CERTIFIED HEALTH & NUTRITION COUNSELOR ONLINE COURSE - SESSION 9:

- **The Fat-Soluble Vitamins: A, D, E, and K**

Has it ever occurred to you how remarkable it is that you can see things? As an infant you were enchanted with the power this gave you. You closed your eyes and the world disappeared. You opened them and made everything come back again. Later you forgot the wonder of this, but the fact remains that your ability to see brings everything into being for you, more so than any of your other senses. Light reaching your eyes puts you in touch with things outside your body, from your friend sitting near you to stars in other galaxies.

Has it ever occurred to you how extraordinary it is that a child grows? From a mere nothing, a speck so tiny that it is invisible to the naked eye, each person develops into a full-size human being with arms and legs, teeth and fingernails, a beating heart and tingling nerves. Years go into the making of an adult human being, with each day bringing changes so gradual they seem undetectable. Only if you are absent during a part of this process do you notice it on your return and remark to a child, "My, how you've grown!"

And when did you last think about your breathing? In, out, in, out, day and night, year after year, you take in the oxygen you need and release it disposing of the used-up carbons whose energy moves you and keeps you alive. The nutrients discussed in this session – vitamins A, D, E, and K – are vital for these and other processes that you make often take for granted.

The Roles of Vitamin A

Vitamin A has the distinction of being the first fat-soluble vitamin to be recognized. It may also be one of the most versatile, because of its role in several important body processes.

Vision

At the place where light hits the retina of the eye, profoundly informative communication occurs between the environment and the person. The eye receives the light and transforms it into signals that travel to the interior of the brain. There a mental picture forms of what the light conveys. For this to happen, the eye must perform a remarkable transformation of light energy into nerve impulses. The transformers are the molecules of pigment (rhodopsin, iodopsin, and others) in the cells of the retina. A portion of each pigment molecule is retinal, a compound the body can synthesize only if vitamin A or its relatives are supplied by the diet.

A mechanical genius could not have designed such a system better. Light itself cannot be conducted through the solid material of the brain, so it is changed into signals transmitted by nerves. But light comes in different colors (wavelengths), which convey needed information. To keep the colors sorted out; the eye uses different light-sensitive cells (cones) to receive them. Blue light is absorbed by one set of cells, green by another, and yellow-red by a third. By day, combinations of these give the full range of color vision. By night, the light entering the eye is of low intensity, and the set of cells (rods) that can receive this light are of one kind only; so by night a person can normally discern only the presence of light but not its color.

The pigment molecules inside the cells absorb the light. Each pigment molecule is composed of a protein called opsin bonded to a molecule of retinal. When a particle of light (a photon) enters the eye, it is absorbed into the retinal molecule, which responds by changing shape (it actually changes color too, becoming bleached). In its altered form retinal cannot remain bonded to opsin and so is released. This disturbs the shape of the opsin molecule.

This shape change disturbs the cell membrane, permitting charged ions to enter and leave the cell. The cell hyperpolarizes (that is, the electrical charge across its membrane changes), and an electrical impulse travels along the cell's length. At the other end of the cell, the impulse is transmitted to a nerve cell, which conveys it deeper into the brain. Thus the message is sent.

Meanwhile, back in the retina and once again in the dark, the changed molecule of retinal is converted back to its original form and rejoined to opsin to regenerate the pigment rhodopsin. Many molecules of retinal are involved in this process. There are about 6 to 7 million cone cells and 100 million rod cells in the retina, and each contains about 30 million molecules of visual pigment. Repeated small losses incurred by visual activity necessitate the constant replenishment of retinal from the blood, which brings a new supply from the body stores. Ultimately, vitamin A and its relatives in food are the sources of all the retinal in the pigments of the eye.

Bright light seen suddenly, when the eyes are dark-adapted, destroys much more retinal than light seen by day, for three reasons. First, the pupil is wide-open at night, to allow as much light as possible to enter the eye. Second a shadowing pigment that protects the rods by day withdraws at night, leaving them exposed. Third, there are many more rods than cones. Hence if a bright light suddenly shines at night through the

wide-open pupil onto the unprotected rods, much of the pigment in them is bleached and momentarily inactivated. More retinal than usual is freed, and more is lost. A moment passes before the pigments regenerate and sight returns. You no doubt remember being "blinded" on occasion by a flashlight shining directly into your eyes. People who must do a lot of night driving, facing headlights from oncoming cars, thus need an increased amount of vitamin A.

The eye is not designed for night driving or, in general, for accommodating itself to bright light at night. The mechanisms of vision evolved over millions of years, before humankind had harnessed electricity and lit up the night with headlights, beacons, and streetlights. In nature, animals in the wilderness have no need to adapt to sudden flashes of bright light at night, because they occur so seldom.

Vitamin A is undeniably an important nutrient, if for no other reason than that it plays a vital role in vision. But only one-thousandth of the vitamin A in the body is in the retina. The vitamin does other things as well.

Retina (RET-in-uh)
The layer of light sensitive cells lining the back of the inside of the eye; consists of rods and cones.

Pigment
A molecule capable of absorbing certain wavelengths of light, so that it reflects only those that we receive as a certain color.

Rhodopsin (ro-DOP-sin)
The light-sensitive pigment of the rods in the retina.

Iodopsin (eye-o-DOP-sin)
The light-sensitive pigment of the cones in the retina. Both rhodopsin and iodopsin contain retinal; the proteins are different.

Retinal (RET-in-al)
The aldehyde form of vitamin A, active in the eye.

Cones
The cells of the retina that respond to bright light and are responsible for color vision.

Rods
The cells of the retina that respond to dim light and convey black-and-white vision.

Opsin (OP-sin)
The protein portion of the visual pigment molecule.

Photon (FOE-ton)
A particle of light energy. Depending on its wavelength, a photon conveys different colors of light.

