Fat Soluble Vitamins
Learning Objectives

● Define vitamins
● Differences between fat and water soluble vitamins
● Describe the deficiencies caused by Vitamins A and D
What are vitamins?

Vitamins are organic substance needed by the body in small amounts for:

1. Metabolism
2. Growth
3. Maintenance
● Vitamins are not sources of energy, nor do they become part of the structure of the body
● Vitamins ARE
  ○ Regulators/Adjusters of metabolic processes. They help to activate enzymes.
  ○ They are either fat soluble or water soluble
● Fat Soluble: Vitamins D, A, K, E
● Water Soluble: Vitamins B and C
Fat Soluble Vitamins

- **Storage**: They are stored like fats in area like adipose tissue and around organs.
- The vitamins can be stored for various lengths of time.
- Toxicity for Vitamin D and A can be fatal.
Vitamin A

Vitamin A describes a group of compounds that include retinol, retinoic acid, retinal, and a number of provitamin A carotenoids such as beta-carotene. All types of vitamin A contain a beta-ionone ring with an isoprenoid chain attached which is referred to as the retinyl group. Both structures are required for vitamin activity.
2 Forms of Vitamin A

There are two different types of vitamin A.

The first type, **PREFORMED vitamin A**, is found in meat, poultry, fish, and dairy products. It is known as the active form of the vitamin, which your body can use just as it is.

The second type, **PROVITAMIN A**, is found in fruits, vegetables, and other plant-based products. The most common type of provitamin A in foods and dietary supplements is beta-carotene. Other forms are alpha-carotene, and beta-cryptoxanthin — are the inactive form of the vitamin found in plants.
Metabolism of Vitamin A

- In order to transport retinol, the blood needs retinol binding protein and prealbumin. Both are synthesized in the liver.
- Therefore, if you are deficient in protein, you have trouble with transportation and usage of vitamins.
Excretion of Vitamin A

- 40% of vitamin A metabolites are excreted in the bile and feces
- 60% is excreted in urine - unless the intake is too high then the excretion in the feces will be higher.
Storage of Vitamin A

- 1 year supply is stored in the liver
- Excessive carotene is stored in the adipose tissue. This can give the skin a yellow tint.
Body Functions that Depend on Vitamin A

1. Vision
2. Bone Growth
3. Maintenance of Epithelial tissue
4. Provitamin A serves as an antioxidant
Hypervitaminosis A

- Acute toxicity occurs after consuming large amounts of vitamin A over a short period of time, typically within a few hours or days.
- Chronic toxicity occurs when large amounts of vitamin A build up in your body over a long period of time.
- Symptoms include changes to vision, bone pain, and skin changes. Chronic toxicity can lead to liver damage and increased pressure on your brain.

Causes of hypervitaminosis A

- Excess amounts of vitamin A are stored in your liver, and it accumulates over time. Most people develop vitamin A toxicity by taking high-dose dietary supplements, possibly due to megavitamin therapy.
Carotenemia

- Ingestion of excessive amounts of carrots is the usual cause of carotenemia, but it can also be associated with ingestion of many other yellow vegetables, as well as some green vegetables.
- Hypothyroidism, diabetes mellitus, hepatic and renal diseases may be associated with carotenemia, but are not caused by ingestion of carotene. The absence of yellow pigment in the sclera and oral cavities distinguishes carotenemia from jaundice. A similar disorder, lycopenemia, is associated with an orange-yellow skin pigmentation as a result of ingestion of large amounts of tomatoes.
- 2-6 weeks after stopping foods, skin can turn to normal
International Units and mcg RAE

Vitamin A is listed on the new Nutrition Facts and Supplement Facts labels in mcg RAE [8]. The U.S. Food and Drug Administration (FDA) required manufacturers to use these new labels starting in January 2020, but companies with annual sales of less than $10 million may continue to use the old labels that list vitamin A in international units (IUs) until January 2021 [9]. To convert IU to mcg RAE, use the following [7]:

