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**Photobiology:**  
The Biological Impact of Sunlight on Health  
& Infection Control



*The Electromagnetic Spectra of Sunlight & Human Health*

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# Photobiology: The Biological Impact of Sunlight on Health & Infection Control



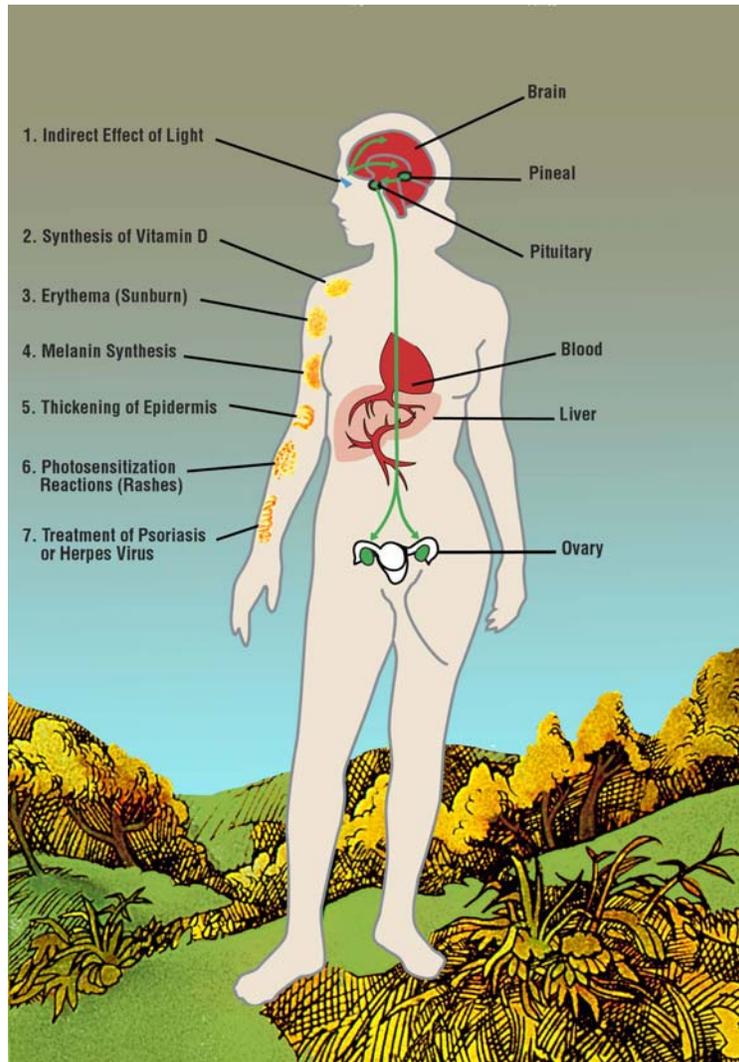
By Harry Braun  
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## Abstract

*Extensive clinical and published medical data has documented that a lack of exposure to specific ultraviolet (UV) wavelengths of sunlight can routinely induce profound pathological conditions in humans and other animals, including microorganisms. Ordinary window glass reflects or absorbs the biologically active UVB spectra of sunlight, and since the 1940s architects and engineers have been designing "sick" buildings with windows that cannot be opened -- or without windows at all. As a result, millions of urban inhabitants have been inadvertently sealed-off from the most energetic spectra of terrestrial solar radiation. The electromagnetic spectra that is provided by existing lighting systems filters out the most energetic UV spectra that are absolutely critical for the production of vitamin D3, the stimulation of the neuroendocrine system, and the destruction of Staphylococcus (Staph) and other microorganisms that can cause serious infections, amputations, and disease in over 2 million patients annually. Over 100,000 of those patients die from acquiring an infection they did not have when they entered the hospital. However, according to a paper published in Applied Microbiology, up to 97 percent of Staphylococci bacteria were destroyed after 8 hours of exposure to fluorescent lamps that were engineered to simulate the visible and non-visible UVB wavelengths of sunlight. As such, the infection control considerations are especially serious given that methicillin-resistant Staphylococcus aureus (MRSA) have become much more deadly while simultaneously acquiring an immunity to virtually all of the known antibiotics. Given that 80% of some hospital-acquired infections are now related to MRSA, and given how common Staph bacteria are, and how they are able to rapidly transfer their new genetic immunities to their fellow bacteria, a significant epidemic is highly likely. Given that such microorganisms have not been able to develop an immunity to the high-energy UVB spectra that exist in sunlight, or fluorescent lamps that accurately simulate sunlight, one of the most effective weapons to combat the spread of MRSA and other infectious microorganisms is to cure the "sick" building by specifying the use of lamps and fixtures that will accurately simulate the natural outdoor sunlight indoors.*

## Background

It has long been known that air, food and water are necessary prerequisites for life. However, extensive laboratory and clinical studies have clearly established that specific wavelengths of electromagnetic energy found in sunlight and exercise are additional environmental factors that directly affect metabolism, human health and productivity [please refer to references 1-14]. In terms of establishing priorities for these basic environmental variables, it is worth noting that without air, one could only survive for a few seconds or minutes. Without water, one could survive for about a week. If one has sufficient air and water but no food, an average person could be expected to live for up to 30 days without serious complications developing (Individuals who fast to death normally survive about 60 days). A lack of exposure to natural outdoor sunlight and exercise will contribute to a gradual degeneration of the body over a period of years, which will predictably result in disease, physical deformities and premature death. As such, proper exposure to the natural outdoor electromagnetic environment can have a profound effect on human health how well one feels on a day-to-day and hour-by-hour basis.



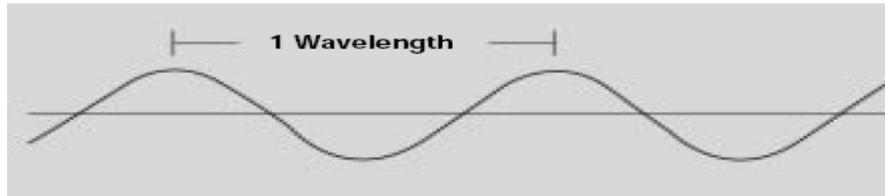
*"The Effects of Light on the Human Body"*

By Richard J. Wurtman, M.D., Ph.D., *Scientific American*, July 1975

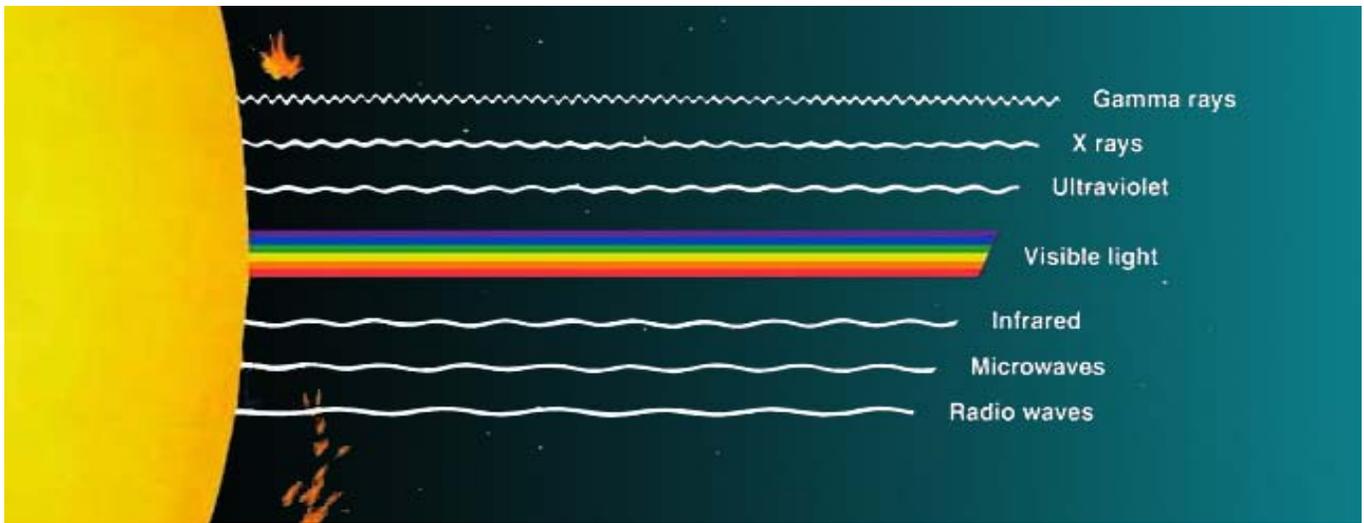
Some of the biological effects of sunlight, which refers to the visible and non-visible ultraviolet (UVA and B) wavelengths of electromagnetic energy, are shown above: (1) The eyes absorb high energy 290 nm UVB wavelengths that stimulate the neuroendocrine system (i.e., the pineal, pituitary and hypothalamus glands that are located deep in the brain) to secrete hormones that impact sexual development and psychological moods, including depression; (2) The skin also absorbs the UVB wavelengths that are needed to synthesize the production of vitamin D<sub>3</sub>, as opposed to the vitamin D<sub>2</sub> that is typically found in dairy products, which can be toxic and is poorly used by the body. According to Dr. Michael Holick at Boston University Medical Center, every cell in the body absolutely requires Vitamin D<sub>3</sub> and yet 90% of those tested in the U.S. had low vitamin D<sub>3</sub> levels of below 40 nanograms per milliliter; (3) Erythema (tanning) results from the secretion of (4) melanin; and (5) the thickening of the epidermis layers of the skin; (6) In some people, light impacts photosensitizers in the blood can cause skin rashes; (7) Sunlight can be used to treat psoriasis, herpes and other skin disorders, as well as Hyperbilirubinemia and neonatal jaundice in infants, a very serious condition whereby an excess amount of bilirubin in the blood destroys brain tissue in infants. Dr. Thomas Wang, a heart specialist at Massachusetts General Hospital, reported that individuals with low vitamin D levels had a 60% increase incidence of heart attacks and strokes, and according to an article in the March 2008 issue *Scientific American*, Drs. Luz Tavera-Mendoza and John H. White, described evidence of a link between vitamin D<sub>3</sub> deficiency and autoimmune diseases like multiple sclerosis (MS), which studies have shown can be controlled by increasing blood levels of vitamin D<sub>3</sub>.