Maintenance of Linings
Fortunately for you, your mucosa are all intact. You may not properly appreciate what these membranes do for you, but consider how important it is that each of these surfaces should be smooth; the linings of the mouth, stomach, and intestines; the linings of the lungs and the passages leading to them; the linings of the urinary bladder and urethra; the linings of the uterus and vagina; the linings of the eyelids and sinus passageways. The cells of all these surfaces – epithelial cells – secrete a smooth and slippery substance (mucus) that coats and protects them from invasive microorganisms and other harmful particles. The mucous lining of the stomach also shields its cells from digestion by the gastric juices. In the upper part of the lungs, these cells possess little whiplike hairs (cilia), which continuously sweep the coating of mucus up and out, so that any foreign particles that chance to get in are carried away by the flow. (When you clear your throat and swallow, you are excreting this waste by way of your digestive tract.) In the vagina, similar cells sweep the mucus down and out. During an infection in any of these location, these surface cells secrete more mucus and become more active, so that a noticeable discharge occurs; when you cough it up, blow your nose, or wash it away, you help to rid your body of the infective agent.

Vitamin A plays a role in maintaining the integrity of the mucous membranes. When vitamin A is not present, the cells cannot produce the carbohydrate normally found in mucus (they produce a protein called keratin instead). Within the body, the mucous membranes line an area larger than a quarter of a football field; so this function of vitamin A accounts for most of the body's vitamin A need. As you might predict, greater losses of vitamin A occur during infection than under normal conditions.

Vitamin A is also essential for healthy skin, another one or two square meters of body surface. Thus all surfaces, both inside and out, are maintained with the help of vitamin A. It has still another role to play during growth.

Mucosa (myoo-COH-suh)
The membranes composed of cells that line the surfaces of body tissues.

Urethra (you-REE-thruh)
The tube through which urine from the bladder passes out of the body. The cells on the surface are known as epithelial (ip-I-THEE-lee-ul) cells.

Mucus (adjective mucous)
A substance secreted by the epithelial cells of the mucosa; muco-polysaccharide.

Keratin (KERR-uh-tin)
A water-insoluble protein; the normal protein of hair and nails. Keratin may be produced under abnormal conditions by cells that normally produce mucus.

Bone Growth
"Growth is when everything gets bigger all together" is a child's definition. Certainly that is how it looks from the outside. Actually, however, the organs and body parts all grow at different rates with different timings. The brain, for instance, reaches 90 percent of its adult size by the time a child is two, but the testes are still baby-size when a male enters his teens. Furthermore, body parts do not just "get bigger"; bones are a case in point.

To enlarge the interior of a brick fireplace, the first thing you have to do is remove some of the old bricks. Similarly, to make a bone larger requires remodeling. To convert a small bone into a large bone, the bone-remodeling cells must "undo" some parts of the small bone as they go.

Vitamin A is required for the undoing. Some of the cells involved in bone formation are packed with sacs of degradative enzymes that can take apart the structures of bone. With the help of vitamin A in a sensitively regulated process, these cells release their enzymes, which eat away at selected sites in the bone, removing the parts that are not needed, as the bone grows longer. (A similar process occurs when a tadpole loses its tail and becomes a frog. As you know, the tail doesn't simply fall off; rather it is reabsorbed, "growing" shorter and shorter until it disappears. As a fetus you also had a tail and lost it, a process that depended on vitamin A.)

Vitamin A's roles in promoting good night vision, the health of mucous membranes and skin, and the growth of bone are well known. Others include parts it plays in:

- Reproduction.
- Maintaining the stability of cell membranes.
- Helping the adrenal glands to synthesize a hormone (corticosterone).
- Helping to ensure a normal output of the hormone thyroxin from the thyroid gland.
- Helping to maintain nerve cell sheaths.
- Assisting in immune reactions.
- Helping to manufacture red blood cells.
- Many others.

Vitamin A research still in progress is yielding many new details of how this nutrient functions in the body. Three different forms of vitamin A are active in the body; retinol (an alcohol), retinal (an aldehyde), and retinoic acid. Each has its own special binding proteins in the cells in which it works. There is also a special zinc-containing binding protein to pick up vitamin A from the liver, where it is stored, and to carry it in the blood. Cells that will receive and use vitamin A also have special receptors for it, as if it were fragile, and had to be passed carefully from hand to hand without being dropped.

Each form of vitamin A triggers specific reactions in cells that are set up to respond to it. Retinol and retinoic acid, for example, act like hormones; they travel into cells, cross the nuclear membrane, and interact with DNA, causing certain genes to express their coded instructions and make specific proteins.

Lysosomes (LYE-so-zomes)
Sacs of degradative enzymes.
Lyso = to break
Soma = body

Vitamin A Deficiency
Either zinc deficiency or vitamin A deficiency can cause the symptoms of vitamin A deficiency, because zinc is part of the protein that mobilizes vitamin A from the liver. Zinc is also part of the enzyme that converts retinol to retinal in the eye. If zinc status is adequate, vitamin A deficiency depends on the adequacy of vitamin A stores.

Up to a year's supply of vitamin A may be stored in the body, 90 percent of it in the liver. If you stop eating good food sources of the vitamin, deficiency symptoms will not begin to appear until after your stores are depleted. Then, however, the consequences are profound and severe.

Area Affected	Main Effect	Technical Name for Symptoms
Eye		
Retina	Night blindness.	
Membranes	Failure to secrete mucopolysaccharide causes changes in epithelial tissue and hyperkeratinization.	
General	Drying (mildest form). Irreversible drying and degeneration of the cornea, causing blindness (most severe).	Xerosis Keratomalacia
Skin	Hair follicles plug with keratin, forming white lumps.	Hyperkeratosis
GI tract	Changes in lining; diarrhea.	
Respiratory tract	Changes in lining; infections.	
Urogenital tract	Changes in lining favor calcium deposition, resulting in kidney stones and bladder disorders. Infections of bladder and kidney. Infections of vagina.	
Bones	Bone growth ceases; shapes of bones change.	
Teeth	Enamel-forming cells malfunction; teeth develop cracks and tend to decay; dentin-forming cells atrophy.	
Nervous System	Brain and spinal cord grow too fast for stunted skull and spine; injury to brain and nerves cause paralysis.	
Immune System	Depression of immune reactions.	
Blood	Anemia, often masked by dehydration.	

