Editorial

Philosophical and Divine Perspectives of Light

The year 2015 commemorates the United Nations Year of Light and Light-based Technologies. The current edition of Vidurava has hence been dedicated for this commemorative occasion.

Diversity in the advancement of our knowledge in the cross-disciplinary use of light in techniques and technologies involving natural and synthetic physico-chemical transformations could be seen from the articles published in this number.

Light as we know was one of the primary natural phenomena that led to the creation and evolution of life on earth. Hence conceptually it could be assumed that light-based technologies in a bio-physical context, originated right from the birth of the Earth planet during the late Precambrian era. It is therefore no surprise that light was also inspirational in a theological or theosophical context, in origination of 'objective realism', as well as of divinity and spiritualism from ancient times.

Thus Buddhist philosophy with a focus on realism expounds a highly complex but convincing analysis of light, as one of the functional elements of the cognitive process of observation or seeing of a visible object. According to Buddhist commentaries, several essential conditions must exist for what has been expressed in philosophical terms as the "eye door process". These are, 1) eye sensitivity (*cakkhuppasāda*), 2) a visible object (*rūparammana*), 3) light (*āloka*), and 4) attention of the mind (*manisikāra*).
When an external object or image impinges on (or contacts) the "eye door", an eye consciousness (*cakkhu-viññāna*) arises followed by the investigating consciousness, which causes origination of the determining consciousness, which in turn discriminates the observed object.

In other religious faiths, divinity or providence is the prime focus on light. In Christianity, according to Biblical references, the first specific creation of God (Genesis – 1) was the creation of light. As the first chapter in the Bible refers to light, so does the last (Revelation 22:1-5), which says that the only light necessary in heaven is God Himself. In Samuel 22, David said: 'For you are my lamp O' Lord, and my God lightens up my darkness'. This is claimed to be the first time God's presence and communication with humans is compared with light.

In Hinduism, Diwali or Deepavali is described as the 'Festival of Lights'. From 'darkness unto light' – the light that empowers to commit to good deeds that which bring people closer to divinity. The illumination of homes with light and the skies with fire crackers is considered an expression of obeisance to the heaven for the attainment of health, wealth, knowledge, peace and prosperity. The concept of light in Islam is reflected in the parable of *Al Nur*. According to which, "Allah is the light of the Heaven and the Earth. The parable of His light, is as if there were a niche: And within it a Lamp: The Lamp enclosed in Glass: The glass as it were a brilliant star, Lit from a blessed Tree". Thus we see how light had enliven the existence of human beings through the millennia.

M. Asoka T. De Silva

Light as a carrier of information

Dr Ruwan Weerasuriya



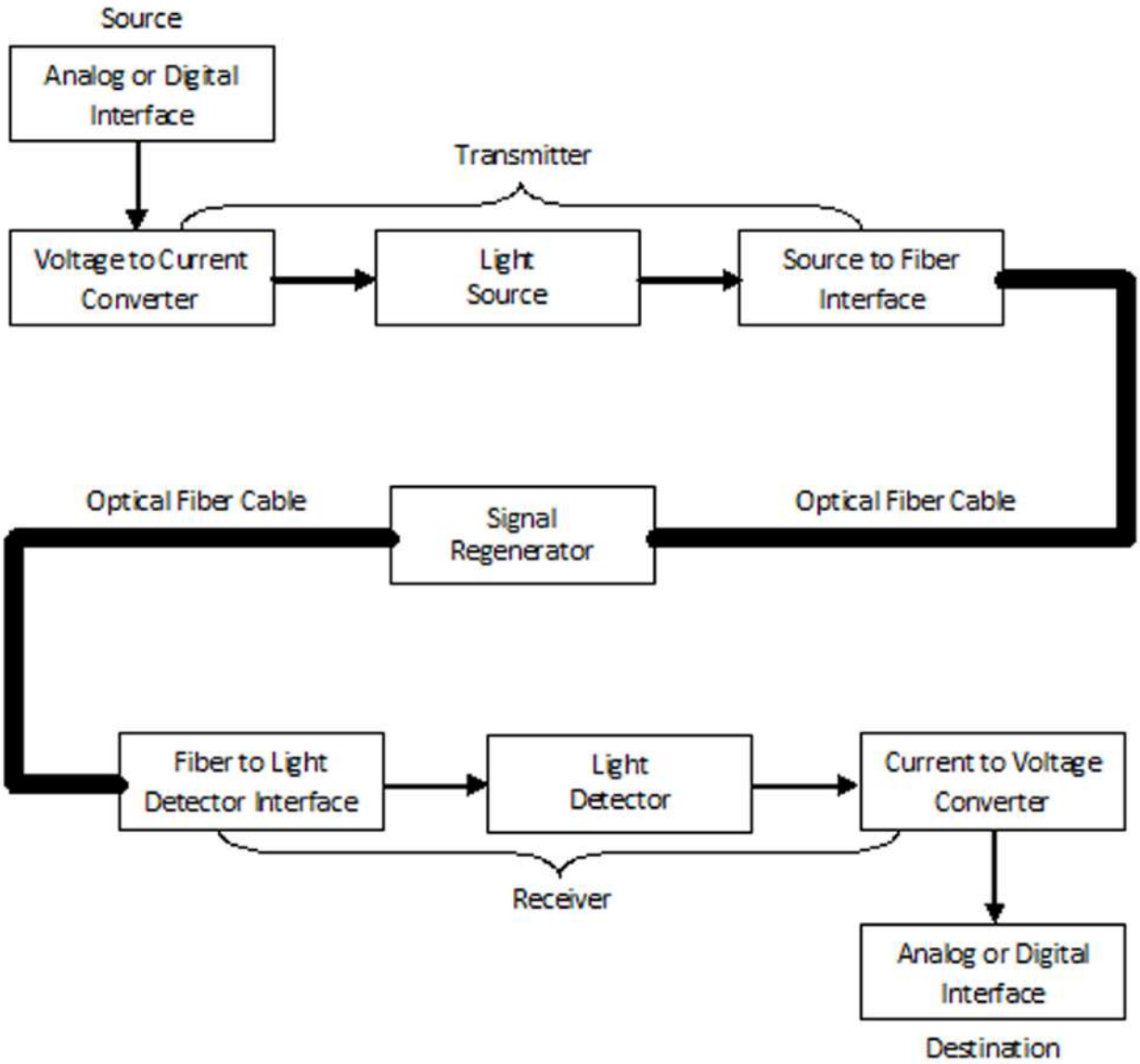
Light as a Carrier of Information

The word 'Information' has gained prime importance in the rapidly evolving technological world nowadays, simply because of the fact that it is information which enables every single task of every process. The scenario is not so different as for a human being: we do every action based on the information we receive from the surroundings. Likewise, every system performs its operations based on the information they received as the inputs. Thus, we can obviously understand that transmission of information from one place to another is to be used in productive manner. In the vast technical fields ranging from spacecraft technology to Nano technology, information transmission plays a vital role. Now that we know how impactful this 'transmission of information' could be to any technocrat, it is important for us to identify the currently available methods to transmit information from one place to another. We use various media to transmit information and this article focuses on how light is used to carry information from place to place. Yes, you read it correct, the world has been using 'light' as a carrier of information for the past few centuries and it is really amazing to see the journey as to how this technology evolved through the years.

History of Evolution

It is very correct to state that the history of the use of light, or more scientifically 'optics', to transmit information from one place to another goes back to hundreds of years. If you do not agree think of ancient people living in a village using smoke signals or fire beacons to communicate with people living in another village. That signal came to our eyes via visible light. Imperial armies were using different colors of flags to indicate the victory or defeat. People identified the different colours with the aid of light. Another instance was the use of mirrors to reflect light and send signals beyond several miles away. All these things simply depict that 'light' is not a new technique used to send information. The aforementioned ones are the most basic and ancient examples of 'light' as a carrier of information. The technological foundation for this concept was laid in 1880, when Alexander Graham Bell experimented with an apparatus called 'photophone'. It is a device built with mirrors and selenium detectors. Sound waves were transmitted using it over a light beam. However, this did not have the potential to be deployed in a real world application, because the effect from water vapor, oxygen and other particles in the air obstruct the transmission at light frequencies through the atmosphere to a great extent. Thus, the very first practical application of optical communication system was invented in 1930 by J.L. Baird (British) and C.W. Hansell (USA). The special feature is that, they were using a medium called 'fiber cable' to guide the light. It is at this point that the concept of fiber cables for the use in optical communication came into discussion, and that marks the inception of optical fiber communication systems. Since 1930, there were major





Source: Advanced Electronic Communication Systems – Wayne Tomasi

breakthroughs which eventually created high-quality, high-capacity and efficient light wave systems that we experience today. In fact, optical fiber cables are now considered as the most promising type of guided transmission medium for most types of communication applications.

These optical fiber systems generally operate in the infrared band of the electromagnetic frequency spectrum which has longer wavelengths than the visible light. The most typical wavelengths being used include, 850 nm, 1300 nm and 1550 nm.

Overview of an Optical Fiber Communication System

The above figure indicates a simplified version of a light wave communications link. The basic building blocks of this system include a transmitter, a receiver and the optical fiber cable.

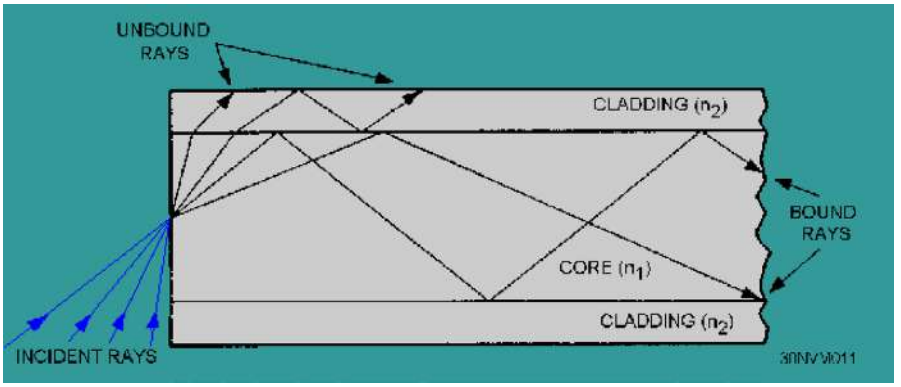
The transmitter comprises a voltage to current converter, a light source and a source to fiber interface.

The purpose of the voltage to current converter is to act as an electrical interface between the input circuitry (Eg: a computer) and the light source. A typical light sources could be an IR LED (Infrared Light Emitting Diode) or a Laser Diode. The amount of light emitted by the light source is controlled by the current received by the source. So in simple terms, the voltage to current converter converts an input signal voltage to a current that could drive the light source, and the output light of the source is directly proportional to

the magnitude of the input signal. Then this output light beam is coupled to the optical fiber cable for transmission.

Once the light enters the optical fiber cable (either glass or plastic), it propagates along the cable. The fiber to light detector coupling device is also as same as the previous coupler and optimize the amount of input light to detector. Even though the best known light detector is human eyes, in communication the same principle is used in devices such as a PIN (p-type-intrinsic-n-type) diode, an APD (Avalanche Photo Diode) or a phototransistor. All these devices perform the same function of converting light energy to current. In order to obtain the transmitted signal, a current to voltage converter is used.

The reason to add a signal regenerator in between the transmitter and receiver is to regenerate the light signal because as the distance increases, the signal strength decreases due to various losses (attenuation), and to get rid of noise. The signal need to be regenerated in the propagation path in order to ensure that the original signal is properly received at the destination.

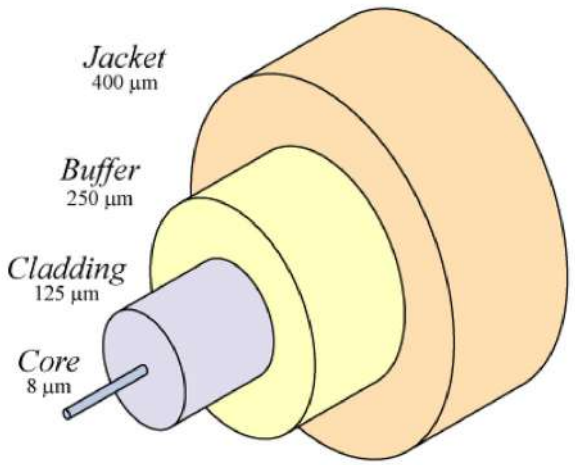


Source: http://www.tpub.com/neets/tm/106-9.htm

Construction of the Optical Fiber Cable

The main parts of an optical fiber cable are called the core and the cladding. The core and the cladding are constructed out of either glass or plastic. The important characteristic of these two parts is that their refractive indices are different to each other. However to ensure the strength of the cable and to protect the core and the cladding, a number of protective coatings are applied around the cladding. The diagram below shows the construction of a practically used optical fiber cable.

The diameter of the core will decide the possible number of patterns of allowable light energy in fiber, and we define this property as the 'mode' of the optical fiber cable. If it only allows a single pattern of light energy, it is called single mode and the others called multi-mode.

