A Brief Introduction to the Physiological Functions of Phytonutrients

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Phytonutrient defined

- Broadly stated, *phyto-chemicals* are chemicals that plants produce to perform metabolic functions. For example, wood creating cellulose, sugar cane manufacturing sucrose, and opium poppies producing morphine.

- *Phytonutrient*, within the context of natural health and nutrition, has come to refer to “non-nutritive” bio-active plant chemicals that humans eat and have or may well have significant positive effects on human metabolism.

- *Most phytonutrients* are not as yet considered essential for life, but they appear to be essential for optimal health and longevity! They therefore may properly be classified as micro-nutrients, along with vitamins and minerals.

Nutraceuticals

- *Phytochemicals* and other bio-active substances from animals that are concentrated or prepared in such a dosage as to have likely "supra-physiological" therapeutic effects are generally becoming referred to as *nutraceuticals*.

Phytonutrient Functions

- facilitate cell-to-cell communication, 2
- modify cellular receptor uptake of hormones, 3
- convert to vitamin A, 4
- repair DNA damage from toxic exposure, 5
- detoxify carcinogens through the activation of the cytochrome P450 and Phase II liver enzyme systems, 6

- serve as antioxidants to help prevent various forms of cancer, 7
- cause apoptosis (cell death) in cancer cells,8
- enhance immune response, 9
- help prevent cardiovascular disease, 10
- help prevent osteoporosis, 11
- help prevent macular degeneration and cataracts. 12

Phytonutrient families

- Phytonutrients can be grouped into families based on their chemical structure and biological activity.1 The technical classification of the major groups of phytonutrients found in our diets includes: *terpenes, organosulfurs, phenols, polysaccarides, and organic acids, and to be more complete, amines and lipids.*
- One food can contain several classifications of phytonutrients. For example, an orange contains terpenes (*carotenoids and limonoids*) and phenols (*bioflavonoids*).

The Terpenes

- The **Terpenes** are any of various unsaturated hydrocarbons, C10H16, found in essential oils and oleoresins of plants used in organic syntheses.
- The major phytonutrient sub-classifications are the *carotenoids*, the *lemonoids*, *saponins*, and the *chromanols*.

The Carotenoids: Powerful Antioxidants for Cancer Prevention, Optimizing Cardio-Vascular Dynamics, Protecting Vision

- ***Carotenoids***, fat soluble plant pigments, function as powerful **antioxidants** and **immuno-potentiaters.**
- Diets rich in carotenoids are linked with a decreased risk of **heart disease, cancer**, and degenerative **eye diseases** such as macular degeneration and cataracts. 8
- There are approximately 600 known carotenoids, 50 of which are present in our diets, mostly from fruits and vegetables. Twenty have been identified in humans. 9

Carotenes and Xanthophylls

- Chemically, carotenoids are classified in two main groups: *carotenes and xanophylls.*
- *Carotenes* refer to the carotenoids that contain only carbon and hydrogen (*beta-carotene and lycopene*).
- *Xanthophylls* refer to compounds that contain in addition a hydroxyl group (*lutein, zeaxanthin, and beta-cryptoxanthin*), a keto group (*canthaxanthin*) or both (*astaxanthin*).

Pro Vit. A Carotenoids

- *Alpha- carotene,*
- *Beta-carotene,*
- *Cryptoxanthin*

Antioxidant Power

- Carotenoids are considered potent membrane antioxidants due to their reactivity with **singlet oxygen**.
- Ranked by **antioxidant power** we can list *astaxanthin, canthaxanthin, beta-carotene, zeaxanthin, and lutein* as all stronger than vitamin E!

Sources: The Color Code

- Leafy green vegetables contain mostly *lutein and zeaxanthin*. **Carrots, oranges, sweet potatoes and squash** contain mainly *carotenes*.
- Interestingly, the yellow **yolk** of eggs is rich in *lutein*, and the *astaxanthin* group from red algae is what makes **salmon** pink.

