MICRONUTRIENT
Your guide to customized optimal nutrition.
Vibrant America is pleased to present to you micronutrient testing that provides a comprehensive extracellular and intracellular assessment of the levels of the most important vitamins, minerals, antioxidants, fatty acids, and amino acids to help you make healthy lifestyle choices in consultation with your physicians and dietitians.

**Testing Methodology:** The blood sample is spun down so that the serum can be taken from the top and RBCs from the bottom. The remaining sample is processed to isolate PBMCs (Peripheral Blood Mononuclear cells). All three subsets are processed separately to isolate appropriate micronutrients for injection into mass-spectrometry. Micronutrients measured in RBCs include: folate, omega-3 and omega-6 fatty acids, and magnesium. Serum micronutrient measurements provide extracellular levels. WBC measurements are done and total WBC counts are taken on an automated cell counter. Intracellular WBC levels are normalized to the total WBC count in a patient’s sample.

**Interpretation of Report:** The test results of micronutrient levels are displayed in 3 columns – Serum, RBC and WBC. Black suggests higher than normal value compared to a reference population and red suggests lower than normal value compared to a reference population. Green suggests normal levels. WBC Measurements are reported as pg/MM WBC- picograms of micronutrient per Million White Blood Cells.

The statements in this report have not been evaluated by the Food and Drug Administration. Please consult your physician/dietitian for medication, treatment, or life style management. This product is not intended to diagnose, treat, or cure any disease.

_**Please Note - It is important that you discuss any modifications to your diet, exercise, and nutritional supplementation with your physician before making any changes. To schedule an appointment with a Vibrant clinical dietitian please call: Toll-Free 866-364-0963**_
<table>
<thead>
<tr>
<th>Abnormal</th>
<th>Recommended Daily Intake</th>
<th>Suggested supplementation</th>
<th>Provider Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A ↓</td>
<td>700 mcg RAE/day for women 900 mcg RAE/day for men</td>
<td>2000 IU/day</td>
<td></td>
</tr>
<tr>
<td>Vitamin B1 ↓</td>
<td>RDA: 1.0 mg/day for females and 1.2 mg/day for males.</td>
<td>25-100 mg/day</td>
<td></td>
</tr>
<tr>
<td>Vitamin B2 ↓</td>
<td>RDA: 1.7 mg/day.</td>
<td>25-50 mg/day.</td>
<td></td>
</tr>
<tr>
<td>Vitamin B3 ↓</td>
<td>RDA: 20 mg/day.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin B6 ↑</td>
<td>RDA: 2 mg/day.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin B12 ↓</td>
<td>RDA: 6 mcg/day.</td>
<td>400 mcg/day.</td>
<td></td>
</tr>
<tr>
<td>Vitamin B5 ↓</td>
<td>AI: 5 mg/day in adults</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin C ↑</td>
<td>RDA: 75 mg/day for women 90 mg/day for men</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin D3 ↑</td>
<td>RDA: 400 IU/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin E ↓</td>
<td>RDA: 15 mg/day</td>
<td>250 IU/day</td>
<td></td>
</tr>
<tr>
<td>Vitamin K1 ↑</td>
<td>AI: 90 mg/day for women 120 mg/day for men</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium ↓</td>
<td>AI: 1000 mg/day</td>
<td>1000-1200 mg/day</td>
<td></td>
</tr>
<tr>
<td>Zinc ↑</td>
<td>RDA: 8 mg/day for women 11 mg/day for men</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper ↑</td>
<td>RDA: 900 µg/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chromium ↑</td>
<td>AI: 35 µg/day for men 25 µg/day for women</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron ↓</td>
<td>AI for iron varies by gender and age</td>
<td>8 mg/day for men; 18 mg/day for women; Iron supplementation not recommended for men and post menopausal women</td>
<td></td>
</tr>
<tr>
<td>Magnesium ↑</td>
<td>AI: 1.8 mg/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choline ↓</td>
<td>AI: 425 mg/day for women 550 mg/day for men</td>
<td>450 mg/day</td>
<td></td>
</tr>
</tbody>
</table>

All supplement and dietary suggestions for specific micronutrients must be evaluated and approved by your provider. Suggested Supplementation is based off references provided at the end of this report. Please see detailed explanation for each micronutrient and follow your ordering providers' recommendation before using this as a therapeutic intake.
<table>
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<tr>
<th>Abnormal</th>
<th>Recommended Daily Intake</th>
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<th>Provider Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inositol ↓</td>
<td>Metabolic cofactor; There is currently no established RDA, AI, or UL for inositol</td>
<td>2-4g/day</td>
<td></td>
</tr>
<tr>
<td>Carnitine ↓</td>
<td>Metabolic metabolite; no recommended intake established</td>
<td>500 mg</td>
<td></td>
</tr>
<tr>
<td>MMA ↑</td>
<td>Metabolic Intermediate; no recommended intake established</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asparagine ↓</td>
<td>There is currently no established RDA, AI, or UL for asparagine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glutamine ↓</td>
<td>There is currently no established RDA, AI, or UL for glutamine</td>
<td>500 mg/day</td>
<td></td>
</tr>
<tr>
<td>Serine ↓</td>
<td>There is currently no established RDA, AI, or UL for serine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coenzyme Q10 ↑</td>
<td>Metabolic Cofactor; no recommended intake established</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cysteine ↓</td>
<td>There is currently no established RDA, AI, or UL for cysteine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glutathione ↓</td>
<td>There currently is no RDA, AI, or UL established for glutathione intake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selenium ↓</td>
<td>RDA: 55 µg/day.</td>
<td>55 µg/day</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Abnormal</th>
<th>Recommended Daily Intake</th>
<th>Suggested supplementation</th>
<th>Provider Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B6 ↑</td>
<td>RDA: 2 mg/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin B5 ↑</td>
<td>AI: 5 mg/day in adults</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin D3 ↓</td>
<td>RDA: 400 IU/day</td>
<td>2000 IU/day</td>
<td></td>
</tr>
<tr>
<td>Vitamin E ↓</td>
<td>RDA: 15mg/day</td>
<td>250 IU/day</td>
<td></td>
</tr>
<tr>
<td>Vitamin K1 ↑</td>
<td>AI: 90 mg/day for women 120 mg/day for men</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All supplement and dietary suggestions for specific micronutrients must be evaluated and approved by your provider. Suggested Supplementation is based off references provided at the end of this report. Please see detailed explanation for each micronutrient and follow your ordering providers’ recommendation before using this as a therapeutic intake.
### WBC Micronutrient

<table>
<thead>
<tr>
<th>Abnormal</th>
<th>Recommended Daily Intake</th>
<th>Suggested supplementation</th>
<th>Provider Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium ↓</td>
<td>AI: 1000 mg/day</td>
<td>1000-1200 mg/day</td>
<td></td>
</tr>
<tr>
<td>Manganese ↓</td>
<td>AI: 1.8 mg/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc ↓</td>
<td>RDA: 8mg/day for women 11mg/day for men</td>
<td>Men: 11 mg/day Women: 8 mg/day</td>
<td></td>
</tr>
<tr>
<td>Copper ↓</td>
<td>RDA: 900 µg/day</td>
<td>25-35 mcg/day</td>
<td></td>
</tr>
<tr>
<td>Choline ↓</td>
<td>AI: 425 mg/day for women 550 mg/day for men</td>
<td>450 mg/day</td>
<td></td>
</tr>
<tr>
<td>MMA ↑</td>
<td>Metabolic Intermediate; no recommended intake established</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asparagine ↓</td>
<td>There is currently no established RDA, AI, or UL for glutamine</td>
<td>500 mg/day</td>
<td></td>
</tr>
<tr>
<td>Serine ↓</td>
<td>There is currently no established RDA, AI, or UL for serine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coenzyme Q10 ↓</td>
<td>Metabolic Cofactor; no recommended intake established</td>
<td>100-200 mg/day.</td>
<td></td>
</tr>
<tr>
<td>Glutathione ↓</td>
<td>There currently is no RDA, AI, or UL established for glutathione intake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selenium ↑</td>
<td>RDA: 55 µg/day.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cysteine ↓</td>
<td>There is currently no established RDA, AI, or UL for cysteine</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### RBC Micronutrient

<table>
<thead>
<tr>
<th>Abnormal</th>
<th>Recommended Daily Intake</th>
<th>Suggested supplementation</th>
<th>Provider Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Folate ↓</td>
<td>RDA: 400 mcg/day for adults</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium ↓</td>
<td>RDA: 300-320 mg/day</td>
<td>300-400 mg/day</td>
<td></td>
</tr>
<tr>
<td>EPA ↑</td>
<td>No recommended intake established</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DPA ↑</td>
<td>Metabolic Intermediate; no recommended intake established</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All supplement and dietary suggestions for specific micronutrients must be evaluated and approved by your provider. Suggested Supplementation is based off references provided at the end of this report. Please see detailed explanation for each micronutrient and follow your ordering providers’ recommendation before using this as a therapeutic intake.
## RBC Micronutrient

<table>
<thead>
<tr>
<th>Abnormal</th>
<th>Recommended Daily Intake</th>
<th>Suggested supplementation</th>
<th>Provider Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA ↓</td>
<td>No recommended intake established</td>
<td>Supplementation usually not necessary</td>
<td></td>
</tr>
<tr>
<td>Omega-3 Index</td>
<td>502 mg/day (EPA + DHA)</td>
<td>1000mg/day (EPA+DHA)</td>
<td></td>
</tr>
<tr>
<td>Total Omega-6</td>
<td>11g/day for females 17g/day for men</td>
<td>Supplementation usually not necessary</td>
<td></td>
</tr>
</tbody>
</table>

All supplement and dietary suggestions for specific micronutrients must be evaluated and approved by your provider. Suggested Supplementation is based off references provided at the end of this report. Please see detailed explanation for each micronutrient and follow your ordering providers’ recommendation before using this as a therapeutic intake.
What Do I Do With The Information From This Test?

Your provider will discuss any nutrient deficiencies identified on the report.

