Lecture 57:

Vitamins

Part 4

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Vitamins To Be Discussed:

- Vitamin C
- Vitamin D
- Vitamin K

Vitamin C (Ascorbic Acid):

- **Vitamin C is a water soluble, heat – sensitive, and immune – boosting nutrient.**

- **Acting as an antioxidant, vitamin C has many roles and functions in the body. The C stands for citrus, wherein this vitamin was found first.**

Functions of Vitamin C:

- **a) It has an antioxidant activity.**
- **b) It promotes the absorption of iron.**
- **c) It is required for the formation of collagen.**
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- **d) It acts as a coenzyme to convert proline to hydroxyproline and lysine to hydroxylysine. Both hydroxyproline and hydroxylysine are important for collagen synthesis.**

- **e) It helps with wound healing.**
- **f) It aids the metabolism of folic acid (vitamin B9), tyrosine, and tryptophan.**
- **g) It functions as a coenzyme in the conversion of tryptophan to 5 – hydroxytryptophan, which is the precursor to serotonin.**
- **h) It helps folic acid convert to its active form, tetrahydrofolic acid.**

- **i) It is important in the conversion of tyrosine to dopamine and dopamine to norepinephrine.**
- **j) It stimulates the adrenal glands to produce and release the hormones epinephrine, norepinephrine, and cortisol (stress hormone).**
- **k) It protects LDL cholesterol and vitamins B1, B2, B5, and B9 from oxidative damage.**
- **l) It supports the production of thyroid hormones.**

- **m) It boosts the immune system against infections (bacterial, viral, and fungal) by stimulating neutrophils and lymphocytes.**

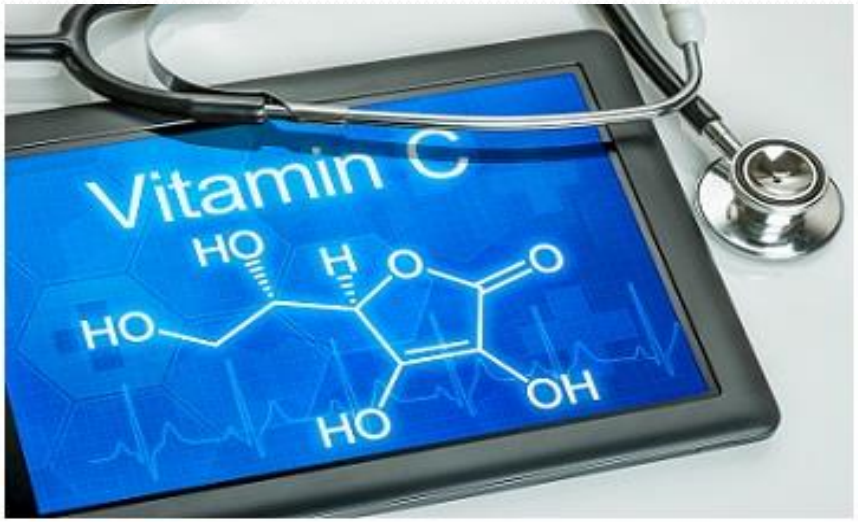
- **n) It may reduce the risk of allergy by decreasing the production of histamine.**

- **o) It is a component of many drug – metabolizing enzyme systems.**

- **p) It may reduce the risk of toxicity with heavy metals, such as mercury, lead and arsenic.**

- **q) It reduces the incidence of certain cancers, especially esophageal and gastric cancers.**

- **r) It has a potential therapeutic role in the treatment of advanced cancers.**



Food Sources and Absorption:

- **Foods high in vitamin C are citrus fruits (lime, lemon, orange, tangerine, and grapefruit), rose hips, green peppers, broccoli, cherries, berries, papaya, tomatoes, potatoes, Brussels sprouts, parsley, asparagus, cabbages, and dark green leafy vegetables.**

Citrus fruits are excellent sources of vitamin C.