Enamel
The hard mineral coating on the outside of the tooth composed of calcium compounds embedded in a fine network of keratin fibers.

Dentin
The softer material underlying the enamel of the tooth, composed of calcium compounds embedded in a network of collagen fibers.

Impaired Night Vision
If the blood bathing the cells of the retina does not supply sufficient retinal to rapidly regenerate visual pigments bleached by light, then a flash of bright light at night will be followed by a prolonged spell of night blindness. This is one of the first detectable signs of vitamin A deficiency. Because night blindness is easy to test, it aids in diagnosis of the condition. (Of course it is only a symptom, and may indicate some condition other than vitamin A deficiency.)

Night Blindness
Slow recovery of vision after flashes of light at night; an early symptom of vitamin A deficiency.

Roughened Surfaces
Instead of staying smooth and well rounded and producing normal mucus, the epithelial cells flatten and harden with vitamin A deficiency, losing their protective mucous coating and filling with keratin instead. In the eye this process leads to drying and hardening of the cornea, which may progress to permanent blindness. In the mouth, drying and hardening of the salivary glands makes them susceptible to infection; failure of mucous secretion in the mouth may lead to loss of appetite. Mucous secretion in the stomach and intestines is reduced, hindering normal digestion and absorption of nutrients, causing diarrhea, and so indirectly worsening the deficiency. Infections of the respiratory tract, the urinary tract, and the vagina are also made more likely by vitamin A deficiency. On the outer body surface, the cells also harden and flatten, making the skin dry, rough, scaly, and hard. Around each hair follicle an accumulation of hard material makes a lump.

Keratinization
The epithelial cells fill with keratin in a process known as keratinization. The progression of this condition to the extreme is hyperkeratosis.
Hyper = too much

Xerophthalmia (zer-off-THAL-mee-uh)
IN the eye, the symptoms of vitamin A deficiency are collectively known as xerophthalmia.
Xero = dry
Ophthalm = eye

Keratomalacia
An early sign is cerosis (drying of the cornea); the latest and most severe stage is keratomalacia (total blindness).
Malacia = softening, weakening

Cornea (KOR-nee-uh)
The transparent membrane covering the outside of the front of the eye.

Follicular Hyperkeratosis
The accumulation of this hard material, keratin, around each hair follicle is follicular hyperkeratosis.

Follicle (FOLL-I-cul)
A group of cells in the skin from which a hair grows.

Abnormal Growth
Because growth and development of the brain and eyes are most rapid in the unborn and in the very young, the effects of vitamin A deficiency are most severe at and around the time of birth. For example, in a child of one or two, stunted growth of the skull may cause crowding of the brain (which is growing rapidly at that age) mimicking the signs of a brain tumor. Tooth growth may also be abnormal. Crooked teeth in a child may reflect a vitamin A deficiency suffered by its mother while its jawbones were forming during her pregnancy. Damage to the eyes is also most pronounced in the young, with blindness the result in thousands of cases of vitamin A deficiency throughout the world. Among nutrition problems afflicting the young of the world, vitamin A deficiency is second in extent only to protein-kcalorie malnutrition.

In the United States as well, the problem of vitamin A deficiency is all too common. The Ten-State Survey revealed that a third of the children under six who were examined had less than the recommended vitamin A intakes. Spanish-Americans and blacks exhibited the most pronounced evidence of deficiency. In the more recent Nation-wide Food Consumption Survey, similarly, about a third of the population surveyed has intakes below two-thirds of the RDA. Some subgroups of the Canadian population are also deficient, notably Canadian and Eskimo women, especially during their pregnancies.

A major source of vitamin A is vegetables, and a probable reason for widespread deficits of vitamin A in children is their refusal to eat vegetables. A section of Session 14 emphasizes the importance of encouraging children to like vegetables and suggests practical ways to ease their acceptance.

Retinol-Binding Protein (RBP)
The protein that carries retinol in the blood. Measurement of RBP is a sensitive indicator of vitamin A status.

Caution:
Naiveté on the part of the well intentioned can cause more harm than good, a result often observed when attempts are made to remedy the problem of malnutrition in the underdeveloped countries. Awareness of the way nutrients function in the body and of their interdependence must precede efforts to correct malnutrition problems, as the case of vitamin A illustrates.

Vitamin A depends on proteins, notably the retinol-binding protein, and on the mineral zinc for its functions and transport in the body. In protein-kcalorie malnutrition, when vitamin A stores are also low, there is a balance of a kind. But when protein is given without supplemental vitamin A, protein carriers that are synthesized in response deplete the liver of the last available stores of vitamin A, thus precipitating a deficiency. Administration of protein has been observed to cause an epidemic of blindness, and when skim milk was offered by UNICEF to children in Brazil. Vitamin A capsules were supplied with the milk, but the parents often ate the capsules or sold them, giving only the milk to the children.

The mineral zinc is also needed, both to free vitamin A from liver storage for transport, and to help an enzyme in the retina to convert retinol to retinal. An apparent vitamin A deficiency may reflect an underlying zinc deficiency that must first be corrected. These examples illustrate the point that whenever nutrition help is given, knowledge must accompany that help.

Vitamin A Toxicity

Vitamin A toxicity occurs when all the binding proteins for vitamin A are swamped and free vitamin A attacks the cells. Such effects are not likely if you depend on foods for your nutrients, but if you take pills or supplements containing the vitamin, toxicity is a real possibility. Overdoses have serious effects on the same body systems that exhibit symptoms in vitamin A deficiency. Children are most likely to be affected, because they need less, they are smaller and more sensitive to overdoses, and it is easy to give them too much in pill form or in other concentrates. The availability of breakfast cereals, instant meals, fortified milk, and chewable candy-like vitamins, each containing 100 percent of the recommended daily intake of vitamin A, makes it possible for a well-meaning parent to provide several times the daily allowance of the vitamin to a child in a few hours. Serious toxicity is seen in small infants when they are given more than ten times the recommended amount every day for weeks at a time. A child herself may also overdose. Liking vitamin pills and thinking of them as candy, she may eat several.