<table>
<thead>
<tr>
<th>Extracellular</th>
<th>Intracellular</th>
<th>Likely Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>No action is required.</td>
</tr>
<tr>
<td>Deficient</td>
<td>Normal</td>
<td>The long term nutrient status is optimal, but short term needs improvement. Consider food sources and/or supplements recommended by your provider. Also consider if genetic SNPs or medications may have an affect on depletion.</td>
</tr>
<tr>
<td>Normal/Excess</td>
<td>Deficient</td>
<td>The short term status of micronutrients is optimal, but absorption may be a problem, as long as extracellular levels are not outside of normal levels. Recommend increasing dietary intake of the nutrient, or increasing supplementation dosage; consider a bioavailable version of the supplement if available. Consider additional follow up testing to identify your source of malabsorption.</td>
</tr>
<tr>
<td>Deficient</td>
<td>Deficient</td>
<td>Consider increasing dietary intake of food sources of the nutrient or increasing supplementation dosage; consider a bioavailable version of the supplement if available. Consider testing for genetic SNPs that affect nutrient status or assessing medication interactions. If retest shows that the nutrient levels are still not optimal, identify the source of malabsorption.</td>
</tr>
<tr>
<td>Micronutrient</td>
<td>Serum</td>
<td>WBC</td>
</tr>
<tr>
<td>--------------</td>
<td>-------</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td>Current</td>
<td>Previous</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>3.00 ↓ (mcg/dL)</td>
<td>32.96–82.27</td>
</tr>
<tr>
<td>Vitamin B1</td>
<td>3.00 ↓ (nmol/L)</td>
<td>164.71–397.23</td>
</tr>
<tr>
<td>Vitamin B2</td>
<td>3.00 ↓ (mcg/L)</td>
<td>23.41–358.5</td>
</tr>
<tr>
<td>Vitamin B3</td>
<td>3.00 ↓ (ng/mL)</td>
<td>5.05–84.36</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td>3.00 ↑ (ng/mL)</td>
<td>0.46–1.76</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>3.0 ↓ (ng/L)</td>
<td>180.0–914.0</td>
</tr>
<tr>
<td>Vitamin B5</td>
<td>3.00 ↓ (mcg/L)</td>
<td>23.23–269.1</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>3.00 ↑ (mg/dL)</td>
<td>0.34–0.71</td>
</tr>
<tr>
<td>Vitamin D3</td>
<td>3.00 ↑ (ng/mL)</td>
<td>0.74–2.46</td>
</tr>
<tr>
<td>Vitamin D, 25-OH</td>
<td>&lt;5 ↓ (ng/mL)</td>
<td>≥30</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>3.0 ↓ (mg/L)</td>
<td>7.6–24.6</td>
</tr>
<tr>
<td>Vitamin K1</td>
<td>3.00 ↑ (ng/mL)</td>
<td>0.22–2.50</td>
</tr>
<tr>
<td>Vitamin K2</td>
<td>3.00 (ng/mL)</td>
<td>≥0.08</td>
</tr>
<tr>
<td>Folate</td>
<td>3.0 ↓ (ng/mL)</td>
<td>4.6–34.8</td>
</tr>
</tbody>
</table>

**Vitamins**

** LAST NAME FIRST NAME MIDDLE NAME DATE OF BIRTH ACCESSION ID **

<p>| AA AA 1991-11-11 1802040003 | Vibrant America | 1021 Howard Ave, Ste B. San Carlos, CA 94070 | 1(866) 364-0963 | <a href="mailto:support@vibrant-america.com">support@vibrant-america.com</a> | <a href="http://www.vibrant-america.com">www.vibrant-america.com</a> |</p>
<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Serum</th>
<th>WBC</th>
<th>RBC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current</td>
<td>Previous</td>
<td>Ref</td>
</tr>
<tr>
<td>Calcium</td>
<td>2.0 ↓ (mg/dL)</td>
<td>8.9~10.6</td>
<td>3 ↓ (pg/MM WBC)</td>
</tr>
<tr>
<td>Manganese</td>
<td>3.0 (ng/mL)</td>
<td>2.6~14.7</td>
<td>3 ↓ (pg/MM WBC)</td>
</tr>
<tr>
<td>Zinc</td>
<td>3.0 ↑ (mcg/mL)</td>
<td>0.8~1.6</td>
<td>3 ↓ (pg/MM WBC)</td>
</tr>
<tr>
<td>Copper</td>
<td>3.0 ↑ (mcg/mL)</td>
<td>0.5~1.2</td>
<td>3 ↓ (pg/MM WBC)</td>
</tr>
<tr>
<td>Chromium</td>
<td>3.0 ↑ (ng/mL)</td>
<td>≤2.1</td>
<td>3 (pg/MM WBC)</td>
</tr>
<tr>
<td>Iron</td>
<td>&lt;5 ↓ (mcg/dL)</td>
<td>59~158</td>
<td>3.0 ↓ (mg/dL)</td>
</tr>
<tr>
<td>Magnesium</td>
<td>3.0 ↑ (mg/dL)</td>
<td>1.6~2.6</td>
<td>3.0 ↓ (mg/dL)</td>
</tr>
<tr>
<td>Copper to Zinc Ratio</td>
<td>1.0</td>
<td>0.7~1.0</td>
<td></td>
</tr>
<tr>
<td>Choline</td>
<td>3.00 ↓ (nmol/mL)</td>
<td>6.90~15.14</td>
<td>3.00 ↓ (pg/MM WBC)</td>
</tr>
<tr>
<td>Inositol</td>
<td>3.00 ↓ (nmol/mL)</td>
<td>5.04~13.20</td>
<td>3.00 (pg/MM WBC)</td>
</tr>
<tr>
<td>Carnitine</td>
<td>3.00 ↓ (nmol/mL)</td>
<td>16.07~39.24</td>
<td>3.00 (pg/MM WBC)</td>
</tr>
<tr>
<td>MMA</td>
<td>3.0 ↑ (nmol/mL)</td>
<td>≤0.2</td>
<td>3.0 ↑ (pg/MM WBC)</td>
</tr>
<tr>
<td>Sodium</td>
<td>&lt;80 ↓ (mmol/L)</td>
<td>136~145</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>2.0 ↓ (mmol/L)</td>
<td>3.5~5.1</td>
<td></td>
</tr>
<tr>
<td>Micronutrient</td>
<td>Serum Current</td>
<td>Previous</td>
<td>Ref</td>
</tr>
<tr>
<td>--------------------</td>
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</tr>
<tr>
<td><strong>Amino Acids</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asparagine</td>
<td>2.00 ↓ (nmol/mL)</td>
<td>16.93–45.04</td>
<td></td>
</tr>
<tr>
<td>Glutamine</td>
<td>2.00 ↓ (nmol/mL)</td>
<td>137.15–204.11</td>
<td>11</td>
</tr>
<tr>
<td>Serine</td>
<td>2.00 ↓ (nmol/mL)</td>
<td>34.89–107.70</td>
<td>0</td>
</tr>
<tr>
<td>Coenzyme Q10</td>
<td>2.00 ↑ (mcg/mL)</td>
<td>0.21–1.38</td>
<td></td>
</tr>
<tr>
<td><strong>Antioxidants</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cysteine</td>
<td>2.00 ↓ (nmol/mL)</td>
<td>103.93–365.08</td>
<td>08</td>
</tr>
<tr>
<td>Glutathione</td>
<td>2.00 ↓ (nmol/mL)</td>
<td>5.50–33.91</td>
<td>1</td>
</tr>
<tr>
<td>Selenium</td>
<td>2.0 ↓ (ng/mL)</td>
<td>70.4–331.90</td>
<td></td>
</tr>
<tr>
<td><strong>Fatty Acids: Omega-3 &amp; 6</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPA</td>
<td>3.00 ↑ (%)</td>
<td>0.16–1.45</td>
<td></td>
</tr>
<tr>
<td>DPA</td>
<td>3.00 ↑ (%)</td>
<td>0.73–1.99</td>
<td></td>
</tr>
<tr>
<td>DHA</td>
<td>3.00 (%)</td>
<td>1.12–9.58</td>
<td></td>
</tr>
<tr>
<td>AA</td>
<td>3.00 ↓ (%)</td>
<td>3.10–20.23</td>
<td></td>
</tr>
<tr>
<td><strong>Total Omega-3</strong></td>
<td>3.00 (%)</td>
<td>1.89–12.82</td>
<td></td>
</tr>
<tr>
<td>Omega-3 Index</td>
<td>3.00 (%)</td>
<td>≥8.01</td>
<td></td>
</tr>
<tr>
<td><strong>Total Omega-6</strong></td>
<td>3.00 (%)</td>
<td>7.43–36.90</td>
<td></td>
</tr>
<tr>
<td>LA</td>
<td>3.00 (%)</td>
<td>1.36–8.62</td>
<td></td>
</tr>
</tbody>
</table>
VITAMINS

**Physiological Function**

- Vitamin A is a group of fat-soluble vitamins which includes retinol, retinal, retinoic acid, and several provitamin A carotenoids, among which beta-carotene is the most important.
- Vitamin A has multiple functions including: growth and development in infants, children and adolescents, maintenance of the immune system, and healthy vision.
- Vitamin A is needed by the retina of the eye for both low-light and color vision.
- Vitamin A also functions as retinoic acid, an important hormone-like growth factor for epithelial and other cells.
- Other important roles that vitamin A plays in the body include: gene transcription, haematopoiesis, and antioxidant activity.

**How it gets depleted**

Vitamin A deficiency may occur with chronic alcoholism, zinc deficiency, hypothyroidism, and use of laxatives.

**Clinical Manifestations of Depletion**

Vitamin A deficiency may result in night blindness, impaired immunity, impaired healing, increased risk of infection, thyroid disorders, leukoplakia or keratosis.

Assess zinc status to assess if zinc deficiency has led to secondary functional deficiency of vitamin A release from liver stores.

**Food Sources**

Food sources of vitamin A include: cod liver oil, liver (turkey, beef, pork, fish and chicken), dandelion greens, fortified cereals and milk, butter, eggs, sweet potato, pumpkin, carrot, cantaloupe, mango, spinach, broccoli leaf (broccoli florets have much less), kale, and butternut squash.

**Supplement Options**

- The RDA for vitamin A is 700mcg RAE/day for women and 900 mcg RAE/day for men. This is the amount needed to prevent chronic deficiency, but more may be needed for optimal health.
- These measurements are the equivalent of 2500 IU/day for women and 3000 IU/day for men of pre-formed vitamin A sources (animal sources).
- The upper intake level (UL) for vitamin A in adults is set at 3,000 µg RAE/day.
- Vitamin A toxicity can occur from taking pre-formed vitamin A from sources other than plant sources.
Vitamin B1 aids in energy transformation and production of ATP. It acts as a coenzyme in the breakdown of carbohydrates, fats and proteins to produce energy.

**Physiological Function**

Vitamin B1 aids in energy transformation and production of ATP. It acts as a coenzyme in the breakdown of carbohydrates, fats, and proteins to produce energy.

**How it gets depleted**

Thiamin can become depleted or deficient from frequent consumption of thiaminases present in higher amounts in raw fish and tannins/tannic acid (tea and coffee).

Thiamin is vulnerable to loss during cooking. Can be depleted with excessive or chronic alcohol intake. There may be higher risk of depletion with gastric bypass surgery.

