AN EVALUATION OF SOLAR RADIATION AND SKIN CANCER CONCEPTS CONTAINED WITHIN HIGH SCHOOL BIOLOGY TEXTBOOKS

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CHAPTER I

THE PROBLEM

Introduction

The sun is the vital source of energy which maintains all life in all of its simplest to complex forms; with the exception of the few various forms of microorganisms whose existence depends upon other natural resources. Life developed on this planet within the sheltered domain of the sun. Over ninety percent of the entire surface of the earth is bathed in this abundant natural resource. However, as radiant as the sun is it is often impossible to find its magnificent rays at the bottom of the ocean floor or in the cool, humid atmosphere found in underground caves. Solar radiation is probably the natural resource with which all are most familiar. Each of us have had a firsthand experience with it in one or more forms such as sunbathing or merely awakening from our sleep as rays from the sun veer through the window pane. For example, on a hazy or cloudy day each one of us looks to the heavens and makes reference to the sun. Often looked upon as a standard natural resource among the ranks of water, plants, and the atmosphere, the sun is the only

resource which humans have no immediate influence over. To date no governmental laws have been mandated to protect the general welfare of the sun, but, however, there have been laws implemented to protect ones freedom to be flourished with sunshine. In some states, new city ordinances have been passed to prohibit homeowners from "stealing" their neighbors sunshine. Several environmentally conscious lawmakers believe that if an untrimmed tree dawns cool shade into a section of a neighbors property, then the tree is inadvertently stealing the neighbors free right to be flourished with sunlight.

The sun is the energy source responsible for the sanity, growth, and sustenance of all humans on earth (Urbach, 1969). Moderate amounts of direct sunshine are beneficial to good health. The action of sunlight on the fatty layers of the skin produces vitamin D which is essential for strong bones and teeth. Sunshine is also linked to the prevention of certain forms of mental depression. However, scientists, doctors, and politicians urge everyone to avoid prolonged exposure to the sun. According to the American Academy of Dermatology the year 1993 produced 700,000 new cases of all skin cancers (FDA, 1993). Upcoming years, according to scientist, will produce 32,000 new cases of malignant melanoma. In a study released by Brown University it was confirmed that about two percent of malignant melanomas are in people younger than age 20 (FDA, 1993).

Despite the many warnings that have been issued by scientific researchers the fact has become evident that the general public does not perceive over-exposure to

ultraviolet radiation as an environmental hazard. In a survey conducted during nineteen ninety, individuals questioned worried less about issues which did not have an immediate effect on their lives: Of those surveyed, only 43% worried about the damaged ozone layer, 34% about the effects of acid rain, and 30% about the greenhouse effect. Speaking candidly, "A significant majority of Americans say that hardly anyone--the public itself (72%), the government (75%), or business and industry (85%)--is concerned enough about the environment" (Gallup, 1991, p. 43). Thus, if an environmental issue is not perceived to effect a person or group of individuals, then few advocates will step forward to petition that corrective changes be made to protect the environment and its natural resources.

For the most part, the American society has managed to make famine and pestilence a thing of the past and we feel we have conquered most threats to our existence. It is this conquering attitude which has greatly influenced mankinds perception about public health. As noted by Young and Yalow (1995), "The perception of reality in our world is too often confused with reality" (p. 1). Perception, as defined by the American Heritage dictionary, is merely "awareness" or "insight" (p. 526). Due to many medical advancements, the general public consistently perceives that man has the ability to cure all diseases (Mader, 1988). This perception, however, is not the case. Today, as a result of this lack of insight, we have the responsibility to instruct teenagers about the dangers of ultraviolet radiation and to teach them methods for minimizing ultraviolet exposure.

Nationally and locally, secondary school curricular programs should be attempting to meet the health education challenge of teaching the general public and the leaders of tomorrow. The development of public attitudes, knowledge, and skills relating to solar radiation exposure and skin cancer is of utmost importance. To achieve this goal it is vital that educators gain an insight as to what young adults are learning about solar radiation and its effect on skin cancer.

Significance of the Problem

Scientific research has proven that radiation exposure is a cause of cancer among the human race. It is generally accepted that, despite the many years of experimentation and research, there is yet no known cure for skin cancer, only preventative and treatment measures which merely extend life as the patient knows it (Ponder, 1990). How successful has the effort been when the patient lives but cannot successfully accomplish what were once simple goals in life? The assumption is that with today's knowledge of early prevention and detection we can presumably alter the deadly consequences of illnesses caused by a deteriorating environment and escape the detrimental effects of skin cancer.

Knowledge is the driving force of human progress. Thus, in order to succeed in life, one must have knowledge of personal health. In today's society children must be taught of the environment, their actions, and how their actions effect individuals and the planet as a whole. To achieve this goal, we must alter our high school curriculum

in science to ensure that all students are aware of (1) how solar radiation effects the normal activity of the human cell, to produce a cancer, (2) how to protect themselves, and, (3) the cause of the noted increase in solar radiation. Just as we teach personal hygiene to children there is a need to teach how to lessen and prevent increases in solar radiation and how to lessen the adverse effects of solar radiation in causing cancer of the skin.

Problem Statement

The purpose of this study was to bring to the forefront what the author feels are the primitive insights of the Oklahoma Suggested Learner Outcomes within the science curriculum (Folks, 1985). It is hoped that the research presented will remind science educators of the true purpose of teaching and allow them the opportunity to recognize, review, and replace current curriculum objectives. As a result of this future educational movement by science instructors, it is assumed that the youth of Oklahoma will become more literate of the causes as well as the long term effects of radiation on both the cell and the human body as a whole.

Purpose of the Study

The primary purpose of this study was to identify and analyze (A) the solar radiation concepts, and, (B) skin cancer concepts found within Biology I and Biology II

secondary school textbooks required by the 1995-1996 Oklahoma State Department of Education. In addition, the primary study included an inquiry into the (C) concepts which present the effect of solar radiation on skin cancer. Secondary goals were also included in the investigation to determine (D) the amount of information Biology I and Biology II textbooks posses concerning the cause in the increase of solar radiation: (E) the amount of information the textbooks posses concerning the cause of the increase of reported skin cancer cases. and, (F) the amount of information detailing the effects of solar radiation on skin cancer which students are exposed to as they progress through the Biology I and Biology II courses across the secondary school grade levels. Furthermore, the study was also conducted to analyze (G) the readability level at which the concept information was assessed, as well as, (H) the number of illustrations presented per page which were representative of the concepts which were canvassed.

The following questions directed this study.

Research question 1

1. *Of the textbooks required by the 1995-1996 Oklahoma State Department of Education for secondary Biology I and Biology II courses, which, if any, contain concepts concerning solar radiation?*

Research question 2

2. *Of the textbooks required by the 1995-1996 Oklahoma State Department of Education for secondary Biology I and Biology II courses which contain concepts concerning skin cancer?*

Research question 3

3. *Do any of the required textbooks for Biology I and Biology II secondary courses present information which mentions the effect of solar radiation on skin cancer?*

Research question 4

4. *What amount of information do the textbooks posses concerning the cause in the increase of solar radiation?*

Research question 5

5. *What is the amount of information the textbooks posses concerning the cause of the increase in reported skin cancer cases?*

Research question 6

6. *As students progress from Biology I into Biology II, what is the amount of information pertaining to the effects of solar radiation on skin cancer in which the students are exposed to?*

Research question 7

7. *To what extent does the readability level of the state required Biology I and Biology II textbooks rate according to grade level?*

Research question 8

8. *How often do the authors present illustrations which are representative of both solar radiation and cancer concepts?*

Definitions of Terms

The following terms are defined as they are used in the study.

1. Amount of information-The number of paragraphs, sentences, and words found in each primary section as directed by Appendix F.
2. Biology -Indicates required/elective science course(s) for students in grades 9-12.
3. Cancer-Any malignant tumor. A tumor that tends to proliferate and spread indefinitely and to increase in virulence (Sherwood, 1989).
4. Cell-The smallest structural unit of an organism that can function independently. It can consist of a nucleus, cytoplasm, and various specialized parts surrounded by a semipermeable membrane.
5. Concept-An idea which is commonly represented by a word.
6. Global warming-An increase in temperatures through the world due to the increased in the levels of man made contaminants.
7. Greenhouse effect-A phenomenon created by the inability of solar rays to exit the atmosphere. Causes changes within atmospheric temperatures.
8. Ozone-Molecules present in the stratosphere whose primary function is to shield the surface of the earth from ultraviolet radiation.
9. Ozone Depletion-A phenomenon classified as the destruction of ozone molecules within the earth's lower stratosphere.
10. Radiation-Energy propagated through space.

11. Solar radiation-Waves of radiant heat emitted from the sun and falling upon the earth.

12. Secondary School-Indicates grades nine through twelve.

13. State adopted textbook list-A list of textbooks that teachers are required to refer to when ordering instructional material.

14. Textbook-The Biology I/II book used and/ or recommended for use within the state of Oklahoma until the year 2000 (Folks, 1985).

14. Ultraviolet Radiation-See Solar Radiation.

CHAPTER II

REVIEW OF SELECTED LITERATURE

Introduction

Today is a day which we have never seen before yet a day which we will never see again.

Unfortunately, if we are concerned about the future of our planet earth then we must find a way to ensure that the youth of today are appropriately prepared to deal with the responsibility of saving the environment. The existing state of the atmosphere, the prevalent low level understanding of basic scientific concepts possessed by the general population combined with the continual desecration of the earth's precious ozone layer are indicative of the need for educators to address environmental issues immediately. It is the intent of this study to examine the solar radiation and skin cancer concepts found within high school Biology textbooks and to evaluate the scope and sequence of the conceptual knowledge presented in the textbooks which are assessed. The following chapter represents a selected review of literature as it relates to skin cancer and the detrimental effects of over-exposure to solar radiation. Also included are the goals which are intended for science and health

education. Categories focused upon include the human cell, cancer, radiation, the ozone layer, global warming, and the fatal consequences of skin cancer excessively exposed to solar radiation . As the diagnosis rates of skin cancer rise it is imperative that the educational efforts increase as well. Thus, the relevance and overall importance of this information should not be underestimated. Every effort to improve and share scientific knowledge of skin cancer and its correlation to solar radiation should be exhausted to ensure that everyone is given an equal opportunity to live healthy lives.

The Human Cell

It has long been accepted that life is based on morphological units known as cells. The cell is the basic unit of life. Cells and their method of cell division are a clue to the developmental relationships among almost all organisms. This similarity between the structure and reproduction of all cells is part of an important biological generalization. the cell theory (Norton, 1981). There are three principles to the cell theory. They are as follows: (1) All organisms are composed of one or more cells. (2) The cell is the basic living unit of organization. (3) All cells arise from preexisting cells (Starr and Taggart, 1987, p. 63). Primarily, the theory proposed that all large organisms are built of cells, structural and functional units which act somewhat independently. The life of the organism depends on all or most of its cells' proper function and control (Alberts and Bray, etc., 1986). The cell theory provides a logical explanation of the way in which multicellular organisms may have evolved from

unicellular forms. It has been emphasized that the basic processes of respiration, photosynthesis, and chromosome activities take place within cells. According to the cell theory, the life of a multicellular organism resides in its cells (Klug and Cummings, 1986).

Cells, though very small, are extremely complex. Scientist have developed a fairly complete picture of cells although much is yet to be learned. There are three structural features that all cells have in common: a nucleus, surrounded by cytoplasm, which is surrounded by a plasma membrane. Biologist have come to realize that there are two major types of cells: procaryotic and eucaryotic. The procaryotic (which means "before the nucleus") cell is found only in the monera class: the bacteria and blue-green algae (Voet and Voet, 1990). The eucaryotic cell (which means "true nucleus") are more complex and contain many organelles. Eucaryotic cells generally contain a nucleus, endoplasmic reticulum, Golgi bodies, lysosomes, transient vesicles, and mitochondria (Starr and Taggart, 1987). Each of the organelles possesses specific functions relevant to the life of the cell.