There is a wide range of vitamin A intakes in which neither deficiency nor toxicity symptoms appear. Recommended intakes in both the United States and Canada are set at about double the minimum necessary to prevent deficiency. Doubtless, many people need not consume amounts this high. The exact upper limit of safety can'' be determined exactly, because people'' tolerances to overdoses vary. Probably the amount of added vitamin A that anyone can tolerate depends on the length of time he takes it and on how much of the vitamin has already accumulated in his body stores before he begins the overdose. Alcohol use makes vitamin A toxicity more likely.

In one case, toxic effects were reported in a person who took daily doses 10 times the recommended intake for only one month; but in others it may take 40 times the recommended intake for several months to elicit symptoms of toxicity. The National Nutrition Consortium advises that adults should avoid intakes of more than 5 to 10 times the recommended amounts to ensure safety. In general, it makes sense to get your vitamin A from natural, mostly plant, sources.

It is possible to suffer toxicity symptoms only when excess amounts of the preformed vitamin from animal foods or supplements are taken. The precursor, beta-carotene, which is available from plant foods, is not converted to vitamin A rapidly enough in the body to cause toxicity but is instead, stored in fat depots as carotene. Being yellow in color, it may accumulate under the skin to such an extent that the overdoser actually turns yellow.

Preformed Vitamin A

Vitamin A in its active form.

Precursor

A compound that can be converted into active vitamin A.

Beta-Carotene

A vitamin A precursor found in plants.

Osteoclasts
The cells that destroy bone during its growth. Those that build bone are osteoblasts.
Osteo = bone
Clast = break
Blast = build

Jaundice (JAWN-diss)
Yellowing of the skin; a symptom of liver disease, in which bile and related pigments spill into the bloodstream.

Disease	Area Affected	Main Effects
Hypervitaminosis A	Bones	Increased activity of osteoclasts causes decalcification, joint pain, fragility, stunted growth, thickening of long bones; pressure increases inside skull, mimicking brain tumor.
	Blood	Red blood cells lose hemoglobin and potassium; menstruation ceases; clotting time slows; bleeding is easily induced.
	Immune System	Stimulation of immune reactions.
	Nervous System	Loss of appetite, irritability, fatigue, restlessness, headache, nausea, vomiting, muscle weakness, interference with thyroxin.
	GI tract	Nausea, vomiting, abdominal pain, diarrhea, weight loss.
	Skin	Dryness, itching, peeling, rashes, dry scaling lips, loss of hair, brittle nails.
	Liver	Jaundice, enlargement, massive accumulation of fat and vitamin A.
	Spleen	Enlargement
Hypercarotenemia	Skin	Yellow color

Caution:
Adolescents should be warned that massive doses of vitamin A taken internally will have no beneficial effect on acne but may cause the miseries in the table above. The belief that vitamin A cures acne arises from the knowledge that it is needed for the health of the skin. As with all nutrients, however, the vitamin promotes health when enough is supplied; more than enough has no further beneficial effects.

However, a relative of vitamin A, vitamin A acid, does sometimes help relieve the symptoms of acne when applied directly to the skin surface. The acid helps loosen the plugs that may accumulate in pores, allowing the skin to cleanse itself naturally. Such a treatment should of course be undertaken only on a doctor's recommendation.

Some of vitamin A's relatives may have a preventive role with respect to cancer. Retinol itself is not one of these, but this doesn't stop gullible people from taking massive doses of vitamin A in the hope of preventing cancer. It is expected that more cases of vitamin A toxicity will be reported in the years to come.

Vitamin A in Foods
Vitamin A terminology is in a period of transition. Vitamin A occurs in a number of different forms, and these convert to the active forms in the body with different efficiencies. In animal foods, vitamin A occurs as retinol-like compounds, which convert, to retinol and its relatives in the body with high efficiency. In plant foods, no biologically active, preformed vitamin A occurs, but plant pigments known as carotenoids can be converted to vitamin A in the body with a lower efficiency. The most active of the carotenoids is beta-carotene. When beta-carotene is split, it yields two molecules, which are converted to retinol.

The active form of vitamin A used for reference is retinol, and the recommended amounts of vitamin A are stated in terms of retinol equivalents (RE). As of 1980, both US and Canadian authorities were using this terminology and were recommending 1,000 RE per day for adult men and 800 RE for women.

Retinol
One of the active forms of vitamin A, similar to retinal. Retinol is an alcohol; retinal is an aldehyde.

RE (retinol equivalent)
A measure of vitamin A activity; the amount of retinol that a vitamin A compound will yield after conversion in the body.

The amounts of vitamin A found in foods, however, are often still reported using an older system of measurement, international units (IU), which are based on some assumptions now known to be not completely

correct. In the future, tables of food composition will report the vitamin A activity in foods in RE. Until they do, you will have to do some computing if you wish to use a table of food values expressed in IU to estimate your vitamin A intake. You will have to remember both terms, RE and IU, and the fact that 1 RE is roughly equivalent to 3.33 IU of vitamin A from animal tissues or 10 IU from plant tissues.

IU (international unit)

A measure of vitamin activity, determined by such biological methods as feeding a given compound to vitamin-deprived animals and measuring the number of units of growth produced. This system was used to measure vitamin A before chemical analysis of the vitamin A compounds and their precursors were possible.

1 RE = 3.33 IU from animal foods or 10 IU from plant foods.
(ON the average, 1 RE = about 5 IU)

The major vitamin A contributors among foods are almost all brightly colored – green, yellow, orange, and red. Any plant food with significant vitamin A activity must have some color, since the vitamin and its plant precursor carotene are colored compounds themselves (vitamin A is a pale yellow; carotene is a rich, deep yellow, almost orange). The dark-green, leafy vegetables contain abundant amounts of the green pigment chlorophyll, which masks the carotene in them. A skilled hostess or restaurateur knows that an attractive meal includes foods of different colors that complement one another, but may not be aware that such a meal probably ensures a good supply of vitamin A as well.

On the other hand, food with a yellow or orange color does not invariably contain vitamin A or carotene. Many of the compounds that give foods their colors, such as the yellow and red xanthophylls, are unrelated to vitamin A and have no nutritional value.