**Clinical Manifestations of Depletion**

Thiamin deficiency can lead to nervous system and cardiac abnormalities.

The most severe form of thiamin deficiency is called beri beri, a condition commonly resulting in weakness, fatigue, confusion, irritability, weight loss, muscle wasting, and peripheral neuropathy.

**Food Sources**

Food sources of thiamin include: pork, organ meats, legumes, sweet potato, brown rice, brewer’s yeast, pine nuts, sunflower seeds, enriched grains*

**Supplement Options**

*Enriched grains include riboflavin

The RDA for thiamin is 1.0 mg/day for females and 1.2 mg/day for males.

The RDA for thiamin during pregnancy/lactation is 1.4 mg/day.

Therapeutic intake of thiamin is commonly 25-100 mg/day.

No UL for thiamin has been set.

Thiamin is commonly found in multi-B vitamin products.

Riboflavin is commonly depleted by excessive or chronic alcohol consumption. Need for riboflavin is increased in the elderly.

**Physiological Function**

Two very important coenzymes involved in energy metabolism are derived from riboflavin to participate in oxidation/reduction reactions.

Riboflavin is also essential for NOS enzyme (nitric oxide synthase) and glutathione reductase which regenerates glutathione, and which is very important for antioxidation/detoxification.

**Clinical Manifestations of Depletion**

Frank deficiency of riboflavin is rare, however, marginal deficiency is common.

Deficiency of riboflavin is associated with fatigue/weakness.

**Food Sources**

Food sources high in riboflavin include: organ meats, dairy foods, eggs, leafy greens (spinach), broccoli, and liver.

*Enriched grains include riboflavin

**Supplement Options**

*The RDA for riboflavin is 1.7 mg/day.

*Common levels of therapeutic intake of riboflavin are 25-50 mg/day.

*No UL for riboflavin has been set.
Niacin is extensively involved in metabolic reduction reactions through NAD-NADPH pathways. Over 200 enzymes in the human body require niacin. Other important major functions of niacin include: fatty acid synthesis, ATP synthesis, DNA repair, lower cholesterol/LDL, aids in circulation.

Physiological Function
Niacin is extensively involved in metabolic reduction reactions through NAD-NADPH pathways. Over 200 enzymes in the human body require niacin.

Other important major functions of niacin include: fatty acid synthesis, ATP synthesis, DNA repair, lower cholesterol/LDL, aids in circulation.

How it gets depleted
Synthesized from tryptophan and uses iron, B6 and riboflavin as cofactors; deficiencies of these companion nutrients may be underlying causes.

Can be depleted by oral contraceptives and statin drugs.

Clinical Manifestations of Depletion
Symptoms of niacin deficiency include: vomiting, constipation, red tongue, headache, fatigue, and depression.
Severe deficiency of niacin is called pellagra. Pellagra is commonly accompanied by the following 4Ds: dermatitis, diarrhea, dementia, death.

Food Sources
The most concentrated sources of niacin are in animal products (pork), peanuts/peanut butter, tofu, and eggs. Also consider food sources high in tryptophan.

Enriched grains provide supplemental niacin.

Supplement Options
- The RDA for niacin is 20 mg/day.
- The UL for niacin is 35 mg/day, but oral administration up to 6g per day has been used without side effects.
- Niacin is often recommended therapeutically for lipid management. Niacin has been shown to lower LDL cholesterol, lipoprotein(a), triglyceride, and fibrinogen levels, while raising HDL levels.
- Flushing can occur at high doses. Aspirin may help reduce flushing. Time release niacin or no-flush niacin is not recommended for therapeutic treatment.
- Monitor liver function carefully with high dose Niacin supplementation.
Physiological Function

There are 117 known B6 dependent enzymes important for metabolic function. Most are aminotransferase reactions (transfer of amino groups for protein metabolism). Vitamin B6 also aids in the absorption of Vitamin B12. B6 converts tryptophan to serotonin and can modulate steroid hormone activity. B6 is involved in the methylation cycle and clearance of homocysteine along with folate and B12.

How it gets depleted

Antibiotics can reduce B6 levels. Oral contraceptives can interfere with B6 metabolism. Food additives such as FD & C yellow #5 may interfere with B6. Drugs such as isoniazid and dopamine may interfere with vitamin B6. Alcoholics are thought to be most at risk for Vitamin B6 deficiency due to low dietary intakes and impaired metabolism.

Clinical Manifestations of Depletion

Depletion of vitamin B6 can manifest as impaired protein synthesis, growth failure, immune dysfunction, microcytic anemia (small RBC's), elevated homocysteine, depression/fatigue, or anxiety. B6 insufficiency should be considered in the instance of mood disorders, nervous system dysfunction, pregnancy, the use of oral contraceptives or amphetamines, and cigarette smoking.

Food Sources

Food sources of B6 include: beef, liver, poultry, and fish. There is a high abundance of B6 in plant foods such as: legumes, whole grains, lentils, soybeans, nuts, seeds, and non-citrus fruits.

Vitamin B6 is better absorbed from animal sources.

Supplement Options

- The RDA for B6 is 2 mg/day.
- The UL for B6 is 100 mg/day.
- High dose supplements are sometimes used to relieve PMS and carpal tunnel syndrome.
- High dose B6 supplementation can cause neuropathies (nerve damage).
- Levels greater than 2 g/day have been shown to induce neuropathy or sensory neuropathy.
- Doses of greater than 150 mg may suppress lactation.
- Therapeutic range for vitamin B6 is considered to be 30 to 500 mg/day.
Vitamin B12 is an important coenzyme when in its active form of methylcobalamin. B12 facilitates the metabolism of folic acid through its primary role as a methyl donor. B12 requires intrinsic factor for absorption, which is calcium dependent.

The role of vitamin B12 in the production of some neurotransmitters may also be evidenced by physiological function.

How it gets depleted

Age is a risk factor for deficiency of B12 due to a natural decline in intrinsic factor. Chronic use of PPIs may reduce HCl and lead to sub-clinical deficiencies.

Some genetic SNPs (such as MTHFR) may lead to deficiencies in active B12 (methylcobalamin).

Clinical Manifestations of Depletion

- Deficiency of B12 can appear as pernicious anemia, usually due to lack of intrinsic factor.
- Another form of anemia associated with B12 deficiency is megaloblastic anemia, when folate is in excess and insufficient B12 is present, which creates a ‘folate trap.’
- Another symptom of B12 deficiency is dementia due to degeneration of myelin.
- In B12 deficiency, methylmalonyl CoA will be metabolized to methylmalonic acid (MMA), which is why MMA is considered the definitive marker for B12 deficiency.
- Achlorhydria (insufficient stomach acid) can lead to B12 deficiency because HCl is required to cleave B12 from intrinsic factor.

Food Sources

Vitamin B12 is synthesized by bacteria and exists in all animal foods. Vitamin B12 is only available from animal sources. The B12 synthesized by gut bacteria may not be a significant source for humans, as it is not absorbed in the colon.

Supplement Options

- The RDA for B12 is 6 mcg/day.
- Consider the upper limit of folate supplementation as a factor for the supplementation of B12, due to potential for folate trap.
- Vitamin B12 is extremely safe. No toxicity from high doses of vitamin B12 has ever been reported.
- Intramuscular injections are often used, particularly in the elderly to bypass intrinsic factor.
- Humans store large amounts of B12 in the liver so larger doses can be given at 6 month intervals.
- Supplementation is highly encouraged on a vegan diet. Due to high storage capacity in the liver, it may take years to deplete the body of B12 after adopting a vegan diet.
- Consider MTHFR genetic, and methyl cobalamin supplementation, particularly with hyperhomocysteinemia.
- Methylcobalamin is the recommended form of supplementation, but may be poorly absorbed in people taking antacids or those with very poor absorption (celiac, intestinal permeability, etc).
- Cyanocobalamin is not recommended for patients with MTHFR mutations.
- Hydroxocobalamin is recommended for patients with autoimmune diseases and elevated nitric oxide levels.
- Glutathione is also required for methylcobalamin to be bound for transport adequately.
- Vitamin B12 supplementation may help manage anemia, asthma, fatigue, hepatitis, dementia, epilepsy, depression, psychosis, irritability, ataxia, numbness, tingling, neuropathy, AIDS, multiple sclerosis, tinnitus, and infertility.
- Supplemental B12 is commonly given in 1000 to 5000 mcg doses.
Vitamin B5 is part of the structural component of coenzyme A. It is also important for synthesis of red blood cells, sex hormones, adrenal hormones, and vitamin D. Another significant function of B5 is to work with carnitine and CoQ10 for fatty acid oxidation/metabolism.

How it gets depleted
It is possible to block absorption of B5 in the intestines by taking high doses of supplemental biotin.

Clinical Manifestations of Depletion
Deficiency of B5 is very rare, however, in a diet that is high in biotin, or if high dose biotin supplementation occurs, B5 may become conditionally deficient due to competition for the same uptake receptor in the intestine.

Food Sources
Food sources of B5 include: beef, pork, chicken, fish, egg yolks, whole grains, legumes, lentils.

Supplement Options
There is currently no RDA established for B5.

The AI for B5 is 5 mg/day in adults, 6 mg/day during pregnancy, and 7 mg/day during lactation.

Because breakdown of B5 is metabolically slow, and deficiency is rare, there is probably no need for supplementation.
Vitamin C has a major function of being an antioxidant. It boosts immunity through increasing white blood cells, in addition to supporting regeneration of vitamin E. Vitamin C can also reduce atherosclerosis, stroke and high blood pressure, and inflammation.

Because of its role in the generation of connective tissue, it is necessary for optimal collagen production. Vitamin C is also an important component of l-carnitine, which is necessary for breakdown of fats into energy.

Physiological Function
Vitamin C has a major function of being an antioxidant. It boosts immunity through increasing white blood cells, in addition to supporting regeneration of vitamin E. Vitamin C can also reduce atherosclerosis, stroke and high blood pressure, and inflammation.

How it gets depleted
Vitamin C is most commonly depleted in the absence of sufficient dietary intake. Vitamin C levels can be depleted during times of severe oxidative stress.

Clinical Manifestations of Depletion
- Low levels of vitamin C have been associated with reduced bone density.
- Signs of deficiency include: bleeding gums, easy bruising, anemia, fatigue, weakness and joint pain. These symptoms are the result of weakened or deficient connective tissues throughout the body.
- Severe cases of vitamin C deficiency are called scurvy.

Food Sources
Food sources of vitamin C include: oysters, tropical fruits such as guava, papaya, pineapple, oranges, kiwi, and cantaloupe; leafy greens such as kale and spinach; cruciferous vegetables such as broccoli, brussel sprouts, cauliflower, and cabbage; berries, such as strawberries, raspberries, blueberries, blackberries, bell peppers, and amaranth.

