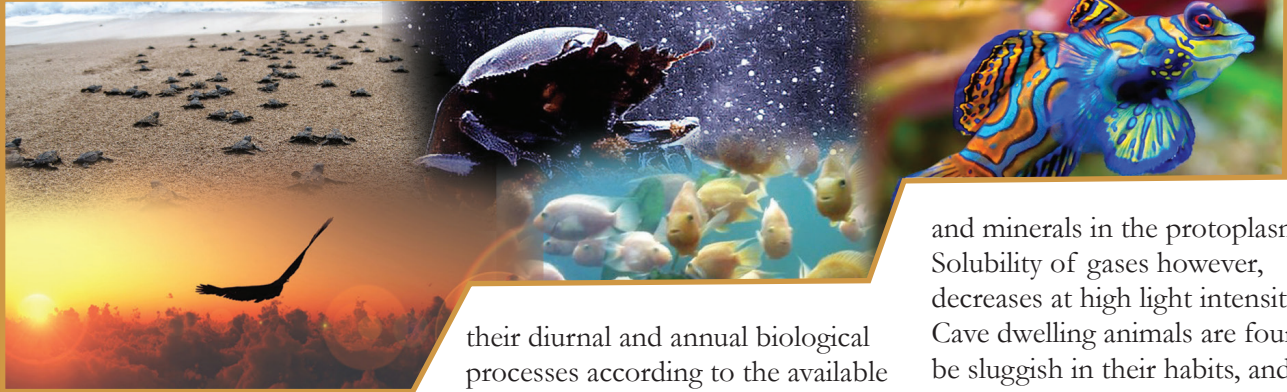


Impact of Light on life on Earth

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

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

All organisms other than the ones that live in deep dark caves, and the bottom of the ocean, have adjusted

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



Ultraviolet rays are known to cause mutational changes in the DNA of various organisms. The metabolic rate of different animals is greatly influenced by light. The increased intensity of light results in an increase in enzyme activity, general metabolic rate and the solubility of salts

and minerals in the protoplasm. Solubility of gases however, decreases at high light intensity. Cave dwelling animals are found to be sluggish in their habits, and to contain a slow rate of metabolism. We all have experienced the tanning of our skin when it is exposed longer to direct sun light. Light influences pigmentation in animals. Cave animals lack skin pigments. If they are kept out of darkness for a long time, they regain skin pigmentation. The darkly pigmented skin of human inhabitants of the tropics also indicate the effect of sunlight on skin pigmentation. The skin

pigment’s synthesis is dependent on the sunlight. It seems that sunlight has a major impact not only biologically, but also sociologically, dividing the human race as white and the coloured. Light also determines the characteristic

patterns of pigments of different animals which serve the animals in sexual dimorphism and protective colouration. Animals that dwell in the depths of the ocean where the environment is monotone, and though pigmented, do not show patterns in their colouration. The influence of light on the

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

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

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

The velocity or speed of the movement of certain animals is also regulated by light. It has been observed that animals when responding to light reduce their velocity of movement and these movements which are non-directional are called photokinesis.

Photokinesis may be a change in linear velocity (rheokinesis) or in the direction of turning (klinokinesis). During photokinesis when only a part of the body of an animal deviates always from the source of light, the reaction is termed photoklinokinesis. Larvae of *Musca domestica* show such movements. When animals are confronted with two sources of light of equal brightness they move towards or away to a position that is the distance between the two lights. This is termed phototropotaxis. Attraction of males towards the flesh of the female is called telotaxis. Movement of animals at a constant angle towards the source of light is called light compass reaction or celestial orientation.



Some organisms, particularly arthropods, birds and fish, utilize their time sense as an aid to find their way from one area to another. To orient themselves, the animals use the sun, moon, or stars as a compass. To do this, they utilize both their biological clock and

observations on the azimuthal position of the sun in relation to an established direction. The azimuth is the angle between a fixed line on the earth's surface and a projection of the sun's direction on the surface.

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



This is termed phototropotaxis. Attraction of males towards the flesh of the female is called telotaxis. Movement of animals at a constant angle towards the source of light is called light compass reaction or celestial orientation. Regularly occurring daily cycles of Light (day; and darkness (night) have been known to exert a profound influence on the behaviour and metabolism of many organisms. Underlying such environmental rhythms of light and darkness are the movements of the earth relative to the sun and the moon.

