International Journal of Scientific & Engineering Research Volume 8, Issue 7, July-2017
ISSN 2229-5518

BIOLUMINESCENCE

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I. INTRODUCTION

Bioluminescence is the production and emission of light by a living organism. It is a form of chemiluminescence. Bioluminescence occurs widely in marine vertebrates and invertebrates, as well as in some fungi, microorganisms including some bioluminescent bacteria and terrestrial invertebrates such as fireflies. In some animals, the light is produced by symbiotic organisms such as Vibrio bacteria. The principal chemical reaction in bioluminescence involves the light-emitting pigment luciferin and the enzyme luciferase, assisted by other proteins such as aequorin in some species. The enzyme catalyzes the oxidation of luciferin.

II. DISCOVERY

In 1667 Robert Boyle documented the air requirement for luminescence. Oxygen had not yet been discovered, but we now recognize that this air requirement was, in reality, an oxygen requirement of the process. This represented a new era in the characterization of bioluminescence rather than just its documentation. The nineteenth century brought scientific voyages such as that of H.M.S. Challenger (1873). Later in that century Raphael Dubois performed a significant experiment where he extracted the two key components of a bioluminescent reaction and was able to generate light. He coined the terms "luciferine" and the heat labile "luciferase". Both Aristotle and Pliny the Elder mentioned that damp wood sometimes gives off a glow and many centuries later Robert Boyle showed that oxygen was involved in the process, both in wood and in glow-worms.

III. PROCESS

Luciferin reacts with oxygen to create light. Carbon dioxide (CO_2), adenosine monophosphate (AMP) and phosphate groups (PP) are released as waste products. Luciferase catalyzes the reaction, which may be mediated by cofactors such as calcium (Ca^{2+}) or magnesium (Mg^{2+}) ions, and for some types of luciferin (L) also the energy-carrying molecule adenosine triphosphate (ATP). The reaction can occur either inside or outside the cell. In bacteria such as Aliivibrio, the expression of genes related to bioluminescence is controlled by the lux operon.

A Equation

$$L+O_2+ATP \quad oxy\text{-}L+AMP+CO_2+PP+\text{Light energy}$$

Luciferin-luciferase reactions are not the only way that organisms produce light. The parchment worm Chaetopterus (a marine Polychaete) makes use of another photoprotein, aequorin, instead of luciferase. When calcium ions are added, the aequorin's rapid catalysis creates a brief flash quite unlike the prolonged glow produced by luciferase. In a second, much slower, step luciferin is regenerated from the oxidised (oxyluciferin) form, allowing it to recombine with aequorin, in readiness for a subsequent flash. Photoproteins are thus enzymes, but with unusual reaction kinetics.

USES

A. For organism

Bioluminescence has many uses in the natural world; it is found in organisms such as bacteria, protozoa, fungi, molds, jellies, insects, squid, fishes, worms, crustaceans and more. They use it for a variety of purposes, including communication, camouflage, illumination, defense, luring and capturing prey, sexual attraction, warning, and more. Symbiotic luminous bacteria may also use it to propagate themselves. In many fishes, such bacteria live in the gut so that fecal pellets continue to glow as they fall to the bottom of the ocean; their luminescence may attract animals that eat them, thus dispersing the bacteria and in the process helping recycle carbon.

B. For human.

1) GFP – Green Fluorescent Protein : was first discovered and extracted from the jelly Aequorea. It is used as a biomarker in many ways today, because its DNA can be cloned and even a tiny amount fused into cells of many other organisms. GFP and similar fluorescent proteins can induce glowing in bacteria, protozoa, plants, nematodes, birds, mammals, fish and many more organisms. Other fluorescent proteins such as Yellow Fluorescent Protein (YFP) have also been developed. Osamu Shimamura, Martin Chalfie and Roger Tsien shared a Nobel Prize for their work in this area.
One of the organisms into which GFP has been inserted is the zebrafish, Danio rerio, a commonly used model organism. The “Glofish” available as pets are a perhaps unfortunate result of this research.

2) Tourism*:* Bioluminescence in the oceans has been observed for centuries.

Today, tourists flock to areas such as Puerto Rico's Vieques Island to witness the magic. In 2005, a glowing area roughly the size of

3) Bioluminescent imaging or BLI *:* allows for noninvasive imaging of biological processes in living animals. Among other uses, this makes it possible to study the processes of various diseases and of treatments for those diseases. It can also be used to locate tumors.

4) Bioluminescent Resonance Energy Transfer, or BRET: is used to map neuronal circuits in order to understand brain function.

5) Quorum sensing: Studies on bioluminescence in bacteria in sea water led to the discovery of what is known as quorum sensing. J. W. Hastings and E. P. Greenberg reported in the Journal of Bacteriology in May 1999 that at low cell densities, the luciferase gene was not transcribed, but luminescent genes do activate at high cell densities when the light emitted is bright enough to serve a purpose. It is now accepted that cell-cell communication in bacteria is common.

Connecticut was first observed from space in the Indian Ocean

6) Tools *:*have been developed that use bioluminescence in many ways. Since adenosine triphosphate (ATP), an energy storing molecule found in all living cells, is required for emission of light, the amount of light is directly proportional to the amount of ATP. Measurements of ATP can therefore detect contamination far more quickly and accurately than traditional culturing. An example of a tool that does this is the BioScan made by GE; there was one on display in the exhibit. This small instrument measures bacteria in water simply and almost immediately.

IV. REFERANCES

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