or light
- Absorption rates vary
  - Digestive enzymes and HCl production
  - Age – less absorbed as we age
  - GI imbalance
  - Mineral type/salt
- Minerals must be chelated to an amino acid to pass through the gut wall

Calcium

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Calcium mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>800</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>1000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>1000</td>
<td>1000 mg daily</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>1000</td>
<td>1000 mg daily</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>1000</td>
<td>1000 mg daily</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>1000</td>
<td>1000 mg daily</td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>1000</td>
<td>1000 mg daily</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>1000</td>
<td>1000 mg daily</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>1000</td>
<td>1000 mg daily</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>1200</td>
<td>400 mg supplemental calcium</td>
<td></td>
</tr>
</tbody>
</table>
Calcium

- Most abundant mineral in the body
- 95-99% in bones and teeth
- 1-5% in nerves, blood, muscles

Calcium: Functions

- Bone health
  - Need for optimal bone density and strength
  - Other nutrients also involved
  - Slows rate of bone loss
  - Can be leached from bone to buffer acidic conditions in blood resulting from diet
  - Sugar, soda, caffeine, alcohol, fried foods, excessive protein

What is comprehensive bone nourishment?

- Bones are formed of a composite structure. They consist of fibrous organic factors which serve as a foundation onto which the bone matrix forms
- This matrix consists of:
  - Calcium
  - Phosphorus
  - Sodium
  - Magnesium
  - Zinc
  - And other minerals
MCHC provides Complete Bone Food

<table>
<thead>
<tr>
<th>Active Ingredients</th>
<th>Bone Ash (Bone Meal)</th>
<th>Microcrystalline Hydroxyapatite Crystals</th>
<th>Other Calcium (carbonates, chelates)</th>
<th>Trace Minerals (magnesium, zinc, sodium, boron, manganese, copper)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral Complex</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>none</td>
</tr>
<tr>
<td>Hydroxyapatite</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>none</td>
</tr>
<tr>
<td>Other Calcium</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>none</td>
</tr>
<tr>
<td>Protein</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>none</td>
</tr>
<tr>
<td>Biologically Active Growth Factors</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>none</td>
</tr>
<tr>
<td>IGF I &amp; II</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>none</td>
</tr>
<tr>
<td>TGFβ I &amp; II</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>none</td>
</tr>
<tr>
<td>Calcitonin</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>none</td>
</tr>
<tr>
<td>Type I Collagen</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>none</td>
</tr>
<tr>
<td>Chondroitin Sulfate</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>none</td>
</tr>
</tbody>
</table>

Comprehensive bone nourishment provides a broad range of essential nutrients needed to build and maintain strong bones. Derived from whole bone extract, the calcium-rich supplement microcrystalline hydroxyapatite concentrate (MCHC) provides many minerals found in bone, in the correct proportions, along with proteins and other organic factors.

Study on Effects of MCHC

Study of 64 postmenopausal women with primary biliary cirrhosis were assigned to 3 groups to see how supplementation affects bone density:

1. No mineral supplementation
2. MCHC supplementation at 8 grams/day
3. Calcium gluconate supplementation

All subjects received Vitamin D supplementation
Results: After 14 months, there was no significant change in serum calcium or inorganic phosphate. But, there were significant differences in bone density.

<table>
<thead>
<tr>
<th>Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASPARTATE (10% Ca)</td>
<td>Well Absorbed</td>
<td>Expensive</td>
</tr>
<tr>
<td>ASCORBATE (10% Ca)</td>
<td>Well Absorbed</td>
<td>Expensive</td>
</tr>
<tr>
<td>LACTATE (18% Ca)</td>
<td>Well Absorbed</td>
<td>May contain allergens</td>
</tr>
<tr>
<td>AMINO ACID CHELATE (20% Ca)</td>
<td>Well Absorbed</td>
<td>Soy Sensitivity</td>
</tr>
<tr>
<td>PHOSPHATE (29% Ca)</td>
<td>Inexpensive</td>
<td>Fair absorption</td>
</tr>
<tr>
<td>LACTATE (18% Ca)</td>
<td>Inexpensive</td>
<td>Antacid</td>
</tr>
<tr>
<td>AMINO ACID CHELATE (20% Ca)</td>
<td>Inexpensive</td>
<td>Soy Sensitivity</td>
</tr>
<tr>
<td>PHOSPHATE (29% Ca)</td>
<td>Inexpensive</td>
<td>Fair absorption</td>
</tr>
<tr>
<td>LACTATE (18% Ca)</td>
<td>Inexpensive</td>
<td>Antacid</td>
</tr>
<tr>
<td>AMINO ACID CHELATE (20% Ca)</td>
<td>Inexpensive</td>
<td>Soy Sensitivity</td>
</tr>
<tr>
<td>PHOSPHATE (29% Ca)</td>
<td>Inexpensive</td>
<td>Fair absorption</td>
</tr>
<tr>
<td>LACTATE (18% Ca)</td>
<td>Inexpensive</td>
<td>Antacid</td>
</tr>
<tr>
<td>AMINO ACID CHELATE (20% Ca)</td>
<td>Inexpensive</td>
<td>Soy Sensitivity</td>
</tr>
<tr>
<td>PHOSPHATE (29% Ca)</td>
<td>Inexpensive</td>
<td>Fair absorption</td>
</tr>
<tr>
<td>LACTATE (18% Ca)</td>
<td>Inexpensive</td>
<td>Antacid</td>
</tr>
<tr>
<td>AMINO ACID CHELATE (20% Ca)</td>
<td>Inexpensive</td>
<td>Soy Sensitivity</td>
</tr>
<tr>
<td>PHOSPHATE (29% Ca)</td>
<td>Inexpensive</td>
<td>Fair absorption</td>
</tr>
<tr>
<td>LACTATE (18% Ca)</td>
<td>Inexpensive</td>
<td>Antacid</td>
</tr>
<tr>
<td>AMINO ACID CHELATE (20% Ca)</td>
<td>Inexpensive</td>
<td>Soy Sensitivity</td>
</tr>
<tr>
<td>PHOSPHATE (29% Ca)</td>
<td>Inexpensive</td>
<td>Fair absorption</td>
</tr>
</tbody>
</table>

**MCHC Effects: cont.**

- **Results:** After 14 months, there was no significant change in serum calcium or inorganic phosphate.
- **But:** there were significant differences in bone density.

- **Bone Density Chart:**

  - Control: No significant change in bone density.
  - Calcium Citrate: +5.5% bone gain
  - Calcium Gluconate: +6.1% bone gain
  - Bone Loss: -5.5%

**Calcium Types and Absorption**

<table>
<thead>
<tr>
<th>Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>CITRATE (22% Ca)</td>
<td>Very well absorbed, reduces risk to kidney stones, absorbed by those with poor digestion</td>
<td>Doesn’t provide all the building blocks necessary for bone formation</td>
</tr>
</tbody>
</table>

**MCHC (34% Ca):**

- Best absorbed calcium source
- Increases cortical bone density
- Arrests trabecular bone loss
- Absorbed by malabsorbers
- Proven scientific studies on humans
- None known
MCHC is MCHC, right?