### The Electromagnetic Spectrum

Sir Isaac Newton was the first investigator to separate visible light into its various component colors by passing the light through a glass prism. It is now known that sunlight is made up of a spectrum of electromagnetic energy units that Albert Einstein referred to as photons. The color and energy level of a photon is dependent on its wavelength; the shorter the wavelength, the higher the energy level. Wavelengths are measured in nanometers (nm), and one nm is one-billionth of a meter in length.



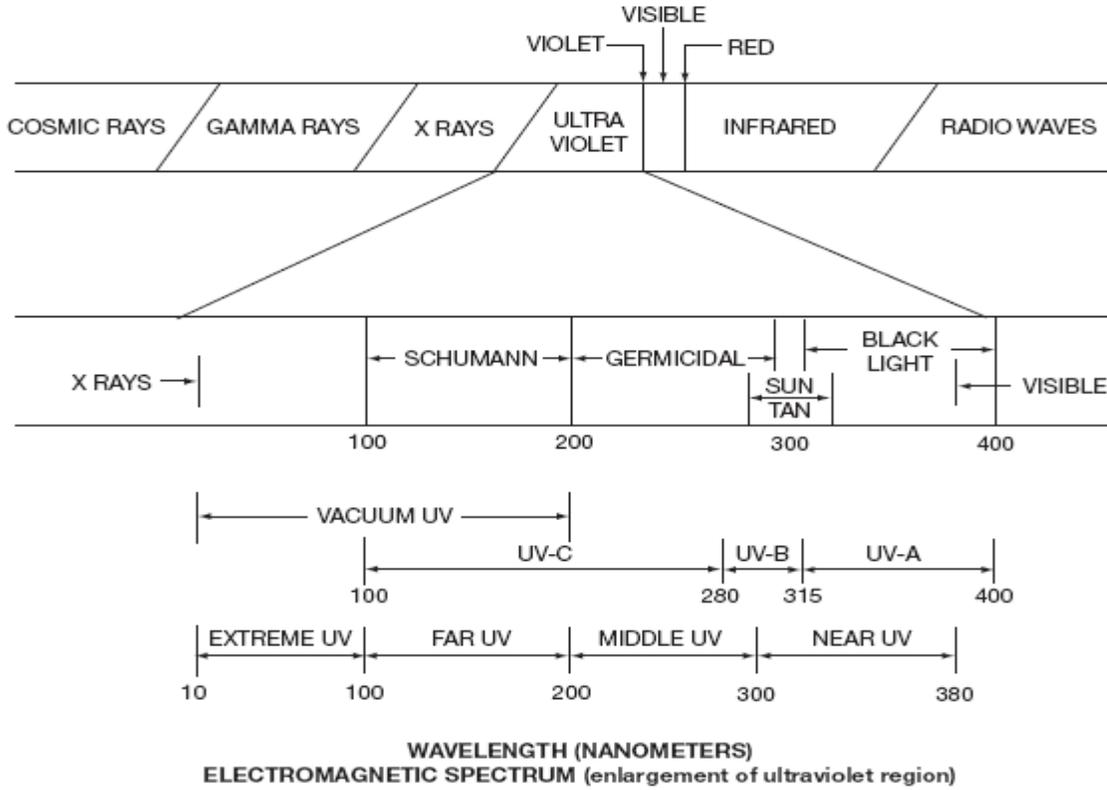
The electromagnetic energy from the Sun that passes through the Earth's atmosphere and actually reaches the surface of the Earth is made up of both the visible and the invisible ultraviolet components of the spectrum. The common term is "sunshine," but the technical term is solar global radiation (SGR), which refers to both the direct and indirect (scattered Sun and sky) daylight that reaches the lower atmosphere and eventually the surface of the earth. This sea of electromagnetic energy varies in its intensity depending on the latitude, the time of year, and time of day. It peaks at noon when the distance of the atmosphere is minimized.



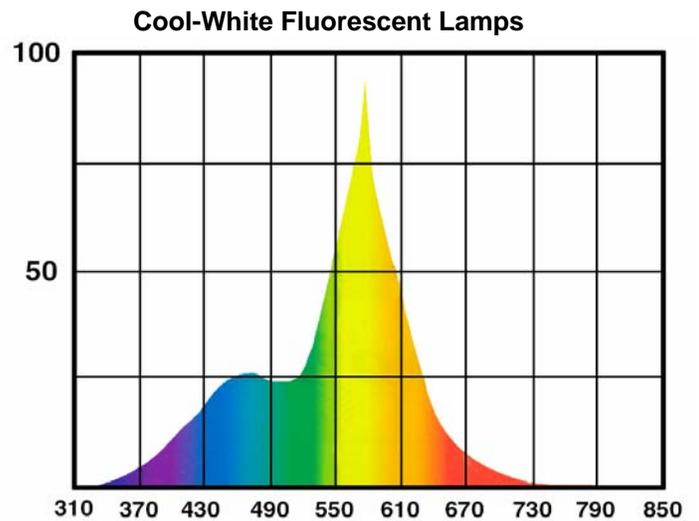
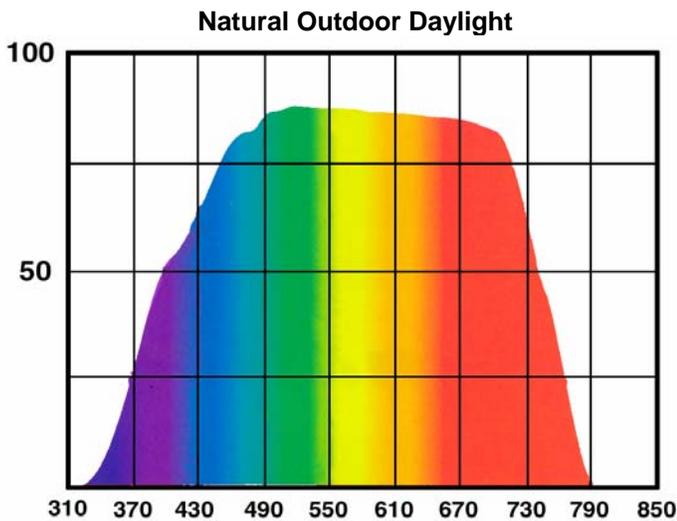
*Note the various wavelengths that are contained in radiation from the Sun*

Given that the energy level of a photon is dependent on its wavelength; and the shorter the wavelength, the higher the energy level, it is significant that as the wavelength decreases, the energy level of the photon increases exponentially. Typically, ultraviolet wavelengths are 700 times more energetic than wavelengths in the visible part of the spectrum. Photons with wavelengths below 290 nanometers (nm) are usually filtered out by the Earth's atmosphere, but with the depletion of the stratospheric ozone layer, which has filtered out the deadly short wave UV, X rays and Gamma rays below 290 nm for more than 3 billion years, the ability of life to survive on land could end. However, extensive clinical data has documented that only a high-energy 290 nm wavelength photon can trigger the vitamin D reaction in the skin or the stimulation of hormones that are secreted from the endocrine glands found deep in the brain. In addition, these high energy ultraviolet wavelengths have also been shown to have important germicidal benefits, including against Staphylococci bacteria, fungi, mold and other microorganisms that are now responsible for over 2 million infections annually in hospital patients, resulting in large numbers of amputations and over 100,000 of those infected died. Of even greater concern is the exponential explosion of these Staphylococci (MRSA) bacterial "superbugs," which have in recent years have become much more deadly while simultaneously becoming immune to most antibiotics.

