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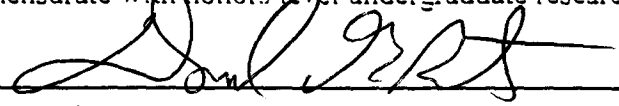
Name: Nikol Erin Hall

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Faculty Mentor: Dr. Don Roberts

PROJECT TITLE: The Effect of Ultraviolet Radiation of the Sun on the Skin

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

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The Effect of Ultraviolet Radiation of the Sun on the Skin

Nikol Erin Hall

**Honors Senior Project
April 2005**

Abstract

Ultraviolet radiation of the sun is becoming increasingly known as the cause of many types of skin cancers. The most prominent cancers being basal cell carcinoma, squamous cell carcinoma, and malignant melanoma, the most severe and deadly of the three. With the current increase in these skin cancers, has come an abundance of studies concerning the mechanism and genes affected by ultraviolet radiation. Although still unclear, many studies are leaning toward a loss of heterozygosity on either the chromosome 9p21-22 region, 9q22.3, 17p13, and/or 4q32-35 as the cause of these serious skin cancers. Upon exposure to UV light, a cascade of photo-induced chemical and biological reactions takes place in the target tissue. A wide range of DNA lesions are caused by the UV radiation that damages the tissue. The UV-induced oxidative DNA damage can block DNA replication and lead to double-strand breaks (DSBs) resulting in loss of heterozygosity. Although the gene and mechanism are still under study, protective measures can be taken to protect oneself from UV-induced skin cancers, such as avoidance of sun exposure, wearing protective clothing, sunscreens, dietary protections, and knowing whether you are at high risk to develop a form of skin cancer from sun exposure. Not all protection is guaranteed, but some protection is better than no protection.

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I. Introduction

Skin disorders are a major issue affecting almost everyone in the world. The number one cause for skin disorders such as sunburn, photodamage, and skin cancer, is exposure to ultraviolet (UV) radiation. What is shocking and ignored by most people is that the predominant exposure to UV light occurs during everyday activities. To date, there are three serious skin cancers, basal cell carcinoma, squamous cell carcinoma, and malignant melanoma that can develop due to overexposure to UV light. The most disturbing thing about these skin cancers is that they are highly preventable, and the adoption of simple precautions can reduce one's risk of developing these skin disorders.

Although much is known about the prevention of skin cancers, less is known about the genes involved and the biochemical/cellular mechanisms that lead to skin cancer. However, there are a number of leads concerning the events that result in the development of skin cancer. Ultraviolet radiation can cause a number of problems including lesions, blockage in DNA replication, and breaks in the DNA strand, as well as a number of other detrimental effects. Although much remains to be determined regarding the mechanism through which skin cancer develops, it is hoped that a consensus can be reached from the work of many scientists, researchers, and physicians. This review takes the opportunity to raise many of the unsolved questions in the areas of skin cancer and consider strategies for more effective treatments and prevention for the future. In the present report, the general characteristics of skin cancer are presented first. Secondly, a summary of the mechanisms of UV damage to cells that lead to the onset of skin cancer are summarized. Finally, protective strategies are considered.

II. Skin Cancers: Overview

Ultraviolet radiation is low wavelength, high energy light that is part of the invisible spectrum of sunlight. In addition to daily exposure to the sun, ultraviolet radiation exposure can also come from tanning beds and sun lamps. UV radiation consists of two types of rays, known as UVA and UVB. UVB and UVA both have wavelengths less than four hundred nanometers (visible violet light), but UVA has longer wavelengths and less energy than UVB. The wavelengths of UVA and UVB are 320-400 nm and 290-370 nm, respectively.

UVB rays are more likely to cause sunburn and skin diseases than UVA. This is due to two reasons: 1. sunlight contains a greater intensity of UVB rays than UVA and 2. because, UVB initially penetrates and damages the outside of the skin while UVA penetrates deep into the layers of skin affecting the internal parts of the body and causing more long term effects. More recently, it has been shown that UVA can also add to skin damage that leads to skin cancers and premature aging (AAD, 2004 and Malick, 2004).

The most damaging skin disorders that arise from excessive exposure to ultraviolet radiation are the three major skin cancers (AAD, 2004): basal cell carcinoma, squamous cell carcinoma, and malignant melanoma. Together basal cell carcinoma and squamous cell carcinoma are known as nonmelanoma skin cancer. Below a brief description of the characteristics and occurrence of these three forms of skin cancer are reviewed.

A. Basal Cell Carcinoma

Basal cell carcinoma is the most common of the three skin cancers (AAD, 2004). This type of skin cancer arises from the basal cells, small round cells found in the lower cell layer at the base of the epidermis, the outer layer of the skin (Figure 1). It is the least dangerous type of skin cancer and has the lowest mortality rate because it only spreads locally and progresses slowly (AAD, 2004). However, the frequency of occurrence of basal cell carcinoma has increased recently with the enhanced ultraviolet radiation exposure. Basal cell carcinoma usually appears as a small, fleshy bump or nodule, sometimes resembling red patches, which is most often found on the head, neck, and hands (Figure 2). Basal cell carcinoma is most common among people that are fair-skinned and have light-colored eyes, hair, and complexions and rarely occurs in African Americans (AAD, 2004). Basal cell carcinoma tumors do not spread quickly and take months and even years to develop with a common size of approximately one inch in radius. Although this is considered the least dangerous skin cancer, untreated basal cell carcinoma will eventually bleed, crust over, heal, and then repeat this cycle. This cancer rarely spreads systemically to other parts of the body, but can continue to spread locally below the skin to the bone, causing severe local damage.