Lutein and Zeaxanthin

- *Lutein and zeaxanthin* are the only carotenoids identified in the macula. There they filter blue light from the retina and inhibit oxidative damage. Such damage leads to **macular degeneration**, the leading cause of blindness in those over 65.
- Researchers at the **University of Utah Medical School** found that *lutein* intake is inversely associated with colon cancer. 10
- A study on serum carotenoid levels in women in India with **breast cancer** showed *lutein and zeaxanthin* to be significantly lower than in healthy controls, at least in postmenopausal women.11

Astaxanthin

- *Astaxanthin,* found mostly in red yeasts and red algae, is now fed to salmon, trout, crabs, krill and shrimp in “fish farms” to provide the **red and pink color** of their natural red algae eating wild brethren.
- This most powerful of the carotenoid antioxidants has been shown to enhance secondary immune response in humans, and help reduce symptoms of **H. pylori, CTS and RA**. 13

Beta-carotene

- *Beta-carotene* intake is associated with reduced risk of breast, stomach, esophageal, and pancreatic **cancers**. 14
- Researchers at **John Hopkins** reported in 1994 that smokers with the lowest blood levels of beta-carotene had approximately a 350% greater risk of **heart attack** as compared to non-smokers with high beta carotene levels.

Beta-cryptoxanthin

- *Beta-cryptoxanthin*, found mostly in fruits like **oranges, tangerine and papayas**, is second only to beta carotene as a source of vitamin A.
- Cryptoxanthin, again demonstrating the uniqueness of each phytonutrient, is the only carotenoid that appears to be related inversely to **bladder cancer** risk. 15

Bio-availability

- Of note, some carotenoids rich foods like carrots and tomatoes yield more *beta-carotene and lycopene*, respectively, when **cooked**.
- *Lutein and lycopene* **require fat** for optimal uptake of carotenoids.
- dietary **fiber inhibits** absorption of *lutein, lycopene, and beta-carotene* by 40% to 75 % 16, 17

Lycopene

- *Lycopene* is most abundant in tomatoes with smaller amounts in **pink grapefruit, water-melon, guava, and rose hips.**
- Lycopene makes up approximately **50% of the total carotenoids** in blood plasma of those persons consuming typical Western diets.
- It protects against prostate, cervical, breast, digestive tract and lung **cancers**, and perhaps **atherosclerosis**. 12

Limonoids

- **Limonoids** are found in citrus fruit peels.
- Limonoids may be specifically directed toward protection of the **lungs**.
- The effects of D-limonene and citrus fruit oils, i.e. orange oil and lemon oil, on induced neoplasia of the lungs and forestomach of female mice inhibited pulmonary adenoma formation and the occurrence of forestomach tumors, thus demonstrating that non-nutrient constituents of the diet may inhibit carcinogen-induced neoplasia.18

Limonoids (cont.)

- Limonoids in large concentrated therapeutic doses (500 mg) in humans have been reported to support **detoxication** of hormones and related substances that can have a negative effect on cellular DNA and cell proliferation.
- Eight ounces of OJ would usually contain approximately 19 mg of d-limonene.

Saponins

- *Saponins* are plant glucosides (plant compounds that can be hydrolysed into dextrose) that have been shown to **lower cholesterol** by binding to it in the digestive track.
- According to the molecular biology web site from **Princeton University**, saponins also inhibit the multiplication of cancer cells by interfering with their DNA.21
- **Alfalfa** and other legumes, especially **soy**, are the most common sources.

Chromanols

- 6-Hydroxychroman (6-chromanol) is the fundamental unit of:
- the tocopherols (vitamin E complex),
- the tocotrienols,
- ubiquinols (Co Q-10),
- phyllochromanols (Vit. K)

Tocotrienols and Tocopherols

- The most familiar chromanols are the *toco-trienols (unsaturated)* and the *tocopherols (saturated) (*alpha, beta, gamma and delta).
- These two naturally occur in **palm oils** and whole grain **germ** and/or **bran**.
- Tocotrienols appear to inhibit **breast cancer** cell growth.
- Tocopherols have been most studied for their **cardiovascular** health effects. 22

Co-Q 10

- Called **Ubiquitone** because it is found, in trace amounts, “all over”, especially tropical oils, cereal bran and germ.
- Co Q-10 has a similar structure to both Vit. E and K. Like Vit. K, the young body can manufacture sufficient Co Q-10.
- Co Q-10 is a powerful antioxidant and works as a catalyst in ATP production in mitochondria.

