Science Horizon

ODISHA BIGYAN ACADEMY

5TH YEAR | 1ST ISSUE | JANUARY 2015

ETERNAL LIGHT

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5TH YEAR **1ST ISSUE** **JANUARY, 2015**

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The Cover Page depicts : **Eternal Light** ***Cover Design : Sanatan Rout***

EDITORIAL

LET THERE BE LIGHT AND MORE LIGHT ON LIGHT

Light is so special and central to our existence that our seers of the glorious past once used to chant *"Deepam Jyoti Paramah Bramhan..."* in the worship of light and fire. They realized in their holistic perception the foundational precursors to life to say *"Pancha Bhutani Mulani"*. These basic necessities must have appeared through the manifestation of the primary source energy *(Tejah)* in its various stages , starting with the sequential creation of all the material ingredients and forces in the vast expanse of space *(Byoma)* over a long period of time to finally realize a suitable rocky-solid surface somewhere like Earth *(Khiti)* with adequate water bodies *(Aapah)* and Atmosphere *(Marutah)* for the emergence of life to be continuously nurtured in the bosom of heat and light of a star such as the Sun. Therefore in quoting the Bible in a lighter vein with : "God said; Let there be Light … and there was Life on Earth" - there is a profound meaning with lot of significance in the statement. In fact light is a form of energy and energy is the primary source of all that exists and the prime mover of everything that happens in the Universe. Life emerged on Earth, continuously being bathed and nurtured in the Ocean of heat and light provided by the Sun, evolving through various stages of its growth, sustenance and development, ultimately endowed with a complex organ like 'Brain' with sufficient intelligence to feel curious and enquire to understand the true nature of Light.

Light with its many splendors is exhibited in the crimson hues of the setting and rising Sun; the richness of the rainbow, the teeming billions of the twinkling starts and the romantic coolness of the Moon in the night sky, the colourful beauty of Nature with its vast blue sky and the deep-blue ocean, has always inspired not only the aesthetic sense but also challenged the human intellect ever since the dawn of human civilization. Light had remained most elusive in its nature through its various interplays with matter in phenomena such as reflection, refraction, dispersion, scattering, polarization, interference and diffraction. It was once thought to be corpuscular in nature by Descartes and Newton in order to explain reflection and refraction by its rectilinear propagation. Then it was found to be wave-like by Huygens, Young and Fresnel in the late eighteenth and early nineteenth century. Later in the mid nineteenth century Maxwell showed that light is an electromagnetic wave capable of propagating in vacuum like X-ray, Micro-wave, Radio-waves, ultraviolet and Infrared radiations. Then in the beginning of the twentieth century it was again found by Planck and Einstein that light behaves as particles in order to explain radiation from a hot body and the photo-emission of electrons from metal surfaces. So what is light? A wave or a particle! It is neither. In fact to-day we know that it has the quantum nature like that of the electron which can not be described in our everyday language. In its quantum nature it is a collection of energy quantas called photons. With this understanding science and technology has been developed to a great extent which has enriched our life in every possible way, and now time has arrived to celebrate the blessing of light and light-based technologies.

The year 2015 is being celebrated as the International Year of Light (IYL-2015) which is a global initiative adopted by the United Nations (UN) to raise awareness of how optical technologies promote sustainable development and provide solutions to worldwide challenges in energy (Solar Energy), communication and education (Indoor lighting by artificial lights, Computer, Laptops, Mobile Phones, World Wide Web etc.) agriculture and health (Laser fencing, Laser surgery, Laparoscopy, Endoscopy etc.) as well. It was launched at the UNESCO headquarters in Paris on 19th January 2015 with unveiling of 1001 inventions on light-based science and engineering to inspire new ideas and hopes for finding solutions for new challenges.

Let us hope, The IYL-2015 will create a forum for scientists, engineers, artists, poets and many other young brilliant brains to be inspired by light to interact both with each other and with public so as to learn more about the nature of light, its many applications with its role, history and culture to prepare for future challenges.

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FOR THOSE WHO LIGHT CANDLES, THE SUN NEVER SETS

Nachieketa K Sharma

Prof. Ajoy Ghatak, is a renowned Professor of Physics at Indian Institute of Technology, New Delhi. He had earned international acclaim as an expert on nonlinear optics and laser physics. With due permission from Prof. Ghatak, a brief essence of his presidential address delivered on the occasion of the celebration of the **International Year of Light (IYL-2015)** during the 84th Annual Session of National Academy of Sciences of India at Jodhpur on 'Optical Fibres', is presented here.

It is the eye which celebrates optics and none other than Prof. ghatak possesses the power of the eye of the soul to render the ongoing Optics Utsav whole.

May I share these beautiful lines with you all:-

"For a thousand years has the daffodil wept,
For the lack of an eye that would render it whole;
Just once in an epoch a person is born,
Who possesses the power of the eye of the soul"

Feynman's incorporation of someones saying, *"The brain has developed a way to look out upon the world"* in his first volume of Lectures on Physics has found a fresh echo recently in **Masayo Takahashi** (Stem cell Person of the year 2014): "The retina has been called the body surface, and for these reasons it serves as a useful and experimentally amenable model of the central nervous system. Until very recently, it was thought that in adult mammals the retina was entirely incapable of regenerating. But we now know that atleast new retinal neurons can be generated after being damaged. This has opened up new hope that the ability to regenerate neurons and even to reconstitute the neural network may be retained in the adult retina. We are now exploring the exciting prospect that, by transplanting cells from outside of the retina or by regeneration from intrinsic progenitor cells, it may one day be possible to restore lost function to damaged retinas."

So by replacing "future with optics" in the beautiful stanza of Allama Iqbal (in his "Sham aur Shair"), we can very well say :-

"The mornings light will polish the face of the sky,
And silent, the night will flee
The world of the Optics will be so very new,
That I cannot express what my mind can see."

And Einstein has rightly said, *"All the fifty years of conscious brooding have brought me no closer to the answer to the question, "What a light quanta? Of course today every rascal thinks he knows the answer, but he is deluding himself."*

So, light and eye will continue to fascinate and challenge human intellect.

"On 20 December 2013, The United Nations General Assembly proclaimed 2015 as the International Year of Light and Light-based Technologies (IYL 2015), because exactly 1000 years back in 1015, Alhazen wrote the first book on Optics. Alhazen was

from Mesopotamia - now in Iraq. According to Nobel Laureate Ahmed Zewail: ***"Civilization would not exist without light - light from our sun and light from the focused and coherent lasers that have now become an important part of our daily lives; from scanning packages at supermarkets, to eye surgery, and to IT communications across oceans. The International Year of Light will surely raise awareness of these powerful discoveries and their present wide-ranging, light-based technologies, which are significant contributors to the world market. As importantly, the International Year of Light will inspire future discoveries and applications for one of the most important elements of our existence : light."***

It so happens that the 2014 Nobel Prize in Physics was awarded jointly to **Isamu Akasaki**, **Hiroshi Amano** and **Shuji Nakamura** for the invention of efficient blue LEDs which has enabled bright and energy-saving white light sources. Further the 2014 Nobel Prize in Chemistry was awarded jointly to **Eric Betzig**, **Stefan W. Hell** and **William E. Moerner** for the development of super-resolved fluorescence microscopy. Both awards are in the general area of optics!! This shows the tremendous importance of optics in current areas of research.

Why 2015 was chosen as the International Year of Light? One of the reasons was that 1000 years back, in the year 1015, *Ibn al-Haytham* (often called as Alhazen) wrote the first book on optics. Alhazens Book of Optics (Arabic: *Kitab al-Manazir*, Latin: *De Aspecti bus or Perspectiva*) had a great influence in the development of optics. Robert S. Elliot wrote the following about the book: *"Alhazen was one of the ablest students of optics of all times and published a seven-volume treatise on optics which had great celebrity throughout the medieval period and strongly influenced Western thought..."*

However, major scientific anniversaries to be celebrated during 2015 are

- Ibn Al-Haytham's works on optics (1015)
- Fresnels theory of diffraction (Fresnel, 1815)
- Electromagnetic theory of light propagation (Maxwell, 1865)
- Einstein's theory of the photoelectric effect (1905) and of the embedding of light in cosmology through general relativity (1915)
- Charles Kao's achievements concerning the transmission of light in fibers for optical communication (1965).

Coming back to Fiber Optics, in 2009, Professor Charles Kao was awarded half of the 2009 Nobel Prize in Physics for groundbreaking achievements concerning the transmission of light in fibers for optical communication. This is truly a very apt recognition of an area which has touched almost everyone. The Chair of the Nobel Committee said *"Charles Kaos discovery made in 1966 led to a breakthrough in Fiber Optics… and revolutionized the way in which information can be transmitted globally.*

In 1966, Charles Kao and George Hockham predicted that if it was possible to produce optical fibers with attenuation less than 20 dB/km, it could compete effectively with the conventional communication systems; a loss of 20 dB implies a power loss by a factor of 100. In 1970, Kapron, Keck and Maurer (at Corning Glass in USA) were successful in producing silica fibers with a loss of about 17 dB/km. In 1970 itself, Alferov in Leningrad and Panish and Hayashi at Bell Labs demonstrated room temperature operation of semiconductor lasers; and thus started the revolution in optical fiber communication. However, in addition to very important applications in communications, the optical fiber is playing an important role in just guiding the light beam from one place to the other, in medical diagnostics and also in numerous areas with fiber based devices like Fiber Bragg Gratings, Fiber Amplifiers and Fiber Lasers. Fiber based sensors have also become an extremely important area." The address of Prof. Ghatak thus went on…

To put it in the words of Byron

"Could love for ever, Flow like a river!"

And let me conclude with Daniel Colladon who after guiding light for the first time by total internal reflection wrote:

I managed to illuminate the interior of a stream in a dark space. I have discovered that this strange arrangement offers ….. one of the most beautiful and most curious experiments that one can perform in a course on Optics."

■

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SWITCH ON THE SUN FOR CLEAN ENERGY

Prof. M. Goswami

Introduction

Energy is a key element in the progress of mankind. Next only to food, man has an insatiable hunger for energy. Without adequate supply of energy man can't survive. In fact man's progress in the socio-economic ladder is intimately connected with the amount of energy he possesses. However, our energy intensive lifestyle has increased the greenhouse gases in the atmosphere that has led to many disastrous events in the world. In order to control the climate change due to greenhouse gas emission, it is imperative that instead of fossil fuels, various renewable sources like sunlight, wind, biomass and such other are to be used to generate electricity. At present different solar energy technologies are available for generating electricity to meet our daily requirement. The device in which light energy or energy of photons is converted to electricity is called photovoltaic cells. The most comsmon photovoltaic cells are made with monocrystalline or polycrystalline silicon. The concept of twenty four hours power generation using solar thermal energy is also coming up in a big way. India being very close to the equator, gets near about 250-350 sunny days in a year. Solar photovoltaics can make, and have been making, an impressive

contribution to urban as well as remote- area infrastructural development in many parts of India. Hence, India's solar photovoltaic achievements seems to be very promising.

Plugging into the Sun

Sun is the centre of the solar system; the heat and light on the planets including earth is because of the radiation from sun. It is a star, which is a large ball of burning gases. Its energy is due to the nuclear conversion of hydrogen into helium through nuclear fusion. The protons liberated at the end of the last reaction above starts reacting with each other again. This is how the nuclear reactions in the sun are self- sustaining. Sun converts 4 million tons of hydrogen into energy every second which is radiated into space. The radiation from the sun that is received on the surface of the earth is mostly (43%) in the visible region of the electromagnetic spectrum with some amount of ultraviolet(UV) and infrared (IR) region, as shown in the figure1. The wavelength range of sunlight is from 2 x 10^{-7}m (6.2eV) to 4.6 x 10^{-6} meters (3.1eV). Wavelength λ of the radiation is related to its energy, E, through the equation $E=hc/\lambda$, where h is the Planck's constant and c is the velocity of light. Thus UV radiation has higher energy than visible or infrared radiation.

Figure 1 shows the energy distribution in a solar radiation spectrum. It is estimated that earth receives around 0.012 PWh amount of power per square mile in a year (where P

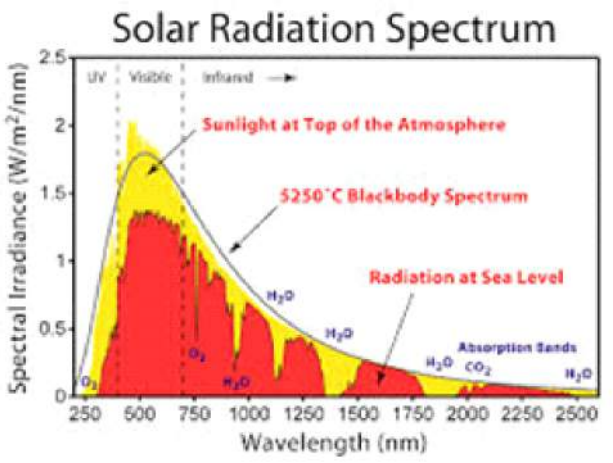

Figure 1 : The Solar Radiation Spectrum

is peta= 10^{15}) and there is roughly 200 million square miles of earth surface including the oceans. The current annual electricity demand across the world is in the range of 16 PWh and is likely to increase to about 36 PWh by 2030. Considering the vast area of the earth, we get almost 20,000 times more solar energy than our electricity requirement, for all practical purposes. Therefore it makes a lot of sense to harness the solar energy for our benefit. The main advantages of solar energy technology are:

- Sun shines on the surface of the earth which means, the fuel required for generating power is free. Unlike fossil fuels like coal and petroleum there is no fluctuations in the price of fuels as well as its availability.
- Most of the solar technology based power generators have no turning or moving parts to wear out or break down. Hence the system does not require much maintenance.

- The solar power generators do not produce any noise. Modular system can be quickly installed anywhere.
- There are no emissions of harmful or polluting gases. This is one of the safest ways of generating power without polluting the atmosphere.

Even with such critical advantages, solar photovoltaic power generating modules are not yet used extensively to exploit the solar radiation that the earth is receiving. Currently the cost of photovoltaic modules and their installations are high. The challenge for the technologists to find a cost effective way of converting the solar energy into usable energy for our applications.

Photovoltaics

When a surface is exposed to solar radiation three things can happen : the radiation can get absorbed by the material, the radiation can get reflected off the surface or the radiation may pass through the material. If the electronic band gap of the material is very large compared to the wave length of the incident radiation, then the radiation will pass through the material. However, if the band gap is in the same range as the energy of the radiation, then there can be absorption by the material. Thus in order to absorb the solar radiation, we need to use materials that have the electronic band gap in the range of the solar radiation spectrum. Materials like silicon, GaAs, GaInP, CdTe, $CuIn_{1-x}$, Ga_xSe_2 are a few examples of solar radiation absorber.

