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Editorial paper

Zebrafish, a model organism

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1. Introduction

Human beings cannot repair damaged muscles on their own, unlike their vertebrate cousin Danio rerio. Commonly known as the zebrafish, it can refurbish virtually all of its organs, including the heart, spine, liver, pancreas, and kidneys [1]. We understand better why it has become a favorite subject for scientists. In India, fifteen laboratories have chosen it as a subject of study to find out if the behavior of its cells can be extrapolated to other organisms.

This small freshwater fish, native to the southeastern Himalayan region, lives in springs, lakes, ponds and rice fields. Its embryo develops in water, making it an ideal study subject for researchers.

The embryo develops outside the mother's body and since it is transparent it is very easy to study it under a microscope. Transparency also makes genetic manipulation techniques easier to use. Zebrafish can provide up to 200 embryos at once, and he is ready to produce more [2].

The zebrafish or Danio rerio is a tropical species of fish in the Cyprinidae family. The adult measures between 4 and 5 centimeters. Its body is adorned with bright, metallic and shiny hues and it is made up of five longitudinal steel blue bands along its length. While the male is rather slender, the female is more rounded. This fish is found naturally, in the form of small schools of at least half a dozen individuals, in India in rice fields, stagnant waters and small streams with slow currents. The zebrafish has one of the largest genomes for a vertebrate, with 26,000 coding genes, which makes it a model of choice for the study of genetics [3].

Since the end of the 1990s, this small fish has been commonly used in the laboratory as a model organism because it has many advantages. A model organism is a non-human species studied in depth in the laboratory to understand one or more biological phenomena. The physiology of a model organism is close to that of one or more other species. The observations of a biological phenomenon drawn from investigations on this model organism can therefore be, at least partially, valid for other species, including humans. This transfer of knowledge from one species to another is made possible by the common origin of all living organisms, the conservation of metabolism and a common part of the genetic heritage during evolution. Model organisms allow important advances in the understanding of living organisms and serve as a modeling tool for the very complex human organism. Model organisms therefore make it easier to carry out complex or impossible studies on other species for technical and/or ethical reasons. Nevertheless, extrapolations from one organism to another must be made with caution because the use of model organisms is not without limits and there is today no perfect substitute for the study of a living organism as complex as humans [4].

The benefits of zebrafish are many! Due to its size, it takes up little space, its breeding is easy and not expensive [5]. It reproduces quickly and in large numbers, and its development is uniform between individuals and rapid since it becomes an adult in less than three months. Moreover, the embryos of this fish develop out of the female and these small fish are transparent in the early stages of their development. Furthermore, it is possible to make the zebrafish transparent in adulthood via a genetic mutation, which makes any surgery or intrusion unnecessary to see what is happening inside the organism, and allows tracking cells or molecules within and interacting with the body. Finally, it is possible to modify this fish using genetic engineering.

Zebrafish are used in both basic and applied research. It is used in immunology, cancerology, toxicology and neurosciences. In this last field, the zebrafish is used for the study of the development of the nervous system, of the retina, of sensory perception, but also for the study of a certain number of disorders of the nervous system [autism, schizophrenia, attention deficit, brain damage, neurodegenerative diseases…], and it is particularly used for the study of neuronal regeneration following spinal cord lesions, since this small fish has astonishing regenerative capacities [6]. However, that with approximately 70 to 85% of human genes having an equivalent in zebrafish, this model is not close enough to humans to directly transpose the results obtained on this fish directly to our species [7]. Today, researchers are listing all the genetic mutations observed in this fish and their consequences in order to create a huge database accessible to all researchers in the world for current and future research, fundamental and applied, in order to better understand a number of diseases.

Zebrafish achieve near-optimal foraging efficiency and intergroup equity have been published [8]. The findings, based on analysis of the common swimming patterns of individual zebrafish and groups, and detailed mathematical models of their behavior, suggest that specialized social interactions enable animals to forage efficiently and result in a more even distribution of fish. food among group members. Living in a group has obvious advantages, including the sharing of responsibilities and resources. Understanding the interactions among zebrafish individuals that give rise to group behavior is therefore essential for studying and analyzing the collective behavior of animal groups and other biological systems.