B. Squamous Cell Carcinoma

Squamous cell carcinoma is not as common as basal cell carcinoma, but is more severe in its effects (AAD, 2004). Squamous cell carcinoma originates in squamous cells, which are thin, flat cells that resemble fish scales. Squamous cells are found in the tissue that forms the surface of the skin, the lining of the hollow organs of the body, and the passages of the respiratory and digestive tracts. This skin cancer initially may appear as a bump or as a red scaly patch. It is usually found on the rim of the ear, the

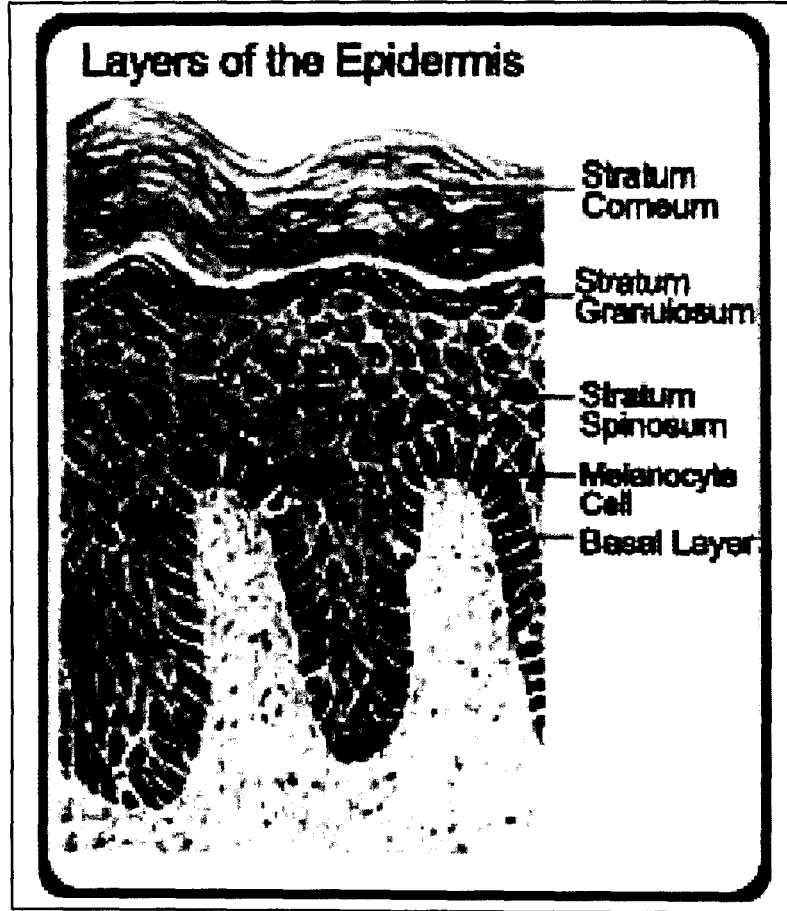


Figure 1 Layers of the epidermis. Shown in the diagram is the outer layer of the skin, the epidermis, and its several layers. Importantly, the stratum, melanocyte and basal layers of the epidermis are shown, which are the sites involved in the development of skin cancer. Figure taken from www.yasoo.com.

A



B

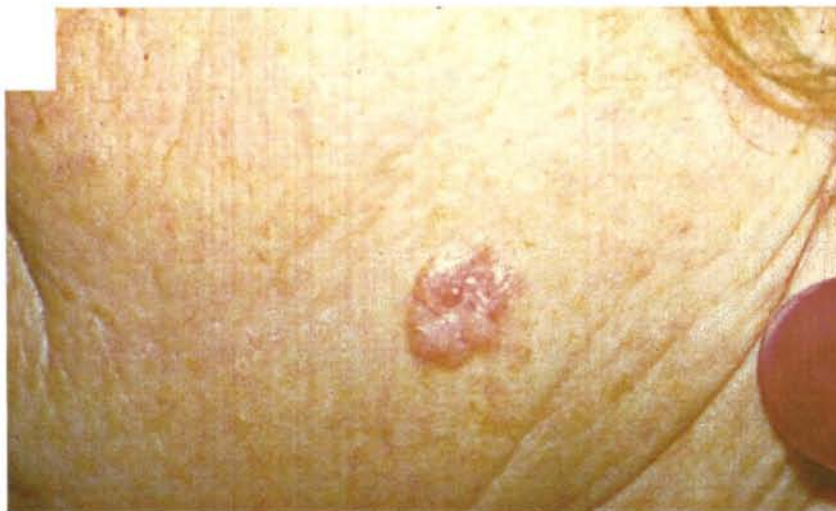


Figure 2 Basal Cell Carcinomas Shown are examples of basal cell carcinoma. Photographs are from www.skincare.com.

face, the lips, and the mouth; again areas that are often overexposed to UV light (**Figure 3**). Squamous cell carcinoma is the second most common skin cancer found in fair-skinned people, but it is rarely found in dark-skinned people. This cancer can develop into large masses and can metastasize and spread to other parts of the body. When found early and cared for correctly, there is a ninety-five percent cure rate (AAD, 2004).

