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Review Article about Ultraviolet (UV) Light

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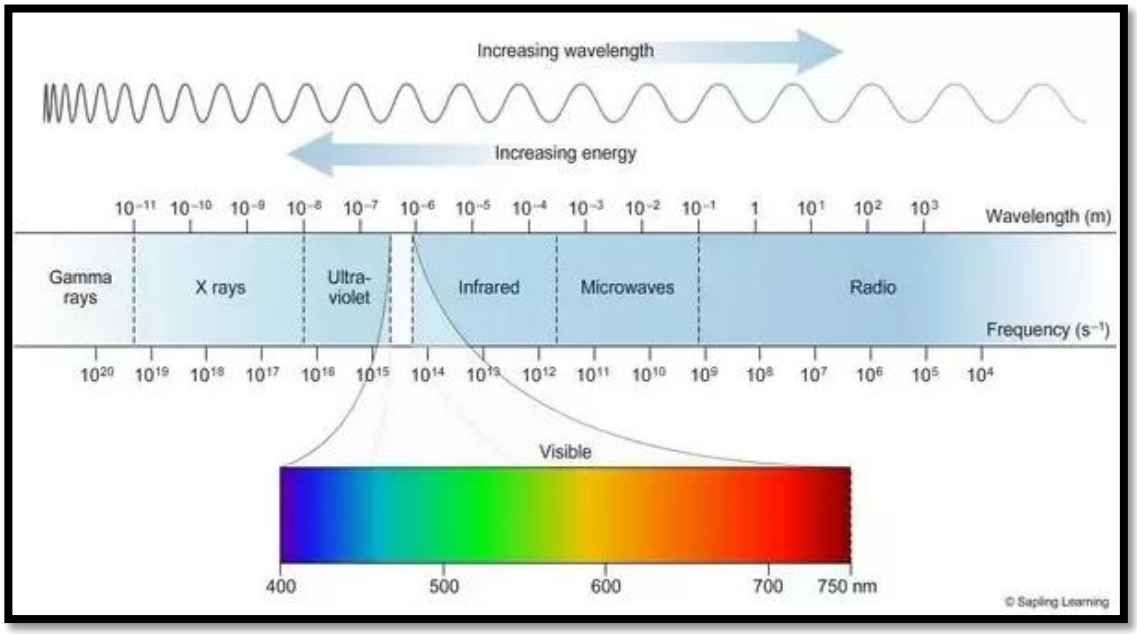
Abstract:

In this research, we conclude our study of ultraviolet rays, their discovery, types and categories. We talked about the sources of ultraviolet rays, and we discussed the effects of ultraviolet rays on human health, such as the benefits and harms of these rays, their effects on the skin, and so on. We also talked about the applications of ultraviolet rays and we also talked about phototherapy with ultraviolet rays. We conclude from this research the extent of the scientific importance in studying these rays.

1.1.Introduction

Ultra Violet (UV) is an electromagnetic wave. Ultraviolet rays are located in the electromagnetic spectrum between visible light and X-rays. Ultraviolet rays have a shorter wavelength than visible light but are longer than X-rays. They are called ultraviolet because the wavelength of violet is the shortest among the colors of the spectrum. Their wavelengths range from 10 nanometers to 400 nanometers, and their energy ranges from 3 to 124 electron volts. As they are ionizing rays,

meaning that they separate electrons from their atoms, they may cause a chemical reaction, which means that molecules that come into contact with them can be charged or "ionized**".**



(Figure 1): The ultraviolet range begins to the left of visible light. The numbers at the bottom of the figure give the wavelength as well as the frequency of the waves.

Ultraviolet radiation is generally divided into three subcategories:

1. Ultraviolet A (UVA) with a wavelength of (315 to 400 nm).
2. Ultraviolet B (UVB) with a wavelength of (280 to 315 nm).
3. Ultraviolet B (UVC) with a wavelength of (180 to 280 nm).

Radiation with a wavelength of 10 to 180 nm is sometimes referred to as vacuum radiation because it is strongly absorbed by air, or extreme ultraviolet radiation, and air usually prevents this radiation from spreading, and it can only be observed in a vacuum.