- **Vitamin C is absorbed well from the upper part of the small intestine.**
- **If dietary intake is less than 100 mg, almost 90% of vitamin C is absorbed.**
- **However, only 50% or less is absorbed when dietary intake is more than 1000 mg.**
- **The absorption of vitamin C is enhanced by flavonoids.**

- **The consumed vitamin C is used by the body within 2 hours and is metabolized to oxalic acid, threonic acid, and lyxonic acid.**

- **The body can store some vitamin C, about 65 mg per one kilogram of body weight.**

- **The highest concentrations of vitamin C in the body are in the adrenal glands, pituitary gland, eyes (especially the retinas), brain, testicles, and ovaries.**

The daily requirement of vitamin C is increased in the following conditions (either due to decreased absorption or increased utilization):

- **a) Smoking.**
- **b) Hemodialysis.**
- **c) Pregnancy.**
- **d) Stress.**
- **e) Infections.**
- **f) Trauma.**
- **g) Alcoholism.**
- **h) Fever.**

- **i) Consumption of antibiotics, corticosteroids, aspirin, or other pain – killers.**
- **j) Exposure to heavy metals, such as mercury, lead, arsenic, and cadmium.**
- **k) Exposure to environmental toxins, such as pesticides, herbicides, and carbon monoxide.**

Athletic Benefits of Vitamin C:

- **a)** It protects the muscles from exercise – induced oxidative damage, promoting muscle growth.
- **b)** It may prevent from overtraining syndrome.
- **c)** It may speed up exercise recovery.
- **d)** It supports protein synthesis.
- **e)** It may have a protective affect against post – exercise myoglobinuria (PEM).
- **f)** It may accelerate the healing process in strains and sprains.

Non – Athletic Benefits of Vitamin C:

- a) Anemia.
- b) Wound healing.
- c) Common cold.
- d) Infections.
- e) Stress.
- f) Cancers.
- g) Infertility.
- h) Bruising.

- **i) Periodontal disease.**
- **j) Eye problems such as glaucoma, cataract, and age – related macular degeneration (AMD).**
- **k) Varicose veins.**
- **l) Cold sores.**
- **m) Asthma.**
- **n) Capillary fragility.**
- **o) Dysmenorrhea.**
- **p) Endometriosis.**
- **q) Inflammation (bursitis, bronchitis, cystitis, dermatitis, sinusitis, gastritis, and prostatitis).**

- **r) Compromised immune system.**
- **s) Osteoarthritis.**
- **t) Rheumatoid arthritis.**
- **u) Atherosclerosis.**
- **v) Discogenic back pain.**
- **w) High LDL cholesterol.**
- **x) Autism.**
- **y) Adrenal exhaustion.**
- **z) Substance (alcohol, nicotine, and caffeine) withdrawal support.**

Vitamin C Deficiency:

- **Overt deficiency of vitamin C in adults occurs when dietary intake of vitamin C drops to below 10 mg per day.**

- **It leads to a disease called "scurvy".**

Signs and symptoms of vitamin C deficiency:

- fatigue
- delayed wound healing
- easy bruising
- loss of appetite
- tiny hemorrhage
- coiled hairs
- inflamed and bleeding gums
- joint swelling and tenderness
- poor digestion
- nose bleeding
- brittle bones

Dosage and Side Effects:

Age or Conditions	RDA for vitamin C
Male, 14 – 18 years old	75 mg
Male, 19 years old and older	90 mg
Female,14 – 18 years old	65 mg
Female, 19 years old and older	75 mg
Pregnancy	85 mg
Breastfeeding	120 mg

- **The usual dose of vitamin C is 1000 – 2000 mg per day. Some conditions may require higher doses.**

- **Consuming more than 2000 mg of vitamin C in a single dose may cause abdominal cramp, nausea, and diarrhea.**

- **Other symptoms include skin sensitivity (flushing of the face), burning feeling while urinating, destruction of the red blood cells (hemolysis), headaches, sleep disturbances, and false – negative guaiac reaction (stool exam will show no blood despite having blood in it).**

Vitamin C should be avoided in the following conditions:

- **a) Kidney stones, oxalate type.**
- **b) G6PD deficiency.**
- **c) Hemochromatosis.**

Interactions:

- **a) Aluminum – containing antacids: vitamin C may increase the absorption of aluminium and risk of toxicity. It should be taken 2 hours before or 4 hours after these kinds of antacids.**

