Chapter 10
Water Soluble Vitamins:  
The B Vitamins and Vitamin C
Vitamins- Overview

**Structure** - vitamins are individual units
**Function** - do not provide energy
they assist the enzymes that release the energy from carbohydrate, fat, and protein
**Food contents** - they are measured in micrograms or milligram rather than grams as in the macronutrients

**Vitamins- Overview**

**Bioavailability** - the rate and extent that a nutrient is absorbed and used. It is based on:
- Efficiency of digestion and transit time
- Previous nutrient intake and nutrition status
- Other foods consumed at the same time
- Method of food preparation (raw, cooked, processed)
- Source of the nutrient (synthetic, fortified, natural)

**The Vitamins** – An Overview
Precursors, also known as provitamins, are consumed in an inactive form and become active vitamins in the body.

**The Vitamins** – An Overview
They are organic
They can be destroyed by exposure to light, oxidation, cooking, and storage.
There are methods used to minimize nutrient losses.
Refrigerate fruits and vegetables.
Store cut fruits and vegetables in airtight wrappers or closed containers and refrigerate.
Clean fruits and vegetables before they are cut.
Use a microwave, steam, or simmer in small amounts of water.
Save cooking water for other uses.
Avoid high temperatures and long cooking times.

**The Vitamins**

**Solubility**

**Vitamins- Overview**

**Toxicity**
More is not better
Tolerable upper intake levels have been established:
The highest amount of a nutrient that is likely to not cause harm for most healthy people when consumed daily

**Vitamins**

**Water Soluble**

**B Vitamins**

**Thiamin**
Riboflavin
Niacin
Pantothenic acid
Vitamin B6
Folate
Vitamin B12
Vitamin C

**Fat Soluble**
Vitamin A
Vitamin D
Vitamin E
Vitamin K

The B Vitamins—As Individuals
The B vitamins are very active in the body:
They do not provide fuel
Coenzymes that assist enzymes in the release of energy.
Other B Vitamins have roles in metabolism and cell replication
There are deficiencies, toxicities and food sources that are unique for each vitamin.

**Thiamin (Vitamin B₁)**

**Thiamin Function:**
Involved in energy metabolism as part of the coenzyme thiamin pyrophosphate (TPP)
Nerve cell function

**Thiamin Recommendations (1998 RDA)**
RDA Men: 1.2 mg/day
RDA Women: 1.1 mg/day

**Thiamin-B1**

**Deficiency:**
Most likely to occur in those with limited kcal intake
Homeless, malnourished
Alcoholics
Alcohol impairs thiamin absorption
Estimated 4 out of 5 alcoholics has thiamin deficiency (80 %)

**Thiamin Deficiency and Toxicity**
Deficiency results in the disease beriberi.
Wet beriberi presents with edema.
Dry beriberi presents with muscle wasting
Symptoms includes nervous system, heart and muscle damage, paralysis,
No reported toxicities

**Beri-Beri-Thiamin Deficiency**

**Thiamin (Vitamin B₁)**
Other Information
Steaming and microwaving are cooking methods that conserve thiamin. Thiamin leaches into water with boiling or blanching. The vitamin is easily destroyed by heat.

**Thiamin in Foods**

**Riboflavin-B2**

**Function:**
Coenzyme FMN (flavin mononucleotide), FAD (flavin adenine dinucleotide) in energy metabolism
Release of energy from nutrients

**Recommendation:**
Men: 1.3 mg/day
Women: 1.1 mg/day

**Riboflavin (Vitamin B\_2)**

**Riboflavin Deficiency and Toxicity**
Deficiency disease is **Ariboflavinosis**
Deficiency Symptoms
Cracks and redness at the corners of the mouth-chelosis
Painful, smooth and purplish red tongue
Skin lesions covered with greasy scales
Inflamed eyelids, sensitivity to light, and reddening of the cornea
No reported toxicities

**Glossitis**

**Riboflavin-B2**

**Food sources:**
Milk and milk products, whole grains, enriched cereals and grains, liver.
Destroyed by UV light
Stable in heat

**The B Vitamins – Riboflavin**

**Riboflavin in Foods**

**Niacin-B3**
Nicotinic acid and Nicotinamide

**Function:**
Coenzyme NAD (nicotinamide adenine dinucleotide), NADP
Energy transfer reactions
Metabolism glucose, fat, alcohol

**Niacin-B3**
Nicotinic acid and Nicotinamide

**Recommendations:**
Can make niacin from tryptophan (amino acid)
Only occurs after protein synthesis needs have been met
60 mg tryptophan = 1 mg niacin
Men: 16 NE/day (niacin equivalents)
Women: 14 NE/day
Niacin (Vitamin B₃)

Niacin Deficiency
A deficiency of niacin results in the disease Pellagra.