1-2 Discovery of Ultraviolet Radiation

The discovery of ultraviolet radiation was related to the scientific observation that silver salts become darker after exposure to sunlight. In 1801, the German physicist Johann Wilhelm Ritter noticed that invisible rays with wavelengths shorter than violet—the visible end of the spectrum—were particularly successful in darkening silver paper impregnated with chloride. He called them "oxidizing rays" to emphasize their chemical reactivity and to distinguish them from the "heat rays" at the other end of the spectrum. The name "chemical rays" was adopted shortly thereafter and remained in use throughout the 19th century. Eventually, the terms chemical rays and heat rays fell out of use and the terms ultraviolet rays and infrared rays were used, respectively. Ultraviolet rays below 200 nanometers are called vacuum rays because they are strongly absorbed by the air, and were discovered by the German physicist Victor Schumann in 1893.

1-3 :Source of ultraviolet rays

- Ultraviolet rays are emitted from the sun in the form of belts of long, medium and short waves, but because the ozone of the upper atmosphere absorbs them, 99% of the radiation that reaches the Earth's surface is from the long wave, which is the least harmful (UVA). For your information, the medium and short wave bands of ultraviolet waves are directly responsible for

the formation of the ozone layer. The sun is the greatest source of UV rays, as 125 watts/square meter reach the Earth's atmosphere in the direction perpendicular to the Earth's atmosphere, or about 9% of all the energy coming into the Earth's atmosphere (1390 watts/square meter). • FP rays are emitted by glowing solid bodies at high temperatures (about 3000 Kelvin) and their spectrum is continuous, but the power of these rays remains weak when compared to the power of FP rays resulting from electrical discharge in gases and vapors, whose spectrum is mostly linear and discontinuous. • Black light or Wood's light (after Robert Williams Wood) is a light that emits long ultraviolet (UVA) radiation and some visible light. It may be made from fluorescent lamps, mercury vapor lamps, light-emitting diodes, or tungsten lamps. Black light works in the same way as regular fluorescent lighting except that it uses only a phosphor and the glass lamp shade is replaced with a dark violet-blue glass shade called Wood's glass, which is coated with nickel oxide to block any visible light with a wavelength above 400 nanometers. Black light has a limited energy output, so it does not cause sunburn, but the longer wavelengths can damage collagen fibers and destroy vitamin A in the skin.

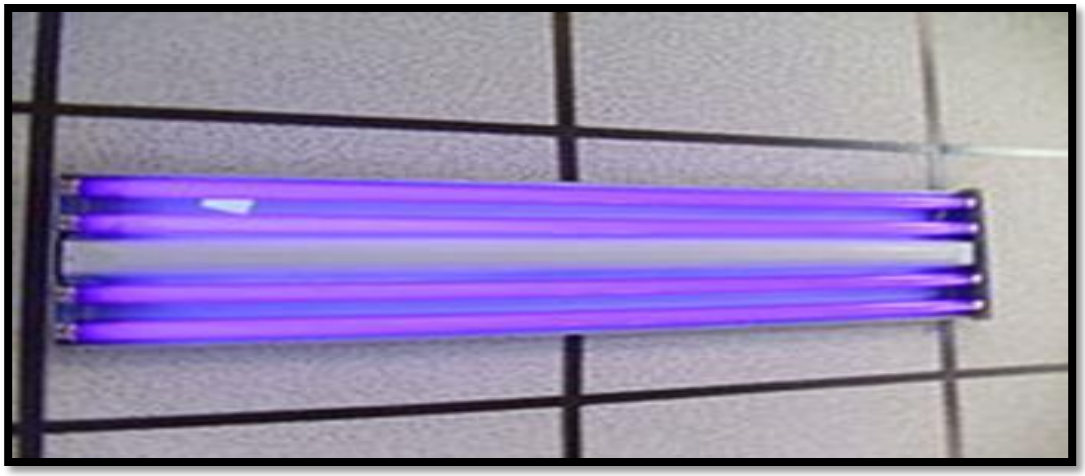


Figure (2) Black light lamp

1.4. Ultraviolet radiation and the ozone layer

Ozone is a blue gas consisting of three oxygen atoms with the chemical formula O3, and its percentage in the atmosphere is small and may not exceed one in a million in some areas, and it is a toxic gas. The ozone layer is a part of the Earth's atmosphere that contains ozone gas in large quantities, and it is largely concentrated in the lower part of the stratosphere of the Earth's atmosphere. Part of the oxygen gas is converted into ozone gas due to the strong ultraviolet rays emitted by the sun and affects this part of the atmosphere due to the lack of thick layers of air above it to protect it. This layer is of vital importance to us as it prevents short ultraviolet waves from reaching the Earth's surface in high concentration and works to regulate the Earth's temperature.

