Keep an Eye on the Argonauta! A comparative evolutionary analysis of key genes for vision in littoral versus deep-sea octopuses

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Project Summary

Cephalopod and vertebrate eyes are an excellent example of convergent evolution. Surprisingly, recent studies demonstrated that cephalopods (squids, octopuses and cuttlefishes), widely known for their incredible colour changing abilities, exhibit extraocular phototransduction thanks to photoreceptor cells widespread on the body skin (Pennisi, 2013; Ramirez & Oakley, 2015). Considering, therefore, that the "vision" in octopuses is a major sense for their complex lifestyle, allowing them extraordinary skills in predation and mimicry, the present project aims to study the evolutionary adaptation of vision in littoral versus deep-sea Octopoda.

The main objective is to understand how the opsin gene family evolved in eye, brain and skin of three "preferentially littoral" octopus species (*Octopus vulgaris*, *Callistoctopus macropus*, *Eledone moschata*) versus three "preferentially deep" octopus species (*Scaeurgus unicirrhus*, *Pteroctopus tetracirrhus*, *Eledone cirrhosa*). The molecular evolutionary analysis will include opsin genes isolated from same tissues of the *Argonauta argo* as outgrup species, as it has a pelagic lifestyle occupaying both littoral and deep-sea habitats. The *A. argo* has been recently selected as the Mollusk of the Year 2021, a worldwide competition organized by The LOEWE Centre for Translational Biodiversity Genomics (TBG), https://tbg.senckenberg.de/mollusc/). Moreover, the project will take advantage from the complete genome of *Octopus bimaculoides* (Albertin *et al.*, 2015) for the opsin genes mining in the seven species of interest.

Oceans represent a screen for the light spectra and exclusively blue wavelengths are able to reach deep waters. Therefore, the present project aims to test two possible evolutionary hypotheses of molecular mechanisms able to explain the extraordinary animal vision in littoral vs deep-sea habitats, using octopuses as "non-model model organisms". In other words, how an extreme habitat as the deep-sea shaped the visual gene repertoire in deep-water octopuses in comparison with related species that spend their life completely (or mostly) in superficial habitats. The first hypothesis is the "gene loss" theory: unnecessary functions (genes) in shallow or deep habitat imply negative selection and gene loss in some components of the light sensing machinery. The second one regards positive selected mutations in functional key amino acids of light sensing genes, the opsins, which may have enhanced the survival fitness of certain species in shallow water or deep-sea habitat.