

Sunlight for Your Health:

A Special Interview with Dr. Michael Holick

By Dr. Joseph Mercola

DM: Dr. Joseph Mercola

MH: Dr. Michael Holick

DM: Sunlight: we all feel better when we're exposed to it, but do we know the reasons why? Hi, this is Dr. Mercola helping you take control of your health. Today I am joined by Dr. Michael Holick, an expert in vitamin D. He will help us understand those reasons.

But before we go on to the lecture, Dr. Holick, that you're going to share with us in the PowerPoint presentation, I'm wondering if you could... Because there are many people, who amazingly don't know of you yet, if you could expand on your background and your history. You've got so many credentials and appointments that it's really amazing. If you could provide that information for us, it would be greatly appreciated.

MH: Sure. I happened to be in the right place at the right time. I knew I wanted to be a physician or a scientist. I went off to the University of Wisconsin and worked with Dr. Hector DeLuca on vitamin D. At the time, vitamin D was thought to be a hormone or a vitamin found in cod liver oil to prevent rickets in children. It wasn't really very interesting or exciting. Then, we began to realize that it took a long time for vitamin D by itself to have its biologic actions. So, I embarked on looking at human blood to see if there was a vitamin D metabolite present. I identified 25-hydroxyvitamin D as the major circulating form of vitamin D, which you now can ask your doctor to measure to determine your vitamin D status.

I went on and got my PhD by identifying the active form of vitamin D known as 1,25-dihydroxyvitamin D. I'm an organic chemist, and my roommate and I were the first to chemically make the act to form a vitamin D, which was used to treat bone disease and kidney failure patients. Because we realized that kidneys activate vitamin D. The reason for the bone disease was they couldn't properly activate it.

DM: And that's available as a prescription drug, right? [It's] Rocaltrol.

MH: That's correct.

DM: Yeah.

MH: And then, I became interested in understanding how do you make vitamin D in your skin. So I worked out basically all of the methods to determine time of days, season of the year, latitude, degrees, skin pigmentation, and obesity on this vital cutaneous process. Then I also realized that the skin had a vitamin D receptor. What that means is that the active form of vitamin D was working in the skin, and I wanted to know why. It turns out that active vitamin D inhibits skin cell growth and modulates it in a very important way.

I then realized that maybe you could use it to treat a very common hyperproliferative skin disorder, [which is] psoriasis. I basically introduced the concept, in the mid-'80s, of topically applying active vitamin D to treat psoriasis. That's really one of the first lines of treatment for psoriasis worldwide. Then

I've done lots of other studies looking at how vitamin D is absorbed by the body and its impact on your health.

DM: On that vitamin D for psoriasis, I'm wondering, prior to your deploying that advancement, if they were using sunlight for the treatment of psoriasis.

MH: They were using ultraviolet B (UVB), which produces vitamin D in your skin. It may be one of the ways that UVB radiation that psoriasis patients are exposed to. It's the reason that works. But they also used what's called PUVA, which is psoralen that you would take as a pill followed by ultraviolet A (UVA) radiation.

DM: Okay, good. Maybe you can provide us with the list of your academic credentials and appointments. I believe you were... Were you a chairman or president of American Endocrine Society?

MH: Sure. I was chief of Endocrine, Diabetes, and Nutrition at Boston University Medical Center from 1987 until 2000. I'm the director of Bone Health Care Clinic. I'm a professor of Medicine, Physiology and Biophysics at Boston University Medical Center. I'm also the director of the Heliotherapy, Light, and Skin research lab here at the university.

DM: Okay, terrific. You were, I guess earlier this year, asked to give a presentation overseas on the benefits of sunlight for health, and you shared that. I was just incredibly impressed with the information that you compiled. Maybe you can sort of give us a primer before we go into the presentation you have for today.

MH: Sure. The primer is that when you're exposed to sunlight, all of the sun's energy is hitting your skin. Over the past 40 years, we've been taught that you should never be exposed to one direct ray of sunlight because it's going to cause skin cancer and damage your skin. But I think what they didn't appreciate is that when you're exposed to sunlight, there's a lot of important biologic processes and chemical synthesis that are going on in your skin.

The presentation that I gave, it gave an overview of not only how vitamin D is produced in your skin but also the impact that sunlight has on helping to make you feel better, helping to regulate blood pressure, and a whole variety of other biologic processes. All because when you're exposed to sunlight, you do make very important biological chemicals in your skin that have important health benefits.

DM: This is distinct from actually swallowing the vitamin D as a capsule, which is why I was so impressed with this presentation. Because there are many people who believe that the sunlight is the best way to optimize your vitamin D levels, and then swallowing pills is a poor second choice but one that unfortunately the vast majority of population has no alternative in the winter months.

MH: Correct. But in spring, summer, and fall, it's very wise to take advantage of sensible sun exposure, and we'll talk about how you can do that in the presentation. Because you're right, that not only does it make vitamin D in your skin but also beta-endorphin, which makes you feel better. [There's also] nitric oxide, which can help lower your blood pressure, and a whole host of other chemicals that you would never obviously get just simply by taking the vitamin D supplement.

DM: Okay, great. Thank you for that introduction. Maybe we can proceed into the presentation now.

MH: Sure. I think the presentation really is "Sunlight for Your Health". I think that, like I said, public's view of the sun over the past 40 years has been never to be exposed to one direct ray of sunlight because if you are, you're at high risk for skin cancer as well as other skin damage including wrinkling. So there's an evolution in thinking about sun exposure, which is in the '50s was the two-piece bathing suit, in the

'70s, was the one-piece bathing suit, and in new millennium now, everybody is wearing lots of sunscreens, a lot clothing, and preventing themselves from being exposed to any direct sunlight.