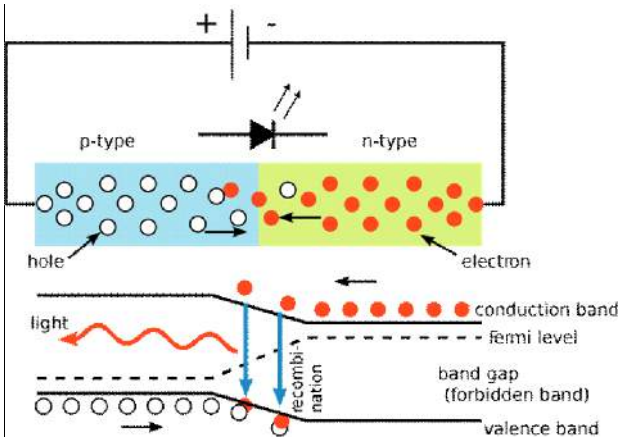

Figure-2 : The Mechanism of pn Junction.

A solar photovoltaic (PV) cell contains a junction of two types of semiconductors **(Figure 2)**. The junction is called a p-n junction, which is formed by putting together a p-type semiconductor layer and a n-type semiconductor layer. The free electrons on the n-type and free holes on the p-type initially move across the junction. When a free electron meets a free hole they cancel each other and disappear in the lattice, leaving behind oppositely charged species on their own side. Because of their movement, the free charge carriers near the junction tend to eat each other, producing a region depleted of any moving charges. This creates a neutral zone called the depletion zone. Any free charge that moves into the depletion zone find itself in a region of no charge. Locally the free charges see a lot of positive charges on the n-type side and a lot of negative charges on the p-type side. These exert a force on the free charge, pulling it back to its own side of the junction away from the depletion zone. Once the depletion zone forms, the negative charge of the p-type semiconductor's extra electron and

the positive charge of the n-type semiconductors extra hole tend to keep the depletion zone free of free charges. A free charge now requires some extra energy to overcome the forces from the donor/acceptor atoms to be able to cross the depletion zone and go over to the other side of the zone. The junction acts like a barrier for any charge flow across it. The free charge carriers can pick up the extra energy in the form of photons from a light source or voltage from an electrical circuit depending on the properties of the materials used to make the junction. It is now clear that for photovoltaic application there is a need to have materials that absorb solar radiation. Such absorption of radiation provides the extra energy for the charge carriers to move through the depletion zone. The free charge carriers would then be collected by electrical conductors for application in the external circuit.

The voltage produced in a single cell is not sufficient for most of the applications. An array of 36 cells is put together in the module. For larger applications, many such modules are connected in series and parallel to obtain the right power output. The output from the modules is dc in nature. An inverter and other electronic control systems are needed to use the power from these modules **(Figure 3)**.

Regarding the materials at the cell level, the PV cells that are being used can be broadly categorised into two groups based on the basic material that is used to make the cells. They are silicon and non- silicon based PV cells.

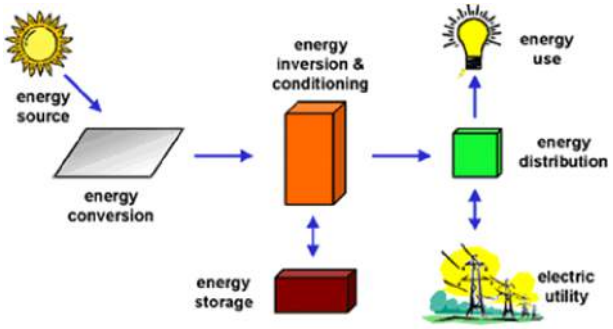

Figure-3 : Componets of a Solar Photovoltaic system.

Solar Thermal to Electricity

The concept behind the usage of a solar thermal system is quite simple. The solar energy is directly collected and converted to electricity using a heat to electricity conversion device. Some kinds of heat engines or thermoelectric converters are the most common devices that are used. The heat from the solar radiation is concentrated on to a heat transfer fluid. In some cases water is directly heated using the solar radiation that is converted into steam. In more advance systems, synthetic oil is used as a heat transfer fluid that produces steam from water. The steam is expanded in a Rankine cycle and finally converted to electricity. The efficiency of conversion depends on factors like the temperature and pressure of the steam. Higher the temperature and pressure, higher is the efficiency of conversion into electricity. In order to increase the temperature and pressure of the steam, the temperature of the heat transfer liquid needs to be higher. Hence more heat from the solar radiation will have to be focussed on the fluid. This brings in a requirement to design the solar radiation concentrators.

Unconcentrated solar radiation can heat the fluid upto 200^{0}C which is enough for heating water and room space in domestic applications. Concentrating solar radiation onto a small area using a parabolic trough or dish with mirrored surface can produce temperature in the range of 400-650^{0}C. A schematic diagram of a solar thermal steam producing system is shown in **Figure 4**.

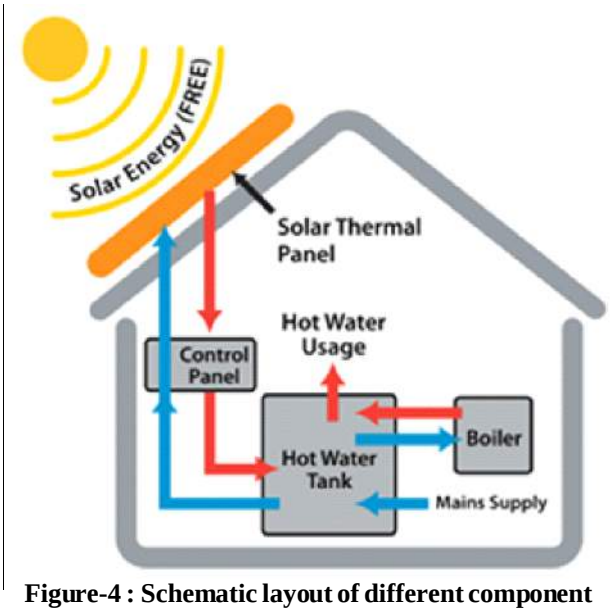

Figure-4 : Schematic layout of different component of a Solar Thermal System.

Some materials like the salts are used in molten form to store the heat. A 19.9 MWsolar thermal power plant has been set up in Spain (called Gemasolar Power Plant) over a 185 hectare area. This plant uses an array of 2650mirrors to reflect light onto a tower top that is 140m high **(Figure 5)**.

The solar radiation heats up the salt to a temperature higher than 500^{0}C and the molten salts are stored in special thermally insulated tanks that can preserve the temperature of the

Figure 5 : Gemasolar Power Plant in Spain.

salts. The molten salt (a mixture of sodium and potassium nitrates) is then used to generate steam and run steam based turbines to generate electricity at any time of the day. It is estimated that Gemasolar will generate about 110 GWh of electricity per year reducing 30,000 tons of carbon dioxide emission and can power 25,000 homes. Thus, this is the first round the clock electricity generation station using solar power.

Indian Scenario

The geographical location of India is quite favourable to take the advantage of solar radiation. The average global radiation received is around 4.5 -5.5 KWh per square meter per day in most part of the country **(Figure 6)**.

With about 250 - 300 clear sunny days in a year in most part of the country solar PV can be judiciously used to meet substantial part of our ever-increasing energy demand. On an average, an Indian house in urban location, with all its modern gadgets, consumes about 250 - 400 KWh electricity per month. Even with partial roof area coverage, it is possible to generate enough power to run house hold electricity demand. In rural and unaccsessible places electricity needs can be achieved by

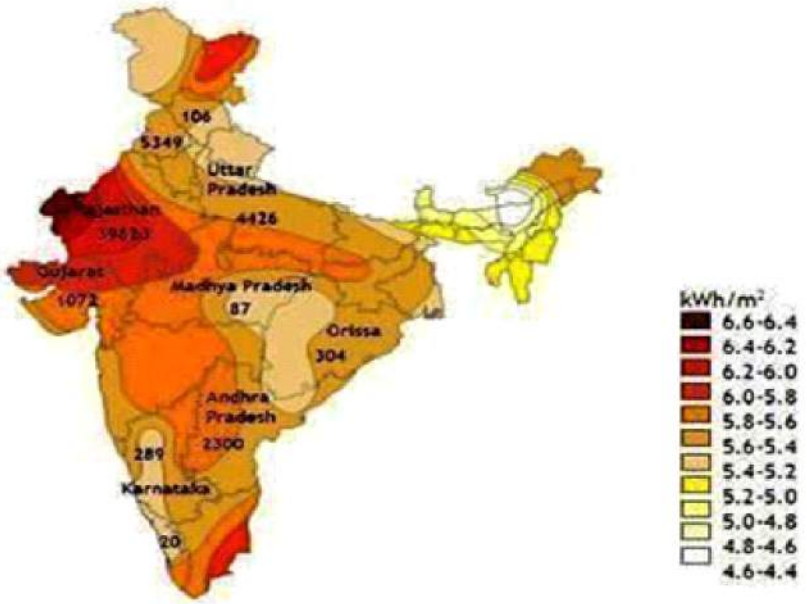

Figure-6 : Solar Direct Irradiance map of India.
Parts of Rajastan, Gujarat and Kashmir receive more radiation than the rest of the country.

setting PV modules on roof tops of houses or even solar parks near villages. This would ensure the saving of cost on establishment and maintenance as well as transmission and distribution of energy. Attempts are made to use the solar PV modules to power the irrigation pumps in remote areas. Government of India is giving certain incentives in terms of tax and customs duty benefits to encourage the manufacturers of solar modules. In the silicon solar PV area, India is the second largest manufacturer in the world and 67 % of the manufactured solar PVmodules are exported. Ministry of New and Renewable Energy has initiated the Jawaharlal Nehru National Solar Mission (JNNSM) under the brand 'Solar India' to encourage Research& Development (R&D), manufacturing and investment in the area of solar technology. The mission of this scheme is to set up20,000 Mw grid- connected power generation capability and off-grid capability of 2000 Mw by 2022. As of March 2014, about 2600 Mw capacity power plants have been installed around the country.

Solar Thermal Power generating plants are not yet set up in the country. Thermal systems mainly for water heating and cooking have been in use extensively all over the country. In Mount Abu (Rajasthan) a solar steam generating system comprising of 6 dishes with 16 sq. m area each is set up for use in kitchens, laundry, sterilization, etc.

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LED LIGHT: BENEFITS AND HAZARDS.

Dr. Dwijesh Kumar Panda

Eco-friendly (lighting emitting diodes) LED have been touted as a super- efficient alternative to traditional bulbs because they use up to 85% less energy and each bulb can last up to 10 years. Philips, the world's biggest lighting maker, reported 58% jump in LED light sales from last year. However, a Spanish study has shown that the light emitted by LED bulbs can damage the cells in the retina by causing oxidative stress. The unpleasantly 'cold light' is reported to have caused symptoms of itchy skin and headaches. A publication in the journal of "photochemistry and photobiology claims that LED radiation causes significant damage to human retinal pigment epithelial cells. The light from LEDs, comes from the short-wave, high energy blue and violet end of the visible light spectrum. They have also been blamed for the changing hues of masterpieces in the galleries. Incandescent bulbs are being phased out in favor of low-energy alternatives such as CFLs, but there are concerns about the safety of the new generation of so -called 'environmentally friendly' lighting.

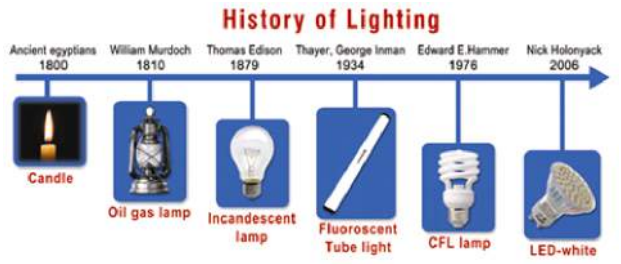
The LED headlights in cars trigger migraine. Light flashes from emergency vehicles at night, can cause seizure in some people. The electromagnetic spectrum ranges from low- frequency waves such as radio waves (TV signals), microwaves, infrared (cable TV), and high frequency ultraviolet to X-rays (used for medical images) and gamma radiation (which kills cancer cells). Unlike sunlight, however, the LEDs light is not intense enough to damage someone's eyes. Only ultraviolet and higher frequencies can cause damage.

The blue wavelength light is perceived as being dangerous to the retina. Damage can be caused if one experiences extremely intense blue light for an extended period of time. It can cause eye strain, Computer vision syndrome - headaches, dizziness, and soreeyes. Eyes have a physical barrier to the spectrum of light. The light passes through the cornea and the lens, which absorb much of the light. As we age, people develop cataracts on their lens and this is another of nature's ways of preventing the blue end of the spectrum of light from coming into the eyes.

The "white light" LED emits much more blue light than conventional lamps, as a consequence it has number of health implications. Cumulative exposure to blue light accelerates aging of the retina and possibly play an etiological role in AMD (age-related macular degeneration). LEDs are expected to become the primary domestic light sources in the near future. Illuminance levels of LED domestic light sources have induced retinal degeneration in albino rats, the exact risks for the pigmented human retina require further study. The light emitting diodes that are to

replace incandescent lamps could be harmful to the skin and eyes. Having discussed the benefits and hazards of LED, a brief history of lighting is in order.

The traditional light bulbs have been used for many years. The halogen lamps that came later contain a gas inside the tube that makes the light much brighter- and lamp more efficient. The fluorescent lamps keep the gas at low pressures and produce brighter light. Solid state lighting devices such as LED a new technology are the main artificial light source of the future.



The 2014 Nobel Laureates Isamu Akasaki Hiroshi Amano and Shuji Nakamura of Japan invented this new energy-efficient and environmental- friendly light source for the greatest benefit to mankind. LED lamps emit a bright white light, long lasting and energy efficient. Since about one fourth of world electricity consumption is used for lighting purposes, the LEDs last up to one lac hours, compared to one thousand for incandescent bulbs and ten thousand hours for fluorescent lights which will save Earth's resources. Red and green light-emitting diodes have been with us for almost half a century, but blue light was needed to really revolutionize lighting technology. Only the combination of red, green and blue produce the white light. It is worth noting that in LED electricity is directly converted into light particles, leading to greater efficiency gains compared to other light sources where most of the electricity is converted to heat and only a small amount into light.

The LEDs do not contain the harmful mercury vapor/dust that come from incandescent and other sources in polluting our water supplies and homes. Many home appliances are equipped with LEDs. They shine their light on LCD screens in television sets, computers, mobile phones and camera. Greenhouse cultivation and sterilization of polluted water is already a reality. It improves the quality of life for more than 1.5 billion people of the world who currently lack access to electricity grid and will benefit from the use of LED lighting.