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

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

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

At one time biologists thought that these rhythmicities were entirely exogenous, that is, the organisms responded only to external stimuli such as light intensity, humidity, temperature and tides. But now it is

well investigated that most animals possess internal or endogenous rhythms in synchrony with the external or exogenous rhythms of the environment, due to which they retain the ability to measure the length of day.

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

The innate character of circadian rhythm is demonstrated by several animals. When *Drosophila* are kept under constant conditions from the larval stage, they will still emerge from pupae with a regular circadian rhythm. Eggs of chicken

and lizards kept under constant conditions produce animals that later show regular circadian cycle. The circadian rhythms have been observed in zooplanktons, polychaete annelids, many insects (Lepidoptera, Diptera, Hymenoptera, Neuroptera, Coleoptera, Orthoptera, Odonata, etc.), most birds, and certain mammals.

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

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

Light in some cases (e.g., Salmon



Piranha fish

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

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

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

The spawning of fish, *Leuresthes tenuis* follows a semilunar cycle.

Certain polychaete worms also exhibit lunar periodicity.

How different organisms see the world?

We see the world with the help of the light. We see all colour patterns and shapes only when the light intensity is high. All the greenery we see in the day time turn to gray and black with the onset of night.

We know that most of the animals found in our environment have eyes. Do they see the same world as we see?

Insects like butterflies and flies and crustaceans like shrimps have complex eyes and consist of large

number of units. Image they see is a mosaic one formed by merging large number of sub images.

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

In general, nocturnal animals have



relatively larger eyes to obtain maximum light. In addition to the larger size, they have a special layer inside the eye which can reflect light like a mirror to facilitate night vision. Eyes of most herbivorous animals such as cattle, sheep, deer, rabbits etc. are located on either side of the head facilitating wide angle vision. That also helps them to escape from predators. However, eyes of predators and arboreal Primates are located on the front surface of the face restricting the vision to relatively a narrow angle. They can get two images of the same object in slightly different angles, and this is known as binocular vision. Brain can analyze

those two images to estimate the distance from the object to eye giving an idea about the depth. This ability is known as three dimensional vision (3D vision). This special ability helps predators to catch a prey, and for arboreal Primates to jump from one branch to another branch accurately. The visible spectrum is the portion of the electromagnetic spectrum that is visible to the human eye. Electromagnetic radiation in this range of wavelengths is called visible light or simply light. A typical human eye will respond to wavelengths from about 390 to 700

nm. Most of the animals are not sensitive to all the colours of the visible spectrum as human beings do. In other words, they do not have colour vision as we do. As an example, dogs do not have colour vision, and they see the world as grey shades. However, eyes of some animals are sensitive to areas of the electromagnetic spectrum outside the visible range. Bees are sensitive to

UV. The well-known carnivorous fish Piranha which is indigenous to South America is sensitive to IR radiation. With this special ability Piranha can recognize a fish or a mammal even in highly turbid waters by detecting IR emitted from those animals.

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



come from the horizon. If the area is illuminated with artificial lights, these hatchlings get confused in finding the direction to the sea which could lead to death. Migratory birds which use sunlight, moonlight and star patterns for finding

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

rhythm has badly influenced the lives of other animals. All nocturnal animals sleep during the day time and activate with the onset of the darkness. High light intensity during the night has badly disturbed the physiological rhythm of these nocturnal animals. While some predators spot their pray with the help of light, pray animals escape from predators hiding in the darkness.

It has been calculated that the overcast night sky of modern cities has thousand time higher illumination than the night sky of 200 years back. It has been observed that there were no frog and toad calls which they use for their reproductive process during the nights with illuminated night sky. According to that situation the amphibian populations are facing threat of extinction due to bad impacts of artificial lights on their reproductive process. We know that sea turtles come to the beach for laying eggs. After hatching those eggs, hatchlings immersing from the eggs should go to the sea as soon as possible for their survival. They find the direction of the sea with the help of the light of the dawn that

their routes are also badly affected by artificial lights. Few millions of birds die every year colliding with artificially illuminated buildings. Success of survival of migratory birds depends on the completion of the reproductive processes on time at the targeted destination. We are aware that a large number of insect die every second while flying towards light. Although, we have illuminated nights for our benefit, unknowingly we are darkening lives of many other animals.

Considering all what has been mentioned above, it is crystal clear that although light has enormous positive impact on the life on earth, darkness too plays an important role for the wellbeing of the lives of plants and animals.



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