So the bottom line is education. It's important to realize that when you're exposed to sunlight, you're exposed to huge amount of energy that's penetrating into your body. It's also important to know that the atmosphere absorbs most of the damaging radiation that the sun is releasing including x-rays, gamma radiation, and ultraviolet C (UVC) radiation.

So, when you look at the solar spectrum for how much UV is actually coming in to planet Earth, it's a very tiny amount. And of all of the energy that's coming in from sunlight, a very tiny amount of less than one percent is responsible for making vitamin D in your skin, estimated at about 0.1 percent ultraviolet B radiation, which is responsible for making vitamin D results during sun exposure on the surface of your skin.

There are two forms of UV radiation that reach the Earth's surface, UVA and UVB. The UVB has higher energy than UVA. UVB has lower wavelength but higher energy. The reason that's important is that you would think that the UVB, which has the highest energy, would penetrate deeply into your skin. But it turns out that it doesn't. The reason is that the protein, DNA, and other chemicals in your epidermis absorb UVB radiation very efficiently.

UVA radiation, on the other hand, is not as absorbed efficiently so it penetrates deep into your dermis and can cause skin damage including cross-linking of your collagen matrix increasing the risk for wrinkling. Bottom line is that the increased wave length and decreased energy means you have deeper penetration of this radiation into your body. In fact, when you're exposed to sunlight, the visible light, like red light and green light, could actually penetrate into your body cavity. We don't yet fully understand what is the effect of that on the human body and on human health.

One of the responses, of course, to skin when exposed to sunlight is that your melanocytes begin to make melanin, which is a natural sunscreen. What happens is that the UVB penetrates into the epidermis and that your melanocytes sit right between your epidermis and dermis. That signal tells your melanocytes to make packets of sunscreen called melanin or melanosomes, and they rise up into the epidermis and they begin to coat all of the very important, sensitive components of your cell, mainly the nuclide of your skin cells. By doing so, it acts as a very effective sunscreen.

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UV exposure also, of course, will cause cross-linking of your DNA. We think that maybe some of that cross-linking activity is actually the signal to the melanocyte to make more melanin. You also have enzymes in your skin that help to break apart these DNA that formed together.

DM: The cross-linking ones? So those enzymes repair the damage, the cross-linking?

MH: Correct, exactly. In fact, the Nobel Prize was given in Chemistry for some of that research that was done to begin to understand that when you're exposed to sunlight and you get this cross-linking of your DNA, these enzymes are there specifically to repair that DNA. If you look at the solar spectrum and you look at what radiation is responsible for causing sun burning and what radiation is causing vitamin D production, as you'll see from the slide, in fact, the erythema occurs principally right at about the peak level of where the vitamin D is being produced as well.

At noon time, about 15 percent of the redness of your skin occurs from UVA exposure but 85 percent is from the UVB. UVA will cause sun burning independent of UVB radiation. The bottom line, of course, and the message that I've always been giving is never want to get a sun burn. That's the most damaging to your skin, increasing risk for skin cancer as well as wrinkling.

Can sunlight damage the skin? I mean, I don't think there's any question that excessive exposure, especially on the top of your hands and of your face, can cause what's called actinic keratosis. These are called pre-skin cancers. If you're constantly getting overexposure to sunlight, they can definitely become either basal or squamous cell carcinomas. These are skin cancers that are usually easy to detect and they're easy to treat. But, of course, everybody worries about melanoma. Melanoma is the deadliest skin cancer. It turns out that most melanomas occur on the least sun exposed areas. It turns out also that the occupational sun exposure decreases risk for melanoma.

The story for the lack of sunlight and its health consequences really began with the industrial revolution. In the 1600s and 1700s, children living in Glasgow, Scotland, throughout most of England in the industrialize cities, developed severe bone disease, [which is] rickets. It was a Polish physician, Jędrzej Śniadecki, in 1822, who recognized something, and that is that he was seeing children that lived in Warsaw. These children had a high incidence of rickets. But the children that lived in rural areas outside of Warsaw didn't. He concluded, in 1822, the strong and obvious influence of sun on the prevention and cure of rickets. This association study basically went unrecognized for 100 years. It would take more than 100 years to appreciate that insight, that sun exposure by itself can cure rickets.

It turns out that also Dr. Niels Ryberg Finsen began to realize that patients with tuberculosis (TB) of their skin when exposed to sunlight and higher intensity light could actually cause dramatic remission in their disease. TB was incredibly common over 200 years ago and even at the turn of the last century. It was a major observation that actually resulted in him getting the Nobel Prize, in 1903, and lupus vulgaris, which is known as TB infection of the skin, was effectively treated.

Also, people at that time, essentially in Europe, were starting to believe that exposure to sunlight has health benefits known as heliotherapy or phototherapy. Upwards of about 165 different diseases were related to lack of sun exposure and that included arthritis, psoriasis, kidney problems, asthma, and the list goes on.

Rickets, at the turn of the century... For example in Boston, about 80 percent of children had rickets that caused bowing of the legs and stature was not as good because it caused growth retardation. It was a Viennese physician, in 1919, who realized that you could actually take children and expose them to radiation from a mercury arc lamp and demonstrated very nicely that he could cure rickets. This then led quickly to the use of ultraviolet lights in hospitals throughout Europe and in the United States as a way of helping to prevent rickets in children.

As the result of Kurt Huldshinsky realizing that when you expose children to radiation from a mercury arc lamp could cure rickets, this led two physicians in New York City, Hess and Unger, to take some children, put them on the roof of their hospital, and demonstrate several months later that the rickets was healed. This was the first clear demonstration that exposure to direct sunlight had a health benefit to children i.e. to help treat and prevent rickets. This led to a novel concept.