Vit K

- Vitamin K is actually a fat soluble phytonutrient (technically a sub-classification of terpenes, a mixed isoprenoid chromanol sub-group known as the quinones). There are actually three kinds of vit. K:
- K1, phylloquinone,
- K2, menaquinone,
- K3, menadione, synthetic Vitamin K.

K Sources

- Leafy greens, broccoli and soybean are major sources of vitamin K1.
- Beef liver, chicken, egg yolk, butter, some cheeses, and fermented soy are Vitamin K2 sources (therefore technically not a phyto-nutrient but rather a "zoo-nutrient", pronounced zoo'-o).
- Fermentation via healthy, eubiotic intestinal micro-organisms occurs as well, providing more Vitamin K2. However, humans enjoy only limited hepatic storage of Vitamin K.

K functions

- Poor vitamin K blood levels and dietary intake are directly correlated with female osteopenia (low bone mineral density) and frank osteoporosis with hip fracture.
- Vitamin K activates osteocalcin and assists in the manufacture of bone matrix G1a protein
- Vitamin K strongly inhibits arterial calci-fication while supporting boney deposition of same! (14, 15).

The Phenol Group: Anti-inflammatory, Anti-clotting, Antioxidant, Immune Enhancers and Hormone Modulators

- **Phenols** include *antho-and beta-cyanins, flavonoids, isoflavones, lignans*, and *lignins*.
- Blue, blue-red and violet colorations seen in berries, grapes and purple eggplant are due to their phenolic content.
- Bilberries, for example, are high in *phenolic anthocyanidins* giving them their reddish hue.

Flavinoids

- **Flavonoids** are perhaps best known for their ability to enhance the effects of ascorbic acid.
- Along with Vitamin C, flavonoids are well known for their ability to protect the vascular system by strengthening, maintaining and repairing capillaries. 2

Vitamin P

- Once lumped together as vitamin P, science has now discovered well over 1,500 flavonoids!
- Here is a partial listing: *anthocyanins, proanthocyanins, flavones, flavonols, flavonones, bioflavinoids, flavin-3-4-diols, isoflavones and catechins.*

Sources

- Flavonoids are found in *apigenin* in chamomile (flavone); *quercetin* in onion and green apples, *rutin* in-buckwheat, *ginkgoflavonglycosides* in ginkgo (flavonols); *hesperidin* in citrus fruits and *silybin* in milk thistle (flavanones); *catechins* in green tea; *isoflavones* in soy; *anthocyanins* in blueberries; and *proanthocyanins* in grape seeds and pine bark.

Flavonoid Functions

- The biologic functions of flavonoids include action against allergies, inflammation, free radicals, platelet aggregation, microbes, ulcers, hepatotoxins, viruses and tumors. 3 Flavonoids inhibit specific enzymes such as the angiotensin-converting enzyme (ACE) that raises blood pressure, and cyclooxygenase that breaks down prostaglandins, thereby inhibiting platelet aggregation.

Functions

- Flavonoids reduce the risk of estrogen-induced cancers via interfering with the enzymes, flavonoids inhibit estrogen synthesase, an enzyme that binds estrogen to receptors.
- Flavonoids appear to retard cataract development by interfering with aldose-reductase, which converts galactose into the potentially harmful galacticol. 4

Anthocyanidins

- *Anthocyanidins* are flavonols that provide cross-links that connect and strengthen intertwined strands of collagen protein.
- Anthocyanidins are powerful water-soluble antioxidants that inhibit free radicals, thereby inhibiting aging, and in larger doses, inflammation and allergic reactions.