- 1 IU retinol = 0.3 mcg RAE
- 1 IU supplemental beta-carotene = 0.3 mcg RAE
- 1 IU dietary beta-carotene = 0.05 mcg RAE
- 1 IU dietary alpha-carotene or beta-cryptoxanthin = 0.025 mcg RAE
Vitamin for issues

Constipation and Vitamin A: Consume for yellow foods. This will increase peristalsis

Inflammation: More chlorophyll might be helpful. Vit. A from food sources that are blue and/or green

Diabetes and Hypoglycemia: This could cause deficiency in converting carotenoids to Vit. A. The better option is to consume retinol containing products.
Vitamin D
Vitamin D deficiency was recognized when there was an Epidemic of rickets in industrialized cities.

- **Rickets** is a disease characterized by softening of the bones because of poor calcium content. This deficiency disease arises from insufficient Vitamin D activity in the body.
- **Osteomalacia:** Adult form of rickets. The weakening of the bones that is seen with this disease is caused by poor calcium content. A reduction in the amount of the Vitamin D hormone activity in the body is the cause.
Vitamin D

Vitamin D is not a “True Vitamin” because there are sources other than diet to obtain Vitamin D.

- Vitamin D2 (ergocalciferol): comes from sunlight and plant-sourced foods.
- Vitamin D3 (cholecalciferol): comes from animal sources
Absorption of Vitamin D

- Both types of Vitamin D are absorbed in the blood.
- 50% of Vitamin D$^3$ is absorbed in the duodenum but the greatest is absorbed in the distal small intestine.
- Intestinal absorption decreases with age, as the capacity of the skin to synthesize cholecalciferol.
Functions of Vitamin D

1. Helps to regulate calcium and bone metabolism
   a. Along with other hormones, especially parathyroid hormone, Vit. D closely regulates blood calcium to supply the right amount to all of its cells.
   b. The Vit. D hormone helps regulate absorption of calcium and phosphorus from the intestine. Vit. D stimulates the DNA to produce more transport proteins in order to increase the absorption rate of calcium and phosphorus.
   c. It also reduces kidney excretion of calcium and it helps regulate the deposition of calcium in the bones. Vit. D stimulates the KD returning calcium to the bloodstream, rather than excreting it in the urine.
Vitamin D Deficiency

- Vitamin D deficiency can happen at any time, during any season at any latitude.
- Who is at risk for Vit. D Deficiency? (highest to lowest)
  - Winter
  - Aged
  - Obese
  - Sun-deprived
  - Dark-skinned
  - Populations further from the equator
- Others who are at risk:
  - Conditions that affect the gut and digestion, like celiac disease, chronic pancreatitis, Crohn's disease, and cystic fibrosis, can reduce vitamin D absorption.
  - Some types of liver disease can reduce absorption of vitamin D because the ailing liver isn't producing normal amounts of bile.
  - Someone with kidney disease, bioactive vitamin D levels decrease as the disease gets worse, and in end-stage kidney disease, the level is undetectable.
Vitamin D Deficiency

1. Rickets
2. Osteomalacia
3. Other symptoms:
   ● Lethargy/Fatigue and Tiredness
   ● Nerve damage/Muscle Pain
   ● Apathy/Depression/Inability to concentrate
   ● Poor Wound Healing
   ● Low thyroid hormones
   ● Decrease immune response
   ● Anemia
Sources of Vitamin D

1. A major source of Vitamin D is the Body! Vitamin D is manufactured in the skin.
   a. 5-30 minutes of sun exposure between 10am -3pm at least 2x/week on the face, arms, legs or back, without sunscreen, usually leads to sufficient Vit. D synthesis.
   b. Sunscreens with a level higher than SPF 8 appears to block Vitamin D producing UV rays.
   c. Dietary sources of Vit. D are critical in latitudes above 43° north: Level with Nebraska and South Dakota between October and April when UVB light does not penetrate the atmosphere.