Cell Division

New cells arise from older ones by a process called cell division (Starr and Taggart, 1987). Cell division is necessary for the growth and repair of multicellular organisms, and for the reproduction of all organisms. In all eucaryotic organisms cell division has two phases. One phase is known as mitosis and results in the

duplication and distribution of the chromosomes. The other phase, meiosis, results in the division of the cytoplasm. Because cells can duplicate themselves exactly, the parent cell's collection of hereditary genes is passed on to the new cells (Klug and Cummings, 1986). Traits that survived natural selection are in this way passed on, and newly formed cells are better able to survive. The precise duplication of the nucleus, the control center, accounts for the close resemblance of the two new cells to the single parent cell that formed them.

A cell that is about to undergo mitosis shows changes in the chromosomes. In all animal cell division there are two sequences of events: mitosis and the division of the cytoplasm. Ordinarily, cells remain in the interphase state of existence. However, as the chromosomes of the cell duplicate the nuclear membrane and the nucleolus break down (Mader, 1988). In addition, the centrioles duplicate themselves (Hole, 1987). From the nuclear and cytoplasmic materials, fibers are organized and become arranged into what is known as the spindle. This phase of mitosis is called prophase. Once the nuclear membrane and nucleolus are no longer visible, one pair of centrioles gradually moves toward an opposite side of the nucleus from the other pair. Here they become arranged more or less in a single plane almost at right angles to the spindle fibers which form the metaphase portion of cell division (Sherwood, 1989). These spindle fibers apparently attach to the chromatids. When the two chromatids of each pair separate from one another during the anaphase stage they move toward opposite ends of the cell (Voet and Voet, 1990). A spindle fiber appears to be fastened

to a certain point, the centromere, on each chromatid (Nybakken, Stebbins, etc., 1979). The fibers then contract and guide the chromatids away from the center of the cell (Mader, 1988). The chromatids eventually arrive at opposite ends of the cell and separate from the spindle fibers. The separated chromatids of the original chromatids of the original chromosome are copies of each other (Van De Graff, 1988). Once separated they are once again referred to as chromosomes. Thus, each end of the cell receives the same number and the same kinds of chromosomes that the cell originally had (Klug and Cummings, 1986). In this way the nuclear material is duplicated. As mitosis continues, new chromosomes become grouped together at both ends of the cell and a nuclear membrane and nucleolus begin to form (Starr and Taggart, 1987). During the final stages of animal cell division no cell plate is formed. Instead, the cytoplasm is divided by a furrow, which deepens until it completely separates the two new cell. The two cells then may grow and divide again.

Cell Mutation

The ability of cells to duplicate by mitosis marked an advance in the gradual evolution of primitive heterotroph(s). Each chromosome became able to duplicate itself accurately. The genetic material of the parent cell was thus transmitted to the new cells formed from it. Despite the built-in safeguard within this duplicating system errors still occur. An error in the duplication of the genetic material is

called a mutation (Starr and Taggart, 1987). Sometimes a variation from the original gene may result from an accidental rearrangement of the letters in the message. Sometimes a mutation may result from a shortage of a particular kind of nucleotide needed to duplicate the coded chain of the gene. Sometimes an outside influence, such as x-rays, or exposure to a form of radiation, may alter the code of the gene (Hole, 1987). Most mutations are not advantageous to an organism.

A mutation may have only a minor effect in the cell (Voet and Voet, 1990). In fact, the effect may be so small that it cannot be easily detected. On the other hand, because they disturb the function of the cell, mutations can often make it impossible for the cell to live. If the mutation affects the production of a very important enzyme or structural protein, the change may cause the death of a cell (Klug and Cummings, 1986). This particular kind of mutation is called a lethal mutation because the cell cannot survive.

Genes may mutate in many ways, however, the causes of most mutations are unknown. To date, scientists do not know why a given gene mutates at a particular time. In an effort to find out more about this process, techniques have been formed to increase the numbers of mutations by artificial means (Fessenden and Fessenden, 1990). The most direct way to increase the rate of mutation is to treat the reproductive cells with external agents of various kinds. Some of the agents that increase mutation rates of genes are temperature, chemicals, and radiation (Mader, 1988). When the temperature of the reproductive cells is increased, the mutation rate

is increased. When cells are treated with compounds of certain kinds, the rate of mutation is increased. High-energy radiation, in the form of x rays, beta and gamma rays, neutrons, and ultraviolet light have also been shown to increase the mutation rates of genes. Sometimes these rate increases are very strikingly high.

Cancer

As multicellular organisms approach maturity, the rate of development gradually diminishes. Differentiation slows or stops when all the organs have reached their adult form and function (Hole, 1987). As a result of this phenomenon, cell division continues in most tissues, but, at a slower rate. Just enough cells are produced to replace those that are lost. Overall growth stops when an organism reaches its mature size (Starr and Taggart, 1987).

If the rate of cell division in an organ suddenly increases again, the chances are that somewhat different cells are produced than are needed by the body (Voet and Voet, 1990). Such uncontrolled growth is referred to as cancerous growth. Thus, both the structural and functional balance of the organism is disturbed. The word cancer refers not to a single disease, but to a variety of different types of abnormal growth and development (Ponder, 1990). If one were to examine the skin of older people clues would be revealed. It gives clues to their occupation, lifestyle, and exposure to the sun. Somewhere between the transient pain and redness of sunburn

and the malignant cancer of melanoma lies the changes that occur in human skin with cumulative exposure to solar light. Solar radiation, absorbed by the skin, leads to permanent damage to RNA and DNA, alterations in connective tissue, and loss of stabilization in membranes. These changes may make little or no difference in the way a person functions, but they can have a profound effect upon the way a person looks.

Intrinsic changes in the skin are just part of the natural aging process, but, they are accelerated in skin which has been damaged by the sun. Extrinsic changes in the skin caused by environmental exposures such as UV radiation are much more significant. Skin which has been overexposed to the sun has many distinguishing signs such as fine and deep wrinkling, pigment alterations, sagging, and changes in the vasculature of the skin (Urbach, 1969). Elastosis, increased numbers of altered elastic fibers, is the most common sign of photoaging. Ironically, these fatiguing effects can also be seen in younger people who have not protected their skin. Much progress has been made in cancer research, but the problem is still a long way from solution. The various kinds of cancer may have a variety of causes. To find these causes we must first understand the basic processes involved in cell division, enlargement, and differentiation. In doing so, each cancer must be focused upon individually.

Skin Cancer

The human skin is composed of two basic parts, the upper layer called the epidermis and the lower layer called the dermis. The cells of the outer epidermis fall off daily (Sherwood, 1989). The epidermis varies in thickness from 30 to 100 microns. At the base of this layer new cells form. Once the new cells are formed they push upward and replace the old surface cells. Underneath this layer is the much thicker dermis containing hair follicles, sweat glands, and many blood vessels.

In this base layer there are many cell types. One type is the melanocyte that produces melanin which is responsible for skin color. Some skin types contain more melanocytes than others which results in both the variation in skin color as well as the overall ability to tan. Africans have the highest concentration of melanocytes and the darkest skin color (Higginson, 1992). The sun stimulates the melanocytes to produce more pigment. Within any ethnic group, when there is an absence of the sun there is a gradual loss of melanin or the acquired tan (Gricouroff, 1958).

Ultraviolet radiation of the base layer of the epidermis damages the cells, thus causing the cells to grow in an uncontrollable manner (Van De Graff, 1988). The amount of damage is influenced by the absorption properties if the epidermis (Coggle, 1971). Light colored skin will not absorb ultraviolet light strongly, thus permitting the light to penetrate more deeply into the basal cell layer. Applications of sunlotions to the skin will increase the ultraviolet absorption of the skin (Gricouroff, 1958). This increase absorption blocks sun rays from penetrating to the basal layer of the skin.

Because the skin is very porous, the lotion will penetrate into the skin pores. Therefore, it is important to use enough lotion to thoroughly saturate the skin. An adequate lotion will allow the skin to thoroughly absorb all of the ultraviolet radiation before it reaches the basal layer of the skin.

Several types of skin cancer are associated with ultraviolet radiation. New cells growing in the epidermis may be modified by ultraviolet radiation which leads to uncontrolled growth and tumors. Benign tumors do not spread to other parts of the body. In contrast, malignant tumors can spread through the blood system to other parts of the body where new tumors can form (Van De Graff, 1988). In contrast, malignant tumors can spread through the blood systems to other parts of the body where new tumors can form (Mader, 1988).

The most common type of skin cancer is basal cell carcinoma which starts in the basal region of the epidermis where new cells grow. If too much solar radiation causes the basal cells to reproduce too fast a tumorous growth forms. Basal cell carcinoma usually starts as a very slow-growing, small, shiny bump or nodule that becomes an open sore taking longer than three weeks to heal (Urbach, 1969). They often bleed, crust over, and open to bleed again. The cancer may be an itchy or tender reddish patch that comes and goes. Often times it may appear as a pale splotch, similar to a scar, and sometimes a circular growth with a raised border and depressed center (Urbach, 1969).

On rare occasions, these cancerous basal cells release from the tumor, enter

into the blood stream, and take up residence in another organ, such as the liver or kidney. At this point, the cancer is diagnosed as metastasized, and is now a threat to life. The survival rate of treated basal cell carcinoma before it has the opportunity to metastasize, is greater than ninety five percent (Higginson, 1992). Unfortunately, the problem will eventually show up again in one out of every five survivors.

The second most common skin cancer is squamous cell cancer which starts in the flat scale-like cells of the upper epidermis. Squamous cells make up most of the epidermis, and, much like the basal cells, they are also susceptible to the same solar radiation alterations. This cancer may look like basal cell cancer, but it may also appear as a wart that bleeds and crusts over (Coggle, 1971).

Cancerous squamous cells grow faster and metastasize more frequently than basal cell carcinoma. Still, the survival rate of treated squamous cell carcinoma before it has a chance to metastasize, is greater than ninety percent (Higginson, 1992). Unfortunately this cancer shows up again at about the same rate as basal cell carcinoma.

Of the three major types of skin cancer, malignant melanoma is the least common and the most serious. In the United States about 300,000 new cases appear each year (Ponder, 1990). Melanomas involve the melanocytes, the cells that give the skin its color. This particular cancer most often originates in or near a mole, birthmark, or "beauty mark". Thus, the more moles a person has, the greater the risk of melanoma. But, it can also occur as a new spot, and range in color from

black to brown to red to blue to translucent (Coggle, 1971). After they appear, they continue to grow with irregular borders. Malignant melanoma kills nearly seven thousand people every year (Higginson, 1992). One in five persons diagnosed with malignant melanoma are dead within five years (Higginson, 1992). But, if detected early, this cancer is cured almost one hundred percent of the time. There is about a fifty-fifty chance of recurrence. New evidence suggests that ultraviolet radiation increased the probability of developing melanoma skin cancers. However, the relation between melanoma and ultraviolet exposure is less direct since melanoma skin cancers can appear on body areas that are not normally exposed to the sun. Thus, instead of cumulative exposure, malignant melanoma appears more often in people who have a history of serious sunburns especially when they were children.

Physicians use several different techniques to remove skin cancer. The choice depends on the extent of the cancer, the position of the cancer on the body, and the risks to the patient. Surgical removal accounts for ninety five percent of treatments (Ponder, 1990). Electrosurgery may be used, in which an electric current burns the border of the removal site to kill any remaining cancer. For those patients who cannot tolerate regular surgery, the cancer may by frozen and removed by a technique known as cryosurgery. Another option, primarily used in elderly patients, is radiation therapy. Radiation therapy utilizes a beam of radiation which is directed at the center of the cancer to kill the bad cancerous cells. Once it has metastasized a melanoma usually requires chemotherapy or immunotherapy.