C. Malignant Melanoma

Malignant melanoma is more destructive than either basal cell skin cancer or squamous cell skin cancer, and is the most severe and deadly of the three skin cancers. "It has been estimated that forty-four thousand Americans develop this form annually and about seventy-three hundred will die from melanoma" (AAD, 2004). Melanoma is a disease in which malignant or cancerous cells form in the skin cells called melanocytes, which are the cells that are responsible for skin color. Melanocytes are found throughout the lower part of the epidermis (**Figure 1**) and give rise to the dark, protective pigment called melanin. Upon onset, melanocytes continue to make melanin, which explains the cancerous cells emerging in mixed shades of tan, brown, and black, although melanoma can also appear as red or white (**Figure 4**). This type of skin cancer spreads very quickly to other tissues or organs, a process referred to as metastasis, which is why treatment is essential. Melanoma can appear as a new lesion on skin without warning, or it may begin in or near a mole, or another dark spot in the skin. Most important, malignant melanoma can occur anywhere on the body.

A



B



C



Figure 3 Squamous Cell Carcinomas Shown are examples of Squamous cell carcinoma. Photographs are from www.skincare.com and matrix.ucdavis.edu.

A



B



Figure 4 Malignant Melanoma Shown are examples of malignant melanoma. Panel A shows an example of a malignant melanoma showing the dark pigmentation typical of this type of lesion. Panel B shows a close up of melanoma and its developing stages. Photographs are from matrix.ucdavis.edu.

III. Genetic and Cellular Mechanisms of Skin Cancer Formation

A. Sunlight Effects on Skin Cells

The largest organ of the body is the skin, which protects against heat, sunlight, and infection. It has two main layers: the epidermis, the upper or outer layer, and the dermis, the lower or inner layer. Overexposure to UV light has both short and long term effects on the skin. "Human skin is protected against UV radiation by melanins (produced by melanocyte skin cells), endogenous pigments that scatter and absorb light. Upon sun exposure, pigmentation is enhanced by stimulated synthesis of melanin in the epidermal melanocytes" (Sies and Stahl, 2004). Thus, melanin is produced in response to sunlight and is what causes the skin to tan. Further, tanning is, a partial protection against the sun to prevent skin damage and other disorders such as skin cancer. Increased pigmentation of the skin offers protection by absorbing the rays or deflecting them from the underlying skin. However, when sunlight exposure is overwhelming or too intense this protective mechanism fails, and the absorption of too much ultraviolet radiation leads to damage of the skin layers. The more it scatters and absorbs light, the skin becomes darker and the damage of the sun becomes deeper, often times resulting in skin disorders. "Upon light exposure, a cascade of photo-induced chemical and biological reactions takes place in the target tissue. As a primary event, light interacts with biological molecules that have chromophore groups" (Sies and Stahl, 2004). A chromophore is a light-absorbing group of a molecule. For example, the bases in DNA or RNA represent light absorbing chromophores of these molecules. "The chromophore may be damaged directly or may act as photosensitizer initiating subsequent chemical reactions" (Sies and Stahl, 2004).

Single or multiple skin cells may become damaged leading to further destruction and breakdown in skin protection. Light induced damage of skin cells leads to a transformation turning them into a cancerous cell. These abnormal cells divide without control and can metastasize and invade nearby tissues and spread in the blood stream through the lymphatic system to other parts of the body.

B. Biochemical and Cellular Effects of UV Light

The damaging effects of UV light on the skin cells can lead to three effects that promote skin cancer: production of damaging reactive oxygen species; modification of DNA bases or breakage of DNA strands; and immunosuppression. Below each of these effects are summarized and considered.

i. reactive oxygen species

It has become known that when light strikes the skin cells in the presence of oxygen, secondary reactive oxygen intermediates are produced. “These reactive oxygen species (ROS, **Figure 5**) may damage molecules and cellular structures” (Sies and Stahl, 2004). At the onset of light absorption, UVB and UVA radiation can cause a transfer of electrons and produce a single molecular oxygen species, such as hydroxide radical (**Figure 5**). Reactive oxygen species such as these target the DNA base guanine and give rise to 8-hydroxydeoxyguanosine (8-OHdG) in the strand of DNA (Ichihashi *et al.*, 2003). With the incorporation of 8-OHdG into the DNA strand, a G to T transversion takes place. During this transversion event a guanine(G) base is replaced by a thymine(T) base in the DNA strand that leads to a miscoding lesion, which can cause cancer cell development in the skin.

Reactive Oxygen Species

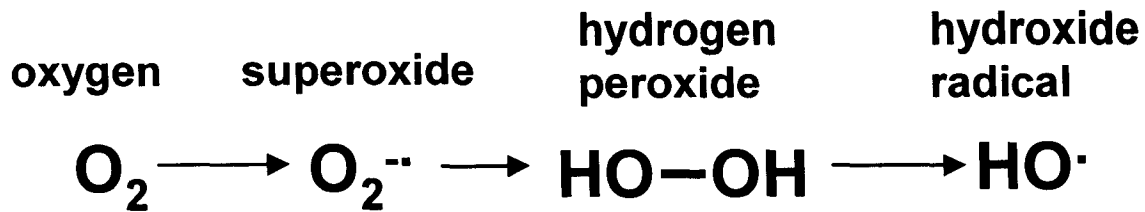


Figure 5 Examples of reactive oxygen species generated by overexposure to UV light.