- All MCHC products are not the same! The source of the bone extract as well as the processing procedure determine the quality of MCHC.
- Some sources may contain high levels of lead and other contaminants
- High heat processing and excessive grinding can destroy the matrix leading to a simple bone meal product
  - Key marker is Type I collagen; should be 17-21%
  - Bone meal is less than 1% Type I collagen

Osteoporosis & Osteopenia

- Bone Health:
  - Weight bearing exercise – 3 or more sessions/week; at least 30 min/session
  - Sunshine and calcium rich foods
  - Avoid extremely acidic foods/habits
- Bone maintenance:
  - Bone Builder Forte (~3000 mg MCHC) – 1 tablet BID w/ food
- Osteopenia:
  - Bone Builder Prime – 1 tablet TID w/ food
  - 1500 mg MCHC + Ipriflavone + Vit D
- Osteoporosis:
  - Bone Builder Prime – 2 tablets TID w/ food OR
  - 3000 mg MCHC + Ipriflavone + Vit D
- Functional Testing – Bone Resorption Assessment (Genova Diagnostics)

Calcium: Functions

- Nerve conduction
  - Muscle, heart and GI tract (peristalsis)
- Neurotransmission
  - Opening of calcium ion channels for an influx of calcium ions is necessary for transmitting an impulse though the synaptic cleft
Calcium: Functions

- Cardiovascular support
  - Supports synthesis and function of RBCs
  - Required for blood clotting
    - Necessary for prothrombinase complexes to function
    - Required at several points in coagulation cascade

Calcium: Deficiency

- Rickets
- Osteoporosis
- Poor blood clotting
- Increased risk of bone fractures
- Muscle cramping/twitching
- Headache
- Dizziness

Calcium: Toxicity

- Toxicity rare
- Kidney stones
- Overconsumption of calcium carbonate/antacids over weeks/months can lead to Milk-alkali syndrome
  - Dizziness, poor appetite, headache, confusion
  - Kidney failure and death possible
Calcium: Therapeutic Considerations

- Likely deficient if:
  - Regular caffeine use
  - Long-term steroid use
  - Drink soda or alcohol regularly
  - Can diminish absorption of thyroxine
  - Take 4-6 hours apart

Calcium: Food Sources

<table>
<thead>
<tr>
<th>Food</th>
<th>mg Calcium</th>
<th>Food</th>
<th>mg Calcium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kale</td>
<td>1400</td>
<td>Sunflower seeds</td>
<td>173</td>
</tr>
<tr>
<td>Spinach</td>
<td>1300</td>
<td>Walnuts</td>
<td>150</td>
</tr>
<tr>
<td>Kelp</td>
<td>1100</td>
<td>Oranges</td>
<td>165</td>
</tr>
<tr>
<td>Kombu</td>
<td>850</td>
<td>White beans (dried)</td>
<td>145</td>
</tr>
<tr>
<td>Wheat/Barley</td>
<td>515</td>
<td>Quinoa</td>
<td>140</td>
</tr>
<tr>
<td>Sesame</td>
<td>445</td>
<td>Mustard greens</td>
<td>140</td>
</tr>
<tr>
<td>Almonds</td>
<td>430</td>
<td>Black beans</td>
<td>150</td>
</tr>
<tr>
<td>Nuts</td>
<td>200</td>
<td>Pinto beans (dried)</td>
<td>135</td>
</tr>
<tr>
<td>Sesame seeds (hulled)</td>
<td>200-200</td>
<td>Broccoli</td>
<td>130</td>
</tr>
<tr>
<td>Spinach</td>
<td>190</td>
<td>Red cabbage</td>
<td>110</td>
</tr>
<tr>
<td>Broccoli</td>
<td>100</td>
<td>Spinach (cooked)</td>
<td>105</td>
</tr>
<tr>
<td>Collard greens</td>
<td>180</td>
<td>Lettuce</td>
<td>105</td>
</tr>
<tr>
<td>Brussels sprouts</td>
<td>180</td>
<td>Radish</td>
<td>80</td>
</tr>
<tr>
<td>Spinach</td>
<td>180</td>
<td>Uncooked</td>
<td>50</td>
</tr>
<tr>
<td>Kelp</td>
<td>150</td>
<td>Shelled</td>
<td>50</td>
</tr>
<tr>
<td>Kale</td>
<td>150</td>
<td>Uncooked</td>
<td>50</td>
</tr>
</tbody>
</table>

Based on 3.5 oz. portions

Phosphorus

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Phosphorus mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-8</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-10</td>
<td>1200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-18</td>
<td>1200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-50</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-18</td>
<td>1200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-50</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1400 mg as a portion of MCHC

* No toxic levels have been reported
Phosphorus

- 2nd most abundant mineral in the body
- 85-90% in bones and teeth
  - As hydroxyapatite
- 10-15% in soft tissues and extracellular fluid

Phosphorus: Functions

- Bone and teeth enamel
  - Hydroxyapatite main component of bone and tooth enamel

Phosphorus: Functions

- Required for all known forms of life
- Energy production
  - Transport cellular energy as adenosine triphosphate (ATP)
- Part of RNA and DNA structural framework
- Phospholipids are main structural components of all cellular membranes
Phosphorus: Deficiency

- Muscle dysfunction
- Muscle weakness, double vision, low cardiac output
- Neurological dysfunction
  - May range from irritability to gross confusion/dementia
  - Instability of cell membranes (due to low ATP)
  - Rhabdomyolysis with increased CPK

Phosphorus: Therapeutic Considerations

- Consider if:
  - Chronic alcohol use
  - Chronic antacid use
  - Malabsorption
    - IBD, low HCl

Phosphorus: Food Sources

- Meat, poultry, fish
- Dairy products
- Soy
- Brewer’s yeast
- Nuts and seeds
- Soda & fast food
  - Not recommended

Muscle dysfunction
- Muscle weakness, double vision, low cardiac output
Neurological dysfunction
- May range from irritability to gross confusion/dementia
- Instability of cell membranes (due to low ATP)
  - Rhabdomyolysis with increased CPK

Consider if:
- Chronic alcohol use
- Chronic antacid use
- Malabsorption
  - IBD, low HCl

Meat, poultry, fish
Dairy products
Soy
Brewer’s yeast
Nuts and seeds
Soda & fast food
Not recommended
Magnesium

