# Vitamins and Nutrition

**Vitamin –**

- **Coenzyme –**

- **Cofactor –**

- **Prosthetic group –**

## Water-Soluble Vitamins

<table>
<thead>
<tr>
<th>Name</th>
<th>Function</th>
<th>Deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vitamin B&lt;sub&gt;1&lt;/sub&gt;</strong> (thiamin)</td>
<td>Precursor to coenzyme thiamin pyrophosphate, which is required for oxidative decarboxylation reactions</td>
<td>Beriberi – muscle weakness, loss of reflexes, numbness, depression</td>
</tr>
<tr>
<td><strong>Vitamin B&lt;sub&gt;2&lt;/sub&gt;</strong> (riboflavin)</td>
<td>Precursor to FAD and FMN, which are prosthetic groups used for redox reactions.</td>
<td>Not named – photophobia, proliferation of capillaries in the eye, dermatitis</td>
</tr>
<tr>
<td><strong>Vitamin B&lt;sub&gt;3&lt;/sub&gt;</strong> (niacin)</td>
<td>Precursor to NAD and NADP, which are coenzymes used for redox reactions.</td>
<td>Pellegra – weight loss, digestive disorders, dermatitis, depression, dementia</td>
</tr>
<tr>
<td><strong>Vitamin B&lt;sub&gt;5&lt;/sub&gt;</strong> (Pantothenic acid)</td>
<td>Precursor to Coenzyme A</td>
<td>Not named – neurological and digestive problems</td>
</tr>
<tr>
<td><strong>Vitamin B&lt;sub&gt;6&lt;/sub&gt;</strong> (pyridoxal and related compounds)</td>
<td>Precursor to pyridoxal phosphate, which is a prosthetic group for amino acid metabolic enzymes and for glycogen phosphorylase</td>
<td>Not named – dermatitis, neuropathy, altered free amino acid levels, depression.</td>
</tr>
<tr>
<td><strong>Vitamin B&lt;sub&gt;12&lt;/sub&gt;</strong> (cobalamin)</td>
<td>Precursor to enzymes used for one-carbon transfer reactions</td>
<td>Pernicious anemia – enlarged fragile erythrocytes, neurological disorders</td>
</tr>
<tr>
<td><strong>Folic acid</strong></td>
<td>Precursor to coenzyme tetrahydrofolate, which is used for one-carbon transfer reactions</td>
<td>Megaloblastic anemia – enlarged fragile erythrocytes, neural tube defects, neurological disorders</td>
</tr>
<tr>
<td><strong>Biotin</strong></td>
<td>Prosthetic group for several carboxylase enzymes</td>
<td>Not named – depression, hallucinations, muscle pain, dermatitis, immunodeficiency</td>
</tr>
<tr>
<td><strong>Vitamin C</strong> (ascorbic acid)</td>
<td>Coenzyme for hydroxylase enzymes</td>
<td>Scurvy – defective collagen synthesis, dementia</td>
</tr>
</tbody>
</table>

## Fat-Soluble Vitamins

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<th>Function</th>
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<tbody>
<tr>
<td><strong>Vitamin A</strong> (retinol and β-carotene)</td>
<td>Precursor visual pigment retinal and to retinoic acid signaling molecules involved in cellular differentiation</td>
<td>Not named – night-blindness, blindness, developmental abnormalities, keratinization of epithelial tissues.</td>
</tr>
<tr>
<td><strong>Vitamin D</strong> (ergocalciferol and cholecalciferol)</td>
<td>Precursor to 1α, 25-dihydroxyvitamin D, a signaling molecule involved in calcium absorption and homeostasis, and in regulation of cellular differentiation</td>
<td>Rickets and Osteomalacia – softening of the bones</td>
</tr>
<tr>
<td><strong>Vitamin E</strong> (α-tocopherol)</td>
<td>Antioxidant, especially in erythrocytes.</td>
<td>Not named – anemia, and possibly other effects</td>
</tr>
<tr>
<td><strong>Vitamin K</strong> (menadione and related compounds)</td>
<td>Precursor to Vitamin K coenzyme used for synthesis of γ-carboxyglutamate residues, especially in clotting factor proteins</td>
<td>Hemorrhagic disease of the newborn, Hemorrhagic syndrome – deficient blood clotting</td>
</tr>
</tbody>
</table>
Niacin (Vitamin B₃)