ii. DNA modification and damage

Upon exposure to UV light the nucleic acid bases of the DNA absorb the ultraviolet light and can induce chemical changes in the DNA that lead to DNA modifications. One of the major photoproducts that emerges is the formation of dimeric pyrimidine bases, such as thymine dimers in the DNA due to the bond that forms between adjacent pyrimidines within one strand (Figure 6). The ultraviolet component of sunlight “covalently links adjacent pyrimidine residues along a strand of DNA. Such a pyrimidine dimer cannot fit into a double helix, and so replication and gene expression are blocked until the lesion is removed” (Berg *et al.*, 2002). Thus these polymorphisms (such as DNA modifications) that occur in the DNA influence the capacity of DNA repair and confer predisposition to UV-induced skin cancer (Colditz *et al.*, 2004). Most important to realize is that the errors caused in the DNA replication process can be devastating to the cells, leading to development of skin cancer.

Along with modifying the DNA strand and disrupting DNA replication, breakage of the DNA can occur due to this disruption in the replication of DNA. “Although UVB exposure does not directly produce DNA double-strand breaks (DSBs), UV-induced

photoproducts cause blockage of DNA replication, which can lead to the formation of double-strand breaks, chromosomal aberrations, and recombination during the course of replication arrest" (Colditz *et al.*, 2004). As stated before, these photoproducts could include the pyrimidine dimers that form in the DNA strand.

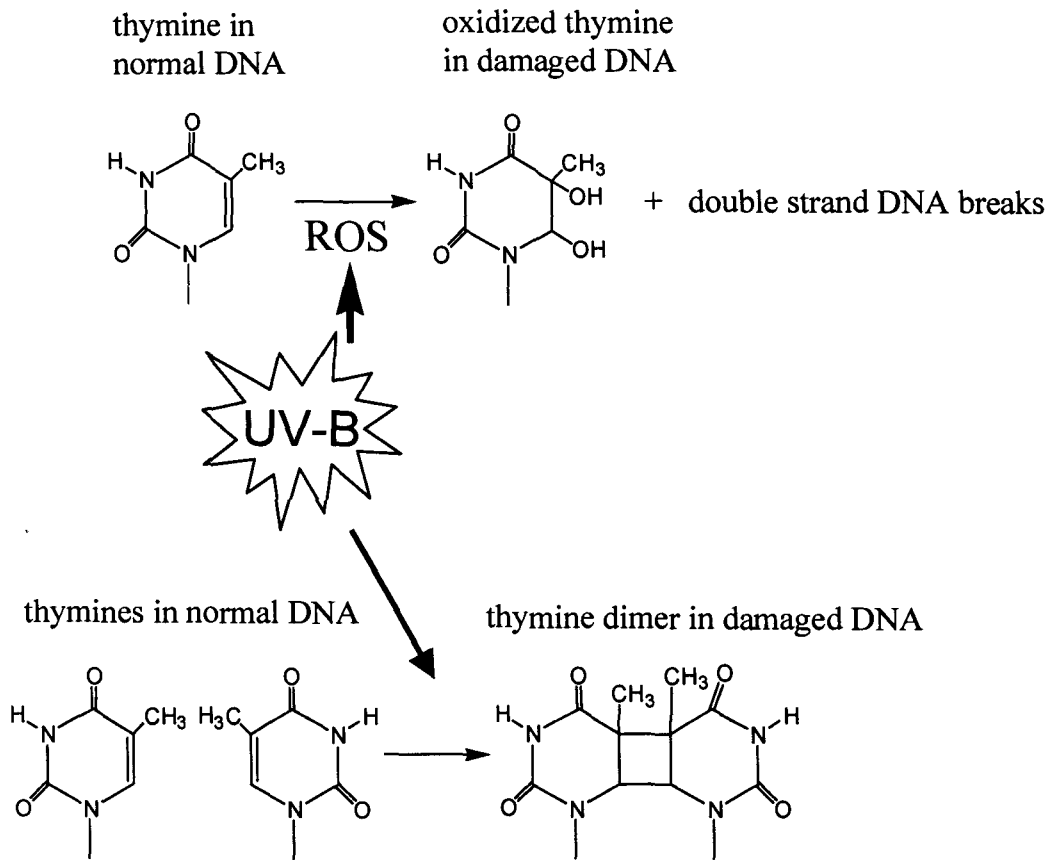


Figure 6 Damaging Effects of UV-B on DNA structure leading to mutation and carcinogenesis.

iii. immunosuppression

Ultraviolet radiation can also lead to immunosuppression that can affect some of the normal, but important cascades and processes of the body. "The chemical reaction

cascade that takes place leads to cellular biochemical responses including not only modified gene expression, but impact on important processes in the body such as kinase-dependent signaling pathways, immune and inflammatory events, or induction of apoptosis” (Sies and Stahl. 2004). In immunosuppression, the immune system that guards against the development of diseases such as skin cancer is impaired. With an impaired immune system, the body has a hard time detecting antigens, or foreign substances that are harmful to the body. There are many other examples of how this particular disruption affects the body. For example, overexposure to ultraviolet radiation can lead to the event of apoptosis, which is programmed cell death. In this particular process, UV radiation damage can lead to the death of many cells that would otherwise be normal and not usually programmed for death.