- **b) Acetaminophen (Tylenol): vitamin C may decrease the urinary secretion of acetaminophen followed by an increase its blood level.**

- **c) Birth control pills: vitamin C may increase the blood levels of estrogen.**

- **d) Nonsteroidal anti – inflammatory drugs (NSAIDs) and aspirin: they increase urinary loss of vitamin C, leading to low levels of vitamin C in the body.**

- **e) Barbiturates: they may decrease the effectiveness of vitamin C.**

- **f) Fluphenazine: vitamin C may decrease the effectiveness of this medication.**

Vitamin D (Calciferol; Cholecalciferol):

- **Vitamin D is a fat soluble vitamin. Being famous as the "sunshine vitamin", vitamin D is a hormone and hormone precursor rather than vitamin.**

- **The most important function of vitamin D is to maintain blood levels of calcium.**

Functions of Vitamin D:

- **a) It increases the absorption of calcium, phosphorous, magnesium, and zinc.**
- **b) It is important for maintaining normal function of the muscles and heart.**
- **c) It is required for a healthy immune system.**
- **d) It may affect inflammation.**

- **e) It is necessary for normal development of the bones and teeth.**
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- **f) It is important for normal function of the nervous system and blood clotting.**
- **g) It is important for regulating blood levels of insulin.**

Food Sources and Absorption:

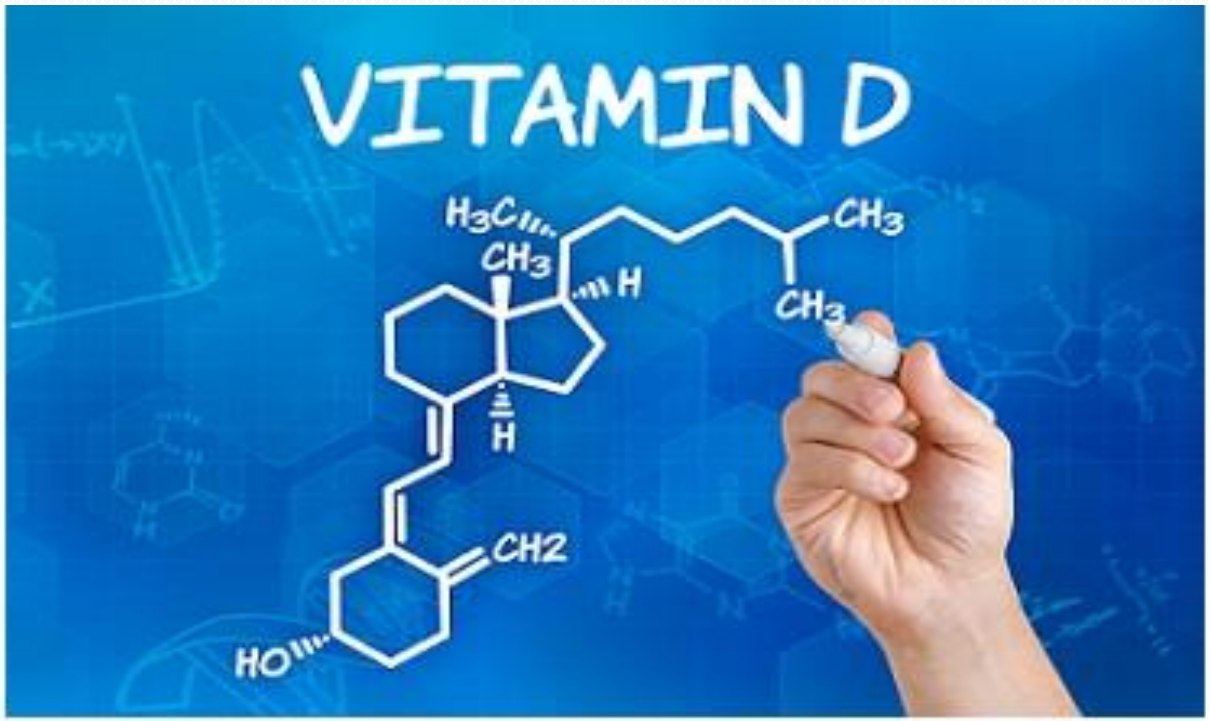
- **Vitamin D is made in the skin by exposing to the sun.**