The Electromagnetic Spectrum in Nanometers [22]



Natural Sunlight / Daylight Compared to Cool White Fluorescent Lamps



*Note the spectral difference between the sunlight found in the natural outdoor environment compared to "Cool White" fluorescent lamps that were developed in 1938 to optimized to maximize light quantity and not quality.*

### Dr. Richard Wurtman, M.D., Ph.D.

While there are a wide-range of distinguished scientists and medical doctors that have made significant contributions in understanding the biochemical mechanisms of electromagnetic energy on human health and productivity, one of the leading investigators is Dr. Richard Wurtman, professor of endocrinology and metabolism at the Massachusetts Institute of Technology (MIT). Dr. Wurtman also lectures at the Harvard Medical School where he received his M.D. degree in 1960. In his landmark paper, "The Effects of Light on the Human Body," published in *Scientific American* in July 1975 [1], Wurtman stated that only minimal sums have been expended to characterize and exploit the biological effects of light, and very little has been done to protect citizens against potentially harmful or biologically inadequate lighting environments. Both government and industry have been satisfied to allow people who buy electric lamps . . . to serve as the unwitting subjects in a long-term experiment on the effects of artificial lighting on human health."

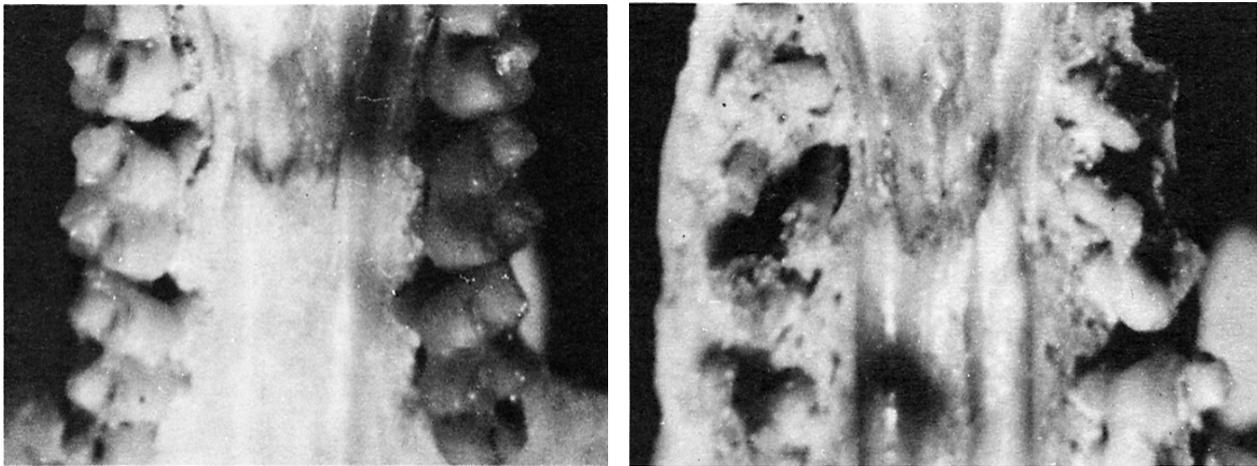
Other key points from Dr. Wurtman's paper include the following:

- Since life evolved under the influence of sunlight, it should not be surprising that many animals, including humans, have developed a variety of physiological responses to the spectral characteristics of solar radiation and to its daily and seasonal variations.
- Research conducted by Dr. John G. Haddad, Jr., and Theodore J. Hahn of the Washington University School of Medicine, demonstrated that from 70 to 90 percent of the vitamin D activity in blood was found to be accountable to vitamin D<sub>3</sub> or its derivatives. The investigators concluded that "sunlight was vastly more important than food as a source of vitamin D, and they pointed out that in Britain and several other European countries, the fortification of foods and dairy products with vitamin D<sub>2</sub> has now been sharply curtailed because of evidence that in large amounts, vitamin D can be toxic, causing general weakness, kidney damage, and elevated blood levels of calcium and cholesterol.
- In addition to the production of vitamin D, investigators have uncovered significant physiological and biochemical responses of the human body to solar radiation or its artificial equivalent, including the treatment of neonatal jaundice, a sometimes fatal disease that is common among premature infants; the synchronization of biological rhythms that are mediated by photoreceptors in the eyes, which stimulate the brain and neuroendocrine organs; the treatment of psoriasis and other skin disorders; the excretion of melatonin, a hormone produced by the pineal organ, which acts on the pituitary gland to impact the maturation and activity of the sex glands.
- A clinical study of the influence of the ultraviolet wavelengths of artificial light on the human body's ability to absorb calcium was undertaken in elderly subjects by Dr Wurtman and his colleague Dr. Robert Neer. The study documented that a lack of exposure to ultraviolet radiation during the winter months significantly impairs the body's ability to absorb calcium, even when there was an adequate supply in the diet. The calcium absorption of a control group that was exposed to conventional incandescent and Cool White fluorescent lamps, and an experimental group was exposed to "Vita-Lite" lamps manufactured by Duro-Test, which simulated sunlight in both the visible and ultraviolet wavelengths was evaluated. Over a period of 11 weeks, the calcium levels on the control subjects fell by approximately 25%, whereas the calcium levels in the experimental group increased by about 15%.

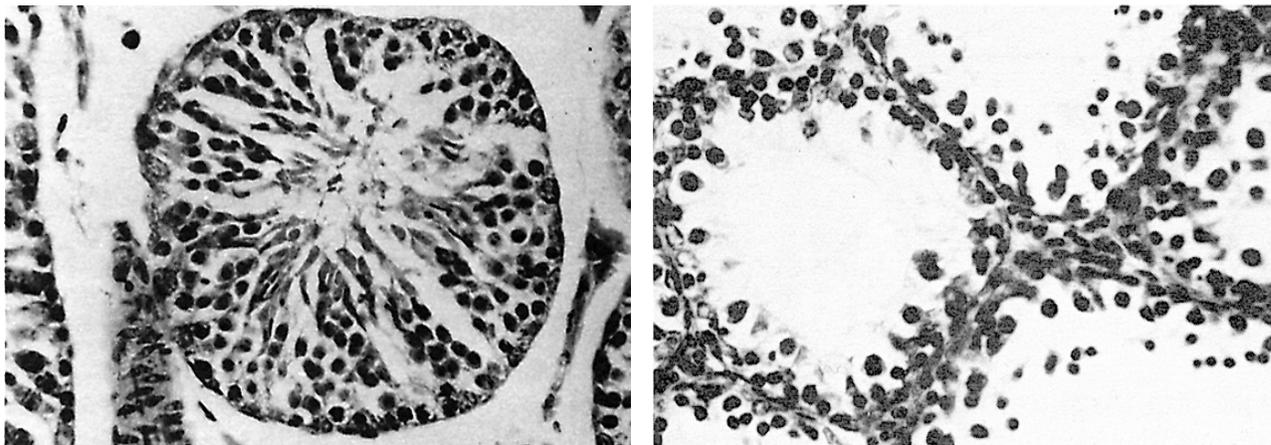
In spite of the extensive investigations of Dr. Wurtman and his colleagues, the news media has provided the general public with an abundance of reports on the risks associated with over-exposure to sunlight. What has not been clarified is that while overexposure to sunlight is never advised, moderate exposure to both the visible and non-visible ultraviolet (UV) spectrum of sunlight is absolutely critical for the health of humans and other mammals. While some dermatologists argue that any exposure to UV wavelengths is dangerous and should be avoided, two critical metabolic functions absolutely require the highly energetic 290 nm UV wavelength photons.