The role of the ozone layer: Although the concentration of ozone in the ozone layer is small, it is very important for life on Earth, as it prevents the leakage of harmful ultraviolet rays (UV) emitted by the sun. They are classified according to their wavelengths into UV-A, UV-B and UV-C, the latter being very dangerous to humans and being completely purified by ozone at an altitude of 35 km. However, ozone gas is toxic at low altitudes, causing bleeding and other things. Exposure of the skin to UV-B rays can cause it to burn (appears as severe redness), and heavy exposure can lead to changes in the genetic code, which results in skin cancer. Although the ozone layer prevents UV-B rays from reaching the Earth's surface, some of them reach the Earth's surface. Most UV-A rays reach the Earth and are not very harmful, but they can also cause changes in the genetic code. Ozone layer depletion allows ultraviolet rays, specifically rays with the most harmful waves, to

reach the Earth's surface, which leads to an increase in the possibility of changes in the genetic genes of living things on Earth.

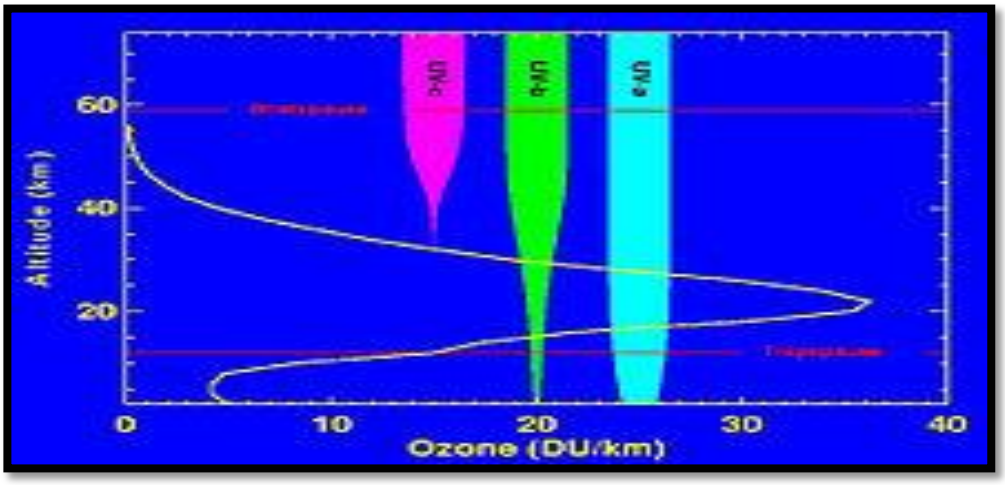


Figure (3) A graph showing ozone levels at different altitudes and UV blocking.

2.3. Sensitivity of DNA to UV rays: To appreciate the importance of protection from UV rays, we can avoid damage from exposure to radiation in the light spectrum (action spectrum), which shows us the effect of biological radiation according to the wavelength. The effect may be skin burns, a change in plant growth or a change in DNA, which leads to genetic damage and damage to collagen fibers, in addition to destroying vitamin A or vitamin C in the skin and generating free radicals. The damage from exposure to radiation changes according to the wavelength. Fortunately, the structure of DNA changes at waves less than 290 nanometers, which the ozone layer blocks significantly. At longer waves that the ozone blocks slightly, DNA is not significantly damaged. If ozone decreases by 10%, there will be a 22% change in DNA from the effect of ultraviolet rays. For your information, the change in DNA leads to diseases such as skin cancer, which explains the importance of the ozone layer to our lives.