2. FOOD!
   a. Salmon
   b. Tuna
   c. Swordfish
   d. Beef Liver
   e. Egg yolks
   f. Mushrooms (D2 is found in them)
   g. Fortified foods (derived from D2)
More on Vitamin D Deficiency

- A body mass index of 30 or higher is associated with low blood levels of Vit. D compared to non-obese people. Greater amounts of subcutaneous fats hold onto the vitamin.
Vitamin D Food Sources

https://www.pbs.org/video/mushroom-vitamin-d-boost-iyyiox/
How much Vitamin D Do I need?

- Recommendations from the US Institute of Medicine suggest that an average daily intake of 400–800 IU, or 10–20 micrograms, is adequate for 97.5% of individuals.

- Blood Levels:
  - Sufficient: blood levels above 20 ng/ml or 30 ng/ml
  - Insufficient: blood levels less than 20 ng/ml
  - Deficient: blood levels less than 12 ng/ml

- A daily vitamin D intake of **1000–4000 IU**, or 25–100 micrograms, should be enough to ensure optimal blood levels in most people.

- 4000 IU is the safe upper limit according to the Institute of Medicine (IOM).

- **Vitamin D intake is recommended at 400–800 IU/day, or 10–20 micrograms.** However, some studies suggest that a higher daily intake of 1000–4000 IU (25–100 micrograms) is needed to maintain optimal blood levels.
Let’s Find some Vit. D sources!

Lisa is a 35-year old women. She lives in Nebraska. Getting out in the sun is difficult for her during the winter. The upper level is 4000 I.U. or about 100 micrograms of Vitamin D. Let’s be conservative with her and let’s have her consume about 65 micrograms of Vitamin D.


- Please provide 2 samples for her. In the first sample include animal and fortified products that will equal to 65 micrograms/day.
- On the second sample, only include non-animal products. Let’s assume that Lisa will take a supplement if she is a vegetarian. Let’s come up with at least 25 micrograms of Vitamin D foods for her.
- Please send me your answer to only me in the comments.
Toxicity

- It is not likely to find food sources of Vit. D that would cause toxicity.
- This is typically only seen in individuals who have accidentally or intentionally taken extremely high doses of vitamin D for long periods of time, such as 50,000–1 million IU/day for months
- **Hypervitaminosis D:** The main consequence of vitamin D toxicity is a buildup of calcium in your blood (hypercalcemia), which can cause nausea and vomiting, weakness, and frequent urination. Vitamin D toxicity might progress to bone pain and kidney problems, such as the formation of calcium stones.
Vitamin E
Vitamin E

History:

- In 1922, H.M. Evans and K.S. Bishop discovered a substance that was deficient in rats that were fed a diet that contained lard. This diet resulted in infertility. The deficiency was corrected when a lipid extract of cereals was added to the diet; this was termed the "anti-sterility factor".
- In 1925, vitamin E was officially recognized as the fifth vitamin. A few years later, the name tocopherol from the Greek word of "toc" (child) and "phero" (to bring forth) was coined to describe its role as an essential dietary substance in normal fetal and childhood development.
- In 1969, the US Food and Drug Administration formally recognized vitamin E as an essential nutrient for humans.
Functions of Vitamin E

1. Protects the Integrity of cell membranes
   a. Serves as an antioxidant
   b. Protects Provitamin A from oxidation
   c. Protects unsaturated fatty acids from oxidation
   d. Preserves stability of polyunsaturated fats
   e. In the red blood cell membranes, Vitamin E protects these cells from oxidizing in the lungs
   f. Helps to protect the lung from air pollution
Absorption of Vitamin E

- This is a Fat Soluble, Antioxidant
- The primary site is the jejunum.
- Absorption rates vary from 20% to 80%
  - Higher intake REDUCE absorption rate
Do We Supplement?