Techniques for detection and treatment of cancerous growth are constantly improving. It is hoped that we may someday be able to prevent as well as control cancer. As scientist continue their research mission we can only be confident that the knowledge we have about cancer will increase as basic research into normal cell production and activity continues. Fortunately, if detected early, skin cancer is one of the most curable forms of cancer, and, skin cancer is also preventable.

Types Of Radiation

Radiation is a feature of the natural environment. Radiation can be viewed as "the emission and propagation of energy through space or through a material medium in the form of waves" (Considine, 1995, p. 2616). Ultimately, the origin of the word implies that energy propagates in a rectilinear direction, and specifically, speaking, this holds for the many different types of radiation encountered.

The major types of radiation may be viewed as electromagnetic, acoustic, and particle, and having within these major divisions a multitude of subdivisions (Gricouroff, 1958). Electromagnetic radiation is classified roughly in order of decreasing wavelength radiation, microwave, visible, ultraviolet, x-rays, and gamma rays. Acoustic sound radiation maybe classified by frequency as infrasonic, sonic, or ultrasonic in order of increasing frequency (Yalow, 1995). In any manner of definition, if indeed it is a fact that life evolved in a radiation-filled environment, however, recent advances in technology have tended to increase the amount of radiation to

which life is exposed.

In order to fully understand and interpret the term radiation one must first view the word from the biological point of view. In doing so, the focus is upon the study of the influence of light or ionizing radiation, such as x-rays or fast particles, on living systems. Radiation biology ranges from a consideration of the effects of visible light on metabolism to the effects of cosmic rays on whole organisms. Because of the enormity of the subject area it is studied, to a large extent, in separate areas. The first division, ionizing radiation, includes high energetic electromagnetic radiation such as x-rays and gamma rays and particulate radiation such as alpha particles, beta particles, neutrons, or heavy charged ions. The second division, nonionizing radiation, consists primarily of ultraviolet radiation, microwaves, and extra low-frequency (ELF) electromagnetic radiation (Shapiro, 1990). Despite their common definition, these two types of radiation have different modes of action on biological material: ionizing radiation is sufficiently energetic to cause ionizations, whereas nonionizing radiation causes molecular turbulence. In both cases, the result is that chemical bonds of molecules may be altered, causing mutations, cell death, or other biological changes.

Ionizing Radiation

Ionizing radiation originates from external sources such as medical x-ray equipment and cathode-ray tubes in television sets or computer video displays or

from internal sources such as ingested or inhaled radioisotopes and is either produced by man (medical, industrial, or military) or occurs naturally (atmosphere).

Ionizing radiation produces random energy releases of great size and generally of great disruptive effect. The action of ionizing radiation is best described by the three stages (physical, chemical, and biological) that occur as a result of energy release in the biological target material (Gricouroff, 1958). The duration of the physical stage approximates the time required for the ionizing radiation to traverse an atom. During the chemical stage, molecular and thermal equilibrium is achieved. The biological stage involves metabolism of the chemical damage.

Nonionizing Radiation

Nonionizing radiation originates from natural sources such as sunlight, the earth's magnetic field, lightning, and static electricity and technological sources such as computer video displays and television sets, microwave ovens, communications equipment, electric equipment and appliances, and high-voltage electromagnetic radiation are also considered in the study of radiation biology.

Extremely low-frequency electromagnetic fields are generated by the electric and magnetic fields associated with high-voltage current in power transmission lines, and also some household and industrial electrical equipment. The biological effects from ELF radiation are the least understood, and the potential consequences are the most controversial. The issue of potential biological damage from this type of

radiation has increased only since the introduction of very high-voltage electric power transmission lines and the occurrence of widespread use of various electrical and electronic equipment (Coggle, 1971).

Microwaves originate from devices such as telecommunications equipment and microwave ovens. Metals reflect microwaves: glass transmits them; and aqueous material absorbs them, accompanied by a rise in the temperature of the liquid (Mader, 1988). Microwave absorption is absorbed unevenly in biological tissue because of the heterogeneity of the dielectric properties of the particular material. Thus, material with a high water content will have a higher absorption coefficient for microwaves. As a result of this phenomenon, microwave absorption is high in skin, muscle, and internal organs, and lower in bone and fat tissue (Gricouroff, 1958).

Microwaves can be lethal when the power intensity and exposure time are sufficient to cause a rise in temperature that exceeds an organism's homeostatic capabilities. Many scientists desire to establish limits of exposure to microwaves based on the absorbed dose of microwave energy, similar to the gray unit that is used for ionizing radiation. However, the difficulty associated with measuring the absorbed dose makes this impractical. Therefore, radiation protection standards are based on exposure values instead of the previously used specific absorption rate (Shapiro, 1990).

Ultraviolet radiation differs from ionizing radiation in that it uses energetic forms and is much more specific. This type of radiation is much less penetrating than ionizing radiation. Since it can penetrate only several layers of cells, the effects

of ultraviolet (UV) radiation on humans are primarily restricted to the skin and the eyes (Coggle, 1971).

Ultraviolet radiation is divided into UV-C (wavelength of 200-280 nanometers), UV-B (280-320 nm), and UV-A (320-400nm) (Shapiro, 1990). The most biologically damaging of the three is UV-A, with UV-B having an intermediate effect on the overall efficiency of biological action. The solar spectrum at the earth's surface contains only the UV-A and UV-B radiations (Urbach, 1969). The stratospheric ozone greatly absorbs UV-C radiation and the shorter wavelength portion of UV-B radiation, thus providing some biological protection. The depletion of the ozone layer caused by stratospheric pollution dramatically reduces this protective action, resulting in a decreased atmospheric absorption of UV-B radiation.

Biological effects can arise only when absorption of ultraviolet radiation occurs. Absorption is dependent on the chemical bonds of the material, and it is highly specific. Absorbed UV-B rays are responsible for the reddening of skin which we describe as sunburn. The technical term for this reddening response of the skin known as erythema (Coggle, 1971). A rare but deadly form of malignant melanoma is induced by exposure to sunlight with common occurrences localized on those regions of the body that are most frequently exposed. The skin is sensitive to only a small portion of the ultraviolet, and ultraviolet is only a small portion of the solar spectrum (Yalow, 1995). The most effective strategy for preventing both sunburn and skin cancer is to block this narrow band of UV-B wavelengths Compared to UV-A and UV-

C, the UV-B rays are more selectively absorbed into critical layers of the skin where new cells are forming. To date, the effects of the less harmful UV-A rays are still being studied (Urbach, 1969).

Survival from ultraviolet irradiation is reduced as the dose of radiation is increased. The four repair systems that enhance biological survival are as follows: photoreactivity, excision, recombination, and SOS repair system(s) (Yalow, 1995).

Photoreaction is an enzymatic repair system that enhances biological survival by splitting dimers in the DNA of cells that have been irradiated by ultraviolet light. The process requires light and is most effective when the wavelengths are in the blue region of the visible spectrum. The repair system is error-free thus making it nonmutagenic. However, the repair must correct the damage before it is copied by DNA replication (Coggle, 1971)

Another system is excision repair. A region of DNA containing bases that have been damaged by ultraviolet radiation is removed enzymatically and followed by the synthesis of new DNA to replace the damaged region (Gricouroff, 1958). There are no errors, and mutant cells that lack this repair system are highly sensitive to ultraviolet radiation. The clinical symptoms of this disease include a high incidence of skin lesions and early death from malignant melanoma (Coggle, 1971). Excision repair operates in the dark, thus, the damage must be corrected before DNA replication copies it. Not all regions of DNA are equally accessible to the action of this repair system. Likewise, it has also been observed that actively transcribed regions of DNA in

mammalian cells are more efficiently repaired than are the nontranscribed regions (Urbach, 1969).

Recombination repair is another repair system. DNA that contains damage is replicated, and gaps in the newly synthesized DNA appear opposite to the sites where there is damage in the parental strand (Coggle, 1971). These gaps are filled in by recombining the portion of the undamaged complementary parental strand with the daughter strand containing the gaps. This repair system is essentially error-free because it occurs after replication of the damaged region.

The final repair system, commonly referred to as SOS, is an inducible repair system. It is activated by a reactive intermediate of DNA metabolism in irradiated bacteria (Coggle, 1971). Any block to the replication of DNA strands signals the SOS repair system which acts by inducing the synthesis of genes which code for proteins that function in the repair of DNA. The alternative excision repair system involves removal of a longer segment of DNA containing the damaged region. This particular repair system is inclined to errors and is thus more susceptible to mutations (Gricouroff, 1958). Yet another manifestation of the SOS response is the induction of DNA replication that can bypass the damaged template region of DNA. This is not an actual repair system since the original damage remains in the DNA, and can best be thought of as a system for tolerating DNA damage (Urbach, 1969). Survival is increased because DNA replication is not blocked by the presence of the damage.

To successfully understand the detrimental effects of solar radiation one must

also study other aspects that inhibit or increase exposure to solar radiation. Latitude, or distance from the equator, is the primary factor for determining the radiation received at the earth's surface. For regions located near the equator the radiation received is high and rarely varies throughout the year. On the other hand, cities with higher latitudes away from the equator receive sun rays at a more slated angle (Yalow, 1995). These rays are much less concentrated and must travel a longer path to gain access through the earth's atmosphere, thus reducing the intensity of the ultraviolet light.

For United States districts such as California, Nevada, and Utah located at latitudes near 40 degrees north, radiation is highest in June and decreases its intensity in winter months (Becklake, 1989). It is in these areas that one hour of summer sun exposure is equivalent to five hours of winter sun exposure. For areas such as Greenland, Norway, and northern Russia, which are located at extreme latitudes of 70 to 80 degrees north, the maxim radiation in the summer is about 30 percent weather than for 40 degrees latitude despite the fact that the days are very long (Duden, 1990). During the winter months the radiation is extremely weak.

Besides latitude, geographical location is yet another factor in determining solar radiation received at the surface of the earth (Johnson, 1993). Oceans, mountains, soil types, temperatures, and vegetation all influence the local climate. The climate affects the cloud cover and humidity which both ultimately influence solar radiation. As a consequence of differences in local climate, latitude alone cannot

describe the large variations in solar radiation observed across a given continent. The unit of solar radiation is the langley, named for American astronomer Samuel P. Langley (Mader, 1988). The technical definition is that one langley is equal to one gram calorie per square centimeter of irradiated surface. In more specific terms, one can merely view the langley as a unit of sun intensity which allows scientist to compare different geographic regions.

Radiation levels greater than 800 langleys occur in the Death Valley region of California. Radiation levels greater than 700 langleys is received in the Southwestern region of the United States. A majority of the western portion of the United States, including the Rocky Mountain region, receives relatively high radiation levels often in excess of 600 langleys due to the relatively dry climate (Mader, 1988). In contrast, most of the central, eastern, and southern portions of the United States receives moderate levels of solar radiation levels - less than 600 langleys. In these areas, the highest recorded solar radiation levels were found in the eastern Carolinas and western Florida. Likewise, Hawaii is rated as very high and Alaska as very low in average solar radiation (Lovejoy, 1992).

In addition to geographical location, solar radiation also varies with the time of year. Throughout the year, the earth revolves about the sun, and the angle of the sun's rays striking a particular latitude will vary. Specifically speaking, the variation of the sun's rays can also be examined on a daily basis. As the earth rotates on its own axis from night to day, the angle of the sun's rays striking the earth will change.

The highest concentration of rays and maximum radiation occurs between twelve noon and one P.M. during both the winter and summer seasons (Duden, 1990). During this time the angle of solar rays on the earth is most direct, and the path of the rays entering through the atmosphere is minimal.