On the third hand, if a plant food is white or colorless, you can be sure it contains little or no vitamin A.

About half of the vitamins A activity in foods consumed in the United States comes from fruits and vegetables, and half of this comes from the dark leafy greens (not iceberg lettuce or green beans) and the rich yellow or deep orange vegetables, such as squash, carrots, and sweet potatoes (not corn). The other half comes from milk, cheese, butter, and other dairy products; eggs; and meats. Since Vitamin A is fat-soluble, it is lost when milk is skimmed. Skim milk is often fortified with 2,000 IU (or about 40 percent of the intake recommended for men) of vitamin A per quart to compensate. The butter substitute, margarine, is usually fortified with 15,000 IU (4,500 RE) per pound. Milks and margarines may also be fortified with vitamin D; read the label to find out.

The safest and easiest way to meet your vitamin A needs, then, is to consume generous servings of a variety of dark-green and deep-orange vegetables and fruits. A one-cup serving of carrots, sweet potatoes, or dark greens such as spinach would provide such liberal amounts of carotenoids that, even allowing for inefficiency absorption and conversion, intake would be sufficient. Alternatively, a diet including more or larger servings of medium sources would ensure an ample intake. No doubt you can find food sources of the vitamin that appeal to you and can easily calculate the minimum amounts you should eat to meet your needs.

The fruit and vegetable family is, of course, one of the four food groups. Its importance for meeting vitamin A needs is reflected in the recommendation that adults have at least four servings a day, including “at least one dark-green or deep-orange” item every other day.

Fast foods are notable for the lack of vitamin A. Anyone who dines frequently on hamburgers, French fries, shakes, and the like is advised to emphasize vegetables heavily – and not just salads – at other meals.

One animal food notable for its vitamin A content is liver. A moment’s reflection should reveal the reason for this. Vitamin A not needed for immediate use is stored in the liver. Some nutritionists recommend that people include a serving of liver in their diets every week or two, partly for this reason.

People sometimes wonder if vitamin A toxicity can result from using liver too frequently. This problem has never been observed except in the arctic, where explorers who have eaten large quantities of polar bear liver have become ill with symptoms suggesting vitamin A toxicity. Liver is an extremely nutritious food, and its periodic use is highly recommended.

Chlorophyll

Chlorophyll is the green pigment of plants, which absorbs photons and transfers their energy to other molecules, initiating photosynthesis.

Photosynthesis
Photosynthesis is the synthesis of carbohydrates by plants from carbon dioxide and water, using the sun's energy.

Folacin
Recall that Folacin, too, is found most abundantly in dark-green vegetables.

The Roles of Vitamin D
Vitamin A helps to remodel bones; vitamin D helps to mineralize them. It is a member of a large and cooperative bone-making and maintenance team made up of nutrients and other compounds, including vitamin C; the hormones parathormone and calcitonin; the protein collagen, which underlies and supports bone; and the minerals calcium, phosphorus, magnesium, fluoride, and others, which compose the inorganic part of bone.

Blood calcium is very active metabolically. It has been estimated that about a fourth of the calcium in the blood is exchanged with bone calcium every minute. The special function of vitamin D is to help make calcium and phosphorus available in the blood that bathes the bones, to be deposited as the bones harden (mineralize).

Vitamin D raises blood concentrations of these minerals in three ways: by stimulating their absorption from the GI tract; by helping to withdraw calcium from bones into the blood; and by stimulating calcium retention by the kidneys. The star of the show is calcium itself; vitamin D is a director.

A description of how calcium moves from food into the blood and into and out of bone is reserved for Session 10, where a closer view of the whole system is provided. The object here is to make you aware of the importance of vitamin D, the risks of deficiency and toxicity, and the ways in which the vitamin can be obtained.

Vitamin D is different from all the other nutrients in that the body can synthesize it with the help of sunlight. Therefore, in a sense, vitamin D is not an essential nutrient. Given enough sun, you need consume not vitamin D at all in the foods you eat. Rather, it is like a hormone – a compound manufactured by one organ of the body that has effects on another. And like certain hormones, it can actually enter a cell, cross the nuclear membrane, attach to specific receptors on the DNA or its protein wrapping, and promote the synthesis of specific proteins.

The liver manufactures a vitamin D precursor, which is released into the blood and circulates to the skin. When ultraviolet rays from the sun hit this compound, it is converted to previtamin D_3, which works its way back into the interior of the body. Slowly, then, over the next 36 hours, the previtamin is converted with the help of the body's heat to vitamin D_3. Two more steps occur before the vitamin becomes fully active. First, the liver adds an OH group, and then the kidney adds another OH group at specific locations to produce the active vitamin. (This is why diseases affecting either the liver or the kidney exhibit symptoms of bone deterioration.) Active vitamin D then promotes the making of several proteins that help with calcium transport into the intestinal cell, and assists them in their action. It also has specific attachment sites in the brain, parathyroid glands, bone, and kidney, where it is thought to regulate the production of proteins that manage calcium homeostasis. In the pancreas, it affects insulin secretion.

There are two ways to meet your vitamin D needs. You can synthesize it yourself with the help of sunlight, or you can eat foods containing the preformed vitamin – chiefly animal foods.

7-dehydrocholesterol
The precursor of vitamin D made in the liver is 7-dehydrocholesterol, which is made from cholesterol. This is one of the body's many "good" uses for cholesterol. The technical name for the final product, active vitamin D, is 1,25-dihydroxycholecalciferol – dihydroxy vitamin D for short.

Mineralization (Calcification)
Mineralization is the process in which calcium, phosphorus, and other minerals crystallize on the collagen matrix of a growing bone, hardening the bone.

Vitamin D Deficiency and Toxicity
Both inadequate and excessive vitamin D intakes take their toll in the United States and Canada, despite the fact that the vitamin has been known for decades to be essential for growth and toxic in excess. The Ten-State Survey conducted in the late 1960s revealed that nearly 4 percent of the children under six who were examined showed evidence of vitamin D deficiency, with several cases of overt rickets. (The more recent Nationwide Food Consumption Survey did not assess vitamin D.) The National Nutrition Survey in Canada revealed low intakes of vitamin D in women and children but no overt cases of rickets – although they may exist in persons not tested. Worldwide, rickets still afflicts large numbers of children.