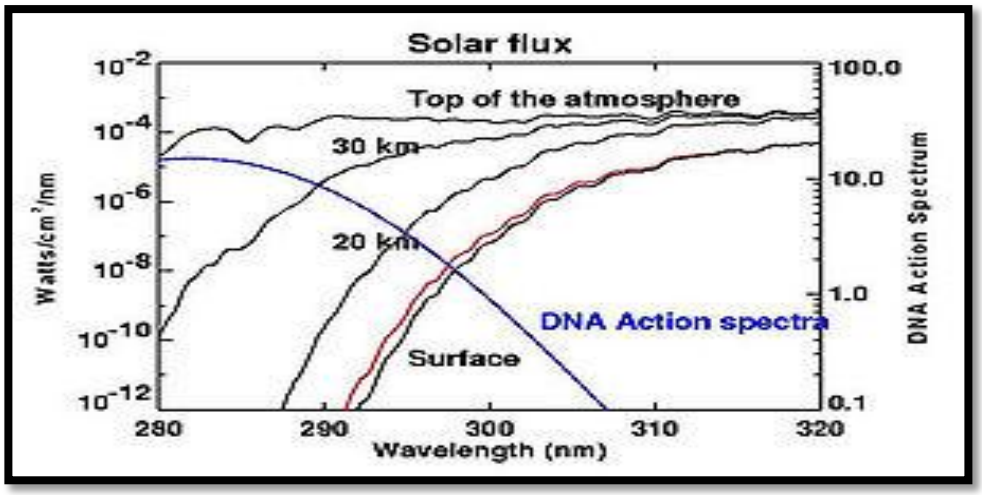


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Figure (4) UV energy levels at different heights, the blue line shows the sensitivity of DNA. The red color shows the energy level at a 10% decrease in ozone.

2.4. Ultraviolet rays and Vitamin D

The sun's rays contain ultraviolet rays (UV), which are of two types: the first is type A, known as (UVA), which is harmful to the skin and shows signs of aging on it, and the second type is B,

symbolized as (UVB), which provides the skin with the energy needed to manufacture vitamin D, but it still has risks. The risks of (UVB) include damaging the skin, causing burns, and destroying cells, which leads to skin cancer, which means that this type, like (UVA), also has health risks.

How does the skin make vitamin D?

- The skin contains the primary factors of vitamin D, called (Vitamin D Precursor).
- The skin absorbs the energy found in ultraviolet rays of the UVB type, and uses it to convert the primary factors of vitamin D into vitamin D3.
- Vitamin D3 is transported to the liver, where it undergoes a chemical process in which a pair of oxygen and hydrogen atoms are added to become (25-hydroxyvitamin D).
- The vitamin is transferred from the liver to the kidneys, where another pair of oxygen and hydrogen is added to become (1.25 dihydroxyvitamin D), which is the final vitamin D that the body needs.

3-1 :Applications of ultraviolet rays

In medicine: Using ultraviolet rays in disinfection and sterilization: Ultraviolet rays are used in disinfection applications because of their ability to inhibit the activity of microorganisms (germs, fungi and viruses) by dismantling the bonds of DNA & RNA molecules by microorganisms and forming new distorted bonds that cause disruption of cell performance and death. This method is called ultraviolet germicidal irradiation (UVGI), and is based on the use of ultraviolet rays with a wavelength of 253¸7 nanometers from the UV-C band to kill microorganisms.

The reason for using this wavelength is that it is between three wavelengths, which are 270 nm, which is most absorbed by nucleic acid bonds, 280 nm, which is most absorbed by protein bonds, and 240 nm, which is most absorbed by peptide bonds, (A peptide is a chain of amino acids. ... A peptide bond is a chemical bond that forms between amino acids to form different proteins and is one of the strong bonds in the structure). The process of disinfection by rays is divided into three types: The first type is air disinfection, where the air flowing through the central ventilation ducts is disinfected by means of ray lamps installed inside these ducts. The second type is used to disinfect surfaces, such as surfaces inside bathrooms, air filters, and cooling coils. The third type is equipment disinfection systems such as surgical instruments, cloths, and tools used in the field of public health and others by inserting them into a chamber containing ultraviolet lamps and equipped with timers that carry out the disinfection process Ultraviolet rays are invisible to humans, but some insects and birds can see them. These rays also help activate chemical reactions in plants, but exposure to them too much kills plant cells.

