Vitamins

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Definition of Vitamin and Mineral

• **Vitamins** are *organic compounds* and **minerals** are *chemical elements* that are required as nutrients in small amounts by an organism.

• A vitamin is:
  – An organic compound *distinct* from fats, carbohydrates and proteins
  – *Natural component* of foods, present in minute amounts
  – Is *essential* for normal physiological function, usually in minute amounts
  – Cause a *specific deficiency syndrome* when absent or underutilized
  – Is *NOT synthesized by the host* in amounts adequate to meet normal physiological needs: human can make vitamins D\textsubscript{3} and B\textsubscript{3}

• **Vitamers** are different forms of a particular vitamin, e.g. vitamins K\textsubscript{1} and K\textsubscript{2}, vitamins D\textsubscript{2} and D\textsubscript{3}, retinol and retinal (vitamin A), etc.
Origin of Vitamin

- Beriberi: a historic disease prevalent in Asian population due to major consumption of polished rice
- 1897, Christiaan Eijkman found antiberiberi factor in water or alcohol extracts of rice polishings
- 1901, Gerrit Grijns suggested beriberi-producing diets lack a certain substance that are important in central nervous system
- 1911, Casimir Funk isolates amine-containing concentrate from rice polishings that cured beriberi in an animal model and names it as “vitamine” for “vital amine”. This was later found to be thiamine, vitamin B1.
- 1912, Funk published the vitamin theory: antiberiberi, antirickets, antiscurvy, and antipellagra vitamines.
- 1920, Jack Drummond suggested to drop “e” from “vitamine” since not all of them are proven to be amines.

Pre-Vitamin History

• 1500 BC – Ancient Egyptians used liver - rich in vitamin A - applied to the eye to treat night blindness.
• 1536 – Jacques Cartier, exploring the St. Lawrence River, uses local native knowledge to save his men from scurvy by boiling the needles from cedar trees to make a vitamin C-rich tea.
• 1795 – British navy adds lemons to sailors' rations, 40 years after a Scottish naval surgeon, James Lind, had urged that citrus fruits be used to prevent scurvy.
• 1884 – Japanese navy eradicates beriberi by feeding sailors meat and fruit in addition to polished white rice, which lacked the thiamine-rich husks.
• 1911 – Casimir Funk names antiberiberi factor as vitamine.
• 1912 – Xavier Mertz – Antarctic explorer – dies of vitamin A poisoning from ingesting sled dog liver after supplies are lost in a crevasse.
In 1913, Elmer McCollum demonstrated two growth factors from diet: fat-soluble A and water-soluble B.

- Fat-soluble A was found to cure both ocular disorders and rickets, which led to the discovery of two factors: vitamins A and D.
- 1919, the antiscorbutic (anti-scurvy) factor found in lemon was named as water-soluble C and later vitamin C.
- 1922, a anti-sterility factor was found, named vitamin E.
- 1929, antihemorrhagic factor was found, named vitamin K.
- 1920 – 1940s, multiple identities of water-soluble B were discovered: vitamins B2, B3, B5, B6, B7, B9, and B12.
## History of Discovery – cont’d

<table>
<thead>
<tr>
<th>Year discovered</th>
<th>Vitamin</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1912</td>
<td>Vitamin B&lt;sub&gt;1&lt;/sub&gt; (thiamin)</td>
<td>Rice bran</td>
</tr>
<tr>
<td>1912</td>
<td>Vitamin C (ascorbate)</td>
<td>Lemons</td>
</tr>
<tr>
<td>1913</td>
<td><strong>Vitamin A</strong></td>
<td>Milk/egg yolk</td>
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<tr>
<td>1918</td>
<td><strong>Vitamin D</strong></td>
<td>Cod liver oil</td>
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<tr>
<td>1920</td>
<td>Vitamin B&lt;sub&gt;2&lt;/sub&gt; (riboflavin)</td>
<td>Eggs</td>
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<tr>
<td>1922</td>
<td><strong>Vitamin E</strong></td>
<td>Wheat germ, Seed oils</td>
</tr>
<tr>
<td>1926</td>
<td>Vitamin B&lt;sub&gt;12&lt;/sub&gt; (cobalamin)</td>
<td>Liver</td>
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<tr>
<td>1929</td>
<td><strong>Vitamin K</strong></td>
<td>Alfalfa</td>
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<tr>
<td>1931</td>
<td>Vitamin B&lt;sub&gt;5&lt;/sub&gt; (pantothenic acid)</td>
<td>Liver</td>
</tr>
<tr>
<td>1931</td>
<td>Vitamin B&lt;sub&gt;7&lt;/sub&gt; (biotin)</td>
<td>Liver</td>
</tr>
<tr>
<td>1934</td>
<td>Vitamin B&lt;sub&gt;6&lt;/sub&gt; (pyridoxine, etc.)</td>
<td>Rice bran</td>
</tr>
<tr>
<td>1936</td>
<td>Vitamin B&lt;sub&gt;3&lt;/sub&gt; (niacin)</td>
<td>Liver</td>
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<tr>
<td>1941</td>
<td>Vitamin B&lt;sub&gt;9&lt;/sub&gt; (folate)</td>
<td>Liver</td>
</tr>
</tbody>
</table>
Classification of Vitamins Based on Solubility