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Magnesium mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-6</td>
<td>130</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-10</td>
<td>240</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-18</td>
<td>410</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>420</td>
<td>100mg-1000mg</td>
<td></td>
<td>&lt;600 mg/day</td>
</tr>
<tr>
<td>25-50</td>
<td>420</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>420</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-18</td>
<td>360</td>
<td>60% in bones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>320</td>
<td>39% intracellular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-50</td>
<td>320</td>
<td>20% in skeletal muscle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>320</td>
<td>1% extracellular</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 60% in bones
- 39% intracellular
- 20% in skeletal muscle
- 1% extracellular

Magnesium: Functions

- Co-enzyme
  - Involved in over 300 enzymatic reactions
    - Glycolysis, creatine phosphate formation (via creatine kinase), nucleic acid synthesis, amino acid activation (protein synthesis), cardiac and smooth muscle contractility, cyclic AMP formation
    - Improves function of insulin receptors
  - Energy production

- Co-enzyme
  - Involved in over 300 enzymatic reactions
    - Glycolysis, creatine phosphate formation (via creatine kinase), nucleic acid synthesis, amino acid activation (protein synthesis), cardiac and smooth muscle contractility, cyclic AMP formation
    - Improves function of insulin receptors
  - Energy production
Magnesium: Functions

- Neuromuscular function
  - Relaxes skeletal muscle
  - Relieves cramping
  - Regulates heart contractility
    - Heart has 20x greater Mg concentration than skeletal muscle
    - Blocks calcium uptake into heart muscle
  - Relaxes smooth muscle
    - Bronchioles, arterioles, relaxes uterine muscles

Magnesium: Functions

- Calcium regulation
  - Helps excrete excess calcium
    - Helpful for kidney stones
  - Necessary for strong teeth and bones

Magnesium: Functions

- Bowel function
  - Promotes bowel movements at higher doses
    - Magnesium citrate – 400-1000 mg/day
  - Osmotic agent
    - Unabsorbed magnesium pulls water into the colon to stimulate motility
  - Non-addictive, non-irritating
Magnesium: Deficiency

- Mg deficiency is common: 2.5-15% of population
- Intracellular Mg can be deficient with normal serum levels
- Muscle twitches/creams
  - Especially calves, feet and toes
- Weakness/fatigue
- Heart irregularities
- Hypertension
- Headaches

Primary causes of Mg deficiency:
- Insufficient dietary intake – only 32% of US population meet RDA
- PPI/antacid use
- Alcoholism
- Malabsorption/increased excretion – Diarrhea, IBD, chronic laxative use
- Supplementation
  - Citrate best for constipation
  - Glycinate and/or amino acid chelate best for muscle pain, bone, spasm, relaxation

Magnesium: Therapeutic Considerations

- Legumes and nuts
- Green vegetables
- Whole grains

Magnesium: Food Sources
Potassium & Sodium

<table>
<thead>
<tr>
<th></th>
<th>RDA</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>&lt;2,400 mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>3,500 mg</td>
<td>100mg-300mg daily</td>
<td>3,900mg regarded as safe</td>
</tr>
</tbody>
</table>

- Regulate fluid balance
  - Blood volume, blood pressure, pH

Potassium & Sodium

**Extracellular water**
- Cells bathed in
- 1/3 of total body water
- Major solutes, sodium and chloride

**Intracellular water**
- Inside the cell
- 2/3 of total body water
- Major solute, potassium

Potassium, Sodium and Chloride

The sodium-potassium pump:
- Sodium ions (Na⁺) are pumped out of the cell and potassium ions (K⁺) are pumped into the cell.
- The energy to drive the pump is released by hydrolysis of ATP.

- Extracellular fluid with high concentration of Na⁺
- Intracellular fluid with low concentration of Na⁺ and high concentration of K⁺
### Potassium: Functions

- Neurological function
- Nerve impulse transmission
- Muscle relaxation
  - Cardiac, smooth muscle and skeletal muscle
- Kidney stones
- Cardiovascular health
  - Hypertension
    - Especially if due to low K, high Na and African American
  - Decreased risk of stroke

### Potassium: Deficiency & Therapeutic Considerations

- Results from vomiting, diarrhea or increased urination (diuretics), or renal disease
- Symptoms: muscle weakness, abnormal heart beat/arrhythmia, decreased reflex response
- Hypertension can result from low K
- Monitor and use cautiously with kidney disease

### Sodium: Functions

- Usually concerned with excess vs. deficiency
- Regulates blood volume, blood pressure, water balance (ICW vs. ECW) and pH
  - Important for hypertension
Hyponatremia

- Very rarely due to low sodium in the diet
- Can occur with congestive heart failure, liver failure, kidney failure and pneumonia
- Most common in endurance athletes (marathon, Ironman, etc.)
- Symptoms include nausea/vomiting, confusion, lethargy/fatigue, loss of appetite, irritability, muscle weakness, spasms/cramps, seizures
- IV saline often needed

Potassium and Sodium: Food Sources

- Potassium
  - Avocado
  - Sweet potato
  - Tomato pate
  - Orange juice
  - Beet greens/spinach
  - White beans
  - Potatoes
  - Bananas

- Sodium
  - Table salt (NaCl)
  - Processed foods
    - Canned vegetables
    - Cured, smoked, canned meats
    - Luncheon meats
    - Spice mixes
    - Soy sauce
    - Salted nuts
    - Catsup
    - Canned soup, etc.

Minerals

<table>
<thead>
<tr>
<th>Major Minerals</th>
<th>Trace Minerals</th>
<th>Metals</th>
</tr>
</thead>
</table>
| Calcium
  - Phosphorus
  - Magnesium
  - Potassium
  - Sodium | Chromium
  - Copper
  - Cobalt
  - Iodine
  - Iron
  - Manganese
  - Molybdenum
  - Selenium
  - Vanadium
  - Zinc | Boron
  - Lithium
  - Nickel
  - Silicon
  - Strontium
  - Tin |
Chromium

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Chromium Dosage</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>11 mcg</td>
<td>1000 mcg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>15 mcg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>25 mcg</td>
<td>3000 mcg</td>
<td>3000 mcg long term with no adverse effects</td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>35 mcg</td>
<td>35 mg/kg</td>
<td>Acute oral toxicity ranges between 1.5 and 3.3 mg/kg</td>
</tr>
<tr>
<td></td>
<td>20-50</td>
<td>35 mcg</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>30 mcg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>21 mcg</td>
<td>25 mg/kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>25 mcg</td>
<td>25 mg/kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>25 mcg</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>20 mcg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chromium: Functions

- Blood sugar control
  - Component of Glucose Tolerance Factor
  - Involved in insulin-signaling pathway

Chromium: Deficiency and Therapeutic Considerations

- Deficiency
  - Elevated blood sugar and/or elevated insulin
  - Glucose intolerance
  - Insulin resistance
Chromium: Sources

- Chromium content in foods varies widely due to differences in soil mineral content, growing season, plant cultivation methods and contamination during processing
- Very little chromium is absorbed from food
- Supplements
  - Chromium picolinate, nicotinate and glycinate are all absorbed well (~98%)