### Golden Hamster Study

In order to carry out a highly-controlled laboratory study, photobiology investigators at Harvard University's School of Dental Medicine and the School of Dentistry at the University of the Pacific in California raised 60 golden hamsters under identical conditions (in terms of diet and exercise) except for the two types of fluorescent lamps that were used in the study. Half of the hamsters were raised under full spectrum lamps that simulated the natural outdoor environment, and the other half were placed under the "Cool White" lamps that have been in widespread use in hospitals, schools and office buildings since the 1940s. After 15 weeks of exposure the animals were sacrificed and examined. The animals exposed to the Cool White lamp environments had 500 percent more tooth decay, and the caries were 10 times as large as the animals that were raised under the full-spectrum lamps. Moreover, it is significant to note that the animals raised under the Cool White lamps had smaller bodies, hearts and sex organs, and the males had no sperm production. Other significant histological differences were also observed in the submandibular gland structures [9].



Note that the molar teeth from the hamsters that were raised under the fluorescent lamps that simulated natural outdoor daylight environment (upper left) had normal tooth decay, whereas the molar teeth from the hamsters raised under Cool White lamps (right) were unable to manufacture Vitamin D<sub>3</sub> and as a result, the calcium they needed was leached from their teeth and bones.



In the case of the sex organs, note that the testis from the hamsters raised under the simulated daylight from full spectrum lamps (upper left) were normal and had normal sperm production, whereas the testis from a hamsters raised under the Cool White lamps (upper right) were severely underdeveloped and malformed. As a result, the animals raised under the Cool White fluorescent lamps had no sperm production. While many people may think that all ultraviolet wavelengths should be avoided and the kind of electromagnetic energy they are exposed to is insignificant, this controlled study of golden hamsters documents otherwise.

### Research Conducted by the Soviet Academy of Medical Sciences

Some of the most comprehensive photobiology epidemiological data was compiled in the 1960s by investigators from the Soviet Institute of General and Community Hygiene under the U.S.S.R. Academy of Medical Sciences, which had collaborated with the Soviet Institute of Biophysics, the Ministry of Public Health and the Institute of Experimental Medicine to conduct extensive clinical and field experience regarding what the investigators referred to as "sunlight deficiency" [10, 11, 12].

As a result of the extensive Soviet research, Sanitary Standards regarding indoor lighting specify full-spectrum lamps for those working in mines, industrial buildings and other areas that are deprived of natural light. Some of the conclusion of the Soviet research are as follows: If the human skin is not exposed to solar radiation (direct or scattered) for long periods of time, disturbances will occur in the physiological equilibrium of the human system. The result will be functional disorders of the nervous system and a vitamin-D deficiency, a weakening of the body's defenses and an aggravation of chronic diseases.

Sunlight deficiency was observed more particularly in persons living in the polar regions and those working underground or in windowless industrial buildings. The simplest and at the same time the most effective measure for the prevention of this deficiency is exposing individuals to ultra-violet wavelengths from lamps that simulated natural outdoor sunlight. Such irradiation was conducted either in special rooms called "photaria" or directly in locations where persons are regularly present in workshops, schools, hospitals, etc. As a general rule the daily dosage of ultraviolet does not exceed half of the average dose which produces a just perceptible reddening of an untanned human skin. The risk of skin cancer was virtually non-existent because the flux level of sunlight at sea level is about 10,000 footcandles in the shade, whereas the flux level from a typical indoor fluorescent lighting system is only about 50 footcandles. Specifically, Soviet investigators were able to determine the following:

*“. . . that ultraviolet radiation intensifies enzymatic processes and metabolism, increases the activity of the endocrine system, promotes the immunobiological responsiveness of the body, and improves the tone of the central nervous and muscular systems. Such a wide range of biological action of ultra-violet radiation is explained by its stimulating effects on the sympathicoadrenal system, which is known to play a major role in adaptive and compensatory reactions of the body. The beneficial effect of ultra-violet irradiation has been confirmed by many years of experience.”[10].*

Soviet researchers have also been able to determine that exposure to full-spectrum EME helps the body to metabolize and remove toxic chemicals. This could be an important consideration given the fact that in the last 30 years, the air, water and food-chain has been increasingly contaminated with a wide range of toxic chemicals that are absorbed initially by plants, and eventually concentrated in the tissue and organs of humans and other animals. However, the natural electromagnetic environment has been radically distorted by air pollution and the development of hermetically-sealed energy-efficient buildings. This means the EME that is provided in the interior spaces of conventional buildings is generated by the lighting system, which usually incorporates the use of incandescent or fluorescent lamps that emit electromagnetic energy that is dramatically different from that found in the natural outdoor environment.

It is important to note that although fluorescent lamps that simulate the electromagnetic spectra of terrestrial solar radiation in both the ultraviolet (UV) and visible wavelengths have been manufactured in the United States by the Duro-Test Corporation (North Bergen, NJ) since 1967, their relatively high cost has been a major factor that has prevented their wide-spread use. However, if federal standards in the U.S. had required that the full-spectrum lamps be mass-produced as they were in the Soviet Union, they would have not been any more expensive than conventional Cool White fluorescent lamps. Indeed, one of the significant factors regarding the Soviet research is that as a communist country it had financial incentive to falsify the research data in order to gain market share.

## A Summary of the Biological Impacts from the Electromagnetic Energy found in Sunlight

The biological effects of SGR exposure on humans or other mammals are classified as direct or indirect, depending on whether the photochemical reaction occurs directly within the tissue (primarily the skin), or whether the photons of a specific wavelength are absorbed by specialized photoreceptor cells located in the retina of the eye. In the case of indirect absorption, the energy is transferred in a vast network of neural pathways to stimulate the endocrine and nervous systems. A lack of exposure to a full spectrum electromagnetic environment can result in numerous pathological conditions, including the following:

- **Vitamin D<sub>3</sub> Deficiency & The Difference between D<sub>2</sub> and D<sub>3</sub>**

The human body requires ultraviolet wavelengths to manufacture Vitamin D<sub>3</sub> and its metabolites, which are now known to be required by virtually every cell in the body, and account for up to 90% of the absorption of dietary minerals in the intestines. This is in contrast to Vitamin D<sub>2</sub> that is provided in dairy products, which poorly utilized by the body and has been sharply curtailed in many European countries because it can be toxic, causing damage to the kidneys and elevated blood levels of calcium and cholesterol. Without Vitamin D<sub>3</sub>, the mineral concentration in the blood drops, causing the minerals to be leached from the skeleton and teeth, and eventually, osteomalacia and osteoporosis will result as well as possibly diabetes, multiple sclerosis; and in infants and children a vitamin D deficiency can lead to rickets and Hyperbilirubinemia [1, 4, 5, 9].

- **Cancer**

According to four separate studies, including one by Dr. Edward Giovannucci, a professor of medicine at Harvard University, Vitamin D<sub>3</sub> significantly helped to protect individuals against lymphoma and cancers of the lung, prostate and, ironically, the skin. Indeed, this research suggests that vitamin D<sub>3</sub> can be expected to prevent 30 deaths for each one caused by skin cancer caused by overexposure to the sun. Most people are not getting enough vitamin D<sub>3</sub> from food and dietary supplements, and although none of the research scientists are suggesting overexposure to sunlight, they do recommend that exposure to “safe sun,” which is defined as 15 to 20 minutes a few times a week without sunscreen, is needed for good health. It is important to note that the intensity of sunlight varies dramatically from the winter, when the sunlight passes through more of the Earth’s atmosphere, compared to the summer when it is directly overhead, as well as the time of time of day [3].

- **Heart Attacks & Strokes**

According to new research published in *Circulation*, a journal published by the American Heart Association, people who have low levels of vitamin D in their blood are at an increased risk for heart attack, heart failure and stroke. Researchers at Harvard Medical School in Boston followed 1,739 people with average age 59, for a 5 year period those with low vitamin D levels had about a 60 percent higher risk of a cardiovascular event such as a heart attack, heart failure or a stroke compared to those with higher levels. The study which was led by Dr. Thomas Wang also found that the risk for heart attack, heart failure or stroke was double in people with both hypertension (high blood pressure) and vitamin D deficiency. Dr. Wang says there is a growing body of new information which suggests that vitamin D may have some actions on the heart and major blood levels, therefore a lack of vitamin D may be associated with the development of cardiac abnormalities.

- **Increased Blood Pressure & Cholesterol Levels**

Photobiology investigators have shown that both blood pressure and serum cholesterol levels can be substantially reduced after exposure to ultraviolet wavelengths from the natural outdoor environment, or fluorescent lamps that simulate the natural outdoors. It is worth noting that the epidemiological data taken from “primitive” population groups who spend virtually all of the solar day outdoors indicates they are essentially unaffected by high blood pressure or the high levels of cholesterol which can lead to the kind of widespread degenerative cardiovascular diseases which are now responsible for approximately half of the deaths in the U.S [7, 8].

