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The composition of sunlight that is biologically important can be separated into four general wavelength regions. Ultraviolet A (UVA), Ultraviolet B (UVB), visible light and infrared. Visible light does not appear to be harmful unless part of photosensitive drug reactions. Infrared originating from sunlight, so far, does not seem to contribute to the risk of skin cancer, although non-solar sources of infrared can cause skin tumors and cataracts. The spectrum of light that has damaging effects is therefore essentially UV light. UVA's spectrum is between 315 and 400nm, and UVB's spectrum is between 280 and 315nm. These different wavelengths penetrate the skin to different depths with ultimately different clinical consequences. UVB makes up only a small percentage of the total UV and do not penetrate as deeply as UVA, yet seem to be the major culprit of both melanoma and nonmelanoma skin cancers. Thus, medically speaking, it is the most important component of sunlight. UVB rays are becoming more abundant too as the ozone layer gets more depleted. UVA, generally thought to be the safe part of the UV spectrum, has now also been implicated with significant risks but not to the extent of UVB radiation. UVA radiation mainly act by potentiating the carcinogenic effects of UVB rays. UVA is even the main wavelength produced by tanning beds. Tanning salon visits are estimated at one million a day and while there has been a strong push to ban them, the FDA has yet to do so because the data is not yet definitive. It has also been found that most people do not use enough sunscreen protection to completely cover the body. According to Dermatology Times you should use 30g (1oz) of sunscreen to do the job, yet most peoples sunscreen bottles last over a year.

UV causes direct cellular damage and alterations in the body's immunologic functioning. Photochemical interactions occur from the absorption of the various wavelengths by molecules such as proteins and DNA. Oxygen species can also be produced, further contributing to the UV induced damage. After sufficient sun exposure, an erythema, or sunburn, will appear. Caused mainly by UVB, it is an increase in blood flow to the region. Continuing exposure to the UVB rays will cause further signs of damage such as wrinkling and irregular pigmentation. Many conclusive studies have shown that sunlight is the major causative agent of melanoma formation, which has the highest rates not surprisingly close to the equator, since the amount of UV rays hitting the earth is latitude dependent. Skin pigmentation also has some protective capabilities. Fair skinned individuals do have a relative deficiency of melanin in the skin, and are at increased risk of developing skin cancer. UVB has been shown to suppress the human immune system which leaves it vulnerable to bacterial or viral diseases that penetrate through or affect the skin. Viruses such as herpes, HIV, and chickenpox can be activated or reactivated. Exposure may even affect the efficiency of vaccinations against disease.

The following six steps have been recommended by the American Academy of Dermatology and the Skin Cancer Foundation to help reduce the risk of sunburn and skin cancer.

1. Minimize exposure to the sun at midday and between the hours of 10a.m. and 3 p.m.
2. Apply sunscreen with at least a SPF-15 or higher that protects against both UVA and UVB rays, to all areas of the body that are exposed to the sun.
3. Reapply sunscreen every two hours, even on cloudy days. Reapply after swimming or perspiring.
4. Wear clothing that covers the body and shades the face. Hats should provide shade for both the face and back of the neck. Wearing sunglasses will reduce the amount of rays reaching the eye by filtering as much as 80 percent of the rays, and protect the lids of our eyes as well as the lens.
5. Avoid exposure to UV radiation from sunlamps or tanning parlors.
6. Protect children. Keep them from excessive sun exposure when the sun is strongest (10 a.m. and 3 p.m.), and apply sunscreen liberally and frequently to children six months of age and older. Do not use sunscreen on children under six months of age -- instead severely limit their exposure to the sun.

Skin cancer is the most common cancer in the United States. It affects over 600,000 individuals annually. Although there are many contributing factors that can result in skin cancer such as heredity, elevation, and arsenic, sunburn and UV rays are still the principal causes. Tanning occurs after exposure to UV light and has a protective action to prevent more skin injury, yet tanning does not help prevent skin cancer, so the belief that a tanned body is a healthy body is not exactly correct. Sunburns can also increase the risk substantially with each serious sunburn increasing the risk up to 50%. Hereditary factors play an important role as well. People of Northern European descent with fair-skin and a family history of skin cancer, are more susceptible.