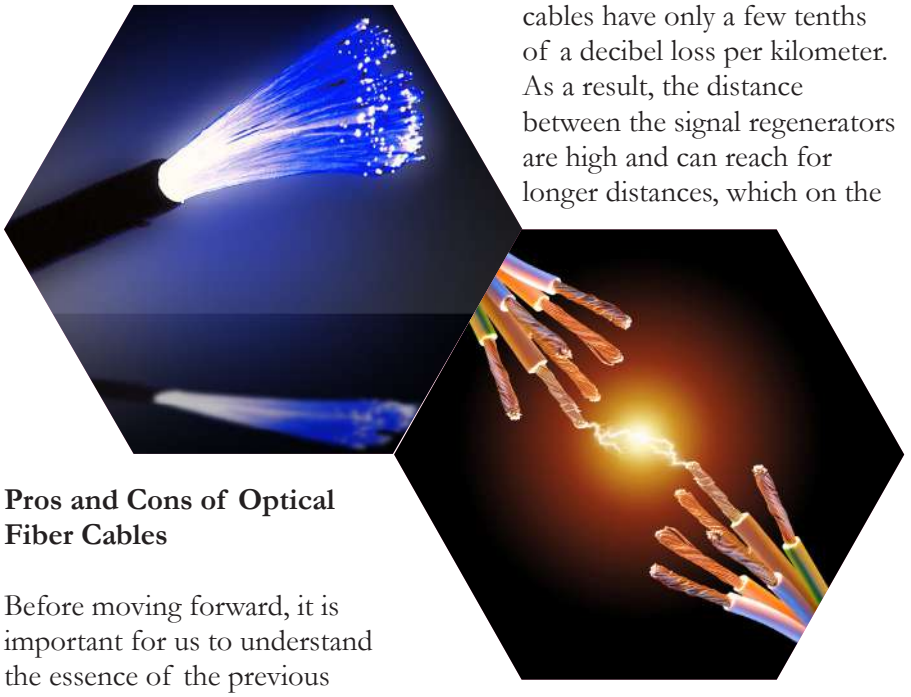


Source: http://www.openoptogenetics.org/images/7/7d/Singlemode_fibre_structure.png

How does Light Propagate in an Optical Fiber Cable?

As stated earlier, the core and cladding refractive indices are different from each other. Precisely, the core has a higher refractive index when compared to the cladding to enable the total internal reflection inside the core. Once the light ray enters the optical fiber cable at an angle (i.e. not perpendicular to the surface) it will not take a direct path to the end. The ray will definitely hit the internal interface between the core and the cladding. Our objective is to always keep the light only in the core and thus we need to ensure the light rays do not go out to the cladding. The only possibility to ensure this is to let the core with a higher refractive index and allow the total internal reflection for a larger amount of received light angles.

The important thing is that, not every light ray that is being launched into the fiber optic cable will undergo total internal reflection. To ensure this, there is an angle being defined as the acceptance angle, which states the maximum angle in which external light rays may strike the air/glass interface and still propagate down the fiber.



Pros and Cons of Optical Fiber Cables

Before moving forward, it is important for us to understand the essence of the previous section of this article. In very simple words, light-wave systems use glass or plastic fiber cables to contain and guide the light waves to reach the desired destination.
The major advantage of optical fiber cables is the greater information capacity when compared to the conventional transmission media like copper cable. Optical fibers have a wider bandwidth (up to several thousand gigahertzes) available at optical frequencies. As a result of this, now we have the ability to allow millions of individual voice and data channels to be sent over a single optical fiber cable.
Because optical fiber cables are nonconductors of electric current, the possibility of the natural interference problems (e.g. lightning) are rare and thus, hardly vulnerable to the crosstalk issue. Due to the same reason, these cables are immune to static interference as well.
The next biggest benefit is the very low amount of transmission losses uncovering in optical fiber cables. In fact, the present day optical fiber cables have only a few tenths of a decibel loss per kilometer. As a result, the distance between the signal regenerators are high and can reach for longer distances, which on the other hand reduce the cost as well. On a negative remark, the optical components incur huge investment costs at the beginning, and thus careful consideration needs to be paid when designing an optical fiber communication system. The cost is further increased because of the requirement of specialized tools, equipment and training to deal with the optical fiber cables. Also, the strength of the cables is questionable to a certain extent and losses could be induced even at the slightest bending of the cable.

Applications of Fiber Optics

Due to the very advantages qualities in light, its applications could be found on various fields. Light-wave systems have broadened the scope of helping to achieve tremendous targets which were not even imagined a few decades ago. Some of the popular applications are briefly described below but definitely not limited to this.

Fiber Optic Interconnects

This is a widely used application of optical communication. An interconnect is the physical connection of two or more fixtures through which communication happens. A broad range of interconnects are available such as simple, simplex patch cords to multi-channel distribution and backbone cables etc.

Networking

Nowadays, networking applications (Facebook, YouTube, twitter, etc) play an important role. Service providers and network operators face a huge challenge with the increasing bandwidth requirement,



and optical systems are a definite solution to expand and extend their networks. Trunk cables, distribution cables, high-density interconnect cables, and standard patch cords are just a few of the many types of products under this category.

Gigabit Ethernet

With the accelerated LAN traffic, gigabit Ethernet comes as a solution to increased data speed and more bandwidth expectations. Due to the immune nature for EMI (Electromagnetic Interference) and RFI (Radio Frequency Interference), fiber optics is a more flexible and suitable option for Gigabit and multi-wavelength transmission in both long and short distances.

In Harsh Environments

Due to their favorable properties, optical fibers could be used in extreme adverse/harsh environments such as conditions in which these products are exposed to extreme high/low temperatures, shock, vibration, radiation, corrosive conditions, high electromagnetic interference (EMI), high radio-frequency interference (RFI), and/or pressure extremes.

Military Applications

Due to the very precise nature of light, optics play a highly specialized role, and cater to specific requirements, and rigorous testing is done to ensure the reliability and performance in the field. Fiber optic technology is used for wide variety of air, sea, ground and space military applications.

Aerospace and Avionics

These applications too are customized to serve different kinds of purposes. As a results of deploying fiber optic technology in this field, sizes and weight requirements are reduced while increasing the performance and bandwidth.



Unmanned Aerial Vehicles (UAV)

This is a growing application for light-wave communication. Optical fiber is used as the primary communication mode between ground control and the antenna controlling the UAV due to its fast and efficient transmission of large amount data over long distances.

Data Storage Equipment

In this context, fiber optics provide the communication link between multiple devices on a network and/or part of a storage system. This connectivity offers very high bandwidth over longer distances, thus could be used for device-to-device connections with faster simultaneous information access even across different geographical locations.

Carrier Networks

These are also known to be the backbone networks, and are used to distribute very large amounts of bandwidth over longer distances. All communications and broadband services offered at the end residential, commercial or institutional level are offered through these. With the FTTx concept, fiber cables usage has enabled network operators to move for higher bandwidth and additional value added services. Through these methods, every household will get a direct fiber termination, thus enabling a high capacity access.



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Theme article : Light and Light based Technologies for Day to Day Life

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Light and Light based Technologies for Day to Day Life

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Since the year 2015 has been declared by the United Nationas as the International year of light, it is a good time to consider the role of light in our lives and in modern technologies. A short summary of the current situation and historical perspective is offered in the following paragraphs.

Light plays two major roles as a supplier of energy and a carrier of information. The energy aspect has led to the development of solar light capture. The mature and commercially viable technology is based on silicon semiconductor photovoltaic cells, which goes back to the time of the first journeys to the moon. It is only now that the scale of manufacturing has risen to the point that such cells are economical enough to be employed in domestic situations in some countries. Still, single crystalline silicon is not cheap to produce. First, quartz sand and coked coal have to be heated to around 2000° in an electric arc furnace. The impure silicon so obtained has to be purified to extremely high levels before it is drawn into a near-perfect single crystal, all of which requires large inputs of energy. Therefore there is ample room for other approaches.

Organic/inorganic dye sensitized photoelectrochemical cells containing nanoparticulate semiconductors such as titanium dioxide has grown as a competing technology over the last three decades. Once photoexcited, the dye can inject an electron into the titanium dioxide matrix which can be routed through an external load to a counter-electrode. In the meantime, the oxidized dye picks up an electron from a redox shuttle (usually iodine-iodide). Diffusion of the oxidized shuttle to the counter-electrode finds an electron waiting for it so that the electrical circuit can be completed. There is a Sri Lankan contribution to these dye sensitized photoelectrochemical cells from the pioneering work of Professor Kirthi Tennakone at the University of Sri Jayawardenapura, University of Ruhuna and the Institute of Fundamental Studies in Kandy. The last few years have seen the emergence of organic-inorganic perovskite-based solar cells (with or without titanium dioxide) which have the advantages of inexpensive solution-processing and rather high efficiencies but which still face concerns over long term stability and heavy metal content. Taken together, it seems quite probable that renewable energy without dependence on fossil fuels and without consequences for climate change can now come directly from the sun.





Most of us receive the bulk of information for living, through our eyes during the day. Our other senses play secondary roles. This

information reception continues during the early part of the night, thanks to artificial illumination. Flames, incandescent bulbs, fluorescent tubes and light emitting diodes have lit up the world around us at various periods of history and circumstance. Instead of simply illuminating objects, light can be employed within active devices to directly create images for our consumption. Photographic film, cathode ray tubes, xerographic media, liquid crystal displays, plasma devices and light emitting diodes have invaded our lives in the form of documents and screens of televisions, computer terminals, personal computers and smart mobile telephones. In more public places such as cinemas and streets, intense illumination sources such as arc lamps also play a role. Though less visible, the information carrying aspect of light is also vital to modern broadband data transmission since fibre optic networks are literally embedded in our societies. Each of the above points has given rise to a large number of major industries, worth many billions of dollars, servicing virtually the entire world.



There are other less visible light based technologies, sometimes serving in life or death situations everyday worldwide, which I would like to concentrate on in the remainder of this article. For instance, some medical diagnostic



systems depend on fluorescent molecules to measure and signal the number of various atoms and molecules that keep us alive. When we are not too well, the numbers of these components are altered. Signalling these altered numbers, say those of sodium ions in our blood, to a clinician allows disease diagnosis and treatment. Such signalling works on the basis that the designed molecules produce an emission intensity which is larger if they encounter a higher concentration of sodium ions. The serum is presented to these fluorescent molecules after passage through a micron filter so that the blood cells are removed. Light emitting diodes provide the necessary excitation energy. Corresponding applications in veterinary situations also exist. These have led to a small number of industries earning hundreds of millions of dollars.

The molecular photoscience underlying the above paragraph deserves to be outlined. The fluorescent molecules are constructed in three parts which are connected together. A fluorescent dye takes care of the interactions with light, whether it is the exciting light or the emitted fluorescence. A receptor deals with the capture and release of the sodium ion. A spacer unit joins the fluorescent dye and the receptor but keeps them apart at a small distance. When the exciting light is absorbed by the fluorescent dye, the energy ingested can be used to instigate a chemical process. Given the appropriate redox potentials, an electron is dug out from the receptor, transferred across the spacer unit and injected into the fluorescent dye. Thus the fluorescent dye is unable to give out any fluorescence light owing to the photoinduced electron transfer (PET) process. Such PET processes lie at the heart of green plant photosynthesis anyway. Thus in the absence of a sodium ion, the three-module fluorescent molecule is held in a dark or 'off' state. However, when the fluorescent molecule meets and captures a sodium ion in the receptor unit, the positively charged sodium ion electrostatically holds



back the electron from transferring to the fluorescent dye unit from the receptor. The shutting-down of the PET process allows the excitation energy to be emitted as fluorescence light. Therefore, in the presence of a sodium ion, the fluorescent molecule switches to an 'on' state. This is the light signal which we see.

The examples considered in the previous two paragraphs involve the fluorescent molecules being embedded in small transparent plastic chips which have millimetre scale channels along which samples of freshly drawn blood would flow. In addition to such *ex vivo* applications (which have easier passage through medical watchdog agencies during the accreditation process), there are new cases emerging where the fluorescent molecules are immobilized on the tips of optic fibres placed within a cannula in a vein, to allow continuous monitoring of the blood. Such monitoring can be really useful in intensive care units where a sudden deterioration of a patent's condition can be picked up and remedied urgently. The case of glucose monitoring has been particularly successful. Problems of white cell attack and subsequent covering up of the fibre tip, which stymied previous efforts along this line, appear to have been beaten by the use of new biocompatible hydrogel coatings.

However, molecules of nanometric size and suitable biocompatibility can even operate inside living cells (alone or within tissue sections) to signal the intracellular concentrations of various atoms and molecules. The fluorescence emission and the exciting light have no difficulty in connecting the intracellular world with our macroscopic domain, owing to the optical transparency of most cell components. Even though the requirement of fluorescence microscopes for these examinations limits their wide usage, the results obtained go to the heart of cellular behaviour. For example, the language of internal messengers inside cells (such as waves of calcium ions) provide the underpinning to many biotechnology industries worth billions of dollars. Here is a light based technology which opens a window on life processes at the cellular level in atomic or molecular detail.

