**Micronutrients Across the Life Cycle – Lecture Outline**

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**Learning Objectives:**

1. Review the foundations of vitamin and mineral metabolism, their role as coenzymes, their essential functions, toxicities, and deficiencies
2. Describe the nutritional significance of vitamins and minerals
3. Identify the major food sources of vitamins and minerals
4. Discuss the major vitamin and minerals and their roles in metabolism across the lifecycle
5. Review the need for micronutrient supplementation in special populations

**Fundamentals: Vitamins and Minerals**

Micronutrients is a classification of compounds that includes vitamins and minerals. They are distinct from macronutrients (fats, proteins, and carbohydrates). Micronutrients have countless important roles in the body; one primary function is to serve as coenzymes/cofactors in macronutrient metabolism. Although they can be found in dietary supplements, **the primary/preferred source is food**. Our body only needs them in trace amounts, but they are essential for normal body function. Our bodies cannot synthesize these nutrients on our own, with 3 notable exceptions (don’t memorize):

* 1. Vitamin D (sunlight)
	2. Vitamin K (gut bacteria)
	3. Niacin (from tryptophan)

Micronutrient functions are complex and interrelated; therefore, signs and symptoms of vitamin deficiencies may be similar.

**Classification:**

There are **13 essential vitamins** that are **classified based on their solubility in water or fat. Minerals are classified based on their dietary requirement.** Macro-minerals are needed in amounts greater than 100mg/day, and micro-minerals (trace minerals) are needed in amounts less than 100mg/day: *(do not memorize these lists, just know how they are classified)*

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| **Water Soluble**  | **Fat Soluble**  |
| Thiamine (B1)  | Vitamin A  |
| Riboflavin (B2)  | Vitamin D  |
| Niacin (B3)  | Vitamin E  |
| Pantothenic Acid (B5)  | Vitamin K  |
| Pyridoxine (B6)  |   |
| Biotin (B7)  |   |
| Folate/Folic Acid (B9)  |   |
| Cobalamin (B12)  |   |
| Vitamin C  |   |

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| **Macro-minerals (>100mg/day)**  | **Micro-minerals (trace) (<100mg/day)**  |
| Calcium (Ca)  | Iron (Fe)  |
| Phosphorous (P)  | Zinc (Zn)  |
| Magnesium (Mg)  | Copper (Cu)  |
| Sodium (Na)  | Selenium (Se)  |
| Potassium (K)  | Chromium (Cr)  |
| Chloride (Cl)  | Iodine (I)  |
|   | Manganese (Mn)  |
|   | Fluoride (Fl)  |
|   | Cobalt (Co)  |
|   | Others  |

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**Metabolism - Vitamins:**

Fat-soluble and water-soluble vitamins significantly differ in their ability to be stored and excreted. **Water-soluble vitamins** are readily excreted in the urine, and thus **deficiencies can develop quickly** without a regular dietary source. Risk for toxicity (excess) is minimal with water-soluble vitamins. In opposition, fat-soluble vitamins are readily stored in body fat. Therefore, deficiency states take longer to develop in the absence of dietary sources. **Toxicities are more likely with fat-soluble vitamins** due to their ability to be stored.

**Metabolism - Minerals:**

In general, minerals are not absorbed as well as most vitamins. **In addition, animal sources of minerals are absorbed better as they are more bioavailable** compared to plant sources. For example, the iron in red meat is better absorbed than the iron found in plant foods. Toxicity from minerals is more likely to occur from excess dietary supplements than from food.

**Vitamin Highlights Across the Life Cycle - Fat-soluble**

*(this handout will only go over certain vitamins/deficiencies that are likely to show up on the exam - refer to the lecture slides for a more complete list)*

**Vitamin D** - **Vitamin D is very important for bone health and immune function**, among many other things. It functions in the regulation of calcium and phosphorous metabolism. It is relatively difficult to obtain from non-fortified food sources, and a primary source for humans is a conversion that occurs with **sunlight** on the skin.

Vitamin D deficiency is one of the most common deficiencies, affecting several unique populations. **Deficiency states are common in the elderly, causing osteoporosis.** Deficiency in **young children lead to Rickets,** a condition which causes growth abnormalities. Other at-risk populations include individuals with darker skin, kidney disease, liver disease, GI diseases, and breast-fed infants.

**Vitamin Highlights Across the Life Cycle - Water-soluble:**

**Vitamin B3 (Niacin)** - Niacin is found in 2 forms, nicotinic acid, and nicotinamide. Its primary function is to assist in the release of energy from macronutrients. **Niacin Deficiency can cause pellagra**, a condition that is remembered for board exams by the “4 D’s” - Dermatitis, diarrhea, dementia, death (*do not memorize*). **Niacin is also a rare water-soluble vitamin that can cause toxicities at higher doses**. Nicotinic acid used to be given to patients to help lower LDL levels, but is no longer recommended due to these toxicities.