The symptoms of an inadequate intake of vitamin D are those of calcium deficiency. The bones fail to calcify normally and may be so weak that they become bent when they have to support the body's weight. A child with rickets who is old enough to walk characteristically develops bowed legs, often the most obvious sign of the disease.

Adult rickets, or osteomalacia, occurs most often in women who have low calcium intakes and little exposure to sun, and who go through repeated pregnancies and periods of lactation. The bones of the legs may soften to such an extent that a girl who grows up tall and straight becomes bent, bowlegged, and stooped by the end of her second or third pregnancy.

Vitamin D deficiency depresses calcium absorption and results in low blood calcium levels and abnormal mineralization of bone. An excess of the vitamin does the opposite. It increases calcium absorption, causing abnormally high concentrations of the mineral in the blood, and promotes return of bone calcium into the blood as well. The excess calcium in the blood tends to precipitate in the soft tissue, forming stones. This is especially likely to happen in the kidneys, which concentrate calcium in the effort to excrete it. Calcification or hardening of the blood vessels may also occur and is especially dangerous in the major arteries of the heart and lungs, where it can cause death.

The range of safe intakes of vitamin D is narrower than that of vitamin A. Half the recommended intake is too little, but over a few times the recommended intake may be too much. Intakes of 100 micrograms per day cause high blood calcium levels in infants, and some infants are sensitive to lower doses than this. Intakes of 250 micrograms per day for four months or 5,000 micrograms per day for two weeks cause toxicity in children and, if further prolonged, in adults. The amounts of vitamin D found in foods available in the United States and Canada are well within these limits, but pills containing the vitamin in concentrated form should definitely be kept out of the reach of children.

Rickets
Rickets is the vitamin D-deficiency disease in children. A rare type of rickets, not caused by vitamin D deficiency, is known as vitamin D refractory rickets.

Osteomalacia (os-tee-o-mal-AY-shuh)
This is the vitamin D deficiency disease in adults. Osteomalacia may also occur in calcium deficiency.
Osteo = bone
Mal = bad (soft)

Pigeon Breast
Bowing of the ribs causes the symptom known as pigeon breast.

Rachitic (ra-KIT-ik) Rosary
The beads that form on the ribs resemble rosary beads; thus this symptom is known as rachitic rosary (the rosary of rickets)

Fontanel
The fontanel is the open space in the top of a baby's skull before the skull bones have grown together.

Thorax
The part of the body between the neck and the abdomen.

Alkaline Phosphatase
An enzyme in the blood.

Vitamin D Conversion
Vitamin D activity was previously expressed in international units (IU) but as of 1980 is expressed in micrograms of cholecalciferol. To convert, use the factor:
100 IU = 2.5 ug
400 IU = 10 ug

Vitamin D RDA
The RDA for vitamin D for adults over 22 is 5-ug cholecalciferol (200 IU). Canadian Dietary Standard: 2.5-ug cholecalciferol.

Vitamin D Deficiency

Rickets	Bones	Faulty calcification, resulting in misshapen bones (bowing of legs) and retarded growth
		Enlargement of ends of long bones (knees, wrists)
		Deformities of ribs (bowed, with beads or knobs)
		Delayed closing of fontanel, resulting in rapid enlargement of head
	Blood	Decreased calcium and/or phosphorus
	Teeth	Slow eruption; teeth not well-formed; tendency to decay
	Muscles	Lax muscles resulting in protrusion of abdomen
	Excretory system	Increased calcium in stools, decreased calcium in urine
	Glandular system	Abnormally high secretion of parathyroid hormone
Osteomalacia	Bones	Softening effect; deformities of limbs, spine, thorax, and pelvis; demineralization; pain in pelvis, lower back and legs; bone fractures
	Blood	Decreased calcium and/or phosphorus, increased alkaline phosphatase
	Muscles	Involuntary twitching, muscle spasms
Hypervitaminosis D	Bones	Increased calcium withdrawal
	Blood	Increased calcium and phosphorus concentration
	Nervous system	Loss of appetite, headache, excessive thirst, irritability
	Excretory system	Increased excretion of calcium in urine; kidney stones; irreversible renal damage
	Tissues	Calcification of soft tissues (blood vessels, kidneys, lungs), death

Sun Exposure

Exposure to sun should be reasonable. Excessive exposure may cause skin cancer.

Vitamin D from Sun and Foods

In rapidly growing children, an intake of close to 10 micrograms (400 IU) of vitamin D a day is recommended; mature adults need half as much. Only a few animal foods supply significant amounts of the vitamin, notably eggs, liver, and some fish, and even these vary greatly, depending on the animal's exposure to sun

and on its consumption of the vitamin in its foods. Neither cow's milk nor human breast milk supplies enough vitamin D to reliably meet human needs; hence cow's milk is fortified, and infants must be given either fortified formula or supplements. The fortification of milk with 400 IU per quart (360 IU per liter in Canada) is the best guarantee that children will meet their vitamin D needs and underscores the importance of milk in children's diets.

Significant amounts of vitamin D can be made with the help of sunlight. It is generally agreed that most adults, especially in the sunnier regions, need not make special efforts to obtain vitamin D in food. If children are taken out in the sun for a while each day at noon, they will receive a protective dose of vitamin D. However, people who are not outdoors much or who live in northern or predominantly cloudy or smoggy areas are advised to make sure their milk is fortified with vitamin D, to drink at least 2 cups a day, and to make frequent use of eggs and periodic use of liver in menu planning.

Darker-skinned people make less vitamin D on limited exposure to the sun. By 3 hours of exposure, however, vitamin D synthesis is strongly pigmented skin arrives at the same plateau as that at 30 minutes in fair skin. The difference may account for the fact that darker-skinned people in northern, smoggy cities are more prone to rickets. The experiments revealing these findings also suggest that overexposure to sun cannot cause vitamin D toxicity, because synthesis of vitamin D is limited to a fixed maximum on each exposure.