Copper

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Copper</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>440</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-10</td>
<td></td>
<td>700</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-16</td>
<td>890</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-50</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-16</td>
<td>890</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-50</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-16</td>
<td>890</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-50</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50+</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Necessary for proper growth, development and maintenance of bone, connective tissue, brain, heart and other organs
- Involved in formation of red blood cells & absorption of iron
- Metabolism of cholesterol and glucose
- Supports immune health and health
Copper: Deficiency

- Elevated zinc and/or cadmium
- High intakes of phytates (grains) and simple sugars and inhibit absorption
- Symptoms:
  - Anemia, poor wound healing, bone and joint problems, CNS impairment
  - Osteoporosis, osteoarthritis, rheumatoid arthritis
  - Connective tissue disorders

Copper: Toxicity

- Stomach upset, nausea, diarrhea, tissue injury and disease
- Tachycardia, difficulty breathing, hemolytic anemia, easy bruising, GI bleeding
- Oxidative damage
- Alzheimer's disease

Copper: Sources

- Food Sources
  - Seafood (shellfish), mushrooms, spinach, leafy greens, seeds, raw nuts (esp. cashews and walnuts), tempeh, barley

- Supplements
  - Best absorbed: gluconate, acetate and sulfate
  - Usually in multi or trace mineral products
  - Generally, aim for a 10:1 zinc:copper ratio
Iodine

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Iodine mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>90</td>
<td>300mcg-600mcg</td>
<td>6 grams per day for several years without toxic effect in those diagnosed as iodine deficient</td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15-18</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>15-18</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>150</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Iodine: Functions

- Thyroid function
  - Necessary for formation of thyroxine (T4) and triiodothyronine
    - Regulates basal metabolic rate

  ![Thyroid Diagram](image_url)

- Hypothyroid, goiters
  - Fatigue, constipation, dry skin, intolerant to cold, low basal temperature, depression, mental slowing, weight gain, thinning hair
  - Can be displaced by chlorine and fluorine
    - Avoid tap water if hypothyroid
    - May need avoid swimming pools that use Cl

Iodine: Deficiency & Therapeutic Considerations

- Hypothyroid, goiters
- Fatigue, constipation, dry skin, intolerant to cold, low basal temperature, depression, mental slowing, weight gain, thinning hair
- Can be displaced by chlorine and fluorine
- Avoid tap water if hypothyroid
- May need avoid swimming pools that use Cl

![Element Diagram](image_url)
Iodine: Deficiency & Therapeutic Considerations

- Breast cancer/fibrocystic breasts
- Stomach cancer
- Radiation exposure
  - Potassium iodide can prevent radioactive iodine uptake

Iodine: Toxicity

- Safe up to 30 mg/kg
  - Extremely safe
- More cytotoxic in the presence of selenium-deficiency
- Hypersensitivity possible (both orally and topically)
- Prolonged use of excess iodine can cause:
  - Thyroid gland hyperplasia, goiter and severe hypothyroidism

Iodine: Sources

- Iodine-rich foods
  - Kelp, sea vegetables, seafood, eggs, dairy products
- Iodized salt
- Supplements
  - Potassium iodide (reduced form)
  - Iodine (oxidized form) – typically topical solutions
  - Kelp
Iron

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Iron Mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>7</td>
<td>&gt; 30-60 mg</td>
<td>&gt; 20 mg/kg</td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15-18</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>19-24</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SGOA = 20 mg)</td>
<td>25-50</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>8</td>
<td></td>
<td>lethal</td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SGOA = 20 mg)</td>
<td>19-24</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Iron: Functions

- Hemoglobin and myoglobin synthesis
- Oxygen transport
- Cellular energy production
- Redox enzymes

Iron: Deficiency

- Anemia
  - Hypochromic/microcytic
  - Decreased hemoglobin (or RBC)
  - Fatigue, weakness, shortness of breath, light-headed, poor stamina, confusion, increased thirst
- Significant anemia necessary before a person becomes noticeable pale
Iron: Therapeutic Considerations

- Poor absorption
  - IBD, post-surgical resection of bowel, low HCl
  - High intake of cow’s milk
  - Inflammation
  - Pregnancy
  - Elderly
  - Vegetarian/vegan
  - Excessive bleeding

Iron: Toxicity

- Poorly excreted/easily accumulated
- Can cause free radical damage & inflammation
  - Can damage heart, liver and joints
- Only supplement iron when labs indicate need
- Keep iron supplements away from children

Iron: Sources

- Food
  - Heme sources (animals) best absorbed (15-35%)
    - Red meat, poultry, fish, eggs
  - Non-heme sources (plants) less absorbed (2-20%)
    - Dark leafy greens, legumes, blackstrap molasses
- Supplements
  - Best absorbed (non-constricting): gluconate, (bis)glycinate, amino-acid chelate
  - Poorly absorbed: sulfate, fumarate
  - Absorption enhanced with ascorbate (Vit C)
Manganese

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Manganese Mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children</td>
<td>4-6</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>1.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>2.2</td>
<td>&gt; 1-3 mg</td>
<td>&gt; 12 mg/day</td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Manganese: Functions

- Cofactor for many enzymes
- Energy production, carbohydrate metabolism, bone development, collagen synthesis, protein and fatty acid synthesis
- Antioxidant protection
  - Superoxide dismutase (SOD)
  - Defense for nearly all living cells

Manganese: Deficiency, Toxicity and Therapeutic Considerations

- Deficiency rare
- Consider if widespread symptoms, including
  - Impaired growth, poor carbohydrate and fat metabolism, loss of hair color, decreased hair/nail growth, fatigue, premature aging
- Toxicity
  - Estimated at >12 mg/day
  - Kidney and/or liver dysfunction
Manganese: Sources

- **Food sources**
  - Pecans and most nuts, whole grains, dark leafy greens/spinach, carrots, broccoli, eggs

- **Supplements**
  - Citrate, sulfate, aspartate, glycinate, gluconate, amino acid chelate

---

Molybdenum

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Molybdenum mcg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>43</td>
<td>&gt; 1.2 mg</td>
<td>&gt; 10 mg/day</td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>46</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>46</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>46</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>46</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>46</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Molybdenum: Functions

- Involved in many enzymes that affect
  - Protein synthesis, metabolism, growth, detoxification, purine metabolism, alcohol detoxification, dental health

---
Molybdenum: Deficiency, Toxicity & Therapeutic Considerations

- Consider if:
  - Fatigue, joint pain, tachycardia, headache, disorientation (sulfite toxicity)
  - Sensitivity to sulfites in foods
  - Toxicity
    - > 10 mg/day
    - Can cause gout (↑ production of uric acid)

Molybdenum: Sources

- Food sources:
  - Pork, beef, lamb, liver, peas, green beans, eggs, sunflower seeds, lentils, cucumber, whole grains