There are even less visible light based science discoveries which await refinement and improvement to the point of societal impact. Commercial and political will also have their parts to play. Now there are fluorescent molecules which can perform computational operations. Though rudimentary by the standards of silicon semiconductor technology, these molecules possess the exclusive advantages of being small and biocompatible enough to operate within living cells (as mentioned in the previous paragraph). For instance, some of these molecules will emit a blue fluorescence signal only if they simultaneously meet protons and sodium ions at concentrations above certain thresholds, so that we have a Boolean AND gate operating with proton and sodium ion inputs and a fluorescence output. A power supply in the form of an ultraviolet light needs to be available. Since life related processes usually involve many synergies, such AND gates can directly detect important situations. For instance, higher than normal levels of sodium ions, potassium ions and protons occurring simultaneously might indicate a serious loss of electrolyte regulation such as what might arise from a failing kidney. A single 'high' fluorescence signal from a three-input AND gate would indicate this condition. Such a direct test could provide quick screening of large populations of people without the need for a medical doctor. However, only the patients yielding a positive test result can then be examined by a medical doctor so that false positives can be weeded

out and proper treatment given to those who need it. In such contexts, 'lab on a molecule' AND gates can save a doctor's time – a precious resource.

Another application of molecular logic based computation which exploits the small size of fluorescent molecules is to aid drug discovery programs. Many of these employ sub-millimetric plastic beads as carriers of the drug candidates. These beads need to be tagged so that their identity is known throughout the drug discovery and evaluation process. However these beads are too small to be tagged by semiconductor-based radiofrequency identification (RFID) chips, which would otherwise have been the obvious choice. Molecular computational identification (MCID) tags come to the rescue. Their fluorescence response pattern to a given set of chemical input commands provides an identity of sufficient diversity to tag a large population of plastic beads.

Certain types of these fluorescent



molecules are now able to perform some of the same computations that all of us do when we observe the world around us, such as detecting the edges of approaching objects so that we can quickly assess if they are friend or foe and then respond accordingly. In this instance, these molecules need to be spread out on a sheet of paper so that a graphical user interface is available, akin to a mouse driven computer screen or a phone touch screen. In this instance, the small size of the molecules means that huge numbers of these operate in a massively parallel fashion on a sheet of paper of centimetre dimensions in order to perform the large area computation.

Some of these fluorescent molecules are also able to perform some of the conscious information processing that we have done since childhood. An example is the creation of outline drawings from a template, just like a portrait artist sketches a person in front of him or her. However, the molecules do not draw the outline directly like an artist would. Rather, they first display a photograph, followed by a slight expansion of it. Finally, they erase the original photograph to leave the regions of slight expansion in the form of thin lines. While it is true that the molecular drawing algorithm is inefficient, it is remarkable that simple molecules can emulate a little piece of human behaviour. Of course, each of these designed fluorescent molecules can only perform one human computing operation, whereas we can perform many such operations repeatedly. Nevertheless, the gap between molecules and humans concerning information handling does not seem as wide as it was previously assumed. For the purposes of this article, it means that the combination of light and molecules can provide a wide gateway into light based technologies for human benefit.

The above paragraphs have summarized how deeply rooted light and light based phenomena are within our societies and ourselves on a day to day basis. It is no wonder then that societal impacts have emerged and will continue to emerge. These examples of light based science discoveries and technologies will only grow if bright young people join in this worldwide adventure and continue their participation into later life.

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Bharat Ratna 1997
Von Braun Award from NASA 2011
Death : July 27, 2015, Shillong, India

Quotes by Abdul kalam

1. Man needs his difficulties because they are necessary to enjoy success.

2. Look at the sky. We are not alone. The whole universe is friendly to us and conspires only to give the best to those who dream and work.

3. You have to dream before your dreams can come true.

4. To succeed in your mission, you must have single-minded devotion to your goal.

5. Great dreams of great dreamers are always transcended.

6. If a country is to be corruption free and become a nation of beautiful minds, I strongly feel there are three key societal members who can make a difference. They are the father, the mother and the teacher.

7. My message, especially to young people is to have courage to think differently, courage to invent, to travel the unexplored path, courage to discover the impossible and to conquer the problems and succeed. These are great qualities that they must work towards. This is my message to the young people.

8. Let us sacrifice our today so that our children can have a better tomorrow.

9. You see, God helps only people who work hard. That principle is very clear.

10. God, our Creator, has stored within our minds and personalities, great potential strength and ability. Prayer helps us tap and develop these powers.

11. Excellence is a continuous process and not an accident.



12. One of the very important characteristics of a student is to question. Let the students ask questions.

13. Let me define a leader. He must

have vision and passion and not be afraid of any problem. Instead, he should know how to defeat it. Most importantly, he must work with integrity.

14. Tell me, why is the media here so negative? Why are we in India so embarrassed to recognise our own strengths, our achievements? We are such a great nation. We have so many amazing success stories but we refuse to acknowledge them. Why?

15. We should not give up and we should not allow the problem to defeat us.

16. Climbing to the top demands strength, whether it is to the top of Mount Everest or to the top of your career. The youth need to be enabled to become job generators from job seekers.



17. Creativity is the key to success in the future, and primary education is where teachers can bring creativity in children at that level.

18. When we tackle obstacles, we find hidden reserves of courage and resilience we did not know we had. And it is only when we are faced with failure do we realise that these resources were always there within us. We only need to find them and move on with our lives.

19. Economy forced me to become a vegetarian, but I finally starting liking it.

20. The bird is powered by its own life and by its motivation.

21. The world has today 546 nuclear plants generating electricity. Their experience is being continuously researched, and feedback should be provided to all.

22. Those who cannot work with their hearts achieve but a hollow, half-hearted success that breeds bitterness all around.

23. Almost half of the population of the world lives in rural regions and mostly in a state of poverty. Such inequalities in human development have been one of the primary reasons for unrest and, in some parts of the world, even violence.

24. No religion has mandated killing others as a requirement for its sustenance or promotion.

25. When grand plans for scientific and defence technologies are made, do the people in power think about the sacrifices the people in the laboratories and fields have to make?

26. In a democracy, the well-being, individuality and happiness of every citizen is important for the overall prosperity, peace and happiness of the nation.

27. Writing is my love. If you love something, you find a lot of time. I write for two hours a day, usually starting at midnight; at times, I start at 11.

28. I was willing to accept what I couldn't change.

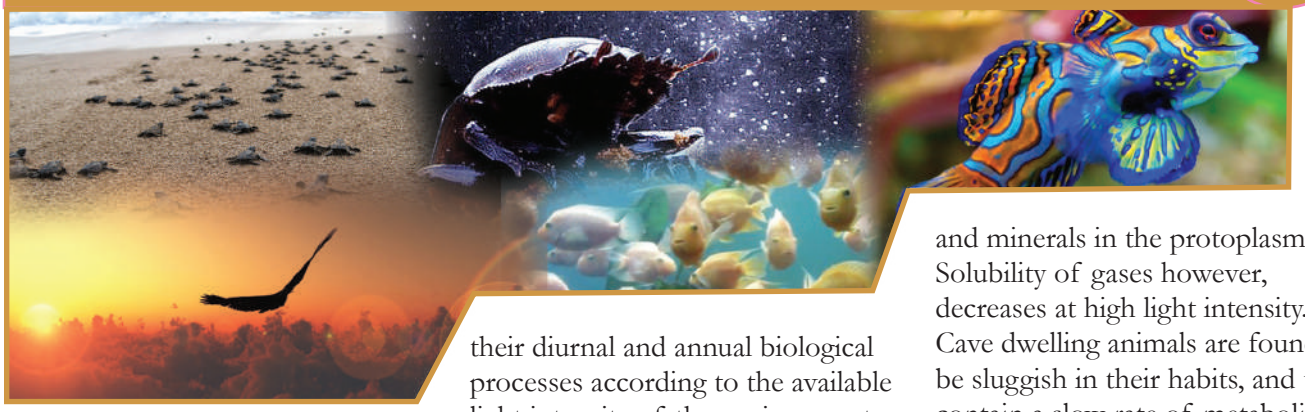
29. Unless India stands up to the world, no one will respect us. In this world, fear has no place. Only strength respects strength.

30. India can live without nuclear weapons. That's our dream, and it should be the dream of the U.S. also.

Mr Thusitha Malalasekara

Impact of Light on life on Earth

Dr Jayantha Wattavidanage



The word "Light' naturally reminds the Sun. Most of the ancient civilizations venerated the sun as a God. The very reason was that they knew that the existence of life on earth depends on energy provided by the sun. In Buddhist philosophy light symbolizes wisdom. Thus, let us explore the impact of light on living beings on our planet.

When we analyze carefully, it is obvious that whatever we eat, was originally produced by green plants or algae with chlorophyll and phytocrome pigments through the process called Photosynthesis using simple inorganic compounds like carbon dioxide and water, as well as light energy received from the sun. All the other heterotrophic organisms live on the food material produced by those autotrophic plants and algae. Therefore, the sole energy source for creating, propagating and maintaining life on earth is the sun. However, it has been reported that a small minority of organisms that live in deep trenches of the ocean depend on the food produced by chemosynthetic bacteria that live in the bottom of the ocean.

All organisms other than the ones that live in deep dark caves, and the bottom of the ocean, have adjusted their diurnal and annual biological processes according to the available light intensity of the environment. The bodies of most animals like mammals, birds and reptiles remain protected by some sort of body covering which save animal tissues from the lethal effects of solar radiations. However, sun rays penetrate such covers of lower animals such as micro organisms and planktonic communities and cause excitation, activation, ionization and heating of protoplasm of different body cells.



Ultraviolet rays are known to cause mutational changes in the DNA of various organisms.

The metabolic rate of different animals is greatly influenced by light. The increased intensity of light results in an increase in enzyme activity, general metabolic rate and the solubility of salts and minerals in the protoplasm. Solubility of gases however, decreases at high light intensity. Cave dwelling animals are found to be sluggish in their habits, and to contain a slow rate of metabolism. We all have experienced the tanning of our skin when it is exposed longer to direct sun light. Light influences pigmentation in animals. Cave animals lack skin pigments. If they are kept out of darkness for a long time, they regain skin pigmentation. The darkly pigmented skin of human inhabitants of the tropics also indicate the effect of sunlight on skin pigmentation. The skin pigment's synthesis is dependent on the sunlight. It seems that sunlight has a major impact not only biologically, but also sociologically, dividing the human race as white and the coloured.

Light also determines the characteristic patterns of pigments of different animals which serve the animals in sexual dimorphism and protective colouration. Animals that dwell in the depths of the ocean where the environment is monotone, and though pigmented, do not show patterns in their colouration.

The influence of light on the

movement of animals is evident in lower animals. Oriented locomotory movements towards and away from a source of light is called phototaxis. Positively phototactic animals such as Euglena, Ranatra, etc., move towards the source of light, while negatively phototactic animals such as planarians, earthworms, slugs, cope- podes etc., move away from the source of light.

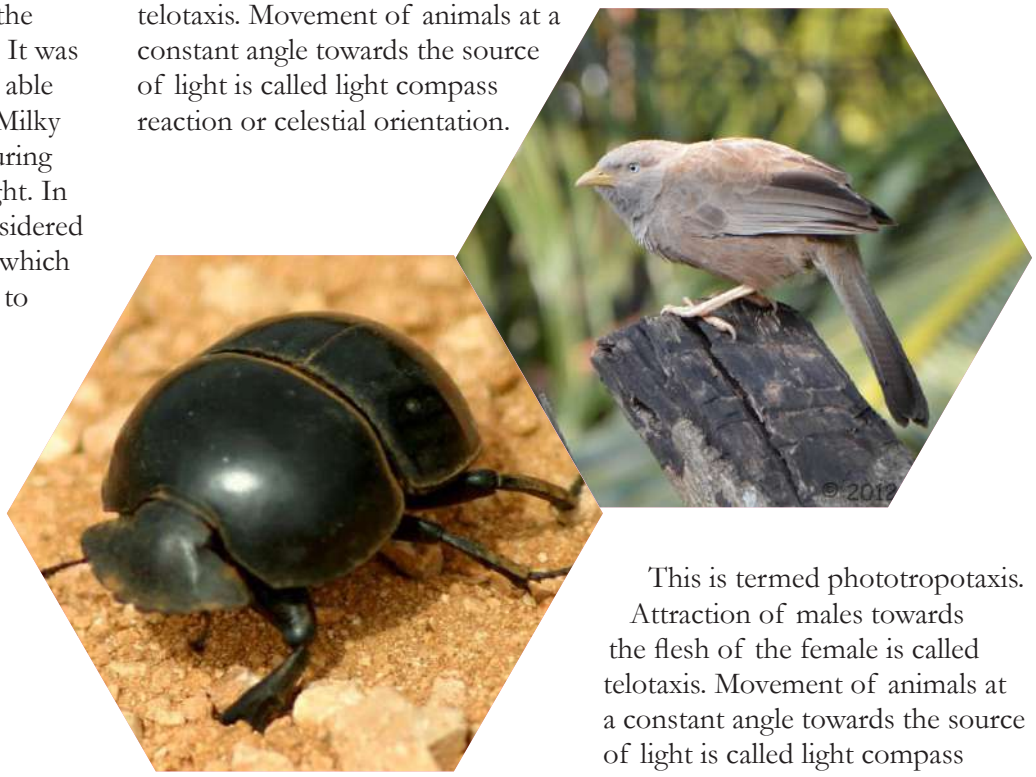
Very recent experiments using African Dung Beetles have revealed very interesting findings on the impact of light on movements of animals. It was found that the Dung beetles find the direction using the polarization pattern of the moonlight during the night. It was also revealed that they were able to use the pale light of the Milky Way to find the direction during the nights without moon light. In fact, the Dung beetle is considered as the first reported animal which uses light of the Milky Way to find the destination.