C. Specific Gene Targets

There has been much speculation concerning the genes that are affected in ultraviolet radiation exposure. Although our knowledge base of the molecular mechanism continues to develop steadily, our understanding of the genes and chromosomes involved has lagged because difficult techniques are needed to try and locate a single or small region that has been impaired by ultraviolet radiation. Studies have isolated chromosome regions in relationship to the three major skin cancers. There is still much to be discovered in this area, but recently significant progress has been made in identifying the genes and chromosomes involved. As stated before, cancer develops from cells that have been transformed. However, cancer is particularly initiated when certain genes or chromosomes become altered or defective. “Skin cancers, like other human tumors, arise from a single transformed cell that presumably

gained growth advantage through damage to the genes that control cell proliferation” (Gomes *et al.*, 2004). There is a precise process that occurs with specific genes that allows cells to develop skin cancer. Once genes and chromosomes become transformed, they often times cannot participate in their normal duties in the body and thus bring about disruption in cellular function that result in abnormalities, such as cancers. It cannot be emphasized enough how crucial the genes and chromosomes are in the operation of the body. “Cell cycle is regulated by two classes of genes: protooncogenes that promote cellular growth and tumor suppressor genes (TSGs) that inhibit it. Mutations of these genes result in alterations of cell growth” (Sironi *et al.*, 2004). A proto-oncogene refers to the undamaged “normal DNA” that is involved in an important cell function in healthy individuals. Upon damage of the DNA by agents such as UV light, this gene undergoes a structural change known as a mutation, which alters its function, leading to uncontrolled carcinogenic growth. At this point it is referred to as an “oncogene.”

In order to recognize the targeted genes, scientists look for a loss of heterozygosity (LOH) at a number of locations along different chromosomes. Loss of heterozygosity occurs when there is one normal and one mutated gene. This can occur through loss or deletion of normal chromosome. By looking for a loss of heterozygosity on the chromosome, they are able to locate the altered gene causing the onset of skin cancer. “The identification of loss of heterozygosity (LOH) at specific loci in a tumoral sample suggests the presence of tumor suppressor gene (TSG) within the deleted region” (Sironi *et al.*, 2004). The tumor suppressor genes are known for each chromosome and when a loss of heterozygosity occurs at these known regions, the

gene causing the alteration in cell growth and development of skin cancer can be determined. However, this is not an easy technique because one must map multiple marker genes on a chromosome in relationship to known tumor suppressor genes in order to determine whether the loss of heterozygosity occurs at a critical position that may result in loss of tumor suppression. Genetic mapping has become one of the most important tools in revealing loss of heterozygosity, which is acknowledged as the major cause of malignant growth.

Scientists and researchers have come to agreement on the location of some of the chromosomal loci that may be critical areas where damage can lead to skin cancers. Other locations are still up for debate. "Loss of heterozygosity in the 9p21-p22 region, has been frequently described in a wide range of human malignancies, including familial melanomas. Also, losses and gains in other regions of chromosome 9 have frequently been observed" (Gomes *et al.*, 2004). Chromosome 9 has always been a common location where DNA damage can lead to the onset of skin cancers. Along with chromosome nine being a common targeted location, damage to specific genes is commonly associated with the onset of skin cancer as well. "The tumor suppressor gene (TSG) commonly involved in human cancers is *p53*; many studies on basal cell carcinoma have been focused on this gene and revealed the presence of UV-induced mutations" (Sironi *et al.*, 2004). The *p53* protein prevents a cell from completing the cell cycle if its DNA is damaged or the cell has suffered other types of damage. Although, this may seem specific, some studies have even more specific regions on the chromosome targeted.

In a recent study, even more chromosomal regions were tested. In a study done by Elena Sironi and colleagues, four major chromosomal regions were identified as showing loss of heterozygosity and linked to skin cancer. They tested many chromosome locations and determined the percentage of the loss of heterozygosity found for each region. Their studies on basal cell carcinoma first demonstrated that, "patched gene and *p53* gene located at 9q22.3 and 17p13 are the main genes responsible for the onset of this tumor" (Sironi *et al.*, 2004). To the surprise of many, a region not commonly known for skin cancer was found to be involved in some cases. In particular, a deletion in the Chromosome 4q region has been observed in certain individuals afflicted with basal cell carcinoma. These findings suggest that a new chromosomal region, the long arm of chromosome 4, could be involved in sporadic basal cell carcinoma. Further analysis of their study found that, "the deletion of the genes *p33ING2 / ING1L* and *SAP30* on chromosome region 4q32-35 could impair the G-1 phase checkpoint control and favor gene silencing" (Sironi *et al.*, 2004). This gives more insight as to the cause of skin cancers. These targeted genes are so important because many of them control the cell cycle, a critical process to cell division. When one is exposed to ultraviolet radiation from sunlight, they are not only damaging cells, but they are also damaging the genes that help produce the cells and provide tight regulation of cell division. When there is an abnormality in these genes, they cannot properly regulate cell division and so the production of uncontrolled rapidly dividing cancerous cells takes place that causes serious damage not only to the cells themselves, but also to the tissues and body as a whole. And as stated before, cancer cells divide without control and affect other parts of the body. When an individual does

not seek treatment or has been exposed too severely, the loss of cell division regulation occurs and subsequent metastasis of these cancerous cells results in severe dysfunction and many individuals end up dying from a highly preventable disease.