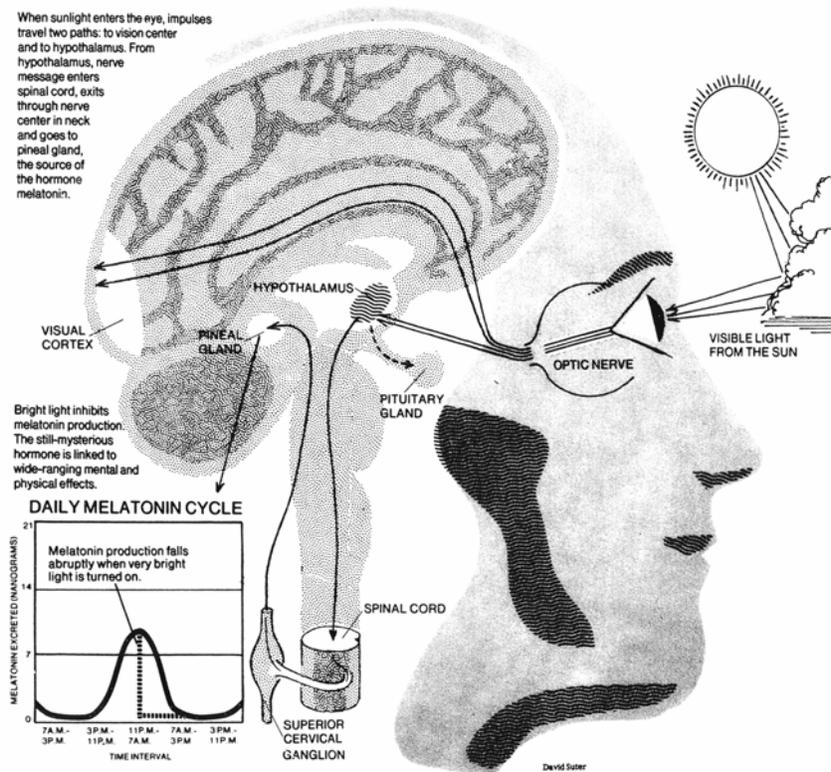
- **Increased Stress & Fatigue**

Studies undertaken by investigators at Cornell University and the Soviet Academy of Medical Sciences documented that students working under fluorescent lamps that simulated natural outdoor daylight experienced less eyestrain, headaches and fatigue than students working under conventional Cool White fluorescent lamps [12, 13].

- **Decreased Sexuality & Increased Levels of Depression**

Research undertaken by Dr. Norman Rosenthal and his colleagues of the National Institute of Mental Health (Bethesda, MD) have confirmed that profound biochemical reactions induced by a lack of exposure to a full-spectrum EME affects moods as well as sexuality, growth and energy levels. A cluster of brain cells referred to as the suprachiasmatic nucleus monitors the electromagnetic spectra that enters the eyes, which is then used to regulate the output of hormones secreted by glands within the endocrine system [14, 15, 16].

### Ultraviolet B Stimulation of the Neuroendocrine System



*The image above was provided courtesy of The New York Times.*

Note in the above illustration how the ultraviolet photons in the natural outdoor environment are absorbed by specialized photoreceptor cells located in the retina of the eye. When the 290 nm ultraviolet energy in sunlight (or fluorescent lamps that simulate sunlight) enters the eyes, it is transferred in a superhighway of neural pathways that travel deep into the brain to the Pituitary and Hypothalamus glands, where some of the energy enters the spinal cord and eventually travels to the Pineal gland that then is able to manufacture the hormone melatonin. The ultraviolet energy is an important environmental factor that impacts the endocrine system, which in turn has a profound impact on how people feel. Indeed, in studies conducted by investigators at the National Institute of Health, when individuals are deprived of the ultraviolet energy, severe depression occurs [1, 14].

## The Significance of Ultraviolet Wavelengths

As the spectral data indicates, visible light ranges from 310 to 790 nm. The shorter wavelengths (310 to 490 nm) are in the violet and blue range of the spectrum, green is from 490 to 590 nm, yellow is from 550 to 620, and orange and red are from 630 to 790 nm. However, the most energetic biologically active wavelengths are in the non-visible ultra-violet (UV) range of 290 to 310 nm. While most people are aware of the dangers of getting too much exposure to the UV spectra of sunlight, extensive research and clinical data that is summarized in this paper document that a *lack* of exposure to these UV wavelengths will also result in profoundly serious impacts to human health and productivity.

Exposure to Sunlight and UV is like exposure to water;  
it is critical for life and health -- but too much of it  
will result in disease and/or death.

**It is a question of balance.**

Sunlight is the basis of the natural outdoor electromagnetic environment, which was critical for the origin and evolution of life on the Earth. However, ordinary window glass will typically reflect or absorbs virtually all of the UV wavelengths of sunlight, and with the wide-spread usage of air conditioning in the 1940's, architects began designing buildings with windows that cannot be opened -- *or without windows at all*, thereby sealing-off millions of urban inhabitants from one of the most basic components of the natural environment. Cool-White fluorescent lamps were developed in 1938 to optimize the energy efficiency of indoor lighting systems by shifting the artificial light to the yellow component of the spectrum, which was radically different from sunlight, and the UV wavelengths -- which were invisible -- were filtered out by the glass enclosure of the fluorescent lamps as well as the plastic diffusers that are placed between the lamps and the areas below that are being illuminated. This was largely due to the realization that skin cancer could be caused by too much exposure to the UV wavelengths of the Sun.

As photobiology and medical research began to show that moderate exposure to UV wavelengths was in fact a critical component of human health, in the 1960s fluorescent lamps were engineered to simulate the natural outdoor environment in both the visible and non-visible UV wavelengths in the U.S. and the Soviet Union. Before long, a wide-range of laboratory and clinical tests were undertaken with these lamps that simulated daylight, and because they emitted the high-energy UV spectra found in sunlight, they were shown to be able to stimulate the endocrine system, generate pre-vitamin D3 in the skin, as well as kill pathogenic Staphylococcus and other infectious bacteria, moulds and fungi.

## Simulated Sunlight & Infection Control

The same wavelengths of ultraviolet (UV) spectra of sunlight that are absolutely critical for the production of vitamin D3 and the stimulation of the neuro-endocrine system, have also been shown to destroy a wide-range of microorganisms, including Staphylococcus aureus (Staph), a common bacteria that can cause serious infections, disease, amputations and death. However, Staph have recently evolved into a rapidly spreading "methicillin-resistant Staphylococcus aureus" (MRSA) "*Superbug*," which has become an even more deadly "flesh eating" bacteria that has simultaneously developed an immunity to antibiotics.

However, according to a paper published in *Applied Microbiology* in 1975, up to 97 percent of Staphylococci bacteria were destroyed after 8 hours of exposure to fluorescent lamps that simulated the visible and non-visible UVB wavelengths of sunlight (down to 290 nm). While bacteria are developing an immunity to antibiotics, they have not been able to develop an immunity to the UV found in sunlight. This germicidal effect of UV is an especially important insight given the exponentially increasing MRSA populations. According to the *Association for Professionals in Infection Control & Epidemiology*, over 2 million American patients are now becoming infected annually from MRSA during hospital stays and over 90,000 of them die from the infections [24, 25]. In spite of this alarming data, because few hospital engineers or medical professionals have an understanding of the importance of ultraviolet spectra found in sunlight and there are no federal regulations in this area of research, most hospitals, schools and other institutions continue to use fluorescent lamps that have no germicidal benefits.

## MRSA



*Staph Infections*

## USA-300

Although there are some 30 varieties of MRSA, the most deadly has been referred to as USA-300. When this drug-resistant staph invades the lungs, it can cause a pneumonia that destroys lung tissue and kills a patient within hours. Toxic proteins carried by USA300 have been implicated in infections that destroy fingers and toes or cause the rare but frighteningly fast skin- and muscle-tissue destruction attributed popularly to "flesh-eating bacteria" - a condition known as necrotizing fasciitis.

Epidemiologists at San Francisco General Hospital have been characterizing this rapidly spreading organism, which now accounts for over 80 percent of their hospital-acquired infections. According to Dr. Chip Chambers, the infectious disease chief of the hospital, "it stormed into town and just took over, displacing everything else." USA300 is as dangerous as they come - it can attack organs throughout the body. Its most disturbing trait, however, is just how easily it gets around. It has been described in at least 44 states and is now spreading in a number of European countries.

In addition, according to an April 9, 2008 issue of *Scientific American*, "Eating at our Defenses" researchers at Harvard University have recently found hundreds of soil bacterial strains that are not only antibiotic-resistant, but they are actually able to metabolize the nutrients in the antibiotics as food, and in some cases, the bacteria evolved to rely on antibiotics for their sole source of energy. The concern is that bacteria have the remarkable ability to transfer their newly acquired defenses to other bacteria worldwide.