Deficiency Symptoms:
- **Diarrhea, Dermatitis, Dementia, eventual Death (“the 4 D’s”)**
- Diarrhea, abdominal pain, and vomiting
- Rash when exposed to sunlight
- Depression, apathy, fatigue, loss of memory, and headache
- Inflamed, swollen, smooth and bright red tongue

Pellagra

Niacin (Vitamin B₃)

Niacin Toxicity
- “Niacin flush” dilates the capillaries and may be painful.
- Toxicity Symptoms with 3-4 X the RDA
  - Painful flush, hives and rash, tingling, burning
  - Headache, reddened face, arms, and chest
  - Excessive sweating
  - Liver damage

Niacin in Foods
RDA for men: 16 mg/day  RDA for women: 14 mg/day

Biotin

**Function:**
- Coenzyme in metabolism that carries CO₂

**Recommendation:**
- Adequate intake: 30 UG/day

Biotin Deficiency
- Rare
- Raw egg whites bind with biotin and prevents absorption

**Food sources:**
- Widespread, can also be synthesized by intestinal bacteria

Pantothenic Acid

**Function:**
- Part of coenzyme-A
  - Assists in synthesis of lipids, steroid hormones, hemoglobin, neurotransmitters

**Recommendations**
- Adequate intake = 5 mg/day

Pantothenic Acid Deficiency
- Rare
- Symptoms include
Insomnia and fatigue
Vomiting, nausea, and stomach cramps
Depression, irritability, restlessness, and apathy
Hypoglycemia and increased sensitivity to insulin

Sources:
- Widespread in foods
- No reported toxicities
- Vitamin B6
- Pyridoxal, Pyridoxine, Pyridoxamine

Function:
- Part of coenzyme PLP (pyridoxal phosphate)
- Active in amino acid metabolism
  - Can transfer amino groups - allows for the synthesis of non-essential amino acids, heme, nucleic acids, lecithin, and the conversion of tryptophan to niacin or serotonin.
- The B Vitamins – B6
  - Three forms
  - Pyridoxal, pyridoxine, and pyridoxamine
  - Conversion to coenzyme PLP
  - Amino acid metabolism
  - Urea metabolism
  - Conversion of tryptophan to niacin or serotonin
  - Synthesis of heme, nucleic acids, & lecithin
- Stored exclusively in muscle tissue
- Vitamin B6

Recommendation:
- 1.3 mg per day (Adults 19-50)

Deficiency:
- Anemia, depression, confusion
- Advanced symptoms include - abnormal brain wave patterns, and convulsions
- Alcohol - encourages loss of B6
- INH (TB Drug) binds with B6
- Vitamin B6-
  - Pyridoxal, Pyridoxine, Pyridoxamine

Toxicity:
- Stored in muscle
- >2 grams >2 months
- Symptoms: depression, headache, fatigue, irreversible nerve damage, numbness, convulsions