IV. Protection from Ultraviolet Radiation

A. Statistics and Risks of Skin Cancer

The threat of developing skin cancer is very serious and imminent. Although the molecular mechanism and genetics of skin cancer development may be very complex, the prevention is very simple. All three major forms of skin cancer are highly preventable. When the risk factors and preventive measures involved are heeded, a person can greatly decrease if not eliminate their chances of developing skin cancer. One of the most important places to start a prevention strategy is to start becoming familiar with who is at risk for skin cancer and knowing the statistics of the occurrence of the disease. Gaining knowledge in these areas not only helps determine if one is at risk, but the recognition of the statistics and risks make the threat of this preventable disease more real and urgent in an individual's life. If one considers how serious skin cancer is and the deaths that it causes, one will be more motivated to prevent and protect him/herself in the future.

As stated before, basal cell carcinoma is the most common form of skin cancer. This form usually develops into the more serious malignant form of skin cancer when not treated. Thus, at the nonmalignant stage, skin cancer could be cured, if one would immediately seek treatment and prevent the disease from progressing. However, surprisingly many let the infection fester and develop into the more complicated

malignant melanoma. "It is projected that this most deadly of all skin cancers will develop on the skin of forty-four thousand Americans annually" (AAD, 2004). This number does not even include the even greater numbers of people that develop the less severe forms of skin cancer: basal cell carcinoma and squamous cell carcinoma. The Food and Drug administration reports that there are a million Americans that are stricken with the potentially deadly disease, which is the most common of all types of cancers, each year. Even worse, "every year, an estimated seven thousand and three hundred Americans will die from melanoma" (AAD, 2004).

Early recognition of the disease and seeking immediate treatment is essential to survival in the case of malignant melanoma. "Approximately, twenty-five percent of melanoma patients will be killed by their disease" (Malick, 2004). Thus, this is a disease that definitely should not be taken lightly, and the number of people getting skin cancer is not decreasing due to disbelief and lack of knowledge of how deadly skin cancer can be. Along with this knowledge, it is also important for one to understand whether they have a high risk factor for developing skin cancer.

In the recent years, it has become clear that certain people are at a greater risk of acquiring skin cancer than others. There are a wide range of risk factors that influence the development of skin cancer. One of the top risks is exposure to natural sunlight and its UV rays. The more one is subjected to the natural rays of the sun, the greater at risk he/she is when it comes to contracting a form of skin cancer. However, some of the additional risk factors that are usually unknown to most people are: a person with unusual moles, exposure to artificial ultraviolet light (tanning booth), and family or personal history of melanoma. Being exposed to sunlight is a great risk, but

individuals with moles or a family history of skin cancer have an increased chance of getting skin cancer.

Another area of concern is the recent popularity of tanning beds. Many use tanning beds as a substitution to sunlight tanning, but the effects of UV radiation are still the same. "There is no such thing as a safe tan. A tan is the skin's response to an injury and every time you tan you accumulate damage to the skin, as well as accelerate the aging process and increase your risk for skin cancer" (Rodriguez, 2002).

As many know by now the risk for UV-related skin disorders such as skin cancer is directly correlated with pigmentation of the skin. The risk factors associated with pigmentation include: being white and older than twenty years, red or blond hair, white or light-colored skin and freckles, and having blue eyes. "Fair-skinned individuals should be advised to protect themselves throughout their lives from excess UV radiation" (Sies and Stahl, 2004). In other words, the darker the skin, the lower the risk of developing skin cancer. Lighter-skinned individuals should reduce their exposure to the natural sunlight as much as possible. However, it is important also to recognize that dark brown or black skin is not a guarantee against melanoma. "Dark-skinned people can develop melanoma, especially on the palms of the hands, soles of the feet, under nails, or in the mouth" (AAD, 2004). Although, lighter skin people have a higher skin cancer risk, darker skinned individuals should also take the necessary precautions to ensure protection. Also, regardless of the color of the skin, those who have jobs or careers that require them to be outside in the sun for long periods of time, such as construction work, are at a higher risk for developing skin cancer due to the intense overexposure to ultraviolet radiation day after day.

Overall, along with reducing one's exposure to ultraviolet radiation in any form (sun or tanning beds) is critical to skin cancer prevention. However people must know that the ultraviolet radiation exposure is not the only factor that plays into skin disease. There are many risk factors that increase one's chances of getting skin cancer along with being exposed to sunlight. One must know whether they have unusual moles and know if melanoma has an existence in the family in order to be aware of the danger of skin cancer. This knowledge forms the basis of a sound preventive strategy.

B. Preventive Measures

With the knowledge of the danger and presence of skin cancer from ultraviolet radiation along with who is at most risk for developing this disease, one must now learn how to prevent or protect themselves from getting skin cancer. Preventive measures are often times looked at as taxing on a person because of their tendency to demand dramatic lifestyle changes from an individual. However, not only are the protection measures simple, but compared to the outcome of developing the potentially deadly disease of skin cancer, it is highly attainable and not too demanding. There are four major areas of protection that have been proven to provide significant protection from ultraviolet radiation.