The first MRSA strain, resistant to the penicillin substitute methicillin, was discovered in 1961. It continues to evolve. More than 200 families of the strain have come and gone since that time, but USA300 is the most dangerous. USA300 initially infected primarily hospital patients, but now it is also infecting individuals with no previous health problems, including suburban moms, executives, doctors, athletes, children and even newborn nurseries. Dr. Perdreau-Remington, the director of the Epidemiology laboratory at San Francisco General Hospital, has been comparing the genes of over 16,000 bacteria samples that have been taken from patients. It was during that screening program, using samples from the clinic, that she found the genetic fingerprint of what would eventually be called USA-300 by the Center for Disease Control.

The unique signature showed up on March 1, 2001. By 2002, USA300 accounted for 14 percent of staph infections acquired at San Francisco General, and the numbers keep rising. Now, more than 80 percent of MRSA infections in this hospital are caused by USA300. The gene map, published in the British medical journal the *Lancet* in February 2006, has yielded clues to why this strain spreads so quickly. The bug appears to have swapped genes from *Staphylococcus epidermidis*, a usually harmless staph species that is commonly found on human skin. Researchers theorize that, by stealing a trick from the milder staph bug, the malevolent USA300 may colonize on human skin more easily than other varieties of MRSA. Given the propensity of staph germs to swap genes, hospital patients provide fertile ground for the evolution of an even more dangerous bug. Dr. Perdreau-Remington believes there's an urgent need for new drugs to combat such a monster.

"This is the horror scenario," she said. "We have very little time left."

## UV & Infection Control

Near the end of World War II, medical investigators from the United States Navy's Department of Epidemiology, which was part of the U.S. Naval Medical School in Bethesda, Maryland documented that ultraviolet wavelengths emitted by fluorescent lighting systems had important infection control characteristics. The results of their clinical tests were published in a paper "ULTRAVIOLET LIGHT CONTROL OF AIR-BORNE INFECTIONS IN A NAVAL TRAINING CENTER, which was published in the *American Journal of Public Health* in May of 1945 [17].

Since that time, all of the major lighting companies in the U.S. and Europe have manufactured fluorescent lamps that emitted ultraviolet spectra, which are specifically intended to sterilize the air and water from infectious microorganisms in a wide-range of applications. However, because the ultraviolet wavelengths of these lamps are optimized at 253.7nm, they are much more energetic – and hence dangerous -- than the 290 nm spectra of photons that are found in the sunlight that reaches the surface of the Earth. As such, such germicidal lamps are never used in general lighting applications. Indeed, many dermatologists believe that there is no such thing as a good UV, and because of the legal concerns that are related to the well established relationship of over-exposure to ultraviolet wavelengths, genetic damage and skin cancer, general purpose lighting systems are specifically engineered not to emit any ultraviolet spectra.

However, given that extensive clinical medical data published in peer-review medical journals has documented that only a high-energy 290 nm UVB wavelength photon can trigger the vitamin D reaction in the skin or the stimulation of hormones that are secreted from the endocrine glands found deep in the brain, the belief that all UV exposure is harmful to human health is obviously and clearly inaccurate. However, given the evolution of MRSA bacterial superbugs that are essentially immune to antibiotics, the infection control considerations, particularly in hospitals, have a much higher sense of urgency. This is especially true when one realizes that a critical element in sterilizing the indoor spaces of hospitals and other public buildings is essentially as simple as changing a light bulb.

## Hospitals "Operate" in "Sick" Buildings

Pennsylvania was the first state to require that hospitals report infections that patients received while they were in the hospital, and according to a report published in 2006 by the Pennsylvania Healthcare Cost Containment Council, over 12,000 patients contacted infections during hospital stays annually, which cost an extra \$2.3 billion in healthcare costs and resulted in over 1,500 deaths [18, 19]. Moreover, the report's authors said the true infection rates and costs are likely much higher because of underreporting by many hospitals, who are understandably reluctant to have patients know that it is very dangerous for them to go to a hospital when they are seriously ill, because they are especially susceptible to acquiring potentially fatal infections that they did not have when they entered the hospital.

It is significant that a study published in *Applied Microbiology* documented that after 8-hours of exposure to fluorescent lamps that simulated the ultraviolet wavelengths found in natural outdoor sunlight, over 90% of the Staphylococci germs were killed [20]. Although fluorescent lamps that simulate the natural outdoor EMR have been commercially available in the U.S. since the 1960s, they are currently not used by any major hospital chain, school district or company.

Other studies by Dr. Dick Menzies, an associate professor of medicine at McGill University in Canada, found that by sterilizing air-conditioning and heating systems with ultraviolet lamps, it greatly reduced the infectious microorganism that contribute to the sick building syndrome. Dr. Menzies and his colleagues found that the exposure to ultraviolet lamps destroyed 99% of the bacteria, mold, fungi and endotoxins that lived in the damp environments around the ventilation cooling coils and drip pans, without any adverse reactions to the hospital staff or patients. Such insights, however, are unknown by most hospital infections control personnel, or the administrators who are responsible for hospital operations policies [21].

## Radiant Exposure for Germicidal Applications

(joules per square meter or watt-seconds per square meter)  
required to inhibit colony formation in 90% of organisms. [22]

<b>Bacteria</b>		<i>Pseudomonas aeruginosa</i>	55	<b>Paramyxovirus</b>	<b>35 (15-55)</b>
<b>Bacillus (vegetative)</b>	<b>32 (13-58)</b>	<b>Salmonella</b>	<b>43 (21-80)</b>	Sindbis virus	55
Bac. anthracis	45	Salm. typhimurium	80	Newcastle Disease	15
Bac. Megatherium	13	Salm. enteritidis	40	<b>Orthomyxovirus</b>	<b>35</b>
Bac. paratyphosus	32	Salmonella typhi	21	Influenza	35
Bac. subtilis	58	<b>Serratia marcescens</b>	<b>32 (7-85)</b>	<b>HIV (Lentiv)</b>	<b>1438 (600-2400)</b>
<b>Bacillus (spore)</b>	<b>118 (11-365)</b>	<b>Shigella paradysenteriae</b>	<b>17</b>	HIV (HTLVIII)	600
Bac. Megatherium	27	<b>Staph</b>	<b>44 (18-110)</b>	HIV (Sup T1)	1450
Bac. subtilis	120	Staph. albus	18	HIV (H9)	2400
Bac. anthracis	45	Staph. aureus	26	HIV (PHA-stim. PBL)	1300
Bac. subtilis (ATCC6633)	365	Staph.epidermis	110	<b>Phages</b>	
Bacillus subtilis	11	Bacteria (cont'd.)		<b>Bacteriophage</b>	<b>152 (65-310)</b>
Bac. subt. spore ATCC6633	152	<b>Strep.</b>	<b>36 (18-65)</b>	Bac. subt. phage SP02c12	150
<b>Campylobacter jejuni</b>	<b>29</b>	Strep. haemolyticus	22	Bac. subt. phage SPP1	195
<b>Clostridium tetani</b>	<b>130</b>	Strep. lactis	62	Bac. subt. phage Ø 29	70
<b>Coryneb. diphtheria</b>	<b>34</b>	Strep. viridans	20	Bacteriophage F specific	292
<b>Citrob. freundii (ATCC8090)</b>	<b>42</b>	Strep. faecalis (ATCC29212)	65	Coliphage f2	310
<b>Enterob. cloaca (ATCC13047)</b>	<b>64</b>	Strep. faecalis	55	Staph. phage A994	65
<b>Escherichia coli</b>	<b>45 (7-58)</b>	Strep. pyogenes	22	Torula sphaerica (milk and cream)	23
Escherichia coli	30	Strep. salivarius	20	Yeasts	59 (23-100)
Escherichia coli (in air)	7	Strep. albus	18	Oospora lactis	50
Escherichia coli (in water)	54	<b>Vibrio</b>	<b>24 (8-39)</b>	Saccharomyces cerevisiae	33-100
Escherichia coli ATCC 11229	25	<b>Yersinia enterocolitica</b>	<b>15</b>	(baking yeast, brewing yeast)	
Escherichia coli ATCC 25922	30	<b>DNA-Viruses</b>		Saccharomyces ellipsoideus	60
Escherichia coli K 12 AB 1157	58	<b>Parvovirus</b>	<b>35 (30-40)</b>	Saccharomyces sp.	80
Escherichia coli B/ r ATCC 12407	53	Bov. parvovirus	40	<b>Fungi</b>	<b>713 (130-3000)</b>
<b>Klebsi. pneumon. ATCC4352</b>	<b>42</b>	Kilham rat virus	30	Aspergillus glaucus	440
<b>Legionella</b>	<b>15 (4-26)</b>	<b>HCC (Dog hepat. Adenov)</b>	<b>265</b>	Aspergillus flavus	600
Legionella dumoffi	24	<b>Herpes virus 57 (15-165)</b>		Aspergillus niger	1320
Legionella gormanii	26	Pseudorabies virus	70	Aspergillus niger (pasta)	1500
Legionella micdadei	15	Herpes simplex MP str.	67	Aspergillus amstelodami (meat)	700
Legionella longbeachae 1	12	Herpes simplex MP str.	15	Candida paraposilosis	220
Legionella longbeachae 2	10	Herpes simplex, type 1	165	Cladospor. herbarum (cold stores)	500
Legionella oakridgensis	22	Vaccinia	18	Mucor racemosus	170
Legionella micdadei	18	<b>RNA-Viruses</b>		Mucor mucedo (meat, bread, fat)	600
Legionella jordanis	11	<b>Picornavirus</b>	<b>72 (36-186)</b>	Oospora lactis	50
Legionella wadsworthii	4	Poliovirus	110	Penicillium chrysogenum (fruit)	500
Legionella pneumophila	25	Poliov type 1 Mahoney	67	Penicillium roquefortii	130
Legionella bozemanii	20	Poliov	133	Penicillium expansum	130
<b>Leptospira</b>	<b>20 (8-28)</b>	Poliov type 1	36	Penicillium digitatum	440
Leptospira biflexa	23	Poliov Mahoney	45	Rhizopus nigricans	1100
Leptospira illini	8	ECBO 80		Rhizopus nigricans (cheese)	1100
Leptospira interrogans	28	Coxsackiev	186	Scopulariopsis brevicaulis (cheese)	800
<b>Micrococcus</b>	<b>80 (61-100)</b>	<b>Reovirus</b>	<b>102 (48-163)</b>	<b>Protozoa</b>	<b>600-1000</b>
Micrococcus candidus	61	Reovirus type 1	48	<b>Algae</b>	<b>3000-6000</b>
Microc. sphaeroides	100	Reov type 1 (Lang str)	163	Green algae, blue algae, diatoms	
<b>Neisseria catarrhalis</b>	<b>44</b>	Rotav	159		
<b>Pseudomonas aerug.</b>	<b>35 (15-55)</b>	Rotav SA11	65		