- Ultraviolet rays help in the production of vitamin D
- The human body also benefits from sunlight in maximizing the effect of vegetables that have been eaten. Within 30 minutes of exposure to ultraviolet rays in sunlight, the body can experience a significant decrease in blood pressure and an improvement in the function of the arteries, thanks to the flow of nitric oxide compounds in the bloodstream. But you should eat vegetables or beets first. • Diseases treated with ultraviolet rays: Skin problems treated with ultraviolet rays are chronic and require multiple treatment sessions, which increases the risk of exposure to these rays and increases the possibility of negative side effects that may last a lifetime. Therefore, controlling the amounts of ultraviolet rays used in phototherapy is important to increase the effectiveness of the treatment and reduce the risks. It is believed that the mechanism of action of this treatment depends on slowing down the excessive growth of cells and changing the immune system, but this is only a belief, and the reason for the response of

some skin diseases to treatment with ultraviolet rays is still unknown. Ultraviolet treatment can be used to solve the following skin problems:

Psoriasis (in English (Psoriasis).

1. Eczema (in English (Eczema).
2. Vitiligo (in English (Vitiligo), which is a skin disease that often appears in the form of white spots on the skin.
3. Cutaneous T-cell lymphoma), which is a rare type of cancer that can affect the skin.
4. Constant itching.
5. Graft-versus-host disease (in English (Graft-versus-host disease), which is a complication associated with bone marrow transplantation. Forensic experts and intelligence agencies use this type of lighting (black light) to analyze crime scenes to lift fingerprints by scanning them with a phosphorous dye.

- Insect control: Ultraviolet traps are used to repel many flying insects by attracting them to ultraviolet light and killing them with electric shock when Entering the light trap.
- Skin: Ultraviolet rays help activate the melanin pigment in the upper skin cells, thus helping to give the skin a color known as tan, in addition to its use in treating skin tissues and blood vessels.
- The effect of ultraviolet rays on the Corona virus: Viruses do not reproduce on their own, but have genetic material, either DNA or RNA, and reproduce by adhering to cells and injecting their nucleic acid. Some viruses emerge from the infected cell (this form of reproduction is called the cyclic cycle), while others integrate into the infected cell and reproduce every time the cell divides. Ultraviolet light can damage the DNA, which is the basis of the virus. The DNA molecule consists of two strands linked together with four bases: adenine, cytosine, guanine, and thymine. These bases are like the alphabet, and their sequence constitutes instructions for cells to reproduce. Ultraviolet light can cause the thymine bases to merge together, distorting the DNA sequence. Because the DNA sequence is incorrect, it can no longer replicate properly, and this is how UV light kills viruses, by destroying their ability to replicate. • Use of UV in ophthalmology: The energy of the argon-fluoride (ArFl) laser (or excimer laser) (Figure 5) is used to correct vision problems by using rays with a wavelength of 193 nanometers (from 157 to 351 nanometers) that are absorbed by protein molecules in the cornea of the eye, causing their bonds to disintegrate. Recently, work has been done on the wavelength of 213 nanometers to provide greater advantages, the most important of which is reducing the damage caused by the rays to the lens.

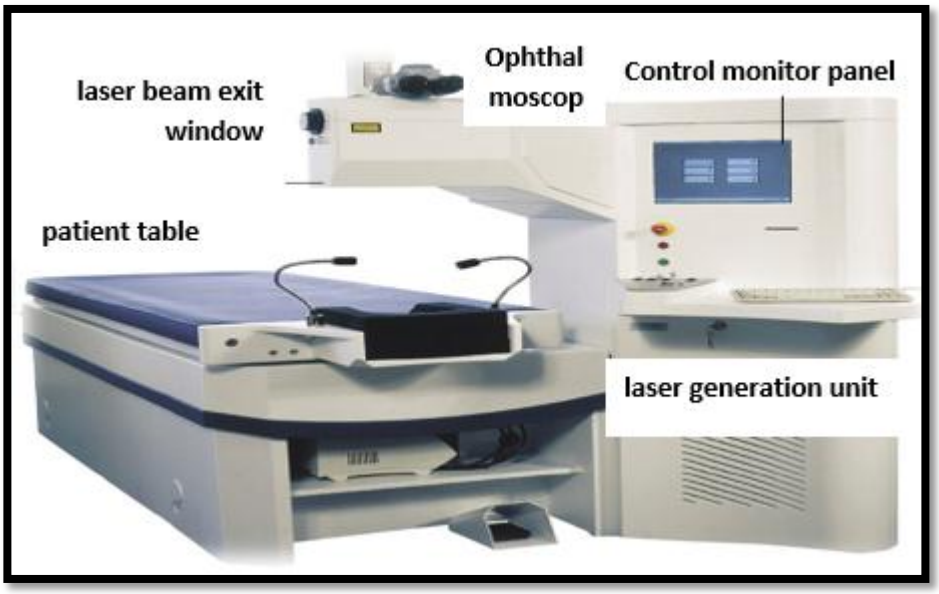

Figure (5): Excimer laser device and its basic parts.

