Bioluminescence physiological regulation through photo-perception: an unexpected functional convergent evolution

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Abstract

Bioluminescence is defined as the production of visible light by a living organism[1]. To fulfil its ecological role (i.e. defense, offense, or communication), bioluminescence needs to be finely controlled. Although nervous or hormonal control mechanisms have been demonstrated to occur[1-4], another type of local control via extraocular photo-perception has been suggested to operate in different marine luminescent taxa. Photoemission and photo-perception association imposed a clear co-evolution between the two light-related processes. Recently, extraocular photo-perception processes were shown or suggested to occur at the level of the bioluminescent production site (i.e. photophore/photocyte) in various marine organisms. Photoreceptor molecular markers, including metazoan prototypical photoreceptor proteins (i.e. opsins), have first been identified in the bioluminescent organ of the cephalopod *Euprymna scolopes*[5]. In this sepiolid, light produced by symbiotic bacteria is perceived by extraocular opsins located in the tissues of the photophore. The discovery of this extraocular photo-perception highlighted the presence of an unsuspected relationship between extraocular perception of light and bioluminescence. Then, studies revealed opsin expression in the photocytes of a ctenophore, *Mnemiopsis leydii*, reinforcing the idea of a local interconnexion between light emission and reception, even in an organism producing its own luminescence[6]. More recently, opsins were specifically demonstrated (i) to be expressed within the photocytes of the ophiuroid *Amphiura filiformis*[7], the photophores of the smalleye pygmy shark, *Squaliolus aliae*[4], the parapodial luminous gland of the polychaete *Tomopteris helgolandica*[8], and (ii) to be expressed and functionally active within the photophores of the shrimp *Janicella spinicauda*[9]. Finally, a deeper characterization of the link between the two processes was made in the lanternshark *Etmopterus spinax*, where not only opsin characterization and localization within the photophore are depicted, but also the morpho-functional action and intracellular pathways linking light emission and perception[10]. Except for the lanternshark, control mechanisms linking both photobiological processes remain unknown. Despite, functional coupling between photoreception and photoemission is suggested to be an astonishing example of functional convergent evolution in luminescent organisms, further investigations need to be done to understand and highlight this unexpected phylogenetically widespread mechanisms.

Keywords:Bioluminescence; Physiological control; Photo-perception; Functional convergent evolution

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Acknowledgements

This work was supported by a grant (T.0169.20) from the Fonds de la Recherche Scientifique (FRS-FNRS, Belgium).