- **About 30 minutes of direct exposure of the face and upper extremities to the sun would make about 10,000 – 20, 000 IU vitamin D depending on the following factors:**

- **1) The time of day: the closer to the midday, the more vitamin D you make. Remember, if your shadow is longer than your height (like winter time), you are not making much vitamin D!**

- **2) The type of skin: fair – skinned people make more vitamin D than dark – skinned people, as the skin pigment (melanin) in dark-skinned people blocks ultraviolet rays entering into the skin. This is why dark – skinned people would need more sun exposure to make enough vitamin D.**

- **3) The further away you live from the equator, the less vitamin D you would make.**



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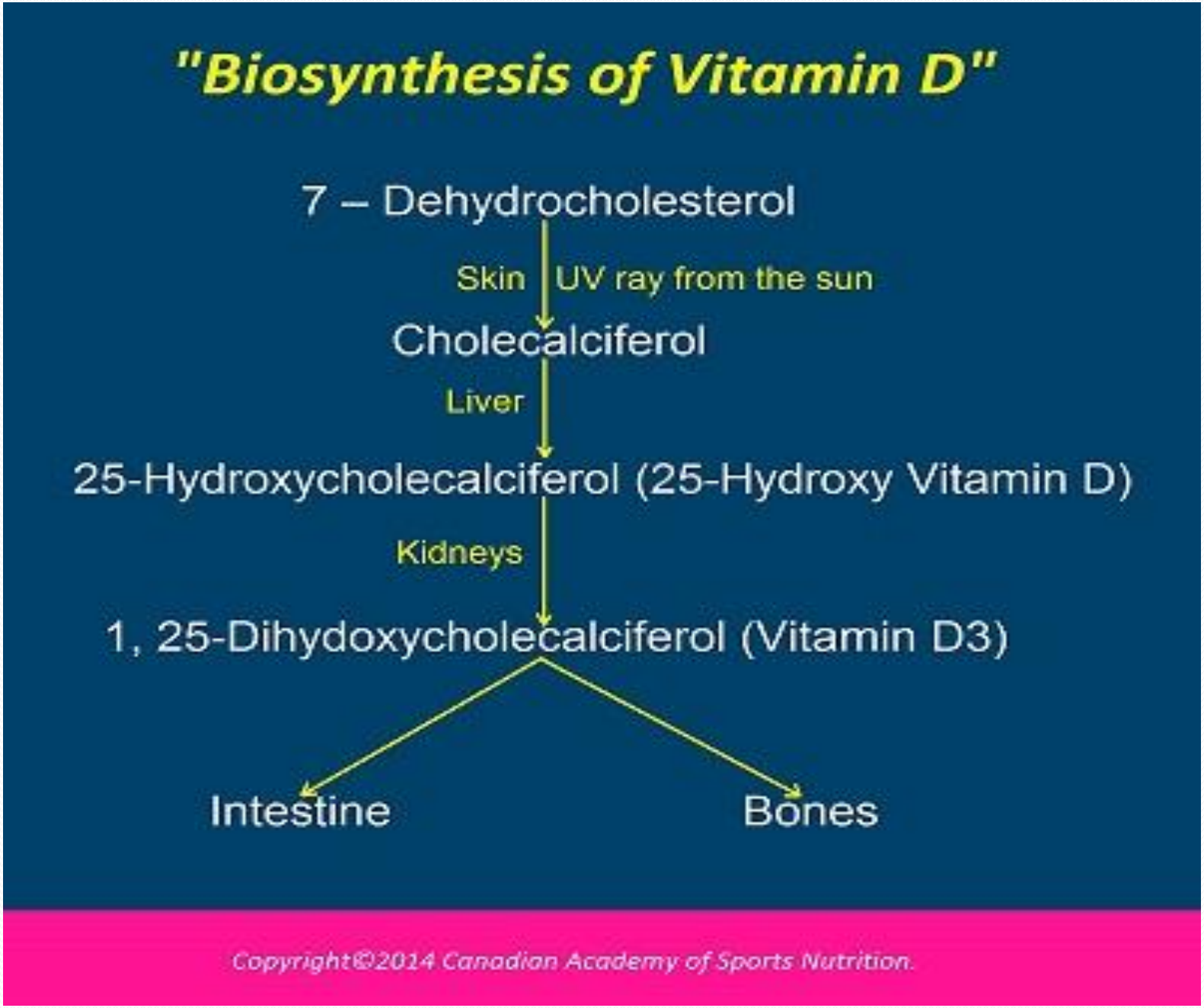
"Biosynthesis of Vitamin D"
7 – Dehydrocholesterol
Skin
UV ray from the sun
Cholecalciferol
Liver
25-Hydroxycholecalciferol (25-Hydroxy Vitamin D)
Kidneys
1, 25-Dihydoxycholecalciferol (Vitamin D3)
Intestine
Bones
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- **Cod liver oil is an excellent source of vitamin D.**