The light directed growth mechanisms are called phototropisms which occur in sessile animals. Phototropisms also include responsive movement of some body parts of some active animal to the light stimulus, such as the movement of flagellum of Euglena towards light and movements of polyps of many coelenterates.

The velocity or speed of the movement of certain animals is also regulated by light. It has been observed that animals when responding to light reduce their velocity of movement and these movements which are non-directional are called photokinesis. Photokinesis may be a change in linear velocity (rheokinesis) or in the direction of turning (klinokinesis).

During photokinesis when only a part of the body of an animal deviates always from the source of light, the reaction is termed photoklinokinesls. Larvae of *Musca domestica* show such movements.

When animals are confronted with two sources of light of equal brightness they move towards or away to a position that is the distance between the two lights. This is termed phototropotaxis. Attraction of males towards the flesh of the female is called telotaxis. Movement of animals at a constant angle towards the source of light is called light compass reaction or celestial orientation.



Some organisms, particularly arthropods, birds and fish, utilize their time sense as an aid to find their way from one area to another. To orient themselves, the animals use the sun, moon, or stars as a compass. To do this, they utilize both their biological clock and observations on the azimuthal position of the sun in relation to an established direction. The azimuth is the angle between a fixed line on the earth's surface and a projection of the sun's direction on the surface.

Using the sun as a reference point involves some problems for animals because the sun moves. The target angle changes throughout the day. But animals which use the sun as a reference, correct their orientation somehow. Such celestial orientation has been observed in fishes, turtles, lizards, most birds, and such invertebrates as ants, bees, wolf spiders and sand hoppers.

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Regularly occurring daily cycles of Light (day; and darkness (night) have been known to exert a profound influence on the behaviour and metabolism of many organisms. Underlying such environmental rhythms of light and darkness are the movements of the earth relative to the sun and the moon.

The earth's rotation on its axis results in alternation of night and day. The tilt of the earth's axis, along with the annual revolution around the sun produces the seasons. The response of different organisms to environmental rhythms of light and darkness is termed photoperiodism. Each daily cycle inclusive of a period of illumination followed by a period of darkness is called the photo-period.

The term photophase and scatophase are sometimes used to denote the period of light and the period of darkness respectively. Different animals have evolved different morphological, physiological, behavioural and ecological adaptations during the course of their evolution to varying photoperiods, which provide them with environmental information regarding the intensities of natural light.

Life evolved under the influence of daily and seasonal environmental changes, so it is natural that plants and animals would have some rhythms or pattern to their lives that would synchronize them with fluctuations in the environment. For years biologists have been intrigued over the means by which organisms kept their activities in rhythm with the 24 hours day, including such phenomena as the daily pattern of leaf and petal movement in plants, the sleep and wakefulness of animals and the emergence of insects from pupal cases

At one time biologists thought that these rhythmicities were entirely exogenous, that is, the organisms responded only to external stimuli such as light intensity, humidity, temperature and tides. But now it is well investigated that most animals possess internal or endogenous rhythms in synchrony with the external or exogenous rhythms of the environment, due to which they retain the ability to measure the length of day.

The internal or endogenous rhythms are approximately of 24 hours duration, while the exogenous or environmental rhythms are exactly of 24 hours duration. The term circadian (derived from the Latin words circa, about, and dies, daily) has been used to denote these daily rhythms. The period of circadian rhythm, the number of hours from the beginning of activity of one day, to the beginning of activity on the next day, is called free running. Photoperiod plays a role in providing time signals, for adjustments of the animals concerned to these daily rhythms. Circadian rhythms apparently are internally driven or are endogenous, and are affected little by temperature changes, though insensitive to a great variety of chemical inhibitors, and are innate, not learned from or imprinted upon the organisms by the environment.

The innate character of circadian rhythm is demonstrated by several animals. When Drosophila are kept under constant conditions from the larval stage, they will still emerge from pupae with a regular circadian rhythm. Eggs of chicken and lizards kept under constant conditions produce animals that later show regular circadian cycle. The circadian rhythms have been observed in zooplanktons, polychaete annelids, many insects (Lepidoptera, Diptera, Hymenoptera, Neuroptera, Coleopteta, Orthoptera, Odonata, etc.), most birds, and certain mammals.

Planktons of sea and lakes provide very interesting instances of circadian rhythms by showing diurnal changes in their vertical distribution. For example, numerous copepods and zooplanktons tend to swim toward the surface at night, and move downwards to deeper layers during the day (see Clarke, 1954).

Impact of light on reproduction of organisms is another interesting area to study. In many animals (e.g., birds) light is necessary for the activation of gonads and in initiating annual breeding activities. The gonads of birds are found to become active with increased illumination during summer, and to regress during shorter periods of illumination in winter.

Light in some cases (e.g., Salmon


Piranha fish

larvae) accelerates development, whereas in other cases (e.g., Mytilus larvae) it retards .

Further, occasionally the output of sunlight is increased by the development of sunspots. As a result of this excess energy is radiated to space and this naturally increases the output of solar energy near the earth. A direct consequence of this is the greater evaporation of water which results in cloud formation to prevent more exposure to sunshine, and thus to equalize temperature and modifying climate.

It can be defined as a biological rhythm in which the maxima and minima appear once or twice in every lunar month at the same time. If the rhythm occurs once in 15 days (14-77 days) it is called as semilunar if it occurs once in 30 days it is called lunar. The lunar cycle or periodicity controls many living activities. For example, marine algae, Dictyota, produces its garnets at the time of full-moon springtide. The spawning of fish, *Leuresthes tenuis* follows a semilunal cycle. Certain poly- chaete worms also exhibit lunar periodicity.

How different organisms see the world?

We see the world with the help of the light. We see all colour patterns and shapes only when the light intensity is high. All the greenery we see in the day time turn to gray and black with the onset of night. We know that most of the animals found in our environment have eyes. Do they see the same world as we see?

Insets like butterflies and flies and crustetians like shrimps have complex eyes and consist of large number of units. Image they see is a mosaic one formed by merging large number of sub images.

Some animals see wide range of colours and sensitive colour contrast. Although we have three different types of corns in the retina of our eye for colour vision, birds have five types of corns providing sensitivity to wider range of colours. Pray birds such as eagles and hawks have sharp eyes with eight times higher resolution than the human eye. This facilitates them to see even a small rat on the ground clearly when they are gliding in the sky.

In general, nocturnal animals have relatively larger eyes to obtain maximum light. In addition to the larger size, they have a special layer inside the eye which can reflect light like a mirror to facilitate night vision. Eyes of most herbivorous animals such as cattle, sheep, deer, rabbits etc. are located on either side of the head facilitating wide angle vision. That also helps them to escape from predators. However, eyes of predators and arboreal Primates are located on the front surface of the face restricting the vision to relatively a narrow angle. They can get two images of the same object in slightly different angles, and this is known as binocular vision. Brain can analyze those two images to estimate the distance from the object to eye giving an idea about the depth. This ability is known as three dimensional vision (3D vision). This special ability helps predators to catch a prey, and for arboreal Primates to jump from one branch to another branch accurately.



The visible spectrum is the portion of the electromagnetic spectrum that is visible to the human eye. Electromagnetic radiation in this range of wavelengths is called visible light or simply light. A typical human eye will respond to wavelengths from about 390 to 700 nm. Most of the animals are not sensitive to all the colours of the visible spectrum as human beings do. In other words, they do not have colour vision as we do. As an example, dogs do not have colour vision, and they see the world as grey shades. However, eyes of some animals are sensitive to areas of the electromagnetic spectrum outside the visible range. Bees are sensitive to UV. The well-known carnivorous fish Piranha which is indigenous to South America is sensitive to IR radiation. With this special ability Piranha can recognize a fish or a mammal even in highly turbid waters by detecting IR emitted from those animals.

While most of the animals are sensitive to light, some animals can generate and emit the light.

On the other hand, all of us emit IR while some produce visible light. This phenomenon is known as bioluminescence. Fireflies, glowworms and animals that live in deep sea emit light as a result of a chemical reaction or with the help of the bacteria. This light is used



for a variety of needs such as intra species communication, finding a pray, and for repeing predators. It has been reported that the colour of the emitting light is associated with the evolutionary period that those animals were evolved. Although we as human beings artificially illuminate the night, it has badly affected the lives of another group of animals. Organisms evolved on earth during last few billion years have adjusted and synchronized their physiological and behevioural processes according to the diurnal and annual light and dark rhythm. Scientists believe that the overlapping nature of their physiological rhythm on varying light intensity has even been written on their genetic material; DNA. Organisms living on this planet have adjusted all their physiological processes such as reproduction, nutrition, resting, sleeping, prevention from predators etc. according to the natural rhythm of varying light intensity. However, we have increased the light intensity of the night in some areas of the planet almost as similar to day time with the help of science and technology. However, this disturbance made to the day- night rhythm has badly influenced the lives of other animals. All nocturnal animals sleep during the day time and activate with the onset of the darkness. High light intensity during the night has badly disturbed the physiological rhythm of these nocturnal animals. While some predators spot their pray with the help of light, pray animals escape from predators hiding in the darkness.

It has been calculated that the overcast night sky of modern cities has thousand time higher illumination than the night sky of 200 years back. It has been observed that there were no frog and toad calls which they use for their reproductive process during the nights with illuminated night sky. According to that situation the amphibian populations are facing threat of extinction due to bad impacts of artificial lights on their reproductive process.
We know that sea turtles come to the beach for laying eggs. After hatching those eggs, hatchlings immerging from the eggs should go to the sea as soon as possible for their survival. They find the direction of the sea with the help of the light of the dawn that come from the horizon. If the area is illuminated with artificial lights, these hatchlings get confused in finding the direction to the sea which could lead to death. Migratory birds which use sunlight, moonlight and star patterns for finding their routes are also badly affected by artificial lights. Few millions of birds die every year colliding with artificially illuminated buildings. Success of suvival of migratory birds depends on the completion of the reproductive processes on time at the targeted destination. We are aware that a large number of insect die every second while flying towards light. Although, we have illuminated nights for our benefit, unknowingly we are darkening lives of many other animals.
Considering all what has been mentioned above, it is crystal clear that although light has enormous positive impact on the life on earth, darkness too plays an important role for the wellbeing of the lives of plants and animals.



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Role of Light in Agriculture

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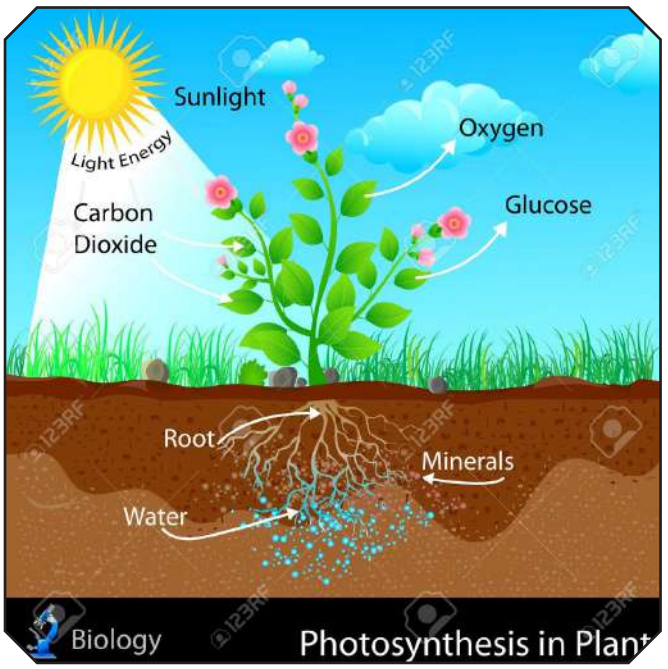
Role of Light in Agriculture

Light provided by the sun, called solar radiation, is the principal source of energy for all life on earth. Plants as the primary producers absorb solar radiation energy via chlorophyll in leaves and store part of it in the chemical bonds of glucose during the process of photosynthesis. Glucose acts as the 'raw material' to synthesize a wide range of biochemical substances which make up plant biomass. Agriculture involves the cultivation of a selected range of plant species for obtaining an economically-important product, which can be human food or beverage, animal feed, industrial products (e.g. cotton fibre, rubber etc.), bioenergy or stimulants (e.g. tobacco). As all products of Agriculture are synthesized within plants using glucose as the raw material, light energy captured during photosynthesis directly influences the agricultural productivity (i.e. amount of product per unit land area).

Many ancient civilizations worshipped the sun in their religious and cultural rituals as they realized its critical role in providing light to sustain their lives. For example, the Sinhala and Hindu New Year festival, which coincides with a period in which the sun is directly over Sri Lanka and which falls after collecting the harvest of agricultural crops during the major cultivation season, can be considered as an expression of peoples' gratitude to the sun, and rejoice in the sunny period that it provides. Interestingly, festivities during the Christmas which includes extensive lighting of towns, streets and homes, can also be regarded as peoples' appreciation of the importance of light as Christmas falls during the period when the solar radiation levels are lowest in the temperate zone of the Northern hemisphere.



As in the ancient past, light is no less important during the present times, especially in agriculture, which has to provide food for an increasing global population that is expected to exceed 10 billion before the end of this century. Different properties of light play different roles in Agriculture. Therefore, it is important to first understand the different characteristics of light.