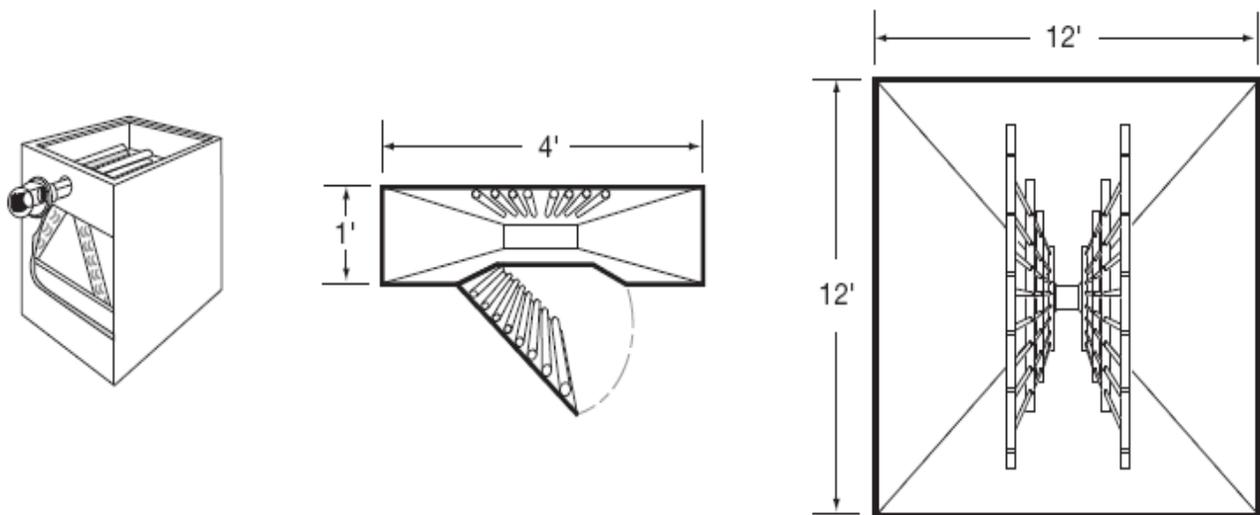
### Hospital Reinfection Considerations

Reinfection is an increasing problem in hospitals and other healthcare facilities because the immune system of patients is already under stress and thereby more susceptible to additional infections. This is compounded by the fact that a hospital is a virtual "microbial zoo" to the extent that a wide-range of infectious microorganisms are, by necessity, brought together in the interior of a hospital environment [23]. This problem is exponentially compounded by the evolution of MRSA bacteria but Staph and most other bacterial microorganisms have not been able to develop a resistance to the ultraviolet spectra that is found outdoors, or that emitted by fluorescent lamps that are engineered to simulate the natural outdoor electromagnetic environment.

### Germicidal Wavelength Classifications

Classifications Used in Illuminating Engineering:	
Classification	Wavelength Region
Ozone-producing	180-220 nanometers
Germicidal	220-300 nanometers
Erythematous	280-320 nanometers
"Black light"	300-400 nanometers
Classifications Used in Photobiology:	
Classification	Wavelength Region
UV-C	100-280 nanometers
UV-B	280-315 nanometers
UV-A	315-400 nanometers

### Typical Methods of Installing UV Germicidal Lamps in Heating & Air Conditioning (HVAC) Ducts



The germicidal data and images shown above were provided by Osram Sylvania Lighting Systems [22]

### Specifications for Fluorescent Lamps that Simulate Sunlight

It is important to realize that solar radiation can be specifically defined and measured, and that whether direct or diffuse, it is rather stable in the proportion of radiation emitted in the near ultraviolet (320-380 nanometers-nm) and visible (380-750 nm) regions, whereas the middle ultraviolet (290-320 nm) region varies with the angle of the sun. The specifications of artificial light sources for the simulation of the full visible and invisible balanced ultraviolet spectra of terrestrial solar global radiation (i.e. sun and sky) for use in general indoor illumination are as follows:

Correlated Color Temperature:	5500 K
Color Rendering Index (CRI): (Natural outdoors = 100)	90 or greater
Near Ultraviolet Radiation: (UV-A = 320 to 380 nm)	254 microwatts per lumen
Middle Ultraviolet Radiation: (UV-B = 290 to 320 nm)	15 + microwatts per lumen
Daily indoor dose (Lux) level: (Lux = 1 lumen/sq. meter)	8 hour exposure at 538 to 3228 Lux (i.e., 50 to 300 footcandles) [10]

### Duro-Test Corporation and Westinghouse

The "Vita-Lite" full-spectrum lamps that simulate the natural outdoor sunlight in both the visible and non-visible ultraviolet wavelengths were developed and manufactured by Duro-Test Corporation (North Bergen, NJ) in the 1960s. They were engineered to have a conventional geometry and loading and based on the wide-range of clinical studies that used the Vita-Lite lamps, which were published in peer-review technical and medical journals, many of which are summarized in this paper, they were listed with the U.S. Food and Drug Administration as a medical device. In spite of the technical progress from the Duro-Test engineering team, however, the relatively high cost of their sunlight-simulating fluorescent lamps, which had a list price of approximately \$14 for a 40 watt 48" tube, was more than 10-times more expensive than Cool White lamps that were in high-volume production. This cost differential has been a significant obstacle for most hospitals, schools and business applications, even though the cost of lamps are only about 1% of the cost of a lighting system. Duro-Test was acquired by Westinghouse Lighting in 2000, and although Westinghouse, Sylvania and General Electric all manufacture sunlight-simulating lamps, they are unaware of the extensive photobiology medical data on UV, and as such, they have all filtered out the UV wavelengths. There are also many smaller companies that also claim to manufacture full-spectrum lamps, but unlike the Duro-Test division of Westinghouse, they do not provide independent engineering data on their UV spectral emissions, or peer-review published medical or clinical data to substantiate their claims.

