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Zebrafish as a Model Organism in Type 2 Diabetes Research: A Comprehensive Review

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Abstract: *Zebrafish (Danio rerio) have gained attention as a practical model for studying Type 2 Diabetes Mellitus (T2DM). Their fast development, see-through embryos, and genetic resemblance to humans allow researchers to track metabolic changes directly in living organisms. This review outlines various zebrafish T2DM models, including those created through diet, chemical treatment, and targeted genetic changes. We discuss how these models help explore disease mechanisms and evaluate potential treatments, along with their benefits and limitations, emphasizing their growing role in diabetes research. [2].*

Keywords: Zebrafish

I. INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a common metabolic disorder marked by insulin resistance and insufficient insulin secretion. Rodents and other mammalian models have long been used to study this disease, but they can be expensive, have long lifespans, and raise ethical issues. Zebrafish provide a convenient alternative because of their small size, quick growth, and genetic accessibility. This review summarizes zebrafish models of T2DM and examines how they contribute to diabetes research. [2]

II. ZEBRAFISH AS A MODEL ORGANISM

Zebrafish are small freshwater fish widely used in biomedical studies. Their transparent embryos allow real-time observation of developmental and physiological processes. Techniques such as CRISPR/Cas9 and morpholino knockdowns make it possible to study the roles of specific genes. Zebrafish also share important metabolic pathways with humans, making them suitable for modeling diseases like T2DM.

III. ZEBRAFISH MODELS OF TYPE 2 DIABETES

3.1 Diet-Induced Models

Overfeeding zebrafish with high-fat diets, such as Artemia, can lead to obesity, insulin resistance, and elevated blood sugar levels. These models mimic some aspects of human T2DM and help study metabolic changes. [2]

3.2 Chemical-Induced Models

Chemicals like streptozotocin (STZ) and alloxan are used to impair pancreatic beta cells in zebrafish, causing high blood sugar. Researchers use these models to examine beta-cell damage and potential therapies for regeneration. [4]

3.3 Genetic Models

Mutations in insulin receptor genes and other relevant genes can be introduced in zebrafish to study insulin signaling and diabetes development. Genetic models allow precise investigation of molecular pathways linked to T2DM. [3]

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Applications in Diabetes Research [5]

- **Understanding Mechanisms:** Zebrafish models reveal how insulin signaling, glucose metabolism, and fat regulation are affected in T2DM.
- **Drug Discovery:** Researchers can screen compounds like metformin and glimepiride for antidiabetic effects using zebrafish.
- **Studying Complications:** Zebrafish are also used to examine diabetic complications, such as eye and kidney problems, to understand disease progression.

Advantages and Limitations [1]

Advantages: [1]

- Quick embryonic development allows rapid experimentation.
- Transparent embryos make in vivo observations easy.
- Advanced genetic tools enable precise gene studies.

Limitations: [3]

- Differences in organ structure, such as the pancreas, may limit direct translation to humans.
- Variations in metabolism can affect interpretation of experimental results.

Future Directions [5]

- Combining genetic, chemical, and dietary approaches to develop more robust T2DM models.
- Conducting long-term studies to better replicate human disease progression.
- Integrating genomics, proteomics, and metabolomics for comprehensive disease insights.

IV. CONCLUSION

Zebrafish are a valuable tool for T2DM research, enabling detailed studies of disease mechanisms and testing of new treatments. Despite some limitations, advances in zebrafish modeling continue to provide meaningful contributions to understanding and managing diabetes.

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