Different characteristics of light: Wave-length distribution

Light is a mixture of wavelengths ranging from 300 to 100,000 nm. Different 'types of light' can be identified based on its wavelength as: Ultra-violet (UV) radiation (300 – 400 nm); Photosynthetically-active radiation (PAR) (400 – 700 nm) and Infra-red (IR) (700 – 100,000 nm). Light within the PAR range, which contains ca. 46-47% of the total energy of solar radiation, is the most important, as only these wavelengths can

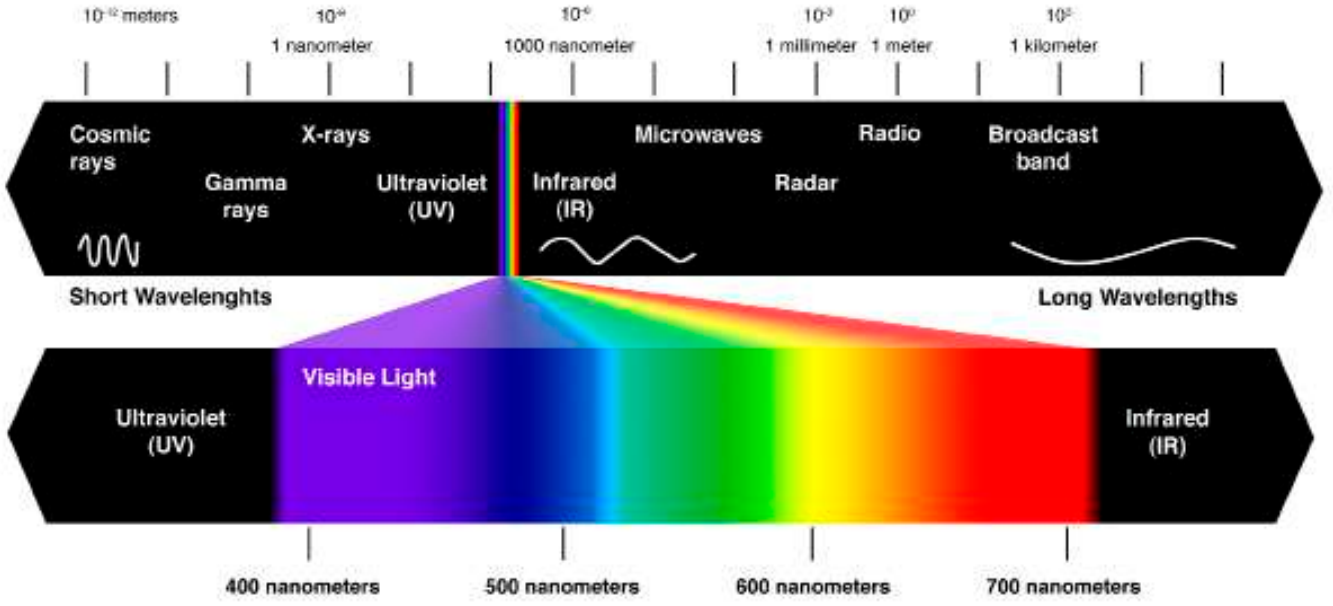
provide energy for photosynthesis and contribute directly to the productivity of agricultural crops. Light in the IR range, which contains ca. 45% of total solar radiation energy, also carries out essential functions in plants by providing energy for transpiration and maintenance of plant tissue temperatures within a range favourable for cellular physiological processes.

Energy content in light

The energy in light is responsible for some of its most important functions in plants. As energy for photosynthesis in agricultural crops is provided by solar radiation, crops growing in sunny environments give higher yields than those in shaded or cloudy environments, when their growth is not limited by water availability. For example, in the major irrigation schemes in the dry zone of Sri Lanka, rice yields are higher in yala (May – August) than in maha (November – February), primarily because of the higher incident radiation levels and lower cloudiness during yala. Similarly, when adequate water and nutrients are provided, a longer duration crop variety (e.g. a 4-month rice variety) produces a higher yield than a shorter duration variety (e.g. a 3-month rice variety). This is because the 4-month variety captures a greater amount of light energy and thereby produces a greater biomass and yield through photosynthesis than the 3-month variety.

The energy content of solar radiation (i.e. light intensity), also controls the vital plant process of transpiration by providing the latent heat energy for conversion of liquid water in leaf cells to water vapour, which then escapes to the external environment through the stomata. Transpiration provides a mechanism to remove the enormous amount of energy that the plant leaves are forced to absorb when they intercept solar radiation to obtain energy for photosynthesis. As such transpiration plays a vital role in thermal regulation enabling plants to maintain their tissue temperatures within a favourable range. During dry periods when plants have to restrict transpiration by partially closing the stomata, leaf temperatures increase because of the accumulation of radiation energy on leaf tissue.

While the energy of light is essential for the vital process of photosynthesis, the high energy levels of solar radiation can be a problem to plants during certain times. For example, during dry periods, photosynthesis is restricted because partial stomatal closure reduces carbon dioxide absorption. However, light absorption cannot be restricted as the leaves are exposed to light during the daytime. In such situations, the excess light energy that accumulates in leaf tissue damages the chloroplasts, thus causing a drastic reduction in photosynthesis. This phenomenon is called photoinhibition. Therefore, in order to produce high yields, crops need mechanisms to prevent photoinhibition. These are called photoprotection

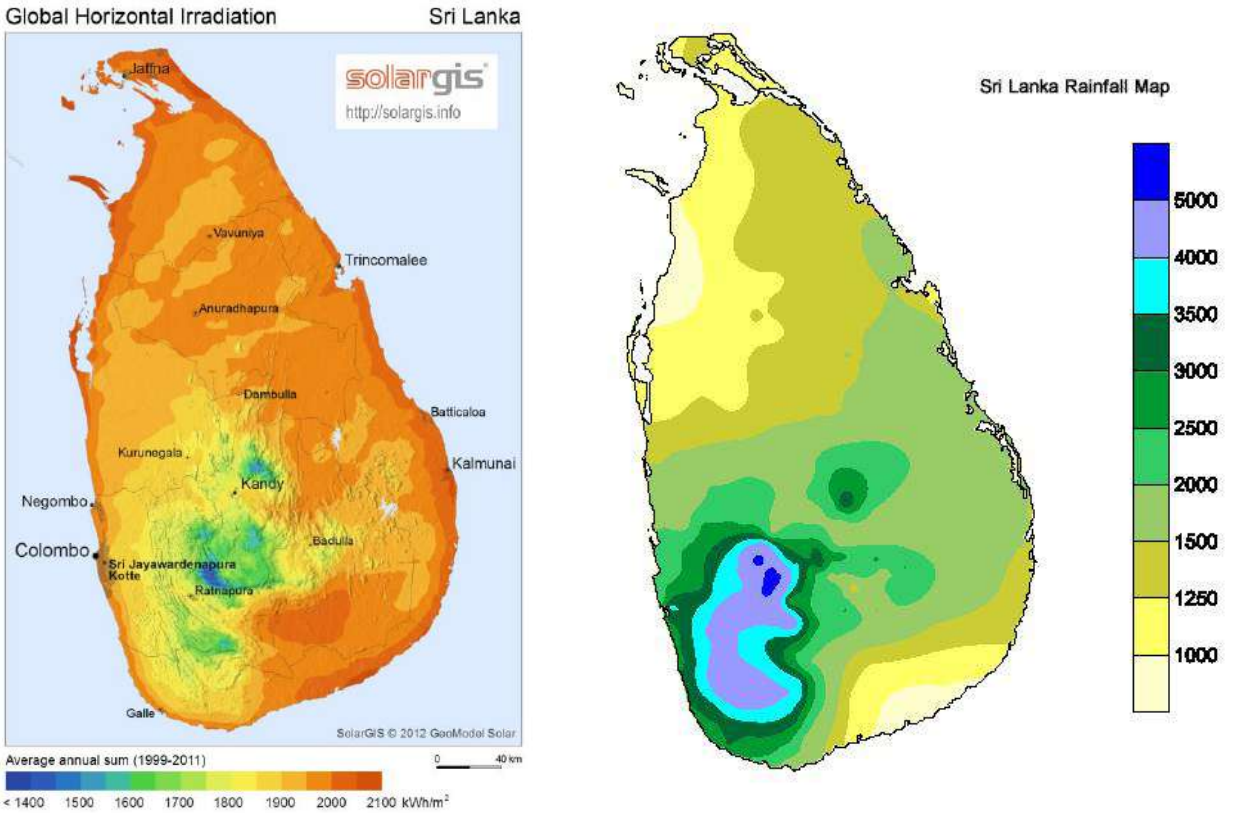


mechanisms. Xanthophyll, a pigment present in most plant leaves, and certain enzyme systems play vital roles in photoprotection. Interestingly, certain crops lack mechanisms of photoprotection and are thus highly vulnerable to photoinhibition. In order to obtain high yields, such crops have to be grown under shade. Our principal export crop, tea (Camellia sinensis) is an example of such a crop.

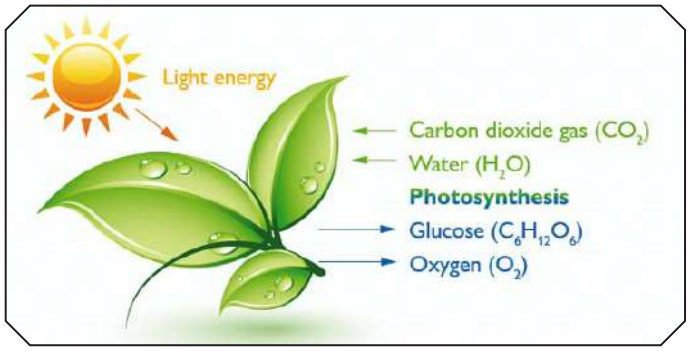
Photoperiod and photoperiodism

Photoperiod is the length of light period during a day. It is the time period between sunrise and sunset and is also termed the daylength. It is another characteristic of light, which plays a vital role in agriculture. In the tropical climatic zone, which is the area demarcated by latitudes of 23 ½° North (Tropic of Capricorn) and 23 ½° South (Tropic of Cancer), the photoperiod is around 12 hours and it does not vary substantially at different times of the year. However, in the temperate climatic zone, which is the area north and south of the tropical zone, the photoperiod fluctuates substantially within the year. Here, photoperiod can be as long as 18 hours during certain times of the year (summer) or as short as 5 hours during certain other times (winter). This variation in photoperiod has a profound influence on agriculture in the temperate zone as crops can be grown in the field only during periods of longer photoperiod. Crops cannot be grown during the winter because the shorter photoperiods do not provide enough radiation energy to support photosynthesis and crop growth. In contrast, crops can be grown throughout the year in the tropical zone, provided there is enough water, as 12 hours of photoperiod is sufficient to provide light energy for photosynthesis.

In addition to its role in determining the periods in which crops can be grown, photoperiod has a profound influence on flowering, which is essential for producing an economic yield in a large majority of agricultural crops. In most crop varieties, the timing of flower initiation is controlled by the photoperiod experienced during the vegetative phase (i.e. the period from germination to the initiation of the first flower). This phenomenon is called *photoperiodism* and crop varieties that show photoperiodism are called *photoperiod-sensitive* varieties. Most crop varieties that are adapted to grow in the tropical zone induce flowering when exposed to shorter photoperiods (usually shorter than 12 hours). A good example is



Maps showing the variation of annual solar radiation intensity (left) and annual rainfall in mm (right) in Sri Lanka



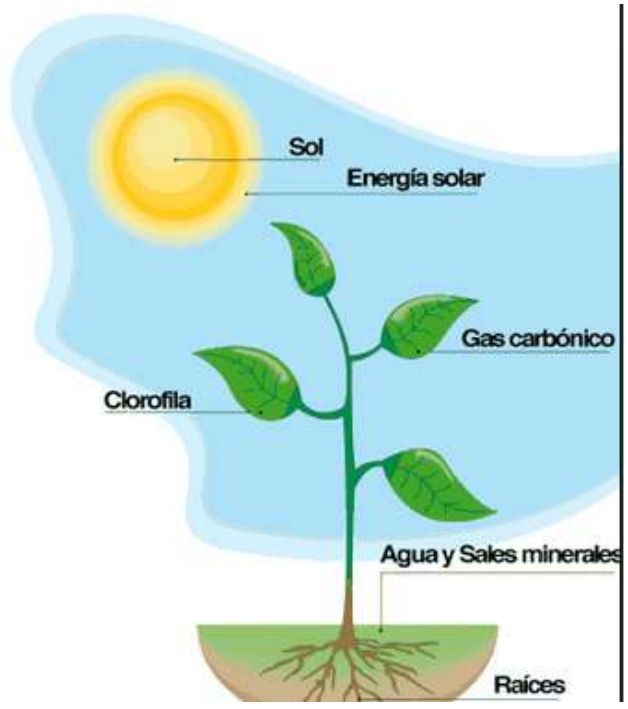
the traditional rice varieties in Sri Lanka, most of which produce panicles only during the *maha* season when the photoperiods are less than 12 hours. Such varieties are called *short-day plants*. In contrast, most crop varieties that are grown in the temperate zone induce flowering only when they experience longer photoperiods (usually longer than 12 hours) during the summer (long-day plants). Here, photoperiodism has evolved as a mechanism to prevent flowering during the shorter photoperiods of the winter when the conditions are extremely unfavourable for producing a high yield in a temperate crop. Similarly, evolution has determined that tropical crops are short-day plants as having a long-day response would make it impossible for them to flower during the shorter photoperiods of the tropical zone. Interestingly, photoperiod sensitivity prevents flower initiation of deep-water rice varieties grown in flood-prone countries such as Bangladesh during the flooding that occurs during periods of longer photoperiods in June-August. Flowering is initiated during the shorter photoperiods experienced during the subsequent period when the flood waters have receded.