The Roles of Vitamin E

Vitamin E is an antioxidant like vitamin C, but fat-soluble. If there is plenty of vitamin E in the membranes of cells exposed to an oxidant, chances are this vitamin will take the brunt of the oxidative attack, protecting the lipids and other vulnerable components of the membranes. Vitamin E is especially effective in preventing the oxidation of the polyunsaturated fatty acids (PUFA), but it protects all other lipids (for example, vitamin A) as well.

One of the most important places in the body in which vitamin E exerts its antioxidant effect is in the lungs, where the exposure of cells to oxygen is maximal. At least two kinds of cells benefit from the vitamin's protection: the red blood cells that pass through the lungs, and the cells of the lung tissue itself. The vitamin acts to:

- Detoxify oxidizing radicals that arise during normal metabolism.
- Stabilize cell membranes.
- Regulate oxidation reactions.
- Protect vitamin A and polyunsaturated fatty acids from oxidation.

Lungs are sometimes also exposed to air pollutants that are strong oxidizing agents, such as nitrogen dioxide or ozone. Ozone causes peroxidation of the cell membrane lipids. A product of this peroxidation can be measured in expired air, and some people produce more of the product when exercising in air contaminated with ozone. Vitamin E supplements restore the normal level, suggesting that vitamin E acts as a scavenger of free radicals.

Follow-up studies using animals have investigated the possibility that peroxidation can occur not only in lungs, but also in liver and adrenal tissue. In these locations, too, vitamin E seems to exert a protective effect.

The role of vitamin E in protecting red blood cell membranes has led researchers to ask whether it might protect white blood cells as well, and perhaps participate in the body's immune defenses. In deed, deficiency of vitamin E suppresses the immune system and supplementation stimulates it in several species of animals. The effect may be direct, by way of the vitamin's action in the membranes of the white blood cells when they interact with antigens, or may be indirect by way of PUFA and prostaglandins.

Oxidant

A compound (such as oxygen itself) that oxidizes other compounds.

Radicals

Unstable molecular intermediates that arise during oxidation reactions. They are highly reactive and readily oxidize other molecules with which they come in contact.

Peroxidation

Production of unstable molecules containing more than the usual amount of oxygen. Hydrogen peroxide, H_20_2, for example, may be produced from water, H_20.

Scavenger

A clean-up agent; for example, a garbage collector or an animal that feeds on refuse and waste. Some similar roles are played by an enzyme containing the trace element selenium. See Session 11.

Vitamin E Deficiency

Studies related to vitamin E's effects have seldom revealed any carryover of animal findings to humans. In fact, of 12 possible diseases associated with vitamin E deficiency in animals, only one has been demonstrated in human beings. When the blood concentration of vitamin E falls below a certain critical level, the red blood cells tend to break open and spill their contents, probably due to oxidation of the polyunsaturated fatty acids (PUFA) in their membranes.

Except to correct erythrocyte hemolysis, no need for vitamin E supplements has been demonstrated in normal human beings under normal environmental conditions. However, abnormal environmental conditions such as air pollution may increase human vitamin E needs. Also, a great many diseases can affect people's vitamin E needs. Among individuals who benefit from vitamin E supplementation are:

- Premature infants, because the transfer of vitamin E across the placenta becomes maximal only right before full-term delivery.
- Infants, children, or adults who can't absorb fats and oils because of liver, pancreas, or gallbladder disease; GI surgery; or inherited diseases.
- Individuals with certain blood disorders.

Two other conditions seen in humans appear to be remediable by large doses of vitamin E. One, a harmless breast disease, is characterized by painful lumps in the breasts, which can be relieved with vitamin E therapy. The other, a leg problem, causes pain on walking and cramps in the calves at night, and also responds to vitamin E therapy.

Vitamin E does not prevent or cure muscular dystrophy in humans. Hereditary muscular dystrophy is a disease afflicting children, who usually die at an early age when their respiratory muscles deteriorate. Nutritional muscular dystrophy, however, is the muscular weakness produced in many animals by a deficiency of vitamin E. This deficiency leads to atrophy of the muscles; it can be cured by reintroducing vitamin E into the diet.

Erythrocyte (eh-REETH-ro-cite)

The breaking open of red blood cells.
Red blood cell.
Erythro = red
Cyte = cell

Hemolysis (he-MOLL-uh-sis)

The vitamin E deficiency disease in human beings. Bursting of red blood cells.
Hemo = blood
Lysis = breaking

Diseases Possibly Remediable by Vitamin E

Both diseases have unwieldy names. One is fibrocystic breast disease, the other in intermittent claudication. Caution: Other very serious conditions can cause lumps in the breasts and cramps in the legs. Don't self-diagnose; see a doctor.
Fibr = fibrous lumps
Cystic = in sacs
Intermittent = at intervals
Claudicare = to limp

Muscular Dystrophy (DIS-tro-fee)

A hereditary disease in which the muscles gradually weaken; its most debilitating effects arise in the lungs.

Nutritional Muscular Dystrophy

A vitamin E deficiency disease of animals, characterized by gradual paralysis of the muscles.

Vitamin E Toxicity

All kinds of people take vitamin E supplements for all kinds of reasons. As a result, many signs of toxicity are now known or suspected, including disturbances of the action of many hormones, interference with vitamin K, alteration of the mechanism of blood clotting, alteration of blood lipid levels, impairment of white blood cell activity, GI distress, and many, many more. Doses of 100 IU, or certainly of 300 IU, should be considered megadoses and should only be taken on a physician's advice, with caution, or not at all.

Vitamin E Intakes and Food Sources

Vitamin E is a kind of alcohol, namely a tocopherol. Several tocopherols occur in foods, the most active is alpha-tocopherol. Alpha-tocopherol occurs in two mirror-image forms, D and L (remember D and L sugars in Session 2), of which the D form is more active. Different forms of vitamin E differ in their activity; to reconcile them the recommended intake is, as of 1980, expressed in terms of "the amount of vitamin E activity equivalent to that of 10 milligrams of D-alpha-tocopherol." Many people were surprised when, in 1980, the RDA for vitamin E appeared to have dropped from the 15 units recommended in 1974 to 10 units. Actually, the units changed, and 15 of the old units give the same activity as 10 of the new ones. The amount of vitamin E recommended is the same.