In 1931, the US government actually set up an agency and sent out brochures to parents encouraging them to expose their infants to sunlight. In fact, it suggested in the advertisement that was sent out, in the brochure, to give the baby a coat of tan. Sunlight, health and growth were heavily promoted. Indeed, mercury arc lamps were readily available in pharmacies especially in Northeastern United States and throughout most of Europe. A parent would go to a local pharmacy and buy one of these lamps. They would have their children wear eye protection, and they would expose their abdomen and arms to this radiation in order to prevent them from getting rickets.

In the meantime, at the University of Wisconsin, Dr. Harry Steenbock realized that if you're going to irradiate people and animals to prevent rickets, why not irradiate the food. So he introduced the concept of adding the precursor of vitamin D to milk and demonstrated that the milk had antirachitic activity. As a

result of that, with the fortification of milk with vitamin D, it basically eradicated rickets as a health problem throughout the United States and in countries that use that practice.

Does sunlight have beneficial effects? What about the good? Well, the production, of course, of vitamin D is good. But also people, when they're exposed to sunlight, feel better. We also know, of course, that sunlight will regulate your circadian rhythm, and that seasonal affective disorder (SAD), which probably affects about 40 percent, or so, of children and adults can be a serious health issue.

Sunlight makes you feel good. When you're exposed to sunlight and you're directly exposed to sun in the summertime, all of those UVB photons are able to get through the atmosphere and some of them reach the Earth's surface and you make vitamin D in your skin. But we went on to show that in the winter time, the sun's rays are more oblique. It has to go through more ozone, and the question was, "Does this have any effect on vitamin D synthesis in your skin?" We went on to show that basically, if you live above Atlanta, Georgia, then you cannot make any sufficient vitamin D in your skin from about November through February. In Boston...

DM: Is there an exception to that? What I learned when we were together is that if you're at elevation, the altitude makes a difference because there's less ozone or less atmosphere for it to penetrate.

MH: Yes, and there's no question about that. We did a study at the base camp of Mt. Everest. Dr. Edward Sauter worked with us. He was on his way up to base camp so we gave him some samples to expose in Agra, which is at sea level, and then all the way up, up to base camp. We could show, in Agra, India, where the Taj Mahal is located, in November, they could not make any vitamin D. But at about 15,000 feet, they were able to make robust amounts of vitamin D. So you're correct. It's that the less atmosphere that you have to go through, the more vitamin D you can produce.

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It was also curious that in Switzerland, it was known back 100 years ago, that if you lived above about 5,000 feet altitude, in the Swiss Alps, that you would not get TB, whereas if you lived below that, you were at high risk for getting a TB infection.

We went on to show that, in fact, in winter time, basically, if you live above Atlanta, Georgia, you make no Vitamin D. Even in Florida, even in Miami, you only make about 10 to 20 percent of the vitamin D that you would make in the summer time. We've also been taught to go out in the early morning and late afternoon to go jogging, make your vitamin D. It's less damaging to your skin. It turns out probably to be one of the worst times to be outside because you're getting blasted by UVA radiation, which can alter your immune system and maybe even increase risk for melanoma. But you make essentially no vitamin D.

Vitamin D is basically made in your skin from about 10am until 3pm for the same reason that you only make vitamin D in the spring, summer, and fall. Because in the early morning and late afternoon, the sun's rays are more oblique and they are absorbed by the ozone layer. As a result, you don't make vitamin D in your skin.

How much do you want to be exposed to sunlight? Of course, we did a study. We took healthy adults and we put them on our tanning bed, in a bathing suit. If they get what's called a "minimal erythema dose," a light pinkness to your skin 24 hours later, and then gave we them an oral dose of vitamin D to see what that was equivalent to. We found that it's equivalent to about taking 15,000 to 20,000 units of Vitamin D. The body has a huge capacity to make vitamin D in your skin. In fact, we went on to show that if you're exposed to a tanning bed for half the time, it would cause a mild sun burn. Just a couple of times a week, it was more effective than taking a thousand units of vitamin D a day, and this is for skin types two, three, and four. So these are people that had relatively dark skin tone.

So does sunlight provide you with your vitamin D requirement? It turns out that even a very nice study in Denmark showed their peak blood levels are always at the end of the summer and the lowest levels are always at the end of the winter. So what I typically recommend, as kind of rule of thumb, is if I know I'm going to get a mild sunburn after being exposed to sun, say in June, at noontime, for about 30 minutes, then I go out for about 10 to 15 minutes, arms, legs, abdomen, and back when appropriate, and always wear sun protection on the face. After that exposure, now put some protection on or wear more clothing to prevent the damaging effects from excessive exposure.

What about skin pigmentation? I always kind of compare Pelé to his girlfriend. Pelé, who's a superb soccer star with very dark skin, would have to be outside four to 10 times longer to make the same amount of vitamin D as his Caucasian girlfriend. The reason is that melanin is a wonderful natural sunscreen, and it absorbs ultraviolet light coming into your skin. As a result, it markedly reduces the efficiency of the skin to produce vitamin D.

We also asked the question, "Why do people feel well when they're exposed to sunlight?" Is it possible that when you're exposed to sunlight that you make a happy substance that makes you feel better? Of course, the happy substance that most runners know, for the runner high, is beta-endorphin. Several studies have been done including studies by my own lab, looking at whether or not exposure of skin cells to ultraviolet light can actually enhance the production of beta-endorphin. When we did a study and looked at both UVA and UVB, it was mainly UVA plus UVB that was able to stimulate your epidermal cells known as keratinocytes to make beta-endorphin.

The obvious next question is, "Does it enter your bloodstream?" A very nice study that was done at Massachusetts General Hospital showed that when they took healthy adults and exposed them to UVA and UVB, they could increase beta-endorphin levels in the blood by about 44 percent. We believe that when you're exposed to sunlight, especially ultraviolet B radiation, you're producing beta-endorphin in your skin, it enters into your circulation, and probably going to your brain. It's basically the endogenous opioid. It makes you feel better.