Melanoma is a malignant tumor which originates in the cells called melanocytes. Melanocytes are found in the basal parts of the epidermis and produce the melanin pigment in response to UV radiation which in turn protects the skin from further sunburn damage. There are in the USA over 30,000 cases a year, and its incidence is increasing 5% annually. Although it is the rarest of the 3 main skin cancers, it causes 75% of the deaths from skin cancer.

According to the American Academy of Dermatology "One person dies from malignant melanoma every hour.

The overall incidence rate for the disease is increasing faster than any other cancer and by the year 2000 an American's lifetime risk of developing melanoma will be 1 in 75. The disease is now the most commonly occurring cancer in females ages 30 - 34." The USA Environmental Protection Agency estimated in 1991 that over the next 50 years 12 million Americans will contract skin cancer and 200,000 will die from melanoma alone. People at high risk of getting melanoma are those who frequently have sunburns, red or blonde hair, blue eyes, family history of melanoma, and fair skin. The staging of Melanoma depends on the depth of the tumor. Treatment, especially for earlier stages is usually surgery, while others can be added such as chemo, immuno, and radiotherapy. A promising new experimental treatment includes vaccine therapy. Some forms of melanoma are estrogen dependent, so a doctor should assess the risk of estrogen therapy. Others recommend the patients not to take vitamin C suspecting it could accelerate melanoma growth.

Within the epidermis there are also other cells called Keratinocytes that can also become malignant. This malignant tumor is called a squamous cell carcinoma and if the tumor comes from the basal Keratinocytes it is a basal cell carcinoma. Squamous cell carcinoma can appear in various forms, usually as nodules or patches. It is the second most common skin cancer in Caucasians and occurs in about 100,000 Americans per year. It has a risk of metastasis or spreading to other body parts but not as much as melanoma. It is usually found on frequently sun-exposed areas, like the face and upper extremities. The cancer has a high cure rate, especially if detected early. Basal cell carcinoma, another non-melanoma carcinoma can appear as a nodule on sun exposed areas. They are characterized by slow growth and late metastasis and has a high cure rate when treated appropriately.

Actinic Keratosis is a skin condition that is premalignant. The rough dry crusty texture makes it easily recognized by touch. This lesion can even occasionally itch. The presence of such a lesion indicates that there has been sun damage, so the lesion appears more commonly on the face, neck and hands. Since it can be the first step towards skin cancer if not treated, squamous cell carcinoma is often seen as a late complication.

Cancer development requires numerous additive genetic changes which occur through the presence of DNA lesions that are not repaired. DNA damage can be due to too much exposure of an exogenous agent or defects of normal DNA repair mechanisms. Three such examples of clinically distinct disorders are xeroderma pigmentosum (XP), Cockayne's syndrome (CS), and a photosensitive form of trichothiodystrophy. These disorders are inherited in an autosomal recessive fashion, are rare, but can lead to serious consequences, even death. Interestingly, of these three diseases with defective DNA repair, only XP has an increased frequency of skin cancer. XP is characterized by a genetic defect of DNA repair mechanisms influenced by UV radiation from any source, but most commonly sunlight. The symptoms of XP can include blindness, deafness, growth and mental retardation, high incidence of eye and skin cancer, and frequent blistering and freckling on even slight sun exposure. Fortunately it is a very rare disorder with less than 1000 recorded cases world wide. It is a life threatening disease with no known cure. The exposure to UV radiation causes additive and irreversible damage. These patients need to be constantly inspected to check for tumors. Normally cells are remarkably efficient in repairing damage done to its DNA. Repair enzymes (which are proteins) function by first recognizing the damaged strand, then excising the damaged section, and lastly filling in the gap with the bases that were originally there. How do the enzymes know what was originally there? Human DNA is double stranded, and the sister strand is always paired in a certain fashion, complimentary and anti-parallel, so that the enzymes can deduce what bases to use when filling in. Exposure of a cell to UV light can result specifically in a defect of the DNA known as pyrimidine dimers which can hinder further DNA replication. The repair enzyme deficient in XP is usually called UV specific endonuclease whose function is to recognize the damaged DNA. There are currently a couple of trial therapies under way. One is a protein or enzyme therapy by Applied Genetics Inc. in which a skin lotion is applied containing the missing endonuclease. The other therapy soon to be attempted is gene therapy in which case the cell could make the missing enzyme. This method however is still quite difficult because it is very hard place genes in sufficient cells in a person to cause a noticeable difference, and there would always be the risk of allergic reactions, for the body might identify this new enzyme as foreign. In the meantime though most XP patients still lead quite restricted lives. Early diagnosis and consequent intervention is key to delay the onset of symptoms which can ultimately lead to death. Symptoms usually start by age 1 or 2 with excessive freckling and easy sunburning. CS is another rare disease in that repair of genes is defective after UV radiation and is characterized by physical and mental retardation that becomes evident within the first few years of life. There is hypersensitivity to UV light but no increase in skin cancer, although survival beyond the second decade is not common.