The short path provides the least shielding by atmosphere absorption and scattering. During the morning and the afternoon, the sun's rays are less concentrated and must pass through a long path through the atmosphere (Lovejoy, 1992). The atmosphere scatters short wavelength ultraviolet radiation more effectively than it does for visible or infrared radiation (Duden, 1990). In essence, the shielding effect of the atmosphere in the morning and afternoon is greatest for ultraviolet radiation.

Ninety percent of ultraviolet radiation occurs before 8:40 am and after 5:30 pm while seventy-two percent of ultraviolet radiation occurs between 10:00 am and 4:00 pm (Johnson, 1993). Scientists believe that exposure to the sun during these crucial hours is hazardous, and, as a result, outside activities should be limited. To avoid this time period it is simply best for one to plan outdoor activities during the extremely early hours of the morning or late evening to keep the total exposure to ultraviolet radiation to a minimum.

Besides the notable danger period, there are still many hours of visible light available in which to work or play outdoors. However, if it is not possible to avoid ultraviolet exposure during the danger period, then sunscreen lotions and other simple precautions should be used. Sunscreen lotion will have its greatest effect in

minimizing exposure to ultraviolet radiation when applied during the 10:00 am to 4:00 pm time period when scientists believe the sun is most intense (Schneider, 1989).

The solar spectrum also changes with altitude. For a particular latitude, the ultraviolet radiation is lowest near sea level (Mader, 1988). To fully expose low areas, the radiation must first pass through the full height of the atmosphere. Likewise, because the atmosphere thins with altitude, so does its protective effect. In contrast, locations at high elevations receive more damaging ultraviolet light (Mader, 1988). The most ultraviolet intense areas are (1) low latitude, (2) height elevation, (3) "sunny" day climates (Smith, 1990).

The primary function of clouds are to absorb solar radiation and scatter its elements (Duden, 1990). Consequently, the changes in cloud cover account for a majority of the variation in total solar radiation across the United States. Despite absorption and scattering, ultraviolet radiation from the sun can still penetrate cloud cover and reach the earth's surface (Johnson, 1993). When the sky is overcast, to the point of raining or snowing, the direct ultraviolet radiation is reduced. When a light cloud cover is, present, ultraviolet radiation is also reduced under the shadow of the cloud.

Although clouds reduce ultraviolet light they do not eliminate it completely (Schneider, 1989). Technically speaking, the clouds actually scatter the sunlight so it is rerouted toward as from many different directions. As a result, the protection one normally receives from hearing a hat is only minimal. Sun rays which strike the

ground are also scattered into all directions (Duden, 1990). The overall intensity of the scattered light increases depending upon the reflective capabilities of the surface.

The reflective ability of the sun rays changes with the types of cloud cover as well as the particular season. Because the reflectivity for some ground covers can be high it is almost not effective for people to wear a hat to protect themselves from the direct rays of the sun. For example, a hat does not provide total protection when a person is standing near snow, water, sand, or concrete. Generally speaking, surfaces that appear darker to the eye reflect less ultraviolet light (Becklake, 1989).

The Ozone Layer

The atmosphere of the earth is a blanket of air that embraces the planet. Air is a mixture of many different gases. Of the many gases which are present in the atmosphere, nitrogen and oxygen are the two which are the most plentiful. Approximately 78 percent of the total volume for the atmosphere is nitrogen, while approximately 21 percent is oxygen. The remaining 1 percent is composed of at least twelve other gases including helium, ozone, carbon dioxide (Duden, 1990) The atmosphere also contains water in the form of tiny ice crystal, liquid droplets, and gaseous water vapor (Johnson, 1993). In addition, tiny particles of dust can also be found amongst the chemical makeup of the atmosphere.

Even through the earth's atmosphere extends many miles above its surface it is not a uniform layer of gas from top to bottom. For example, the height as well as

the thickness of the ozone layer vary in different places depending upon the time and seasons. Due to the pulling force of gravity on the molecules of gas that make up the air, the gas molecules are plentiful and closer together. Thus, the atmosphere closer to the ground is more dense than the atmosphere height overhead. As gases travel out from the surface of the planet they become progressively less dense. As a result, gas molecules that are located at greater distances from the earth are less numerous and farther apart (Becklake, 1989).

The atmosphere of the earth can be divided into four regions which contain boundaries that are often difficult to distinguish. The first region is called the troposphere. This part of the atmosphere is the region closest of the earth. It extends approximately 6.5 miles above the surface of the planet (Mader, 1988). The troposphere contains the air we breathe as well as a substantial amount of water vapor. This region is the area where most of the earth's weather occurs.

Beyond the troposphere is the stratosphere. The boundaries of the second region extend approximately 6.5 to 30 miles upward (Mader, 1988). Air located in the stratosphere is less dense than the air located in the troposphere, likewise, there is very little water vapor found in this region. Jets fly in the lower region of the stratosphere. This region is most commonly known for accommodating the ozone layer (Duden, 1990). Ozone is a form of oxygen which acts as a shield by blocking most of the rays emitted by the sun from reaching the surface of the earth (Johnson, 1993). Ozone located within the air we breathe is dangerous. Ozone located within the

stratosphere is safe. Unfortunately, the stratosphere, which is an essential element of the earth's ultraviolet shield, is currently being destroyed by pollutants released human activity (Cline, 1992, Lovejoy, 1992).

Beyond the stratosphere is the mesosphere, which extends 50 miles above the plant, and the thermosphere. The outer boundary of the thermosphere is approximately 600 miles above the earth's surface (Mader, 1988). Immediately beyond the thermosphere is the beginning of airless space.

Oxygen is an essential part of life of many of the inhabitants of earth. Oxygen gas is made up of two oxygen atoms that are bonded together (Duden, 1990). Like oxygen, ozone is also a gas that is made up of oxygen atoms. However, one molecule of ozone contains three atoms of oxygen bonded together (Mader, 1988). Chemically, oxygen and ozone are two extremely different substances. Ozone is and invisible gas, however, if there is an abundance of it in the atmosphere it can be seen as a pale blue haze. Unlike oxygen, ozone is poisonous to cells. On the one hand, breathing ozone can harm people and animals, yet, ozone in the second region of the atmosphere is absolutely necessary for the protection and well being of nearly all of the living things on earth.

Ozone is made in the stratosphere (Johnson, 1993). In this region of the atmosphere ozone is produced, broken down, and then reformed on a continual basis. The key ingredients involved in this ozone cycle are oxygen, ozone, and energy from the sun (Smith, 1990). Ironically, it is ultraviolet radiation emitted from the sun that

powers the ozone cycle in the stratosphere. The actual production of ozone begins very high in the stratosphere where powerful ultraviolet rays collide with oxygen molecules. Once an oxygen molecule is hit by an UV Ray, the oxygen molecule absorbs energy from the ray. As a result, the bond that holds the two oxygen atoms together breaks, and the oxygen molecule splits apart to from two single atoms of oxygen (Mader, 1988). The individual oxygen atoms combine to form ozone. Ozone molecules are also assaulted by UV rays. When ozone molecules are struck by the UV rays, they also absorb energy from the ray and break apart, leaving behind oxygen molecules and single oxygen atoms stems. Next, the single oxygen atoms quickly combine with other oxygen molecules to from new ozone molecules, which in turn, are broken down to start the entire process once again (Becklake, 1989). As a result of this continual ozone cycle, approximately, the same amount of ozone is produced as is broken down in the stratosphere. Therefore, the amount of ozone gas in the stratosphere should remain relatively constant.

A constant and stable ozone layer is important for life on earth because the UV rays that are absorbed in the ozone layer are extremely dangerous to the inhabitants of the earth. By absorbing most of the UV radiation that is emitted from the sun, ozone molecules in the stratosphere region form a protective shield that protects life on earth from damaging ultraviolet radiation. Without the ozone layer, few living things would survive on our planet (Schneider, 1989).

The first sign that the ozone shield was in trouble occurred during the late

1900's (Gore, 1993). British scientists working in Antarctica discovered that during the spring seasons ozone was "disappearing" from the stratosphere above them. Thus, it was the discovery of the "hole" in the ozone layer.

The ozone shield was first formed in the stratosphere over 500 million years ago (Lovejoy, 1992). Today it protects us along with all the other forms of life on earth. The possibility of this protective layer being destroyed or even damaged by man is frightening. Yet, but, that is what is occurring this very moment.

Global Warming

There is no issue today which seems to be more difficult to solve than the global warming caused by greenhouse gases. The world has been warming for more than one hundred years and may warm in the future at a rate unheard of in recorded history. Our industrial and agricultural advances as well as forest destruction result in the accumulation of greenhouse gases, including carbon dioxide, nitrous oxide, methane, ozone, chlorofluorocarbons, and others (Schneider, 1989). These compounds, along with water vapor, are transparent to sunlight but absorb infrared radiation. Their presence in the atmosphere reduces the loss of heat from the earth's surface to outer space thereby making the world warmer and producing what is referred to as "global warming".

Rarely has any scientific issue been more controversial than this particular one. This is so primarily, because of the difficulty of proving the cause and effect and

because of the drastic measures which must be taken in order to reduce greenhouse gas concentrations in the atmosphere. These moderately high temperatures are proving to be difficult scientifically, politically, and economically, but, in order to lower them, they must be addressed abruptly. What evidence, if any, exist which could confirm or deny the presence of greenhouse warming?

Greenhouse gases have long lifetimes. Once they enter into the atmosphere they remain there for decades or even centuries. This fact suggests that if their emission continues uncontested, their concentrations will continue to grow in the atmosphere long into the future and the world will eventually become much warmer. Rising temperatures also suggest that something must be done soon to lessen the effects. Some scientists believe that the world is indeed warming and will soon warm at an unprecedented rate. In addition, they also believe that very little action will be taken in adequate time to avoid a serious rise of the global temperature. As a result of no action, sea levels will rise, the number of storms will increase, ocean currents will change, species will become extinct, ecosystems will be disrupted, and agricultural production will be altered. The ecosystems of forests, lakes, and grasslands already hampered by human activity will also undergo disastrous changes..

The historical segment of this phenomena originally began in 1974 when two scientists from the University of California at Irvine spoke openly of the destructive impact of chlorofluorocarbons (CFCs) on the atmosphere (Time, 1993). However, before issuing a ban on these prominent chemicals, scientists found the need to theoretically

prove that, first, CFCs actually attacked the ozone layer, and, second, that humans produced enough CFCs to create an ozone problem. After only a few years of investigative studies scientists reluctantly concluded that CFCs were in fact a hazard to the atmosphere. By 1978 the United States elected to ban the use of CFCs in aerosol sprays. Simultaneously, the U.S. also maneuvered to implement an international ban upon aerosol sprays (Schneider, 1989). However, the Presidential election of Ronald Reagan during 1980 hindered American efforts to preserve the atmosphere (Cline, 1992). Likewise, efforts were also obstructed when Du Pont failed to continue any scientific research because of the lack of importance placed upon the issue by the new government (Linden, 1993). With failing sanctions, Du Pont leaders began to publically challenge what scientists referred to as the CFC crisis. In fact, shortly after the new government came into power, several notable scientist began to question how alarming the CFC crisis was. During 1983 one scientific publication predicted that if the total production of CFC were to remain level, the overall loss of the ozone layer would not be as severe as previously reported (Linden, 1993).

Acting upon scientific data which concluded the ozone layer would remain unharmed if CFC levels remained constant, businessmen allied and rallied on the assumption that the CFC market had reached maturity. However, the market resurged and Du Pont officials once again found themselves at the front of the battle. Du Pont argued that the U.S., a developed country, was no longer manufacturing harmful CFCs, however, the rapidly increasing populations of the developing countries were constantly

demanding CFCs (Linden, 1993).