In real-life situations, animals are likely to encounter multiple food sources or threats, where maintaining a tight group may not be beneficial for all group members. Indeed, shoal and group species have been shown to disperse when confronted with distributed resources. We aimed to characterize group foraging in complex environments and to map functional interactions among group members. Harpaz and Schneidman studied free foraging by groups of adult zebrafish in an open arena [9]. They tracked the feeding behaviors of a single adult zebrafish and groups of three or six fish in a large circular arena with shallow water, where small flakes of food were scattered on the surface. Tracking these activities revealed that the fish picked up on the swimming maneuvers of their shoal mates that indicated the presence of food, and reacted by swimming towards those spots. The team then compared the predictive power of a family of mathematical models, based on inferred functional and social interactions between zebrafish. The model that accurately describes the foraging behaviors of individuals and groups suggests that interactions among fish allow them to combine individual and social information to achieve near-optimal foraging efficiency and promote more equal food intake. within groups.

The identification and validation of new therapeutic targets is an important area of research to promote innovative approaches to treat brain diseases. Today, the mouse is a widely used model to characterize the potential of new targets. However, this animal model shows many limitations for upstream studies, not being, for example, suitable for large-scale studies. On the other hand, the time required and the associated costs, not to mention the growing constraints linked to work on mammals, largely limit the use of this model.

The zebrafish model has proven to be a complementary and more adaptable model, making it possible to rapidly analyze a biological process, and above all to develop and validate new tools that can then be used in mammals [10]. It can be used to set up models of human pathologies. Indeed, most physiological and developmental processes, as well as the genetic mechanisms that control them, are conserved between humans and fish. On the other hand, the transparency of larvae and young fish is ideal for the application of optogenetics and optopharmacology techniques [11]. Zebrafishes are now, and rightly, considered an excellent alternative for early animal studies

References

[1] Arjmand B, Tayanloo-Beik A, Foroughi Heravani N, Alaei S, Payab M, Alavi-Moghadam S, Goodarzi P, Gholami M, Larijani B. Zebrafish for Personalized Regenerative Medicine; A More Predictive Humanized Model of Endocrine Disease. Front Endocrinol. 2020 17; 11:396. https://doi.org/10.3389/fendo.2020.00396.

[2] Cassar S, Adatto I, Freeman JL, Gamse JT, Iturria I, Lawrence C, Muriana A, Peterson RT, Van Cruchten S, Zon LI. Use of Zebrafish in Drug Discovery Toxicology. Chem Res Toxicol. 2020; 33:95-118. https://doi.org/10.1021/acs.chemrestox.9b00335.

[3] Postlethwait JH. The zebrafish genome: a review and msx gene case study. Genome Dyn. 2006; 2:183-197. https://doi.org/10.1159/000095104.

[4] Baldridge D, Wangler MF, Bowman AN, Yamamoto S; Undiagnosed Diseases Network; Schedl T, Pak SC, Postlethwait JH, Shin J, Solnica-Krezel L, Bellen HJ, Westerfield M. Model organisms contribute to diagnosis and discovery in the undiagnosed diseases network: current state and a future vision. Orphanet J Rare Dis. 2021 ;16[1]:206. https://doi.org/10.1186/s13023-021-01839-9.

[5] Adhish M, Manjubala I. Effectiveness of zebrafish models in understanding human diseases-A review of models. Heliyon. 2023 Mar 13;9[3]: e14557. https://doi.org/10.1016/j.heliyon.2023.e14557.

[6] Vaz R, Hofmeister W, Lindstrand A. Zebrafish Models of Neurodevelopmental Disorders: Limitations and Benefits of Current Tools and Techniques. Int J Mol Sci. 201920[6]:1296. https://doi.org/10.3390/ijms20061296.

[7] Davis EE, Frangakis S, Katsanis N. Interpreting human genetic variation with in vivo zebrafish assays. Biochim Biophys Acta. 2014 ;1842[10]:1960-1970. https://doi.org/10.1016/j.bbadis.2014.05.024.

[8] Harpaz R, Schneidman E. Social interactions drive efficient foraging and income equality in groups of fish. Elife. 2020 ;9: e56196. https://doi.org/10.7554/eLife.56196.

[9] Harpaz R, Schneidman E. Social interactions drive efficient foraging and income equality in groups of fish. Elife. 2020 ;9: e56196. https://doi.org/10.7554/eLife.56196.

[10] Rubbini D, Cornet C, Terriente J, Di Donato V. CRISPR Meets Zebrafish: Accelerating the Discovery of New Therapeutic Targets. SLAS Discov. 2020 25:552-567. https://doi.org/10.1177/2472555220926920.

[11] Simmich J, Staykov E, Scott E. Zebrafish as an appealing model for optogenetic studies. Prog Brain Res. 2012;196:145-162. https://doi.org/10.1016/B978-0-444-59426-6.00008-2.