- **Other food sources are fish, egg yolks, liver, and butter. Every 100 grams of catfish and salmon contains about 425 IU and 360 IU vitamin D, respectively.**

- **Vitamin D from animal sources is in the form of vitamin D3, whereas vitamin D from plant sources is vitamin D2. Mushrooms and dark green leafy vegetables are the best sources of vitamin D2.**

Food sources of vitamin D.

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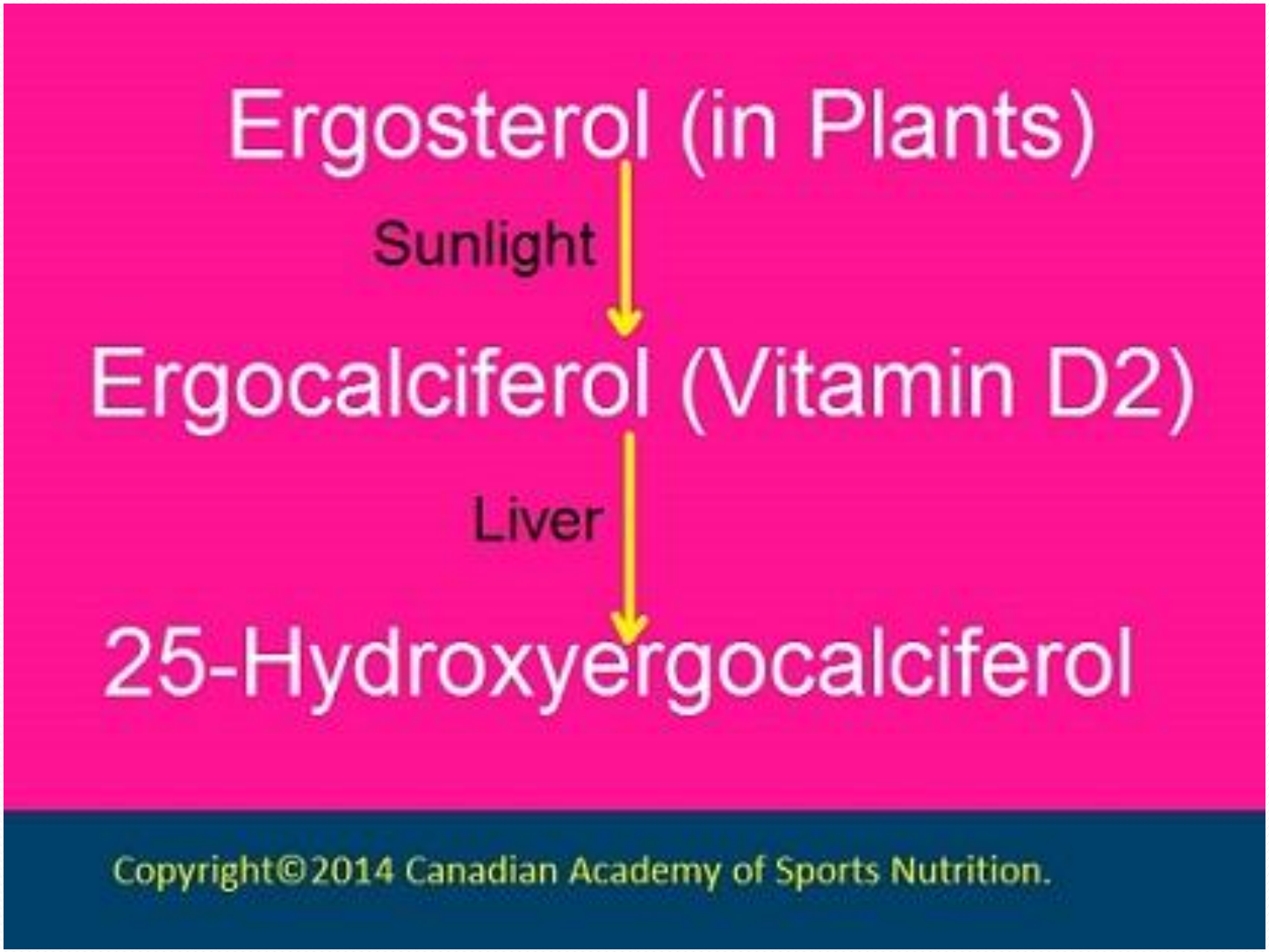
Ergosterol (in Plants)
Sunlight
Ergocalciferol (Vitamin D2)
Liver
25-Hydroxyergocalciferol
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- **Vitamins D3 and D2 have equivalent biologic activity and are activated equally well in humans.**
- **Vitamin D is stored mainly in the liver and small amounts in the spleen, skin, brain, and bones.**
- **The absorption of vitamin D is diminished by mineral oils.**