Supplement Options
- The RDA for vitamin C is 75 mg/day for women and 90 mg/day for men. 120 mg/day is recommended during pregnancy and lactation.
- The half-life of vitamin C in circulation after supplementation is about 30 minutes, therefore, large singular doses of vitamin C may not be as therapeutic as smaller, more frequent doses of vitamin C.
- In addition to taking supplemental vitamin C, α-Lipoic acid helps restore vitamin C levels when depleted.
Vitamin D regulates the function of hundreds of genes, supports the immune system, supports production and function of endocrine hormones, is important for normal growth and development of bones and teeth, tightly regulates the levels of calcium and phosphorus being absorbed intestinally as well as released from bone, regulates cell differentiation and growth, and may play an important role in regulating mood.

Physiological Function

Vitamin D deficiency is very common in the U.S. The most common reasons for vitamin D deficiency include: lack of sun exposure and regular use of sunscreen. Individuals with darker pigmented skin are at greater risk for vitamin D deficiency.

Chronic liver disease and kidney failure are risk factors for vitamin D deficiency.

Some medications can deplete vitamin D: anti-inflammatory medications, antibiotics, anticonvulsant medications, cholesterol lowering medications, laxatives and anti-ulcer.

Conditions that have been associated with low vitamin D status include: Alzheimer’s disease, asthma, autism, cancer, cavities, colds and flus, cystic fibrosis, dementia, depression, diabetes 1 and 2, eczema and psoriasis, hearing loss, heart disease, hypertension, infertility, inflammatory bowel disease, insomnia, macular degeneration, migraines, multiple sclerosis, Crohn’s disease, muscle pain, obesity, osteomalacia, osteoporosis, periodontal disease, preeclampsia, rheumatoid arthritis, schizophrenia, seizures, septicaemia, and tuberculosis.

Food Sources

Food sources of vitamin D include: dairy products, such as fortified milk and yogurt, fortified orange juice, egg yolks, liver, fatty fish, such as salmon, tuna, mackerel, sardines, shrimp, mushrooms grown in adequate sunlight, baker’s yeast.

Naturally occurring sources will contain vitamin D3, whereas fortified sources (baker’s yeast) will contain D2.

The previously established RDA of 400IU/day has been found to be insufficient for therapeutic needs. Common doses are used between 1000 and 10,000 IU/day.

Vitamin D comes in two forms: D2 (ergocalciferol) and D3 (cholecalciferol); both forms can be converted to active vitamin D in the body (25-hydroxyvitamin D).

Vitamin D is produced when skin is exposed to ultraviolet light from the sun.

Supplementation with Vitamin D is almost always necessary, as it is extremely difficult to meet needs though diet and sun exposure alone. Consult with your practitioner for supplement recommendations and target goal for serum levels.

Because vitamin D can be stored or trapped in adipose tissue (fat cells) obese individuals and pregnant women have higher vitamin D requirements.

Obtaining too much vitamin D from sun exposure is not possible, but it is possible to obtain too much from supplementation.

Vitamin D toxicity has been observed in individuals taking greater than 50,000 IU/day, but intake levels less than 10,000 IU/day are unlikely to cause toxicity.
Vitamin E is an important antioxidant that reduces the formation of reactive oxygen species (ROS) that result from fat oxidation. Vitamin E also regulates cell signaling, influences immune function, and inhibits coagulation.

**How it gets depleted**

Vitamin E may become depleted or deficient due to intestinal malabsorption. Smoking also depletes the body’s vitamin E stores.

**Physiological Function**

Vitamin E is an important antioxidant that reduces the formation of ROS that result from fat oxidation. Vitamin E also regulates cell signaling, influences immune function, and inhibits coagulation.

**Clinical Manifestations of Depletion**

Vitamin E deficiency may result in peripheral neuropathy, ataxia, muscle weakness, skeletal myopathy, retinopathy, and increased risk of CVD, red blood cell destruction, prostate cancer, and cataracts.

**Dietary sources**

Dietary sources of vitamin E include: plant seeds (such as sunflower seeds), walnuts, hazelnuts, olive oil, canola oil, wheat germ oil, sunflower oil, safflower oil, tomato, avocado, spinach, and Swiss chard.

**Supplement Options**

- The RDA for vitamin E is 15mg/day.
- The UL for vitamin E is set at 1000 mg/day in order to prevent interference in vitamin K clotting pathways.
- The only supplementary form of vitamin E that reverses deficiency symptoms is $\alpha$-tocopherol.
- In addition, $\alpha$-Lipoic acid is an important co-factor that can aid in restoring vitamin E levels when depleted.
Vitamin K is a group of fat-soluble vitamins. This group of vitamins includes two natural vitamins: vitamin K1 and vitamin K2. Vitamin K1, also known as phylloquinone, phytoenadione, or phytomaneadione. Vitamin K2, the main storage form in animals, has several types, referred to as menaquinones. Bacteria in the colon can convert K1 into vitamin K2.

Vitamin K assists with blood clotting, supports the formation of bone and bone matrix, and aids in glucose to glycogen conversion for storage in the liver.

**How it gets depleted**

Dietary deficiency of vitamin K is extremely rare unless there has been significant damage to the intestinal lining, such as in inflammatory bowel disorders (Crohn's, ulcerative colitis, etc), liver disease, cystic fibrosis, and fat malabsorption disorders.

Taking broad-spectrum antibiotics can reduce vitamin K production in the gut.

Individuals with chronic kidney disease are at risk for vitamin K deficiency. Individuals with ApoE4 genotype may be at greater risk for low vitamin K.

**Physiological Function**

Vitamin K is a group of fat-soluble vitamins. This group of vitamins includes two natural vitamins: vitamin K1 and vitamin K2.

Vitamin K1 is also known as phylloquinone, phytoenadione, or phytomaneadione. Vitamin K2, the main storage form in animals, has several types, referred to as menaquinones. Bacteria in the colon can convert K1 into vitamin K2.

Vitamin K assists with blood clotting, supports the formation of bone and bone matrix, and aids in glucose to glycogen conversion for storage in the liver.

**Clinical Manifestations of Depletion**

Symptoms of vitamin K depletion or deficiency include: excessive bleeding, menorrhagia, bruises that form easily, or appearance of ruptured capillaries.

**Food Sources**

The best sources of Vitamin K1 are plant foods, especially dark leafy vegetables.

The best sources of vitamin K2 include some fermented foods predominantly natto and some rare fermented cheeses, and liver.

**Supplement Options**

The AI for vitamin K is set at 90 µg/day for women and 120 µg/day for men.

Individuals who are on certain anti-clotting medications should consult with their medical provider about their dietary vitamin K intake.

Individuals suffering from blood clotting disorders, osteoporosis, coronary artery disease, cancer, liver disease, celiac disease, Crohn's disease, ulcerative colitis or cystic fibrosis should discuss dietary intake of vitamin K with their healthcare provider.
MINERALS

Physiological Function
Calcium is a mineral that is a major component of bones and teeth, is required for muscle contraction, nerve transmission, cellular metabolism, and aids in blood clotting.

How it gets depleted
Calcium stores in the blood are not depleted metabolically, however, calcium stores elsewhere in the body may become depleted, conditionally, due to increased demand.

Low dietary intake of calcium during times of growth or stress may result in low stores of calcium. Evaluate vitamin D and magnesium levels alongside calcium status.

Iron supplementation may interfere with calcium absorption, and it is recommended to take iron supplements at least 2 hours apart from a meal containing calcium-rich foods.

Clinical Manifestations of Depletion
A deficiency of calcium causes osteoporosis. Some research connects low calcium intake to increased risks of high blood pressure, colon cancer and preeclampsia (high blood pressure and excess protein in the urine of a woman more than 20 weeks pregnant).

Food Sources
Good sources of calcium are: dairy foods, salmon, turnip greens, *Chinese cabbage, kale, bok choy and broccoli. Sardines and other canned fish with bones are additional sources. Some foods such as orange juice and bread are fortified with calcium. *Chinese cabbage, kale and turnip greens contain absorbable calcium. Spinach and some other vegetables contain calcium that is poorly absorbed.

Supplement Options
- The AI for adults aged 19 to 50 is 1000 mg/day. Because calcium is so critical to preventing bone disease later in life, the AI is higher for adolescents.
- The AI for males and females aged nine to 18 is 1300 mg/day. For those aged 51 and older, the AI is 1200mg/day.
- The UL for calcium is 2,500 milligrams. Excess calcium may cause mineral imbalances because it interferes with the absorption of iron, magnesium, zinc and other minerals.
- Forms of calcium supplementation available include calcium carbonate, calcium citrate, calcium citrate malate, calcium gluconate, and calcium lactate.
- Calcium citrate is the preferred form of calcium for individuals with hypo- or achlorhydria (low or insufficient stomach acid). In order to maximize absorption of calcium supplements, limit doses to no more than 500mg/dose.
- Supplementation of calcium should be accompanied by concurrent adequate vitamin D supplementation due to insufficient vitamin D levels impairing cellular calcium absorption, which can lead to atopic calcium deposits in epidermal tissue.
- Iron supplementation may interfere with calcium absorption, and it is recommended to take iron supplements at least 2 hours apart from a meal containing calcium-rich foods.
Zinc is critical for normal growth and sexual maturation. It plays a role in the immune system and is important to the proper function of at least 300 enzymes. Zinc plays a critical role in the structure of proteins and cell membranes. Zinc also regulates gene function, influences cell signaling, hormone release, and nerve signaling.

**Physiological Function**

Zinc deficiency causes delayed growth and sexual development, decreased immune function, altered sense of taste, hair loss, pregnancy complications, and gastrointestinal distress. Loss of zinc from cell membranes impairs their function and increases the susceptibility of the membrane to oxidative damage. Loss of zinc through malabsorption increases susceptibility to infections through depressed immune function. Increased urination in individuals with diabetes mellitus may lead to marginal zinc deficiency. Individuals that may have higher risk of zinc deficiency include: pregnant and lactating women; patients receiving total parenteral nutrition (TPN); malnourished individuals; individuals with eating disorders such as anorexia nervosa; individuals with impaired intestinal absorption and/or persistent diarrhea such as celiac disease, Crohn’s disease, and ulcerative colitis; alcoholics and individuals with liver disease; individuals over 65 years of age; strict vegetarians.

**How it gets depleted**

Insufficient dietary intake, especially in populations that rely heavily on cereal grains for caloric intake, due to high levels of phytic acid impairing uptake of zinc. While higher doses of supplementary zinc uptake impair the uptake of copper, intake of copper does not impair the uptake of zinc except when zinc status is already at least marginally deficient. Supplementation of elemental iron may decrease absorption of zinc. For this reason, pregnant women and individuals with anemia that are supplementing iron may need to take supplemental zinc, separate from iron supplement.