Studies have also been done by Dr. Andrzej Slominski, again, showing very nicely, taking people and exposing them to ultraviolet light and demonstrating when they took a biopsy that beta-endorphin was being produced. So we have a variety of different types of studies that provide very strong evidence that when you're exposed to sunlight...

Probably one of the reasons you feel better is you're making beta-endorphin in your skin. It also, of course, gives you a feeling of relaxation in stress and helps in pain management. So there are a lot of different benefits from beta-endorphin being produced in your skin that often is not completely appreciated. Even, there have been studies to look at depression, whether when exposed to sunlight do depression levels decrease. This is possibly due to the production of beta-endorphin in your skin. At least one of the studies was very suggestive that that was in fact the case.

We also know, of course, that when you're exposed to sunlight, it's the blue light coming through your eyes that regulates your circadian rhythm and it goes through the pineal gland and what is doing is it's decreasing the production of melatonin, which is a hormone that can help you sleep. For people with seasonal affective disorder, one of the major causes is their inability to be able to appreciate the intensity of sunlight coming in, in the fall and winter months. As a result, they're unable to suppress their melatonin levels. Because their melatonin levels are constant throughout the day, they want to sleep all the time, and they get depressed.

We're now recognizing that bright light therapy about 10,000 lumens for about 30 minutes to an hour, in the morning, is quite effective in helping to suppress melatonin levels; therefore, makes people feel more awake and have less of these seasonal affective disorder symptoms that would otherwise occur.

But one of the other questions that I was curious about was, “If you’re exposed to sunlight on your skin and not through your eyes, is it possible that your skin cells also have biologic clocks that possibly your skin cells actually know when they’re being exposed to sunlight and what the time of day is?” I had a look at that. Well, it turns out that there are studies that have been done, for example, even in fruit flies. They have what are called transcription factors. These are factors that are made by the cell to help regulate nuclear activity and expression of genes, and these are called clock genes or period genes. A study that was published many years ago, in *Science*, showed that even fruit flies have these clock genes spread throughout their entire body.

So, with that information, I decided to do a study, and to simply have exposed human-cultured skin cells to ultraviolet A and ultraviolet B radiation, and to look at whether or not we could see by, what’s called immunofluorescence, the increase in the production of these so-called circadian rhythm genes, clock and period genes. What we’re able to show very nicely is that the Period 1 gene was markedly increased in its production just by being exposed to ultraviolet B radiation. Similarly, the alpha-clock gene was as well.

What about hypertension? It turns out curiously that blood pressure is higher in the winter time than it is in the summer time, and that there is this seasonal effect. So when you feel better in the summer time, you’re more relaxed and that certainly could be one of the explanations for why your blood pressure is lower in the summer time. So we did a study and what we did was to ask the question since we knew that vitamin D seemed to have an effect on blood vessels. Is it possible that when you’re exposed to sunlight you’re making vitamin D in your skin and that vitamin D that eventually is getting activated is helping to regulate your blood pressure?

So we took healthy adults and put them on our tanning bed that we have in our clinical research center here at the university. We exposed them to the tanning bed UVB radiation. Then, what we did was we put a plastic filter over the lamps so it blocked out the UVB and exposed healthy adults to this radiation to act as a control. What we found was that those that were exposed to UVB radiation raised their blood levels of 25-hydroxyvitamin D, which is a measure of your vitamin D status by about 100 percent.

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The UVA group, there was no change in their blood level. So we’re confident that the study design was appropriate, and that we’re looking only at the effect of increasing the production of vitamin D as it related to the blood pressure. What we found was the systolic and diastolic blood pressure decreased by as much as 6 millimeters of mercury. Those exposed to UVA radiation, there was no benefit at all. From this study, we believe that, yes, when you’re exposed to sunlight and you’re making vitamin D, it does have effects, probably causing vascular relaxation, and therefore helping to lower your blood pressure.

That’s consistent with a lot of other data that’s out there to show that peripheral vascular disease has been associated with vitamin D deficiency. About 80 percent reduced risk of having peripheral vascular disease, if you simply are vitamin D sufficient at 25-hydroxyvitamin D level of greater than 30 nanograms per milliliter.

The Framingham Heart Study showed that those that were vitamin D deficient are at 50 percent higher risk of having a heart attack. So we think that vitamin D is playing a very important role in cardiovascular health. But also, it turns out that the skin can also make nitric oxide. Nitric oxide, of course, got a lot of publicity because it’s basically how Viagra works. It causes vasodilation of blood vessels.

There have been several studies to show that when you’re exposed to ultraviolet light, that skin cells produce nitric oxide. It also turns out that nitric oxide has a lot of other health benefits. It can induce melanin production. It can alter immune function. It can enhance wound healing. It has antimicrobial

effects. The production of nitric oxide in the skin, when you're exposed to sunlight, has a lot of biologic effects.

Also, we now begin to realize that when you're exposed to sunlight, that part of the hemoglobin molecule releases actually carbon monoxide. Carbon monoxide, in very tiny amounts being released, actually can cause vasodilation. Again, it can reduce your blood pressure. It can act as a neurotransmitter. It can have effects on your nervous system. It causes relaxation, and it has anti-inflammatory activity.

What is the effect of vitamin D on the immune system? It's known that those that live at the lowest latitude have the least risk of developing multiple sclerosis (MS). Of course, multiple sclerosis is an autoimmune disease. We also know that if you live above Atlanta, Georgia for the first 10 years of your life, you have 100 percent increased risk of developing multiple sclerosis for the rest of your life, no matter where you live on this planet.