The most significant and logical measure is avoidance of sun exposure. Sun avoidance is the best defense against skin cancer. Over exposure to sunlight (including tanning) is the main cause of skin cancer especially when it results in sunburn and blistering. Some other factors that are important in avoiding the sun is repeated medical and industrial x-ray exposure, scarring from diseases or burns, occupational exposure to such compounds as coal, tar, and arsenic, and family history (AAD, 2004). Of all

people, fair-skinned people who sunburn easily should avoid the direct exposure of the sun. "Prevention means guarding the skin against the known causes of skin cancer. Since the sun's ultraviolet rays are the main culprit, the most effective preventive method is sun avoidance" (AAD, 2004). A person should seek shade most between the hours of ten o'clock a.m. to four o'clock p.m. when the ultraviolet rays are the most intense, especially when your shadow is shorter than one is tall. This is most effective, but also the most difficult because outside activities are common at these very hours. Holidays, such as the fourth of July, are a very good example of direct sun exposure during these intense ultraviolet radiation hours. People tend to forget how long they have been standing in the sun and do not recognize that while standing at a barbeque their skin is being damaged, especially if they are without protection. If, however one cannot avoid being outside, such as a job or during holidays, one should always seek shady spots to stand in during these peak hours. Also, those who live at high altitudes should be very careful to avoid the sun because they are closer to more intense dangerous rays of sunlight

Along with avoiding the sun as much as can be allowed, one should wear protective clothing. Even if one has to be in the sun, there are a number ways to protect the skin. The use of hats and umbrellas that block the sunlight from directly striking the skin are good examples of protective measures. One should wear light-colored, tightly woven, protective clothing, and wide-brimmed hats that have at least a three-inch brim. "Cover-up clothing is another excellent way to block UV radiation, especially for those who don't care to bother with lotions. A number of companies now make specialty sun blocking clothing, which are very effective. Clothing may be rated by SPF or by UPF,

Ultraviolet Protection Factor, which is also a multiplier of how much longer you can stay in the sun” (AAD, 2004). One can choose to wear other non-specialty clothing that can also efficiently protect from the sun, however, one should be very careful in this selection. The AAD warns that a wet, light-colored shirt can transmit almost as much light to the skin as no protection at all. One can estimate a garment’s ability to block the sun by holding it up to a light source. The more light penetrates through the fabric, then the more UV radiation will likely penetrate it as well. Since most people refuse to give up the outdoors, wearing protective clothing can be literally a lifesaver for many.

Another important protective measure is the application of sunscreens or lotions. Sunblock and sunscreen products come in a variety of formulas including lotion, gels, creams, and even oils. Technically, sunblocks reflect UV radiation, effectively repeling it, while sunscreens have UV chromophores that absorb UV light preventing penetration into the skin. For either type, the most important thing is the level and kind of protection indicated. “The SPF, or Sun Protection Factor number, indicates how much longer you can stay in the sun than the approximate amount of time it would take you to get burned without protection. Experts recommend all skin types should wear an SPF of fifteen or higher when outdoors during the day for more than fifteen minutes” (Malick, 2004). It is recommended that one apply lotions liberally. As a guideline, it is necessary that a person should apply at least one shot glass full of product to exposed areas every two to three hours. Children should be taught early to use sun protection due to the fact that it is thought that a child will receive about eighty percent of his/her sun exposure before the age of eighteen. Children under six months should not have prolonged sun exposure, but if unavoidable, sunscreen should definitely be used. As was stated

before a fair-skin person who burns in twenty minutes can endure 15 times the exposure time (three hundred minutes) without burning.

Sunscreens and sunblocks are to be used as part of a program to avoid the sun, but should not be used as an excuse for increasing sun exposure. "There are other rays that still go through the skin such as UVA and infrared that can age the skin and damage the skin's immune system" (AAD, 2004). When using sunscreen and sunblock, the SPF number only applies to UVB rays and not UVA. One must buy a product that specifically says that it protects from UVA rays for added protection to this radiation. "The FDA points out that sunscreen does not prevent skin cancer, and that using a UVB-only product may be bad for health in the long run since it allows people to stay out longer and be exposed to more UVA rays over time" (Malick, 2004). For UVA protection, the American Academy of Dermatology (AAD) advises selecting a "broad-spectrum" sunscreen that contains benzophenones, oxybenzone, sulisobenzone, titanium dioxide, zinc oxide, and Parsol 1789 (butyl methoxydibenzoylmethane, also called avobenzene). As said before, avoidance of the sun is the most protection that a person can provide him/herself. But sunscreens and sunblocks can offer that protection when one's activity or lifestyle requires direct exposure to the sun.

One of the more subtle ways of protection against skin cancer is through dietary changes. This area of protection is still under study and development, but there are a few products that can offer significant protection to the skin from the sun. Tomato paste has been found to offer protection from UV radiation. "Tomato paste contains high amounts of the tomato-specific carotenoid lycopene and was selected as a natural dietary source providing carotenoids to protect against UV-induced erythema in

humans” (Sies and Stahl, 2004). Over a period of ten weeks of consumption, a significant amount of protection was achieved. The carotenoid levels in the skin that protect the skin rose from point four micromole/L to point seven micromole/L (Sies and Stahl, 2004). Also, the group that consumed tomato paste showed a significantly lower amount of erythema formation than the control group.

Also, vitamins E and C have been shown to offer protection. “Short-time intervention with high doses of both vitamin E and C also affords some protection” (Sies and Stahl, 2004). Although, these dietary measures cannot offer full protection against ultraviolet radiation, as part of a protection program they can decrease one’s chances of developing skin cancer from UV exposure. The important consideration in a preventive strategy is not to choose a single measure. Rather, it is wise to acknowledge all the proven approaches to prevent skin cancer and use as many of them as one can afford to prevent the onset of this deadly disease.