After suffering a severe setback Du Pont officials eventually set their sights on mending a bruised reputation by returning to their original position, Du Pont scientists and authorities vowed to remove their business from the CFC manufacturing industry (Linden, 1993). Despite the rapid pace in which authorities moved to halt the overall production of CFCs, mankind will ultimately pay the price for the delay in decision making. Over the ten year period in which the issue was debated between scientists, policy makers, and businessmen, an estimated total of 19 billion pounds of CFCs were produced internationally (Linden, 1993). Even today, scientists are still engaging in philosophical debate as to how bad the global warming trend is, however, President Clinton and Vice President Gore have vowed to initiate a plan which would reduce greenhouse gases back to 1990 levels by the year 2000 (Time, 1993). Unfortunately, environmentalist predict that once again, economics will alter major decisions which will ultimately effect our environment.

Causes Of The Increase In Solar Radiation

Scientists know that greenhouse gases, by absorbing infrared heat, can produce a warmer lower atmosphere and global surface, while at the same time making the stratosphere cooler. A greenhouse gas is any molecule that absorbs radiation in the part of the infrared spectrum near the range of ten. Carbon dioxide has long been recognized as a greenhouse gas whose atmospheric concentration is steadily

increasing. In addition, there are also other gases whose concentrations are also increasing to an enormous amount. These gases include methane, nitrous oxide, ozone, and chlorofluorocarbons.

Carbon dioxide has been increasing in atmospheric concentration due to the burning of fossil fuels, cement production, and forest destruction. During the 1950's the invention of infrared gas distinguisher made the accurate measurement of carbon dioxide possible on a daily basis (Johnson, 1993). By 1958 a permanent carbon dioxide measurement station was installed on the Hawaiin island Mauna Loa which is located in the middle of the Pacific Ocean, isolated from any direct contamination of carbon dioxide produced by large metropolitan areas (Becklake, 1989). Months later a second measurement station was established in the South Pole. Ironically, the carbon dioxide levels recorded at the two stations were relatively equal, approximately 3.18 parts per million.

In an effort to resolve researchers curiosity, scientists resorted to measuring the preindustrial levels of atmospheric carbon dioxide by escavating air trapped in ice cores in the Greenland and Antarctic ice caps (Gore, 1993). During the last Ice Age, almost 40,000 years ago, atmospheric carbon dioxide levels were as low as 180 parts per million. By 1991 carbon dioxide measurements recorded at the Mauna Loa and the South Pole were approximately 355 parts per million (Becklake, 1989). Indicating an annual increase of 1.76 parts per million per year. With this ongoing rate increase scientists question what the future will bring. If the world were to immediately limit

the growth rate of the use of fossil fuels to zero then the doubling of carbon dioxide levels in the atmosphere would not occur until the later half of the twenty-second century. Unfortunately, there is no foresight of that occurring. Indeed, carbon dioxide levels are increasing, but, researchers must also remind themselves that, first, carbon dioxide is not the only greenhouse gas, and, that, second, the others with the exception of nitrous oxide, have a greater annual rate of increase.

Methane is a more effective greenhouse gas when compared to carbon dioxide. The decay time of methane is approximately seven to ten years, thus accounting for its reduced effectiveness as a greenhouse gas over a long period of time (Schneider, 1989). However, its rate of increase in the atmosphere is twice the rate of increase of carbon dioxide. Incidently, this is because methane reacts photochemically in the atmosphere to form ozone, carbon dioxide, and water vapor, the indirect contribution to greenhouse warming is estimated to be even higher than previously estimated.

Specifically speaking, methane plays a major role in the overall chemical composition of the atmosphere. Within the troposphere level methane is involved in photochemical reactions that consequently determine the concentrations of ozone and hydroxyl--gases which are responsible for the removal of almost all gases that are produced by natural processes as well as human activities (Becklake, 1989). Methane also influences the chemical composition of the stratosphere. The oxidation of methane is an important source of stratospheric water vapor and OH radicals, whose chemical reactions ultimately lead to the conversion of ozone destroying nitric oxide

and the nitric oxide reaction enhances to a much lesser reactive nitric acid. However, the reactions of hydroxyl radicals with hydrochloric acid, promote the formation of ozone destroying carbon radicals (Urbach, 1969).

Measurements of methane concentrations from air trapped in the ice at Vostok, Antarctica showed amounts over the last 160,000 years to range from as low as 350 parts per billion to 650 parts per billion depending upon existing glacial conditions (Gore, 1993). Approximately 200 to 300 years ago, the concentrations of methane began to increase to its present concentration of 1,700 parts per billion (Lovejoy, 1992). The puzzle in the study is the fact that the increase in atmospheric methane has been caused by human activities. Methane is produced by the anaerobic decomposition of organic matter in wetlands, landfills, the rumens of cattle, and rice fields (Miller, 1982). Other human activities such as coal mining (extraction of oil and gas, refining, and distribution) and fossil fuel burning also generate methane. Methane emissions are growing with the increasing human population, however, because of the earth's limited amount of space, some of these sources will be restrained. The doubling time for methane in the atmosphere is roughly forty six years, nearly twice the rate for carbon dioxide or for fossil fuel use (Lovejoy, 1992).

Nitrous oxide is doubly effective as carbon dioxide is a greenhouse gas. It remains in the atmosphere for about as long as carbon dioxide and is slowly increasing. A majority of the atmospheric nitrous oxide originates from the natural nitrogen cycle in which fungi and bacteria act in the denitrification of compounds in

the soil. The overall source of the small increase of nitrous oxide in the atmosphere is not determined, but scientists attribute it to the increased use of fertilizers and the high combustion temperatures of fossil fuel burning power plants. Nitrous oxide is likely to continue to increase in the future because of the continually increasing demand from the human population for food and energy.

Ozone is both a powerful infrared absorber as well as an effective greenhouse gas. Ozone occurs naturally in the stratosphere, where it is generated photochemically by sunlight as it reacts to ozone molecules (Schneider, 1989). Unfortunately, due to human error, this indispensable element of the earth's ultraviolet shield is currently being destroyed by the release of chlorine molecules from evasive chlorofluorocarbons. Yet, on the other hand, the ozone level is increasing within the troposphere as a result of air pollution released by the combustion of fossil fuels. Ozone decays rapidly in the lower atmosphere, thus, its overall rate of increase within the atmosphere is about the same as that of carbon dioxide (Lovejoy, 1992). Presently, scientists believe that ozone is contributing merely nine percent of the total greenhouse effect (Becklake, 1989). Scientifically speaking, ozone is not a direct result of human activity, but, in the lower troposphere, ozone is produced indirectly through chemical reactions which involve emissions of methane, hydrocarbons, and carbon monoxide.

Chlorofluorocarbons, also known as freons, were first formally used during the 1960s, primarily for air conditioning, as foaming agents for the production of plastic

foam products, and as cleansing agents for electronic circuitry. Initially the use of freons grew to an enormous rate, but, now, due to government regulations, the overall use of chlorofluorocarbons has decreased. Chlorofluorocarbons are extremely effective greenhouse gases because they contain infrared absorption bands focused in the primary window. In addition, chlorofluorocarbons have slow decay rates (Duden, 1990). As a result of their longevity, sanctions have been implemented to limit the use of chlorofluorocarbons

An increased concentration of greenhouse gases in the stratosphere will eventually lead to more radiation loss to space and an overall cooling of the upper atmosphere. Reduction in the stratosphere level of ozone will eventually lead to reduced absorption of solar ultraviolet radiation and reduced heating. These two processes will ultimately result in a cooling of the stratosphere: causing an increase in both solar radiation and skin cancer. The predicted rate of global warming and drastic changes in precipitation patterns will strongly affect agriculture and ecosystems. There are many possible changes, such as the increasing carbon dioxide levels which improve photosynthetic productivity and water use efficiency by plants, or, increased precipitation improving agricultural outputs. Despite these additional assets, we must also remind ourselves of the negative outcomes. These forces may inevitably drive the climate system too quickly into conditions that are too severe for most ecological adaptation to take place. Finally, there is always the question of the human condition: whether our food supply will be adequate; whether resources will be

renewable; whether the climate will provide a comfortable setting; and finally, if and how will the increased exposure to solar radiation will effect the exposed epidermal cells of the human race.

The Effects Of Solar Radiation On Epidermal Cells

With the change of seasons, the blossoming of plant life in the spring and its death in the fall, there also seems to be a synonymous change in the appearance of man. During the winter months, when the sun shines only tenuously and with what appears to have very little effect on the earth, people become desolate, isolated, sullen, and pale. However, when the sun rises again their complexions begin to change. This slow change in skin texture occurs almost unnoticed. Yet, if most Americans were to spend one spring day enjoying the enticing ultraviolet rays of the sun, unprotected, the areas exposed to the sunshine would become red and inflamed only hours after the exposure. Eventually, the exposed areas gradually mature into a tan produced by pigment deposition in the skin. Thus, if the exposure to the sun is excessive, then an enticing day in the sun can ultimately lead to blistering or even sunburn. It is not the warming feeling that we experience during our stay in the sun which causes skin irritation that occurs only a few hours later, but only the short wave, ultraviolet element of the radiation. If, by chance, this ultraviolet radiation could reach earths surface minus other rays, we would not be able to see it with our

eyes. Also, because it is such a small amount of the total of the sun's rays that we would not normally look upon it as mere warmth.

It has been proven that prolonged exposure to sunlight will result in the development of skin cancer in humans. Clearly, a number of studies support the theory that exposure to sunlight is a casual factor in the cause of skin cancer within humans. Among earlier studies, scientists believe that skin cancer occurs most commonly on frequently exposed areas such as the head, neck, arms, and hands (Urbach, 1969). In addition, they also believe that racial groups who have pigmented skin sunburn less easily when compared to their white counterparts. And, among the members of the Caucasian race, those individuals who spent excessive hours outdoors appeared to have a greater prevalence of skin cancer (Urbach, 1969).

In a study conducted by Konrad Buettner it was concluded that if unadapted white skin is exposed to solar radiation during the primary hours of the day for approximately ten to twenty minutes the following steps occur: sunburn becomes visible to the human eye; several people develop the early stages of pigmentation; the skin emits a characteristic odor; and, vitamin D is produced from sterols (Urbach, 1969). If the doses of radiation are intense, then, approximately two to three days later, one or both of the following symptoms will occur: late stage of pigmentation; and, blistering (Urbach, 1969). Essentially, sunburn is caused by light of the sun penetration into deeper layers of the skin where light is scattered and finally reflected into several directions. As the light permeated through the skin, blood in the vessels

intercepts the light, thus beginning the painful process.

In more conclusive studies, scientists revealed that radiation damage to the skin is a result of the injuries produced in the tissues of the epidermis, the dermis, and subcutaneous layers. Although the primary site of damage is the originating layer of the epidermis, the first response is shown within the capillary system of the dermal layer. Dilation of these capillaries along with the release of naturally produced histamine produce the characteristic reddening of the skin known as erythema (Ponder, 1990). The capillaries dilate in an attempt to make-up for the reduction in the oxygen supply. During the latter phase of erythema the shallow layers of the epidermis are lost as a direct result of the radiation killing several of the germinal cells. This mild sunburn may last for a few weeks and then eventually dwindle, leaving only brown patches in the skin.

Damage to the skin is the direct result of injury to the epidermis, the dermis, and the subcutaneous layer. As the radiation doses increase the symptoms--inflammation and reddening, blistering, loss of epidermis--also increase in severity. Limited exposure to solar radiation can lead to a mild sunburn and healing occurs in only a few weeks. Unlimited exposure to solar radiation can cause extensive injury and healing may take months or even years to occur.

Oklahoma: High School Science Courses

During the academic year 1983-84 Oklahoma educators began the task of

formulating a list of suggested learning outcomes in the five primary learning areas for students in grades one through eight. The initial goal was to introduce several objectives for which educators could construct a firm curriculum which would eventually provide a quality education for the pupils of Oklahoma schools. Likewise, during the next academic year, 1984-85, the Oklahoma State Department of Education also devised a list of learner outcomes in the five primary areas of Language Arts, Science, Math, Reading, and Social Studies for grades nine through twelve. As a result of this cooperative culmination, dozens of educators across the state of Oklahoma met and eventually validated the suggested learner outcomes.