### Full-Spectrum Diffusers & Fixtures

Diffusers are the plastic sheets that are placed in the fixture to "diffuse" or scatter the light from the fluorescent lamps throughout the room area. However, most diffusers in wide-spread use are manufactured with acrylic formulas which prevent the important ultraviolet wavelengths from passing through the plastic lens material. There are three basic options to overcome this problem. The least expensive option is to special order diffuser material which will not filter-out or absorb the emissions of full-spectrum lamps. Most major manufacturers, such as Rohm and Haas (Philadelphia, PA) or KSH (St. Louis, MO) have ultraviolet-transmitting (UVT) acrylic diffusers available upon request that allow most of the UV wavelengths to pass through the material [26]. The best diffuser option, however, is to use "egg-crate" types of diffusers, which can be made out of aluminum, wood or acrylics. Egg-crate diffusers are about 2 to 4 times more expensive than UVT acrylic sheets, but they allow the greatest amount the UV wavelengths to enter the area being illuminated. The optimum fixture for a full-spectrum lighting system involves installing 3 or 4 fluorescent lamps in reflective metal troughs with a 4-inch square egg-crate enclosure that allows the optimum level of visible and non-visible UV wavelengths to pass into the area below the lighting fixtures.

### Cost-Benefit Considerations

There are many lamps called “Full-Spectrum,” which have no documentation as to their specifications. True full-spectrum fluorescent lamps are not in high-volume production, and as such, they are typically 6 to 8 times more expensive than conventional Cool-White lamps that have been mass-produced since the 1940s. While this price differential is a formidable obstacle that has prevented the wide-spread use of full-spectrum lamps, it is interesting to note that the cost of lamps is the least expensive component of a typical lighting system (i.e., about 2 to 3 percent). About 90 percent of the cost of a lighting system is for the electricity used to power the lamps and ballasts. About 8 percent is for the labor to periodically replace the lamps. As a result, the cost of lamps typically constitutes less than one percent of an institution's operating overhead. Yet, lamps are the only piece of equipment that emits significant levels of electromagnetic energy into the work environments where most individuals spend the vast majority of each solar day.

In addition to being more expensive and requiring a full-spectrum diffuser, a standard 32 or 40 watt full-spectrum fluorescent lamp that is color corrected to 5,500 Kelvin color temperature only emits about 70 percent of the lumens of a conventional Cool-White fluorescent lamp. Thus, simply replacing Cool-White lamps with full-spectrum lamps will result in a noticeable loss of foot-candles (or quantity of light) in a given area. (Note: A foot-candle is equal to one lumen per square foot; A lumen is the amount of light that is spread over a square foot of surface by one candle when all parts of the surface are exactly one-foot from the one-candle light source.) In order to minimize energy consumption of the lighting system, many facility engineers have already reduced foot-candle levels to a minimum (i.e. 50 foot-candles). Thus, a one-to one replacement of Cool-White lamps with full-spectrum lamps will result in a reduced lumen output.

In order to minimize the impact of the reduced lumen output, it is necessary to install additional fixtures and lamps to compensate for the lumen loss of a full-spectrum lighting system. This option not only increases the number of lamps and fixtures which must be purchased, but the additional lamps and ballasts will also increase electricity demand and consumption. While these additional costs may appear to be significant, they are minuscule when compared to the billions of dollars in increased medical costs – not to mention permanent injuries and deaths – which can result by not having such lamps in hospitals, schools and office buildings. In the State of Pennsylvania alone, re-infections increased healthcare costs by over \$2.3 billion, and over 1,500 people died from being infected with a microorganism that they were exposed to at the hospital.

### Summary

Visible light is only a small part of the electromagnetic spectrum, which extensive clinical data has shown to be an important environmental variable in maintaining human health and productivity. It is possible to provide full-spectrum lighting that effectively simulates the electromagnetic energy (EME) found in the natural outdoor environment. In evaluating the cost-benefit trade-offs of a full-spectrum lighting system, there are both physical and behavioral considerations. It is difficult to place obstacles to productivity such as fatigue, headaches and eyestrain into a cost-benefit calculation. However, there is also extensive scientific literature that documents that a lack of exposure to balanced UV and visible spectra may be a significant variable in contributing to the development of degenerative diseases, which seem to inflict primarily urban-industrial populations who live out their lives in buildings that are sealed-off from the sea of electromagnetic radiation that has powered biological metabolism for millions of years.

If such medical and productivity issues can be impacted by proper exposure to electromagnetic energy, along with reasonable exercise and nutrition, billions of dollars could potentially be saved in disability payments and hospital costs. Hospitals and healthcare facilities have a life and death incentive to simulate daylight indoors because of the infection control considerations that could save hundreds of thousands lives annually. In addition, the ability of individuals to live and work in a biologically healthy environment can profoundly affect how they feel throughout the day, which can have a profound impact on their productivity. While MRSA Staph bacteria have become resistant to most of the antibiotics now available, they have not developed a resistance to the high-energy ultraviolet radiation found in outdoor sunlight, or from fluorescent lamps that simulate the natural outdoor electromagnetic environment that is created by sunlight.

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Harry W. Braun III has been working as an energy and environmental analyst for the past 35 years. He is CEO of Sustainable Partners International LLC ([SustainablePartners.com](http://SustainablePartners.com)), a systems integration firm that is involved in photobiology research and the development of the “BioLight” lighting system that simulates sunlight, as well as a number of renewable energy development projects, including a \$150 million wind farm project in New Mexico. Harry is the author of numerous technical papers, as well as *The Phoenix Project: Shifting from Oil to Hydrogen*, a 360-page book that provides a scientific overview of the origin of matter and life in the known universe, how the “big bang” created hydrogen atoms, which gravity condensed into the stars, which then emitted the electromagnetic spectra (i.e., sunlight) that served as the spark for the origin and evolution of life on the Earth.

The book also provides an overview of how the U.S. and other countries can rapidly shift from non-renewable fossil and nuclear fuels to renewable solar hydrogen production systems, which will resolve many of the most serious economic and environmental problems. The book reviews both the positive and negative aspects of exponential growth, which explains why humanity is on the threshold of both a nanotechnology utopia and an ecological oblivion. It is why we on *Spaceship Earth* are all like passengers aboard the *Titanic*, and there is only a limited amount of time left to “change course.” Although hydrogen is often mentioned as the “Holy Grail” of all energy sources, Harry Braun is the only technical analyst who has provided a specific plan for how this “transition of substance” can happen by 2020 by mass-producing wind and other solar powered hydrogen production systems, and modifying every *existing* vehicle, appliance and power plant to use hydrogen fuel. Harry’s Phoenix Project plan was recently peer-reviewed and published in the July issue of the *Chemical Industry & Chemical Engineering Quarterly (CI&CE)*, Vol.14, Number 2, which can be found on the CI&CE journal web site: [www.ache.org.rs/CICEQ](http://www.ache.org.rs/CICEQ).

Harry is the founder and Chairman of the Phoenix Project Foundation ([PhoenixProjectFoundation.US](http://PhoenixProjectFoundation.US)), which is a non-profit, scientific educational organization that is focused on educating the general public about the critical interrelationships of exponential growth, energy, the economy, and the environment, as well as the origin of life, protein evolution, photobiology, molecular biology and U.S. foreign policy. He is also Chairman of the Phoenix Project Political Action Committee ([PhoenixProjectPac.US](http://PhoenixProjectPac.US)), which is focused on the political aspects of helping to organize Hydrogen Hearings in the U.S. Congress, which will be a prerequisite for the passage of Fair Accounting Act and Photobiology legislation that Harry has proposed in his book. The Fair Accounting Act legislation is the “trigger mechanism” for shifting to the solar hydrogen economy because it will provide the financial incentives for oil and other energy companies to rapidly become solar hydrogen companies, with an energy resource that will provide a renewable rate of return because it is both pollution-free and inexhaustible. The Photobiology legislation is intended to establish specific guidelines for the lighting industry with respect manufacturing general purposing lighting that will simulate the spectral wavelengths of the natural electromagnetic radiation that is found in sunlight.

Harry received a Bachelors degree from Arizona State University in 1971. His undergraduate work was in history and general science, while his graduate work focused on evolutionary biology and anthropology. His post graduate research has been in the areas of energy technologies and resources, photobiology, molecular biology and protein evolution. Harry has been an Advisory Board Member of the International Association for Hydrogen Energy ([iahe.org](http://iahe.org)) since 1981. This international peer-review professional society is composed of over 2,500 Ph.D.-level scientists, chemists and engineers from over 45 countries. Harry ran for Congress in 1984 against John McCain, and was an independent presidential candidate in 2004. His campaign platform can still be viewed on the [BraunforPresident.US](http://BraunforPresident.US) website).