Bioluminescent Fungi - Magic and Mechanism

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Compared to bioluminescence in bacteria, we know surprisingly little about the nature of the chemical reactions responsible for *fungal* bioluminescence, or even why this phenomenon occurs in fungal species. How does bioluminescence differ from other forms of light emissions? Definitions:

- **Fluorescence** is where energy from an external light e.g., UV light, is absorbed by a chemical, such as fluorescein or rhodamine, and *immediately released* at a longer wavelength e.g. green or red respectively.
- **Phosphorescence** is energy from an external light absorbed and released at a longer wavelength *sometime later*.
- **Chemiluminescence** is the production of light from a chemical reaction.
- **Bioluminescence** is a type of chemiluminescence where light is generated by a chemical reaction inside a living organism.

Bioluminescence in fungi is an oxygen-dependent 2-step reaction, involving substrates generically termed *luciferins*, which is catalyzed by one or more of an assortment of unrelated enzymes referred to as *luciferases*.

- Step 1 is loading chemical energy from a respiration process onto a 'special molecule'.
- Step 2 is taking this energized special molecule, called a ***"luciferin"*** (meaning fire carrier), and combining it with oxygen in the presence of a special enzyme, called a ***"luciferase."*** The result is water, a low energy or energetically decayed luciferin, and a *photon of light*.

Riboflavin has been identified as a luciferin for one fungal species, *Lampteromyces japonicus*. Bioluminescence has been likened to the reverse of photosynthesis. In photosynthesis, a living organism captures light and carbon-dioxide (CO_2) to make organic materials and release oxygen. In bioluminescence, light, water and CO_2 are released by breaking apart organic materials using oxygen. There are many different luciferins and luciferases depending on whether the organism is a species of fungi, insects, fish, dinoflagellates or bacteria. The luciferases show no homology to each other and the luciferins are also chemically unrelated. Most luciferins and luciferases involved in fungi remain largely unidentified. In contrast to bioluminescence in non-fungi that is either bluish (bacteria) or yellowish (firefly), all recent studies and observations indicate that bioluminescent fungi emit a *greenish* light with a maximum around 520-530 nm. Whilst quorum-sensing (QS) is involved in 'switching on' bioluminescence in some species of bacteria, research is being undertaken to investigate the role, if any, QS has in fungal bioluminescence.

To date, bioluminescence has been reported in more than 50 white-spore-species of fungi, worldwide. More than two-thirds of these bioluminescent species belong to the genus *Mycena*. Other genera containing luminescent species include *Armillaria*, *Omphalotus* (including *Lampteromyces* and luminescent *Pleurotus* species), *Gerronema*, *Panellus* and *Dictyopanus*. Depending on the fungal species, bioluminescence can vary in intensity as well as its location in different parts of the fungus. Whilst bioluminescence typically occurs in the mycelium and/or the basidiomes or some portion thereof, it is found only in mature spores of *Mycena lamprospora*. There is no correlation between the edibility of a mushroom and its bioluminescence. *Armillaria* bioluminescence has maximum intensity at 7.30pm and minimal at 7.30am. Bioluminescence is independent of light and darkness but is affected by pH, temperature and oxygen levels.
Why some species of fungi glow while most others do not is still speculative? Hypotheses for fungal bioluminescence include:

- To attract invertebrates that aid in spore dispersal
- The attraction of predators of mycetophagous invertebrates
- A warning to nocturnal heterotrophs that might consume the fungus or its substrate
- DNA repair using a photo-reactivation process as occurs in bioluminescent bacteria

Further reading:

http://www.mykoweb.com/articles/BioluminescentFungi.html
http://www.quorumsensing.eu/Quorum%20Sensing%20Presentation.pdf
http://www.ias.ac.in/jarch/jbiosci/5/53-62.pdf
http://justfreepapers.com/paper.aspx?ID=12404
http://www.ars.usda.gov/SP2UserFiles/person/5208/ARTHROPODS%20ATTRACTED%20TO%20LUMINOUS%20FUNGI%202.pdf
H. J. Weitz. Naturally bioluminescent fungi. *Mycologist* (2004) Vol. 18: p4-5
H. Niitsu, N. Hanyuda and Y. Sugiyama. Cultural properties of a luminous mushroom, *Mycena chlorophos*. *Mycoscience* (2000) Vol. 41: p551-558.