Catechins

- *Catechins*, found in tea, are members of the flavan-3 class of flavonoids. The most common catechins are
- gallic esters, named epicatechin (EC),
- epicatechin gallate (ECG),
- epigallocatechin (EGC), and epigallocatechin gallate (EGCG), viewed as the most significant. . 5

Catechin Benefits

- Benefits include:
- promotion of apoptosis of cancer cells in prostate, stomach, skin, lung, breast and colorectal tissues.
- perhaps related to anti-angioneogenesis . 5
- lowers cholesterol and inhibits its oxidation .
- perhaps a protective effect on Parkinson's.

Isoflavones

- **Isoflavones**, of which *genistein* and *daidzein* are the most known and studied, are most abundant from kudzu, soy beans and other legumes.
- In spite of their name, isoflavones are rather distant cousins of flavonoids.

Isoflavone Functions

- Isoflavones, which are phytoestrogens, effectively modulate estrogen levels in humans and are therefore often of clinical value in low estrogen states like menopause, or imbalanced and toxic estrogen sensitive conditions like breast, uterine and prostate tumor growth.
- It is now well recognized that peoples who consume traditional diets rich in fermented soy foods experience less breast, uterine and prostate cancers.

Lignans

- **Lignans** are found in seeds and grains, especially flaxseed. The lignan found in flaxseed is called *secoisolariciresinol glucoside (SDG)*.
- The **National Cancer Institute** reports that vegetarians have higher concentrations than omnivores, as do tumor free patients when compared with breast and colon cancer patients.

Lignan Functions

- According to Dr. Dan Junke and Charles A. Weisman, authors of, Flaxseed Lignan - The Power of SDG in Promoting Health, lignans are weak phytoestrogens that also have anti-viral, anti-bacteria, anti-fungal, antioxidant, and immune enhancing properties.
- Lignans are not to be confused with *lignins* which are a non-carbohydrate dietary fiber that, along with polysaccharides, occur in the cell walls of plants.

The Organosulfur Group: Detoxifiers, Cardiovascular Risk Reducers, and Non-Specific Immunity Supporters

- Cruciferous vegetables were the first to be promoted by the **American Cancer Society** as cancer preventive!
- Generally, the organosulfur group provides sources of sulfur vital for phase II enzymes activities (such as for glutathione S-transferase AKA GST) involved in detoxication of carcinogens.

Glucosinolates

- More specifically, organosulfurs provide *glucosinolates* which are converted into several bio-transformation products in the human body, particularly *indole-3-carbinol, isothiocyanates, and thiosulfonates*. The sulfur compounds in these three groups are slightly different and, consequently, each has specific health benefits.

Indoles, isothiocyanates, thiosulfonates

- The **indoles** and **isothiocyanates** are in the *cruciferae family* of brassica and mustard plants: horse radish, cabbage, broccoli, Brussels sprouts, kale, arugula, bok choy, cauliflower, mustard seeds and greens, watercress, turnip greens, daikon, wasabi, and kohlrabi.
- The **thiosulfonates** are predominant in the *allium family:* garlic, onion, leek, asparagus, shallots, chive and scallion

Organo-sulphur functions

- Cruciferous consumption of 1-2 servings per day (150 –220 gm) reduced breast cancer risk by 40-50% in post-menopausal women. Elevating daily intake from the current average 9 gm per day to 193 gm garnered a favorable shift in urinary excretion ratio of *2-hydroxy*- versus *16-alpha-hydroxysterone*. 3
- Inhibition of esophageal, lung and several other cancers has been shown in animal studies
- Activation of *cytochrome P450 enzymes* was the likely cancer-protective method. 4

Glucosinolates

- These glucosinolates also facilitate apoptosis, the disintegration of cells, an important function in the prevention and elimination of tumors.
- *2 eligs, Michael A., M.D., Diet and Estrogen Status: The Cruciferous Connection, Journal of Medicinal Food Vol I, Number 2, 1998, p. 78.*

Sulforaphane, I3C and DIM

- The protective agents of the brassica family are thought to be most especially the phytonutrients:
- isothiocyanate *sulforaphane*, and
- And the indole *indole-3-carbinol (I3C*), with its metabolite *diindolymethane* (DIM).

I3C and Breast Cancer

- indole-3- carbinol up-regulates the tumor suppressor and DNA repair gene BRCA1 through an estrogen receptor.
- I3C compound increases BRCA1 and works to block the estrogen receptor alpha from signaling cancer growth.
- Especially important in young women

Phytonutrient variability

- Phytonutrient content of cruciferous vegetables can vary widely. For example, sulforaphane (of import as it helps turn on t4 cells so they recognize cancer cells and destroy them) in three-day old broccoli sprouts was measured and found to be *ten - to - one hundred times higher* than the amount in mature broccoli. 7
- One-hundred and twenty-five (125) mg of such broccoli “super sprouts” may be equal to approximately one five-ounce serving of most mature broccoli! 5

Bio availability

- Nontheless, The Journal of the National Cancer Institute relates that it only took three and one-half servings a week of broccoli, Brussels sprouts and cauliflower, which contain high levels of indoles, to decrease the risk of prostate cancer by 41 percent. 8 Interestingly, the bio-availability of indoles is increased by light cooking.

Thiosulfonates

- Though the **thiosulfonates** are also able to assist Phase II detoxication, and thereby enhance protection against carcinogenesis, they are perhaps better known for their ability to promote a more favorable HDL- LDL ratio, lower blood pressure and stimulate non-specific immunity

Functions

- Like their cruciferous cousins, when thiosulfonates are cut or smashed the sulfur compounds release bio-transformation products including: *allicin, ajoene, allylic sulfides, vinyl dithin and D-allyl mercaptocysteine.* Some of these are considered anti-atherosclerotic, some antioxidant, some anti-cancer agents, while others are antibacterial, antiviral and antifungal. 9,10,11,12

Commision E Monograph Functions

- The Commission E monograph in Europe declares garlic antibacterial, anti-mycotic, lipid-lowering, an inhibitor of platelet aggregation (thus prolonging bleeding and clotting time) with concomitant enhancement of fibrinolytic activity.

Organic Acids: Antioxidant Cancer Preventives, Liver Protectors, and Inflammatory Mediators

- Phytochemicals in this group are small to large complex carbon compounds, which include *esters and lactones*, and are found in grains, herbs, teas, a few vegetables and some fruits. 13
- Examples: *oxalic acid* in spinach, rhubarb, tea and coffee; *tartaric acid* in apricots and apples; *cinnamic acid* in aloe and cinnamon; *caffeic acid* in burdock and hawthorn; *ferulic acid* in oats and rice; *gallic acid* in tea, *coumaric acid* in tumeric; *salicylic acid* in spearmint; *tannic acid* in nettles, tea, berries.

Ellagic Acid

- Perhaps of most current interest is **ellagic acid**, which is found in guava, currants, apples, grapes, strawberries, and most particularly in red raspberries and wild chart cherries. According to the **The Hollings Cancer Institute at the University of South Carolina**, ellagic acid is a proven anti-carcinogen, anti-mutagen, and anti-cancer initiator!

Triple Protection

- For breast, pancreas, esophageal, skin, colon and prostate cancer cells **ellagic acid** strongly inhibits cancer cell division within 48 hours, and promotes apoptosis (normal cell death) within 72 hours.
- **Ellagic acid** prevents the destruction of the *p53 gene* by cancer cells.
- **Ellagic acid** inhibits mutagenesis and carcinogenesis is by forming adducts with DNA, thus occupying binding sites 14

Wide Spectrum Support

- OA's can form complexes with other phytochemicals to yield a new more powerful compounds. For example, gallic acid with polyphenolic catechins form *catechin gallates,* as in green tea. 15
- Thus the oft repeated conservative guideline in supplementing phytonutrients for general health benefits: consider first a wide spectrum from fruits, vegetables, legumes, grains and spices, of all colors, over mega doses of single or several phytonutrients.