This laser is used to reshape the outer surface of the eye (corneal reshaping) in order to correct vision problems related to poor refraction of light in the eye. Since the energy of the photons is absorbed by the surface layer, the deeper tissues are protected from damage. Figure (6) shows the differ patient table eye, and shows the absorption rate of each of these media for the different wavelengths. It is noted that rays with a wavelength smaller than 280 nanometers are completely absorbed in the corneal layer without passing into the inner layers of the eye, and the longer the wavelength (from 300 to 360 nanometers), the greater the possibility of the rays passing into the eye, and thus affecting the inner layers.

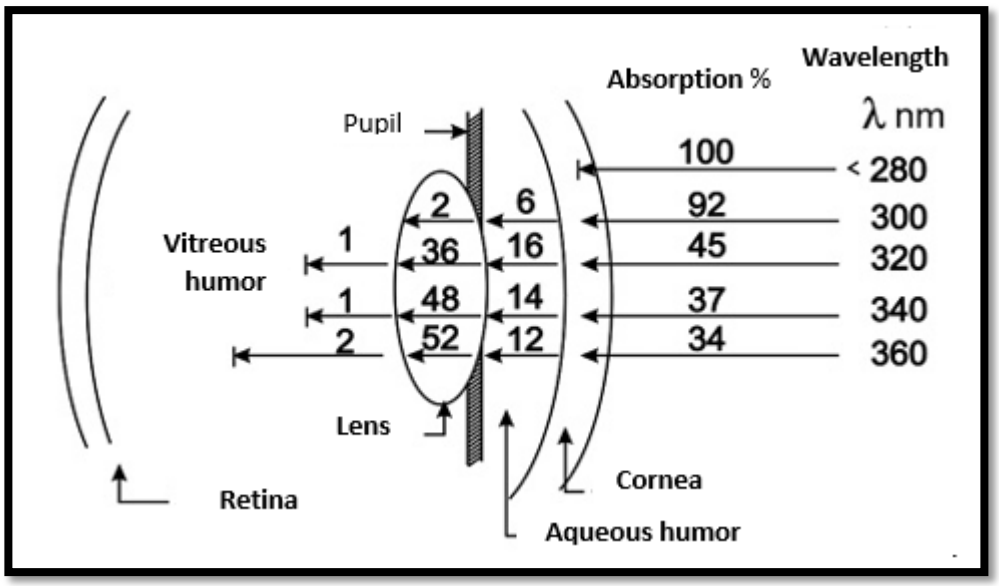

Figure (6) The rate of ultraviolet rays passing through the eye tissues.

- Use of ultraviolet radiation in photochemotherapy: The principle of extracorporeal photochemotherapy (ECP) is based on extracting venous blood from the patient, isolating the white blood cells, then chemically treating them with 8-methoxypsoralen and exposing them to ultraviolet radiation from the UV-A band, then re-injecting them into the patient (Figure 7). This process is repeated once every few weeks for a few months. It is believed that this process

stimulates the patient's immune response to malignant lymphocytes. This method has achieved promising results in treating some lymphomas.