- Supplements
  - Amino acid chelate or aspartate best
  - Usually used in 'multi-mineral' products

Selenium

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Selenium mcg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-6</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>55</td>
<td>100-400 mcg</td>
<td>&gt;Should not supplement &gt;400 mcg daily</td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>55</td>
<td></td>
<td>&gt;=900 mcg is toxic</td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15-18</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>55</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Selenium: Functions**

- Antioxidant protection
  - Cofactor for reduction of antioxidant enzymes
  - Glutathione peroxidases
    \[ 2 \text{GSH} + \text{H}_2\text{O} \rightarrow \text{GSH-Px} \rightarrow \text{GSSG} + 2 \text{H}_2\text{O} \]
- Protection against mercury toxicity
  - Binds with methyl mercury
- Thyroid hormone production
  - Activate and deactivates T4 & T3

\[ 2 \text{GSH} + \text{H}_2\text{O} \rightarrow \text{GSH-Px} \rightarrow \text{GSSG} + 2 \text{H}_2\text{O} \]

**Selenium: Deficiency, Toxicity & Therapeutic Considerations**

- Consider if:
  - Hashimoto’s disease
    - 21% reduction in TPO AB wit o.2 mg/day
  - Mercury toxicity/exposure
  - Antioxidant need
    - Immune support, inflammatory conditions, detoxification
  - Toxicity
    - Garlic breath, hair loss, fatigue, irritability, cirrhosis

**Selenium: Sources**

- Food sources:
  - Brazil nuts, kidney, tuna, crab, lobster, nuts, whole grains, meat, eggs
- Supplements
  - Selenomethionine, amino acid chelate, aspartate
Vanadium

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Vanadium mcg</th>
<th>Therapeutic Dosage</th>
<th>ToxicDosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>N/A</td>
<td>&gt;50 mcg - 1.5 mg daily</td>
<td>&gt;1.8 mg/day</td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>N/A</td>
<td></td>
<td>&gt;20 mg daily</td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Blood sugar control

- May be able to mimic the actions of insulin
  - Activates insulin receptor
  - Stimulates glucose oxidation & transport
  - Inhibits lipolysis in adipose tissue
  - Stimulates glycogen synthesis in the liver & muscles
  - Increases glucose uptake & utilization


Vanadium: Deficiency, Toxicity & Therapeutic Considerations

- Only recently considered an essential nutrient
- Deficiency rare
- Consider if:
  - Type 1 or Type 2 Diabetes or insulin resistant
  - Poorly absorbed (~5%)
### Vanadium: Sources

- **Food sources**
  - Mushrooms, shellfish, black pepper, parsley, dill, whole grains, beer and wine

- **Supplements**
  - Vanadyl sulfate (100 mg = 31 mg elemental vanadium)

### Zinc

<table>
<thead>
<tr>
<th>RDA</th>
<th>Age</th>
<th>Zinc mg</th>
<th>Therapeutic Dosage</th>
<th>Toxic Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>4-6</td>
<td>3</td>
<td>&gt;15 mg daily</td>
<td>&gt;500 mg can be toxic</td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>15-18</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>15-18</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19-24</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-50</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50+</td>
<td>11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Zinc: Functions

- Found in over 300 enzymes
- Only metal which appears on all enzyme classes
- Metabolism of carbohydrates, proteins and lipids
- Protein and DNA synthesis
- Anti-oxidant (component of Cu-Zn SOD)
- Plays a role in taste, smell, hormone production, immune health, prostate and reproductive organ health, GI health, detoxification, eye health, learning, neurotransmission, gene expression, programmed cell death, etc...
Immune health
- Zinc found in all WBC and is necessary for proper function
- Antioxidant (Cu-Zn SOD)
  - Combats free radical damage in all tissues
  - Speeds up healing process after injury
- Shown to shorten the duration of colds
  - 80-100 mg/day

Prostate and reproductive organ health
- Highest concentration of zinc found in prostate
- High levels of Zn also found in testes
- Evidence that Zn may preferentially kill prostate cancer cells

In children
- Growth retardation, delayed sexual maturation, infection susceptibility and diarrhea
- Decreased immunity / Poor wound healing
- Alopecia, impaired appetite, impaired digestion, reproductive issues
- Depression
- Eye and skin lesions, macular degeneration
Copper and/or iron deficiency
- Displaces copper and causes decreased absorption
- Anemia (can be microcytic, normocytic or macrocytic), neutropenia, peripheral neuropathy, color/vision loss
- Ataxia, lethargy

**Zinc: Toxicity**

**Zinc: Therapeutic Considerations**
- Failed zinc tally test
- White spots on fingernails
- Prostate health
  - BPH, prostatitis, cancer
- Infertility, especially male
- Low testosterone
- Immune/healing support
- Depression
- Poor sense of smell/taste
- Chronic alcohol use

**Zinc: Sources**
- Food
  - Oysters, pumpkin seeds, beans, sea vegetables, nuts, seeds, peas, seafood, meat
  - High in whole grains but poorly absorbed
  - Bound to phytic acid
- Supplements
  - Best: gluconate, picolinate and citrate
  - Lozenges can help with sore throat & colds
  - Zinc carnosine: effective for H. pylori
Major Minerals | Trace Minerals | Metals
---|---|---
- Calcium | - Chromium | - Boron
- Phosphorus | - Copper | - Lithium
- Magnesium | - Cobalt | - Nickel
- Potassium | - Iodine | - Silicon
- Sodium | - Iron | - Strontium
- | - Manganese | - Tin
- | - Molybdenum | -
- | - Selenium | -
- | - Vanadium | -
- | - Zinc | -

Other Trace Minerals & Metals

<table>
<thead>
<tr>
<th>Element</th>
<th>RDA</th>
<th>Functions</th>
<th>Deficiency</th>
<th>Toxicity</th>
<th>Food Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt</td>
<td>N/A</td>
<td>Required for synthesis of B12</td>
<td>Rare; pernicious anemia</td>
<td>Rare</td>
<td>N/A</td>
</tr>
<tr>
<td>Boron</td>
<td>2.1 mg</td>
<td>Reduces calcium excretion; activates Vitamin D</td>
<td>Unknown</td>
<td>Rare</td>
<td>N/A</td>
</tr>
<tr>
<td>Lithium</td>
<td>1 mg</td>
<td>Mood stabilization</td>
<td>Bi-polar disorder</td>
<td>Kidney failure</td>
<td>N/A</td>
</tr>
<tr>
<td>Silicon</td>
<td>5 mg</td>
<td>Connective tissue formation</td>
<td>Wrinkles, thinning hair, brittle nails</td>
<td>Rare</td>
<td>Grains, nuts, seeds</td>
</tr>
<tr>
<td>Strontium</td>
<td></td>
<td>Calcium uptake into bone</td>
<td>Osteoporosis, bone fracture</td>
<td>Rare</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Summary of mineral effects on body systems
Conditionally Essential Nutrients