The suggested learner outcomes for science are based upon the theory that science education conceives a kinship between science and society with the eventual goal being the cultivation of a scientifically literate citizen. Science,--the observation, identification, description, experimental investigation, and theoretical explanation of natural phenomena--in the educational form, is an interaction of both people and natural phenomena based upon the human will to continually acquire knowledge. Thus, the primary purpose of science education is to teach people the anatomy and physiology of the human body so they may successfully interact with their environment. General science education in Oklahoma also includes the goals for students to (1) have general knowledge of major concepts and principles, (2) be able to apply the practical methods of scientific problem solving to decision making, (3) understand the relationship of science and technology and how it will change society,

(4) produce general scientific skills which will allow positive participation in a professional career as well as every day idle activities, and, (5) inherit a specific amount of respect for the environment as a whole. As a closure to these general science principles, educators added that this scientific knowledge is subject to change due to the rapid pace in which scientist discover new concepts.

Of the eleven specific areas of science within the secondary science level, only Biology I and Biology II were selected for analysis because the two subjects deal specifically with life and living organisms. In secondary school science a variety of teaching methods are used within the Biology I and II classroom. Typically, teachers introduce a specific concept and provide a structural frame to build upon before assigning a textbook section to be read. In order to build upon this frame teachers also require students to relate their laboratory activity to the concepts presented in their textbooks as well as read other outside materials. Laboratory experiences are consistently integrated into lectures, class discussions, and assigned reading from the textbook. As a general rule, science textbooks are used more frequently in average classes and less in above-average classes. In doing so, teachers are allowed to focus upon the hands-on teaching method with advanced students. The content of the textbook still remains as a major guide to the teacher and determines the content taught. In cases where students are unable to read the textbook, teachers adjust by using oral presentations, demonstrations, and student executed experiments for analyzing information.

Summary

In trying to identify the appropiate strategy for achieving a "sun conscious" and scientifically literate citizen, educators have discovered that the framework begins with the information the learner is exposed to during his or her formal educational years (van Manen, 1991). The conceptual framework which the student has developed and uses as a basis for acquiring additional knowledge is critical to the students fundamental quality of life. The purpose of this study is to identify and analyze the solar radiation and skin cancer concepts found within secondary school Biology textbooks listed on the 1995-96 Oklahoma State Department of Education list of textbooks adopted for the 1995-1996 school year. The state adopted list of textbooks is an accumulated collection of textbooks that teachers are required to draw upon when purchasing instructional material for their classrooms.

CHAPTER III

METHODOLOGY

Introduction

The primary purpose of the study was to identify and analyze the solar radiation and skin cancer concepts found within High School Biology texts used in the state of Oklahoma. The purpose of this chapter is to describe the methods and procedures followed in conducting the study. Oklahoma educators find themselves responsible for instructing a multi-racial group of individuals. The population of Oklahoma averages around 3,200,000 residents. Of those, 2,300,000 are adults, and, 30,540 of those became high school graduates during the 1992-1993 school year. In all of its 77 counties, there are 554 school districts in Oklahoma with a total of 461 high schools in all. Presented in this chapter is a description of the textbooks that were sampled, testing instruments which guided the investigation, and the methods and procedures which were used to collect and evaluate the data.

Textbooks Selected for the Study

The textbooks that were investigated in this study represented all of the

eighteen texts listed on the 1995-96 annual textbook allocation list accumulated by the instructional materials section of the Oklahoma State Department of Education. Roughly one third to one half of the registered school districts, when funds are abundantly allocated, update classroom textbooks by selecting from the state adopted list. This is a comprehensive list, and, the only list that educators may refer to when they are using allocated monies for the purpose of purchasing textbooks. A total of 18 high school Biology books were examined; 5 were published during or prior to the year 1991, while 13 were published during or after the year 1992. The books examined were listed as required texts for high school Biology courses I and II.

Instrumentation

In this chapter four instruments were used to evaluate the solar radiation and skin cancer concepts found within the Biology textbooks required by the 1995-96 Oklahoma State Department of Education. The primary purpose was to analyze the textbooks for the "amount of information" concerning (1) solar radiation, (2) skin cancer, and, (3) concepts which stress the effects of solar radiation on skin cancer. Also investigated was (4) the amount of information Biology I and Biology II textbooks posses concerning the cause in the increase of solar radiation as well as (5) the increase in the reported cases of skincancer. Secondary objectives sought to disclose the amount of solar radiation and skin cancer concepts students were exposed to as they progressed from the Biology I course into the Biology II course. Finally, (7) the

readability level of the concepts was assessed, as well as (8) the number of illustrations, those representing skin cancer and solar radiation concepts presented per page. A copy of the 1995-1996 Oklahoma State Department of Education annual textbook allocation for science was obtained. The list contained the textbooks used for Biology I, Biology II, Chemistry I, Chemistry II, Earth Science, Environmental Science, Physical Science, and Physiology high school science coursed. All texts for Biology I and Biology II were studied. A list of the textbooks analyzed can be found in Appendix A labeled "Textbooks Used in the Study". Categorically, the books were divided into two sections: textbooks which would be used for all classes, and, textbooks which would be used specifically for above-average students. All samples were published between 1990 and 1995.

A large amount of the study was guided by the Guiding Questionnaire found in Appendix G. This portion of the analysis contained questions which were written by the author to further detail the amount of information which was studied concerning exposure to solar radiation and the common causes of skin cancer. The 'yes or no' questions contained on the questionnaire were designed to allow the author the opportunity to both present factual information concerning the concepts found and present a thorough discussion and explanation of the information collected.

To provide a more comprehensive insight into the content of this collection of books, a variety of indicators were used: readability level, and the frequency of illustrations used. The Dale-Chall formula was used to measure readability of those

text sections dealing with the content being studied. (Dale & Chall, 1948). Other measurement tools were considered, but the Dale-Chall method is a validated procedure which has been verified as as a good tool since its introduction during the late 1940's. Illustrations were analyzed according to frequency. It is not the purpose of this study to analyze the effects of the illustrations. However, it is necessary to believe that illustrations often provide an excellent visual adaptation of the subject being explained. Thus, because illustrations play a large role in content textbooks, the books were assessed in terms of the number of illustrations presented per page. The noting of these illustrations was further detailed by including such characteristics as whether they were photographs, diagrams, cartoons: whether they added new information or repeated information from the text. The number of each was calculated.

Procedure

Each of the eighteen high school Biology textbooks listed in the Oklahoma State Department of Education 1995-1996 annual textbook allocation catalog were obtained. In order to become more familiar with the textbook(s) which were to be used in the study, the table of contents of each book was scanned to find any major areas such as Human Biology, Immunity, Protection, etc.. The early stages of the survey were guided by Appendix E. In following the format of Appendix E-"Frequency of Key Words"- each of the ten key words were searched for within the table of contents. As a word was

located, an asterix was placed in the space provided according to the number the word was assigned to validate that the word was found. Likewise, in the space provided, labeled 'pg.', the accompanying page number(s) were also recorded. If a synonymous form of the word was found, the word was written in the blank space and the page(s) were also recorded. If the word was not found, the space was left blank. Once all of the words were checked for within the table of contents the exact same procedure was followed to locate the ten key words within the table of index and finally the glossary.

Once the pages were recorded it was established that the subjects were primarily confined to a certain section of the textbook--the primary section. The primary section is defined as the section whose primary concern was to address skin cancer. As a result of this principle observation, the pages listed were located and the latter section of Appendix E was completed to further verify and detail the finding of the concept. All questions were completed except for the final question which made reference to the Dale-Chall formula (Appendix B).

Following the completion of Appendix E, Appendix F was then incorporated into the analysis of the primary section. Appendix F, appropriately labeled "Amount of Information," was used to determine the amount of information contained within each primary section concerning solar radiation and skin cancer. The focus of this Appendix was to detail the number of paragraphs, sentences, and words contained in each primary section. Appendix F further elaborated upon Appendix E by demanding

the number of times each of the ten key words were listed as well as the words which were used most and least frequently within each primary section.

Next, each of the primary section(s), which introduced the theories of skin cancer and solar radiation were analyzed and scored using the Dale-Chall method of predicting readability (Appendix B). Analysis of each primary section required an exact tally of the number of paragraphs, number of sentences, as well as the number of words to determine the amount of information. Upon the completion and tabulation of the formula the resulting scores were graded according to the Dale-Chall correction table (Appendix C) and the remaining question on Appendix G--"to what grade level does the author develop the content of the primary section according to the Dale-Chall format for predicting readability"-- was answered.

Once the Dale-Chall formula for predicting readability was completed "the identical sections" and page numbers were used to analyze the illustrations of the text (Appendix H). Both the types of Illustrations as well as the total number of illustrations were tabulated and scored to give an exact count.

The qualitative analysis of the data was determined by computing the frequency, percentage rates and ranking the information. The study, which focused upon the analysis of textbooks, was reviewed and processed as exempt by the Oklahoma State University Instructional Review Board as found on the final page of the study.

CHAPTER IV

PRESENTATION OF DATA

The primary purpose of this study was to identify and analyze (A) the solar radiation concepts, and (B) skin cancer concepts found within Biology I and Biology II secondary school textbooks required by the 1995-1996 Oklahoma State Department of Education. In addition, the primary study also included an inquiry into the (C) concepts which present the effect of solar radiation on skin cancer. Secondary goals were also included in the investigation to determine (D) the amount of information Biology I and Biology II textbooks posses concerning the cause in the increase of solar radiation: (E) the amount of information the textbooks posses concerning the cause of the increase in the number of reported skin cancer cases: and, (F) the amount of information detailing the effects of solar radiation on skin cancer which students are exposed to as they progress through Biology I and Biology II courses across the secondary school grade levels. Furthermore, the study was also conducted to analyze (G) the readability level at which the concept information was assessed, as well as, (H) the number of illustrations presented per page which were representative of the concepts which were covered. This chapter seeks to present the data collected throughout the study and to summarize the results of the analysis of the accumulated

data. The chapter is organized in this manner: a brief discussion and summary of the data collected from the study, and, a presentation of the data collected from the textbooks that were analyzed.

All research is based up the results of the analytical tools used to determine the extent of the amount of solar radiation and skin cancer concepts found within the state required Biology textbooks of Oklahoma. Table I presents the grade-equivalent readability score for the Biology I and Biology II textbooks that are listed on the state adopted textbook list. Of the eighteen books listed two were not analyzed because they failed to present any information concerning skin cancer and solar radiation. A majority of the books adopted for use within the Biology I courses were rated for the 13-15th grade level (college). Of the remaining six books, two were rated for the 11-12th grade level and 16 and above (college graduate) grade level. Once again, the 13-15th grade level outweighed the other levels by adding four while the 11-12th grade level gained one textbook; the 9-10th grade level as well as the 16 and above grade level scored zero in the final analysis of the Biology II textbooks.

TABLE I

READABILITY SCORES FOR SECONDARY BIOLOGY TEXTBOOKS-

-SECTIONS CONTAINING INFORMATION ABOUT SOLAR

RADIATION AND SKIN CANCER (n=18)

Intended Audience	Book Listing *	Grade-Equivalent (readability scores)**
BIOLOGY I	A	13-15th grade (college)
science n=12	B	16 (college graduate)
	C	9-10th grade
	D	9-10th grade
	E	13-15th grade (college)
	F	13-15th grade (college)
	G	16 (college graduate)
	H	11-12th grade
	I	11-12th grade
	J	13-15th grade (college)
	K	No concepts
	L	13-15th grade (college)
BIOLOGY II	M	13-15th grade (college)
science n=6	N	11-12th grade
	O	13-15th grade (college)
	P	13-15th grade (college)
	Q	13-15th grade (college)
	R	No concepts

*see Appendic A: **grade-equivalent scores for each book represent the mean score of the primary sections

Table II further elaborates the findings explained in Table I. It presents the findings of the analysis of illustrations pertaining to the underlying written concepts that were found within the texts. Of the eighteen books analyzed, five of the textbooks have no pictorial depictions of the concepts. Only one textbook, a Biology I book, had an abundance of illustrations with a maximum of six. The remaining twelve textbooks were found to have five or less pictorial illustrations.