- Fat-soluble vitamins: A, D, E, K
- Water-soluble vitamins: B’s and C
  - B1, thiamine; B2, riboflavin; B3, niacin; B5, pantothenic acid; B6, pyridoxine, pyridoxal, or pyridoxamine; B7, biotin; B9, folate; B12, cobalamin
Storage and Excretion

• Fat-soluble vitamins: ADEK
  – Well retained in the body and tend to be stored in fatty tissues: adipose, muscles, liver
  – Therefore, it takes time to reach a deficiency state
  – More likely to cause toxicity on over-dosage because of the slow clearance

• Water-soluble vitamins: BC
  – Excreted rapidly and not well retained
  – Need regular replacement
  – Only vitamin B12 and B9 retained and stored at significant level in the body
Functions

• Per definition, vitamins are essential to many life processes
  – Energy production by oxidation of biological molecules
  – Making biological molecules
  – Maintenance, growth, development, and/or production
  – Some vitamins participate in protection processes as antioxidants directly or indirectly: E, C, A, B2
Who Takes Vitamin/Mineral Supplements and Why?

- It is estimated that ~50% of adult population in the US takes some type of dietary supplement, typically to “improve/maintain overall health”.
- 75% of products are used without care-provider recommendation.
- US Supplement industry is $37 billion
Multivitamins

• It is estimated that ~30% of the adult US population take multivitamins daily.

• A clinical trial of male physicians taking multivitamins concluded there was a very modest, but (statistically) significant, reduction in total cancers with daily multivitamin use (NEJM, 308:1871 (2012)).

• Do we need to supplement diets with vitamins/multivitamins? Under certain circumstances.
When are Vitamin Supplements Worthwhile?

• Inadequate intake – alcoholics, poor, elderly, dieters, poor diet

• Increased needs – pregnancy, lactation, infants, smokers, injury, trauma, recovery from surgery, infection, certain genetic disorders of metabolism

• Poor absorption – elderly, gastrointestinal disorders, specific GI surgeries, e.g. gallbladder removal, gastric bypass, cystic fibrosis, severe diarrhea, drug-induced vitamin deficiencies – e.g. long term antibiotic use, cholestyramine, mineral oil
Dietary Reference Intakes (DRI)


- Estimated average requirements (EAR): the average daily nutrient intake level estimated to meet the requirements of half of the healthy individuals in a group.

- Recommended Dietary Allowance (RDA): the average daily dietary intake level; sufficient to meet the nutrient requirements of nearly all (97-98%) healthy individuals in a group. Calculated from the EAR.

- Tolerable Upper Limit (UL): maximum adult daily intake unlikely to cause harm.

RDA = 1.2(EAR)
Daily Values (DVs)

- Set by FDA
- Two groups: Daily Reference Values (DRVs) for energy-producing nutrients, e.g. fats, carbohydrates, protein etc. and Reference Daily Intakes (RDIs) for vitamins and minerals.
- A DV is often, but not always, similar to one's RDA for that nutrient.
- DV is primarily used for labeling purposes. % DV on label is based on 2,000 calories/day diet for adults and children over 4 yrs.
Designate both DRV and RDI
Standardization

• Units of biological activity (IU) superceded, where known, by potencies based on weight (mg, mg) of the most active vitamer.
• Institute of Medicine guidelines use weight.
• FDA labels use both.