- There is no data conclusive supporting that supplementation of Vitamin E will prevent cancer, cataracts, Parkinson's disease or Alzheimer's.
  - However, vitamin therapy can help fight these.
- In regard to cardiovascular disease, there was a noted increased incidence of stroke in those who supplemented Vit.E.
- Another finding was that men who supplemented for 5.5 years or more, had an increase rate of 17.5% to get prostate cancer.
- Unless you’re vitamin E deficient, you likely don’t need to supplement with it. If you have a fat malabsorption disorder or follow a low fat diet, you may be at an increased risk of vitamin E deficiency.
Deficiency

- Deficiency is rare.
- Symptoms in infant include:
  - Irritability, fluid retention, anemia
- Symptoms in adults include:
  - Lethargy, loss of balance and anemia
People at Risk for Vit. E Deficiency

- Chronic Liver Disease
- Fat Malabsorption syndrome: Celiac Disease, Cystic Fibrosis
- Hemodialysis patients,
- Red blood cell disorders
- Some elderly
Toxicity

- Not know to happen with natural foods
- Excessive supplementation can cause GI problems, muscle weakness, double vision, increased bleeding tendency.
- Inhibition of Vitamin K Metabolism
Food Sources of Vitamin E

- The Recommended Dietary Allowance (RDA)
  - Males and Females ages 14 years and older is 15 mg daily (or 22 international units, IU), including women who are pregnant. Lactating women need slightly more at 19 mg (28 IU) daily.

- Wheatgerm oil
- Sunflower seeds
- Almonds
- Sunflower oil
- Safflower oil
- Hazelnuts
- Peanut butter
- Canola oil
Vitamin E interactions with Drugs

- Cholestyramine, mineral oil and alcohol may reduce the absorption of Vit E from the intestine.
- Vitamin E can enhance the action of anticoagulant drugs on blood clotting.
- Anticonvulsants such as phenobarbital, phytonin, carbamazepine may lower blood plasma levels of Vitamin E by altering absorption, distribution and metabolism.
- Isoniazid decreases Vit E absorption
- Neomycin impairs utilization of Vitamin E.
- Caution with overacting thyroid, HTN and rheumatic heart disease
Vitamin K
Vitamin K

- In 1929, there were tons of chickens suffering from hemorrhagic diseases. This was associated with low-fat, cholesterol-free diets that the chickens were on.
- In 1941, Vitamin K was identified to be responsible for delaying clotting time
- Frequently prescribed as medication.
- Impact on the effectiveness of Warfarin, the anticoagulant
- Antidote for warfarin overdoses
2 Types of Vitamin K

- **Vitamin K$_1$**: Found in Plants and absorbed in the jejunum
- **Vitamin K$_2$**: Synthesized by intestinal bacteria and absorbed in the distal small intestine and the colon
The Storage of Vitamin K

- Stored in the cell membranes of the LUNGS, KIDNEYS, BONE MARROW and ADRENALS
- Estimated 50-100 milligrams is stored in the body
- Turn-over is every 1.5 days
- Most of it is excreted in the feces via bile or urine
Functions of Vitamin K

1. Blood Clotting
2. Bone Metabolism

This is due to Vitamin K dependent proteins.
Vitamin K Deficiency

- Excessive Bleeding
  - This could look like:
    - bruises easily
    - gets small blood clots underneath their nails
    - bleeds in mucous membranes that line areas inside the body
    - produces stool that looks dark black (almost like tar) and contains some blood
Deficiency in Babies

Doctors will look for the following signs and symptoms in babies:

- Bleeding from the area where the umbilical cord is removed
- Bleeding in the skin, nose, the gastrointestinal tract, or other areas
- Bleeding at the penis if the baby has been circumcised
- Sudden bleeding in the brain, which is extremely dangerous and life-threatening
Who is at risk?

- Long Term antibiotic therapy
- A diet severely lacking green leafy vegetables.
- Fat absorption problems from GI diseases may hinder Vit. K absorption, resulting in prolonged clotting time.
- Babies
  - Inadequate amounts of vitamin K cross the placenta.
  - The intestines of the babies are sterile and it takes 24 hours for babies to start making Vitamin K
  - Breast milk is low in Vit. K
  - The liver of the newborn does not use the vitamin efficiently.
Vitamin K Deficiency Treatment

- Vitamin K1.
  - Usually an oral medication.
  - Can be injected under the skin.
  - American Academy of Pediatrics recommends that newborns get a single shot of 0.5 to 1 mg vitamin K1 at birth. A higher dose may be necessary if the mother has been taking anticoagulants or anti-seizure drugs.