**Vitamin B6 (Pyridoxine)** - **Pyridoxine is another rare water-soluble vitamin that can be toxic at higher doses**. Women can take this during pregnancy to relieve nausea symptoms in appropriate amounts (10-25 mg three times a day) with no ill effects to the fetus. In appropriate amounts (no more than 100 mg/day) it may help with relieve premenstrual syndrome (PMS) symptoms. However, at too high of levels, it may cause sensory neuropathy (walking difficulties, hand/foot numbness).

**Vitamin B12 (Cobalamin) -** Vitamin B12 assists in hemoglobin production, among other important functions. **Vitamin B12 deficiency can therefore lead to anemia**. This is much **more common among vegans and vegetarians**, since this vitamin is almost exclusively found in animal

**Vitamin B9 (folate)** - Folate is an important vitamin involved in embryonic development of the neural tube. **Folate deficiency during pregnancy can result in neural tube defects**, such as spina bifida.

**Mineral Highlights Across the Life cycle:**

**Iron -** Iron is essential for blood production, as well as oxygen transfer from blood to tissues. **Iron Deficiency is the leading source of Anemia worldwide (Iron Deficiency Anemia)**. At-risk populations include infants/young children, pregnant women, women with heavy menstruation, and the elderly.

**Micronutrient Considerations for Special Populations***:*

1. **People with alcohol abuse disorder** are at increased risk of various micronutrient deficiencies and are often deficient in several. The **most common deficiency is thiamine (B1),** as body stores are depleted within 4 weeks. This can lead to wet **Beri Beri** (cardiac) or dry Beri Beri (neurologic).

1. **Patients with bariatric surgery are another especially vulnerable population, and often develop multiple deficiencies.** This is because the Roux-en-Y procedure (gold standard) bypasses the stomach and much of the duodenum, where a significant amount of nutrient absorption normally occurs. The most common deficiencies in these patients include vitamin D (up to 80% of patients) and Iron (anemia).

1. **Vegan/Vegetarian patients** are at increased risk of various deficiencies because several micronutrients are more abundant in animal-based foods. The most prevalent deficiency is **Vitamin B12 (causes anemia, mentioned above)**, which is found almost exclusively in animal-based foods. This can easily be obtained through fortified foods (cereals, plant-milk, nutritional yeast), or though supplements.

1. There are several **drug-nutrient interactions** that all clinicians should be aware of.

* 1. **Coumadin (Warfarin)** works against the action of vitamin K to prevent blood clots. Therefore, a **consistent intake of vitamin K** is necessary to maintain effects of the drug.
	2. Metformin (common medication for diabetics) can cause a vitamin B12 deficiency. It is now recommended that patients monitor B12 levels every 6 months while taking the drug.
	3. Tetracyclines and Fluoroquinolones (antibiotics) - absorption is disrupted by chelation with metallic cations (iron, calcium, magnesium, aluminum). Patients should avoid consuming these within 4 hours of medication.
	4. Isoniazid (TB drug) lead to low levels of vitamin B6. Supplements should be taken while on this drug.
	5. Methotrexate (antineoplastic, common drug used for rheumatoid arthritis leads to low folate levels. Supplementation is recommended.
	6. Corticosteroids decrease the absorption of calcium, and this can lead to osteoporosis. Supplementation and monitoring are required for patients on longterm corticosteroids.

**Micronutrient Supplements** *(not testable)*

A recent study showed that 79% of American adult women and 94% of men use dietary supplements, yet less than ¼ of these were recommended by a health provider. Multi-vitamins

(MVI) are the most common, and the most common reason is to “improve general health/wellness”. As of now, there is insufficient evidence supporting the use of MVI to reduce risk of heart disease, cancer, or other chronic disease. However, about 1/3 of Americans may be at risk for one or more micronutrient deficiencies. This is significantly higher in non-Hispanic black populations (55%), individuals from low-income households (42%), those without high school diplomas (42%), underweight (42%), and obese individuals (39%). Therefore, screening of the following higher-risk populations is recommended:

* Pregnant women, children, and adolescents
* Geriatric patients
* Low income-food insecure
* Obese/overweight
* Non-Hispanic Black
* Chronic conditions: IBD, cancer, ETOH/substance use disorder, HIV, COPD, diabetes, GI malabsorption, visual impairment, dexterity issues, visual impairments, etc.
* Diets: Weight-loss diets, vegan, vegetarian