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A Review on Bioluminescence and its Applications

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Abstract— *Bioluminescence is a natural light emitting phenomenon that is emitted by the several terrestrial, marine and some fresh water organisms. This phenomenon could be found in all the major taxonomic groups that are known to comprise around 700 genera of bioluminescent organisms. Though their luminescence emissions are due to two principal components i.e. luciferin and luciferase, yet for many bioluminescent organisms the chemistry involved in the luminescence emission is remains unknown. Over all the bioluminescent organisms, luminescent bacteria are mostly scrutinised paradigm for bacterial and host symbiosis that led researchers to find many genes which involved in luminescence control and symbiosis. However, the principal proteins and genes involved in different luminescent organisms including bioluminescent bacteria are being mostly used for biotechnological applications such as detection of environmental pollutants, contaminants in foods, and more significantly as reporter genes. The motif of this review is to address the knowledge on current studies on bioluminescence aspect and its applications.*

Keywords— *Bioluminescence distribution, bioluminescence applications.*

1. INTRODUCTION

Bioluminescence is an interesting chemical reaction whereby a conspicuous visible light emitted by the several luminescent organisms. The history of this phenomenon could be found in terrestrial, freshwater and particularly marine environments [5]. Yet, all most of all the luminous organisms share similar chemical components involved in the luminescence emission refer to as luciferin and luciferase. Particularly this phenomenon is enormously common in deep sea, especially from aphotic zone to till the bottom of the sea. This emission could be found over all the major phyla which represent at least one genus, except few groups refer to plants, birds, amphibians, and mammals. This phenomenon covers diverse hues, reactions and emission patterns. The proteins and genes involved in the luminescence of some organisms have a wide importance in medical and biotechnological applications [12]. In this review we shall devote to talk very briefly about bioluminescence of different organisms, current aspects, and applications.

2. BIOLUMINESCENCE IN THE BIOSPHERE

The biodiversity and distribution of bioluminescent organisms could be seen in every environment pertaining to terrestrial, freshwater, and marine environments. Though the distribution of luminescent organisms are known to be predominant in marine, however very scarcely in fresh water environment also luminous animals (*Latia neritoides*) can be seen. As everyone knows fireflies are the most commonly found terrestrial luminous organisms and fewer mushrooms [12]. For a list of terrestrial, freshwater and marine luminous animals refer Shimomura (2006), and Wilson and Hastings (2013).

3. FUNCTIONS OF BIOLUMINESCENCE

It has been specified that bioluminescence may involve in different functions such as defensive and offensive purposes, mating, and propagation [1, 12].

4. PRINCIPAL OF BIOLUMINESCENCE REACTION

Although for most of the luminescent organism's chemical reactions are well known, yet there are many unknown light emitting reactions are to be discovered [1]. The basic principal behind the light emission is as follows:

$$\text{Luciferin} + O_2 \xrightarrow{\text{Luciferase}} \text{Oxyluciferin} + \text{Light}$$

However, this reaction differs on the type of luciferin present in the luminous animal.

5. TYPES OF BIOLUMINESCENCE EMISSION

Bioluminescence emission could be found in different patterns as flashes (Fireflies, Squids, Odontosyllis), continuous glow (Bacteria, fungi), blinking (Bacteria), wavy (sea pansy, *Renilla*), and switched on and off system (Angler fishes). Interestingly some bioluminescent organisms such as ophiuroids and earthworms emit luminescence in presence of stimulating chemicals like KCl.

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6. TYPES OF BIOLUMINESCENCE HUES

The bioluminescence emission of different luminous organisms ranges from 400 nm to 700 nm [4]. Emission colors includes green (*Odontosyllis phosphorea, Mycena fera*), yellow (Fireflies, bacteria), red (*Phrixothrix hirtus*, *Malacosteus niger*) blue (bacteria (Fig. 1), jellyfishes), and pink (*Photonectes waitti*) [12].

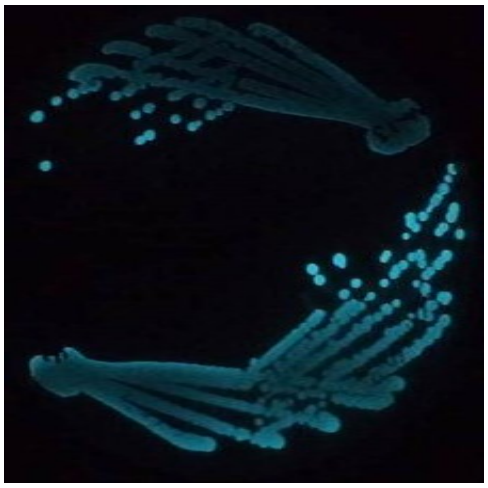

Fig. 1: Showing the mostly scrutinised bioluminescent bacteria

7. TYPES OF PROTEINS INVOLVED IN BIOLUMINESCENCE EMISSION

There are five different luciferins responsible for the bioluminescence of most of the known bioluminescent organisms. They are bacterial luciferin (a derivative of riboflavin), dinoflagellate luciferin (related to the chlorophyll structure), firefly luciferin (requires ATP for bioluminescence), coelenterazine (extremely common, found in several species), and vargulin (found in Ostracods). However, emission mechanisms of many luminescent organisms are yet to be discovered [1]. Noticeably fluorescent proteins such as GFP (in jellyfishes) and lumazine protein (in *Photobacterium phosphoreum*) are also known to be involved in emission of intense luminescence.

8. CURRENT FOCUSES ON BIOLUMINESCENCE ASPECT

Phenomenons such as quorum sensing of luminescent bacteria, horizontal gene transfer of lux genes among luminescent and non-luminescent bacteria [6] are the interesting areas on bacterial bioluminescence. Besides, acquirement of luciferins through food chain by some marine organisms (ex. euphausiids feed on zooplankton) is another significant area of research [1].

9. APPLICATIONS OF BIOLUMINESCENCE

Important applications that currently being practiced are the development of autoluminescent plants for light production [7], and whole-cell biosensors for detecting various toxicants [8, 9, 10]. Besides, cloning studies of luciferases of different luminescent organisms and their fluorescent proteins such as the well-known green fluorescent protein (GFP) have got a wide importance in bioluminescent Imaging (BLI) to study the interaction of infectious microorganisms with living cells [11].

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