Studies have been done, one particularly at Harvard, in the Nurses' Health Study, and they showed that nurses had the highest intake of vitamin D. It reduced their risk of getting multiple sclerosis later in life by 41 percent. Studies have also shown, curiously, in a mouse model that kind of mimics multiple sclerosis, that if you gave these mice... If you made them vitamin D deficient, you gave some mice vitamin D and you gave some mice just ultraviolet D radiation to produce vitamin D and also to have other effects like producing nitric oxide, beta-endorphin, and other chemicals, is that it was more effective in reducing the development of multiple sclerosis in these mice than vitamin D treatment alone. This exposure to sunlight, yes, it's important for vitamin D production but probably has a lot of other biologic effects that we're only now beginning to uncover.

We also are recognizing that there's a gene in your pituitary gland called POMC, which is the pro-opiomelanocortin gene. This gene that's in your pituitary gland is also found in your skin cells. Dr. Slominski showed very nicely that when exposed to UVB radiation, that gene is turned on. Why is that important? That gene is part of the reason that you release beta-endorphin because a piece of that gene that is being transcribed will produce beta-endorphin. But it also produces adrenocorticotrophic hormone known fondly as ACTH. Why is it important? Because this hormone goes to your adrenal glands and it tells your adrenal glands to make cortisol, which can help to modulate your immune system. It also has other effects including regulating other types of inflammatory activity.

Studies have been done to show, for example, that ACTH given to rheumatoid arthritis patients and multiple sclerosis patients can help them in their treatment. It may be that one of the explanations for why there's a reduced risk for rheumatoid arthritis with being exposed to sunlight and reduced risk of multiple sclerosis living at lower latitudes is in part due to production of ACTH, which can modulate your immune system and can therefore have less autoimmune activity that's responsible for these two diseases. In fact, the study was done, again, in Iowa, showing that women who had the highest intake of vitamin D reduced the risk of rheumatoid arthritis by about 44 percent.

Type 1 diabetes is a major health issue for children and for young adults, right? It's a loss of being able to produce insulin by the beta islet cells in your pancreas. Again, curiously, if you live at the equator, you have a 15-fold less likelihood of developing type 1 diabetes than if you live in the far North such as in Scandinavian countries. It turns out that a study was done in Finland, back in the 1960s. Finland realized that they were high risk of their children having vitamin D deficiency, and they didn't want them to get rickets.

Back in the 1960s, they were giving children, during the first year of their life, 2,000 units of vitamin D a day. Dr Elina Hypponen decided to actually follow those children for 31 years and ask the question, "For children who were getting 2,000 units of vitamin unit a day, what was its impact on them getting type 1

diabetes?" She reported in *The Lancet*, back in 2001, an 88 percent reduced risk of getting type 1 diabetes simply by being on 2,000 units of vitamin D a day during their first year of life.

But then, all of a sudden, experts became concerned that vitamin D at these levels was going to cause toxicity. In Finland, they decreased that to 1,000 units. In the '80s, in the '90s, and in the new century, they decreased it to 400 units a day. You'll see on this slide, this marked increase in type 1 diabetes incidents and you have to wonder if it's due to the fact that they decreased vitamin D intake in these infants during the first year of life.

Other effects on immune system... It turns out that the immune cell known as the macrophage, which is basically like a Pacman or a Pacwoman of your immune cell system, it gobbles up infectious organisms, viruses, and bacteria. The question has always been, "How does it relate to vitamin D?" Because it was known that back in the 1850s, they were giving cod liver oil to patients that had tuberculosis. They found that they actually responded to cod liver oil therapy. We know that activated macrophages, believe it or not, can activate vitamin D just like what the kidneys do. The question is why.

Like I said, back in the 1849 or 1850, it was reported that cod liver oil was effective in helping to treat TB. So vitamin D was reported to protect against TB. This also led, of course, to the use of solariums at the turn of the last century for helping patients with TB. We now know why Dr. John Adams and Dr. Robert Modlin and [inaudible 39:43] did a very nice study. What they showed was that if you take a macrophage and you infect it with a tuberculosis bacteria, the first thing that the cell does is it turns on its genetic machinery in order to activate vitamin D. Why? Because activated vitamin D goes back into the nucleus and tells the nucleus to make a defensive protein, which is known as cathelicidin, and that protein now will glob on to the bacteria and cause it to die.

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So now, we're beginning to understand why vitamin D is so important in helping to fight infectious diseases. It also turns out that the study done at Yale University, that adults who have the highest blood levels of 25-hydroxyvitamin D at 38 nanograms per milliliter reduced their risk of getting upper respiratory tract infections by about 50 percent.

Separate from the Yale study that showed that improvement in your vitamin D status reduces risk of upper respiratory tract infections in adults, like I said, by almost 48 percent, a study was done in Japan where they gave school children, during the winter time, 1,200 units of vitamin D a day, just during the winter time. They measured their blood to see what their potential was for developing influenza A infection and also evaluated them clinically and showed a 42 percent decreased risk of developing influenza A infection simply because they were taking 1,200 units of vitamin D a day.

They also showed very nicely that when they looked at as manic attacks that occurred often in these children during winter time, it reduced asthmatic attacks by as much as 90 percent. So, vitamin D was very effective in helping to reduce risk for influenza A infection.

There's been good evidence that vitamin D may help to cause relaxation of your respiratory tract. As you know, asthma is a constriction of the muscles in the respiratory tract making it difficult to breathe. There is some good evidence that vitamin D is playing a role in how the immune system is causing the release of substances that causes these constrictions. There's been an association to suggest that improvement in vitamin D status especially in pregnant women and in young children reduces risk of raising infections and asthmatic attacks during those first few years of life.