Benefits of Vitamin D:

- a) Osteoporosis.
- b) Osteomalacia (softening of the bones in adults).
- c) Rickets (softening of the bones in children).
- d) Cancer prevention (especially prostate, breast, and colon cancers).
- e) Tuberculosis.
- f) Psoriasis.
- g) Multiple sclerosis.

- **h) Crohn`s disease.**
- **i) Cystic fibrosis.**
- **j) Burns.**
- **k) Depression.**
- **l) Celiac disease.**
- **m) Hypertension.**
- **n) Diabetes.**
- **o) Insulin resistance.**
- **p) Migraine.**
- **q) Parkinson`s disease.**

Vitamin D Deficiency:

- **The optimal level of vitamin D in the blood for good bone health is more than 20 ng/ml (50 nmol/L).**
- **Signs and symptoms of vitamin D deficiency appear when daily dietary intake declines to below 2 mcg.**
- **Regardless of the cause, the signs and symptoms of vitamin D deficiency are mainly due to decreased calcium absorption.**

- **Mild to moderate vitamin D deficiency has usually no symptoms.**

- **Early manifestations of vitamin D deficiency are muscle soreness, weakness, depressed mood, and generalized bone pain.**

- **Chronic vitamin D deficiency results in low level of calcium in the body, leading to skeletal deformities and softening of the bones (osteomalacia in adults; rickets in children).**

Potential risk factors for vitamin D deficiency are:

- **a) Old age.**
- **b) Lack of sun exposure.**
- **c) Dark skin.**
- **d) Obesity.**
- **e) Malabsorption of fat.**
- **f) Liver disease.**
- **g) Kidney diseases, such as renal failure and nephrotic syndrome.**
- **h) Medications: barbiturates, phenytoin, rifampin, isoniazid, and ketoconazole.**

Dosage and Side Effects:

The RDAs for vitamin D in adults:

- **under 70 years old: 600 IU (15 mcg)/d.**
- **older than 70 years old: 800 IU (20 mcg)/d.**

- **The upper limit intake of vitamin D has been set at 4000 IU a day. Contrary to common beliefs, acute intoxication of vitamin D is rare and usually results from excessive ingestion of vitamin D.**

Vitamin D toxicity causes hypercalcemia (increased blood levels of calcium), which is manifested by:

- **weakness**
- **headaches**
- **nausea, diarrhea, loss of appetite, and dry mouth**
- **confusion**
- **constipation and disorientation**
- **kidney stones**
- **excessive thirst (polydipsia)**
- **excessive urination (polyuria)**

Interactions:

- **a) Aluminium – containing antacids: vitamin D may increase the absorption of aluminum and its toxicity.**

- **b) Calcium – channel blockers: vitamin D may decrease the effectiveness of these medications by increasing the blood levels of calcium.**