**Food Sources**

Oysters, beef and clams are rich sources of absorbable zinc. Whole grains also contain zinc, but it is less available for absorption due to high phytic acid content of grains.

**Supplement Options**

- The RDA for zinc is 8mg/day for women and 11mg/day for men.
- The UL for zinc is 40mg/day. Long-term supplementation of zinc at levels of 60mg/day or greater interfere with absorption of copper.
- Zinc lozenges are commonly used to shorten the duration of the common cold.
- Zinc comes in the forms of: zinc acetate, zinc gluconate, zinc picolinate, zinc sulfate, zinc carnosine.
- Zinc carnosine has been used in combination therapies to aid in supporting the health of the epithelial linings of both the stomach and the intestines during times of physiological stress such as stomach ulcers and impaired intestinal barrier function.
- Zinc can be toxic when consumed in large doses, or when taken for prolonged periods of time in the absence of a zinc deficiency.
- Single doses of 200-450mg of zinc may induce vomiting and gastrointestinal distress.
Copper assists with the transport of iron, supports energy production within cells, supports methylation and gene transcription that affects cellular detoxification mechanisms, neurotransmitter generation, supports the myelin sheath around nerves, and aids in connective tissue development. Copper is important for redox reactions and is a potent antioxidant for this reason. Copper also supports melanin production in the cells of hair, skin, and nails. Most serum copper is found in ceruloplasmin and elevated levels may be an indicator of increased inflammation and oxidative stress, rather than specifically excess copper in the blood.

Physiological Function
- Copper assists with the transport of iron, supports energy production within cells, supports methylation and gene transcription that affects cellular detoxification mechanisms, neurotransmitter generation, supports the myelin sheath around nerves, and aids in connective tissue development.
- Copper is important for redox reactions and is a potent antioxidant for this reason.
- Copper also supports melanin production in the cells of hair, skin, and nails.
- Most serum copper is found in ceruloplasmin and elevated levels may be an indicator of increased inflammation and oxidative stress, rather than specifically excess copper in the blood.

How it gets depleted
Deficiencies or excesses of copper are rare in healthy people, however, copper deficiency can occur in the following populations: infants or children fed only cow’s milk formula; premature infants and infants or children with recurring diarrhea; individuals with malabsorption syndromes such as celiac disease, bowel resections, Crohn’s disease, and ulcerative colitis; individuals with cystic fibrosis; individuals with high supplemental zinc intake for prolonged periods of time.

Consider testing for the presence of celiac disease or neurological indications of demyelination to assess if copper deficiency may be associated.

Clinical Manifestations of Depletion
- Copper may become deficient or depleted in the presence of supplemental zinc intake at or above 60mg/day for prolonged periods of time.
- Because copper is critical to iron metabolism and red blood cell formation and function, anemia can be a clinical sign of copper deficiency, as iron becomes trapped in the liver without adequate copper to facilitate transport.
- Copper depletion is rare, but can be seen in Wilson’s disease, in which dietary copper intake does not affect copper status. Severe copper deficiency may also lead to cardiovascular abnormalities and cardiomyopathy, however, some epidemiological studies suggest that elevated levels of copper may also be associated with increased atherosclerosis.
- Low levels of neutrophils may be seen in individuals with copper deficiency, as well as anemias that do not respond to iron supplementation.
- In children, copper deficiency may lead to impaired growth, neurological problems, and loss of skin pigmentation.

Food Sources
Rich sources of copper include liver, shellfish, cashews, hazelnuts, almonds, peanut butter, lentils, mushrooms, and sunflower seeds.

Supplement Options
- The RDA for copper in adults is 900 μg/day.
- The UL for copper is 10 mg/day, which has been shown not to produce liver damage in healthy individuals.
- Copper supplementation of 2 mg/day is usually sufficient to correct deficiencies of copper.
- Copper is most commonly available in the following supplemental forms: cupric oxide, copper gluconate, copper sulfate, copper amino acid chelates.
- Some research suggests elevated blood levels of free unbound copper, which depletes zinc levels, may have an association with the onset of Alzheimer’s disease, and supplementation of copper in this population is not recommended if zinc deficiency is suspected.
**Physiological Function**

Chromium is an essential nutrient used in trace amounts in humans that acts as a cofactor for chromodulin, a peptide that enhances the effect of insulin on target tissues, which aids in regulation of blood sugar and lipid metabolism.

**How it gets depleted**

Deficiency is very rare, but can occur in patients receiving IV parenteral nutrition, without supplemental chromium added, and individuals who regularly participate in endurance exercise.

**Clinical Manifestations of Depletion**

Chromium deficiency can contribute to the development of diabetes and metabolic syndrome. Even mild deficiencies of chromium can produce problems in blood sugar metabolism, and contribute to other symptoms such as anxiety or fatigue.

**Food Sources**

Food sources of chromium include: brewer’s yeast, especially beer, broccoli, grape juice, meat and whole-grain products. Some fruits, vegetables, and spices provide chromium. Romaine lettuce, raw onions and ripe tomatoes are all good sources.

**Supplement Options**

- The AI for chromium is 35 µg/day for men and 25 µg/day for women.
- Increased needs may be present during pregnancy and lactation.
- Supplemental chromium is generally not needed as dietary consumption easily meets physiological needs.
- Supplementation is poorly studied and insufficient evidence exists to provide recommendations, but chromium picolinate is a form commonly used in treatment of insulin resistance and diabetes.
Iron is required for the production of red blood cells (a process known as hemopoiesis), but it's also part of hemoglobin (that is the pigment of the red blood cells) binding to the oxygen and thus facilitating its transport from the lungs via the arteries to all cells throughout the body. Once the oxygen is delivered, the iron (as part of hemoglobin) binds the carbon dioxide which is then transported back to the lung, from where it gets exhaled. Iron is also involved in the conversion of blood sugar to energy.

The production of enzymes (which play a vital role in the production of new cells, amino acids, hormones and neurotransmitters) also depends on iron, this aspect becomes crucial during the recovery process from illnesses or following strenuous exercise.

The immune system is dependent on iron for its efficient functioning. Physical and mental growth require sufficient iron levels, particularly important in childhood and pregnancy, where the developing baby solely depends on its mother's iron supplies.

Iron is lost by the body through a variety of ways including urination, defecation, sweating, and exfoliating of old skin cells. Bleeding contributes to further loss of iron which is why women have a higher demand for iron than men. If iron stores are low, normal hemoglobin production slows down, which means the transport of oxygen is diminished, resulting in symptoms such as fatigue, dizziness, lowered immunity or reduced ability for athletes to keep up with their training programs. Since our bodies can't produce iron itself, we need to make sure we consume sufficient amounts of iron as part of our daily diet.

Mild iron deficiency can be prevented or corrected by eating iron-rich foods and by cooking in an iron skillet. Because iron is a requirement for most plants and animals, a wide range of foods provide iron. Good sources of dietary iron have heme-iron as this is most easily absorbed and is not inhibited by medication or other dietary components. Two examples are red meat, and poultry.

Non-heme sources contain iron, though it has reduced bioavailability. Examples are lentils, beans, leafy vegetables, pistachios, tofu, fortified bread, and fortified breakfast cereals. Iron from different foods is absorbed and processed differently by the body; for instance, iron in meat (heme iron source) is more easily absorbed than iron in grains and vegetables (non-heme iron source) but heme/hemoglobin from red meat has effects which may increase the likelihood of colorectal cancer. Minerals and chemicals in one type of food may also inhibit absorption of iron from another type of food eaten at the same time. For example, oxalates and phytic acid form insoluble complexes which bind iron in the gut before it can be absorbed.

Because iron from plant sources is less easily absorbed than the heme bound iron of animal sources, vegetarians and vegans should have a somewhat higher total daily iron intake than those who eat meat, fish or poultry. Legumes and dark-green leafy vegetables like broccoli, kale and oriental greens are especially good sources of iron for vegetarians and vegans. However, spinach and Swiss chard contain oxalates which bind iron making it almost entirely unavailable for absorption. Iron from nonheme sources is more readily absorbed if consumed with foods that contain either heme-bound iron or vitamin C.

Symptoms of iron deficiency can occur even before the condition has progressed to iron deficiency anemia. Symptoms of iron deficiency are not unique to iron deficiency. Iron is needed for many enzymes to function normally, so a wide range of symptoms may eventually emerge, either as the secondary result of the anemia, or as other primary results of iron deficiency. Symptoms of iron deficiency include: fatigue, dizziness, pallor, hair loss, twitches, irritability, weakness, pica, brittle or grooved nails.

How it gets depleted
Iron is lost by the body through a variety of ways including urination, defecation, sweating, and exfoliating of old skin cells. Bleeding contributes to further loss of iron which is why women have a higher demand for iron than men. If iron stores are low, normal hemoglobin production slows down, which means the transport of oxygen is diminished, resulting in symptoms such as fatigue, dizziness, lowered immunity or reduced ability for athletes to keep up with their training programs. Since our bodies can't produce iron itself, we need to make sure we consume sufficient amounts of iron as part of our daily diet.

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Iron is needed for many enzymes to function normally, so a wide range of symptoms may eventually emerge, either as the secondary result of the anemia, or as other primary results of iron deficiency. Symptoms of iron deficiency include: fatigue, dizziness, pallor, hair loss, twitches, irritability, weakness, pica, brittle or grooved nails.

Supplement Options
Frequently used forms of iron in supplements include ferrous and ferric iron salts, such as ferrous sulfate, ferric gluconate, ferric citrate, and ferric sulfate. Because of its higher solubility, ferrous iron in dietary supplements is more bioavailable than ferric iron. High doses of supplemental iron (45 mg/day or more) may cause gastrointestinal side effects, such as nausea and constipation. Other forms of supplemental iron, such as heme iron polypeptides, carboxyl iron, iron amino-acid chelates, and polysaccharide-iron complexes, might have fewer gastrointestinal side effects than ferrous or ferric salts. Many medicinal herbs can offer iron boosting properties to those who suffer from iron deficiency. These medicinal properties can easily be assimilated into the bloodstream as a hot water infusion (tea). Iron enhancing herbs include yellow dock, red raspberry leaf, gentian, yellow root, turmeric, mullein, nettle, parsley, ginseng, watercress, and dandelion.
Important functions of magnesium include: assisting enzymes in more than 300 chemical reactions in the body, supporting cellular activity, participating in muscle contraction, aiding in blood clotting, and as a critical component of bone/skeletal tissue.

**Physiological Function**

- Magnesium is part of chlorophyll so leafy greens are rich in magnesium. Best food sources include: oats, brown rice, spinach, Swiss chard, almonds, cashews, hazelnuts, potatoes, bananas, milk, raisins, halibut, avocado, black strap molasses, and chocolate.