It also turns out that if you look at the spectrum of sunlight and what is responsible for causing redness to your skin or sun burning, it occurs in the UVB range. If you look at what the sunlight is responsible for causing some DNA damage, that occurs in UVA range. If you look at what's called reactive oxygen

species (Dr. Mercola talks about a lot about this - using antioxidants to help in your health), again, it's in the UVA range, as you could see on the slide.

DM: Excuse me for a moment. Is that related to what you've mentioned earlier because the UVB, even though it has more power, it doesn't really penetrate deeply because it's absorbed by the superficial cells?

MH: Correct. So, what UVA is doing is it's penetrating into your dermal capillary bed in your dermis having effects on your immune system. Vitamin D, of course, is produced in the UVB range. But a lot of immunosuppression occurs in the UVA range. Again, it's for the reason that we just discussed, that UVA is penetrating more deeply through your epidermis, into your dermis, and affecting the dermal capillary bed where your immune cells are present and also where your immune cells lie in your dermis. The thinking is that not only does exposure to sunlight make vitamin D that has regulatory properties on your immune system but the UVA radiation does as well. It's probably playing a role in helping to reduce risk for autoimmune diseases.

There are other studies that have now been done to show other health benefits of vitamin D separate from what we've talked about. They're now beginning to use red lasers and blue lasers to affect collagen activity in your dermis. There have been studies to show that the effect of red, and even infrared light, is pretty effective in reducing wrinkling and fine lines, and to improve your intradermal collagen density. Blue light has been shown to do the same thing. Studies have also shown that it enhances wound healing. There are a variety of biologic effects of light on the skin that are above and beyond vitamin D.

But what about the rest of the story for vitamin D? Like I said, once you make it in your skin, it gets activated in your liver to 25-hydroxyvitamin D. Major circulated form is the form that you ask your doctor to measure to determine your vitamin D status, and then it goes to your kidneys. It gets activated to 1,25 dihydroxy Vitamin D.

We knew, back in the 1970s and 1980s, that your intestine, bone, and kidneys... These are the organs that regulate calcium metabolism and have what's called the vitamin D receptor. These vitamin D receptors interact with the active form, unlocks genetic information to then cause you to increase intestinal calcium absorption, to help you in mobilizing calcium from the skeleton, and to conserve calcium in the kidneys. We began to realize in the 1980s and 1990s that not only do these cells and tissues have a vitamin D receptor but your colon, prostate, breast, brain, heart, and blood vessels, just to name a few, also contain a vitamin D receptor. So the obvious question is why.

One of the first pieces of scientific evidence was developed by Dr. Toshio Suda, back in 1979. What he showed was that if you took a leukemic cell that had a vitamin D receptor and incubated it with the active form of vitamin D, that leukemic cell became normal. It transformed back into a normal cell. This began to introduce the concept. Maybe some of these association studies suggesting that exposure to sunlight reduces your risk of cancer may be related to vitamin D. In fact, one of the early association studies that was done was in 1950, if you can believe it, where they showed that if you were indoor working and living in San Diego, you had eight times higher risk of developing a deadly cancer and dying of that cancer than if you work outdoors such as navy personnel working on a ship.

Can sun bathing, which is a very popular concept back in the 1930s and 1940s, cut your risk of cancer? In fact, a study was done by Dr. Frank Apperley, published in 1941. He realized that if you lived in the Northeast, you are more likely to die of cancer than if you lived down South. He thought, at the time, that it's obvious why. Because if you live down South, you're going to get some skin cancer, which is easy to detect and easy to treat. He reasoned that skin cancer is easy to treat [because] you develop an immune system to that cancer. Now, you have an immune system that is possibly able to control all cancers and suggested that that was the mechanism that actually caused a decreased risk of developing cancer for those who had the most sun exposure.

In the 1990s, the Garland brothers began to realize that, yes, the higher the latitude that you live, the higher was your risk for colorectal cancer as well as ovarian cancer and a variety of other cancers. They then began looking at the literature and concluded that if you simply increase your vitamin D intake to 1,000 units a day, you could potentially reduce your risk of developing colorectal cancer by as much as 50 percent. A study done at the Nurses' Health Study at Harvard showed that nurses that had the highest intake of vitamin D maintained a blood level 25-hydroxyvitamin D of about 50 nanograms per milliliter reduced their risk of getting breast cancer by about 48 percent.

A very nice study was done in Canada where they showed that if you, as a young girl or a young woman, had the most sun exposure compared to women that wore sun protection all the time or worked indoors all the time, those who had the most sun exposure, as teenagers and young adults, had a 69 percent reduced risk in breast cancer later in life. Women of 20 to 29 years of age, who had the most sun exposure, reduced that risk by about 51 percent. By the time they were in their late 40s and early 50s, there was no benefit.

This shows that, I think very clearly, that exposure to sunlight or sensible sunlight exposure, throughout your life, really helps reduce risk of deadly cancers later in life. Even Dr. William Grant, who had worked for National Aeronautics and Space Administration (NASA) for many years and is now retired, showed very nicely that the more sun exposure that you had, as both for woman or as a man, you had less likelihood of dying. There was a reduced risk for mortality by those who had the most sun exposure. We believe that's principally due to both reduced risk for cancer as well as cardiovascular disease, which I'll be talking about in a minute.

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What is this association? How is it possible that exposure to sunlight and improving your vitamin D status could reduce your risk of cancer? Well, you would think it's simple, right? The kidneys activate vitamin D. I've already told you that activated vitamin D inhibits cancer cell growth. So you would argue that if you are exposed to a lot of sunlight or if you're making a lot of vitamin D in your skin from sun exposure, your kidneys are making more active vitamin D, this anti-cancer agent, bathing your body in this anti-cancer agent reducing your risk, it doesn't work that way. The kidneys will only make active vitamin D to regulate calcium metabolism. If it made any more, your blood calcium will go much higher, you would start calcifying your blood vessels and your kidneys, and ultimately you could die.

