Chapter 1

General Introduction

General introduction to signal transduction systems

The transition from unicellular to multicellular life forms is one of the most significant events in the evolutionary history of life on Earth. This jump opened up entirely new avenues for complexity and specialization, significantly impacting the biodiversity and complexity we observe today (Buss 1987; Smith et al. 1997; Brunet and King 2017).

Multicellularity allowed for the differentiation of cells into specialised types, each performing specific roles within the organism. This specialisation increased efficiency, enabling multicellular organisms to grow larger and survive in a wider range of environments. For example, the development of specialised cells for vision, reproduction, or immunity would not be possible without multicellularity (Bich et al. 2019). Additionally, it establishes a cooperative framework, driving the evolution of complex behaviours and traits as cells collaboratively respond to environmental challenges (Ruiz-Trillo and Nedelcu 2015).

The occurrence of multicellularity marked a turning point in the annals of life, opening the door to a new level of complexity. This progression from unicellular to multicellular organisms marked not only a physical transition but a paradigm shift in the way evolution sculpted life. Suddenly, organisms were no longer merely single entities adapting to their environment; they became complex systems of specialised cells evolving collectively. This cooperative interaction between cells allowed for an unprecedented level of adaptation and survival, expanding life’s potential to exploit a wider range of environments. Within this context of multicellularity, evolution found a new arena to manifest, shaping not just individual cells, but also the intricate systems they composed.

The concept of evolution is the foundation of modern biological sciences and is critical to our understanding of life’s complexity, diversity, and continuity. Charles Darwin, the eminent nineteenth-century naturalist, provided the bases of evolutionary thery with his book “On the Origin of Species” (REF). Evolution is a process that results in heritable changes in a population spread over many generations. It signifies the gradual transformation of living organisms from their simplest primitive state to complex and diversified forms. Evolution operates on the basic of “descent with modification”, meaning species evolve and adapt over time to their environment by gradual genetic changes. The modified descendants then diverge from their ancestors as they acquire unique characteristics. These differences accumulate over lond periods, leading to the creation of entirely new species, a process known as speciation.

Evolution is the fundamental biological process that describes the changes in heritable traits within populations over successive generations. It occurs through mechanisms such as natural selection, genetic drift, gene flow, and mutations, leading to the diversification and adaptation of species to their respective environments. In the context of animal physiology, evolution is highly relevant as it underpins the development and function of the physiological traits that allow animals to survive, reproduce, and thrive in their ecological niches. The study of evolution holds paramount importance in various scientific disciplines, providing insights into the history, functioning, and future of living organisms. Through the lens of evolution, we can understand how certain physiological features have emerged and persisted due to their adaptive advantages, shaping the anatomical and biochemical characteristics of animals. The study of evolution in animal physiology provides crucial insights into the co-evolutionary relationship between organisms and their environment, shedding light on the mechanisms that have allowed animals to withstand environmental pressures, exploit available resources, and ultimately, perpetuate their genetic legacy.

Applied evolution/Why it’s important to study evolution

As our planet faces ongoing environmental challenges, evolutionary studies become increasingly vital. Investigating how animals have evolved in response to past environmental changes can offer valuable insights into their potential to cope with current and future challenges, such as climate change and habitat destruction. One remarkable example of applying evolutionary studies to a specific animal system is the exploration of vision. Vision is a fundamental sense for many organisms, enabling them to navigate their environment, detect prey or predators, and communicate with conspecifics. Throughout the history of life, vision has undergone remarkable adaptations in response to the diverse ecological challenges faced by different species.

Thus, the study of evolution is essential for comprehensive life’s history, adaptation, and the mechanisms driving the process of change. Exploring the evolution of defferent physiological processes we unlock invaluable insights into the ways species have adapted to their environments, and in which moments of the speciation some of the important genes emerged or got lost. Here I provide a detailed evolutionary analysis of different systems ............

In summary, the general aim of this work was to obtain insghts into the evolution of the visual and immune system, by the means of ......

References

Bich L, Pradeu T, Moreau J-F. 2019. Understanding Multicellularity: The Functional Organization of the Intercellular Space. *Frontiers in Physiology* [Internet] 10. Available from: https://www.frontiersin.org/articles/10.3389/fphys.2019.01170

Brunet T, King N. 2017. The Origin of Animal Multicellularity and Cell Differentiation. *Developmental Cell* 43:124–140.

Buss LW. 1987. The Evolution of Individuality. Princeton University Press Available from: https://www.jstor.org/stable/j.ctt7zvwtj

Ruiz-Trillo I, Nedelcu AM. 2015. Evolutionary Transitions to Multicellular Life: Principles and Mechanisms edited by Iñaki Ruiz-Trillo and Aurora M. Nedelcu. *Advances in Marine Genomics 2. Springer* 91:370–371.

Smith T late PJM, Szathmary E, Smith T late PJM, Szathmary E. 1997. The Major Transitions in Evolution. Oxford, New York: Oxford University Press