



Illuminating the Future: *Danio Rerio* as Game Changing Model for Vision Restoration

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The *Danio-rerio* model has emerged as a revolutionary tool in biomedical research, offering genetic similarity to humans, cost effective, rapid reproduction rates. With 70% of the human genes having the similarity with *danio-rerio*, this model has become as the instrumental in studying genetic disorders, drug discovery, disease modelling. This article talks about the advantages of this model compared to laboratory animals. This paper mainly focuses on the vision restoration by using this model. Blindness remains as the one of the most challenging medical conditions, with limited regenerative capacity in the human retina. However, *danio-rerio* possess a unique ability to regenerate the damaged retinal cells through the activation of the muller glial cells, offering a

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promising avenue for the vision restoration in the humans. This remarkable regenerative mechanism has fuelled cutting edge research aimed at developing novel therapies for retinal diseases such as macular degeneration and retinitis pigmentosa. This paper explores the regenerative potential of danio-rerio in curing blindness, highlighting the molecular pathways that drive retinal repair. Additionally, this explores the how these insights are being translated into the ground breaking gene and stem cell therapies for human eye diseases. By harnessing the regenerative power of danio-rerio, we move closer to a future where blindness may no longer be irreversible.

Keywords: *Danio rerio*; retinal regeneration; muller glial cells; vision restoration; blindness cure; regenerative medicine; regenerative potential.

1. INTRODUCTION

Blindness is the state of unable to see or having the limited vision that cannot be corrected by the contact lens (Engeszer R.E, et al., 2007). Severity, correction, visual acuity, legal blindness, Visual field are some of the key concepts of the blindness (Streisinger G, et al., 1981). Now a days world-wide despite of age everyone are facing the vision loss problems (Tonon F., et al., 2020), this problem is due to various reasons but the ultimate goal is the restoration of the vision (Chen X, et al., 2021). But this vision restoration is irreversible in humans, this is due to the inactivation of the muller glial cells in the human eyes.



Fig. 1. *Danio rerio* Fish

Danio rerio which is a fresh water fish mainly native to south Asia (Hason M, et al., 2019). They share a significant genetic similarity with humans making them valuable for studying for the human diseases (Lenis-Rojas O.A., et al., 2022). The major thing to elaborate about this *danio rerio* is that it is having the 70% (Wang X, et al., 2022) genetic similarity with the humans as well as they are having the transparent embryos which allows the real time observation of the organ development (White R.M, et al., 2008). This has become a preferred model in research due to the unique biological and genetic characteristics (Lam S.H, et al., 2004). This *danio rerio* also works same as laboratory animals but their abundant applications and uses are known to very minute range of population (Barriuso J, et al., 2015).

Danio rerio is a species of freshwater ray finned fish belonging to the family *danio nidae* of the order cypriniforms (Dekens M.P, et al., 2003) Native to south Asia, it is a popular aquarium fish, frequently sold under the trade name danio (Tonon F, et al., 2022) and thus often called a tropical fish although it is both tropical and subtropical (Tonon F., et al., 2016).

2. SCIENTIFIC CLASSIFICATION

Domain - Eukaryota (Li L, et al., 2012)
Kingdom - Animalia (Voisard P., et al., 2022)
Phylum - chordata (van den Boom J, et al., 2018)
Class - Actinopterygii
Order - Cypriniformes
Family – *Danio nidae*
Genus - *Danio*
Species – *Danio rerio*

This small tiny fish is an important and widely used vertebrate model organism in the scientific research, (Diogo P., et al., 2023) particularly in the developing biology, but also gene function, oncology, teratology, and drug development, (Doughnon G., et al., 2022) in particular preclinical development. It is also notable for its regenerative abilities, and has been modified by the researchers to produce many transgenic strains (Rosa J.G.S., et al., 2022).

Some of the advantages of this *danio rerio* model includes- genetic similarity, (Ghaddar B, et al., 2022) rapid development of the embryos, high reproduction rate, transparent embryos, Low maintenance cost and ethical benefits, Amenable for molecular and genetic analysis (Russo C., et al., 2023). As this fish eggs are developed outside the mothers body it is an ideal model for the organism studying in the early development (Hamilton F, et al., 1822). The life cycle of *denio rerio* mainly involves the cleavage stage, sphere stage, gastrulation and epiboly, organogenesis, hatching, and adult form (Spence R., et al.,

2008). This model able to regenerate the retinal cells this is because the muller glial cells are present, and also it contains the more number of cones and it is having the excellent colour vision (Kimmel C.B, et al., 1995). The steps involved in the retinal regeneration of the *danio rerio* model includes- Injury, muller glial programming, cell division, migration, differentiation (Howe K., et al., 2013).

Human retinal cells lack this vision restoration due to the absence of the muller glial reprogramming or the inactivation of the Muller glial cells in the eye (Lieschke G.J, et al., 2007). So, by understanding the similar mechanism in the *danio rerio* to activate the muller glial cells helps to restoration of vision in humans (Westerfield M, et al., 2014).

3. APPLICATIONS

Danio rerio are extensively used in the biomedical research due to their unique advantages like rapid development, transparency, and mainly genetic similarity to the humans (White R.M., et al., 2015).

1. **Disease Modeling:** Human disease research- This *danio rerio* is used to model human diseases by the reproducing genetic mutations in this fish, observing their development, and testing potential therapies (Bai Q., et al., 2011). This allows researchers to study the pathogenesis of various diseases, including cancer, cardiovascular diseases, and neurological diseases.
2. **Drug Discovery and Toxicology:** These are used in preclinical research to identify potential drugs and assess their toxicity (Bandmann O., et al., 2010). This fish larvae have been used to detect the retinal toxicity in pharmaceutical compounds.
3. **Developmental Biology:** These are used for studying the developmental processes, such as the organogenesis and the tissue regeneration.
4. **Studying Regenerative Medicines:** They are known for their remarkable regenerative capabilities, making them ideal for studying regeneration and developing strategies for repairing damaged tissues in the humans (Das S., et al., 2014).
5. **Genetic and Molecular Studies:** These fishes are used to identify the function of a

gene involved in various biological processes (Laird A.S., et al., 2016).

6. **Toxicological Studies:** They are used in ecotoxicity testing to assess the impact of substance on aquatic organisms and their environment (Chaturvedi B et al., 2022). They are also used to investigate the effects of the nanoparticles on biological systems (Boehmler W., et al., 2004).
7. **Fluorescent Imaging:** *Danio rerio* are used for fluorescent imaging techniques to understand the biological process *in vivo* (Norton W.H.J, et al., 2008).

4. CONCLUSION

Danio rerio is the one of the best models for understanding the clear live mechanisms which are likely happening in our bodies. This transparent embryo mainly helps to study the live growth of this tiny fishes. This model not only for the vision restoration and for the several other diseases to study the live mechanisms and to discover the newer drugs, and to minimise the usage of the laboratory animals and to reduce the work load and cost, this model is promoting as one of the unique models for performing the various research activities, drug discoveries and other studies related to humans.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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