Nicotinic acid

Nicotinic acid

Nicotinamide

Nicotinamide

Nicotinamide adenine dinucleotide [NAD]

Nicotinamide adenine dinucleotide 2'-phosphate [NADP]

2 electrons + 1 proton

2 electrons + 1 proton

Oxidized NAD(P)

Reduced NAD(P)H
Alcohol Dehydrogenase

Substrate binding

Proton abstraction

Hydride transfer

Substrate dissociation
Riboflavin (Vitamin B₂)

Ascorbic Acid (Vitamin C)
**Thiamin (Vitamin B₁)**

![Thiamin (Vitamin B₁) and Thiamin pyrophosphate](image)

**Pantothenic Acid (Vitamin B₅)**

![Pantothenic Acid (Vitamin B₅) and Coenzyme A (CoA-SH) and Acetyl Coenzyme A (Acetyl-CoA)](image)

**Biotin**

![Biotin and Carboxylase prosthetic group and Carboxybiotin](image)
**Folic Acid**

![Folic Acid diagram](image)

**Cobalamin (Vitamin B<sub>12</sub>)**

![Cobalamin diagram](image)
**Vitamin B₆**

Pyridoxal

Pyridoxine

Pyridoxamine

Pyridoxal phosphate

Pyridoxal phosphate

Schiff base to α-amino acid

\[
\begin{align*}
&\text{R} \quad \text{C}=\text{O} \quad + \quad \text{H}_2\text{N}-\text{R} \quad \underset{\text{Aldehyde or ketone}}{\xleftrightarrow{\text{Aldel}}}
\end{align*}
\]

\[
\begin{align*}
&\text{R} \quad \text{C}=\text{N}-\text{R} \quad + \quad \text{H}_2\text{O} \quad \underset{\text{Amine}}{\xleftrightarrow{\text{Amine}}}
\end{align*}
\]

\[
\begin{align*}
&\text{R} \quad \text{C}=\text{N}-\text{R} \quad + \quad \text{H}_2\text{O} \quad \underset{\text{Schiff base}}{\xleftrightarrow{\text{Schiff base}}}
\end{align*}
\]
Aminotransferases

\[
\begin{align*}
\text{\(\alpha\)-Ketoglutarate} & \quad \text{Aspartate} & \quad \text{Glutamate} & \quad \text{Oxaloacetate} \\
\text{\(\alpha\)-Ketoglutarate} & \quad \text{Alanine} & \quad \text{Glutamate} & \quad \text{Pyruvate}
\end{align*}
\]

\[ \text{Aspartate aminotransferase} \]

\[ \text{Alanine aminotransferase} \]
Serine Hydroxymethyl Transferase

\[
\begin{align*}
\text{Serine Hydroxymethyl Transferase} & \\
\text{Tetrahydrofolate (THF)} & + p\text{-amino benzamide-glutamate} & \xrightarrow{\text{Serine hydroxymethyl transferase}} & \text{Tetrahydrofolate (THF)} & N^5,N^{10}\text{-Methylene Tetrahydrofolate} & + p\text{-amino benzamide-glutamate} & \text{Glycine}
\end{align*}
\]
**Vitamin K**

Menaquinone-7
(Vitamin K₂)

Phylloquinone
(Vitamin K₁)

Menadione
(Vitamin K₃)

Glutamate

\[ \text{CO}_2 + \text{O}_2 \]

\[ \gamma\text{-carboxy-glutamate} \ (\text{Gla}) \]

\[ \gamma\text{-glutamyl carboxylase} \]

Vitamin K Cycle

Vitamin K epoxide reductase

Vitamin K epoxide reductase

Warfarin
(Wisconsin Alumni Research Foundation)