A person's need for vitamin E is higher if the amount of PUFA he consumes is higher. Fortunately, vitamin E and the polyunsaturates tend to occur together in the same foods.

Vitamin E is widespread in foods. About 60 percent of the vitamin E in the diet comes directly or indirectly from vegetables oils in the form of margarine, salad dressings, and shortenings; another 10 percent comes from fruits and vegetables; smaller percentages come from grains and other products. Soybean oil and wheat germ oil have especially high concentrations of vitamin E; cottonseed, corn, and safflower oils rank second, with a tablespoon of any of these supplying more than 10 milligrams (more than the RDA) of the vitamin. Other oils contain less (for example, peanut oil supplies about half as much per tablespoon). Animal fats such as butter and milk fat have negligible amounts of vitamin E.

Vitamin E is readily destroyed by heat processing and oxidation, so fresh or lightly processed foods are preferable as sources of this vitamin. The processed and convenience foods often used by the elderly and nursing homes may contribute to a vitamin E deficiency if their use continues over several years.

Tocopherol (tuh-KOFF-er-all)

A kind of alcohol. Alpha-tocopherol is one of several forms of tocopherol, and D-alpha-tocopherol is the "right-handed" version.

Vitamin E RDA

The RDA for vitamin E for adults is:
10 mg for men
8 mg for women

Vitamin K

Vitamin K seems to act primarily in the blood clotting system. There, its presence can make the difference between life and death. At least 13 different proteins and the mineral calcium are involved in making a blood clot, and vitamin K is essential for the synthesis of at least 4 of these proteins, among them prothrombin, the precursor of the protein thrombin.

When any of these factors is lacking, blood cannot clot and hemorrhagic disease results; if an artery or vein is cut or broken under these circumstances, bleeding goes unchecked. (As usual, this is not to say that the cause of hemorrhaging is always vitamin K deficiency. Another cause is hemophilia, which is not curable by vitamin K.) Deficiency of vitamin K may occur under abnormal circumstances when absorption of fat is impaired (that is, when bile production is faulty, or in diarrhea). The vitamin is sometimes administered before operations to reduce bleeding in surgery but is only of value at this time if the vitamin K deficiency exists. Toxicity is not common but can result when water-soluble substitutes for vitamin K are given, especially to infants or to pregnant women. Toxicity symptoms include red cell hemolysis, jaundice, and brain damage.

Vitamin K can be made within your GI tract – but not by you. In your intestinal tract there are billions of bacteria, which normally live in perfect harmony with you, doing their thing while you do yours. One of their "things" is synthesizing vitamin K that you can absorb. You are not dependent on bacterial synthesis for your vitamin K, however, since many foods also contain ample amounts of the vitamin, notably green leafy vegetables, members of the cabbage family, and milk.

The body resists vitamin K deficiency and it is seldom seen except when an unusual combination of circumstances conspire to bring it about. When it does occur, however, it can be fatal. The scenario goes like this: a patient is in the hospital; he has been given antibiotics to prevent or overcome infection, and he is being fed a formula diet that does not include vitamin K. The antibiotics have killed his intestinal bacteria, and his vitamin K stores are depleted. Now he goes into surgery, and when he bleeds, his blood fails to clot normally, so he bleeds to death. The combination of antibiotics, unsupplemented formula diet, and surgery raises a warning flag and requires that clotting time be checked before surgery is performed.

Brand new babies are commonly susceptible to a vitamin K deficiency, for two reasons. First, a baby is born with a sterile digestive tract; he has his first contact with intestinal bacteria as he passes down his mother's birth canal, and it takes the bacteria a day or so to establish themselves in the baby's intestines. Second, a baby may not be fed at the very outset (and break milk is a poorer sources of vitamin K than cow's milk). A dose of vitamin K (usually in a water-soluble form similar but not identical to the natural vitamin) may therefore be given at birth to prevent hemorrhagic disease of the newborn; it must be administered carefully to avoid toxic overdosing. People taking sulfa drugs, which destroy intestinal bacteria, may also become deficient in vitamin K.

Vitamin K
K stands for the Danish word koagulation (coagulation or clotting)

Hemorrhagic (hem-o-RAJ-ik) Disease
The vitamin K deficiency disease.

Hemophilia
A hereditary disease having no relation to vitamin K but caused by a genetic defect that renders the blood unable to clot because of lack of ability to synthesize certain clotting factors.

Jaundice
Yellowing of the skin, due to spillover of bile pigments from the liver into the general circulation.

Intestinal Flora
The bacterial inhabitants of the digestive tract.
Flora – plant inhabitants

Sterile
Free of microorganisms, such as bacteria.

Menadione (men-uh-DYE-own)
The synthetic substitute usually given for vitamin K.

CERTIFIED HEALTH & NUTRITION COUNSELOR ONLINE COURSE - SESSION 9 **– QUESTION & ANSWERS**

NAME: _____

ADDRESS: _____

PHONE: _____

FAX: _____

E-MAIL: _____

Please be sure to fill out the information above, complete the test and e-mail or fax it back to us at iridology@netzero.net or 425-955-4639. We will grade your question & answer session and will let you know if we have any questions or concerns.

1. Fill in the following equation: ____ RE is roughly equivalent to _____ IU of vitamin A from animal tissues or _____ IU from plant tissues.

2. Deficiency of vitamin A causes the following:

3. The recommended intake for vitamin A is _____ ____ for women, _____ ____ for men.

4. Vitamin D promotes:

5. Deficiency of vitamin D causes:

6. Vitamin E protects the _____.

7. The recommended intake of vitamin E is _____ to _____ _____ per day for adults.

8. Vitamin K promotes:

9. Keep track of your diet for 7 days. Calculate the amount of vitamin A, D, E and K in your diet. Are you getting enough? Vitamin A _____ Vitamin D _____ Vitamin E _____ Vitamin K _____.