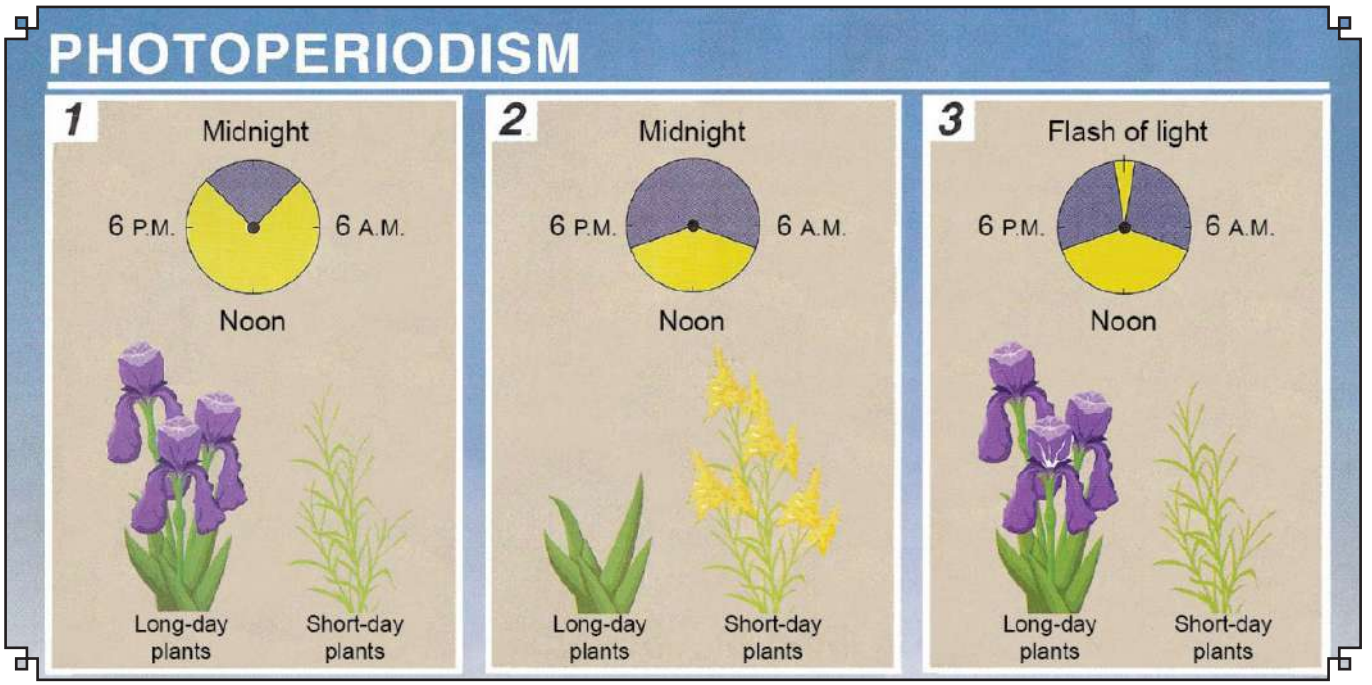
Despite its evolutionary significance in ensuring survival of the crop by inducing flowers during the most favourable periods, photoperiodism is regarded as a hindrance in modern agriculture. This is because photoperiod-sensitive crop varieties can be grown only during certain times of the year which fits-in with their specific photoperiod requirement. Therefore, most modern high-yielding varieties of the major crops have been bred to be photoperiod-insensitive (also called *day-neutral*). In these varieties, flowering is not sensitive to variations in photoperiod, thus enabling them to be grown at any time during the year, if other resources such as water are available and environmental conditions such as temperature are favourable.

Detailed experiments on photoperiodism have shown that it is controlled by *Phytochrome*, a pigment present in the leaves. These experiments have also shown that it is really the length of the night period, rather than the length of the daylight period, that controls the photoperiodic response. Therefore, short-day plants require night periods longer than 12 hours for flower induction while the long-day plants require shorter night periods for flowering.

Role of photoperiod and solar radiation intensity in determining agricultural productivity in the tropical and temperate zones

Crops grown in the temperate zone produce substantially higher yields in comparison to crops in the tropical zone. For example, rice crops in temperate climates such as Japan, Korea and China produce grain yields up to 15 tons per hectare while yields of rice crops in tropical climates (e.g. Sri Lanka, India, Thailand, The Philippines etc.) do not exceed 8 - 10 tons per hectare even when grown with adequate water, nutrients and protection from pests and diseases. This yield superiority of temperate crops is brought about by the longer photoperiods during the growing season (spring and summer) of the temperate zone, which enable greater photosynthesis and biomass production in comparison to the relatively shorter photoperiods in the tropical zone.





Interestingly, daily total solar radiation levels during the growing seasons are approximately similar in the tropical and temperate zones. However, in the tropical zone, the daily total energy of solar radiation is distributed over a shorter photoperiod with high radiation intensities during the middle part of the day. Photosynthesis of crops having the C3 pathway reaches its maximum rate at irradiance levels which are about 50% of maximum radiation intensity during the mid-day in a tropical climate. Therefore, a significant amount of light energy is wasted during the middle period of the day in a tropical climate because the radiation intensity is higher than the maximum intensity that is required to achieve maximum photosynthesis. This is called *light saturation*. In contrast, in the temperate zone, the daily total energy of solar radiation is distributed over a longer photoperiod, thus avoiding high radiation intensities during the middle hours of the day. This minimizes the wastage of light energy through light saturation, and ensures that a high proportion of solar radiation energy is used for photosynthesis, thus enabling achievement of the substantially higher crop yields of the temperate crops.

Variation of light intensities received in different parts of Sri Lanka

The examples described above highlight the importance of properly harnessing the energy of solar radiation in agriculture to achieve high yields. Thus, it is important to know the levels of light energy received in different regions of Sri Lanka.

The solar radiation map of Sri Lanka shows that the radiation intensities are highest in the dry zone, especially in the north-western, northern and eastern coastal belts. The radiation levels are lowest in the central highlands while they are generally lower in the wet zone in comparison to the dry zone. Interestingly, comparison of the solar radiation and rainfall maps of Sri Lanka show that solar radiation intensities are lower in regions of higher rainfall (e.g. wet zone). In contrast, radiation intensities are higher in regions of low rainfall. This creates a dilemma and a challenge for Sri Lankan agriculture as both solar radiation and rainfall are essential resources for increasing agricultural production. Accordingly, a proper balance between these two resources has to be achieved to maximize agricultural production and productivity in Sri Lanka.



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Light and Light based Technologies used in Medicine

Dr Anjula De Silva



Light and light based technologies used in medicine

Introduction

Light from the sun is the main energy source for the planet earth. Humans as a part of the earth get energy from plants and animals in terms of food which are nourished by the energy of light. When our body dysfunctions (i.e. when we contract a disease), the energy distribution in our cells and related chemical bonds become abnormal. Some of these abnormalities can be corrected by applying controlled dosages of energy in terms of light. Light can be used as a therapeutic tool and a diagnostic tool. Also light can be used in its normal form or after augmentation such as in laser. This article describes specific applications of such uses of light in medicine.



Phototherapy is the term used for the application of light in its normal form for therapeutic purposes. This includes areas such as neonatal care, dermatology and for mental and sleep related disorders.

Neonatal jaundice



Applying blue light in the wavelength range of 420-480 nm is a well-established technique to treat neonatal jaundice where energy in the blue light is capable of converting excess toxic bilirubin in the blood to a form which can be removed from the body through urine and feces.

Dermatology

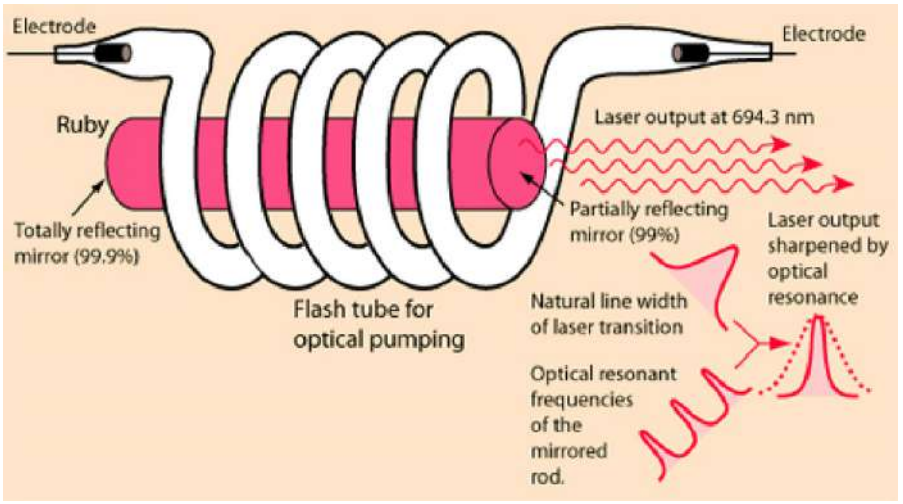
Light in dermatological treatments are used to slow down the cell growth and inflammation that causes skin abnormalities. Dermatologically, narrow band UVA (320-400 nm) and UVB (290-320 nm) light is used to treat psoriasis, vitiligo and other inflammatory skin disorders. Photodynamic therapy is a highly effective cosmetic skin treatment which enhances the appearance of skin. It uses a photosensitiser which is applied on to the sun-damaged or discoloured skin area and expose to light of specific wavelength (blue or red). This combination generates free radicals and highly reactive singlet oxygen which leads to a sunburn like effect that exfoliates the superficial damaged layers of skin. Apart from cosmetic purposes, blue light photodynamic therapy is used to treat acne by reducing bacteria in the skin and to remove melanoma cells which contributes to skin cancer.

Mental disorders

Light therapy is a promising treatment method for seasonal/ non-seasonal depression, insomnia and dementia where the patient is expected to sit or work near a light box emitting bright white light.

Laser

Compared to the therapeutic applications of light in normal form, augmented light has a wider scope. Among many light augmentation methods, laser (light amplification by stimulated



emission of radiation) light help treating patient across most medical disciplines, including dermatology, dentistry, cardiology, neurosurgery and eye surgery. A laser device effectively makes atoms in a crystal pump out photons (light particles) all at once so that they line up to form a really concentrated light beam. The flash tube around the crystal flashes and supply photon energy to the atoms, which electrons of the crystal absorbs and move to a higher energy state. The instability at this level return these electrons back to a lower energy state radiating the photon energy in terms of light. When this photon hits an already excited atom, it will radiate two photons of light giving rise to an amplification of light by stimulation. A mirror at one end of the crystal keeps the photons bouncing within the crystal and a partial mirror at the other end let some escape outside which we see as a very concentrated beam of powerful laser light which bounces some photons back into the crystal.

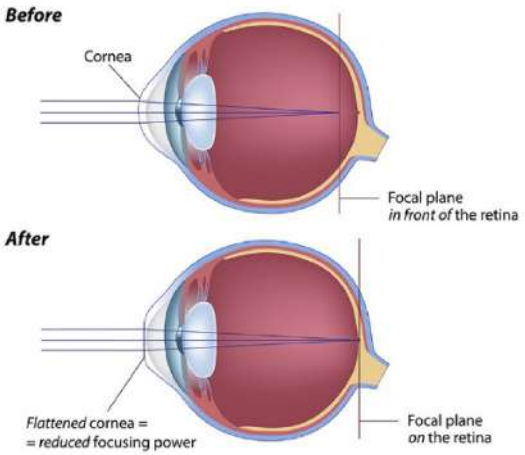
Angioplasty

Laser angioplasty is a technique used to open coronary arteries blocked by plaque. In this procedure, a catheter is inserted into an artery, then moved towards the blockage; once there, a laser at the tip of the tube sends pulsating beams of light to vaporize the plaque.

Cancer treatment and surgery

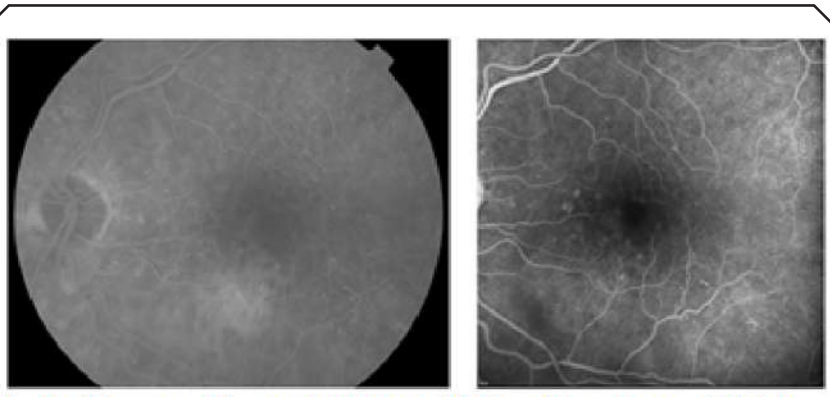
Laser is used for treating cancer and cancer surgery in vocal cords, oesophagus, cervical, skin, lung, vaginal, vulvar, penile and in certain lung cancers. The precision and the minimal damage to the normal tissues make laser surgery preferable over conventional surgical tools. As a result, patients usually have less pain, bleeding, swelling, and scarring. Treatment for superficial cancers which are on the surface of the body or the lining of internal organs are very easy with laser technology, whereas cancers at harder to reach places are accessed with the use of optical fibres. Carbon dioxide (CO_2) lasers, Neodymium:yttrium-aluminum-garnet (Nd:YAG) lasers, laser-induced interstitial thermotherapy (LITT) and Argon lasers are some of the different types of lasers used for cancer treatment. Photodynamic therapy can also be conducted using laser light instead of normal form of light such as for the treatment of certain cancer tumors because cancer cells can be selectively destroyed while sparing most healthy cells. The photosensitizing agent is usually injected into the blood so that they get collected more in cancer cells than in normal cells. When the laser is focused directly on the tumor, the cancer cells absorb the light triggers a chemical reaction which destroys the cancer cells.