TABLE II

ANALYSIS OF THE READABILITY AND ILLUSTRATIONS FOR SOLAR RADIATION AND SKIN CANCER CONCEPTS (n=18)

Subject/Intended audience	Book Listing*	Readability Score (Dale-Chall)	Illustrations Per Textbook**
BIOLOGY I	A	13-15th grade	2
science n=12	B	16th grade	0
	C	9-10th grade	1
	D	9-10th grade	2
	E	13-15th grade	6
	F	13-15th grade	4
	G	16th grade	2
	H	11-12th grade	5
	I	11-12th grade	2
	J	13-15th grade	0
	K	No concepts	0
	L	13-15th grade	4
BIOLOGY II	M	13-15th grade	3
science n=6	N	11-12th grade	0
	O	13-15th grade	1
	P	13-15th grade	1
	Q	13-15th grade	2
	R	No concepts	0

*see Appendix A. **indicates illustrations observed which correlate to the concepts of solar radiation skin cancer.

Table III introduces the eight guiding questions stated in Appendix G. Only one textbook, (5.6 %), introduced a laboratory or extracurricular activity for the concept to the reader. Likewise, only a mere three, (16.7 %) of the textbooks analyzed contained any questions pertaining to the concepts that would allow the reader the opportunity to further concentrate on the subject. Of the eighteen textbooks, eight (44.4%) of the Biology textbooks mentioned the primary cause of skin cancer. While three (16.7%) of the Biology II textbooks mentioned the primary cause of skin cancer. Five (27.8%) and four (22.2%) of the Biology I and Biology II textbooks analyzed offered a theory for the cause in the reported increase in the rates of skin cancer. Few of the textbooks offered a rational for the cause in the increase of solar radiation--Biology I, four (22.2%) offered no rational, while only three (16.7%) of the Biology II textbooks offered no rational. As for the answer to the final question dealing with safety precautions for protecting oneself from over-exposure to solar radiation, three (16.7%) of the Biology I textbooks while only one (5.6%) of the Biology II textbooks introduced a way to protect the skin from over-exposure to solar radiation.

TABLE III

RESULTS OF SKIN CANCER AND SOLAR RADIATION CONCEPTS COMBINED (n=18)

Guiding Questions	Biology I (n=12)		Biology II (n=6)	
	Yes	No	Yes	No
1) Is there a laboratory or extracurricular activity found within the book which further illustrates solar radiation or skin cancer?	1 (5.6%)	11 (61.1%)	0	6 (33.3%)
2) Are there any questions at the beginning or end of the text which further discuss solar radiation or skin cancer?	3 (16.7%)	9 (50%)	0	6 (33.3%)
3) Are there any pictorial illustrations?	9 (50%)	3 (16.7%)	4 (22.2%)	2 (11.1%)
4) Does the textbook mention the primary cause of skin cancer?	8 (44.4%)	4 (22.2%)	3 (16.7%)	3 (16.7%)
5) Is there a suggested theory for the cause in the reported increase in the rates of skin cancer?	5 (27.8%)	7 (38.9%)	4 (22.2%)	2 (11.1%)
6) Does the textbook discuss the theory of the greenhouse effect? Ozone depletion? Global warming?	9 (50%) 8 (44.4%) 6 (33.3%)	3 (16.7%) 4 (22.2%) 6 (33.3%)	5 (27.8%) 4 (22.2%) 6 (33.3%)	1 (5.6%) 2 (11.1%) 1 (5.6%)
7) Is there a suggested rational for the cause in the increase of olar radiation?	8 (44.4%)	4 (22.2%)	3 (16.7%)	3 (16.7%)
8) Are there any safety precautions listed for the correct manner to protect the skin from over-exposure to solar radiation?	3 (16.7%)	9 (50%)	1 (5.6%)	5 (27.8%)

Table IV shows the cumulative results of the eighteen textbooks that were analyzed. Seventeen textbooks (94.4%) were scored as "yes", while one textbook (5.6%) was scored as "no" to the the introductory question whose focus was upon whether an extracurricular activity was found. Results of the second question were three (16.7%) "yes" and fifteen (83.3%) "no". Of the textbooks surveyed thirteen (72.2%) contained related pictorial illustrations while five (27.8%) did not. Eleven (61.1%) of the books mentioned the primary cause of skin cancer, while seven (38.9%) of the books did not mention the primary cause of skin cancer. Question number five offered equal results, with a score of nine (50%), one-half of the texts suggested a theory for the cause in the reported increase in the rates of skin cancer while the other half did not. Overwhelmingly, fourteen (77.8%) of the textbooks discuss the theory of the greenhouse effect, while twelve (66.7%) discuss the theory of the depleting ozone layer, and, eleven (61.1%) mention the theory of global warming. Correlating to the theories of the greenhouse effect, ozone depletion, and global warming, eleven (61.1%) of the eighteen textbooks analyzed introduce a rational for the cause in the increase of solar radiation. Unfortunately, only four (22.2%) of the eighteen books surveyed mentioned the correct way-- avoid rolonged exposure to the sun,use sunscreen, wear or use protective clothing to protect the skin from over-exposure to solar radiation.

TABLE IV

CUMULATIVE RESULTS OF SOLAR RADIATION AND SKIN CANCER CONCEPTS (n=18)

Guiding Questions	Yes	No
1) Is there a laboratory or extracurricular activity found within the book which further illustrates solar radiation or skin cancer?	1 (5.6%)	17 (94.4%)
2) Are there any questions at the beginning or end of the text which further discuss solar radiation or skin cancer?	3 (16.7%)	15 (83.3%)
3) Are there any pictorial illustrations?	13 (72.2%)	5 (27.8%)
4) Does the textbook mention the primary cause of skin cancer?	11 (61.1%)	7 (38.9%)
5) Is there a suggested theory for the cause in the reported increase in the rates of skin cancer?	9 (50%)	9 (50%)
6) Does the textbook discuss the theory of the greenhouse effect? Ozone depletion? Global warming?	14 (77.7%) 12 (66.7%) 11 (61.1%)	4 (22.2%) 6 (33.3%) 7 (38.9%)
7) Is there a suggested rational for the cause in the increase of solar radiation?	11 (61.1%)	7 (38.9%)
8) Are there any safety precautions listed for the correct manner to protect the skin from over-exposure to solar radiation?	4 (22.2%)	14 (77.8%)

CHAPTER V

CONCLUSIONS DERIVED FROM TEXTBOOK ANALYSIS

Summary

This study was conducted to identify and analyze the solar radiation and skin cancer concepts found within secondary school (grades nine through twelve) Biology textbooks required by the 1995-1996 Oklahoma State Department on Education. Furthermore, the primary objective was to assess the amount of information which discussed the effects of solar radiation on skin cancer; the cause in the increase of solar radiation; and, the cause of the increase in reported skin cancer cases. Secondary goals were to determine whether or not students were exposed to information explaining the effect of solar radiation on skin cancer as they progressed from Biology I into Biology II. An additional goal was to measure the readability of the information found and identify the number of illustrations representative of the skin cancer and solar radiation concepts. After establishing a classification system, the study was conducted. The eighteen Biology I and Biology II textbooks listed on the 1995-1996 Oklahoma State Department of Education allocation list were surveyed to achieve the objectives of the study.

Findings

Answers to eight research questions were investigated throughout this study. The presentation and analysis of data for this analytical research will be reported as they relate to each of the questions. The results of the analysis of the data are as follows:

Research Question One: Of the textbooks required by the 1995-1996 Oklahoma State Department of Education for secondary Biology I and Biology II courses, which, if any, contain concepts concerning solar radiation?

Of the surveyed secondary science textbooks analyzed, textbooks which were approved for use within Biology I courses, on average, contained the most information about what caused the increase in solar radiation. Of the eighteen books analyzed, only three (16.7%) of the Biology II required textbooks contained a rational for the cause in the increase in solar radiation.

Research Question Two: Of the textbooks required by the 1995-1996 Oklahoma State Department of Education for secondary Biology I and Biology II courses which contain concepts concerning skin cancer?

Of the eighteen textbooks required for Biology I and Biology II courses, sixteen were found which contained information which disclosed concepts concerning skin cancer.

Research Question Three: Do any of the required textbooks for Biology I and Biology II secondary courses present information which mentions the effect of solar

radiation on skin cancer?

An examination of the eighteen textbooks reveals that eight of the Biology I textbook authors and three of the Biology II textbook authors mention, briefly, the cause and effect relationship between solar radiation and skin cancer. Of the eleven books which did contain information on the subject, only one textbook, a Biology I text, utilizes the space needed to thoroughly explain the cause and effect relationship between solar radiation and skin cancer.

Collectively speaking, the textbooks required for the Biology I course contain the most information about the effect of radiation on cancer. Less than 50 per cent of the books examined directly mentioned the effect of solar radiation on skin cancer, however, a vast majority did mention and thoroughly explain the effect of radiation treatment (chemotherapy) on cancer in general. Thus, to date, authors tend to believe that discussing cancer, as a whole, is far more important than focusing upon the specifics of cancer.

Research Question Four: What amount of information do the textbooks posses concerning the cause in the increase of solar radiation?

An examination of the eighteen textbooks reveals that 78 per cent discuss both the pros and cons of the theory of the greenhouse effect. Furthermore, 66.7 per cent of the textbooks discussed the theory of ozone depletion, while 66 per cent of the textbooks discussed the theory of global warming. In addition, the textbooks also emphasized the need to protect the environment. Specifically speaking, authors use a large amount of space to detail the 'cause and effect' relationship of a polluted

environment versus the human race.

Research Question Five: What is the amount of information the textbooks posses concerning the cause of the increase in reported skin cancer cases?

Of the eighteen textbooks analyzed, five (27.8%) and four (22.2%) of the Biology I and Biology II textbooks offered a theory for the cause in the reported increase in the rates of skin cancer. Many of the authors contribute the increase in the reported skin cancer cases to the overall outdoor lifestyle of the American public.

Research Question Six: As students progress from Biology I into Biology II, are they exposed to any information which explains the effects of solar radiation on skin cancer?

A complete examination of the radiation and cancer concepts found within the Biology textbooks reveals that there is no substantial difference in the space utilized to present the information which explains the effect of radiation on cancer in the textbooks used for Biology I and Biology II. Thus, the textbooks for Biology I and Biology II are similar to one another in that no one is more difficult than the other. Initial analysis of the data disclosed that there may be a silght difference--less than thirty per cent--in the amount of information contained within textbooks required for the Biology I course. However, this difference can be attributed to the ratio of books listed as required for Biology I and Biology II high school science courses. The ratio for Biology I is greater than the ratio for Biology II.

Research Question Seven: To what extent does the readability level of the State required Biology I and Biology II textbooks rate according to grade level?

Of the eighteen books analyzed in the survey, two were not analyzed due to the lack of relative information, five of the Biology I texts scored at the reading level of 13-15th (college) while two were rated at the 16th level (college graduate). A total of four books were rated at their age appropriate levels; two at the 9-10th grade level and two at the 11-12th grade level. On the other hand, four of the Biology II texts were rated at the 13-15th grade level (college), while the 11-12th grade level attained only one textbook at its level.

Research Question Eight: How often do the authors present illustrations which represent either solar radiation or cancer concepts?