Acknowledgement:

The author wishes to acknowledge Professor (Dr.) Trilochan Pradhan for the necessary help and guidance in the preparation of this article.

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CHANDRASEKHAR VENKAT RAMAN AND HIS RAMAN EFFECT

Dr. Ramasankar Rath

With the great discovery of the so called Raman effect by Chandrasekhar Venkat Raman in the year 1928, for which the Nobel committee decided to associate his name by awarding him the Nobel Prize for Physics in 1930; India shot into prominence as a land of scientific culture. To speak the truth, his contribution to science is much more than winning the Nobel prize. Real evaluation of his work should be made in terms of his research pursuit in spite of the heavy odds of the Indian Laboratories of his time.

C. V. Raman graduated in science from the presidency College of Madras, when he was only sixteen years old and obtained his master's degree in Physics in 1907 at nineteen years. Born in a Tamil family of Madras presidency in 1888, he breathed his last in the year 1970. He worked as a Professor of Physics in Calcutta University from 1917 to 1933, during which period a team of research students worked under his supervision on the scattering of light in the IACS (Indian Association for the Cultivation of Science). He was awarded the Nobel prize for his work on the scattering of light and the discovery of Raman effect. In 1933 he left Calcutta to join the Indian Institute of Science at Bangalore (now called Bengaluru) as Professor becoming the Director of the Research Institute in 1948 which bears his name.

Raman effect belongs to the scattering of light in the visible range which helps in determining the structure of a molecule. To be more specific, if a monochromatic light beam (i.;e. a light beam of single colour) of frequency ν_0 emitted through a transparent medium (mainly liquid, but gaseous or solid medium also will do) is analysed by a spectroscope, one would observe less bright secondary spectral lines on either side of the original spectral line with a frequency shift of ν_M. This phenomenon is known as Raman effect.

Due to this shift facter ν_M, the frequency of the secondary spectral line on one side of the original are of frequency ν_0 gets enhanced to $\nu_0 + \nu_M$. The opposite thing happens on the otherside of the original spectral line with frequency $\nu_0 - \nu_M$. These changes in frequency and the relative intensities of brightness are not the characteristic of the source that emits the original light beam, but of the medium through which the beam is getting scattered. The spectral lines on the lower frequency side are called the stokes lines and on the higher frequency side, the antistokes lines. If the intensities of these lines are denoted respectively by Is and Ia, Raman proved theoretically, which was also experimentally verified, that $I_a/I_S = \exp(-h\nu/kT)$. The exponential term on the right side of the formula was further reminded of this term in Planck's formula for black body radiation.

According to quantum theory, Raman effect is a consequence of the collision between the photons of the incident light of energy $h\nu_0$ and the material particles of the medium in oscillatory or/and rotatory motions. The well known Physicist R.W.Wood of that time said that Raman effect provided as strong a proof as the photo-electric effect of Einstein in support of quantum theory. Though wood was less known to the mathematical community, it is worthwhile to know that Niels Bohr had proposed his name for the Physics Nobel prize jointly with Raman in 1930 and also for the previous year's prize.

Incidentally Smekel had predicted the existence of Raman's spectrum in 1923, but had not been able to prove his claim. Niel Bohr said that Raman's achievement was a rare combination of classical and the quantum techniques of Physics. Raman essentially followed classical methods in analysing the different phenomenon of oscillations of nature whether in the theory of optics or in accoustics. He disagreed with Rayleigh when he explained the blueness of the Mediteranean sea through the theory of blueness of the sky. Raman applied to the diffraction of light the Einstein-smolukowski Stochastic Theory of fluctuations and the attendant correlations. In this effort he was supported by his collaborators, amongst whom was K. S. Krishnan.

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ENERGY METAL THORIUM

Er. Mayadhar Swain

We get electricity from conventional sources as thermal power, hydel power and nuclear power. Nuclear power is a clean source compared to thermal power. In the world today about 16% of electricity is available from nuclear power plants. The fuel of nuclear power is uranium. But this is scarcely available in the Earth and so nuclear power is not developed as expected earlier. Another metal from which nuclear power can be generated is thorium.

Nature

Thorium is a naturally occurring, slightly radioactive metal. . It was discovered in 1828 by the Norwegian mineralogist Morten Thrane Esmark and identified by the Swedish chemist Jöns Jakob Berzelius and named after Thor, the Norse god of thunder. Esmark found a black mineral on Lovoya Island, Norway and gave a sample to his father who was a noted minorologist. His father could not identify it and sent it to Berzelius. Its atomic number is 90 and its symbol is Th. It exists in nature in a single isotopic form i.e. Th-232.

When pure, thorium is a silvery white metal that retains its lustre for several months. However, when it is contaminated with the oxide, it slowly tarnishes in air, becoming grey and eventually black. Thorium dioxide (ThO_2), also called thoria, has one of the highest

melting points of all oxides (3300^{0}C). When heated in air, thorium metal turnings ignite and burn brilliantly with a white light. Pure thorium is soft, very ductile and can be cold-rolled and drawn. Thorium is slowly attacked by water, but does not dissolve in most common acids, except hydraulic acid.

Isotopes

Thorium has 27 radioisotopes with a range in atomic mass from 210 to 236. The most stable isotopes are Th-232 (half-life of 14.05 billion years), Th-230 (half-life of 75380 years), Th-229 (half-life of 7340 years) and Th-228 (half-life of 1.92 years). All the remaining isotopes have half-lives that are less than 30 days and the majority of these have half-lives that are less than ten minutes.

Source

Thorium is found in small amounts in most rocks and soils. It is three times more abundant than uranium. The most common source of thorium is the rare earth phosphate mineral, monazite. It contains up to about 12% thorium phosphate, but 6-7% on average. World monazite resources are estimated to be about 12 million tonnes, two-thirds of which are in heavy mineral sand deposits on the south and east coasts of India. There are substantial deposits in several other countries. Estimated world thorium resources which can economically be exploited are given in the following table.

Estimated World Thorium Resources

Country	Thorium Reserves (Ton)	% of total
Australia	489,000	19
USA	400,000	13
Turkey	344,000	11
India	519,000	21
Venezuela	300,000	10
Brazil	302,000	10
Norway	132,000	4
Egypt	100,000	3
Russia	75,000	2
Greenland	54,000	2
Canada	44,000	2
South Africa	18,000	1
Other countries	33,000	2
World total	**2,810,000**	**100**

Thorium as a Nuclear Fuel

In a nuclear power plant, energy is produced by nuclear fission of uranium. Nuclear fission is the breakup of a nucleus into two sizeable fragments. For example, Uranium-235 (U-235) is readily fissionable by slow neutron producing krypton and barium. The reaction is:

$$_{92}U^{235} + {}_0n^1 = {}_{36}Kr^{89} + {}_{56}Ba^{144} + 3{}_0n^1$$

During the break up, 3 neutrons are liberated. These neutrons are used to fission other uranium nuclei what is then formed a chain reaction.

Thorium (Th-232) is not itself fissile and so is not directly usable in a nuclear reactor. However, upon absorbing a neutron, it transmutes to Uranium-233 (U-233), which is an excellent fissile fuel material. Hence to use thorium as nuclear fuel, it is required that

Th-232 is first irradiated in a reactor to provide the necessary neutron dosing. The U-233 that is produced can either be chemically separated from the parent thorium fuel and recycled into new fuel or be used in-situ in the same fuel form.

It is possible to design thorium fuels that produce more U-233 in nuclear reactor than the fissile material they consume. Hence the technology is often called breeding and the reactor is known as fast breeding reactor.

Advantages of Thorium as Nuclear Fuel

The advantages of thorium as nuclear fuel compared to uranium are given below:

1. Weapon-grade fissionable material (U-233) is harder to retrieve safely and clandestinely from a thorium reactor.
2. Thorium produces 10 to 10000 times less long-lived radioactive waste.
3. Thorium mining produces a single pure isotope, where as the mixture of natural uranium isotopes must be enriched to function in most common reactor designs.
4. Thorium can not sustain a nuclear chain reaction without priming, so fission stops by default in an accelerator driven reactor.

India's Plan for Thorium

India has huge resources of easily-accessible thorium (especially in the monazite sands in Kerala and Odisha), one of the largest in the world and relatively little uranium. With much restriction on import of uranium, India has planned to use thorium in a big way. The nuclear power program of India has been planned in three stages.

Stage-I

Power is generated in thermal reactors using natural uranium as fuel with heavy water as moderator. Natural uranium contains 0.7% of U-235, the fissile material and balance is mostly U-238 which is not fissile. But some U-238 absorbs a neutron and is converted to U-239 which then transforms to plutonium-239 (Pu-239) by successive radioactive decay. Pu-239 does not occur in nature.

Stage-II

Pu-239 is fissionable and can be used in plutonium-based reactor to produce electricity. Th-232 will be put in the plutonium reactor and on absorbing one neutron; it turns into U-233.

Stage-III

U-233 will be used in the third generation advanced heavy water reactor. Fed with thorium, this U-233 breeder would produce power and cook up more U-233. 75% of power will be from thorium.

India has a 40 MW Fast Breeder Test Reactor at Kalpakkam in which ThO_2 is irradiated, producing U-233. India currently envisages meeting 30% of its electricity demand from thorium by the year 2050.

Other uses of Thorium

When heated in air, thorium metal turnings ignite and burn brilliantly with a white light. Because of this property, thorium is used as light bulb elements, lantern mantles, arc-light lamps, welding electrodes and heat-resistant

ceramics. Glass containing thorium oxide has a high refractive index and is used in high quality lenses for cameras and scientific instruments.

Thorium is a component of the magnesium alloy series, called Mag-Thor, used in aircraft engines and rockets and imparting high strength and creep resistance at high temperature. Thorium is also used in its oxide form in gas tungsten arc welding to increase the high-temperature strength of tungsten electrodes and improve arc stability.

Nuclear Power Plant

Conclusion

Canada, Germany, India, the Netherlands, the United Kingdom and the United States of America have made experiments using thorium as a substitute nuclear fuel in nuclear reactors. There is a growing interest in developing a thorium fuel cycle due to its safety benefits, absence of non-fertile isotopes, and its higher occurrence and availability when compared to uranium. India's three stage nuclear program is possibly the most well-known and well-funded of such efforts in the world.

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RICE STRAW - AN ALTERNATE ENERGY SOURCE FOR RURAL INDIA

Prof. Gopendra Kishore Roy

Out of the different power generation routes, thermal power from coal, gas and oil accounts for about 70% of total generation. In addition, the burning of the fossil fuels is associated with the release of solid (particulate matter) as well as gaseous pollutants (toxic and green house gases) which are potential threat to our environment. However, an ever-increasing demand of the society for energy against the backdrop of rapidly-dwindling reserves of nonrenewable fossil fuels, has necessitated the hunt for alternate and renewable energy sources.

Rural India energy scenario- A few 'hard facts':

- About 70% Indians living in rural areas continue to use animal dung, agricultural wastes and fire wood as fuel for their cooking.
- The thermal efficiency of the above traditional sources used in conventional heating appliances (chulhas) is as low as 15%.
- Concentration of particulates in households burning biomass is 2000µg/m^3, which is much higher than the permissible limit of 150µg/m^3.

- For domestic lighting 55% of the rural households depend on electricity and the balance on kerosene.
- Use of traditional fuel is estimated to cause around 400,000 premature annual deaths due to various respiratory problems.

Domestic wastes, which include agricultural waste and other biomass generated in rural households can be a potential source for energy.

Rice Straw: A potential energy source:

After China, India is the largest producer of paddy. In 2011-12,India produced about 105 million tons of paddy with nearly 140 million tons of paddy straw. Of the straw produced, about half is used as animal fodder. While a small amount is consumed in brick kilns, mushroom cultivation, paper and packaging industries, the rest is mostly burnt in the fields. For example, Punjab, which contributes about 60% of the total rice production of the country burns nearly 12 million tons of rice straw in the field per year. A recent satellite image released by NASA showing millions of hectares of field across Punjab covered with fire and smoke received international attention. Burning of rice straw emits gases like carbon dioxide, methane, carbon monoxide, nitrogen oxide, sulphur oxide and large amount of particulate matters, which adversely affect human health as well as the environment.

Composition of rice straw:

Constituents	Amount%
Cellulose	43-49
Hemi-cellulose	23-28
Lignin	12-16
Ash	15-20
Silica	9-14

Calorific Value : 15.2-17.5KJ/Kg.

Power generation from rice straw:

At present, a good amount of rice straw is used in the rural household for cooking in the traditional appliances (open chulhas) where hardly 15% of the heat content is utilized. The effective utilization of the potential heat of the rice straw can be achieved through power generation.

There are primarily two different routes to generate power (electricity) from rice straw;

(i) By converting it into briquettes (also called 'White coal or 'Bio-coal')

(ii) By direct firing

Power generation from rice straw briquettes ;

Briquettes are high density solid blocks formed out of loose low density straw through the process of briquetting. A power driven press raises the temperature and pressure of the fine pieces of straw to 120^0C and 150 Mpa respectively thereby making the lignin of the straw to melt. The liquid lignin binds the fine straw pieces and when cooled re-solidifies binding the materials to uniform solid briquettes(Fig.-1).

Fig.1: straw briquettes

Briquettes are easy to store, transport and fire. In addition, these are cleaner to handle and contribute less to the air pollution compared to direct burning of the straw.

The straw briquettes can be used for any type of thermal application like steam generation in power plant boilers directly or by the co-firing technique, where a portion of the coal in an existing power plant furnace is substituted by straw briquettes. Recently, the Ministry of New and Renewable Energy has issued directive to use up to 20% mix of coal to fire biomass plants (using briquettes of straw or other biomass) thus allowing them to run during off-cycles for agro-wastes like straw etc.

Power generation by direct firing of straw:

In a direct combustion system, biomass is burned in a combustor or furnace to generate hot gas, which is fed into a boiler to generate steam to be expanded through a steam turbine or steam engine to produce mechanical or electrical energy (Figure-2).

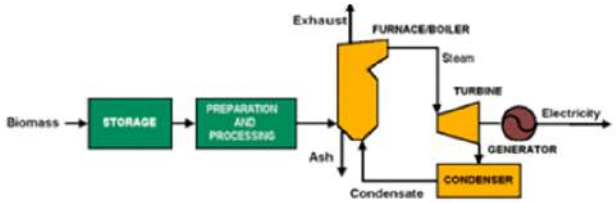

Fig.-2 : Direct straw (bio-mass) combustion steam-turbine- system of power generation:

Small-scale (100 to 1,500 kW) steam engine/gen-sets and steam turbines (100 to 5,000 kW) that are fueled by solid biomass are currently available in Europe.