Sources:
- Meat, fish, poultry, potatoes, bananas, watermelon, fortified cereals
- Vitamin B6 in Foods
- RDA for adults (19 to 50 yr.): 1.3 mg/day
Folate
Folacin, Folic Acid
Function:
Coenzyme-THF-Tetrahydrofolate
Transfers carbon compounds in metabolism
Synthesis of DNA
Converts B12 to its active form
Recommendations:
400 micrograms per day-Adults
Synthetic folate in foods and supplements is more bioavailable
Folate’s Absorption and Activation
Folate
Folacin, Folic Acid
Folate is critical in reducing the incidence of
Neural Tube Defects:
The brain and spinal cord develop from the neural tube
Defects in its formation early in pregnancy may result in neural tube defects such as spina bifida and anencephaly
Supplements of folate taken 1 month before and 1st three months of gestation can help prevent defects
0.4 mg (400 micrograms) daily
Spina Bifida
Folate
Heart Disease:
In current research
Low folate levels and high levels homocysteine increase the risk of heart disease
High homocysteine-enhances blood clot formation.
Folate breaks down homocysteine and reduces levels in the bloodstream
Folate
Folate Deficiency
Deficiency Symptoms
Impairs cell division & protein synthesis
Macrocytic anemia, also called megaloblastic anemia – large cell type
G.I. tract deterioration-diarrhea
Smooth, red tongue
Mental confusion, weakness, fatigue, irritability and headaches
Folate
Folacin, Folic Acid
Enterohepatic circulation:
• Excess is secreted in bile and reabsorbed
Most vulnerable of all the vitamins to interactions with medications
Anticancer drugs
Antacids and aspirin
Sources:
Legumes, vegetables, spinach, fortified grains
Folate in Foods
RDA for adults: 400*(micrograms)/day
Cobalamin-B12
Function:
DNA, RNA Synthesis
Maintains myelin sheath that surrounds nerve fibers.
Bone cell activity and metabolism
Activates folate
Requires “intrinsic factor” in stomach for absorption
Secreted into bile and reabsorbed
Cobalamin-B12
Deficiency:
Usually related to poor absorption, not poor intake
lack of intrinsic factor or hydrochloric acid
Can occur with atrophic gastritis (stomach cell damage)
decreases production of intrinsic factor
Lack of intrinsic factor = Pernicious Anemia
Leads to folate deficiency-anemia
Paralysis of nerves and muscles
B12 protects the myelin sheath surrounding nerve fibers
Vegan diet increases risk (may take up to 3 years)
Vitamin B12
Recommendation:
2.4 micrograms per day
Enterohepatic circulation- most is reabsorbed
Food Sources:
Animal products
meat, poultry, eggs, milk, dairy
Destroyed by microwave heat
Normal & Anemic Blood Cells
B Vitamin Deficiency Symptoms
Metabolic Pathways Involving B Vitamins
Vitamin C
Vitamin C Functions
As an Antioxidant
Defends against free radicals
Protects tissues from oxidative stress and damage
As a Cofactor in Collagen Formation
Collagen is used for bones and teeth, scar tissue, and artery walls.
Works with iron to form hydroxyproline which is needed in collagen formation

Vitamin C

Vitamin C Roles

As a Cofactor in Other Reactions

Vitamin C needs increase during body stress, i.e. infections, burns, extremely high or low temperatures, heavy metal intakes, certain medications, and smoking.

As a Cure for the Common Cold

Conflicting research

At least 200 mg of Vit C daily decreases the duration of a cold

Vitamin C deactivates histamine like an antihistamine and decrease nasal congestion.

Vitamin C

Recommendations:

M - 90mg       F - 75mg

May need extra in stress:

Infection, burns, high or low temp

Heavy metal intake

Aspirin

Oral contraceptives

Cigarette smoking add 35 mg

Vitamin C – Recommendations

Prevent overt symptoms of scurvy

Absorption maximum

200 mg

Higher vitamin C levels for smokers

Vitamin C

Vitamin C Deficiency

Deficiency disease is called scurvy

Deficiency Symptoms

Bleeding gums and loosened teeth

Anemia – small cell type

Atherosclerotic plaques and pinpoint hemorrhages

Bone fragility and joint pain

Poor wound healing and frequent infections

Muscle degeneration and pain, hysteria, and depression

Rough, brown, scaly and dry skin and blotchy bruises

Vitamin C Deficiency

Scurvy

Vitamin C

Vitamin C Toxicity

Toxicity Symptoms

Nausea, abdominal cramps, diarrhea, headache, fatigue and insomnia

Hot flashes and rashes
Interference with medical tests, creating a false positive or a false negative
Aggravation of gout symptoms, urinary tract infections, and kidney stones
Upper level for adults: 2000 mg/day
Vitamin C
Vitamin C Food Sources
Citrus fruits, cantaloupe, strawberries, papayas and mangoes
Cabbage-type vegetables, dark green vegetables like green peppers and broccoli, lettuce, tomatoes and potatoes
Other Information
Also called ascorbic acid
Easily destroyed by heat and oxygen
Vitamin C in Foods
End of Chapter 10
Water Soluble Vitamins
Highlight 10
Vitamin and Mineral Supplements
Vitamin/Mineral Supplements
When to use:
1. Correct overt deficiencies
2. Improve nutrition status
3. Reduce disease risk
4. Support increased needs
5. Improve bodies defenses
Vitamin/Mineral Supplements
Who should take them:
1. People with nutrient deficiencies
2. People eating <1600 Kcal
3. Vegans
4. Stages of life cycle
5. Decreased calcium intake, lactose intolerance
7. Diseases that interfere with digestion and absorption.
8. Medications that interfere with the bodies use of nutrients.
Arguments Against Supplements
Toxicity
Supplement users are more likely to have excessive intakes
Issues with children
Life-threatening misinformation
No guarantee of supplement effectiveness
Unknown needs
“Ideal” supplements
False sense of security
End of Chapter 10: