

The Validity of the Pharmanex BioPhotonic Scanner and a Review of The Literature

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The arrival of the BioPhotonic Scanner in the United States in 2003 was originally a “non-event.” Very few people knew of it. In the space of the last five years, however, and with the explosive growth of the parent company that introduced the scanner to the U.S. market, more and more people are becoming aware of this device as well as a totally unique and performance guaranteed line of supplements and nutritional systems offered by the same company.

As CEO and Founder of Cady Wellness Institute, it is imperative to me that any technology or laboratory assessment that I use for my patients meets the standards of current science, is thoroughly supported in the peer reviewed medical literature by multiple citations that reinforce each other, and offers clear benefits that are unavailable by other technologies or assessments. It is also important to me that it be affordable for the patient, and that any measurement obtained offers me “actionable data” which I can use to directly improve either a patient’s physical health, or mental health, or both.

A quick review of the important points relating to the BioPhotonic Scanner follows:

- Pharmanex, a division of NuSkin, owns the patent rights to the BioPhotonic Scanner for the next 19 years
- The BioPhotonic Scanner is the only method available to painlessly and quickly obtain a living tissue measurement of total body antioxidant status by Raman spectroscopy.
- Simultaneously, Pharmanex is the only company that has a *product guaranteed to perform in any specific manner*: in their case, the guarantee is to raise the skin carotenoid score – something which is globally associated with improving antioxidant status, and a key concept that will be reviewed in this paper.

A review of the original patent for the BioPhotonic Scanner is instructive. Here follow relevant excerpts from the United States Patent Application 6,205,354 – granted March 20, 2001, and awarded to Werner Gellermann and colleagues at the University of Utah. All quotes are directly excerpted from the patent. It should be noted that the patent was granted as specified, meaning that the US Patent Office was satisfied with the claims and the supporting documentation.

From the Abstract:

“A method and apparatus are provided for the determination of levels of carotenoids and similar chemical compounds in biological tissue such as living skin. The method and

apparatus provide a noninvasive, rapid, accurate, and safe determination of *carotenoid levels which in turn can provide diagnostic information regarding cancer risk, or can be a marker for conditions where **carotenoids or other antioxidant compounds** may provide diagnostic information.* Such early **diagnostic information** allows for **the possibility of preventative intervention.**” [emphasis by Cady]

Also from the Abstract:

“In this technique, laser light is directed upon the area of tissue which is of interest. A small fraction of the scattered light is scattered inelastically, producing the carotenoid Raman¹ signal that is at a different frequency than the incident laser light, and the Raman signal is collected, filtered, and measured. The resulting Raman signal can be analyzed such that the background fluorescence signal is subtracted and the results displayed and compared with known calibration standards.”

Specifically, the patent claims (Claim #9): “A method for noninvasively determining **the antioxidant status in skin tissue.**” [emphasis by Cady]

It is important to be aware of exactly what the scanner measures: “**a detection of the total carotenoids content in human skin.**” Notably, the vibration of all of the double bonds of all carotenoids, as measured by Raman Spectroscopy, detects basically *all* of the skin carotenoids. Specifically listed in the patent are the following: **all-trans-beta-carotene, lycopene, alpha-carotene, gamma-carotene, phytoene, phytofluene, seapreno-beta-carotene, 7,7’ dihydro-beta-carotene, astaxanthin, canthaxanthin, zeaxanthin, lutein, beta-apo8’ carotenal, violaxanthins, and rhodoxanthin.** This is considerably more than “skin carotene.” The patent notes, “These are chain-like molecules with different lengths and attachments, all having a carbon backbone with alternating carbon double and single bonds, respectively. The vibration of these bonds, *common to all carotenoids*, can be detected with Raman spectroscopy. It is known from separate measurements that the wavenumber shifts of these carotenoids are generally in the range from 8000 to 2000 cm.sup.-1 (wavenumbers).”

The question then arises: what is the relevance of measuring carotenoids in the skin? The answer is two-fold: first, carotenoids in the skin are, in and of themselves, quite relevant in terms of the likelihood of malignant lesions such as basal cell carcinoma and melanoma [references follow]. Secondly, these reading are reflective of total body antioxidant status.

¹ See appendix, and article by Vishwas Purohit. Interestingly, the first hint of the discovery of the “Raman effect” occurred when Sir Chandrashekhra Venkata Raman was on a sea voyage and became fascinated with the extremely deep blue color of the Mediterranean Sea and attempted to discover the reason. He rejected the theory that it was caused by a “reflection from the sky” and showed in 1922 that it was the scattering of light by water molecules which accounted for the “color shift.” For the discovery of the “inelastic scattering of light,” he was awarded the Nobel Prize in Physics in 1930. His discovery became extremely relevant with the advent of lasers and was soon applied to use in spectroscopic applications for identifications of compounds - using the same effect he had witnessed so many decades ago on the opalescent Mediterranean Sea.

The relevance of skin carotenoids is repetitively cited throughout the patent. It is noted that “carotenoids are an important component of the skin’s antioxidant defense systems, where they are thought to act as free radical and singlet oxygen scavengers.” Also noted is the “correlation between the levels of carotenoids, retinoids, and similar chemical substances in the skin and the risk of skin cancer and other skin disorders. People with low levels of carotenoids in their skin are *at a significantly greater risk of getting skin cancer.*”

The relationship between carotenoids assessment and the implied amount of antioxidant protection is claimed as follows: “The present invention not only provides for a rapid, non-invasive assessment of carotenoids levels in a variety of human tissues and bodily fluids, but also has many additional beneficial uses. ***These include assessing the overall antioxidant status in human tissue....***”

There are multiple interfacing and collectively synergistic papers and assertions in the peer-reviewed medical literature to support this claim in the patent application, and many more have appeared since the patent was awarded.

- 1) Carotenoids began to be clearly identified in 1992. Khachik and colleagues noted that five were abundant in the human diet, and that among these, five carotenoids – beta carotene, alpha carotene, lycopene, lutein, and zexanthin – are found in the blood and known to be important in human health.²
- 2) Carotenoids by themselves are potent antioxidants. Tsuchiya and colleagues, writing in 1994³, noted that a typical carotenoids molecule is able to sustain more than 20 free radical hits by lipid radicals before it becomes completely destroyed. Also, obviously, if the carotenoids molecules are appearing in the skin, they have been absorbed by other cells of the body – along with their presumptive antioxidant effects. Tsuchiya and colleagues, with Lester Packer as a co-author, also published the first paper on this topic in 1992.⁴
- 3) There is an exciting six-year rapid advance in the literature looking at the consumption of lycopenes and carotenoids in terms of the risk of prostate cancer. As early as 1998, Giovannucci and Clinton published two studies beginning to examine the link between tomatoes, *lycopene*, and the development of prostate cancer.^{5 6}

² Khachik F et al. Separation and quantification of carotenoids in human plasma. *Methods Enzymol.* 1992;213:205-19.

³ Tsuchiya, M et al. Antioxidant activity of alpha-tocopherol, beta carotene, and ubiquinol in membranes:cis-parniaric acid-incorporated liposomes. *Method Enzymol.* 1994; 234:371-83.

⁴ Tsuchiya M et al. Antioxidant radical-scavenging activity of carotenoids and retinoids compared to alpha-tocopherol. *Methods Enzymol.* 1992; 213:460-72.

⁵ Giovannucci E, Clinton SK. Tomatoes, lycopene, and prostate cancer. *Proc Soc Exp Biol Med.* 1998 Jun;218(2):129-39.

⁶ Clinton SK, Giovannucci E. Diet, nutrition, and prostate cancer. *Annu Rev Nutr.* 1998;18:413-40.

Four years later, Miller joined Giovannucci in noting that “*lycopene is one of the compounds in raw and processed tomato products that may contribute to a lower risk of prostate cancer.... Other carotenoids and phytochemicals in tomato products may also contribute to the proposed benefits.*”⁷

Two years later, the matter was settled. Wu and colleagues analyzed 450 incident prostate cancer cases diagnosed from 1993-1998 and compared them to 450 controls by age, time, month, and year of blood donation.⁸ “We found a *statistically significant inverse association between higher plasma lycopene concentrations and lower risk of prostate cancer*, which was restricted to older participants and those without a family history of prostate cancer.” They continued: “This observation suggests that tomato products may exhibit more potent protection against sporadic prostate cancer rather than those with a stronger familial or hereditary component. In addition, our findings also suggest that among younger men, **diets rich in beta-carotene may also play a protective role in a prostate carcinogenesis.**”

Thus, it is clear that carotenoids themselves possess potent biologically active and chemoprotective effects. Protection against prostate cancer is just one of the benefits. There are multiple others including skin cancer prophylaxis^{9 10}, and atherosclerotic disease prophylaxis¹¹.

In terms of protection from skin cancer, the authors note that “Optical, non-invasive methods, *like resonance Raman spectroscopy*, allow a qualitative and quantitative online detection of the kinetics **of antioxidants such as carotenoids in the skin.**”¹²

In terms of prevention of lipid peroxidation and the conversion of LDL under oxidative stress to cause the promotion of arterial plaques, three groups of antioxidants are specifically mentioned: Vitamin E, the carotenoids, and the polyphenolic flavonoids.¹³

- 4) Setting their own potentially beneficial effects aside, and focusing on implied levels of other antioxidants, it's important to note that as early as 1995, correlation between levels of carotenoids as well as other antioxidants, **specifically the tocopherols**, was

⁷ Miller EC et al. Tomato products, lycopene, and prostate cancer risk. Urol Clin North Am. 2002 Feb;29(1):83-93.

⁸ Wu K, et al. Plasma and dietary carotenoids, and the risk of prostate cancer: a nested case-control study. Cancer Epidemiol Biomarkers Prev. 2004 Feb;13(2):260-9.

⁹ Wright, TI et al. Chemoprevention of nonmelanoma skin cancer. J Am Acad Dermatol. 2006 Jun;54(6):933-46

¹⁰ Darwin M et al. Functional food and bioavailability in the target organ skin. Hautarzt. 2006 Apr;57(4):286-90.

¹¹ Aviram M. Dietary antioxidants and paraoxonases against LDL oxidation and atherosclerosis development. Hanb Exp Pharmacol. 2005;(170):263-300.

¹² Wright et al. 2006. Loc cit.

¹³ Aviram M et al, 2005. Loc cit.

noted. Peng and colleagues, writing in *Nutrition and Cancer*¹⁴, took note of the fact that micronutrients such as beta-carotene, Vitamin A and Vitamin E are *potential chemopreventive agents*. However, in 1995, their concentrations in human target tissues were largely unknown. In this study, the levels of seven carotenoids, two retinoids, and two tocopherols were measured in both plasma and well as buccal mucosal cells as well as skin samples from 96 healthy subjects. The data clearly showed a correlation **between the levels of micronutrients in plasma as well as skin**. Their conclusion was that **“the status of these micronutrients in the skin may be estimated from their plasma concentrations.”**¹⁵ The reverse, of course, also holds true. And it bears emphasizing that there was a correlation between the levels of the carotenoids and the tocopherols – Vitamin E.

Other considerations in this study were also remarkable, including the fact that “the plasma and tissue concentrations of most micronutrients were lower in smokers than in nonsmokers and *higher in vitamin supplement users than in nonsupplement users*.” Further, *“The differences remained significant [even] after adjustment for age, gender, and diet intake estimates.”*¹⁶

Remarkably, and this was an incidental finding, lycopene was unique among the seven carotenoids studied because its concentration was not affected by either smoking or supplement users, but went down steadily with age. This correlates with other studies that show an age-related decline in retinol, total tocopherols, total xanthopylls, and total carotenoids in the frontal lobes of aging human brains.¹⁷

- 5) It is also important to be fully aware that carotenoids are part and parcel of the total antioxidant network. Lester Packer, Ph.D., known as the “father of antioxidants” and the author of hundreds of scholarly papers in peer-reviewed journals, published **The Antioxidant Miracle** in 1999.¹⁸ In it, Packer took note of Vitamins C & E, as well as Coenzyme Co-Q10 (ubiquinone), Alpha Lipoic Acid, and Selenium as all functioning as part of the antioxidant network. He specifically noted carotenoids as a first line of defense and their protective effect on Vitamins C and E. Later, Stahl and Sies, writing

¹⁴ Peng YM et al. Concentrations and plasma-tissue-diet relationships of carotenoids, retinoids, and tocopherols in humans. *Nutr Cancer*. 1995;23(3):233-46.

¹⁵ Other corroboration on this point appears. El-Soehy and colleagues at the Harvard School of Public Health, using actual adipose tissue biopsies in addition to plasma levels, reported in 2002 that “the usefulness of adipose tissue and plasma carotenoids as biomarkers of intake is similar, although correlations for individual carotenoids vary substantially.” El-Soehy A, et al. Individual carotenoid concentrations in adipose tissue and plasma as biomarkers of dietary intake. *Am J Clin Nutr*. 2002 Jul;76(1):172-9.

¹⁶ Peng YM et al. *Loc cit*.

¹⁷ Craft NE, et al. Carotenoid, tocopherol, and retinol concentrations in elderly human brain. *J Nutr Health Aging*. 2004;8(3):156-62.

¹⁸ Packer, Lester. *The Antioxidant Miracle*. John Wiley & Sons, Inc. © 1999.

as recently as May 2005¹⁹, noted that “there is convincing evidence that carotenoids are important components of the antioxidant network. ...Lutein and zeaxanthin are the predominant carotenoids of the retina and are considered to act as photoprotectants preventing retinal degeneration.” In terms of disease prevention, Stahl and Sies also reviewed that the *consumption of a diet rich in carotenoids [which would show up in the skin and be measurable] has been “epidemiologically correlated with a lower risk for several diseases.”*

- 6) In a different paper, Sies and colleagues **clearly identified carotenoids as one of the dietary antioxidants** [thus, part of the “antioxidant network”] along with vitamins E and C, polyphenols, and other micronutrients (specifically Selenium as an example) also in May, 2005.²⁰
- 7) The need to look outside the conventional water-soluble anti-oxidants, such as Vitamin C, was noted in a paper by Yeum and colleagues in 2004.²¹ Specifically, they noted “Conventional assays to determine antioxidant capacity primarily measure the antioxidant capacity in the aqueous compartment of plasma. Consequently, *water soluble antioxidants such as ascorbic acid, uric acid, and protein thiols mainly influence these assays, whereas fat-soluble antioxidants such as tocopherols and carotenoids play only a minor role* [in being picked up in the assay – note by Cady]. However, there **are active interactions among antioxidants located in the hydrophilic and lipophilic compartments of plasma**. Therefore, **new approaches to define the ‘true’ total antioxidant capacity of plasma should reflect the antioxidant network between water- and fat-soluble antioxidants** in plasma.” In other words, measuring Vitamins C and E were no longer enough.
- 8) The actual anti-cancer effects of the antioxidant carotenoids were specifically mentioned, as well as their function as “potent antioxidants” in Sharoni et al., 2003.²² Specifically they asserted the following: “It is widely accepted that diet changes are a powerful means to prevent cancer. The possible involvement of transcriptional activity in the **anticancer activity of carotenoids** will be the focus of this review. *Carotenoids function as potent antioxidants, and this is clearly a major mechanism of their action*. In addition, **carotenoids action involves interference in several pathways related to cancer cell proliferation** and includes changes in the expression of many proteins participating in these processes.”

¹⁹ Stahl W, Sies H. Bioactivity and protective effects of natural carotenoids. *Biochim Biophys Acta*. 2005 May 30;1740 (2):101-7. Epub 2004 Dec 28.

²⁰ Sies H, et al. Nutritional, dietary and postprandial oxidative stress. *J. Nutri*. 2005 May;135(5):969-72/

²¹ Yeum et al. Biomarkers of antioxidant capacity in the hydrophilic and lipophilic compartments of human plasma. *Arch Biochem Biophys*. 2004 Oct 1; 430(1):97-103.

²² Sharon Y et al. Modulation of transcriptional activity by antioxidant carotenoids. *Mol Aspects Med* . 2003 Dec;24(6):371-84.

- 9) The benefits of the carotenoids and their relative importance in the antioxidant network notwithstanding, there is further evidence that levels of carotenoids are actually predictive of levels of other, more conventionally thought of, antioxidants such as Vitamins C and E. Svilaas and colleagues examined the consumption of fruits and vegetables, and measured serum carotenoids as well as other more conventionally measured water-soluble antioxidants in 2,670 adults.²³ They found that the ability of carotenoids to predict serum levels of other antioxidants was stronger than the predictive ability of alpha, beta, delta, and gamma-tocopherols as well as glutathione. *In other words, the level of carotenoids is actually more important than the total level of Vitamin E – a much more conventionally cited antioxidant – in inferring the total antioxidant protective level of the system.*

This is tantamount to a paradigm shift in the literature, where, suddenly, the measurement of a skin carotenoids score can legitimately be used to infer the total antioxidant capacity of the system.

- 10) Historically, the convenience of carotenoids as a measure of antioxidant status and their accessibility to Raman analysis [use of the BioPhotonic Scanner instead of blood testing or urine testing for inflammatory metabolites consistent with low anti-oxidant status] was asserted and first published in the peer-reviewed medical literature as early as 1998 by Bernstein and colleagues at the University of Utah where the scanner was originally under development.²⁴ This paper investigated the correlation of Raman measurements on human flat-mounted retinas and eyecups and in experimental animal eyes, and correlated this with macular carotenoids levels determined by high performance liquid chromatography [a conventional way to do it, but one that requires tissue or blood samples]. The results described were as follows: “Carotenoid resonance Raman scattering proved to be a highly sensitive and specific method for the noninvasive measurement of macular pigments in the human retina. Signal strength scaled linearly with actual macular carotenoids content as measured by HPLC.” Their conclusions were as follows: “This new noninvasive optical method will facilitate studies of ocular carotenoids distributions and their role in degenerative diseases of the eye and may allow for the rapid screening of carotenoids levels in large populations at risk for vision loss from age-related macular degeneration, the leading cause of blindness in the elderly in the United States.” The authors took note that “a prototype clinical instrument is under development.”

- 11) Four years later, following the awarding of the patent and further refinement of the scanner, Bernstein struck again in the medical literature. Bernstein and Gellerman, sometimes writing with others, published three papers in quick succession in 2002.
- a. In the first, they noted that Raman signals correlated perfectly with carotenoids content. They asserted, “The Raman technique is objective and quantitative

²³ Svilaas A, et al. Intakes of antioxidants in coffee, wine, and vegetables are correlated with plasma carotenoids in humans. J Nutr. 2004 Mar;134(3):562-7.

²⁴ Bernstein P et al. Raman detection of macular carotenoids pigments in intact human retina. Invest Ophthalmol Vis Sc. 1998 Oct;39(11):2003-11.

and may lead to a new method for rapid screening of carotenoids pigment levels in large populations at risk for vision loss...²⁵

- b. A second paper confirming the measurement of carotenoids in the living primate eye was published in *Methods of Molecular Biology*.²⁶
- c. Their third paper²⁷ looked at Raman measurement of macular carotenoids in normal subjects and compared them to levels in age-related macular degeneration patients. It was published in the leading journal of its field, *Ophthalmology*. Their conclusions agreed with the hypothesis, which they asserted again, that “low levels of lutein and zeaxanthin [two major carotenoids in the human macula] may represent a pathogenic risk factor for the development of AMD [age related macular degeneration].” They further asserted that “Resonance Raman measurement of macular carotenoids pigments could play an important role in facilitating large-scale prospective clinical studies of lutein and zeaxanthin protection against AMD, and this technology may someday prove useful in the early detection of individuals at risk for visual loss from AMD.”

12) The move from the use of the scanner to detect carotenoids noninvasively in the eye, all the way to using the scanner to detect total body carotenoids levels by scanning the hand was complete in 2000. This was a run up to the patent application for the scanner and served to establish the baseline science behind it. In an amazing article, Hata et al, writing in *Journal of Investigative Dermatology*, correlated the carotenoids score determined by Raman spectroscopy (the BioPhotonic Scanner) to levels of carotenoids obtained from tissue specimens of human skin removed from people in abdominoplasty procedures.²⁸ The experimental subjects were having abdominoplasty and had levels of carotenoids measured on skin removed from their abdomen using standard high-performance liquid chromatography. This was cross-referenced with carotenoids levels obtained from other areas of their skin using the BioPhotonic Scanner.

The “set up” of this paper and the research is remarkable. First, in their abstract, the authors note that “carotenoids are thought to play a significant part in the skin’s anti-oxidant defense system, and *may help prevent malignancy*.”

²⁵ Gellermann, Bernstein et al. In vivo resonant Raman measurement of macular carotenoids pigments in the young and the aging human retina. *J. Opt Soc Am A Opt Image Sci Vis*. 2002 Jun;19(6):1172-86.

²⁶ Bernstein, Gellerman. Measurement of carotenoids in the living primate eye using resonance Raman spectroscopy. *Method Mol Bio*. 2002;196:321-9.

²⁷ Bernstein, et al. Resonance Raman measurement of macular carotenoids in normal subjects and in age-related macular degeneration patients. *Ophthalmology*. 2002 Oct; 109(10):1780-7.

²⁸ Hata et al. Non-invasive Raman spectroscopic detection of carotenoids in human skin. *J Invest Dermatol*. 2000 Sep; 115(3):441-8.

They then note: “inability to measure skin carotenoids content readily has, however, made it difficult to establish the relationship between carotenoids concentration and the occurrence of cutaneous malignancy.” In other words, it’s been impossible to measure skin carotenoids unless you want to sacrifice a large piece of your skin for it to be prepared for examination with HPLC. Most people are unwilling to do that, no matter how interested they would be in learning their “skin carotenoid scores.” It is also unreasonable to expect people to part with a piece of their flesh for a casual screening for health status. Since the abdominoplasty patients were going to be parting with large hunks of their flesh anyway – under total anesthesia - it was not a disincentive to participate in the experiment.

The authors look back to what has been done when they assert: “we have measured in vivo [in living tissue – eyes, specifically] carotenoids concentration using a noninvasive optical method, Raman spectroscopy.”

They then state the purpose of their paper: “***To validate our instrumentation***, abdominoplasty skin was evaluated by both Raman spectroscopy and high-performance liquid chromatography determination for carotenoids content.” In other words, this is going to be a paper about whether or not skin carotenoids scores are valid – obtained with Raman laser spectroscopy (the BioPhotonic scanner), when they are compared with skin carotenoids scores obtained by actually taking hunks of tissue from people’s bodies, macerating it, liquefying it, and then analyzing it with HPLC.

This is how they did it: “Evaluation of the Raman signal in specific carotenoids solutions was also performed [from the abdominoplasty patients]. Precision of Raman measurements within skin sites, within subjects, and between subjects was measured. Sensitivity of the method was evaluated as a function of anatomical region and the distribution of carotenoids within the stratum corneum.”

During their investigation, they *also* compared total levels of carotenoids at the exact site of actinic keratoses (pre-cancerous lesions) and basal cell carcinoma lesions with the levels of skin surrounding the lesions ***as well as the exact same sites on the bodies of age matched controls.***

Their results were astonishingly crisp:

- a. “Our results indicate that the Raman scattering method reflects the presence of carotenoids in human skin and is **highly reproducible.**” [In other words, it correlated extremely well with carotenoids levels obtained from the “pieces of tissue” method.]
- b. “Evaluation of five anatomical regions demonstrated significant differences in carotenoids concentration by body region ***with the highest carotenoids concentration noted in the palm.***” [This established the palm as the body site from which measurements would be taken.]
- c. In looking at risk factors for skin cancer and the presence of precancerous lesions, they note: “Comparison of carotenoids concentrations in basal cell carcinomas, actinic keratosis, and their perilesional skin demonstrate a

significantly lower carotenoids concentration than in region-matched skin of healthy subjects. These results represent the first evidence that carotenoids concentration in the skin correlate with the presence or absence of skin cancer and precancerous lesions.

13) One year later, Ermakov et al, writing with Gellerman, published “Resonance Raman detection of carotenoid antioxidants in living human tissues” in the journal Optics Letters.²⁹ In their abstract, they assert: “We have used Resonance Raman scattering as a novel noninvasive optical technology to measure carotenoids antioxidants in living human tissues of healthy volunteers. By use of blue-green laser excitation, clearly distinguishable carotenoids Raman spectra superimposed on a fluorescence background are obtained. The Raman spectra are obtained within less than a minute, and the required laser light exposure levels are well within safety standards. Our technique can be used for rapid screening of carotenoids levels in large populations and may have applications **for assessing antioxidant status and the risk for diseases related to oxidative stress.**” [Note – they are asserting broadly that this is not just about “carotenoids in the skin”, but, rather, is relevant for all disease states which are related to decreased antioxidant capacity.]

In this paper, they cite the work of Boileau and colleagues³⁰, who had previously reviewed an inverse correlation between high dietary intake of carotenoids and the risk of various cancers, cardiovascular disease, and degenerative diseases – and not just simply skin cancer. In other words, the higher your diet in carotenoids, the less likely your chances are for these diseases.

They took note of the fact that they had already used their scanner to measure carotenoids levels in the skin, retina, oral cavity, and other tissues of the body.

These investigators specifically noted that in human skin, the five most concentrated carotenoids antioxidants are lycopene, alpha-carotene, beta carotene, phytoene, and phytofluene, with lycopene and the carotenes accounting for 60 – 70% of total carotenoids content.

They again took note of the difficulty – not to mention pain and suffering – of obtaining skin carotenoids scores with previous methods: “The standard technique for measuring carotenoids is high-pressure liquid chromatography. This chemical method works well for the measurement of carotenoids in serum (blood) but is difficult to perform in tissue, **since it requires biopsies and processing of relatively large tissue volumes.**”

The authors scrupulously describe their methods and the science behind Raman

²⁹ Ermakov, et al. Resonance Raman detection of carotenoid antioxidants in living human tissues. Optics Letters. 2001 Aug 26(15):1179-1181.

³⁰ Boileau T et al. in Antioxidant Status, Diet, Nutrition, and health. A.M. Paps, ed. (CRC Press, Boca Raton, FL, 1999), p. 144

spectroscopy in this paper. Among other things, there is a careful review of why the palm has been chosen as the best site for scanning:

- a. Carotenoid levels in the palm are among the highest found in skin (because carotenoids are lipophilic and palm skin has a high lipid/protein ratio);
- b. Differences in pigmentation among various skin types are minimal in the palm;
- c. The stratum corneum thickness of the palm (approximately 400 micrometers) is high compared with other skin sites. Thus, the laser penetration depth in this skin layer, which is highly scattering, confines the measurement to this layer – the stratum corneum. As such, it decreases variability of the scoring.

Their conclusions: "...resonance Raman scattering appears to be a *feasible optical technique for the measurement of carotenoids antioxidants in living human tissue*. **It is precise, accurate, specific, and sensitive. Most importantly, it is noninvasive and suitable for clinical studies.** Pending a careful calibration of our measurement with that determined by high-pressure liquid chromatography, it should be possible to replace the highly invasive chemical method with a completely noninvasive and quantitative optical alternative. The laser excitation power used on our experiments is well below safety standards and can be easily increased to permit nearly real-time data collection. Our Raman technique may become a useful method to evaluate the correlation between tissue carotenoids levels and risk for malignancies or other diseases associated with oxidative stress."³¹

- 14) In their most recent paper, in the Nov-Dec 2005 issue of Journal of Biomedical Optics³². Ermakov and colleagues reviewed the main results achieved with Raman spectroscopy thus far. They take note of the fact that "initially we applied the method to the detection of macular carotenoids pigments, and more recently to the detection of carotenoids in human skin and mucosal tissues." They review the selection of the human palm as the ideal site for scanning. Summarizing the literature and the clinical findings using the BioPhotonic scanner to date, they assert: "These experiments reveal that carotenoids are a good indicator of antioxidant status. **They show that people with high oxidative stress, like smokers, and subjects with high sunlight exposure, in general, have reduced skin carotenoid levels, independent of their dietary carotenoid consumption.** We find the Raman technique to be precise, specific, sensitive, and well suitable for clinical as well as field studies. The noninvasive laser technique may become a useful method for the correlation between tissue carotenoid levels and risk for malignancies or other degenerative diseases associated with oxidative stress."

This is a remarkable assertion, because **it crisply relates low skin carotenoids**

³¹ Ermakov et al, 2001, loc cit.

³² Ermakov IV, et al. Resonance Raman detection of carotenoids antioxidants in living human tissue. J Biomed Opt. 2005 Nov-Dec;10(6):064028

scores with the presence of oxidative stress, and not just the consumption of dietary carotenoids. Their forward looking conclusion also addressed the correlation between tissue carotenoids levels and the actual risk for malignancies **in general** – and not just in terms of skin cancers. It also specifically addresses “degenerative diseases” – which include atherosclerosis, dementias, etc., all of which have literature to support the role of oxidative stress.

15) Finally, if one searches the database of the National Library of Medicine on the topic of “Raman spectroscopy with carotenoids with antioxidant” there are 169 citations found as of August, 2006. The more general search on “Raman spectroscopy with antioxidants” yields 224 papers. Obviously, not all are specifically relevant to humans and total antioxidant status, but a number of them are well worth reviewing.

Historically, it is fascinating to trace the history of Raman spectroscopy before it was used in its current form and patented at the University of Utah. It was been used at the very foundation of its recent patent development to study carotenoids in the eye.

- 1) Looking outside the eye and the skin as far back as 1998, and at the University of Texas, Raman spectroscopy was used for the clinical diagnosis of cervical precancers via a fiber optic probe.³³
- 2) Going back even further to 1992, in a much earlier form before the BioPhotonic scanner and its immediate precursors were designed, Raman spectroscopy was used as a diagnostic technique in separating diseased and normal biomedical media.³⁴ The authors concluded that: “A comparison of the intensity differences between various Raman modes as well as the number of Raman lines, enables one to distinguish normal GYN [gynecological] tissues from diseased tissues.”

Following the granting of the patent in 2001, further research on the clinical relevance of the scanner was performed by Pharmanex. In a paper published in-house by one of their chief scientists, significant data points were obtained correlating scan scores with fruit and vegetable consumption, smoking, and LifePak usage.³⁵

- **1,375** subjects entered into the population study, drawn from the ranks of NuSkin Enterprises, the parent company of Pharmanex.
- The mean score of these subjects was 19,072 Raman units, with a standard deviation of 8,828 units. The lowest measurement obtained was 1,556 units;

³³ Madadevan-Jansen, A. Development of a fiber optic probe to measure NIR Raman spectra of cervical tissue in vivo.. Photochem photobiol. 1998 Sep;68(3):427-31.

³⁴ Liu CH, et al. Raman, fluorescence, and time-resolved light scattering as optical diagnostic techniques to separate diseased and normal biomedical media. J Photochem Photobiol B. 1992 Oct 30;16(2):187-209.

³⁵ Smidt, C. Clinical screening study: use of the Pharmanex ® BioPhotonic scanner to assess skin carotenoids as a marker of antioxidant status. Pharmanex, LCC, 75 West Center Street, Provo, UT. 2002

- the highest level was 73,416. The majority of the subjects (68%) fell between 10,244 and 27,900 Raman units for the “Skin Carotenoid Score.”
- There was, as expected, a pronounced, positive relationship between fruit and vegetable consumption which was reported and the BioPhotonic measurements:
 - i. 1 or less serving/day netted a score of 16,827 +/-6,725
 - ii. 2-3 servings/day : 19,669 +/-8,557
 - iii. 4 -5 servings: 23,997 +/- 12,648
 - iv. 6 or more servings: 25,377 +/- 12,953 units
 - 562 subjects – a little less than half – also provided urine specimens for an MDA test³⁶. There was a linear, stair step progression upward toward optimum (low) levels of MDA as the scan scores increased. In other words, the higher the BioPhotonic scanner score, the less evidence of oxidative damage and stress on the system.
 - Smoking had the opposite effect: non-smokers had the highest scan scores on average: approximately 20,000. The more one smoked, the lower the scan score... all the way down to a mean of 11,593 for five or more cigarettes per day. Smoking and its antioxidant burden is well known³⁷; it is only logical to suspect that the scan scores would have gone down, but the dramatic almost two-fold difference is startling.
 - Finally, there was a strong and obvious correlation between the use of LifePak® supplementation and skin carotenoid measurements. Subjects who routinely consumed two packs of LifePak® supplements³⁸ at the recommended dosage of one packet twice daily measured 61% higher than those not using LifePak (p<0.001). In general, these routine LifePak users had about the same BioPhotonic skin measurements as people who reported eating more than five servings of fruits and vegetables daily. Statistical analysis showed no confounding variables related to any significant changes in fruits or vegetables consumed by the study subjects.

Several obvious conclusions arise from this clinical study. First, the usual things that one associates with changes in total body antioxidant status correlated with the scan scores. If you smoked, you scanned less. If you ate more fruits and veggies, you scanned higher. And

³⁶ a relatively well known but non-specific test of urine to determine levels of malondialdehyde – a known marker for oxidative stress and presumptively indicative of either low levels of antioxidants, high levels of oxidative stress, or both.

³⁷ Lesgards JF et al. Assessment of lifestyle effects on the overall antioxidant capacity of healthy subjects. *Environ Health Perspect.* 2002 May;110(5):479-86. Notably, Lesgards and colleagues also found *nonsmoking, vitamin and/or mineral supplementation, and regular physical activity were closely associated with **increased** overall antioxidant status; tobacco smoking, psychologic stress, alcohol consumption, moderate vegetable, low fruit, and low fish consumption were all associated with **decreased** antioxidant capacity.* High natural ultraviolet light was associated with decreased antioxidant capacity to a lesser degree.

³⁸ This formulation was the best of its time, but inferior to the current LifePak Nano.

if you took two packets of LifePak per day, you scanned 61% higher. Thus, two positions were established:

- 1) The BioPhotonic scanner obtained scores which were logically what one would predict based on known models of oxidative stress and the dietary use of higher consumption of fruits and vegetables; the “skin carotenoid score” appeared to be an **excellent** biomarker of antioxidant status.
- 2) Taking Pharmanex LifePak supplements improved the scores 61%. If one admits to the validity of the BioPhotonic scanner as a measurement of levels of oxidative stress, then the fact that the scan scores went up on LifePak supplementation shows that the supplements don't just “raise skin carotenoid scores” but contribute to the total antioxidant status of the body.

A follow-up study by Smidt, this time looking exclusively at scan score increases as a function of LifePak supplementation, produced similar results.³⁹ 25 healthy volunteers were recruited and supplemented their diet with LifePak for 12 weeks. BioPhotonic skin carotenoid readings increased significantly from a baseline value of 18,828 units to 32,175 units at the end of the study. This increase was not related to any changes in fruits or vegetables consumed throughout the study period.

Indeed, a previous study by Smidt and colleagues in 1999⁴⁰ examined functional effects of LifePak® supplementation rather than scanner scores for a very simple reason: there was no scanner in existence at the time! Other ways had to be found to determine if the supplements were performing. Looking back at this study and then correlating it with new studies produces remarkable clarity at the interface between the BioPhotonic Scanner as a piece of measuring technology and the use of LifePak supplementation as something that is worth measuring. It is also pleasing to note that one of the three centers for this study was at GFI Pharmaceutical in Evansville, IN. The other two were the University of California at Davis Medical Center and the Pharmanex Research Institute in Provo, Utah.

In this 1999 study, Smidt and colleagues evaluated lipid peroxidation as a function of LifePak supplementation, and they concomitantly measured changes in plasma levels of ascorbic acid, beta-carotene, alpha-carotene, and alpha-tocopherol along with a **functional measurement** of antioxidant status: decreased LDL-oxidation. In a cross-over study involving 50 healthy non-smokers, 25 patients were placed on LifePak and 25 received placebo for six weeks. An intervening wash-out period of six weeks was interposed between the first six weeks and the final six weeks, where the groups were crossed over or “flipped.”

Their findings included the following:

³⁹ Smidt, C. Effect of LifePak supplementation on antioxidant status using BioPhotonic Raman spectroscopy. Pharmanex, LLC, 75 West Center Street, Provo, UT 84601, 2003.

⁴⁰ Smidt, CR et al. The effects of a nutritionally complete dietary supplement (LifePak®) on antioxidant status and LDL-oxidation in healthy non-smokers. Federation of American Society for Experimental Biology. 1999;13(4). Pharmanex Clinical Study Report published February 23, 2000.

- LifePak supplementation (1999 formulation) prolonged the time to LDL oxidation from 43 minutes to 51 minutes – an increase in 18%
- Ascorbic acid levels were increased 38%
- Alpha-carotene levels were increased 678%
- Beta-carotene levels were increased 114%
- Alpha-tocopherol levels were increased 84%.

Their conclusions, not surprisingly, were that LifePak “significantly increased antioxidant status, and decreased LDL oxidizability in healthy non-smokers.”

Finally, and most recently, these results were replicated in a large scale, multi-center, double-blind, placebo controlled study.⁴¹ The results are unfortunately not yet published. This study included 155 non-smokers, ages 18 – 65 recruited in the Houston, Texas area. 75 subjects received supplementation with LifePak in a double-blinded fashion, and 75 subjects received placebo “dummy” packets made up to look exactly the same. Blood and urine samples were taken at the start and end of the supplementation period and analyzed for vitamin C, vitamin E, carotenoids, and vitamin A, as well as serum oxygen radical absorption capacity, as well as markers of free radical damage: serum total alkenals hydroperoxides, urinary alkenals, 8-hydroxyguanosine, and 8-epiPGF. Plasma samples were prepared for LDL oxidizability assays.

An exact 18% prolongation of lag time of LDL oxidizability resistance was again obtained, with other results including increased total serum oxygen radical absorption capacity by 5%. The conclusions were: “LifePak ® supplementation for 6 weeks significantly increased antioxidant status, reduced serum alkenals, and improved LDL resistance to oxidation in healthy non-smokers consuming typical U.S. diets.”

REVIEW OF THE EVIDENCE OF THE LITERATURE:

In looking at the preponderance of the evidence in the medical literature, it is important to note that the BioPhotonic scanner, in its current iteration, comes from an honorable and multi-decade long progression from bench science to patented invention. Raman spectroscopy has been used in everything from ascertaining pathological gynecological tissue and precancerous lesions, to assessing risk factors in the retina for macular degeneration as a function of carotenoid levels, and finally to its current design where a quick two minute scan of the palm of your hand will reveal your current antioxidant status to a remarkably accurate degree.

⁴¹ Smidt CR, et al. Double-blind, placebo-controlled study of the effects of LifePak ® supplementation on antioxidant status, free radical activity, and resistant to LDL-oxidation. [unpublished – abstract provided reference from Pharmanex, Provo Utah]

There is also abundant evidence that Pharmanex LifePak supplements, based on their formulation, significantly and potently increase antioxidant levels as evidenced not only by skin carotenoid scores, but direct analysis of blood levels of Vitamins C and E, as well as alpha and beta-carotene. Perhaps most significantly, the supplements actually **perform** in terms of functionally reducing LDL-oxidizability. Evidence abounds, reading the literature syntopically and as an integrated whole, that the Raman index, or the “Skin Carotenoid Score,” is a legitimate and extremely valuable approximation of total body antioxidant status.

FINAL QUESTIONS & NEWS UPDATES:

Finally, the question remains: Why not just eat more carrots and tomatoes to raise your skin carotenoids scores? Wouldn't that be sufficient?

Indeed, you could raise the Skin Carotenoid Score measured by the BioPhotonic Scanner by eating lots of carrots and lots of tomatoes. This would be, as Martha Stewart used to say, a “good thing.” My advice would be to eat as many as you possibly can, as well as green vegetables and cruciferous vegetables. However, the weight of the literature is against you in terms of being able to get all of your nutrients up to the US recommended “RDA’s” from diet alone, even with lots of veggies on your plate. Additionally, simply driving up your antioxidant score with determination, and avoiding the trace minerals and elements, plus B-vitamins and all the other antioxidant vitamins (C, and E), as well as neglecting the vitamins and minerals required for bone health would simply be stupid.

In the 1996 survey of the United States Department of Agriculture looking at how much of the required nutrients Americans get from their diet, the problem of pervasive lack of adequate nutrient intake was identified: [not one person in the 5,188 people surveyed nationwide in the USDA review on “Continuing Survey of Food Intakes by Individuals” got 100% of the recommended daily allowances for all vitamins and nutrients](#), including Vitamin A. Between 1994 and 1996, the USDA viewed the population in the same study. [Of 16,103 people nationwide who participated, again, there was no one that got 100% of all vitamins and nutrients required](#). The highest percentage was B-12, of which 82.8% of the population met the RDA. The lowest was the mineral Zinc, of which only 26.6% got enough. [Worrisomely – and representing a tragedy waiting to happen, only 66.8% of the population had adequate amounts of folate](#), the one critical nutrient required to prevent spina bifida in children. All too commonly, the pregnancy is conceived and is well underway before women become aware that they are pregnant and need to be on prenatal vitamins. The damage is already done. [These references from United States Department of Agriculture Agricultural Research Service Web site.⁴²]

Rather than exclusively eating lots of carrots or tomatoes, it appears reasonable that supplementation with a good, solid multivitamin would be recommended. Indeed, the bastion of conservative anti-holistic medical practice, the *Journal of the American Medical Association*, finally featured a paper in 2002, where the authors, Drs. Fletcher and Fairfield,

⁴² <http://www.ars.usda.gov/Services/docs.htm?docid=7716>

noted that “suboptimal intake of some vitamins, *above levels causing classic vitamin deficiency*, is a risk factor for chronic diseases and **common in the general population**, especially the elderly.⁴³ They specifically note that “suboptimal levels of vitamins B6 and B12 are a risk factor of cardiovascular disease, neural tube defect, and colon and breast cancer, and that low levels of vitamin D contribute to osteopenia and fractures, and that low levels of the antioxidant vitamins (Vitamins A, E, and C) [no mention of the carotenoids, unfortunately – Cady] may increase risk for several chronic diseases.” Their recommendation: **“Pending strong evidence of effectiveness from randomized trials, it appears prudent for all adults to take vitamin supplements.”** The presence of this statement in the Journal of the American Medical Association represents nothing less than a tectonic shift in its previous stance that “people should be able to get all of the vitamins and nutrients they needed from diet alone” – even though that position flew in the face of all scientific evidence to the contrary, including the USDA CSFII reports previously cited.

And, as Smidt and colleagues substantiated in 1999, eating lots of carrots and tomatoes will most likely not raise your carotene levels 114 to 678%, nor your vitamin C levels by 38% nor your alpha-tocopherol levels by 84%.⁴⁴

The original “LifePak” supplementation multivitamin antioxidant system was developed before the BioPhotonic Scanner came into existence, and it was conceived and formulated based on what should be in a multivitamin supplement that would reproduce what would be in the system of people eating a diet high in fruits and vegetables. The formulation has been enhanced with new “Nano” technology to increase the absorption of antioxidants and carotenoids, including such critical nutrients as Coenzyme Q10.

Compared to other nutritional companies, Pharmanex has the largest amount of scientists on its payroll of any other nutraceutical company in existence. There are 125 scientists listed⁴⁵ on its website, by name, specialty, and location. The Pharmanex scientists are divided into Clinical Pharmacology, Chemistry Group, QA/QC, and R&D Group – Provo, as well as at Zhejiang Cinogen Pharmaceutical Company (Huzhou, China), the Information Group in China, the Raw Material Sourcing scientists, the Business Development scientists (scanner), and the Global Product Support scientists in Taiwan, the United States, Hong Kong, Japan, Philippines, Thailand, Korea, Malaysia, Australia, Belgium/Central Europe, Norway/Scandinavia, and Singapore. It is a multinational company with two research centers in China and one in the United States.

CONCLUDING COMMENTS:

⁴³ Fletcher RH, Fairfield KM. Vitamins for chronic disease prevention in adults: clinical applications. JAMA. 2002 June 19;287(23)3127-9.

⁴⁴ Smidt et al. FASEB 1999. Loc. cit.

⁴⁵ http://www.pharmanex.com/corp/pharmanews/scientists_fulllist.shtml - searched August 27, 2006

The clinicians and CWI, as well as me personally, have used and frequently recommend supplements from other companies in addition to those from Pharmanex. All of us will continue to do so. To presume that there is a one source, simplistic answer for every nutritional, neuroendocrinologic, or detoxification problem that walks through our doors is naive. At CWI, we frequently treat patients who have failed to get better every place else.

However, Dr. Whitney Gabhart, ND – the naturopathic physician and educational consultant at CWI and I, as well as multiple staff members are taking LifePak Nano as the foundational nutritional support program that we use. My personal antioxidant score varies in the high 60,000 to low 70,000 range based on dietary choices, LifePak Nano supplementation, and several other supplements that I take. Until late fall of 2008, I hadn't had an upper respiratory infection in three years – quite a run given the amount of commercial airline flying I've done.

In considering the “price:performance” proposition of other multivitamin offerings compared to Pharmanex, there are several pitfalls: there is no other product that has a specific “performance guarantee” that it will do anything measurably in improving your health. As well, every other nutritional supplement company is shut out of rapid measurement and assessment of the performance of their products by Raman spectroscopy for a live biomarker tissue measurement because only Pharmanex holds the patent rights to do so.

It is objectively unknown to me if the high-dollar supplements from the premium nutraceutical companies would perform as well as those from Pharmanex. I doubt it. Their formulations do not include the significant amount of specifically targeted antioxidants that the Pharmanex preparations include, and there is simply no objective, countervailing evidence that they would perform in this area. My personal experience from personally numerous people taking supplements from the other “MLM” companies is more direct: their products do not significantly increase antioxidant levels as measured by the Skin Carotenoid Score.

The situation becomes even more interesting when one considers the chemical and formulating “ancestry” of the current LifePak line of supplements. The first human who was not a clinical patient or a research subject, Nathan Ricks, took one packet of the forerunner of LifePak every day for eight years before he sat with his hand in front of the scanner prototype at the Cancer Research Institute of the University of Utah. He scanned at 48,000 – the highest scan ever recorded at that time.⁴⁶ It is clear that the scientists formulating the original LifePak products were clearly on the right track with their focus on antioxidant supplementation at the time, in addition to adequate supplementation of all other necessary vitamins and minerals. Further research, development, and acquisition of new technologies and delivery systems has only served to solidify their position as the market leader.

Since the time that Pharmanex acquired the scanner rights and deployed it for the first time in the United States in 2003, a novel “feedback loop” has been set up between people taking Pharmanex supplements, a questionnaire about which and how many of the supplements the person takes *that is completed while the person is being scanned*, and the integration of that information with ongoing scan scores by *frequent uploading of data to the company*. This

⁴⁶ Ricks, Nathan. Personal communication with Louis B. Cady, M.D., August, 2006.

data base correlates what the person is being “fed” in terms of supplements, (as well as dietary intake of fruits and vegetables), body mass index, consumption of other supplements, and change in scan scores. In that sense, people on the LifePak supplement line (as well as other specific Pharmanex products) continue to serve as valid sources of data to allow the Pharmanex scientists to see if their current vitamin formulations are raising BioPhotonic Scanner scores as they intended. It is also worth noting that these scan scores are extremely important to the company, and not just from a point of academic interest: if the antioxidant levels do not rise as measured by the skin carotenoid score in two months, Pharmanex refunds every penny paid for supplements over the preceding two months. Based on my survey of steadily increasing scan scores of patients that I place on these supplements, I suspect that the day is rare indeed when anyone qualifies for a refund.

Since the integration of the **formulate-feed-scan-reformulate** scenario with the arrival of the BioPhotonic Scanner, Pharmanex subsequently acquired the patent rights to formulate their latest supplement line, LifePak Nano™, with “nano-ized” versions of the carotenoids as well as Coenzyme Co-Q10, rendering them even more capable of raising skin carotenoid (and antioxidant) levels. This appears to be validated in reports of recent scan score “jumps” when people switched from the standard LifePak line to the “Nano-ized” version. Thus far, as of late fall 2008, no other nutritional supplement maker has a line of “nano-ized” multivitamins, and it is unlikely that they will have them in the near future since Pharmanex has secured the patent rights to that technology, as well.

The scanner, itself, has been updated. The original scanner used a laser to elicit the Raman shift effect, took nearly an hour to calibrate, would only stay in calibration for four hours, and was very sensitive to temperature fluctuation. The second version⁴⁷, or “S2” came out in 2006, and featured the replacement of the laser with an easier to calibrate high intensity monofrequency LED light source, was easier to calibrate, and would stay in calibration for five days. The third version, or “Everest” version⁴⁸ because it was developed by Pharmanex for a research project to measure antioxidant levels of Sherpas on a climb up Mt. Everest⁴⁹, became available in 2007. A major software upgrade is pending in January of 2009, which should make the BioPhotonic Scanner even more useful in collecting and organizing data.

In the final analysis, and specifically in considering the needs of the patient, only a few questions legitimately remain in terms of obtaining life-tissue measurements of antioxidant status and then deploying a performance guaranteed complete and balanced multi-vitamin, multi-mineral, multi-trace element, and multi-antioxidant system:

- “What is in the best interest of the patient/client?”
- “What is the relevant science published in the peer-reviewed medical literature?”
- “What can I personally do in my practice that is the patient’s/client’s best interest?”

⁴⁷ http://www.pharmanex.com/corp/library/pdf/pip/s2_scanner.pdf

⁴⁸ http://www.nuskinenterprises.com/en/library/pdf/scannerS2_factsheet.pdf

⁴⁹ <http://www.vmdsonline.com/pharmanex>

Perhaps the most uplifting way to terminate this discussion is to review the concept of “doing right by your patient,” summed up by William J. Mayo, M.D., in 1935⁵⁰: “Perhaps the ability not only to acquire the confidence of the patient, but to deserve it, to see what the patient desires and needs, comes through the sixth sense we call intuition, which in turn comes from wide experience and deep sympathy for and devotion to the patient, giving to the possessor remarkable ability to achieve results.”

I believe that as long as we as clinicians balance the competing claims of various companies (who also wish us to use their products and services) on the fulcrum of science and a veneration for the integrated and balanced opinion of the peer reviewed medical literature, we will be able to make the correct, logical choices to promote the health and welfare of our patients.

And, in the final analysis, that’s all that really matters.

[see following page for in-depth discussion of the Raman Effect]

⁵⁰ Mayo, Charles Horace. Aphorisms of Dr. Charles Horace Mayo, 1865-1939, and Dr. William James Mayo, 1861-1939. Mayo Foundation for Medical Education and Research, Rochester, MN, 1988.

The Raman Effect
By Vishwas Purohit –
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<http://www.buzzle.com/editorials/4-1-2005-67909.aspb>



The Raman effect, a scattering of a portion of monochromatic light when it is passed through a transparent substance, is the counterpart for visible light of the Compton effect for the X-rays. The American experimental physicist Robert Williams Wood considered it 'one of the most convincing proofs of the quantum theory of light'. In addition to the light of the original frequency, the spectrum of the scattered light contains weaker lines (Raman lines) differing from the original frequency by constant amounts and due to the gain or loss of their energy experienced by the photons because of their interaction with the vibrating molecules of the substance through which they pass.

Since no two compounds have the same Raman Spectrum and since the intensity of a Raman line of a substance is proportional to its concentration, Raman spectroscopy can be used in qualitative and quantitative analysis. It is also employed in the elucidation of the structures of molecules, the study of the interactions between molecules and the calculation of thermodynamic properties.

Much information about a molecule can be deduced from its Raman spectrum. For example, for a diatomic molecule the effective moment of inertia in the lowest vibrational energy state and from this the effective inter-nuclear distance for this state can be obtained. Because homo-nuclear molecules such as H₂ and N₂ have no permanent dipole moment, they yield no pure rotational or vibrational infrared spectrum and therefore can be studied only by their Raman effect (although electronic spectra can yield rotational spectra). From an analysis of the vibrational-rotational bands there can be obtained the classical vibrational frequency of the diatomic molecule, the moments of inertia and inter-nuclear distances for higher vibrational states, the force constant, the dissociation energies, the zero point energy, the potential energy curve as a function of the inter-nuclear distance, and the rotational and vibrational energies needed for thermodynamic calculations.

Raman spectral data can also be used to detect interactions between molecules. For example, if hydrogen bonding is present, Raman displacements corresponding to C single bond H and C double bond O vibrations appear at values much lower than their normal values. The weakness of the scattered radiation has been the greatest deterrent to the widespread adoption of Raman spectroscopy as an analytical technique. Since the more intense the primary radiation source, the greater the intensity of the Raman spectra, the advent of lasers transformed this method of largely academic interest into a highly practical, powerful tool with a number of commercially available instruments and installations in many industrial laboratories. If Raman were alive today, he would undoubtedly be amazed and pleased by the multifaceted uses now made of his 'new' radiation.