Role of gene duplications in the evolution of bioluminescence

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Abstract

The ability to produce light has convergently evolved dozens of times on this planet. However, given the diversity of luciferases and luciferins, it nonetheless remains a challenge to find a common principle for how a luciferase could evolve from a non-luminous protein. Gene duplications are responsible for many crucial changes over evolutionary time, from color vision in primates to bone formation in vertebrates. The principle is that a duplicated gene is free to evolve a new function, a process called neofunctionalization. Previous research has identified that many luciferases are related to other enzymes not involved in luminescence, thus are likely cases of neofunctionalization. Here I examine the role of gene duplications on the origin of bioluminescence in animals, considering cases in cnidarians, arthropods, and molluscs. Such duplications are widespread, found in most cases where a luciferase or photoprotein has been cloned, in some cases emerging from very large protein families. Octocorals and squid appear to have a single specialized enzyme emerging in a few species following a duplication affecting the whole clade. However, in the adenylating enzymes, fireflies, squid, and luminous flies all have large lineage-specific expansions, of which only a few members are identified as luciferases. Rather unusually, a few luciferases (*Vargula* luciferase and *Gaussia* luciferase), appear as sequence isolates, with no similar enzymes in public databases. Given the parallel origins of bioluminescence in certain protein families, particular proteins may have a propensity for evolving this function, perhaps by having affinity for lipophilic molecules whereupon a single point mutation allows the coordination of molecular oxygen.

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