An investigation of the tabulated data reveals that, as a whole, 13 (72.2%) of the textbooks offer pictorial illustrations while 5 (27.8%) of the textbooks do not. Specifically speaking, fifty per cent of the Biology I textbook authors used pictorial illustrations where as only twenty two per cent of the Biology II textbook authors used pictorial illustrations.

Discussion

In general, the results of this study suggest that the Biology textbooks required by the 1995-1996 Oklahoma State Department of Education contain a very low percentage of information about solar radiation and its detrimental effects on skin cancer. However, a vast majority of the required textbooks thoroughly define cancer.

After examining all eighteen of the texts, the authors impression was that the

Biology I textbooks required contained the most information about both skin cancer and solar radiation. Yet, even though the analysis shows that the information exists, it is presented in a format whose reading level is entirely inappropriate for its suggested reading audience. Thus, a majority of the students are not able to comprehend the concepts about solar radiation and skin cancer. Furthermore, it was determined that a large portion of the textbooks analyzed contained numerous pictorial illustrations, thus possibly indicating an effort by the authors to visually interpret the concepts and relate to readers who learn by sight. The pictorial ilustrations can be helpful, but, not as effective because of the apparent inability of the reader to interpret the concepts.

It is the authors opinion that the textbook writers fail to disclose the true problem--skin cancer is on the rise in America. Instead of addressing the issue, the textbook writers have opted to take a reverse approach by mentioning, first, the correct manner in which to protect the skin from exposure to solar radiation. Factually speaking, three (16.7%) of the Biology I textbooks and one (5.6%) of the Biology II textbooks mentioned the proper procedures needed to protect the skin from exposure to solar radiation. Each of the textbooks which mentioned ways of protecting the skin from excessive exposure to solar radiation encouraged readers to use suncreen. Indeed, this is relative information, however, it was mentioned in only one compete sentence, and, no other precautionary measures were given.

Altogether, the Biology textbooks attribute, often indirectly, the increase in solar radiation to one or more of the three scientific theories--global warming,

ozone depletion, and greenhouse effect. It was found that a great number of the textbooks analyzed focus upon the earth as a whole, thus eliminating the specific focus upon the human race. Few of the textbooks analyzed initiate a discussion of the cause in the reported increased rates of skin cancer, yet, those which speak openly blame the increase on the greenhouse effect and the depletion of protective ozone molecules within the atmosphere

Recommendations for Further Study

The findings and conclusions of this study lead to the following recommendations for further study:

1. Do the state adopted textbooks for middle school general science courses contain any solar radiation and skin cancer concepts?
2. Do any of the other available high school science courses such as Chemistry, Physics, Life Science, or Anatomy and Physiology reveal more solar radiation and skin cancer concepts?
3. A study which focuses upon the teacher manuals used within the Biology and Biology II courses.
4. A study which surveys high school teachers and/or high school students knowledge of solar radiation and skin cancer.

The final four suggestions for further research are but a small number of the many possible areas open for further study. The four instruments used are relatively

brief and need more study in order for educators to fully discover the need to introduce this simple yet important concept to the future leaders of Oklahoma. Oftentimes, as Americans, we do not assail an issue until it poses a problem. True, it is never too late to learn, or is it? Science educators of Oklahoma proudly boast that they teach the children of Oklahoma the basics of health. When should one learn about skin cancer? When they are diagnosed with the dreaded disease?

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APPENDIX A

TEXTBOOKS USED IN THE STUDY

BIOLOGY I

TITLE	PUBLISHER	DATE OF EXPIRATION
A. Addison-Wesley Biology '94	Addison	2000
B. Basic Biology '92	AM Guid	2000
C. Biology: An Everyday Experience'92	Glencoe	2000
D. Biology: The Dynamics of Life '91	Glencoe	2000
E. Biology: Living Systems '94	Glencoe	2000
F. Holt Biology: Visualizing Life ,94	HRW/HBJ	2000
G. Modern Biology	HRW/HBJ	2000
H. Heath Biology	Heath	2000
I. Biological Science: An Ecological Approach	Kendall	2000
J. Biology '93	Prent-H	2000
K. Biology: The Science of Life '91	Scott	2000
L. Biology: The Unity and Diversity of Life	Wadswth	2000

BIOLOGY II

M. Campbell Biology '93	Addison	2000
N. Life: The Science of Biology, 3/E '92	Freeman	2000
O. Biology: A Journey Into Life, 2/E '91	HRW/HBJ	2000
P. Biological Science: A Molecular Approach	Heath	2000
Q. Biology Today '93	Mosby	2000
R. Marine Biology:An Ecological Approach	Scott	2000

APPENDIX B

Dale-Chall Formula for Predicting Readability

SAMPLE TAKEN FROM THE TEXTBOOK _____

Article: _____ Page No. _____ Page No: _____

Author: _____ From: _____ From: _____

Publisher: _____ To: _____ To: _____

Date: _____

1. Number of words in the sample.....	_____	_____
2. Number of sentences in the sample.....	_____	_____
3. Number of words not on Dale list.....	_____	_____
4. Average sentence length (divide 1 by 2).....	_____	_____
5. Dale score (divide 3 by 1, multiply by 100).....	_____	_____
6. Multiply average sentence length (4) by .0496..	_____	_____
7. Multiply Dale score (5) by .1579.....	_____	_____
8. Constant.....	_____	_____
9. Formula raw score (add 6, 7, and 8).....	_____	_____

Average raw score of _____ samples..... _____ Analyzed by _____ Date _____

Average corrected grade-level..... _____ Checked by _____ Date _____

APPENDIX C

Chall's Stages of Reading Development

The folowing stages indicate the reading maturity required by various reading materials.

Stage 1 (Grades 1,2), Ages 6-7: Initial Reading
During this primative stage learning the alphabet and how to correlate the letters with the correct parts of spoken words are of utmost importance. Learners learn to associate written words with the simple words which comprise their vocabulary.

Stage 2 (Grades 2,3), Ages 7-8: Confirmation
In stage two the learner does not gain any new information, but, rather finds himself affiliating what he has already known. The decoding process which began in stage one continues and is eventually perfected by the conclusion of this stage.

Stage 3 (Grades 4 to 8), Ages 9-13: New Information
Within this stage children learn to read. Generally speaking, the learner reads for new knowledge such as facts, concepts, and 'how to' do things. Likewise, the child also incorporates a learning process--how to find information in a sentence, paragraph, chapter, or book. In addition to acquiring and developing this process the learner also has an overall increase in vocabulary. During the latter half of stage 3 the child begins to read to learn new information. Characteristics described earlier are perfected as the learner begins to react more critically to the textbook.

Stage 4 (High School), Ages 14-18: Multiple Viewpoints
This stage is characterized by reading from multiple viewpoints. Because secondary schools often require the student to use a variety of textbooks, the student must deal with more than one set of facts, viewpoints, and theories, and, ultimately derive a conclusion after thoroughly analyzing the material. The material that is read is now more complex.

Stage 5 (College and beyond), Ages 18 and above.
The reader constructs knowledge on a very high level. Knowledge previously learned about the subject and general knowledge are needed for complete comprehension of the textbook. Both the topic and terminology of the text are difficult. This stage is classified primarily by reading extremely complex materials.

APPENDIX D

Dale-Chall Readability Formula

Correction Table

FORMULA RAW SCORE	CORRECTED GRADE-LEVELS
4.9 and below	4th grade and below
5.0 to 5.6	5-6th grade
6.0 to 6.9	7-8th grade
7.0 to 7.9	9-10th grade
8.0 to 8.9	11-12th grade
9.0 to 9.9	13-15th grade (college)
10.0 and above	16 (college graduate)

APPENDIX E

FREQUENCY OF KEY WORDS

SAMPLE TAKEN FROM THE TEXTBOOK: _____

Author: _____

Publisher: _____

Date: _____ Course Requirement: Biology I or II (circle one)

KEY WORDS

1) cancer
2) chlorofluorocarbons
3) epidermal cells
4) global warming
5) greenhouse effect
6) melanoma
7) ozone depletion
8) radiation
9) skin cancer
10) solar radiation

TABLE OF CONTENTS:		TABLE OF INDEX:		GLOSSARY:	
1)_____	pg._____	1)_____	pg._____	1)_____	pg._____
2)_____	pg._____	2)_____	pg._____	2)_____	pg._____
3)_____	pg._____	3)_____	pg._____	3)_____	pg._____
4)_____	pg._____	4)_____	pg._____	4)_____	pg._____
5)_____	pg._____	5)_____	pg._____	5)_____	pg._____
6)_____	pg._____	6)_____	pg._____	6)_____	pg._____
7)_____	pg._____	7)_____	pg._____	7)_____	pg._____
8)_____	pg._____	8)_____	pg._____	8)_____	pg._____
9)_____	pg._____	9)_____	pg._____	9)_____	pg._____
10)_____	pg._____	10)_____	pg._____	10)_____	pg._____

** indicates word was found*

APPENDIX F

AMOUNT OF INFORMATION

PRIMARY SECTION: Title of Section_____ Pages:_____

Number of paragraphs _____

Number of sentences _____

Number of words _____

How many times are any of the ten key words listed?:

1)	cancer	_____	_____
2)	chlorofluorocarbons	_____	_____
3)	epidermal cells	_____	_____
4)	global warming	_____	_____
5)	greenhouse effect	_____	_____
6)	melanoma	_____	_____
7)	ozone depletion	_____	_____
8)	radiation	_____	_____
9)	skin cancer	_____	_____
10)	solar radiation	_____	_____
			totals

_____
TOTALS

Which word was used the most often?_____

Which words were used the least?_____

Which words were not found?_____

APPENDIX G

GUIDING QUESTIONNAIRE

Is there a laboratory or extracurricular activity found within the book which further illustrates the concept? yes or no (circle one)

Are there any questions at the beginning or end of the text which further discuss the concepts? yes or no (circle one)

Are there any pictorial illustrations? yes or no (circle one) (see Appendix H)

Does the textbook mention the primary cause of skin cancer? yes or no

Is there a suggested theory for the cause in the reported increase in the rates of skin cancer? yes or no

Does the textbook discuss the theory of the greenhouse effect? yes or no. Ozone depletion? yes or no. Global warming? yes or no

Is there a suggested rational for the cause in the increase of solar radiation? yes or no

Are there any safety precautions listed for the correct manner to protect the skin from over-exposure to solar radiation? yes or no

*To what grade level does the author develop the content of the primary section according to the Dale-Chall format for predicting readability?

4th-and below 5th-6th 7th-8th

9th-10th 11th-12th 13th-15th (college)

16th-and above (college graduate)

APPENDIX H

Illustrations

SAMPLE TAKEN FROM THE TEXTBOOK_____

Illustration #1	Illustration #2	Illustration #3	Illustration #4
page:_____	page:_____	page:_____	page:_____
photograph____	photograph____	photograph____	photograph____
diagram_____	diagram_____	diagram_____	diagram_____
cartoon_____	cartoon_____	cartoon_____	cartoon_____
other_____	other_____	other_____	other_____

********ILLUSTRATION OF********

_____	_____	_____	_____

Totals:

pages_____
photographs_____
diagrams_____
cartoons_____
other_____

** indicates illustration was found*

2

VITA

Melissa J. Furch

Candidate for the Degree of

Master of Science

Thesis: AN EVALUATION OF SOLAR RADIATION AND SKIN CANCER CONCEPTS CONTAINED WITHIN HIGH SCHOOL BIOLOGY TEXTBOOKS

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OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 11-20-96 **IRB#: ED-97-036**

Proposal Title: AN EVALUATION OF SOLAR RADIATION AND SKIN CANCER CONCEPTS CONTAINED WITHIN HIGH SCHOOL BIOLOGY TEXTBOOKS.

Principal Investigator(s): Kate Baird, Ted Mills, Melissa J. Furch

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

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Chair of Institutional Review Board

cc: Melissa J. Furch