Polysaccarides

- A polysaccaride is a carbohydrate that can be decomposed by hydrolysis into two or more molecules of monosaccharides; more especially : one of the more complex carbohydrates (as cellulose, starch, or glycogen) called also glycans.
- Plant cells are surrounded by a poly-saccharide-rich immuno-protective wall.

Functions

- Some wall polysaccharides bind heavy metals, stimulate the immune system, modulate cell to cell interactions, are a sources of biologically active signaling mechanisms, or regulate serum cholesterol.

Fiber

- Dietary fiber refers to such long chains of glucose molecules not digested by human enzymes.
- Soluble – delays GI transit, delays glucose absorption, lowers blood cholesterol, prebiotic
- Insoluble – speeds GI transit, increases fecal weight, slows starch hydrolysis, delays glucose absorption

Sources of Fiber

- Cellulose – insoluble, indigestible constituent of plant cell walls
- Hemicelluloses – soluble and insoluble fiber in cereal fibers
- Pectins – soluble fiber of vegetables and fruits (citrus, apples)
- Gums and Mucilages – soluble fiber as in aloe vera and, acacia
- Lignin – non-polysaccharide fiber – insoluble fiber woody parts of vegetables: carrots, strawberry seeds

Immune Modulation

- Beta Glucan, a polysaccaride found in yeast cell walls and oat bran, has been found to modulate macrophage cells to better recognize, engulf and destroy foreign invaders or tumor cells, produce more essential cytokines to stimulate the immune system and boost bone marrow production, and activate a chain reaction that mobilizes and amplifies the entire immune response.

Aloe Vera

- Aloe leaves are extremely rich in long chain polysaccharides made from mannose joined through a beta 1-4 linkage.
- In aloe vera the polysaccharides, *aloe-mannan* and *acemannan* showed anti-tumor, anti-inflammatory, and immuno-suppressive activities Yakugaku Zasshi. 2003 Jul;123(7):517-32.

The Amines: Carcinogen Deactivators and Enzymatic Therapy

- **The amines include both chlorophyll (as in *chlorella, spirulina, hydrilla, and the leafy greens and grasses*) and**

- **Plant enzymes (as in *papain and bromelain*).**

Chlorophyll

- Chlorophyll is well known to detoxify carcinogens found in cooked muscle meats (*heterocyclic amines*), smoked or barbecued foods (polycyclic hydrocarbons), and peanut mold (*aflatoxin*). 16
- Chlorophyll has also been recognized for its anti-inflammatory, anti-mutagenic, and antioxidant properties. 17,18
- A naturally occurring chlorophyll derivative, *pheophorbide*, showed antioxidant activity against lipid auto-oxidation comparable to alpha-tocopherol, aka vit. E. 17,19,20

Therapeutic Benefits

- *Chlorophyll* has been cited as strengthening the immune response, therapeutic for inflammation of the ear and the mucous membrane of the nose and sinuses, supportive of normal kidney function, accelerating wound and ulcer healing, and reducing fecal, urinary, and body odor in geriatric patients. 21,22

Plant Enzymes

- *Plant enzymes* are well accepted as useful in assisting digestion, having the advantage of being active in a wide PH range. Taken in between meals, they assist in injury resolution by increasing the blood enzymes available to digest proteins related to fibrolytic and inflammatory process and immune responses.

Lipids: Non-nutritive Notes

- Non-nutritive functions of lipids include the eicosanoid modulating effects of the fatty acids and the immune and cholesterol effects of the phytosterols.
- An isoprene is an oily, volatile hydrocarbon. Isoprenoids are polymers whose carbon skeletons consist in whole or in large part of isoprene units joined end to end; e.g., Terpenes: Vitamin A, K and E and the coenzymes Q have isoprenoid side chains

Ecosinoids: Omega 3 and 6 EFA

- Omega 6 fatty acids convert to PGE1 via the linoleic-acid (LA) to gamma-linolenic-acid (GLA) to dihomo-gamma-linolenic-acid (DGLA) to the anti-inflammatory series one prostaglandins (PGE1).
- Omega 3 EFA converts to the Omega 3 to the anti-inflammatory PGE3, while also preventing inappropriate Omega 6 arachidonic acid cleavage via the delta-5-destaurase enzyme (D5D).