Bloom's Syndrome is also related with sunlight exposure by skin color changes becoming much more evident in sun exposed areas, but also with other more severe problems such as respiratory illness, susceptibility to cancers, and short stature. Bloom's occurs due to fragmented chromosomes. Chromosomes are the part of cells that contain our DNA. Bloom's patients therefore should avoid environmental exposures that precipitate chromosome fragility such as x-rays and chemotherapy.

Another set of conditions that require protection from UV rays are albinism and vitiligo. Albinism is a group of inherited conditions with little or total absence of pigment in their eyes, skin or hair. According to the National Organization for Albinos and Hypopigmentation (NOAH) one in 17,000 Americans have some form of albinism.

All forms have vision problems while some additionally have skin and hair problems. Although most have blue eyes, the color of the iris can also be red, violet, hazel, or even brown. The more understood form of albinism is due to lack of an enzyme called tyrosinase which is needed to produce pigment, namely melanin. The inheritance of the disease is usually in an autosomal recessive fashion, meaning both parents must carry the defective gene to have a child with albinism. Since the body has two sets of genes an asymptomatic person can have normal pigmentation and yet carry the defective gene. If parents previously had a child with albinism, genetic testing and counseling is possible via amniocentesis which consists of placing a needle into the uterus for a fluid sample. Among the most common eye conditions in albinism are rapid to and fro movements, ocular muscle imbalance, bright light sensitivity, and visual problems. In general people with albinism have a normal life span, although life threatening skin cancers do occur with a higher frequency than the general population, especially if sun protection is not used. If skin protection such as lotion is applied, people with albinism can experience the outdoors like anyone else. Sunscreens should be at least SPF 20 - 30. "SPF" meaning "sun protection factor" is a standard test number. The SPF x 10 gives you the total number of minutes a person could theoretically sit in the sun without burning. The concern is that the SPF system measures mainly UVB protection, leaving out the much deeper penetrating UVA, so the FDA is considering adding a second rating for it. Vitiligo is a skin disorder where white spots appear usually bilaterally on the same location. The problem arises when the melanocytes are killed by our own immune system, thus being classified as an autoimmune disease, and is characterized by leaving patches of white areas on the skin. It sometimes runs in families indicating that hereditary factors may play a role, and while most patients show slow progression the problem can disappear altogether. It is estimated that 1% of the population is affected, often manifesting itself with other autoimmune disorders such as diabetes, Addison's, and pernicious anemia. It has even been known to occur in times of severe stress. Vitiligo is more debilitating in dark skinned individuals, as the changes become more apparent. Treatment of vitiligo has shown mixed results and include cover-up cosmetics, UVA light treatment to gradually return color in the patchy areas, and even transplanting melanocytes into the white areas. Some patients, instead of trying to gain their color back, choose to remove the color from normal areas to attain a uniform skin tone. This process, called depigmentation, is done via a prescription cream called monobenzone, and is irreversible.