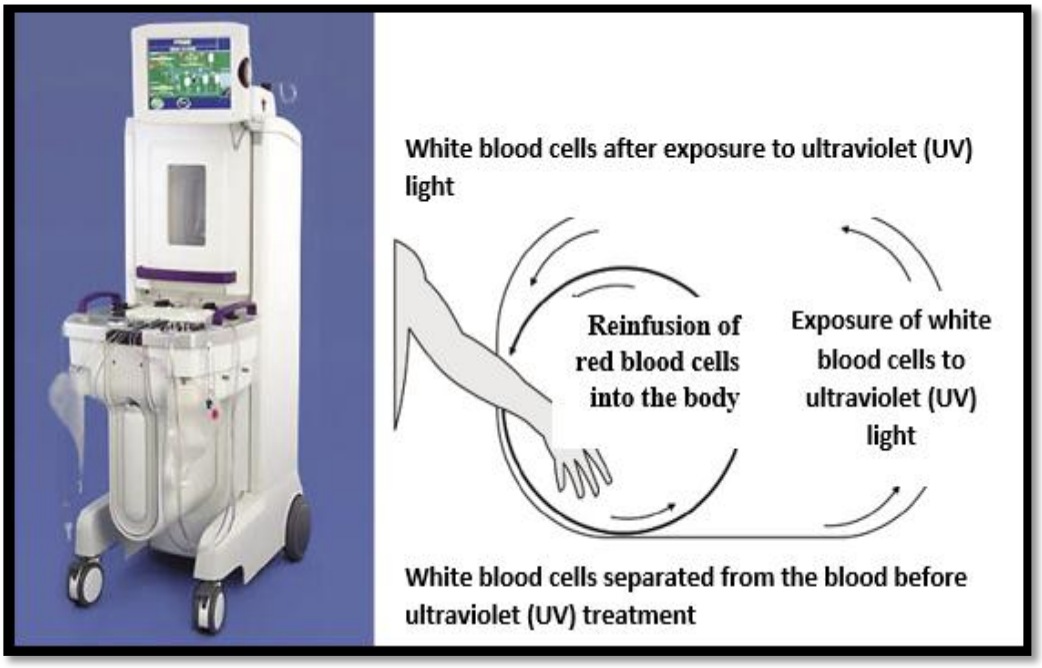

Figure (7) The device used in photo pharmacological treatment

chemical markers: Ultraviolet fluorescent dyes have many uses such as biochemistry and forensic evidence, and there is the Green Fluorescent Protein GFP which is used in genetics as a chemical marker, and proteins have the efficiency and ability to absorb the ultraviolet beam and as we said it has a benefit in biochemistry and related disciplines.

The immune system: Ultraviolet rays of the type basically help to redistribute some elements in the main and secondary cells in the immune system, thus changing the immune response by stimulating antibodies to protect the body from diseases.

3-2 :Other applications of ultraviolet rays

Industry :

1. It is used in telescopes in cases of solar imaging and it is present in solar observation rockets during the nineties. Also printing on silicon chips to make electrical circuits.
2. Ultraviolet rays are used in the manufacture of thin electronic circuits.
3. Photolithography and laser technology uses deep ultraviolet rays (DUV or Deep UV) for wavelengths less than 300 nanometers.
4. Museum archaeologists use this technology (black light) to check for fake artifacts and artifacts, as most modern paint materials contain phosphorous components.
5. Maintenance workers use this technology (black light) to identify leakage points, as the machine is injected with a dye containing a fluorescent substance and then black light is shone on it to identify the location of the leak with great accuracy.
6. Security officers use this technology (black light) to identify counterfeit currencies, as some countries' securities minting authorities make a small phosphorous strip that is not visible to the naked eye, but shines when a beam of black light is shone on it.

7. In semiconductor manufacturing processes, frequencies with a wavelength of less than 200 nanometers are used using vacuum waves.

Science: Ultraviolet astronomy is generally used to refer to observations of electromagnetic radiation in the ultraviolet wavelength spectrum between about 10 to 320 nanometers. If a celestial body emits a lot of ultraviolet rays, this is evidence that high-energy processes and reactions are taking place in it.

- Ultraviolet rays are used to study the energy levels of different atoms.
- Ultraviolet rays are used to determine the distance between galaxies and stars.
- Ultraviolet rays are used by scientists to study the durability of materials before using them in various industries.
- The science of spectroscopic studies of ultraviolet and visible light is widely used in chemistry to analyze chemical structure, especially conjugated systems. Ultraviolet radiation is used to measure visible light to determine the presence of a certain amount of radiation and is generally used in various laboratories. *Ultraviolet light is used to analyze minerals and gemstones and for detection and documentation work by various collectors. Raw materials have a look under visible light but the degree of glow varies under ultraviolet, or even varies between short and long ultraviolet. *Used in lighting, where fluorescent lamps ionize the vapor in their tubes, causing the electrons in the gas to emit photons with the same frequencies as ultraviolet rays, and a phosphor layer on the inner side of the tube changes the ultraviolet light into visible light *Ultraviolet rays are used to analyze the chemical composition of the compound through color changes, and this process is often used in chemical plants, hospitals, water quality control laboratories, the petrochemical industry and the food industry.