Phytosterols

- Phytosterols = plant *sterols* and plant *stanols*
- chemical structures similar to that of cholesterol,
- found in rice bran, wheat germ, corn oils, soybeans, nuts and seeds.
- In concentrated form, called plant stanols.
- Phytosterols are present in very low levels in the body as they are difficult to absorb.
- But they block cholesterol absorption.

Other Sources

- Algae and fungi also manufacture phytosterols. For example, as presented at the **American Heart Association's** 39th Annual conference in 1999, *ergosterol* from red yeast grown on rice has lipid lowering effects similar to statins.
- Various mushrooms, seaweeds, and spirulina contain many sterols, including *fuctosterol, sitosterol, ergosterol*.

Health Benefits

- Binding dietary cholesterol so it is eliminated.
- improving the control of blood sugar in diabetics
- reducing inflammation among patients with autoimmune diseases such as RA and lupus.
- Specially prepared and concentrated phytosterols (*sterols and sterolins*) from sesame seed are used to modulate immune function through thymus hormones (T1 and T2) and interleukins, while modulating DHEA/Cortisol balance as well.7

Hormone Modulation

- Phytosterols mimic hormone precursors or modulate hormones themselves. Swedish tree pollen, pumpkin seeds, pygeum, and saw palmetto are all used in cases of benign hyper-trophic prostate disease (BHP) and prostatitis.
- These phytosterols inhibit the conversion of testosterone to dehydroxytestoterone (DHT). 5

Conclusion

- Phytochemicals can be grouped into families based on their chemical structure and biological activity.1
- We have made a very cursory review of the major phytonutrient compounds, namely the *terpenes, polysaccharides, lipids, phenols, organosulfurs, organic acids, and amines*.

Phytonutrient Functions

- facilitate cell-to-cell communication,2
- modify cellular receptor uptake of hormones,3
- convert to vitamin A,4
- repair DNA damage from toxic exposure,5
- detoxify carcinogens thru Phase I and II liver enzyme systems,6
- serve as antioxidants to help prevent various forms of cancer,7
- cause apoptosis (cell death) in cancer cells,8
- enhance immune response,9
- help prevent cardiovascular disease,10
- help prevent osteoporosis,11
- help prevent macular degeneration and cataracts.12 .

Take Home Message

- The take home message is that our dietary and supplementation habits would do well to include a wide variety of whole plant foods and whole food supplements nutrient dense in a broad spectrum of phytonutrients.

ORAC

- **ORAC**, short for **O**xygen **R**adical **A**bsorbance **C**apacity, is a test tube analysis that measures the total antioxidant power of foods and other chemical substances.
- Dr. Guohua Cao, a physician and chemist, developed the ORAC test at the National Institute on Aging in Baltimore, Maryland.,

ORAC

- According to Dr. Cao, "The ORAC value covers all the antioxidants in foods. You cannot easily measure each antioxidant separately, but you can use the ORAC assay to identify which phyto-nutrients are the important antioxidants. *It may be that combinations of nutrients found in foods have greater protective effects than each nutrient taken alone*."

ORAC

- In the studies, eating plenty of high-ORAC foods raised the antioxidant power of human blood 10 to 25 percent. Based on the evidence so far, evidence suggests that daily intake be increased to approximately 5,000 ORAC units to have a significant impact on plasma and tissue antioxidant capacity.

Appendix

- http://www.biopharmasci.com/downloads/Physiological_Functions_of_Phytonutrients.pdf
- http://www.biopharmasci.com/downloads/PhytonutritionWhitepaper.pdf

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