- **c) Thiazides: vitamin D may increase the risk of hypercalcemia resulted from these medications.**

- **d) Cimetidine: this medication may lower the effectiveness of vitamin D.**

- **e) Anti – seizure medications (barbiturates and phenytoin): they may increase the metabolism of vitamin D, reducing its effectiveness.**

- **f) Rifampin: it may decrease the effectiveness of vitamin D.**

- **g) Isoniazid: it may impair the activation of vitamin D in the liver.**

- **h) Ketoconazole: it may impair the activation of vitamin D in the kidneys.**

Vitamin K:

- **Being famous as the "blood clotting vitamin", vitamin K is a fat soluble vitamin.**
- **There are two natural forms of vitamin K: K_1 (also known as phylloquinone, phytomenadione, and phytonadione), and K_2 (menaquinone).**
- **Vitamin K_3 (menadione), K_4, and K_5 are synthetic forms of the vitamin.**

- **Vitamin K2 has several subtypes with menaquinone – 4 (MK-4) and menaquinone – 7 (MK-7) being the most studied forms.**

Functions of Vitamin K:

- **a) Vitamin K has a key role in normal blood clotting.**

- **b) It is important for bone metabolism.**

Food Sources and Absorption:

- **Vitamin K1 can be found abundantly in green leafy vegetables, such as kale, dandelion greens, mustard greens, spinach, collard greens, parsley, Swiss chard, turnip greens, broccoli, Brussels sprouts, and vegetable oils.**

- **MK-4 is found in meats, eggs, liver, and dairy products.**

- **MK-7 is made by bacteria during fermentation, and is found in fermented soybeans (natto) and fermented cheese.**

- **The intestinal bacteria can make vitamin K2, not vitamin K1. Moreover, vitamin K1 can be converted to vitamin K2 in the body as well.**

- **Up to 60% of dietary vitamin K is absorbed with the help of fats and bile from the upper part of the small intestine.**
- **Then it is carried to the liver to be used to make clotting factors.**
- **Small amounts of vitamin K are stored in the liver and fatty tissues.**
- **Calcium and vitamin E may reduce the absorption of vitamin K.**

Benefits of Vitamin K:

- a) Warfarin overdose.
- b) Osteoporosis (especially MK-4).
- c) Cystic fibrosis.
- d) Celiac disease.
- e) Crohn`s disease.
- f) Alzheimer's disease.
- g) Morning sickness.
- h) Acute myeloid leukemia (AML) (especially vitamin K2).

- **i) Myelodysplastic syndrome (especially vitamin K2).**
- **j) Lymphoma (prevention only).**
- **k) Cancers, especially liver and prostate (prevention only).**
- **l) Heart disease.**
- **m) Topical application for: scars, bruises, stretch marks, burns, rosacea, and spider veins.**

Vitamin K Deficiency:

- **Deficiency of vitamin K is uncommon.**
- **The symptoms appear when dietary daily intake of vitamin K drops to below 10 mcg.**
- **The main symptoms are bruising and bleeding.**

Predisposing factors for vitamin K deficiency are:

- a) Liver disease.
- b) Malabsorption of fat.
- c) Antibiotic use.
- d) Celiac disease.
- e) Crohn`s disease.
- f) Bulimia.
- g) Vitamin E overdose.
- h) Medications: salicylates, barbiturates, and cefamandole.
- i) Radiation therapy.

Dosage and Side Effects:

- **Men:** 120 mcg per day.
- **Women:** 90 mcg per day.

- Vitamin K1 and K2 are nontoxic and easily stored or eliminated, but the synthetic form (vitamin K3) could build up in the body and cause toxicity.

- Symptoms of toxicity may include hemolytic anemia, jaundice, and allergic reactions.

Interactions:

- **a) Warfarin: vitamin K decreases the effectiveness of this medication.**
- **b) Barbiturates: they may deplete vitamin K from the body, increasing its demand.**
- **c) Aspirin: vitamin K may decrease the blood – thinning effect of aspirin. On the other hand, aspirin decreases blood levels of vitamin K.**

Homework:

- 1) Describe the athletic benefits of vitamin C.
- 2) Describe how the body makes vitamin D when exposed to the sun and the factors affecting it.