4-1 :The harm of ultraviolet rays to human health

Ultraviolet rays are a form of ionizing radiation (radiation that has enough energy to remove an electron from an atom or molecule), as ionizing radiation can damage DNA in cells, but ultraviolet rays do not have enough energy to penetrate deeply into the body, so they do not cause harm to internal organs, and their effect is limited to both the skin and the eye. It is worth noting that (UV-B) rays contain more energy than (UV-A) rays, so (UV-B) rays are known as the main rays that cause sunburn.

UV rays harm the eye

- Inflammation or burning of the cornea (the front part of the eye), which is called snow blindness or photokeratitis.
- Formation of cataracts (clouding of the eye lens).
- Occurrence of pterygium (tissue growth on the surface of the eye.

UV damage to the skin: *Liver spots, actinic keratosis, and solar elastosis. *Skin burns, which is damage to skin cells as a result of exposure to energy from ultraviolet rays. *Occurrence of a number of degenerative changes in the cells, fibrous tissues, and blood vessels of the skin, in addition to pigmented spots in the skin, such as freckles, moles, and pigmentation. * Acceleration of skin aging, as ultraviolet rays destroy collagen and connective tissues located under the upper layer of the skin, causing wrinkles, brown spots, and loss of skin elasticity.

How to protect yourself from UV damage?

•Prevention Use sunscreen: Apply a broad-spectrum sunscreen with an SPF of 30 or higher on sunny and cloudy days at least 30 minutes before going outdoors. Broad-spectrum means the product provides protection against two types of harmful UV rays: UVA and UVB.

•Wear protective clothing: *A wide-brimmed hat provides good sun protection for your eyes, ears, face, back, or neck. *Sunglasses that provide 99-100% UV protection reduce eye damage from sun exposure. *Loose, tightly woven clothing provides additional sun protection. •Limit sun exposure at noon: UV rays are strongest between 10 a.m. and 4 p.m. So try to minimize your exposure to the sun during these hours. •Minimize your exposure to the sun during the afternoon: The sun's ultraviolet rays are most intense between 10 a.m. and 4 p.m. So try to minimize your exposure to the sun during these hours. •Do not use tanning beds, medical ultraviolet lamps for treating diseases, and home tanning devices, including beds, lamps, and booths that emit ultraviolet rays. The amount of ultraviolet radiation produced during tanning at home is similar to the amount produced by sunlight because ultraviolet rays emitted by sunlight and artificial sources, such as tanning beds and medical ultraviolet lamps for treating diseases, are carcinogenic. •Self-tanning products and spray tans in beauty salons are healthy options for those who want to appear tanned.

4-2 :The effects of ultraviolet rays on plants *Impairing photosynthesis in many types of plants. * Reducing the size and quality of many types of rice, soybeans, winter wheat, cotton, and corn. * Reducing the productivity of phytoplankton in aquatic ecosystems, which greatly affects the global carbon cycle, because phytoplankton store huge amounts of carbon in the ocean. *Increased susceptibility of plants to diseases. *Change in the color and thickness of leaves, wrinkling of the cotyledon, and inhibition of the growth of the hypocotyledonous stalk, in addition to changes in the elongation of the stem, leaves and roots. *Causing the appearance of irregular spots on leaves exposed to ultraviolet rays, which later turn into brown necrotic spots and then die. Ultraviolet radiation damage to animals *Damage to the DNA of cells, which causes some negative effects such as increased mutations and inhibition of reproduction. *Lack of pigment in the skin of animals exposed to solar radiation for long periods, which leads to an increased likelihood of developing skin diseases. *Pink eye in light-skinned cow breeds. Ultraviolet radiation damage to water * Rising temperatures of surface waters of lakes and oceans, which leads to changing the habitats of many species in marine ecosystems. *Increased temperature differences between surface and deep waters, which creates barriers to the upward mixing of nutrients needed for photosynthesis, and increases the exposure of organisms living in surface waters to higher levels of ultraviolet radiation. *Reduced ice cover on lakes and oceans in polar regions and the Alps, which increases the exposure of organisms to ultraviolet radiation. * Increased carbon dioxide, which increases the acidity of the oceans and inhibits the ability of many marine organisms to form external structures that absorb ultraviolet radiation.

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