Besides skin conditions, UV radiation is also a factor in eye conditions. The eye is one of the most radiation sensitive organs. Laboratory studies show that chronic UVB exposure is a major factor of cataract formation. This occurs over time due to absorbed UV radiation by the lens in the eye. Specifically, a photochemical process occurs, causing denaturation of the lens proteins. As the lens becomes more opaque, blindness results. Cataract formation is the major preventable cause of blindness worldwide. People in tropical areas and young children are most susceptible. The reason of child susceptibility is due to their less well developed pigmentation of the eye. Vision loss due to UV can also occur by directly damaging the retina or pterygium formation, which is a "fleshy" growth of the white of the eye which can block vision. Exposure of the eye to UV can also induce melanoma of the eye and photokeratitis. Photokeratitis is also known as sun blindness or welder's flash, and is basically a painful burn on the surface of the eye. Protection from these disorders is via sunglasses, although ironically exposure to the UV radiation may be enhanced by sunglasses that poorly absorb UV because the pupil opens wider to compensate for the reduced visible light.

One good point about sunlight is that it can produce vitamin D in the skin. Vitamin D is considered both a hormone and a vitamin. It participates in normal cell growth, and could play a role in cancer prevention. Vitamin D also helps in the regulation of blood sugar by acting on insulin, and more importantly calcium and phosphorus, enabling bone and teeth to harden. In vitamin D deficiency bones soften to the point that they curve, a condition in children known as rickets and osteomalacia in adults.

Ultraviolet radiation can be brought to good use if used appropriately. It can be used as a germicidal agent. Bacteria in air or water can be killed using UV radiation. Even more effective is the UV radiation used synergistically with ozone. The two sterilants work together in a low cost reliable way.

Edited when necessary from "Guidelines for Protecting the Safety and Health of Health Care Workers", NIOSH 1988. Parts of this section may be somewhat dated but the majority of the information is still useful or helpful as a starting point. Please note that in the case of citations, standards, recommendations, guidelines, etc. that there may be and probably is more recent literature than 1988. Please consult more recent references if you are addressing a specific problem.

Hazard location

UV radiation may be emitted from germicidal lamps, some dermatology treatments, nursery incubators, and some air filters in hospitals.

Potential health effects

Over-exposure may result in the burning of exposed skin and serious eye effects. Eye exposure is especially dangerous because the results of over exposure are not immediately evident. Damage is apparent only 6 to 8 hrs after exposure. Although resulting conjunctivitis can be extremely painful, it is usually temporary. Long-term unprotected exposure can lead to partial loss of vision, accelerated skin aging, and increased risk of skin cancer (NIOSH 1977b).

Standards and recommendations

No OSHA standard exists for UV radiation exposure, but NIOSH has made recommendations for UV light in the spectral region of 200 to 400 nanometers (nm). For the spectral region of 315-400 nm, NIOSH recommends that the total amount of UV radiation allowed to strike unprotected skin or eyes (based either on measurement data or on output data) be no greater than 1.0 milliwatt (mW) /cm<sup>2</sup> for periods greater than 1000 sec; for exposure times of 1000 sec or less, the total radiant energy must not exceed 1,000 mW sec/cm<sup>2</sup> (1.0 joule/cm<sup>2</sup>) (NIOSH 1973b). For the UV spectral region of 200 to 315 nm, the total amount of UV radiation allowed to strike unprotected skin or eyes should not exceed the levels described in the NIOSH criteria documents for UV radiation (NIOSH 1973b).

The following recommendations were developed by ACGIH 1987:

Duration of exposure per day	Effective irradiance (microW/cm <sup>2</sup> )
8 hr	0.1
4 hr	0.2
2 hr	0.4
1 hr	0.8
30 min	1.7
15 min	3.3
10 min	5
5 min	10
1 min	50
30 sec	100
10 sec	300
0.5 sec	6000
0.1 sec	30000

Exposure control methods

The best preventive approach to UV exposure in hospital settings including newborn and intensive care nurseries is to provide a strong educational program and to issue protective glasses for potentially exposed workers. The use of shaded glass is usually sufficient to prevent damage to the eyes. Enclosures and shielding may also be used.