In India, the pioneering work in this direction has been done by Punjab Biomass Power Limited. A 50:50 joint venture between Bermaco Group (a supplier of boilers and other power plant equipments) and Gammon Infrastructure Projects Ltd, has completed a 12MW plant near Ghanaur village in the Patiala district of Punjab with paddy straw as fuel. The feeding of the fuel is by a long belt conveyor after the shredding of the straw to small pieces. An electrostatic precipitator ensures minimal atmospheric pollution.

Bermaco-Gammon plans for nine more similar projects in Punjab, six in Haryana. Bermaco Group also plans for 26 units in Bihar to be followed by a series of more projects in other states in different joint ventures with power trading corporation and other corporate bodies. Bermaco is planning to set up 20 biomass plants generating about 300MW during the next three years and about 1000MW during the next six years. Locating biomass-based power plants in rural areas of most of the districts in India will be of direct benefit to the rural communities.

Conclusion:

Energy sufficiency or energy security, is, of paramount importance for the economic development of a country. While adequate steps have been taken to cater to the ever-increasing energy need in keeping with the changed quality of life of the urban population and that of the industrial sector, the energy security of rural India has so far not been a very significant concern to the planners and economists. Fora balanced economic development of the country and improvement of the quality of life in the rural sector, proper attention is warranted towards the energy scenario of rural India. In view of the huge tonnages of agro-residues like rice straw available in the country, medium-sized biomass-based power plants can quickly augment our power generating capacity in most of the rural areas thereby offering a viable solution to the rural energy security in the near future.

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ATOMIC ENERGY AND RADIATION : MYTHS VS. REALITIES

Rajata Kumar Mansingh

Atom is the smallest possible particle of an element with a diameter of the order of ten billonth part of a metre. Each element has its own characteristic atoms. Just as a wall is built of bricks or stones, billions and billions of atoms make matter. All living and non-living things are made of matter.

In 1896, French physicist Henry Becquerrel discovered radioactivity of Uranium salts by its effect on a piece of unexposed photographic film. Later in 1897 Marie Curie and her husband Pierre Curie succeeded in isolating two more radioactive elements Polonium and Radium. Energy coming out from a radio-active source is in the form of a radiation. Radioactive atoms emanate radiation termed as Nuclear Radiation. The three main types of radiations emitted by radioactive substances are alpha (α) rays, beta (β) rays and gamma (γ) rays.

Exposure to radio-active sources, and medical X-rays delivers a large dose. Those working in the nuclear industry, coal miners and X-ray technicians etc. subjected to such exposures may higher risks than the general public. Therefore it is strictly regulated by government exposure limits and monitoring. The effects depend on the levels of exposure and the period of time over which the radiation

is received. We can broadly classify exposure levels as low, moderate and high. Each one of us is exposed to natural radiation which can be classified at a low level. The medium level of exposure is up to about 100 times as much as the natural one and the levels of exposure beyond these can be classified as of high levels. Exposures at moderate and low levels over long period of time cause only delayed effects. Appearance of cancer is the most important among these. We now know that cancer can be caused by many things including the various toxic chemicals always present in the air we breathe, the water we drink and the food we eat. There is no clear evidence that cancer is caused by lower doses. The statistical data available provide no definite evidence and the interpretations vary. The absence of clear indications arises because there are many different causes of cancer. Yet to be on the safe side, it is always assumed that cancer can appear due to low level of exposures and necessary radiation protection measures must be taken. Exposures at high levels received over a short period of time produces immediate symptoms like nausea and vomiting but there is no threat to life. But as dose levels increase, the chances of recovery diminish. The levels that can lead to loss of life are about 1000 times greater than the low levels of exposure as found in Nature.

Major public perceptions leading to concerns about nuclear energy is based on four wide spread myths, needs to be answered and explained carefully which is quite challenging.

- **The first myth is that;** 'Nuclear reactors are likely to breed weapons' has little foundation in experience.The first five countries to build Atomic bombs did so before moving to electricity generation through nuclear power reactors. Thus, technically speaking, power reactors were and are not necessary intermediate steps for making nuclear bomb.

The fear of nuclear proliferation is simply misplaced in the global warming debate. Currently maximum carbon emission is found in countries which have nuclear weapons. Thus, almost every where the reduction in carbon emission could yield important benefits for climatic protection. Proliferation is not even an issue in this context.

- **The second myth is that;** 'A nuclear power plant itself is like a bomb which, in case of an accident, can explode and release fatal doses of radiation'. These fears are based on the collective memories of accidents at Three Miles Island and Chernobyl.

The simple truth about the accident at Three Miles Island is that public health was not at all endangered. The only outside effect was an inconsequential release of radiation which was negligible when compared to natural radiation in the atmosphere.

The Chernobyl accident was a tragedy with serious human and environmental consequences but we must remember that even this accident involving massive release of radiation did not result in anything so much as to be comparable to an atomic explosion.

- **The third myth** is about the question of Nuclear Waste and its Management. As per the myth, nuclear waste is an insoluble problem a permanent and accumulating environmental hazard.

On the contrary, it is the fossil fuel and not nuclear power that presents an insoluble waste problem. This has two aspects. One is the huge volume of waste products, primarily gases and particulate matter. Another is the method of disposal which is dispersion into atmosphere. None of the above two problems seems recoverable through technology.

- **The fourth myth** is about radiation and any thing associated with it. No doubt, exposure to large doses of radiation can be dangerous as they may cause two types of biological effects i.e. Somatic effect and Genetic effect.

Toxic chemicals released from chemical and petrochemical industries, coal fuelled power stations and burning of fire wood and cow dung can also cause similar biological effects.

We live in a naturally radioactive world. We are exposed to radiation from the sun and outer space, also from the naturally occurring radioactive materials present in the earth, the house we live in, the buildings where we work, the food and drink , we consume. There are radioactive aerosols and gases in the air we breathe; and even our own bodies contain naturally occurring radioactive elements. This is inescapable.

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PLANNING AND MODELLING FOR ENERGY-EFFICIENT BUILDINGS

Utkal Ranjan Mohanty

Planning is the process for developing an unique system and ideal approach to fulfil a predefined goal and objectives on the basis of assesing the present scenario. It is meant for betterment which can be the strengthening of resource base, efficient resource utilization and fulfilment of human needs. On the other hand, modelling is the process of generating abstract, conceptual, graphical or mathematical models of an event. Modelling is an essential and inseparable part of all scientific activity, and many scientific disciplines have their own ideas about specific types of modelling. There is an increasing attention for modelling in fields such as philosophy of science, systems theory and knowledge visualization. Traditionally, the formal modelling of systems has been via mathematical model which attempts to find analytical solutions enabling the prediction of the behaviour of the system from a set of parameters and initial conditions.

Meeting the energy access, challenges and ensuring lifeline supply of clean energy to all, requires planning in capacity building and supply. The challlenge is to ensure cost-effective energy supply at the same time conforming to norms set for minimizing global warming.

Therefore, a precise estimate of demand is important for the purpose of setting tariffs.

In the present situation, many buildings even during the day (when there is sunshine) need to switch on the lights, which is wastage of energy. The buildings also require a lot of cooling for comfort. If the buildings are designed for north south orientation and glare free daylight with appropriate shading devices that would reduce a lot of energy requirment in the buildings and also if the predominant wind direction is taken into account while planning for buildings, then this would reduce a lot of lighting and cooling requirement of the building. Besides, if the building walls are properly insulated this would also reduce a lot of cooling requirement.

Each and every building should be a hub of innovation and follow energy efficient norms. The building should be aesthetically designed with several features of passive solar design, energy-efficiency and water and waste management systems. Some detailed outlines of the different energy conservation measures that should be taken at any building; are as follows.

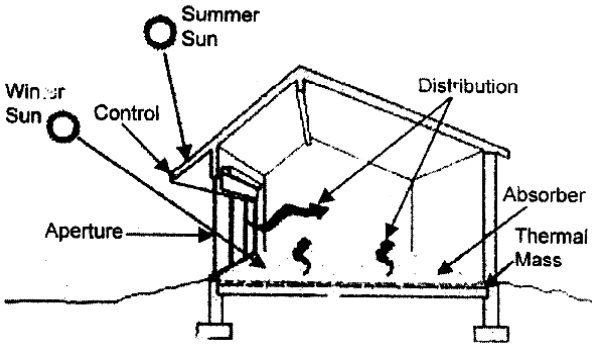
i. Passive solar design

ii. Glare-free day light

iii. North South Orientation

iv. Minimum windows on East, West & South facades

v. Shading devices on the predominant wind direction should be taken into account in designing the open space.



Energy-efficient-lighting and day light integration

i. Recess mounting luminaire fitted with CFL for task lighting.

ii. Surface mounted single/twin horizontal mounting CFL down lighter for task lighting and common areas.

iii. High lumen output and controlled Light distribution.

iv. Fitted with mirror optics reflectors and baturing louvers for glare-free uniform illumination.

v. Energy saving electronic ballast should be used properly.

vi. Lighting load can be reduced from 2W/ sqft to 1W/sqft.

vii. Where daylight is available, fixtures may be fitted with continuous dimming electronic ballast. These fixtures may be controlled by light sensors.

viii. In areas with non-uniform illumination, occupancy sensors should be installed.

ix. Overall energy saving potential is 70% approximately.

Thermal Insulation of Walls :

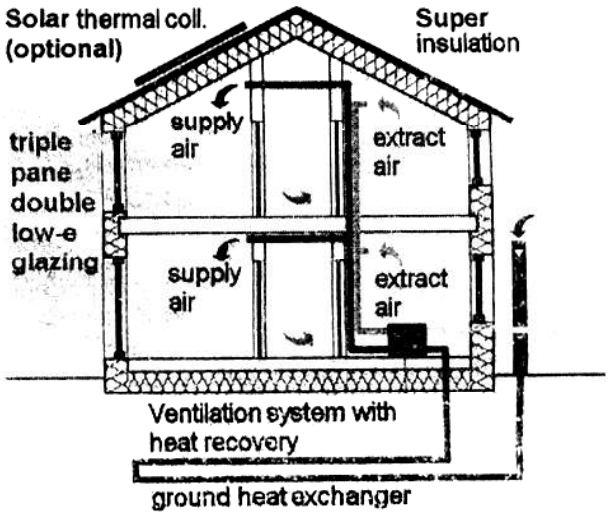
Use of efficient double glazing window units help significantly the heat gained through window glazing in the summers and the heat lost in the winters without compromising on the day lighting integration and the levels of

visual comfort. The walls that are exposed to the harsh solar rays have a stone cladding which is fixed to the wall by channels. The air gap between the wall and the stone cladding by itself acts as an insulation layer. On the facades rock wool insulation is also provided in the wall. Energy efficiency is further proposed to be enhanced by insulation in the roof slab. The campus should be equipped with three types of cooling systems;

(a) Variable refrigerant system volume (VRS) system - This modern type of Air conditioning system which is similar to a split AC is highly efficient under partial loading conditions and beneficial to areas with varying occupancy. It allows customized control of individual zones, eliminating the use of chilled water piping, ducting and piping room.

(b) Earth Air Tunnel (EAT) - The EAT can be used in rooms which uses the heat sink property of the earth to maintain comfortable temperatures inside the building. The air that passes through the buried pipes gets cooled in summer and heated in the winter. Depending upon the severity of the climate, supplementary system can be used. This gives energy saving of approximately 50% as compared to conventional system.

(c) Thermal Mass Storage(TMS) - TMS involves storing energy when available and using when required. Here cooling of thermal mass is done during night hours. This thermal mass is used to cool air in day time. This system gives an energy saving of almost 40%.



Water Management :

Buildings should be provided with low-flow fixtures such as dual flush toilets and sensor taps for both saving energy & water. This would result in 25% saving in water use.

Waste Water Utilization :

Treatment of waste water generated from biological process is done by a combination of micro-organisms and bio-media filter. Low area also requires construction of this type of treatment plant. Treated water meets the prescribed standards for land scape irrigation. On the other hand, very low energy consumption is needed for operation of treatment plant.

Rain Water Harvesting :

Rain water run-off from roof and the side will be used for recharge aquiter through (i) Enhance the sustainable yield in areas where over-development has depleted the aquifer (ii) Conservation and storage of excess surface water for future requirements and (iii) Improve the quality of existing ground water by dilution.

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GLOBAL CLIMATIC CHANGE AND ITS IMPACT ON THE SEA-LEVEL

Girija Prasad Mohapatra

One of the major concerns of the scientific community and the government agencies is the present 'Climate change' and its impact on the earth that has direct societal bearing and could last till the ongoing century and beyond. Scientific derivations has proved that the atmosphere is rapidly getting warmer to the extent of temperature rise by 1^0C (18^0F) during the last 100 years. This change has followed the end of another recent cold period known as the "Little Ice Age" in the 19th century. Consequent to this global atmospheric raise in temperature the sea-level has been rising about 1 to 2 millimeters per year. This rise of sea-level is ascribed to the reduction in volume of ice caps, ice fields in the polar region, and mountain glaciers in addition to the thermal expansion of ocean water.

Several models have been worked out to decipher the rise of temperature by another 50 or 100 years but there is no unanimity in projection by which the temperature rise is expected within the above time frame. The models and projections by IPCC (Inter-governmental Panel for Climate Change) are widely referred to Figure-1 and 2 although not free from generating debates. The exponential rise in atmospheric temperature undoubtedly relegated to the factor of emission of carbon dioxide due to the factors related to industrial growth and vehicular movement.

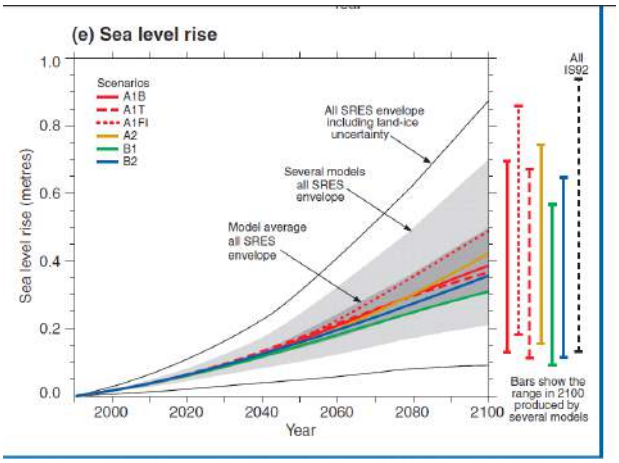


Figure 1 - Projected sea-level rise model by IPCC from 2000 to 2100AD

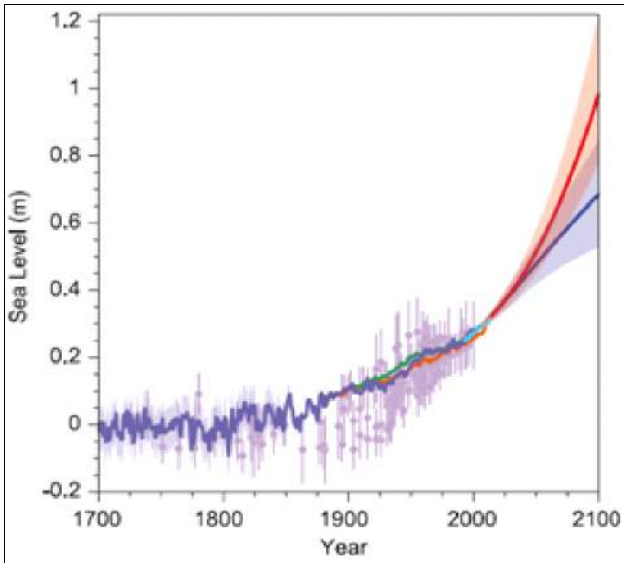


Figure-2 Sea-level changes during last three hundred years and projection up to 2100 AD by IPCC.

The Government of India has formulated the 'National Action Plan on Climate Change (NAPCC)' with a view to enhancing the ecological sustainability of India's development.

Sea-level Change:

The most significant aspect of atmospheric temperature rise is rise in sea-level and inundation of coastal tract including

wetland. The rise of the sea-level is primarily due to expansion of warming oceans and fresh water input from the polar and mountain glaciers. It is also estimated that thermal expansion is the significant contributor to the Sea-level rise than the melting of ice. The impact due to storms could be more severe than actual rise in the sealevel by 2080. About 70% of the global coastlines are projected to experience a relative sea-level change within 20% of the global mean sea-level change (IPCC-2013).

IPCC report indicates that "Global Sea-level is projected to rise during the 21st century at a greater rate than during 1961 to 2003. As per the report, global Sea-level reaches 0.22 to 0.44 m above 1990 levels, and is rising at about 4 mm/ yr^{-1}." However, this rise will not be even but vary from place to place.

Basically the expansion of the ocean water will interact with the coast in a faster way causing imbalance in sediment supply in the active coastal zone as a result of which there will be landward migration of the coastline inundating the low-lying coast and wetland including the estuarine, lagoons, inlets. The river mouths being the most dynamic place of interaction of rivers and the sea, the locus of the delta building will be in a regressive stage, unless the sediment supplies are in dynamic equilibrium with the coastal processes. In other words, a rising Sea-level implies an increase in sediment demand, which if not supplied results in coastal retreat. The corollary effects will be on the ground water through saline water incursion, affecting drinking and agricultural water. Several studies have indicated that the coastal upwelling pattern shall have a dynamic change which may also affect the marine ecosystem in the sea.

In addition to coastal inundation the other factors that are thought to influence the coastal zone are increased storminess, higher waves and changes in prevalent wind directions. It is a matter of concern to gauge the circulation pattern in the oceans which could affect the prevailing monsoon (?). The reduction of sediment to the coast is estimated in the tune of 1.4 ± 0.3 billion metric tons per year, because of retention within reservoirs. Over 100 billion metric tons of sediment and 1 to 3 billion metric tons of carbon are now sequestered in reservoirs constructed largely within the past 50 years. This will add to the sediment budgetary stress in the coastal zone in addition to the Sea-level rise by climate change.

Climatic Change in the Geologic Past:

In the earth's history, several such climatic variations have taken place which could be more severe in magnitude than the present one. There the impact was on the organism or evolving organism other than mankind.

The sea-level changes for the last 300 million years have been reconstructed by seismo-stratigraphy, i.e. from the seismic characteristic of the geologic formation (Figure-3). Since the Triassic period (say about 260 million years ago) till the present day nearly 100 global Sea-level changes have been identified with a periodicity of 100,000 years.

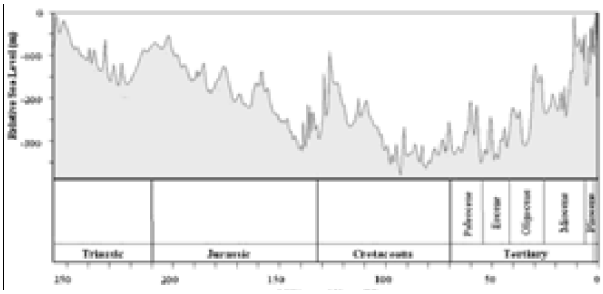


Figure-3 Sea-level variation in the last 260 million years past

Since middle of Cretaceous (100 my), the frequency of Sea-level fluctuation was relatively more. Several factors can be attributed towards the sea-level oscillation such as;

- Variation in the volume of ocean basins
- The mass of ocean water due to density variation
- Local or regional tectonics
- Gravitational and rotational variation of the earth
- Changes in atmospheric pressure winds, oceanic circulations etc. (Pirazzoli, 1991).

For the last 2 million years (Pleistocene), there were four major glacial and interglacial periods, which are referred to as Gunz, Mindel, Riss and Wurm in Europe (Figure-4). During the last interglacial between about 120,000-140,000 years ago, atmospheric and water temperatures are believed to have been somewhat higher than present-day values the magnitude of which is still debated.

The last glaciations reached its peak around 20000-18000 years back (Figure-4) and its maxima (Last Glacial Maxima; LGM) in India is recorded in the same period which is in confirmation with the global curve, several phases of sea-level transgression and climatic

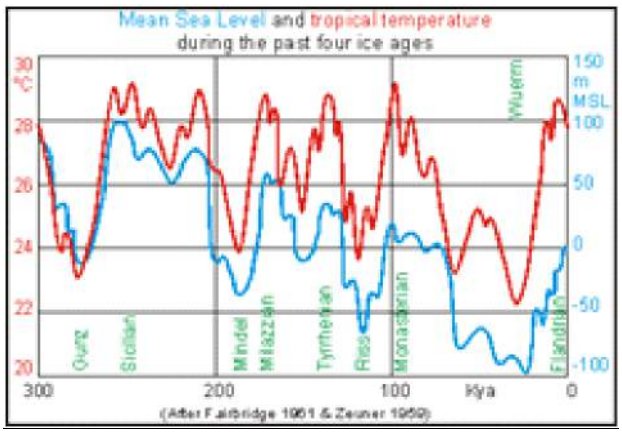
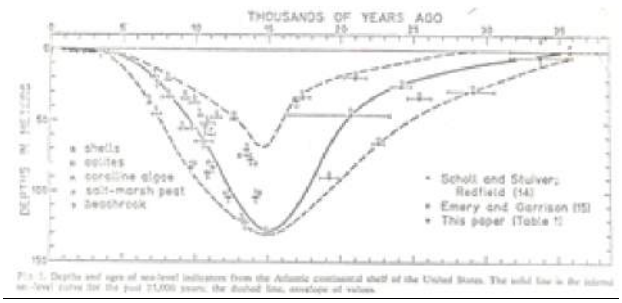


Figure-4 Glacial and inter-glacial period during Pleistocene period.

changes since last Glacial Maxima has been recorded in Indian Continental Shelf (Mohapatra etal 2002, 2003, Faruque etal 2008). During the LGM the sea-level was nearly 125 m below the present one. Due to the climatic variation the sea-level started to rise in pulses till it was almost stabilized around 6.5 to 7.0 thousand years back (Figure-5).



(Figure-5, Sea-level curve during last 35000 years back till present)

Since the LGM, various relative sea-level curves have been worked out (Figure-6), but the trend is almost alike with minor variation by different workers in different geographical location of the world.

The sea-level can be construed to have stabilized in the east coast of India around 6500 yrs BP. (Bruckner,1989). This was followed by

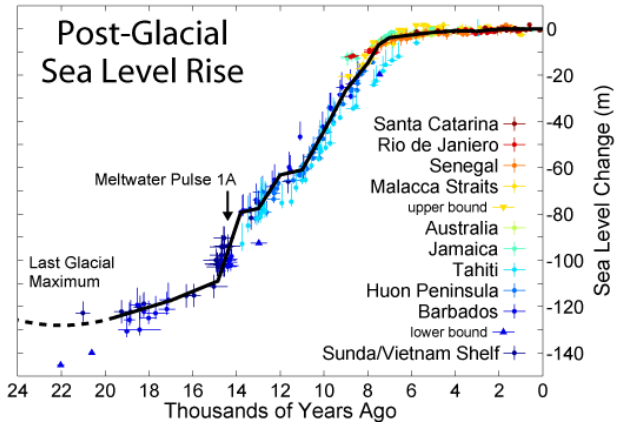


Figure-6 Post glacial Sea-level rise since last 20000 years back.

the deltaic build up by the rivers, particularly Mahanadi, Godavari and Krishna, where as the Cauvery shifted its course from Palk Bay to the present position during the same period. During the post sea stabilization period the Sea-level was 3 m higher than at present before 5.6 k. yrs. and also between 4.3 to 2.5 k. yrs B.P. (Banerjee, 2000).The coralline terraces of Rameswaram, Mandapam sandstone (Figure-7) at the southern side of the Indian peninsula corroborate a higher strand line than the present during the post sea stabilization period.

Other Factors related to sea-level rise:

The temperature and sea-level rise will be associated with several other oceanic parameters such as

- Alterations in precipitation patterns and subsequent increase of freshwater, nutrients, and sediment to the sea.

Figure-7 Mandapam sandstone at the southern side of the Indian peninsula corroborate a higher strand line than the present during the post sea stabilization period

- Increased ocean temperature will result in alterations in circulation patterns, changes in frequency and intensity of coastal storms, and increased levels of atmospheric Carbon Dioxide. The frequency of more storms and tropical cyclones shall have tremendous stress on the coastal belt including the estuaries and lagoons.
- Higher water temperatures and changes in freshwater delivery will alter estuarine stratification, residence time, and eutrophication.
- The corals of the Indian coasts and Islands may have the bleaching affect and growth

Table-I

Ecoregion*	Total Area (km^2)*	Area inundated by 1m sea-level rise (km^2)	% inundated by 1m sea-level rise	Area inundated by 6m sea-level rise (km^2)	% inundated by 6m sea-level rise
Orissa semi-evergreen forests	21,321	1,539	7.2	4,229	19.8

will be affected because of the acidification of the coastal water. (Dissolved carbon dioxide).

- It is also reported that "Ocean warming is expected to cause pole-ward shifts in the ranges of many other organisms, including commercial species, and these shifts may have secondary effects on their predators and prey" (Hoozemans et al.,1993).

Indian scenario:

India has 7500 km length of coastline and many major cities such as Kolkata, Visakhapatnam, Chennai, Kochi, Mumbai etc are situated right on the coast with high population density. Indian coast assumes its significance because of the industrial activities, concentration of population, and trade related activities at the ports. Many of the oil exploration and refinery facilities are located in those cities. Besides discharge of waste effluent and municipal sewage etc affects the coastal area.

In the event of Sea-level rise by 1m an aerial extension to the tune of 13,973 square kilometer (3%) of the Indian subcontinent is estimated to be prone for inundation. In the extreme case of 6m rise the inundation of 60,497 square kilometer (14%) of the land area is estimated (Zafar-ul-Islam etal, 2013). Scientists of National Institute of Oceanography have estimated that the Sea-level in Indian coast is rising by 1.09 to 1.75 mm per year where as that Gangetic Delta has an anomalous rise to the tune of 5.74 mm per year.

Another extreme case of 7m projection Global Sea-level Map by Geology.com indicated an inundation even up to 60 km from the present shoreline in Mahanadi, Brahmani delta. This includes major part of the districts of Jagatsingpur, Kendrapara, Bhadrak of Odisha. An estimate of the affected area of Odisha has been worked out by Hossain as in the following table. The tropical cyclones in the east coast has maximum incidence of heat in Odisha coast (Figure-8), if the frequency of such storms and cyclones increases as predicted, a considerable loss could be apprehended.

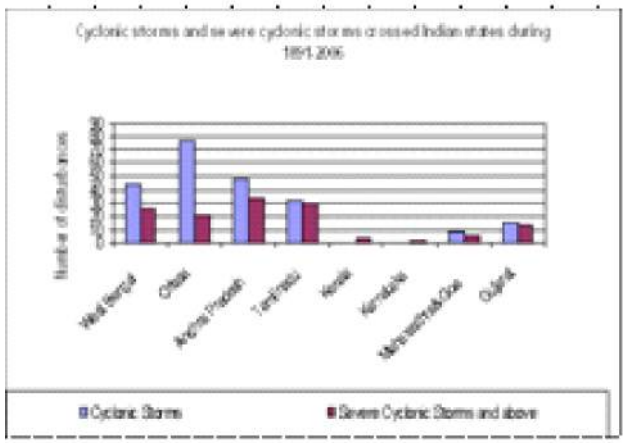


Figure-8 Incidence cyclonic storms in East coast of India

Conclusion:

So far the research undertaken by the governmental and other scientific agencies and individuals, has established that the earth is witnessing a climatic change due to rise in atmospheric temperature and consequently the Sea-level rise at global level is inevitable. However, some of the riddles are to be analyzed and synthesized prior to any meaningful conclusion:

The climatic changes of the present magnitude or more have happened in the history of the earth. This has no impact on the human race as it was yet to evolve.

The climatic change is cyclical. The periodicity may go beyond thousands of years. We are now in interglacial period and are not sure about its continuation.

The sea-level rise will affect the continents differently. Each country, region and local geographical, geological and anthropogenic factors have direct bearing on the magnitude of the sea-level rise.

There could be several variable factors and derivatives (coastal settings, climate diversity, coastal and oceanic dynamics) that need to be analyzed for the Indian sub-continent, for evolving an appropriate model for the projection of Sea-level change up to 2100 AD. Projections of future relative Sea-level changes at specific locations presuppose an understanding of the physical processes that operate. IPCC in its 2013 assessment reported that regional sea-level rise could behave independent of global rise and could vary on the factors of dynamic redistribution of water masses due to wind, air pressure, fresh water influx, oceanic currents, air-sea heat transaction etc.

Although all possibilities are factored in global context, a micro level research and study is essential so as to mitigate any contingency. If it is assumed that the temperature is rising since the last part (nineties) of the 20th Century, a base level data can be created with the existing parameters and if any gap is there the same can be abridged without further delay. It has been indicated that coastal protection strategies and changes in the behavior or frequency of storms may be more important than the projected acceleration of sea-level rise in determining future coastal erosion rate.

The recent naturals such as cloudburst in Uttarakhand or Phailin (cyclone) in Odisha or the frequent land slides in the Himalayas, coastal erosion in different parts of India etc. are to be corroborated with the atmospheric change. It has to be established that there is a deviation from the normal which is related to climate change.

When it is expected that the mountain glaciers would melt, its impact on the coast and deltas due to more fresh water and sediment influx has to be considered. Sediment and fresh water input from the riverine sources such as Ganges, Mahanadi-Brahmani, from Godavari, Krishna and Cauvery as these rivers have formed major deltas, draining major part of Indian Peninsula and extra Peninsula. Considerable variation in salinity and density exists all over the coastal areas due to abundant freshwater discharges, especially during the rainy months. The coastal circulation is mainly driven by river runoff and wind thrust and is influenced by branches of the Equatorial Current system. Strong wind-driven upwelling and sinking are seen along the eastern Indian coast.

It has been observed that many of the coastal erosion are related to the dynamics of major river mouth as substantial changes takes place at or near the river-mouths due to interaction of rivers and open sea. The riverine fresh water input combined with monsoonal wind driven current causes dynamic changes in the coast. A detailed physical parameter has been described by Varkey etal, 1996. On the available physical parameters modeling of the circulation is unique.

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And God said "Let there be light";
and there was light.

- *Genesis*

Nature, and Nature's laws, lay hid in night;
God said, Let Netwton be ! and all was light.

- *Alexander Pope*

Maxwell could say, when he was finished with his discovery. 'Let there be electricity and magentism, and there is light.'

- *Feynman*

With the genius, nature remains in eternal union :
What the one promises, the other certainly redeems.

- *Schiller*

SMOKELSS TOBACCO AND CANCER

Prof. Niraj K. Tripathy

The term smokeless tobacco implies use of unburned tobacco in the finished products. A variety of smokeless tobacco products are available for oral or nasal use. Products intended for oral use are sucked, chewed or applied to the gums or teeth, while fine tobacco mixtures are usually inhaled into the nostrils.

Tobacco is obtained from the tobacco plant. This plant is thought to have originated on the mainland between North and South America. Its cultivation probably started nearly 5000 years back. Tobacco seeds were discovered during archaeological excavations in both Mexico and Peru around 3500 BC indicating that tobacco was an article of value to the inhabitants of these areas (Voges, 1984). American Indians were probably the first people to smoke, chew and snuff tobacco, as early as the 1400s (Christen *et al.*, 1982). According to the same authors these natives inhaled powdered tobacco through a hollow Y-shaped piece of cane or pipe by placing the forked ends into each nostril and the other end near the powdered tobacco. This instrument was called a *'tobago'* or *'tobaca'* and the word was later changed by the Spaniards to 'tobacco'. In 1499, Amerigo Vespucci found Indians on Margarita Island, off the coast of Venezuela, who chewed a green herb known as tobacco to quench their thirst as it increased salivation. He also reported that the Indians chewed tobacco leaves to whiten their teeth and to alleviate hunger (Voges, 1984).

The Native Americans, chewed tobacco as it was thought to have several medicinal uses, viz., to alleviate toothache, to disinfect cuts by spitting the tobacco juice and saliva mixture onto the wound, and to relieve the toxic effects of snake, spider and insect bites (Axton, 1975). When smoking was forbidden on British naval vessels for fire hazard, sailors began chewing tobacco and snuff. In Europe, tobacco was regarded as a prophylactic during the plague and, for those who did not like smoking, chewing was an alternative. Chewing tobacco became popular in the USA only during the first half of the 19th century (Gottsegen, 1940). Although by the 1890s, public outcry made tobacco chewing a socially unacceptable behaviour and unlawful in public places (Christen et al., 1982) and Anti-spitting laws were passed in New York and Philadelphia in 1896 and in Toronto, Canada, in 1904 (Kozlowski, 1981), chewing, nevertheless, remained the dominant form of tobacco use in America until the expansion of the cigarette industry in 1918 (Maxwell, 1980).

The native populations of Brazil were the first people known to use snuff. The Dutch, who named the powdered tobacco 'snuff', were using the product by 1560 (Christen *et al.*, 1982). In India, dry snuff was once commonly used nasally, but is now used mainly orally. It is frequently prepared at home by roasting coarsely cut tobacco on a griddle and then grinding it to a fine powder.

The tobacco used in a particular product has a decisive influence on its chemical composition. It varies with the plant species

used, curing, processing and storage. During product manufacture, tobacco is blended to achieve a specific percent of nicotine content and pH. The pH greatly influences the concentration of unprotonated and bioavailable form of nicotine. The components of tobacco include alkaloids like nicotine (85-95% of total alkaloids), terpenes, polyphenols, phytosterols, carboxylic acids, aromatic hydrocarbons, aldehydes, ketones, amines, nitriles, N- and O-heterocyclic hydrocarbons. Ammonia, ammonium carbonate and sodium carbonate are applied to control nicotine delivery by raising pH of the product and subsequently the level of unprotonated nicotine which is most readily absorbed through the mouth into the bloodstream (Djordjevic et al., 1995). The majority of commercial tobacco products are made from the plant N. tabacum species, grown throughout the world with great variation in alkaloid content. In randomly cultivated varieties, the alkaloid content ranges between 0.17 and 4.93%. Another species, N. rustica is cultivated in Eastern Europe, Asia Minor and Africa where the cured leaves may contain up to 12% of nicotine.

Multiple carcinogens have been identified in smokeless tobacco products (IARC, 2007). These include: *(a) Tobacco-specific N-nitrosamines* like the carcinogens N^1-nitrosonornicotine (NNN), and 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK) formed from tobacco alkaloids during curing, fermentation and ageing; *(b) N-Nitrosamino acids* with secondary amino groups have been identified in smokeless tobacco. Some of these include N-nitrososarcosine (NSAR), N-nitrosoazetidine-4-carboxylic acid (NAzCA), 3-methylnitrosamino) propionic acid (MNPA), 4-(methylnitrosamino) butyric acid (MNBA), N-nitrosoproline (NPRO), N-nitrosohydroxyproline (NHPRO) and so on (Hoffmann et al., 1995). Of these, NSAR, MNPA, MNBA and NAzCA are carcinogenic in experimental animals; *(c) Volatile N-nitrosamines* which include N-nitrosodimehtylamine (NDMA), N-nitrosopyrrolidine (NPYR) and N-nitrosopiperidine (NPIP); *(d) PAHs* including benzo [a] pyrene, benz [a] anthracene, chrysene, benzofluoranthenes, and dibenz [a,h] anthracene. Other carcinogenic compounds in smokeless tobacco products include formaldehyde, acetaldehyde, acrolein and crotonaldehyde (Stepanov et al., 2010). Further, the nitrite/nitrate content strongly influences the levels of carcinogenic nitrosamines in the product.

There is sufficient evidence in humans that smokeless tobacco causes cancer of the oral cavity (IARC, 2012). Studies on the natural history of oral cancer suggest that several types of potentially malignant conditions like leukoplakia (white patch) and erythroplakia (red patch) precede the development of cancer of the oral cavity (Pindborg et al., 1996). Chewing khaini (raw tobacco with lime) leads to cancers of the gall bladder (Shukla et al., 2008). Strong positive associations for cancers of the tongue and floor of mouth, gingiva and buccal and labial mucosa were observed in a study in India (Jacob et al., 2004). According

to Phukan et al. (2001) it involves the risk of oesophageal cancer. Further, most of the products are reported to be genotoxic in both in vivo and in vitro test systems.

India is one of the major producers of smokeless tobacco products in Asia. It is processed differently to produce a variety of tobacco products. The presence of a strong domestic demand for tobacco products for chewing and application has influenced the cultivation of tobacco plants in some states like Tamil Nadu, Uttar Pradesh, Bihar, West Bengal and Orissa (Reddy and Gupta, 2004). In 2002, 40.6% of the total tobacco produced was used in cigarettes, 33.3% in bidi production and 12.4% for manufacturing smokeless forms.

Betel leaf, areca nut, slaked lime and tobacco in various forms is consumed in different parts of the country. In several parts of the world, smokeless tobacco is invariably chewed with lime which is responsible for highly alkaline pH (Nair et al., 1992), facilitating ready absorption of nicotine in the oral mucosa. In addition, several other products are also in great demand in India. Gutka is commercially made of sun-dried finely chopped tobacco, areca nut, slaked lime, catechu, flavourings, and sweeteners and sold in attractive pouches. Khaini is made from sun-dried or fermented coarsely crushed tobacco leaves. Mawa is a product made from sun-cured areca nut, crushed tobacco leaves and slaked lime. Naswar/nass is prepared from sun-dried powdered tobacco, oil, flavourings, colourings and slaked lime. Tobacco leaves boiled with lime and spices until dry with colours and flavours is used to prepare zarda which is chewed with areca nut and spices and is an important component of betel quid. Dry snuff is fire-cured, fermented and powdered tobacco used for sniffing. Gudhaku is a paste made of powdered tobacco and molasses used as a tooth paste while Khiwam is a chewing paste of tobacco extract, spices, and additives. Gudaku is applied to the teeth and gums with the finger, by people in the States of Bihar, Orissa, Uttar Pradesh and Uttaranchal.

The use of tobacco, including smokeless tobacco, has been controversial since its introduction several centuries ago. In 1590, tobacco was prohibited in Japan, and users either lost their property or were jailed. During the mid 1600s, Pope Urban VIII banned the use of snuff in churches, and Pope Innocent X banned its use by priests in the Catholic Churches. Similarly, the Parsees and Sikhs of India, Buddhist monks of Korea, members of the Tsai Li sect of China, and some Ethiopian Christian sects forbade the use of tobacco (Christen et al., 1982). A Chinese law in 1638 stated that anyone who possessed tobacco would be beheaded. King James I of England and Ireland was a strong anti-smoking advocate and increased taxes on tobacco by 4000% to reduce its import into England. In 1633, the Sultan Murad IV of Turkey announced use of tobacco a capital offence, punishable by death by hanging, beheading or starvation. The Russian Czar Michael Fedorovich prohibited the sale of tobacco and stated that users would be subjected to physical punishment and

persistent users would be killed. In Bavaria, Germany, in 1652, tobacco was available only on a doctor's prescription (IARC, 2007).

Legislation in India began with the promulgation of the Cigarette Act, 1975. Following the example of the state of Maharashtra in 1987, some other states like Goa and Delhi prevented smoking and spitting on government premises. In June 1999, Indian railways banned the sale of tobacco and tobacco products on railway platforms. In September the following year, the Government amended the Cable Network Rules and banned television advertisements for tobacco and tobacco chewing was prohibited in Government schools. The Cigarettes and Other Tobacco Products Act, 2003 prohibited its advertisement in media and sports sponsorships. It also prohibited smoking in public places and disallowed the sale of tobacco in any form to persons under 18 years of age and within 100 yards of educational institutions. Clear health warnings in local languages and in English were made mandatory on all packages of tobacco products. Beginning with Tamil Nadu in 2001, ban orders have been issued in several states including Odisha against the sale, manufacture and storage of gutka.

Although the Government takes several measures to ban the production and use of tobacco products in the country, the consumption of such smokeless products has not gone down appreciably. The consumers of such products need to realise the dreadful health hazards of tobacco products and restrain from their use so that the production and marketing of such products can be checked.

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WHAT MADE US TO WALK?

Dr. Soumendra Ghosh

Long long years ago a clan of human ancestors were living in the middle of a dark forest some where in Africa. They were our own species called *Homo sapiens.* Life of those men like apes were not different from the life of the great apes of today. Like the gorilla and gibbon, those apes were living monogamously in groups. However, some anthropologists believe the apes were polygamous like the chimpanzees. In either case, these apes were happy in their way and contented in their environment. They spent most of their days on the treetops munching languidly on fruits and berries.

Then one day they decided to leave the forest for nearby savanna (land with tall grass and bushes, occassionally with trees). Why did they take such a decision ? Was it over population ? Scarcity of food ? Or perhaps some climatic change which made the savanna to grab the forest, one tree at a time until fruits and berries were lost and the apes who used to get their food easily did not find them any more.

Life for the hominins were harder on the savanna. No trees, no fruits or berries. They have to move miles in search of food. Temperature in Savanna was high. They have to breathe dry and hot air. There were seasons of drought. There were fierce animals who didn't mind baby ape for their lunch.

The apes did not run back into the forest. They learned to live by their wits. They lived together, fought together. They started communicating by gestures. They produced some sounds by imitating lion's roar or whistles of birds. They made fire as a deadly weapon against prowling lions. But the best thing fire did was cooking of food. Foods like raw meat, potatoes were baked. Fire not only changed food's chemistry, it changed the biology of man. Humans had an easier time chewing and digesting old favourites such as raw meat and nuts when they were cooked. Where chimpanzees spend five hours a day chewing raw food, a single hour suffices for people eating cooked food. Some scholars believe there is a direct link between the advent of cooking, the shortening of human intestinal track and the growth of human brain. By shortening the intestine and decreasing their energy consumption, it opened the way to jumbo brains of sapiens.

This story of the ape who stood up on two legs has been told many times over the past century, which is based on a hypothesis called the 'Savanna hypothesis'. Few questions still remain unanswered i.e the question regarding the location where the transformation took place whether it was in Africa or some where in South East Asia. If global warming or some other climatic factors destroyed the thick forest, then it should have been a global phenomenon, the bipedalism should have occurred simultaneously. How did it happen ? One person got up and others followed or the whole clan one fine morning got up and started walking on two legs ?

One thing for sure is that it was the shift from life in the forest to life in a more open

habitat (plain land with tall grass), forced them to walk on two legs. Bipedalism allowed hominids to see over tall savanna grass, perhaps to escape predators and move more efficiently over long distance. The free hands with fingers and a thumb moving in opposite direction helped them to manipulate, make tools, gather nuts and grains even do fishing.

In the classic 'Savanna hypothesis' emphasis on climatic change and shift of habitat from forest to open grass land played some role in the origin of bipedalism. Darwin believed the stage for the drama was in Africa, where man's closest relatives the African apes still lived. By the turn of the century, some anthropologists however believed that the critical move to the grassland occurred in Asia. The discovery of bones of a primitive hominid from Southeast Asia Island of Java made the researchers think again on the venue. Later it was proved that the bone was of Homo errectus, a different species who were living there. In such a situation the transformation from quadripedal locomotion to bipedal locomotion would have occurred simultaneously at many places on the globe. Researchers argue that the Dawn man had the guts and wits to go out there and grab it. Like the entrepreneurial spirit of modern man, our ancestors had the same spirit. It may be due to some enterprenurial gene' which is conserved till today.

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INSECTS ON OUR MENU

Dr. Ramesh Chandra Parida

As the per capita arable land and agricultural productivity are approaching their limits, it is becoming increasingly clear that alternative routes have to be found to feed the teeming millions that add to our population every year. Therefore, various unconventional sources, such as different kinds of fungi, algae, diatoms etc have come under the scanner to prove their viabilities to supplement our food and nutritional requirements in the years to come. Now insects have been added to the list, as the Food and Agriculture Organization (FAO) has hailed those as under utilized source of food for the people and the livestock and called upon for its optimal utilization in a recently released report (13.05.2013) in Rome, the Head Quarter of the UN agency.

At present, about 2 billion people of the world have been already supplementing their diets with insects. They , not only include the tribals of India, but also the common people of a number of other countries, like China, Japan, Thialand, Myanmar, the US and the Europe, where those are even considered as delicacies.

Insects are rich in protein, aminoacids (particularly, the essential aminoacids) fats, minerals and vitamins (Table-I). Moreover, unlike pork or meat, those are free from cholesterol and are better assimilated. These are also extremely efficient in converting feed into edible meat. On an average, they can

Table 1 : Nutritional values of some animal products compared with those of some insects. * (Per l00 gm)

Sl. No.	Animal/Insect	Nutrients			Vitamins			Minerals			K.cal
		Protein (gm)	Fat (gm)	Carbo-hydrate (gm)	Thiamine (mg)	Rebo-flavin (mg)	Niacin (mg)	Ca (mg)	P (mg)	Fe (mg)	
1.	Chicken Raw	21.0	7.0	2.0	0.12	0.91	5.2	23.0	142.0	1.7	157
2.	Pork Raw	17.0	5.0	Trace	0.43	1.24	6.0	35.0	132.0	2.7	117
3.	Fish Raw	19.0	12.0	0.0	0.15	0.35	8.4	5.0	239.0	1.0	189
4.	Egg (Whole)	13.0	12.0	1.0	0.1	0.29	0.1	54	210	2.7	162
5.	Milk (cow)	3.5	4.0	5.0	0.04	0.17	0.1	118	-	-	68
6.	Macrotermesp. (Isaptera)	38.4	46.1	8.0	8.7	67.4	47.7	4.0	438	41.7	613
7.	Rhynochophorus (Loleoptera)	18.1	-	-	201.3	131.7	38.9	18.6	31.4	72.8	561
8.	Usta sp.	76.3	-	-	244.7	112.2	26.0	35.5	69.5	197.2	-

*(Besides insects are also rich in Cu and Zn)

convert 2kg of feed into 1kg of insect meat, while cattle need 8 kg of feed to produce the same quantity of meat. Besides, to feed our cattle we need plants, grassland, forest land and agricultural land to produce grains and fodders. Those have their adverse impacts on our environment. Besides all ruminating animals like cattle produce methane, the number -two greenhouse gas. From these points of view, insects are much less polluting too. All these factors make the UN agency's pleas stronger for us to become insectivorous.

At present, the most widely used insects as human food include grass hopper, locusts, caterpillars, cicadas, moths, ants, white ants, butter flies , crickets, bees and different type of beetles. The FAO's Edible Insect Programme is also examining the potentials of arachinds, such as , spiders, scorpions etc for this purpose.

However, not all insects are safe to eat. Some of those produce toxic metabolites and defensive chemicals. Besides, those like bees, wapses and ants bear stings and caterpillars have sting hairs, which have poison glands at their bases. Moreover, certain insects are capable of producing strong allergic reactions and some others serve as vectors or intermediate hosts of pathogens. Therefore, proper food processing and screening are necessary before those are served on the dining tables.

The insect world consists of the largest number of speices. Scientists believe that it may be as large as 80 crores. However, only 7 lakh 50 thousand of those have been identified so far, out of which 90% are edible. Therefore, the total biomass of these insects has been visulised to be quite high, comparable with all the fishes available in all the seas, oceans and

other water bodies. Under such circumstances, the FAO's proposal to expand our habit of insect eating may appear justified , from the point of view of relieving the world from the burden of hunger and malnutrition. However, its ecological angle should also be viewed side by side.

Man is an unscrupulous eater. We know how the numbers of many of the species of domesticated animals and birds like goats, sheeps, cattle, buffalos , fish, chicken etc have shrunken, owing to his voracious eating habits. Even environmentally unsustainable intensive rearing of those in captivity has not helped much. Similarly, wild animals such as deers, rabbits, porks, various kinds of water fowls, dolphins, sharks etc are no exceptions. Most of them are now threatened with existinction.

Some more recent examples are bullfrogs and crows. We are aware of the disasters that befell on our environment and ecology, which seriously affects our agriculture and public health, when we started exporting the delicious frog legs to the European countries and began killing crows, in order to save the grains that they eat. Now those have come under the protected categories and to remove their names from the Red Data Book (List of animals, birds and plants that face extinction), we are rearing those in captivity.

The disaster can be of greater dimension if we all opt for eating insects indiscriminately, thereby pushing them to the brink of extinction, as most of them are the prime pollinators. It has been established without ambiguity that the decline of the populations of bees and butterflies due to loss of habitats and extensive use of insecticides in the last few years, have adversely affected the agricultural productivity. On the other hand , spiders are considered as the friends of the farmers, because they catch and devour harmful insects, thereby reducing the use of environmentally hazardous insecticides in the crops. Other insect species must be having similar unique relationships with our ecology, some of which are known and some other unknown.

The population of almost all insects are declining, particularly, the known ones, mostly due to deforestation and urbanization (loss of habitat) indiscriminate use of insecticide, adoption of mono-culture in modern agriculture and climate change, acid rain and air pollution due to emission of toxic gases from industries and automobiles. Therefore, the question arises that if we turn to extensive insect eating, will it not worsen these ecological problems ? In fact, it will and the solution lies with opting for environment -friendly steps like aforestation and organic farming and of course, insect-farming. Recently, such a farm has been set up in Netherlands and China and the US are planning to follow it. Therefore, if we want insects to play an useful role to meet our nutritional requirements in the years to come, we must also try it.

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SPIDERS -THE CIVIL ENGINEERS

***Animesh kumar Mohapatra**
****Priyamvada Pandey**

Introduction

Phylum Arthropoda is the largest phylum and the real rulers of the earth. They have conquered not only land and air but also the vast sea. They are highly diversified and industrious in nature-from the deep sea to mountain peaks, in size from the king crab with its 12-foot arm span to microscopic insects and crustaceans, and in taste from chocolate covered ants to crawfish jambalaya and lobster Newburg.

Spiders, the unique member of Arthropoda are blessed with unique quality of craftsmanship combined with matchless patience. They are the classic weavers and superb architects. Though dull in appearance but very prompt in action, and deserve to be different from other creatures on the earth. Spiders are the invertebrates belonging to the order *Araneae* of the class *Arachnida* under phylum *Arthropoda.* Spiders are air-breathing arthropods that have eight legs and chelicerae with fangs that inject venom. They are the largest order of arachnids and rank seventh in total species diversity among all other orders of organisms (Fig.1). Spiders are found worldwide on every continent except Antarctica, and have become established in nearly every habitat with the exceptions of air and sea colonization. About 43,678 species of spider and 109 families have been recorded by taxonomists.

Spider silk

Spiders have the unique quality of producing silk which is used by them to construct beautiful spider webs. Spider silk is a protein fiber spun by spiders. Spiders use their silk to make webs or other structures, which function as nets to catch other animals, or as nests or cocoons to protect their offspring. They can also use their silk web to suspend themselves. Many small spiders use silk threads for ballooning, the popular scientific term for the dynamic kiting spiderlings use for dispersal. They extrude several threads into the air to be themselves carried away by winds. Although most rides will end a few yards later, it seems to be a common way for spiders to invade islands. The extremely fine silk that spiders use for ballooning is known as gossamer.

Figure 1 : Different types of spider

Spider's silk glands

Anatomically (Fig.2) spiders differ from other arthropods in a way that their body segments are fused into two tagmata : the cephalothorax or prosoma and abdomen or opisthosoma, joined by a small, cylindrical pedicel. There are seven types of silk glands (Fig. 3) which are present at the lower side of abdomen of the spider. The abdomen bear appendages that have been modified into spinnerets that extrude silk from seven types of silk glands with the help of finger-like processes at the end of each spinneret called spigots.

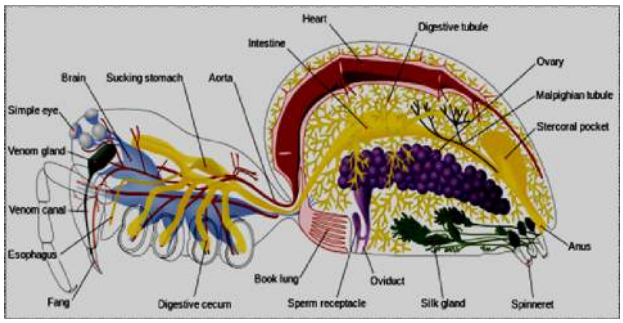

Figure 2. Anatomical representation of spider's body

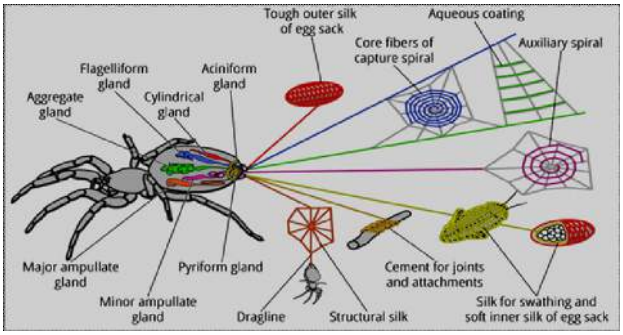

Figure 3. Different types of silk glands present in spider

The seven types of silk glands and their functions are:

1. *Ampullate (Major) gland:* It secretes dragline silk used for the web's outer rim and spokes and the lifeline. As per unit weight it can be as strong as steel, but much tougher.
2. *Ampullate (Minor) gland:* Its secretion is used for temporary scaffolding during web construction.
3. *Flagelliform gland:* Its secretion form spiral silk used for the capturing lines of the web. It is sticky, extremely stretchy and tough.
4. *Tubuliform gland:* Its secretion form egg cocoon silk used for protective egg sacs. It is the stiffest silk.
5. *Aciniform gland:* Its secretion used to wrap and secure freshly captured prey; used in the male sperm webs; used in stabilimenta. It is two to three times as tough as the other silks, including dragline.
6. *Aggregate gland:* It secretes a silk glue of sticky globules.
7. *Pyriform gland:* Its secretion used to form bonds between separate threads for attachment points.

Composition and Chemistry of the spiders' silk

Spider silk is an impressive material having lightweight stretchy and stronger than steel. It is a polypeptide, scleroprotein nature containing collagen and keratin. Spidroin is the main type of protein present in spider's dragline silk. Spidroins are big protein molecule 250-350 kDa and with no L.Wt of 3,500 amino acid residence (Fig.4). They are present in a polymeric organization, mostly based on highly homogenized tandem repeats. There are 100 tandem copies of 30 to 40 amino acid residues. On the other hand,

spidroins also have non-repetitive amino (N) and carboxyl (C) terminal domains of approximately 150 and 100 amino acids respectively. There are two types of spidroins: spidroin 1 and spidroin 2. Spidrion consists of approximately 42% glycine and 25% alanine as the major amino acids. The remaining amino acids are mostly glutamine, serine, leucine, valine, proline, tyrosine and arginine. Spidroin 1 and spidroin 2 differ mainly in the content of their proline and tyrosine amino acid residues. N- and C-terminal domains share little resemblance, except that they are both rich in serine and both are largely amphipathic α-helical secondary structures. In the N-terminal domain, there are signal peptides which regulate spidroin secretion from cells of the silk gland.

Spidroin protein consists of one repetitive region of 100 tandem repeats in between two non-repetitive N-Terminal and C-Terminal domains. The 100 tandem repeats are divided into polyalanine and glycine- rich regions. Alanine appears in blocks of six to fourteen units that form β-sheets. These alanine blocks can stack to create crystalline structures in the fiber, linking different protein molecules together. Glycine is present in different motifs, such as GGX and GPGXX (where X may be alanine, lysine, glutamine or phenyl alanine), that have also specific secondary structures. Glycine-rich regions are more amorphous and contribute to extensibility and flexibility. Motif (GGX)n is characteristic in spidroin 1 and GPG and QQ are typical in spidroin 2.

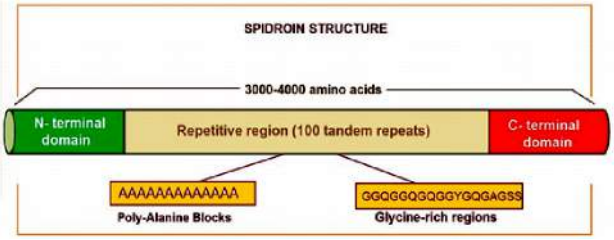

Figure 4. Structure of spidroin

Mechanism of silk formation

In "Lock and trigger" model for spider silk formation, the gradual pairing up of the N-terminal domains, locks spidroins into a network of many protein molecules, while the changes of structure in the C-terminal domains could trigger the rapid polymerization of soluble spidroins into insoluble fibers. During the passage through the narrowing tubes to the spinneret the protein molecules align and form partial crystallisation parallelly. This occurs through self-assembly of the molecules where the polyalanine regions link together via hydrogen bonds to form pleated β-sheets. These β-sheets act as cross-links between the protein molecules and impart high tensile strength on the silk. The crystalline regions are very hydrophobic which aids the loss of water during solidification of spider silk. This also explains why the silk is so insoluble. Water molecules are unable to penetrate the strongly hydrogen bonded β-sheets. The glycine-rich spiral regions of spidroin aggregate to form amorphous areas and these are the elastic regions of spider silk. Overall, a generalised structure of spider silk is considered to be crystalline regions in an amorphous matrix. However, it may involve

mechanical and frictional forces that arise during passage through the spider's spinning organs. Spidroins have a helical and unordered structure when stored as soluble proteins in silk glands, but when converted to silk their structure changes completely to one that confers a high degree of mechanical stability.

The silk glands are located on the lower side of the abdomen and contain a watery fluid known as 'dope' in which protein molecules can move freely. This fluid passes through to the spinneret via a multitude of microscopic tubes where water recovery and solidification begins. Fluid from different glands can lead to the same spinneret. There are usually two to eight pairs of spinnerets but this can vary depending on the species. The substance exits through the spigots which are mobile, finger-like protrusions and the resulting silk emerges as a solid. There are many spigots that so many fibres are bound together like a cable.