- May become essential under certain conditions:
  - Coenzyme Q10 (CoQ10)
  - Alpha lipoic acid
  - Amino acids
    - Acetyl-L-carnitine
    - L-arginine
    - L-lysine
    - L-glutamine
    - N-acetyl-cysteine
    - 5-hydroxytryptophan (5-HTP)

Coenzyme Q10 (CoQ10)

- Three redox states

CoQ10: Functions

- Vital for energy production
  - Component of electron transport chain
  - Generates ATP
  - 95% of the human body’s energy is generated this way
  - Very important for heart, liver, kidney, brain and muscle function
CoQ10: Therapeutic Considerations

- Statin and beta-blocker use
  - CoQ10 shares a biosynthetic pathway with cholesterol
  - Statin use can reduce serum CoQ10 levels by 40%
  - Can lead to heart attack, severe muscle pain, memory issues, fatigue

Inflammation & Chronic Pain
- Diabetes, Cancer
- Brain health
  - Dementia, Parkinson's disease, concussions
- Cardiovascular disease
  - CHF, hypertension, MI
- Migraine headaches
- Fatigue issues
  - Chronic fatigue, fibromyalgia
- Mitochondrial dysfunction

CoQ10: Therapeutic Considerations

- Has the potential to inhibit effects of warfarin (Coumadin) by reducing INR
  - CoQ10 very similar structure to vitamin K1
    - Competes with and counteracts warfarin's anticoagulation effects
**CoQ10: Food Sources**
- Meat and fish
- Organ meats
- Avocado

**CoQ10: Dosing & Toxicity**
- Toxicity not observed
  - Studies done at 3600 mg/day tolerated well
- Supplementation
  - Oil emulsion
  - Typical dosing: 100-400 mg/day
  - Statin/beta-blocker use: 200+ mg/day
  - Migraines: 100 mg TID for 3 months
  - Chronic disease: 200-3200 mg/day

**Alpha-lipoic acid (ALA)**
- Potent antioxidant
  - ALA and metabolite DHLA both antioxidants
  - Increases production of glutathione
  - Can also regenerate other antioxidants
Carbohydrate metabolism
- Improves glucose uptake and fasting blood sugar
- Improves insulin sensitivity
- Decreases postprandial glucose levels
- Modulates inflammatory response
- May suppress vascular inflammation
- Inhibits NF-kB
- Enhances detoxification

Diabetes/Insulin Resistance
- Peripheral neuropathy
- Weight loss
- Chronic alcohol use/liver disease
- Detoxification/chelation
- Brain health/injury
- Inflammatory disorders
- Cardiovascular disease
- Ischemia (cerebral)/brain injury

Toxicity rare; more likely if thiamine deficient
- Alcoholics – supplement with thiamine

Supplementation
- Diabetes and peripheral neuropathy: 600-1200 mg/day
- Peripheral arterial disease: 300 mg BID
**ALA: Sources**

- Food Sources
  - Red meat
  - Organ meats
  - Spinach
  - Broccoli
  - Potatoes
  - Yams
  - Carrots
  - Beets
  - Nutritional yeast

---

**L-carnitine**

- Body can synthesize from lysine and methionine
- Most found in cardiac and skeletal muscle

---

**L-carnitine: Functions**

- Key role in cellular energy production
- Essential for beta-oxidation of long-chain fatty acids in mitochondria to make ATP
L-carnitine: Therapeutic Considerations

- Hyperthyroidism
  - Blocks entry of thyroid hormones into cell nuclei
  - Can significantly improve symptoms
  - Can reduce ALT, AST, GGT and ferritin
- Angina/heart attack
- Diabetes
  - Can improve insulin sensitivity
- Male infertility- increases sperm motility
- Hyperlipidemia – can ↓ Lp(a), LDL and trigs
- Fatty liver

L-Carnitine: Sources

- Food Sources:
  - Grass fed red meat – 1 mg/gram
- Supplementation
  - Typically, 2-6 grams/day in divided doses
  - No more than 2 grams at one dose

L-Arginine

- Can be synthesized from citrulline
  - Often not sufficient; must be consumed
- Precursor for nitric oxide (NO) synthesis
  - Causes vasodilation
- Can improve
  - Hypertension
  - Erectile dysfunction
  - Inflammation
L-Arginine: Functions

- Collagen formation and wound healing
- Secretion of growth hormone
- Pregnancy
  - Can reduce blood pressure and lengthen pregnancy for women with gestational diabetes and/or pre-eclampsia

L-Arginine: Therapeutic Considerations

- Hypertension, CHF
- Sickle cell anemia
- Pulmonary hypertension
  - Helps produce NO – reduces blood pressure
  - Decreases endothelin-1 (a vasoconstrictor)
- Erectile dysfunction
- Injury – bone or soft tissue
  - Improves repair and reduces healing time

L-Arginine: Sources

- Food sources:
  - Red meat, poultry, fish/seafood, dairy products
  - Wheat germ, oatmeal, nuts & seeds, chickpeas

- Supplementation
  - Typically, 2-6 grams/day in divided doses
  - Post workout or injury: 1-3 grams
  - To increase NO production: start with 1.5-6 grams with 200-400 mg magnesium glycinate
L-Lysine

- Essential amino acid for everyone
- Needs increase with viral infections
  - Herpes simplex
  - Epstein Barr
  - Suppresses viral replication

L-Lysine: Therapeutic Considerations

- Cold/canker sores
- Acute and chronic viral infections

Supplementation
- Oral: typically 1-6 grams/day
  - 1000 mg TID for 3 weeks, then 500 mg BID ongoing
- Topically: for herpes simplex, a specific combination of lysine plus zinc oxide (Super Lysine Plus+) – applied every 2 hrs PRN

L-Glutamine

- Most abundant amino acid in the body
- Produced primarily in skeletal muscle
- Many tissues require glutamine
  - Immune system
  - GI tract
  - Kidneys
  - Liver
  - Muscles
- Additional glutamine needed in times of stress, injury and/or illness
**L-Glutamine: Functions**

- **Immune support**
  - Can enhance function of immune cells
  - Increase lymphocyte proliferation, bacterial killing by neutrophils and phagocytic activities of macrophages
  - In cancer patients, show to restore NK cells function and improve protein metabolism

**L-Glutamine: Therapeutic Considerations**

- Following surgery or injury
- Compromised immunity and/or illness
- Severe acute and/or chronic stress
- Gastrointestinal disorders/imbalance
  - Enterocytes need glutamine to rebuild and repair
  - GI tract one of the largest utilizers of glutamine
- Cancer
- Muscle wasting
- Prevent chemo/radiation induced GI toxicity
- Athletes