The body cleverly designed a different way because this was a real conundrum. Until the mid-1990s, when we worked with Dr. Gary Schwartz and showed that human prostate cells, obtain at the time of prostate biopsy, had the ability to activate vitamin D, we then began to realize that there's a new major function of vitamin D that we haven't appreciated before, which is, yes, vitamin D is important for your bone health. But if you can raise your blood levels of 25-hydroxyvitamin D into healthy range of about above 30 nanograms per milliliter, now, this 25-hydroxyvitamin D can get activated in prostate, colon, breast, and brain, and this active vitamin D has the ability to regulate up to 2,000 genes in your body, either directly or indirectly. That's about one-sixth of the human genome. The question is...

DM: Let me stop you there for a moment. It's good thing. It's an important point. So it's not what was previously thought until your lab discovered it. It works systemically by increasing the activated vitamin D. But you proved that it work locally at the cellular level. Is that correct?

MH: That's what's key. That not only is it working in cellular level but what the body cleverly did was it activates vitamin D, say in your colon cell or your brain cell. Well, that activated vitamin D, if it ever got back into your bloodstream, it would now have an effect on your calcium metabolism, which would not be good. So what did the body do? It developed a system that as soon as activated vitamin D is produced in your colon, breast, or brain, it immediately induces its own destruction. So, it is made. It has its

positive biologic effects on your health, and it's already revved up its own destruction so it gets destroyed before it ever leaves the cell. That's clever of Mother Nature.

So, yes, you make active vitamin D in your kidneys for regulating calcium and bone metabolism. But now, we realized that a major new component of the vitamin D story is you're activating vitamin D locally in these cells and they're having all these effects on all your genes, and then the cell destroys it so it never gets into the bloodstream and it never has an effect on calcium metabolism.

How to prove the point? We did a study, and I think it's the first study that's ever demonstrated this. We asked a simple question, "How does your body know what your vitamin D status is?" Ultimately, it's your genes that know. What we did was we took healthy adults in the winter time, and we knew they were going to be vitamin D deficient.

We gave them 2,000 units of vitamin D a day or 400 units of vitamin D a day for a period of three months. We got their white blood cells at the beginning, before we gave them the vitamin D, and at the end of the study. We looked at how many genes were being expressed before they were getting vitamin D and after they were getting vitamin D. What we found, as you could see in this slide on the left-hand side, you see all these blue lines, these are all the genes that are turned off and are not working very well. On the right-hand side, you see all of these orange, yellow, and white genes. These are genes that are being turned on.

What we found was that after we gave 2,000 units of vitamin D a day, it improved the vitamin D status. The 291 genes totally changed their activity. A significant number that were not working at all suddenly woke up and started working. Many of the ones that were working, that were potentially damaging our health, all were shutdown. In fact, when we analyzed these 291 genes, they regulated more than 80 different metabolic processes including improving DNA repair, causing death of cells that are potentially becoming malignant, reducing oxidative stress on your cells, altering metabolic processes in a variety of ways, and increasing anti-inflammatory activity. So, my message is clear. Feed your genes right and improve your vitamin D status.

Bottom line for the vitamin D story is vitamin D deficiency is a disease of neglect. There's a mountain of evidence now linking vitamin D deficiency to chronic illnesses, some of which we haven't talked about including type 2 diabetes, neurocognitive dysfunction, cardiovascular disease (that I briefly touched upon), infectious diseases, common cancers, and autoimmune diseases have all been related to vitamin D deficiency.

What do you want your blood level to be? A study was done to ask the question, "What were our hunter-gatherer forefathers'?" How much vitamin D were they making? What was their blood level of 25-hydroxyvitamin D? A very nice study was done in Africa, in Maasai warriors, who are outside every day. They measured their blood level of 25-hydroxyvitamin D. Lo and behold, on average, it was about 48 nanograms per milliliter. So, between 40 and 60 nanograms per milliliter is what we consider to be the preferred range to be at for health.

The bottom line is that the Endocrine Society Clinical Practice Guidelines Committee that makes the recommendations to physicians how to treat or prevent vitamin D deficiency and healthcare professionals [say that] your level should be at least 30 nanograms per milliliter. Forty to 60 is a good range, and we know up to 100 is perfectly safe.

So, when you think about this and think about the disease burden worldwide regarding vitamin D deficiency... We haven't had time to really discuss the vitamin D deficiency issue, but bottom line is 40 percent of children and adults globally, whether they live in Australia, Brazil, Canada, United States, and Europe, 40 percent are deficient and 60 are insufficient. As a result, disease burden, low birth rate, stunted

growth, type 2 diabetes, hypertension, fracture, common cancers, infectious diseases, and autoimmune diseases, all are associated with vitamin D deficiency.

It's estimated that if you just improve vitamin D status worldwide, you could reduce healthcare cost across the board probably by about 25 percent. So we've always appreciated the beneficial effects of the sun and I showed this cartoon from *The New Yorker*, and it says, "Johnny, a spot of sunshine. Play in it and get your vitamin D." So, we've always appreciated that sunlight was important for vitamin D but I realized, back at the turn of the century, that people weren't getting the message. They were so fearful of the sun, always wearing sun protection. So I started promoting sensible sun exposure.

How did you get the message out to the public? Very much like what you do, I decided to write a book. In 2004, I wrote my first book for the general public, *The UV Advantage*, and discussed many of the health benefits of sun exposure that we've talked about. I also wrote a book more recently, in 2010, called *The Vitamin D Solution: A 3-Step Strategy to Cure Our Most Common Health Problems*, a three-part strategy to help prevent and treat vitamin D deficiency.