**How it gets depleted**

- Alcohol will lead to increased excretion in urine.
- Prolonged use of diuretics will lead to increased urinary excretion.
- Excessive sweating/long bouts of endurance exercise.
- Hyperparathyroidism, Chronic renal failure, malabsorptive conditions (celiac disease, Crohn’s disease, partial bowel resection) diabetes (30% show signs of depletion).
- Age is a risk factor for magnesium depletion because intestinal absorption of magnesium declines with age.

**Clinical Manifestations of Depletion**

- Primary magnesium deficiency is rare.
- Deficiency is usually secondary to another condition.
- Signs and symptoms of deficiency include weakness, heart irregularities, muscle cramps/twitches, insomnia, mental confusion, fatigue, irritability.
- Magnesium deficiency can impede Vitamin D and calcium absorption; increasing risk for bone mineral density disorders.
- Magnesium depletion is commonly associated with other disease states including both type 1 and type 2 diabetes, hypertension, endothelial dysfunction, asthma, and migraine headaches.

**Food Sources**

**Supplement Options**

- The UL for magnesium is 350 milligrams from supplements or medicines because it may cause diarrhea. Severe toxicity may cause confusion, loss of kidney function, difficulty breathing and cardiac arrest. Individuals with kidney disease are at higher risk for magnesium toxicity.
- The use of supraphysiological doses of magnesium can be used therapeutically. Supplemental magnesium is available in several different salts/chelations including: magnesium oxide, magnesium glycinate, magnesium chloride, magnesium citrate, and magnesium threonate. These compounds have different absorption, bioavailability, and therapeutic values.
- Magnesium oxide and magnesium citrate are typically recommended for their ability to draw water into the gastrointestinal tract and facilitate a laxative effect to produce a bowel movement. Also, it can help alleviate acid reflux.
- Magnesium citrate has better bioavailability and is typically preferred over magnesium oxide. Citrates have also been shown to bind oxalates and may be the best form for those following a low oxalate diet.
- Magnesium glycinate has good bioavailability and is recommended to help increase magnesium levels without the bowel side effects.
- Magnesium malate is a form of magnesium that has been studied for its positive effects on depression, chronic fatigue, diabetes, and cardiovascular disease.
- Magnesium Threonate has recently been studied to cross the blood brain barrier and improve memory and brain function and potentially relieve headaches and migraines.
- Many studies have shown that supplemental Mg at doses ~400 mg/day reduces blood pressure in mildly hypertensive patients and pregnant women with preeclampsia.
Manganese is important in many enzyme-mediated chemical reactions including enzymes involved in antioxidant actions in mitochondria and enzymes involved in the synthesis of cartilage in skin and bone. Manganese also activates enzymes that participate in metabolism of carbohydrates, amino acids, and cholesterol. In addition, enzymes that incorporate manganese convert the neuro-excitatory glutamate to glutamine.

**Physiological Function**

Manganese is important in many enzyme-mediated chemical reactions including enzymes involved in antioxidant actions in mitochondria and enzymes involved in the synthesis of cartilage in skin and bone. Manganese also activates enzymes that participate in metabolism of carbohydrates, amino acids, and cholesterol.

In addition, enzymes that incorporate manganese convert the neuro-excitatory glutamate to glutamine.

**How it gets depleted**

- Iron supplementation may decrease absorption of dietary manganese.
- Intestinal absorption of manganese is reduced when iron stores (ferritin levels) are higher, and tends to be lower in men than women.
- Magnesium supplementation has been shown to decrease manganese levels through reduced intestinal absorption or increased urinary excretion.

**Clinical Manifestations of Depletion**

- Manganese deficiency is rare.
- Symptoms of manganese deficiency are impaired growth, particularly skeletal abnormalities, and possibly glucose tolerance abnormalities.
- Toxicity is also uncommon and is most frequently the result of exposure to airborne manganese dust.
- Symptoms of toxicity include multiple neurological problems that resemble Parkinson’s disease. In children, exposure to elevated levels of manganese in drinking water has been associated with increased rates of attention deficit hyperactivity disorder, cognitive decline, and behavioral problems.
- Individuals with liver failure are at risk for manganese toxicity-associated neurological symptoms.

**Food Sources**

Tea and coffee are significant sources of manganese in the American diet. Additional sources are nuts, whole grains, legumes and some fruits and vegetables, such as leafy greens.

**Supplement Options**

- The AI for manganese is 1.8 mg/day.
- The UL for manganese is 11 mg per day.
- Supplementation of manganese is not generally necessary, and may result in toxicity.
Choline is metabolized within cellular mitochondria resulting in production of trimethylglycine; TMG plays a role in supporting methyl donation processes either directly (methylating homocysteine) or indirectly through supporting production of S-adenosyl methionine (SAMe). Choline is converted into acetylcholine (ACh).

Depletion of choline is typically not a concern, and limited information exists on how depletion would happen primarily, however, lower intake of choline may lead to inefficient methylation.

Deficiency in dietary choline is known to increase hepatic triglyceride accumulation. This results in lower blood triglycerides, but increased accumulation of triglycerides in the liver.

Subjects with a mutation in the MTHFR enzyme seem to place more burden on choline in methylation cycles. Depletion of choline can also lead to muscle damage.

Eggs, liver, and peanuts are the best sources of choline. Poultry, fish, and cruciferous veggies are good sources of choline.

*Dietary choline sources, including lecithin (phosphatidylcholine), may increase serum TMAO in humans, although the evidence is mixed.

The AI for choline is 425 mg/day for women and 550 mg/day for men.

The UL is 3,500 mg/day.

Choline bitartrate is the most common supplemental form of choline for most general purposes, such as liver health.

CDP-Choline and Alpha-GPC are commonly used for nootropic purposes.

Supplemental choline can enhance systemic methylation. Excessive consumption of choline ≥7,500 mg has been associated with low blood pressure, excessive sweating, fishy body odor, and gastrointestinal side effects.
Inositol derivatives are used in the cellular signaling process after the insulin receptor is activated; it is crucial for the development of peripheral nerves, helps move fats out of the liver, promotes the production of lecithin, and is anti-arteriosclerotic, and anti-atherogenic.

**How it gets depleted**

Inositol can be released from phytate compounds via intestinal bacteria breaking phytate-degrading enzymes (Lactobacillus plantarum, Lactobacillus brevis, Lactobacillus curvatus, L. gasseri B. subtilis and Saccharomyces cerevisiae).

If many courses of antibiotics are used, there may be some depletion of inositol from microbiome conversion.

Inositol is also stored in the liver, spinal cord nerves, and in the brain and cerebral spinal fluid.

**Clinical Manifestations of Depletion**

- There do not appear to be any clinical manifestations of depletion of inositol. Inositol can be synthesized in the human body from glucose-6-phosphate, a derivative of glucose, therefore, deficiency would be rare.
- Urinary levels of inositol derivatives (D-chiro-inositols and myo-inositols) are seen as a biomarker for insulin resistance.
- Conditions associated with depletion of inositol, however, are depression, anxiety, PCOS, diabetes, CVD, and obesity.

**Food Sources**

Good dietary sources of inositol include: oranges, cantaloupe, prunes, navy beans, grapefruit, limes, blackberries, kiwis, rutabagas, fresh green beans, unrefined molasses, stone ground wheat, bran flakes, and pumpernickel.

**Supplement Options**

- There is currently no established RDA, AI, or UL for inositol. Myo-inositol is noted for its benefits to female fertility and insulin sensitivity, and is used often in treatment for PCOS in dosages of 2-4 g/day.
- Higher doses of inositol are used to treat psychiatric conditions like depression and anxiety/OC defense in much higher doses of 12-18 g/day; some mild gastrointestinal distress is noted with the higher doses and may need to be consumed in split doses.
- Lowering blood glucose can be seen with doses of inositol around 2-4 g/day.
- Currently supplementation of inositol has shown some promise in treating Alzheimer’s to reduce progression of fibril formation.
- Inositol may decrease LDL-C and ApoB in persons with metabolic syndrome with doses of 5-10 g/day.
- Doses of inositol of 4 g/day have been associated with improvement of all markers of glycemic control and insulin resistance in gestational diabetes.
Carnitine is an essential co-factor in the metabolism of lipids and the production of cellular energy. It promotes neuroprotection through antioxidant properties and modulation and promotion of synaptic neurotransmission. Carnitine can be rate-limiting in ketone body uptake by brain astrocytes, and also reduces oxidative stress.

**Physiological Function**

Carnitine is found naturally occurring in high amounts in red meat, eggs, and dairy products.

**How it gets depleted**

Carnitine deficiency is rare in individuals who consume an omnivorous diet. Iron and Vitamin C are required for endogenous carnitine synthesis, and endogenous synthesis can also be impaired by severe liver disorders.

Deficiency may be found in vegetarians and vegans, and individuals with impaired absorption of nutrients, such as in inflammatory bowel disorders and celiac disease.

There may be increased demand for carnitine during ketosis.

**Clinical Manifestations of Depletion**

Symptoms of carnitine depletion or deficiency include: male infertility, impaired muscle metabolism of energy, which can cause myopathy, hypoglycemia, muscle necrosis, myoglobinuria, lipid-storage myopathy, hypoglycemia, fatty liver, and hyperammonemia with muscle aches, fatigue, confusion, and cardiomyopathy.

**Food Sources**

Carnitine is found naturally occurring in high amounts in red meat, eggs, and dairy products.

**Supplement Options**

- There is currently no established RDA, AI, or UL for carnitine intake.
- Supplementation of carnitine has been used in treatment of chronic degenerative diseases of the brain and for slowing down the progression of Alzheimer’s disease.
- Carnitine supplementation in athletes has not been shown to consistently produce performance benefits.
- Carnitine comes in supplement form as L-carnitine.
- Some research suggests that diets high in carnitine may have associations with cardiovascular inflammation due to the over-abundance of opportunistic microbes that convert dietary carnitine to trimethylamine oxidase (TMAO). Consider testing levels of these bacteria to assess if TMAO levels are due to intestinal dysbiosis.
Methylmalonyl-CoA is converted into succinyl-CoA in a reaction that requires B12 as a cofactor; succinyl-CoA then enters the Krebs cycle where it functions to produce energy.

How it gets depleted

MMA does not get depleted, as it is a marker of B12 status, however, B12 can be depleted through either inadequate dietary consumption, or reduced methylation of cyanocobalamin to methylcobalamin.

Clinical Manifestations of Depletion

Levels of MMA are elevated in 90-98% of patients with B12 deficiency.

It is not recommended to test MMA levels in the elderly, as they can be elevated in the absence of a B12 deficiency in this population.