Eye surgery

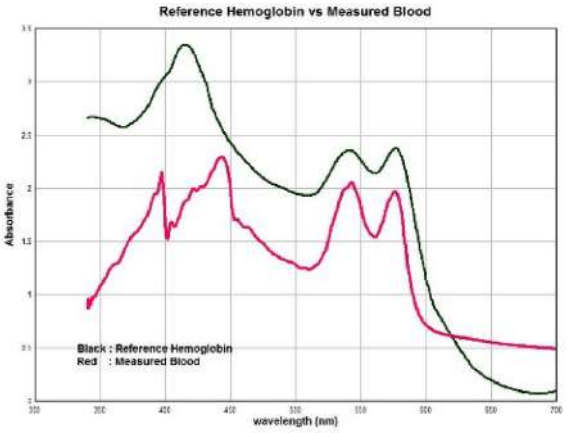
Performing eye surgery using laser as a tool is very common these days due to the high success rate and the precision the surgeon can achieve. 'Laser vision correction' is a common phrase used for refractive eye surgery. Here, the laser is used to reshape the cornea to correct short-sightedness, long-sightedness and uneven curvature of the cornea by adjusting the focal point back on to the retina. Usually the patient does not need to wear an eye glass once this surgery is performed. The common laser used for this type of surgery is called excimer laser which uses UV light to vaporize and remove tissue from the eye's surface during vision correction procedures. Non-refractive eye surgery includes repair of retinal tears, cataract surgery and glaucoma surgery. A cataract is a cloudiness of the eye's crystalline lens due to aging or disease which prevents light from forming a clear image on the retina. During cataract surgery, a patient's impaired natural lens is removed using Nd-YAG laser and replaced with a synthetic lens to restore the lens's transparency. Glaucoma is a group of diseases that damage the eye's optic nerve which is frequently characterized by raised eye pressure resulting in vision loss and blindness. Argon or Nd-YAG laser is used to burn areas of the trabecular meshwork located near the base of the iris to increase fluid outflow thereby reducing the eye pressure.



Left: Fluorescein angiogram with fundus camera. Right: Same eye photographed with cSLO.

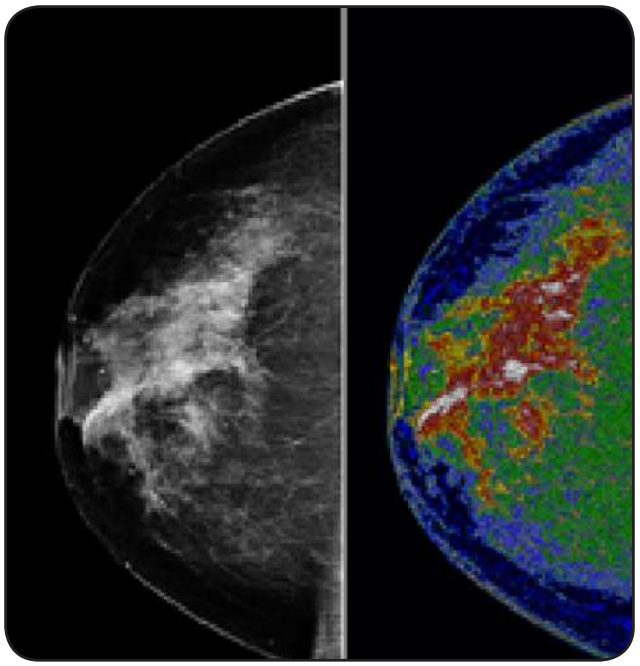
Personalized medicine

Personalized medicine refers to the concept that detection and treatment of disease can be tailored to match the characteristics of the individual patient and their particular pathology, moving away from the 'one size fits all' traditional approach. Light based technologies play a vital role in this futuristic treatment method by enabling the identification of nanoparticles using known biomarkers to limit the therapeutic dose exclusively to that targeted tissue volume.



Target drug delivery

Light can also be used as a tool to target drug delivery. Current research on the drug delivery systems is focused on developing systems capable of delivering the adequate dose of drug at the target site, avoiding collateral effects and enhancing the therapeutic efficiency. In the case of cancer, light sensitive systems are particularly useful for direct treatment of malignant cells and minimizing damage to healthy cells. This process enables an easy and precise control of the medication. Switching the light



on and off also triggers or stops the release of medication. Near infrared (NIR) light (0.75–1.4 μm) is particularly useful as an agent capable of triggering the drug release since NIR does not cause significant heating in the area of its application.

Laser imaging

Scientists are also gaining an insight into how diseases develop and how cells react to disease, using a technique called laser imaging.

Confocal scanning laser ophthalmoscopy

Confocal scanning laser ophthalmoscopy (cSLO) is an ophthalmic imaging technology that uses laser light instead of a bright flash of white light to illuminate the retina. Confocal imaging is the process of scanning an object point by point by a focused laser beam and then capturing the reflected light through a small confocal pinhole. The result is a sharp, high contrast image of the object layer located at the focal plane. The advantages of using cSLO include improved image quality, small depth of focus, suppression of scattered light, patient comfort through less bright light, 3D imaging capability and effective imaging of patients who do not dilate well.

Diffuse optical tomography (DOT) DOT is a non-invasive technique that utilize light in the near infrared spectral region to measure the optical properties of physiological tissue. It works best on soft tissues such as breast and brain tissue. By monitoring spatial-temporal variations in the light absorption and scattering properties of tissue, regional variations in oxy- and deoxy-haemoglobin concentration as well as cellular scattering can be imaged. Based on these measurements, spatial maps of tissue properties such as total haemoglobin concentration, blood oxygen saturation and scattering can be obtained using model-based reconstruction algorithms. DOT have applications including breast cancer imaging, brain functional imaging, stroke detection, muscle functional studies, photodynamic therapy and radiation therapy monitoring.

Spectrophotometry

Spectrophotometry data is often represented by a spectrum, i.e. a plot of the response of interest as a function of wavelength. Spectrophotometry allows scientists to identify the makeup of organic and inorganic compounds with the use of UV, visible and IR of the light. Different molecules or inorganic compounds absorb energy at different wavelengths. Spectrophotometers use a light source to shine an array of wavelengths through a monochromators. The spectrophotometer then compares the light intensity passing through the sample to that passing through a reference compound. Spectrophotometers are used in laboratories to measure the concentrations of DNA or RNA samples, to measure the growth of bacteria cultures, to analyse blood, urine and saliva in pathology laboratories and to analyse melanoma in tissues.

Conclusion

Medical use of light and light based technologies are not limited to above mentioned application. Also, there is a high potential in exploring how light can be used to improve the field of healthcare in the years to come because light is a basic form of energy and the human body and its functionality is a complicated structure of energy based systems.



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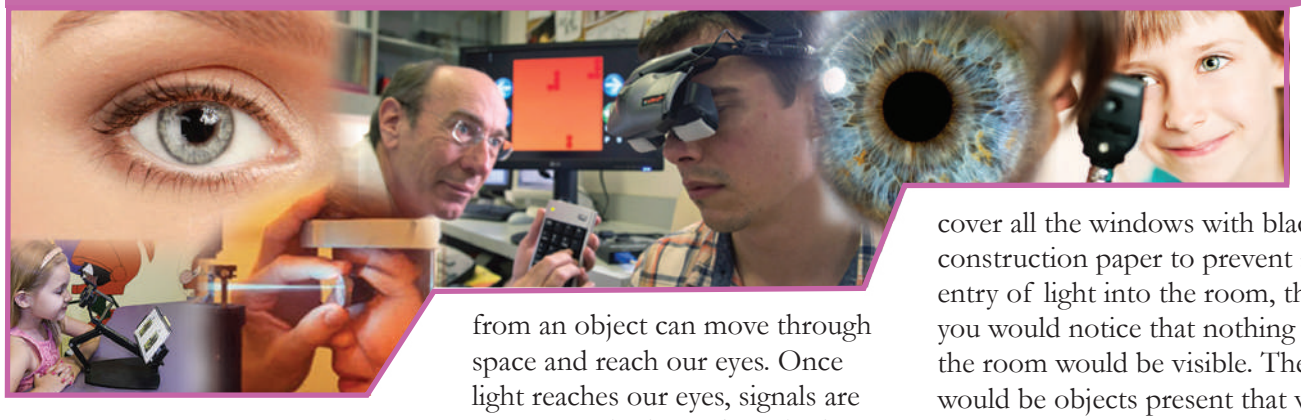
Light and Human Vision

Ms Kushlani Damithri Wimalaguna



LIGHT AND VISION DEVELOPMENTS

We see things every day, from the moment we get up in the morning until we go to sleep at night. We look at everything around us using light. We appreciate the crayon drawings of children, fine oil paintings, swirling computer graphics, gorgeous sunsets, a blue sky, shooting stars and rainbows. We rely on mirrors to make ourselves presentable and sparkling gemstones to show affection. But did you ever stop to think that when we see any of these things, we are not directly connected to it? We are in fact, seeing light -- light that somehow left objects far or near and reached our eyes. Light is all our eyes can really see. In order to get a fuller understanding of why we see things as we do, it helps to learn a little about the physics of light. Light is after all, that which enters our eyes and causes us to see.

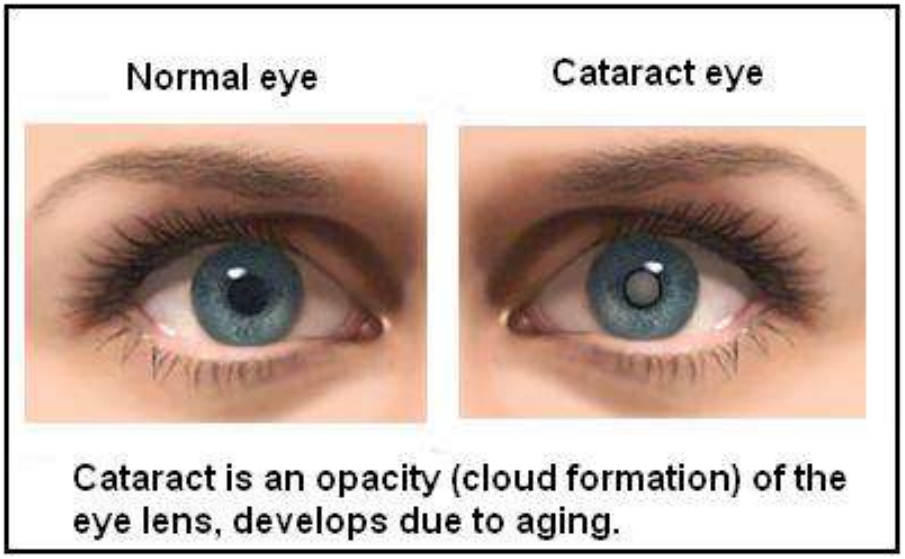
The Role of Light to Sight

The bottom line is: without light, there would be no sight. The visual ability of humans and other animals is the result of the complex interaction of light, eyes and brain. We are able to see because light from an object can move through space and reach our eyes. Once light reaches our eyes, signals are sent to our brain, and our brain deciphers the information in order to detect the appearance, location and movement of the objects we are sighting at. The whole process as complex as it is, would not be possible if it were not for the presence of light. Without light there would be no sight.



If you were to turn off the room lights for a moment and then cover all the windows with black construction paper to prevent any entry of light into the room, then you would notice that nothing in the room would be visible. There would be objects present that were capable of being seen. There would be eyes present which would be capable of detecting light from those objects. There would be a brain present which would be capable of deciphering the information sent to it. But if there was no light the room and everything in it would look black. The appearance of black is merely a sign of the absence of light. When a room full of objects (or a table, a





shirt or a sky) look black, then the objects are neither generating nor reflecting light to your eyes. And without light, there would be no sight.

That brings us to the question: What is Light? A very simplistic answer would be "Light is Energy". It is like saying that "Steve Waugh is a cricketer". So how do you define light?

As does light gives vision , over exposure during life span causes damage to the eye. However, in the "natural" environments with natural and man-made lights, the most offending portions of the EM spectrum are the UV-A (315 nm to 400 nm), UV-B (280 nm to 315 nm), and "blue-light" portion of the visible spectrum (380 nm to 500 nm). Our atmosphere generally protects us from UV radiation below 280 nm. Additionally, as the cornea and crystalline lens absorbs almost all natural UV radiation, UV radiation is thought to cause damage to the anterior eye, while short visible light ("blue-light") can cause damage to retinal structures. Also, as the damaging processes are thought to be at least partially photochemical in nature, the damaging effects can be cumulative in nature, which may compound across one's lifetime.

The blue-violet light that was discovered as part of this study is a 40 nm band of visible light that causes the maximum retinal cell death. Over time, our eyes are exposed to various sources that emit this blue-violet light (e.g., the sun, LED lighting, CFLs). Combining that with the use of tablets, TVs, computer screens and smart phones, enhances our exposure to blue-violet light. This cumulative and constant exposure to the blue-violet light is bound to increase over time and has the potential to cause damage to the retinal cells, which will gradually lead to retinal cell death, and in turn lead to AMD.

The level of light emitted by newer energy-saving lighting techniques (e.g., LED, CFLs) is very high. For example, CFLs, white LED light and even sunlight emit high levels of blue-violet light compared to the rest of the blue light spectrum. This underscores the need for us to protect our eyes from the harmful bands of blue-violet light.

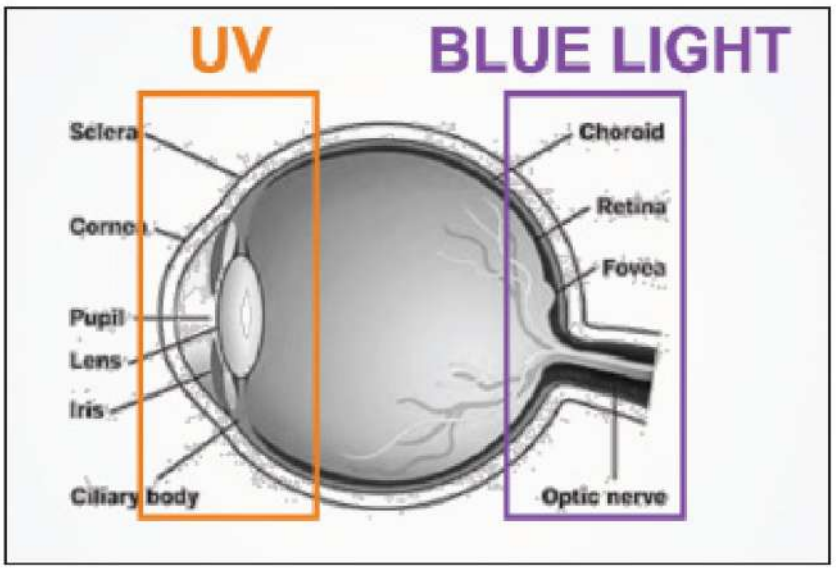
New Technologies that have improed Human Vision.

There are many technological vision developments that are at research level for further advancements.

Bionic Eye

- Google Specs
- Retinal implants/Brain Implants to restore Vision.

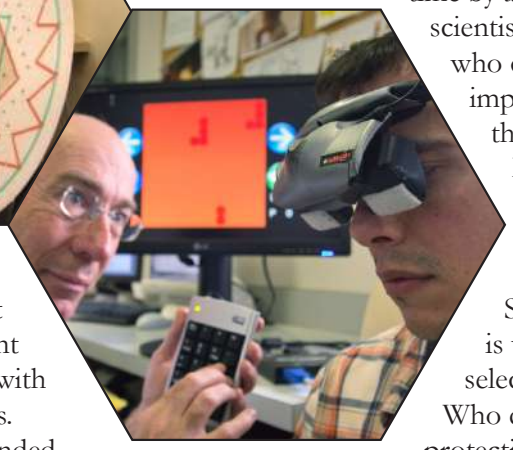
Apart from these there are



Dangers of light to the eye. UV light affects the front of the eye; blue light affects the back.

practically beneficial vision restorement plans executed world wide.
1).Vision Therapy.
2).Specialized lenses for ARMD and Cataract.





Protection from UV and Blue-Violet Light

How can we screen the harmful blue rays of light and allow the helpful blue rays of light to penetrate through and get into the eye? Essilor and the Paris Vision Institute established a goal of finding a selective light filter or a lens to block out UV as well as the harmful blue-violet light and yet allow the blue-turquoise light and the longer wavelengths of light to continue to penetrate through it. They did this with Light Scan, a patented, selective, no glare technology with three key features: 1) it selectively filters out harmful blue-violet and UV light, 2) it allows the beneficial visible light, including the blue-turquoise light, to pass through, and 3) it maintains an excellent transparency of the lens, so that there is no color distortion, and you get excellent clarity with the lens.
They ended up providing a lens with a front-side as well as a back-side protection. The front side of the lens deflects UV light as well as about 20% of the blue-violet light, thereby deflecting away the harmful rays. And the back side protects the patient from the reflective glare that comes off the back surface of the lens, mainly from UV light. Traditional blue blockers give pretty sunsets, but that is not what is requred. You do not want color distortion; you want your colors to be natural. The traditional blue blockers do not discriminate in the blue light spectrum. They just block all the blue light. This new lens technology is based on laboratory studies over a four-year period of time by an eminent group of scientists as well as clinicians, who came up with some very important data that allowed them to zoom in on the light that was needed to be blocked, and permit the light that was needed to get through. So this new lens design is very specific for more selective light.

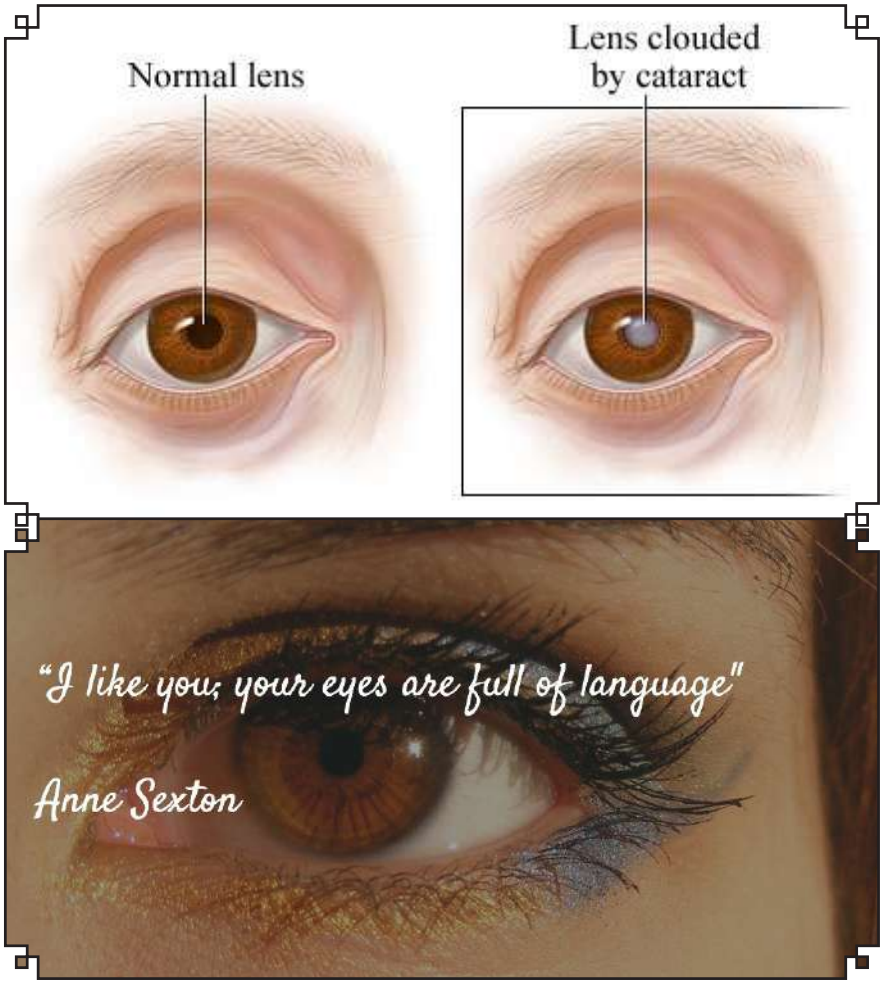
Who deserves the most protection? Those who experience high exposure to white LED or fluorescent light bulbs in offices and homes, frequent users of LED computer monitors, tablets, or smart phones, and those at risk for AMD, particularly those at high risk with family history, smokers, etc. Many companies are working on technology to look for harmful blue light, and ways to block these while allowing healthy blue light to remain.
Optical companies that currently offer blue-blocking technology include Nikon (SeeCoat Blue), Essilor (Crizal Prevencia), PFO Global (iBlu coat), HOYA (Recharge), VSP (UNITY BluTech) and Spy Optic Inc. (Happy Lens). We need to inquire from patients if they currently protect their eyes on a daily basis, if there is a family history of macular degeneration, and how much time they spend in front of a digital device or computer. We also need to find out if our patients are currently protecting their eyes against UV damage, which means that there is a lot of homework out there for us. These are the questions that are



expected to come to the forefront as this new technology continues to evolve.

Vision Therapy

Amblyopia, also known as lazy eye, is a common childhood condition, and is defined as defective vision in one or both eyes, which is present with no anatomical defect in the neuronal pathway of vision. This is not immediately resolved with wearing glasses. Amblyopia develops during early childhood (infancy to 12 years or older) due not to uncorrected vision needs. During this age it is usually reversible; however, if left untreated it will remain as a permanent visual defect unto adulthood. Factors commonly associated with amblyopia include squint, refraction errors between the two eyes, and stimulus deprivation such as cataract or ptosis. Unilateral refractive amblyopia may go unnoticed for years as the child usually has good visual acuity in the good eye , and poor vision in the bad eye. The condition may remain undiagnosed until school age. Bilateral refractive amblyopia can be detected sooner as the child may struggle with close work or complain of reduced or blurred vision. The best time to correct amblyopia is during infancy and early childhood , even though latest research show improvements till 40 years of age. The treatment aims at obtaining the best possible visual acuity in the amblyopic eye. The initial treatment is full time wear of appropriate eye power. This is usually followed by promoting the use of the amblyopic eye through limited use of the good eye . Thereon certain vision therapy techniques using computer directed instructions are conducted by a vision therapist. Treatment options included total occlusion, partial occlusion, use of cycloplegic drug of the good eye and other vision therapy techniques. Occlusion treatment was first described in 1772 and involves patching the non-amblyopic eye with an opaque patch. Another penalization was used for centuries and involves the instillation of atropine sulphate (a long acting topical cycloplegic agent) into the good eye to blur the near vision activities and force the amblyopic eye to be used. There are different opinions on the number of hours of patching per day as well as the number of days that atropine penalization should be prescribed.



The only center in Sri Lanka starting Vision Therapy is the Wickramarachchi Company, which has a mission with a vision to eliminate the reversible blindness from childhood.

Last but not the least , protect your eyes. Wear proper UV protected sunglasses , and not be hesitant do wear the correct eye glasses to correct any eye power. Your eyes are your actual wealth, and that you will realize when your eyes are closed temporarily.

Ms Kushlani Damithri Wimalaguna

Late Dr. A. Kathirevetpillai

An Appreciation

It is with a deep sense of sorrow that we announce the demise of our colleague and friend Dr. A Kathirevetpillai, the Editor of the Tamil Number of the *Vidurava*, the Science Magazine of the National Science Foundation.

Dr. Kathirevetpillai began his professional career as an experimental officer in the Entomology Department of the Tea Research Institute, Talawakelle in 1963, and retired on 9th July 1997 after 35 years of dedicated service. In 1969, he rose to the rank of Research Officer in Plant Physiology in the Division of Plant Physiology / Plant Breeding and Propagation, and in January 1992 he was appointed Head of the Division of Agronomy, in which capacity he served until retirement. Significantly, from 1985, until retirement he also functioned as the joint editor of the official TRI publication.
Dr. Kathirevetpillai received his doctorate from the Postgraduate Institute of Agriculture, University of Sri Lanka, Peradeniya in April 1977 for his thesis titled *'Studies on Vegetative Propagation and Early Growth of Tea (Camellia sinensis (L). O. Kuntz)'*. He received special training in Plant Breeding in New Delhi in 1977, and in 1978, he followed a special 6-momth training in Advanced Methodology in Growth Hormone Analysis at the University College of Wales in UK.

It was indeed a sad coincidence that his last contribution was to be an article titled *'Biotechnology for Improvement of the Tea Crop'* to the *Vidurava*, which he wrote less than 3 months before his demise. The Chairman and Members of the Editorial Sub-Committee (for *Vidurava*) of NSF join us in conveying to Mrs. Kathirevetpillai and members of his family our deepest sympathies on their sad loss.

M. Asoka. T. De Silva and Dr. Nalini C. Gnanapragasam



What have you learnt from the Vidurava November 2015 issue? Scan your own memory!

Light as a Carrier of Information

Questions

1. In the vast technical fields ranging from spacecraft technology to nanotechnology, information transmission plays a vital role.

2. It is not correct to state that the history of the use of light, or more scientifically 'optics', to transmit information from one place to another goes back to hundreds of years.

3. The main parts of an optical fibre cable are called the core and the cladding.

4. An important point is that, every light ray that is being launched into the fibre optic cable will undergo total internal reflection.

5. Optical fibres have a wider bandwidth available at optical frequencies.

Light and Light-based Technologies for Day to Day Life

Questions

1. Light plays two major roles as a supplier of energy and as a carrier of information.