In the book, I also pointed out excessive sun exposure, [and that] sun burning experience increases risk for non-melanoma skin cancer, which is easy to detect and easy to treat. Yes, it is the most common cancer but it is easy to detect and easy to treat. But people worry the most, of course, about the deadly skin cancer, melanoma. It turns out that most melanomas occur on the least sun exposed areas, and occupational sun exposure actually decreases your risk for melanoma.

A study done in 2003 by Dr. Cornelis Kennedy's group and published it, saying that by contrast lifetime sun exposure appeared to be associated with the lower risk of malignant melanoma, *Journal of Investigative Dermatology*, 2003. I always like to point out that Charles Schulz really was a very thoughtful person and, I think, had great wisdom. One of his Peanuts character cartoons, here, Linus was getting a note from his mom saying, "Are you sitting in the sun? I hope so." A little sun is good as long as we're not overdoing it. Perhaps 10 minute a day. This time of the year is about right, and he was right on target.

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In this day and age, what we see is that people are wearing sun protection all the time. The Slip! Slop! Slap! message is: Australia has now estimated that 40 percent of children and adults in Australia are vitamin D-deficient. There was a study done by Australian dermatologists who were on vacation in summer time. They got their blood level and measure 25-hydroxyvitamin D, and 87 percent were vitamin D-deficient.

We know that the brain has a vitamin D receptor. The brain can activate vitamin D, and it plays a major role in neurotransmission. Vitamin D deficiency has been associated with cognitive dysfunction, increased risk for schizophrenia, Parkinson's disease, stroke, epilepsy, and even Alzheimer's disease. One study that was done showed that those who were most vitamin D-deficient had a relative risk of having neurocognitive decline by about 31 percent. The obvious question is, "Can you get enough vitamin D from your diet? Are there other health benefits of being exposed to sunlight?"

I hopefully convinced you that you basically cannot get enough vitamin D from your diet, only fish, cod liver oil, and mushrooms exposed to sunlight are the only sources. You get a little bit from dairy and now from orange juice, about 100 units in a serving. But we estimate that children, during their first year of life, the Endocrine Society Clinical Practice Guidelines recommends 400 to 1,000 units a day. For children who are one to 18 years of age, they [should get] 600 to 1,000 units. My preference, personally, for teenagers, it should be like adults, at least 1,500 to 2,000 units a day.

You cannot get this from dietary sources. So, what's the best source? Of course, it's sensible sun exposure. How do you know that? Well, it turns out that time of day, season of the year, latitude, degree of skin pigmentation, all have influences. So we develop an app, DMinder.Info. It will tell you anywhere on the globe, anytime of the year, and for any skin type, whether you can make vitamin D, how much vitamin D you're making, and it will actually warn you to get out of the sun so that you don't get a sun burn and you don't significantly damage your skin.

I'm always asked how much vitamin D do I take. I take approximately 4,000 units a day from all of my sources. My blood level on average is about 55 to 60 nanograms per milliliter. There's no question, I don't think, that lack of adequate sun exposure and vitamin D deficiency has a major health impact. In fact, many of these chronic illnesses that I've talked about, if any of them turned out to be associated with sunlight deficiency and vitamin D deficiency, there really is no downside to improving your vitamin D status just as what was done over 100 years ago when ultraviolet lights were used in hospital settings to help fight infections and to prevent rickets in children.

We did a study in tanners, in Boston and asked a simple question, "Does it have any impact on their health?" One of the best ways, of course, is just looking at bone mineral density. We looked at tanners who were exposed to at least to tanning beds at least once a week versus non-tanners, and looked at their blood levels of 25-hydroxyvitamin D in the middle of the winter. Tanners had robust healthy levels, on average of about 50 nanograms per milliliter. Non-tanners, those who never went to a tanning bed and basically were just having a couple of glasses of milk a day, their blood levels on average were about 18 nanograms per milliliter. When we looked at their bone mineral density, we showed that in fact, tanners had higher bone density in both their hip as well as in their lumbar spine.

Vitamin D does play a role in your bone health, and sun exposure helps to provide that. We think that the tanning or using a tanning bed that has UVB will improve your vitamin D status and improve your bone health. Also, consistent with the National Health Survey Data, it showed the higher your 25-hydroxyvitamin D, no matter whether you are Caucasian, African, American, or Hispanic, the higher is your bone density.

To summarize, if you look at the spectrum of sunlight that reaches the Earth's surface, UVB radiation is responsible for making vitamin D and certainly will cause sun burning if exposed to too much. It also improves beta-endorphin production in your skin that makes you feel better. The UVA radiation also produces beta-endorphin but it also modulates your immune system. It also produces nitric oxide and carbon monoxide that cause vascular relaxation and may improve wound healing and help fight infections among other biologic processes.

Blue light is certainly important for regulating circadian rhythm and suppressing melatonin levels in helping to improve your mood and have less symptoms of seasonal affective disorder in the winter time, so bright light therapy works. Now, more studies are being shown that red light, infrared light, and even blue light exposed to the skin can improve wound healing, can reduce wrinkling appearance, and has other biologic effects.

There is no downside, in my opinion, to improving your vitamin D status and getting some sensible sun exposure. I don't think we need to be a genius to know this, that we need sensible sun and vitamin D supplement recommendations. It's not a hypothesis, right? Even the World Health Organization (WHO) talks about sunshine and health, and says, "The sun's rays provide warmth and light that enhance your general feeling of well-being. It stimulates blood circulation. Some UV radiation is essential to the body as it stimulates the production of vitamin D. There is no doubt that a little sunlight is good for you."

I thank you very much for your kind attention.

DM: Terrific. Well, we really appreciate all your knowledge, wisdom, and years of effort in this field, to help us understand the full value, or at least highlights of the values, of being exposed to the sunlight on a regular basis in addition to the vitamin D benefits. Thank you.

MH: It's my pleasure. Thank for the opportunity, and have a delightful day.

[End]