**L-Glutamine: Supplementation**

- Significant side effects not reported
- Typically: 3-6 grams powder TID
  - Up to 40 grams/day have been used
  - Often used in combination with other supportive nutrients (aloe, DGL, slippery elm, marshmallow root, etc.) for GI function
  - Athletes: 5-10 grams 15-30 minutes after workout and before bed to stimulate muscle repair
  - Ideally, take before meals and/or on an empty stomach
N-acetyl cysteine (NAC)

- Antioxidant protection
- Precursor of glutathione
- Also acts as an antioxidant itself
- Support for detoxification and toxicity

NAC: Functions

- Decrease inflammation
- Reduces cellular production of TNF-α and IL-1
- Neurotransmitter function
  - Increase uptake of cystine, which increases glutamate in the synapse
  - This inhibits further release of glutamate, which can improve compulsive behaviors and addiction
NAC: Therapeutic Considerations

- Acetaminophen poisoning
- Inflammatory disorders
  - RA, OA, chronic pain, GI disorders
- Compulsive behaviors
  - OCD, trichotillomania, addiction
- Lung and heart disorders
  - Reduces mucus viscosity
  - Anti-inflammatory and antioxidant
- Allergies/upper respiratory congestion

NAC: Therapeutic Considerations

- Supplementation
  - Acetaminophen overdose
    - Oral loading dose of 140 mg/kg of a 5% solution should be administered (through a straw)
    - Seventeen additional doses of 70 mg/kg as a 5% solutions should be given every 4 hours, for a total dose of 1330 mg/kg over 72 hours
    - Other conditions – 600-1000 mg BID/TID

5-Hydroxytryptophan (5-HTP)

- Precursor to serotonin & melatonin
- Cannot be shunted to niacin like tryptophan
- Easily crosses the BBB
- From Griffonia simplicifolia
5-HTP: Functions

- Serotonin production

![Amino acids and Monoamine neurotransmitters diagram]

- Optimal results when balanced with catecholamine precursors
  - L-tyrosine and/or L-dopa

www.amino-acid-therapy.com

5-HTP: Therapeutic Considerations

- Depression
- Appetite suppression
- Sleep aid/Insomnia
- Fibromyalgia
- Chronic pain
- Migraines

5-HTP: Therapeutic Considerations

- Side effects
  - Nausea/GI upset upon starting
    - Severe serotonin deficiency
    - Need to start more slowly so body can adjust
  - Nausea/GI upset after onset
    - Imbalance between serotonin and dopamine
    - Carbohydrate intolerance
5-HTP: Therapeutic Considerations

- Supplementation
  - Typically 100-300 mg 5-HTP daily in divided doses balanced with 10x L-tyrosine
    - i.e., 150 mg of 5-HTP + 1500 mg L-tyrosine BID
  - Can potentiate effectiveness and side effects of SSRI medications
  - Use with caution with MAOI medications
  - Learn more at: www.amino-acid-therapy.com

Phytonutrients

- "phyto" means "plant" in Greek
- Responsible for color and smell of many foods
- Have biological significance but are not established as essential nutrients
  - i.e., carotenoids and flavonoids
- ~4,000 phytonutrients

Red phytoneutrients

<table>
<thead>
<tr>
<th>Phytonutrient</th>
<th>Benefits</th>
<th>Found In</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclapene*</td>
<td>Reduces the risk of prostate, breast, and skin cancer; reduces the risk of heart attacks</td>
<td>Tomato-based products (tomato juice, spaghetti sauce, tomato soup, tomato paste), watermelon, jujube, grapes, fresh tomatoes, guava</td>
</tr>
<tr>
<td>Anthocyanins*</td>
<td>Reduce the risk of cancer; powerful antioxidants; help control high blood pressure; reduce the risk of diabetes complications; reduce the risk of heart attacks; reduce the risk of Alzheimer's disease</td>
<td>Red raspberries, sweet cherries, strawberries, cranberries, beets, red apples (with skin), red cabbage, red onion, kidney beans, red beans</td>
</tr>
<tr>
<td>Astaxanthin</td>
<td>Proton antioxidant, particularly for the liver; gastroprotective effects; immune stimulant; Chemosynergistic.</td>
<td>Microalgae, yeast, salmon, trout, krill, shrimp, crayfish, crustaceans.</td>
</tr>
</tbody>
</table>

*Provided by the National Cancer Institute, www.cancer.gov
Vegetables
- Beets
- Red potatoes
- Radishes
- Rhubarb
- Red apples
- Red cabbage
- Red peppers

Fruits
- Cherries
- Cranberries
- Pink grapefruit
- Red grapes
- Pomegranates
- Raspberries
- Strawberries
- Tomatoes
- Watermelon

Orange phytonutrients

<table>
<thead>
<tr>
<th>Phytonutrient</th>
<th>Benefits</th>
<th>Found in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta-carotene*</td>
<td>Powerful antioxidant; boosts immunity; reduces risk for cancer; reduces risk of heart attacks; helps maintain good vision.</td>
<td>Carrots, sweet potatoes, pumpkins, butternut squash, cantaloupe, mangos, apricots, peaches</td>
</tr>
<tr>
<td>Bioflavonoids*</td>
<td>Powerful antioxidants; Works with vitamin C to reduce the risk of heart attacks, reduce the risk of cancer, and helps maintain strong bones/joints, healthy skin, and good vision.</td>
<td>Oranges, grapefruit, lemons, tangerines, clementines, peaches, apricots, nectarines, pears, pineapple, yellow raisins, yellow peppers</td>
</tr>
</tbody>
</table>

Vegetables
- Butternut squash
- Carrots
- Pumpkin
- Butternut squash Sweet corn
- Sweet potatoes
- Yellow peppers
- Yellow tomatoes
- Yellow summer or winter squash

Fruits
- Yellow apples
- Apricots
- Cantaloupe
- Grapefruit
- Lemons
- Nectarines
- Oranges
- Papayas
- Peaches
- Pears
- Passion fruit
- Pineapple
- Tangerines
- Watermelon

www.naturalpathhealthcenter.com
Yellow-green phytonutrients

<table>
<thead>
<tr>
<th>Phytonutrient</th>
<th>Benefits</th>
<th>Found In</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lutein* /Zeaxanthin</td>
<td>Helps maintain good vision; reduces the risk of cataracts or macular degeneration.</td>
<td>Kale, spinach, leafy greens (turnip, collard, mustard), romaine lettuce, broccoli, green peas, kiwi fruit, honeydew melon</td>
</tr>
<tr>
<td>Indoles*</td>
<td>Reduce the risk of cancer (particularly breast and prostate cancers); reduce the risk of tumor growth in cancer patients.</td>
<td>Broccoli, cabbage, brussels sprouts, kale, choy, arugula, Swiss chard, turnips, rutabaga, watercress, oakleaf, kale</td>
</tr>
<tr>
<td>Chlorophyll</td>
<td>Powerful antioxidant</td>
<td>All green vegetables</td>
</tr>
<tr>
<td>Folate</td>
<td>Methylating; cell growth.</td>
<td>Leafy greens</td>
</tr>
</tbody>
</table>

