**Evolution of Nocturnality and Nocturnality's effect on the evolution**

There have constantly been debates about the origination and order in which nocturnality and diurnality appeared. Yet generally accepted theory is the 'nocturnal bottleneck' in placental mammals proposed by Walls in 1942. It is described that these species could survive only by avoiding daytime activity during times in which dinosaurs were the dominant taxon. The visual system of reptiles, birds, and three existing taxa of the mammalian lineage were compared by Walls to reach the theory. [1] The review composed by Gerkema et al. claims that collected testimony implies the photoreception for both visual and non-visual systems in eutherian mammals in the Mesozoic era demonstrated a sign of adapted traits and peculiarity a nocturnal lifestyle. Additional data can also support the argument by showing the permanent loss of UV protection which initially restricted exposure to solar radiation in eutherian animals, together with endothermy and small body size, which allowed an active use of the night and was not limited to Mesozoic mammals. [2]

Recent developments in reconstructing the traits of ancestral animals offer the opportunity to improve our knowledge of how these diel activity patterns evolved and how they look in ancestral animals. One of the most critical findings is the nocturnality of common ancestors of living birds, which exhibit significant diversified diel activity patterns, and can be generally categorized as diurnal, nocturnal, and cathemeral (i.e., active both day and nights). [3] Although most species were considered to be mainly diurnal, many of them exhibit partial nocturnal activities, suggesting widespread nocturnality of living birds to various extents. [4] For truly nocturnal birds such as owls and kiwis, substantial evolutionary modifications have been shown of visual genes as an adaptation to nocturnality. Although the genetic basis under the partial nocturnality of living birds remains not entirely clear, recent studies have already started to demonstrate the existence of a night-vision-specific brain area in nocturnally migratory songbirds, suggesting even partially nocturnality requires some genetic adaptation, which implies it may not have evolved independently and is more likely have been inherited from their common ancestor.

Although there's little attention posted on diel activity patterns of avian ancestors, and published studies on ancestral birds obtained inconsistent results based on different methods, one recent study revealed, consistent with a serious of the previous research, in the molecular level that the current common ancestor of living birds was cathemeral. In particular, this molecular study conducted by Wu and Wang [5] detected *GRK1* and *SLC24A1*(Figure 1), which are rod-expressed genes involved in photo-response recovery, contributing to motion detection.

Different diel activity patterns may have dramatic effects on animal evolution. It is due to the difference in environments and selection pressure posed on different animals. Ambient natural light level at night is reduced compared to daytime, with the lower temperature and altered biotic factors such as competitors and predators. Wu claimed that the adaptation to nocturnality itself might substantially shape an animal's evolution. Owls have evolved large and tubular-shaped eyes to detect dim light, asymmetrical ear openings for increasing accuracy of sound localization, evolutionarily modified feathers for silent flight without being detected by their prey, and even substantial evolutionary modification in their vision genes improved night vision. These nocturnality-specified adaptations have also appeared in other truly nocturnal birds. [3]

A recent study attempts to answer the question as to why so many modern-day mammals retain these nocturnal characteristics even though they are not active at night. The leading answer is that the high visual acuity that comes with diurnal characteristics isn't needed anymore due to the evolution of compensatory sensory systems, such as a heightened sense of smell and more astute auditory systems. In a recent study, recently extinct elephant birds and modern-day nocturnal kiwi bird skulls were examined to recreate their likely brain and skull formation. They indicated that olfactory bulbs were much more prominent in comparison to their optic lobes, suggesting they both have a common ancestor who evolved to function as a nocturnal species, decreasing their eyesight in favor of a better sense of smell. [6]

The anomaly to this theory were anthropoids, who appeared to have the most divergence from nocturnality than all organisms examined. While most mammals didn't exhibit the morphological characteristics expected of a nocturnal creature, reptiles and birds fit in perfectly. A larger cornea and pupil correlated well with whether these two classes of organisms were nocturnal or not. [7]

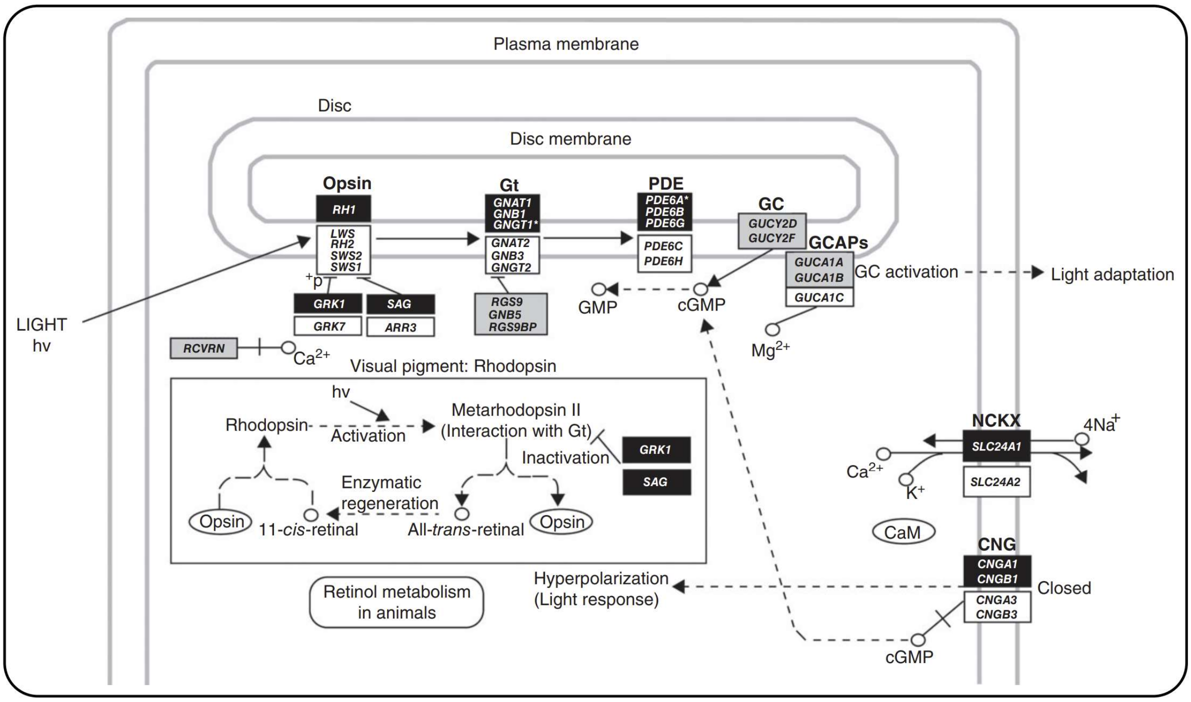


Figure 1. The genes involved in rod and cone phototransduction pathways. Dark, white, and grey rectangles indicate the genes involved in the phototransduction pathways of rods, cones, and both, respectively. *shows gene loss of GNGT1 and PDE6A in both reptiles and birds. Retinal transcriptome sequencing sheds light on the adaptation to nocturnal and diurnal lifestyles in

raptors. Invasion of ancestral mammals into dim-light environments inferred from adaptive evolution of the phototransduction genes. [3]

**Reference**


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