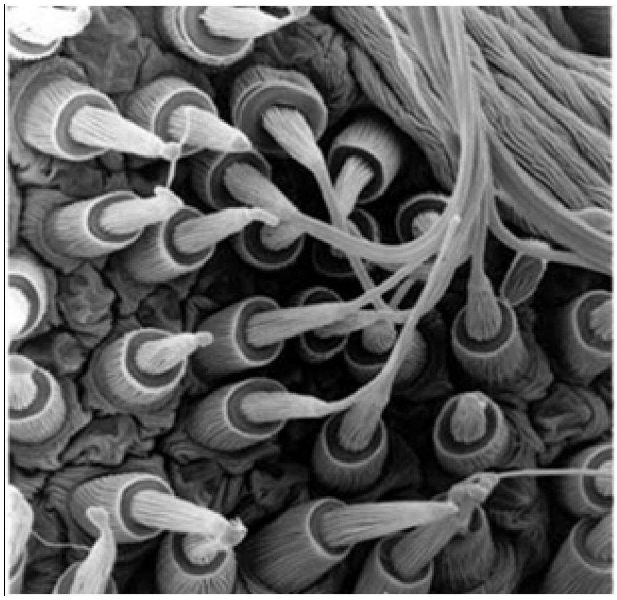

Figure 5. Images of the spinnerets

How spiders construct their web ?

The spiders frame their web step by step in a form of decorative stabilimentas in the following manner (Fig. 6 and 7):

- Spider releases a single thread of silk with a tiny flattened silken sail at its tip. This allows the wind to blow on the silk, until that gets connected with something. In this way spider sets up the bridge from where the building up of the web starts.
- Then the animal moves back and forward along the bridge thread and adds more silk on it to make it stronger. Then it will start to set the centre of the web, and give it a 'V' shape. The two arms of 'V' are well placed to make two of the major spokes of the web.
- Spider fixes a new thread to the point on the 'V' and reels itself down to ground to find an anchor point & fastens the vertical thread to the surface.

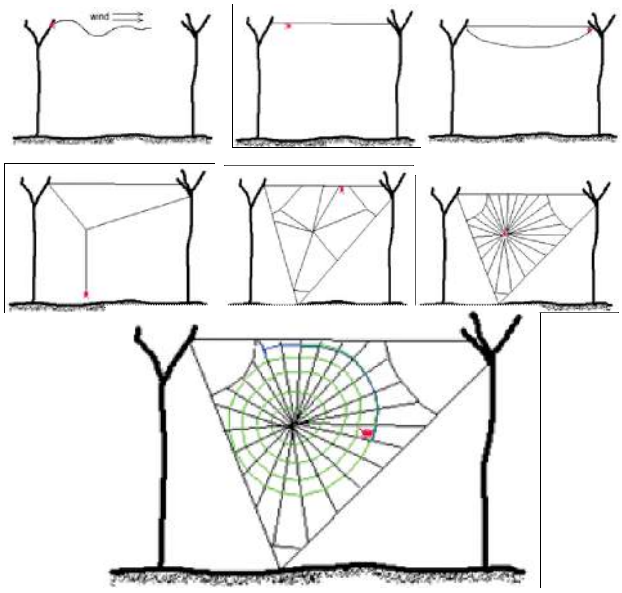

Figure 6. Steps in the constuction of a spider web

- Then that put some frame threads between the anchor points. This will be the outside frame of the web.
- After putting the frame threads, Spider starts to lay the radius threads. The silk used to make the frames and radius is not sticky. They serve for supporting purpose. And Spider will walk on that radius so that the animal does not get entangled by her own silk. Spider goes back and forth from the web centre and the frame to lay the radius
- Then the animal put the auxiliary spiral silk, from centre to the outer frame. This auxiliary spiral silk is used by spider as reference for laying the capture spiral, the sticky silk. The auxiliary spiral silk will be removed later.
- When Spider reaches the outer most frame, it returns and starts to lay capture spiral, the sticky silk. It spirals from outside towards the centre. It uses the auxiliary spiral silk (Fig.7) as reference, and will remove it in the mean time.
- The web gets completed when the spider lays down the stick silk closer to the centre.
- Then it sits in the centre of the web, with each leg on each silk sensing if there is any prey being caught. When the spider sits off the web, it keeps in touch by a special signal thread running from retreat to the centre hub. This signal thread is under tension & it instantly transmits the signal to her about the prey being caught in the web.

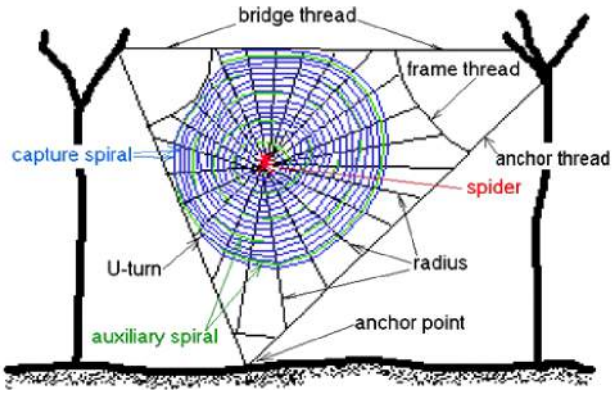

Figure 7. A well decorated spider web

Types of webs

Generally the spiders construct two types of webs: Orb web and cob web.

1. Orb webs: These are the characteristic feature of the family-Araneidae. About half of the potential prey that hit orb webs (Fig. 8) escape. A web has to perform three functions: intercepting the prey (intersection), observing its momentum without break (stop), and trapping the prey by entangling it or sticking to it (retention). No single design is best for all

Figure 8. Orb web

prey. For example: wider spacing of lines will increase the web's area and hence its ability to intercept prey, but reduce its stopping power and retention; closer spacing, larger sticky droplets and thicker lines would improve retention, but would make it easier for potential prey to see and avoid the web, at least during the day. However, there are no consistent differences between orb webs built for use during the day and those built for use at night. In fact there is no simple relationship between orb web design features and the prey they capture, as each orb-weaving species takes a wide range of prey.

Cob web: Members of the family Theridiidae and others like house spiders, daddy long leg spider, weave irregular, tangled, three-dimensional webs, popularly known as cobwebs (Fig. 9). There seems to be an evolutionary trend towards a reduction in the amount of sticky silk used, leading to its total absence in some species. The construction of cobwebs is less stereotyped than that of orb-webs, and may take several days.

Figure 9. Cob web

How spider webs attract insects?

Spiders lure insects by using the mutual 'electrical attraction' of their web to their prey. Flying insect's wings create an electric charge which in turn acts as a magnet for the spider's web - sucking them to their doom in the sticky silk. Orb-weaver spiders attract insects to their webs with ultraviolet (UV) decorations. During construction of the webs, spiders are known to sporadically add zigzag patterns leading out from the centre. These patterns are created with special white silk forming visual spectrum with UV rays-300nm-700nm, known to reflect much more lights than other strands in the web and prey gets attracted towards the web.

Why don't spiders get stuck in their own webs?

Spiders spin two types of silk - sticky and non-sticky silk. They avoid walking on sticky threads. In addition spiders have movable

Figure 10. Spider web showing zig-zag pattern leading from center.

claws on their feet that grip and release the web's threads as they walk. The sticky fluid or aqueous coating was only released by aggregate gland on capture spiral but spiders run on radial spokes which is non-sticky in nature.

How do spiders walk upside-down?

In addition to the tarsal claws, a tuft of hair called a scopula (Fig. 11) is found at the tip of the spider foot, which the animal uses to attach itself to the walking surfaces. The long hairs which are distributed over the entire foot are sensitive to touch. It is because of Van-der -Waals force of attractions between the hairs at tip of the foot and the surfaces on which they walk, these thousands of tiny hairs create multiple contact points between the spider and the surface that increase the spider's ability to hang on. The hairs are both small and flexible. At the molecular level, even the smoothest surfaces are rough, so if the spider's hairs were rigid, the arachnid could make contact only with certain parts of the surface. But because the hairs are malleable, they can make contact with more of the surface area even with the weak forces.

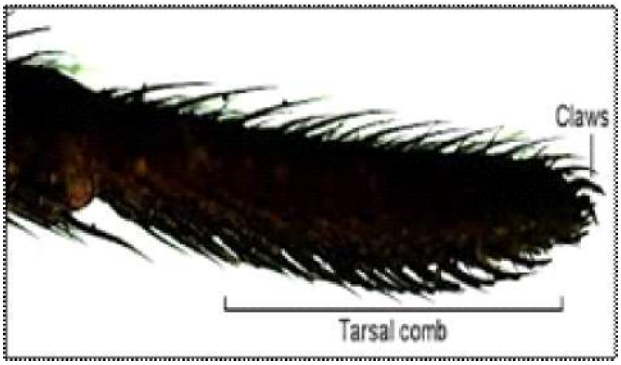

Figure 11: A scanning electron microscope micrograph of the foot showing scopula.

Some interesting facts about spiders

1. All spiders do not weave webs. Generally the female and young male spiders weave webs. Females are larger than males.
2. Spiders do not stick to their own web because only the central spiral part of the web is sticky, not the spokes. The spider knows where to move.
3. Webs lose their stickiness after about a day due to factors such as dust accumulation and exposure to air. In order to save energy the spider eats its own web before making a new one so the protein used for making silk threads gets recycled.
4. Capture spiral part of the web is most elastic, rich in glycine and it can be extended up to 20 times its length to capture or wrap the prey while the dragline silk only extend 30% of its original length.
5. Spiders use a wide range of strategies to capture prey: trapping it in sticky webs, lassoing it with sticky bolas, mimicking the prey to avoid detection, or running it down. Most of them detect prey mainly by sensing vibrations. Spiders' guts are too narrow to take solid material so they liquidate their food by flooding them with digestive enzymes and grinding with the bases of their pedipalps, as they do not have true jaws.
6. Most spiders generally undergo the phenomenon of kleptoparasitism - i.e. steal or theft of the food or prey.

7. Non poisonous spiders - the family Uloboridae - they have lost their venom glands, and kill their prey with silk web. Red back spider is the Most Poisonous spider.
8. Largest spider web - Darwin's bark spider - orb weaver spanning over rivers, streams, lakes. Smallest spider web is made by Patu marplesi.
9. World's largest spider is male goliath bird-eating spider and smallest is Patu marplesi.
10. Cannibalism by females is very much common in spiders.

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SCIENCE OF CITY FARMING -1

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Food is the basic need of every person around the world and thus he can benefit by growing his own food. The Productive resources are shrinking gradually. Cities are developing over green areas. The city dwellers are generally consumers. Our Kitchen Garden Assocaition (KGA)'s mission is to encourage every household in a city to be prosumer (producer cum-consumer). Each member of the family will have just a space right out just around home or roof top or verandas and balcony or wall of the building. KGA will teach them how to grow just the minimum food themselves. The agro- ecological condition of the available space in cities is suitable to grow vegetables only. Vegetables are quick maturing high yielding and nutritious crops. Being short duration crops they need highly fertile soils containing well composted organic parts and mineral parts in equal volume. These organic parts then impart good form and structure to the soil. Such soils can maintain good moisture level and air content favorable for good growth and flush of roots in it and micro organism also flourish to decompose complex organic materials to simple mineral nutrients while the mineral parts relate to the available nutrient level in the soil. The fertility level of the soil is achieved and maintained by properly collecting and incorporating or by

proper recycling of various biodegradable products of both plants and animals origin, so that it wi!l be optimally available in the early growth cycle of the crop as most of these mineral parts of the soil are generally harvested in the first growth period by the plants and later before tillering or flowering phase of growth. The nature has built its food chain through evolving the process of photosynthesis to harvest the Sun by employing green leaves. The first product of the food chain that green leaves produce is glucose. The green Chrlophyll part in the leaves can harvest sunlight which they use for photolysis of water coming to the leaves through the roots. Then it combines with carbon dioxide part of the air reaching the Mesophyli zone of the leaves through the stomatic pores. At the end the first six carbon sugar (glucose) is formed. The oxygen produced from the water in to the process is released in the air.

Overall reaction is :

$$6CO_2 + 12H_2O \xrightarrow{\text{SUNLIGHT}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

The most important aspects of the above discussion is that to harvest the optimum sunlight, the plants must build a canopy area of leaves as per the index number of the crop occupying a specific ground area for its maximum growth. Here three things involve :

1. Ground area of the plant for its maximum growth.
2. The optimum canopy area of the leaves of the plant.
3. Leaf Area Index (LAI) = the index number of the crop. The optimum canopy area of leaves per unit ground area is known as leaf area index or the index number of the crop.

Thus LAI = Canopy area of leaves upon ground area.

2.5 of canopy area of leaves is 2.5 and the ground area for maximum growth of plant is 0.5, then.

LAI= 2.5/0.5 = 5

i.e., 5 is the leaf area index or the index number of the crop.

The grower should be well acquainted with this relationship. To build up a canopy, the growers are required to provide maximum ground area with required nutrients and water for crop growth, so that the plants will be capable of taking full advantage of the sun light it has to harvest.

(To be continued)

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Chief Patron & Settler Kitchen Garden Association
Mob:-9439332219/9437455680

When you turn your eyes to heave
skyworld to the azure flow,
when at dusk the Sun is driven
down in crimson fireglow
There in Nature's deepest kernel
healthy, glad of heart and sight
you perceive the great eternal
essence of chromatic light.

- Goethe on Newton's experiment

GUIDELINES FOR CONTRIBUTING ARTICLES FOR THE MAGAZINE

1. "SCIENCE HORIZON" aims at developing the scientific outlook of students as well as the general people and seeks to give them information on scientific developments. It is published as a monthly magazine.
2. The authors desirous of writing and contributing articles to the magazine should first assimilate the ideas of the theme and present it in simple language and popular style.
3. The authors are requested to write clearly on one side of A/4 size paper. The relevant pictures in 4cm X 6 cm size are welcome. Photo copies of manuscripts are not accepted for consideration.
4. Each article will be ordinarily of two to three printed pages in A/4 size papers.
5. The article shall be profusely illustrated with pictures.
6. At the end of the article the author should give the references and suggestions for further reading.
7. The reference of books, journals, sources, ideas and essential points collected by the writer should be mentioned in the bibliography. This will enhance the quality and fidelity of the writing and give the reader an opportunity for making further studies.
8. Matter translated from other languages and illustrations should indicate the original sources otherwise those would not be accepted. The articles which are not published, can not be returned to the authors.
9. As far as practicable the articles should be based on contemporary science and must be easily comprehensible to students at the secondary level.
10. The writers should present difficult concepts of science through stories of everyday life, heart-rendering songs, pictures, satirical cartoons or attractive dramas.
11. All units in the articles should be given in the metric system.
12. The title of the article should be brief and attractive. Moreover, subtitles may be given in long articles. The writings should be coherent and cohesive.
13. There should not be repetition of specific words. While ensuring the contemporary spirit of the writing, it should reflect some valuable lesson for the society. It is also necessary to avoid mistakes in spelling, language use and factual details.
14. The Editor & the Editorial Board of "Science Horizon", Secretary of the Academy or Odisha Bigyan Academy shall not be responsible for the views of the authors.

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