V. Conclusion and Future Aspirations

Skin cancers are no longer a thing of the past. Incidence of skin cancer has been increasing, and researchers and scientists are becoming more convinced that it is due to overexposure to ultraviolet radiation from the sun. Although there is still much to be learned, there is considerable evidence and information concerning the mechanism and causes of skin cancer formation. The three major skin cancers: basal cell carcinoma, squamous cell carcinoma, and malignant melanoma show a direct correlation to exposure to ultraviolet radiation. This radiation causes chemical changes to take place not only within the skin, but also within the entire body. Ultraviolet

radiation damages the protective cells in the skin and disrupts normal cellular processes, disrupting DNA replication of skin cells. Furthermore, UV exposure results in the damage of critical regions of the chromosome, and the alteration in the function of critical genes involved in the control of cell division. Although these studies have narrowed down the chromosomal regions and gene targets, more research is needed to understand specifically how this damage results in the onset of cancer and the spread of the disease.

In addition to increasing our knowledge of the molecular and genetic components of skin cancer and ultraviolet radiation, it is important to develop a preventive strategy for these potentially deadly cancers. It is necessary for people to educate themselves about the risks factors involved and about who is most at risk for developing skin cancers. There are a number of preventive programs and methods and it is best to use as many as possible. Since the more protection a person uses, the lesser the risk of developing skin cancer. It is proven that precautions such as avoiding the intense sun, wearing protective clothing, sunscreens, and dietary protections decrease chances of developing skin cancer significantly. In recent studies, it has been shown that these prevention programs are best abided by when taught at childhood. Also, prevention cannot be effective unless children and parents are educated as to the importance and seriousness of developing skin cancer. "Improvement in sun protection practices among children holds great promise for prevention, and parents and caregivers play important roles. Health promotion programs are most likely to succeed when based on systemic planning process including an understanding of current practices, beliefs, social norms and environments" (Glanz 1999). To increase the likelihood of a

successful prevention program, it is important that people are educated and changes are not implemented by adults and children, but also by schools, recreation centers, and places of employment.

The environment must also be a focus of change. Dr. Karen Glanz, a researcher for Emory University, is a part of a SunSmart Program study in Hawaii (Glanz, 1999). Her program involves not only protection, but also explaining to children what skin cancer is, what it does, and how serious it can be. She also has worked with schools, camps, and other areas to set up more shaded areas for protection from the sun, especially for children whose activities require them to be outside. She believes in working with the community to develop a specific program centered around each type of community or family. These and other types of programs not only provide standard information, but also are actively involved in informing the communities of skin cancer risks, and working with places where people are commonly overexposed to the sun. This type of active involvement in the community is a positive step for the future education and prevention of skin cancers.

In the future, as more information develops in the unknown areas of the biological aspect of skin cancer and ultraviolet radiation, even more effective ways of preventing and treating skin cancer will develop. With all the new molecular and genetic knowledge, the future development of additional possibilities in treatment and prevention looks promising. However, regardless of the new developments, it cannot be stressed enough that the start of prevention during childhood is the best mechanism of ensuring a steady and faithful program of protecting oneself into adulthood. Also, along with focusing on the children and adults, schools, jobs, summer camps, and other

places must be targeted as part of the prevention program due their crucial role in the lives of kids and adults. Places must be provoked to offer more protection when people are at the playground, park, camp, outside of work taking a break, construction sites, etc. Working individually and as a community, the incidence of skin cancer can decrease, possibly becoming a rare disease. However, for this to occur, everyone needs to assume responsibility to not only inform and protect themselves, but to also inform others and help them understand the real threat of sun exposure and skin cancer.

Literature Cited/References

- American Academy of Dermatology. Skin Cancer. AAD. 2003-2004.
<<http://www.aad.org/>>
- Colditz, Graham A., *et al.* Polymorphisms in DNA double-strand break repair genes and skin cancer risk. *Cancer Res.* 2004 May 1;64(9):3009-13.
- Glanz, Karen, *et al.* Formative research for developing targeted skin cancer prevention programs for children in multiethnic Hawaii. *Health Educ Res.* 1999 Apr;14(2):155-66.
- Glanz, Karen, *et al.* Guidelines for school programs to prevent skin cancer. *MMWR Recomm Rep.* 2002 Apr 26;51(RR-4):1-18.
- Gomes, Gabriela Pereira, *et al.* Allelic imbalance studies of chromosome 8 suggest major differences in chromosomal instability among nonmelanoma skin carcinomas. *Sao Paulo Med J.* 2004 Jan 8;122(1):18-21
- Ichihashi M, Ueda M, Budiyo A, Bito T, Oka M, Fukunaga M, Tsuru K, Horikawa T. UV-induced skin damage. *Toxicology.* 2003 Jul 15;189(1-2):21-39.
- Malick, Amy. No Day at the Beach The Sun and Skin Cancer: Protection=Prevention. abc news. 2004 June.
- Sies, Helmut and Stahl, Wilhelm. Nutritional Protection Against Skin Damage From Sunlight. *Annu. Rev. Nutr.* 2004. 24:173-200
- Sironi E, Cerri A, Tomasini D, *et al.* Loss of heterozygosity on chromosome 4q32-35 in sporadic basal cell carcinomas: evidence for the involvement of p33ING2/ING1L and SAP30 genes. *J Cutan Pathol.* 2004 Apr;31(4):318-22.