*Provided by the National Cancer Institute, www.cancer.gov

Vegetables
- Arugula
- Asparagus
- Green beans
- Broccoli
- Brussels sprouts
- Green cabbage
- Cucumbers
- Lettuce
- Green onions
- Peas
- Green pepper
- Spinach
- Zucchini

Fruits
- Avocados
- Green apples
- Green grapes
- Honeydew melon
- Kiwi
- Limes

Blue-purple phytonutrients

<table>
<thead>
<tr>
<th>Phytonutrient</th>
<th>Benefits</th>
<th>Found In</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthocyanins*</td>
<td>Reduce the risk of cancer; powerful antioxidants; reduce the risk of age-related memory loss; help control high blood pressure; reduce the risk of diabetes complications; reduce the risk of heart attacks; reduce the risk of Alzheimer’s disease</td>
<td>Blueberries, blackberries, purple grapes, black currants, elderberries</td>
</tr>
<tr>
<td>Phenolics*</td>
<td>Powerful antioxidants; may slow some of the effects of aging.</td>
<td>Dried plums (prunes), raisins, plums, eggplant</td>
</tr>
</tbody>
</table>

*Provided by the National Cancer Institute, www.cancer.gov
Eat as many deep colored foods as possible daily
Phytonutrients: Therapeutic Considerations

- Can be degraded by processing/cooking
  - Exception is lycopene and some carotenoids
    - Increases with cooking
      - Tomatoes, broccoli, Brussel sprouts, kale, collard greens
- Cell wall must be broken to release
  - Chewing and/or blending

Enzymes

- Accelerate (catalyze) chemical reactions
- Necessary for almost all metabolic processes in the cell in order to sustain life
- Most are proteins
- Two main types
  - Metabolic
  - Digestive

Metabolic Enzymes

- Speed up or slow down reactions
- Often require cofactors (vitamins and/or minerals) to work properly
Digestive Enzymes

- Break down food into smaller building blocks to facilitate absorption by the body
- Found in saliva, stomach, pancreas & intestines

Proteases/Proteolytic enzymes
- Break down proteins into small peptides and amino acids
- Stomach: pepsin
- Pancreas: trypsin & chymotrypsin

Lipases
- Split fat into fatty acids and glycerol
- Saliva: lingual lipase
- Gastric and pancreatic lipases

Amylases
- Split carbohydrates into simple sugars
- Saliva: amylase (ptyalin)
- Pancreas and small intestine

Nucleases
- Split nucleic acids into nucleotides

Digestion and Enzymes

- Digestion begin in the mouth (fats and carbs)
- Stomach
  - Protein & fat digestion
  - Pepsin and HCl, lipase
  - Kill foreign invaders
- Liver
  - Fat digestion (bile)
- Small intestine
  - Pancreatic juice
  - Brush border enzymes
- Large intestine
  - Absorption & waste removal
Pancreatic Enzymes

- Pancreatic juice contains:
  - Proteases
  - Trypsin
  - Chymotrypsin
  - Elastases
  - Carboxypeptidase
  - Amylase
  - Lipase
Proteases/Proteolytic Enzymes

- Pepsin
- Trypsin
- Chymotrypsin
- Carboxypeptidase
- Bromelain
- Papain

Proteolytic Enzymes

- Taken with food – will digest proteins/food
- Taken on an empty stomach, can:
  - Greatly reduce inflammation
  - Break down scar tissue
  - Improve immunity
  - Speed healing

Modulation of the Inflammatory Process

- Proteolytic enzymes
  - Bromelain (pineapple), papain (papaya), proteases, trypsin, chymotrypsin, pancreatin
  - Reduce pain and inflammation and promote recovery
  - Inhibit pro-inflammatory compounds, remove wastes and improve circulation to speed healing
  - Significantly reduce pain and inflammation
  - Also very good for acute pain/truma
**Amylases**

- Break down complex carbohydrates into smaller chains or simple sugars
  - Amylase/ptyalin
  - Maltase
  - Lactase
  - Sucrase

**Lipases**

- Degrade fats/triglycerides into fatty acids and glycerol
  - Acidic lipases
    - Lingual lipase
    - Gastric lipase
    - Do not require bile to work
    - Make up ~30% of fat digestion
  - Alkaline lipases
    - Pancreatic lipase
Pancreatic Digestive Enzyme Formula
- Use with normal HCl production
- Serving size: 1 tablet

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Amount Per Serving Value</th>
<th>% Daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protease</td>
<td>104,000 USP units</td>
<td></td>
</tr>
<tr>
<td>Amylase</td>
<td>104 USP units</td>
<td></td>
</tr>
<tr>
<td>Lipase</td>
<td>16,640 USP units</td>
<td></td>
</tr>
</tbody>
</table>

Non-animal Derived Digestive Formula
- Use when suboptimal HCl
- Work over a larger pH range than animal-based enzymes
- Serving size: 2 tablets

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Amount Per Serving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protease I</td>
<td>20,000 PC</td>
</tr>
<tr>
<td>Protease II</td>
<td>200,000 USP</td>
</tr>
<tr>
<td>Protease III</td>
<td>40,000 RUT</td>
</tr>
<tr>
<td>Amylase</td>
<td>20,000 DU</td>
</tr>
<tr>
<td>Lipase</td>
<td>2,000 LU</td>
</tr>
<tr>
<td>Cellulase</td>
<td>2,000 CU</td>
</tr>
<tr>
<td>Phytase</td>
<td>600 UNITS</td>
</tr>
<tr>
<td>Maltase</td>
<td>400 DP</td>
</tr>
<tr>
<td>Lactase</td>
<td>400 LAC U</td>
</tr>
<tr>
<td>Invertase</td>
<td>400 SUMNER</td>
</tr>
<tr>
<td>Amla Fruit</td>
<td>40 mg</td>
</tr>
</tbody>
</table>
Based on the theory that “like heals like”
- Consuming a glandular/tissue extract can provide the necessary nutrients needed for healing/repair
- Thought to help carry nutrients to target tissues

Most common sources
- Cow (bovine), Pig (porcine) & Sheep (ovine)

Frequently used for:
- Thyroid, adrenal, thymus, reproductive organs

Tissue specific
- Demonstrated through radioactive isotope tracing
- Contain nutrients necessary for organ/tissue healing
  - Do NOT contain hormones; can contain hormone precursors

Restorative
- Support biochemical balance of both underactive and overactive conditions
- Overdosing not noted

May be contaminated
- Antibiotics, steroid hormones, pesticide residues, drugs, chemicals, and other toxins
- Difficult to regulate quality batch-to-batch
- Possibility of virus/prion contamination
  - Theoretical, no data to support
  - FDA regulates that bovine ingredients may be obtained ONLY from animals raised in countries free of BSE
Questions???