Food Sources

There are no food sources of MMA.

Food sources of B12 include: animal proteins, including dairy. *Fortified breakfast cereals may also contain B12.

Supplement Options

Consider supplement recommendations for B12.
Asparagine is a non-essential amino acid required for development and function of the brain. Asparagine can be synthesized from glutamine and aspartate. Asparagine is also required for DNA and RNA synthesis and removal of the cellular waste product ammonia.

**How it gets depleted**

Asparagine deficiency is not likely due to its endogenous synthesis and ubiquitous presence in both plant and animal foods.

**Physiological Function**

Asparagine deficiency is not likely due to its endogenous synthesis and ubiquitous presence in both plant and animal foods.

**Clinical Manifestations of Depletion**

There are no known deficiency symptoms of asparagine that have been well reported or well studied, but possible symptoms of asparagine depletion could include fatigue or cognitive decline in adults.

**Food Sources**

Dietary sources of asparagine include: dairy, whey, beef, poultry, eggs, fish, seafood, asparagus, licorice root, legumes, nuts, seeds, soy, and grains.

**Supplement Options**

There is currently no established RDA, AI, or UL for asparagine.

Asparagine is rarely supplemented directly, due to its endogenous production in the body, but could be indirectly supplemented through glutamine.
Glutamine is a conditionally essential amino acid (conditional mainly during times of disease or muscle wasting, such HIV/AIDS, cancer, or severe infections). In the intestinal lining, glutamine is the preferred source of fuel for intestinal epithelial cells and the main energy source for leukocytes (immune cells). Other important functions of glutamine include: transporting nitrogen between cells, acting as a precursor to glutathione production, acting as a precursor to nucleotides (for DNA and RNA synthesis), participating in gluconeogenesis in the absence of adequate carbohydrate intake, blunting the rise of blood glucose after consuming carbohydrate-rich meals, and

**Physiological Function**

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**How it gets depleted**

Glutamine is known to be depleted in certain types of physiological stress such as burns, major trauma, and cancers that consume available intra-cellular glutamine stores more rapidly than skeletal muscle can generate it, leading to increased muscle wasting.

During physical activity, serum glutamine is consumed for longer endurance events (2+ hours); some evidence exists that chronic endurance exercise reduced glutamine levels to affect immune cell function and proliferation.

**Clinical Manifestations of Depletion**

Glutamine depletion or deficiency is rare, as glutamine can be made endogenously and is ubiquitous in the food supply from both plant and animal sources. Some studies suggest an increase in intestinal permeability when intestinal epithelial cells lack sufficient glutamine, as well as insufficient availability for leukocyte function.

**Food Sources**

- Very good sources of glutamine include: whey, casein, milk, white rice, corn, and tofu.
- Good sources of glutamine include: meat and eggs.

**Supplement Options**

- There is currently no established RDA, AI, or UL for glutamine.
- Glutamine is typically sold as L-glutamine and doses have been studied in humans ranging from 500 mg/day - 50g/day. Higher doses (>10 g/day) are commonly used in the treatment of intestinal barrier permeability.
- Supplementation of glutamine has not been shown to enhance muscle growth in healthy individuals; typically an increase in serum insulin results after consumption of glutamine due to increased conversion to glucose. This may impact individuals with insulin resistance.
- Glutamine supplementation is also potentially beneficial to improve mental focus and concentration, as well as curbing cravings for sugar and alcohol.
- In some individuals, glutamine is converted more efficiently to glutamate, which can lead to a neuro-excitatory state, increased anxiety, tension headaches/migraines, and even tachycardia. If any of these symptoms occur after consuming glutamine, discontinue
D-serine is a neuromodulator, produced in glial cells of the brain, and modulates the functions of neurons. Serine can be considered a nootropic nutrient. Serine enhances binding of other compounds at NMDA (N-methyl-D-aspartate) receptors.

**How it gets depleted**

Serine can be synthesized endogenously from dietary glycine, which is not considered an essential amino acid.

Serine deficiency would be rare, however, supra-physiological doses may be necessary to confer benefit over standard dietary intake.

Serine deficiency would be rare, however, supra-physiological doses may be necessary to confer benefit over standard dietary intake. It does not appear that depletion of serine is common, but side effects of low levels of serine in the brain appear to be correlated with a higher risk for addiction behaviors and some neurodegenerative conditions.

**Physiological Function**

D-serine is a neuromodulator, produced in glial cells of the brain, and modulates the functions of neurons. Serine can be considered a nootropic nutrient.

Serine enhances binding of other compounds at NMDA (N-methyl-D-aspartate) receptors.

**Food Sources**

Foods high in glycine include: fish, meat, dairy, sugar cane, soybeans, spinach, kale, cauliflower, cabbage, pumpkin, banana, kiwi, cucumber, and beans.

**Supplement Options**

- There is currently no established RDA, AI, or UL for serine supplementation or intake.
- Serine can be supplemented to reduce symptoms of cognitive decline and reduce symptoms of cocaine dependence and schizophrenia.
- Phosphatidylserine is a common supplemental phospholipid that contains serine.
- Doses of 30mg/kg of bodyweight are commonly used in cognitive decline patients.
ANTIOXIDANTS

**Physiological Function**
CoQ10 is a fat-soluble compound primarily synthesized by the body and also consumed in the diet. It is found in virtually all cell membranes and participates in the mitochondria to convert carbohydrates and fatty acids into ATP. CoQ10 also supports cell signaling, gene expression, stimulation of cell growth, inhibition of apoptosis, control of thiol groups, formation of hydrogen peroxide, and control of membrane channels.

**How it gets depleted**
CoQ10 is most commonly depleted through use of cholesterol-lowering medication, such as statins. Other causes of CoQ10 deficiency include genetic mutations that limit biosynthesis, unknown reasons in the aging process, cancer, and smoking.

**Clinical Manifestations of Depletion**
Signs of CoQ10 deficiency include muscle weakness and fatigue, high blood pressure, and slowed thinking; more extreme symptoms of CoQ10 deficiency include chest pain, heart failure, and seizures.

**Food Sources**
Food sources of CoQ10 are considered poor sources of the nutrient. Foods that contain more CoQ10 than others include organ meats from red meat sources. Nuts are considered a moderate source but would have to be eaten in extreme amounts to get the daily requirement.

**Supplement Options**
- There is currently no established RDA, AI, or UL for CoQ10.
- CoQ10 comes in both ubiquinone and ubiquinol forms; ubiquinol is considered the active form, however, the body uses both forms as needed.
- Typical doses required to restore minimum CoQ10 levels while using statin drugs are 100-200 mg/day.
- Intestinal absorption of CoQ10 is limited, but optimized if consumed with a meal containing fat.
- There are really no adverse symptoms with high dose 
- CoQ10 supplementation; however, supplementation is typically not recommended for pregnant or lactating women due to lack of controlled studies.
Cysteine has antioxidant properties itself, but is also a precursor molecule to glutathione production, the master antioxidant. Cysteine is also an important source of sulfide for iron-sulfide metabolism. Cysteine will bind metals easily to its thiol group, such as iron, nickel, copper, zinc, and heavy metals such as mercury and lead, which may confer some chelation benefits. Cysteine counteracts acetaldehyde effects from consumption of alcohol and can reduce hangovers.

How it gets depleted

Cysteine can be synthesized endogenously as long as sufficient methionine is available in the diet. Depletion is extremely rare.

Physiological Function

- Cysteine has antioxidant properties itself, but is also a precursor molecule to glutathione production, the master antioxidant.
- Cysteine is also an important source of sulfide for iron-sulfide metabolism.
- Cysteine will bind metals easily to its thiol group, such as iron, nickel, copper, zinc, and heavy metals such as mercury and lead, which may confer some chelation benefits.
- Cysteine counteracts acetaldehyde effects from consumption of alcohol and can reduce hangovers.

Clinical Manifestations of Depletion

Depletion or deficiency of cysteine is not common, as cysteine can be made endogenously, but can conditionally be required in greater amounts due to its strong antioxidant and detoxification properties.

Food Sources

Dietary sources of cysteine include: meat, poultry, eggs, dairy, red peppers, garlic, onions, broccoli, Brussels sprouts, oats, granola, wheat germ, and lentils.

Supplement Options

- There is currently no established RDA, AI, or UL for cysteine.
- Cysteine is typically purchased in supplement form as N-acetyl-cysteine (NAC).
- Cysteine can be purchased as L-cysteine in powder form.
- For general antioxidant support, doses start at 500mg/day and can increase depending upon direction from medical provider.

AVOID: D-cysteine or D-cystine, which are toxic.
Glutathione is the master intracellular antioxidant. Glutathione is the main non-enzymatic antioxidant in intestinal epithelium. The only cells in the body that have been found to be able to absorb intact GSH are hepatocytes, intestinal mucosal cells, and retinal cells.

GSH can also conjugate target compounds for removal through hepatic/renal excretion or through removal into the intestinal lumen and through fecal elimination.

Alpha-lipoic acid appears to support the transport of cystine (two bonded cysteine molecules) between cells for uptake to generate glutathione, and therefore, may increase glutathione synthesis provided that cysteine levels are adequate.

**How it gets depleted**

- Glutathione levels deplete naturally during aging, however, this could be related to decreased protein intake in aging individuals.
- Pro-inflammatory states and elevated oxidative stress will drain GSH stores and require a conditionally greater intake of either high cysteine foods or NAC as a supplement to increase endogenous GSH production.
- Conversion of depleted glutathione back to its active state is achieved through an NADPH-dependent enzyme, so it stands to reason that low levels of NAD (or niacin, nicotinic acid) could further limit this conversion back to active GSH forms.
- Consider mutations in GSHPx gene to determine if deficiency or depletion is genetically influenced.

## Clinical Manifestations of Depletion

Symptoms of glutathione depletion or deficiency include: fatigue, increased oxidative stress, inflammation, cancer, and infections.

## Food Sources

Dietary glutathione consumption does not correlate with systemic levels of glutathione, but sources of glutathione are fruits and vegetables such as: asparagus, avocado, spinach, broccoli, cantaloupe, tomato, carrot, grapefruit, orange, zucchini, strawberry, watermelon, papaya, red bell pepper, peaches, lemons, mangoes, cauliflower, and cabbage.

## Supplement Options

- There currently is no RDA, AI, or UL established for glutathione intake.
- Glutathione cannot enter cells intact, and must be synthesized inside the cell in order to be effective, therefore, supplementation usually has negligible benefit.
- Supplementing the building blocks such as N-acetyl-cysteine, glutamic acid and glycine, of which NAC is the only one that may be necessary to supplement, may increase cellular production of glutathione.
- Direct glutathione supplementation has only been shown to benefit slowing the breakdown of nitric oxide in the bloodstream.
Selenium is an essential trace element required for immune function and for the synthesis of thyroid hormones, through its actions in selenoproteins such as iodothyronine deiodinase, and the direct conversion of thyroxine (T4) to triiodothyronine (T3).

Additionally, this mineral assists enzymes in protecting cell membranes from damage and selenium is a critical component of antioxidant reactions, by supporting the production of selenoproteins, such as glutathione peroxidase.

Selenium helps to regenerate vitamin C and vitamin E from their oxidized forms, supporting antioxidant action of these vitamins.

**How it gets depleted**

Individuals at risk for low levels of selenium or selenium depletion are patients who have had bariatric surgery, celiac patients, and Crohn’s disease patients.

**Clinical Manifestations of Depletion**

- Selenium deficiency is very rare in developed countries. Low selenium intake may decrease an individual’s ability to fight viral infections. Some research also links low intakes to some cancers. Toxicity causes brittle hair and nails and is most likely to occur with supplements.
- Selenium deficiency may not always produce overt symptoms of disease, but may manifest as increased oxidative stress in deficient individuals, due to decreased action of glutathione peroxidase, decreased antioxidant regeneration, decreased conversion of thyroid hormones, and reduced methionine metabolism.
- Severe selenium deficiency can result in Keshan disease, in which the heart becomes enlarged alongside cardiac insufficiency. Selenium supplementation prevents further progression of the condition, but does not reverse damage that has already occurred.

**Food Sources**

Food sources of selenium include: Brazil nuts, tuna, cod, turkey, chicken breast, beef roast, sunflower seeds, and ground beef. Organ meats, seafood, other meats, and whole grains are additional sources.

Depending upon the soil in which they are grown, Brazil nuts are one of the richest sources of selenium.

**Supplement Options**

- The RDA for selenium is 55 µg/day.
- The UL for selenium is 400 µg/day, including food sources.
- Protein-based food sources of selenium appear to be the most effective at increasing circulating levels of glutathione peroxidase.
- Selenium supplementation in individuals with autoimmune thyroiditis has been shown to reduce circulating autoantibody levels.
- Selenium supplementation has been found to reduce viral load progression in individuals with HIV.
- Selenium supplementation in persons with sepsis and septic shock has shown to reduce mortality.
- Selenium comes in the following supplemental forms: sodium, selenite, sodium selenate, selenomethionine.
- Selenomethionine has been shown to increase blood levels of selenium more effectively than the inorganic forms of selenium (selenite and selenate). Sodium selenate is absorbed to a lesser extent than sodium selenite, but sodium selenate is retained in greater amounts.
- Selenium supplements are not recommended for individuals with or at risk for diabetes mellitus.
FATTY ACIDS: OMEGA-3 & 6

Physiological Function
- Eicosapentanoic acid (EPA) is an omega-3 fatty acid that participates in the health of cellular membranes, mediates lipid actions, and reduces inflammatory responses in the body.
- EPA and DHA influence the types of inflammatory response mediators made in favor of anti-inflammatory eicosanoids such as leukotrienes, prostaglandins, and thromboxanes. EPA and DHA are also noted for moderate to strong anti-depressant effects.
- Specific to EPA, it has been shown to suppress signaling of TNF-α in adipocytes.
- EPA also increases cerebral oxygenation.
- EPA appears to have some beneficial influence on regulating levels of leptin and increasing adiponectin.
- EPA may enhance adaptive immunity by stimulating B cell responsiveness.

How it gets depleted
Lower dietary intake of omega-3 fatty acids is the primary reason for deficiency of EPA, or low levels of EPA.

Certain genetic polymorphisms such as reduced activity of the FADS1 and FADS2 genes may lead to reduced conversion of ALA into EPA and DHA.

Clinical Manifestations of Depletion
EPA can be manufactured in the body from ALA, as well as retroconverted from DHA. However, relying solely on intake of ALA to provide adequate levels of EPA is not recommended due to poor or inefficient conversion from ALA to EPA.

Lower levels of EPA or deficient intake of EPA have been linked to increased risk for cardiovascular disease, arrhythmia, blood clots, heart attacks, stroke, elevated triglyceride levels, increased growth of atherosclerotic plaque, reduced vascular endothelial function, skin cancer, and increased inflammation.

Lower levels of EPA are also associated with lower brain mass in older adults.

Food Sources
Good sources of EPA include: fatty fish such as Pacific herring, salmon, oysters, tuna, and omega-3 enriched eggs.

Food sources of ALA, the essential fatty acid EPA precursor include: flaxseeds and flaxseed oil, chia seeds, walnuts, and canola oil.

Supplement Options
- Currently, no official dietary intake recommendations have been established.
- Several official health organizations have proposed a minimum dietary intake level of 500 mg/day of EPA+DHA.
- Because the efficiency of conversion of ALA to EPA is so low, supplementing EPA is generally recommended to meet therapeutic doses.
- High dose supplementation of omega-3 fatty acids (including EPA) has been shown to reduce the need for non-steroidal anti-inflammatory drugs (NSAIDS).
- Persons suffering from ulcerative colitis have been shown to need fewer corticosteroids when supplementing with high dose omega-3 fatty acids.
- Adverse side effects observed with high dose omega-3 fatty acids from supplement form include gastrointestinal upset and loose stools.
- Omega-3 supplements including EPA and DHA should be used with caution in persons with clotting disorders or on anti-clotting medication.
Docosapentanoic acid (DPA) is a structurally similar omega-3 fatty acid to EPA. DPA is an intermediary omega-3 fatty acid between the conversion of EPA and DHA. DPA supports the production of healthy blood vessels and reduces clotting.

How it gets depleted

Deficiency of DHA is typically due to low dietary intake of high DPA foods.

Clinical Manifestations of Depletion

Low levels of DPA are associated with increased risk of thrombosis and stroke death.

Food Sources

Good sources of DPA include: fish oil, fatty fish such as salmon, and grass-fed beef.

Supplement Options

Adverse side effects observed with high dose omega-3 fatty acids from supplement form include gastrointestinal upset and loose stools.
Arachidonic acid is considered a conditional essential fatty acid and is a structural component of cell membranes-particular cell membranes of the central nervous system (nerve and brain cells).

AA is also a metabolic precursor for proinflammatory signaling molecules (eicosanoid) synthesis.

How it gets depleted
A low AA level with a high or normal LA level likely indicates a delta-6-desaturase deficiency. Activity of this enzyme can be impaired with increased age, alcohol use, certain genetic defects or nutrient deficiency or excess.

Clinical Manifestations of Depletion
Low levels of AA are somewhat rare but can lead to an impairment to cell membrane functions of the central nervous system. Children with attention deficient or hyperactivity disorders have been shown to have low levels. Low levels could also lead to an inappropriate or insufficient immune response or delayed wound healing.

In western cultures, high levels of AA tend to be more problematic as they are associated with many proinflammatory conditions including heart disease, diabetes, arthritis and other autoimmune conditions. High levels of AA stimulate the production of proinflammatory cytokines.

Food Sources
AA can be made endogenously inside the body from the parent compound Linolenic Acid. The rate of conversion is largely dependent on the activity of the delta-6-desaturase.

Supplement Options
It is rarely necessary to supplement with arachidonic acid. If levels are deficient consider linolenic acid levels and factors that could influence delta-6-desaturase enzyme.

To reduce endogenous AA production, reduce dietary intake of vegetables oils high in LA (corn, soy, canola, safflower oil).

Fish oil supplementation or increased intake of EPA fatty acids in the diet can also lower AA.
### Key Terms/Glossary

**AI**  
Adequate Intake. A nutrient measure used when RDA cannot be determined due to insufficient data. AIs are approximations of nutrient needs and based on average intake in a healthy population.

**Antioxidant**  
A chemical compound that serves to quench free radicals and other reactive species produced by the process of oxidation, thereby reducing cellular protein damage, as well as inflammation.

**Cofactor**  
A substance that is required for the activity of an enzyme or another protein in a biochemical reaction.

**Conditionally Essential**  
Nutrients that become essential only in certain situations: stress, drug interactions, illness, aging, etc.

**Enriched**  
Refers to refined cereal grains that have had nutrients added back after processing removes the bran and the germ layers. In the United States, enriched grains have the B vitamins (thiamin, riboflavin, niacin, folic acid) and iron added in. Fiber is not added back to enriched grains.

**Essential**  
Refers to a nutrient that is required for life and body function that the body cannot synthesize (produce) on its own. For dietary vitamins, minerals, fatty acids, and amino acids, many, but not all, are essential.

**RDA**  
Recommended Daily Allowance. The estimated amount of a nutrient or calories per day set by the Food and Nutrition Board of the National Research Council. RDA intake level for a particular nutrient that will meet the needs for healthy individuals. RDAs are usually determined for different groups (male, female, children, elderly, pregnant, lactating, etc.) RDAs were originally developed during World War II for soldiers’ meal ratios with the intention to prevent frank nutrient deficiencies. They do not take into consideration interactions/depletions from medications or lifestyle factors.

### Citations/Sources

RISK AND LIMITATIONS

This test has been laboratory developed and its performance characteristics determined by Vibrant America LLC, a CLIA and CAP certified laboratory performing the test. The test has not been cleared or approved by the U.S. Food and Drug Administration (FDA). Although FDA does not currently clear or approve laboratory-developed tests in the U.S., certification of the laboratory is required under CLIA to ensure the quality and validity of the tests.

However, laboratory error can occur, which might lead to incorrect results. Some of them may include sample mislabeling or contamination, operational error, or failure to obtain data for certain micronutrients. Vibrant's laboratory may need a second sample to complete the testing. Vibrant America has effective procedures in place to protect against technical and operational problems; however, such problems may still occur. Examples include failure to obtain the result for a specific micronutrient due to circumstances beyond Vibrant’s control. Vibrant may re-test a sample in order to obtain these results but upon re-testing the results may still not be obtained. As with all medical laboratory testing, there is a small chance that the laboratory could report incorrect results. A tested individual may wish to pursue further testing to verify any results.

All supplement and dietary suggestions for specific micronutrients must be evaluated and approved by your provider. Suggested Supplementation is based off references provided at the end of this report. Please see detailed explanation for each micronutrient and follow your ordering providers' recommendation before using this as a therapeutic intake.

A limitation of this testing is that most scientific studies have been performed in Caucasian populations only. The interpretations and recommendations are done in the context of Caucasian studies, but the results may or may not be relevant to tested individuals of different or mixed ethnicities. Please note that pediatric ranges have not been established for these tests. Interference studies have not been established for individuals on immunosuppressive drugs. Based on test results and other medical knowledge of the tested individual, health care providers might consider additional independent testing, or consult another health care provider.