

Introduction

Teeth are mineralized organs unique to vertebrates. While highly diverse in morphology and function, their development relies on evolutionarily conserved molecular mechanisms. Despite extreme phenotypic diversity in vertebrate dentition (particularly in fish), molecular regulatory networks governing odontogenesis remain inadequately characterized. Research links dental developmental disorders to aberrant BMP signaling pathways. Systematic investigation of pharyngeal tooth development in fish will bridge knowledge gaps in piscine odontogenesis and provide novel insights into mammalian tooth development.

Results and Discussion

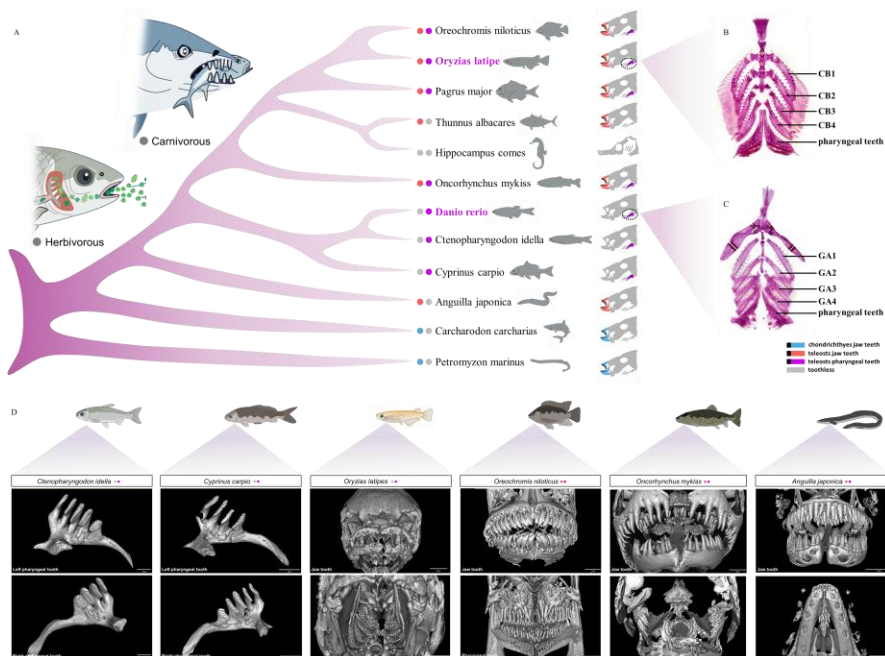


Fig1. Analysis of the Evolutionary Diversity and Morphological Characteristics of Fish Teeth

Phylogenetic analysis reveals the remarkable evolutionary diversity of fish dentition. Different taxa have evolved distinct dental systems, and their specific tooth morphology is also highly specialized for particular diets, demonstrating exquisite adaptations for feeding functions.

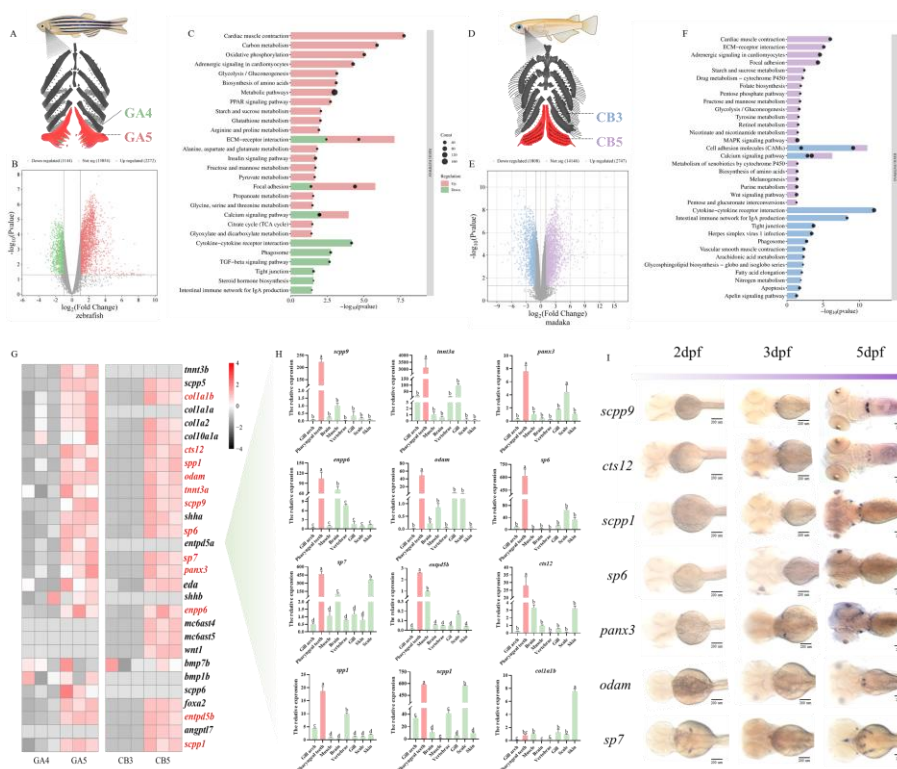


Fig2. Screening for Key Regulators of Pharyngeal Tooth Development in Fish.

Cross-species comparative transcriptomics suggests that *scpp9* is a key regulator of zebrafish pharyngeal tooth development, distinguished by its significant spatiotemporal expression specificity in contrast to other candidate genes.

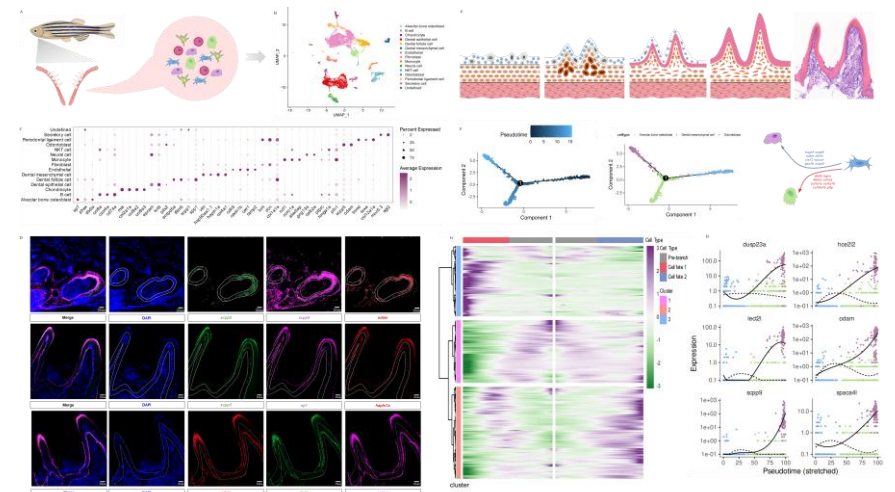


Fig3. Construction of a Single-Cell Atlas for the Pharyngeal Tooth and Analysis of Cell Differentiation Trajectories During Its Development.

We constructed the first single-cell atlas of the zebrafish pharyngeal tooth and found that *scpp9* is highly expressed in odontoblasts, suggesting that it may play a key regulatory role during their differentiation process.

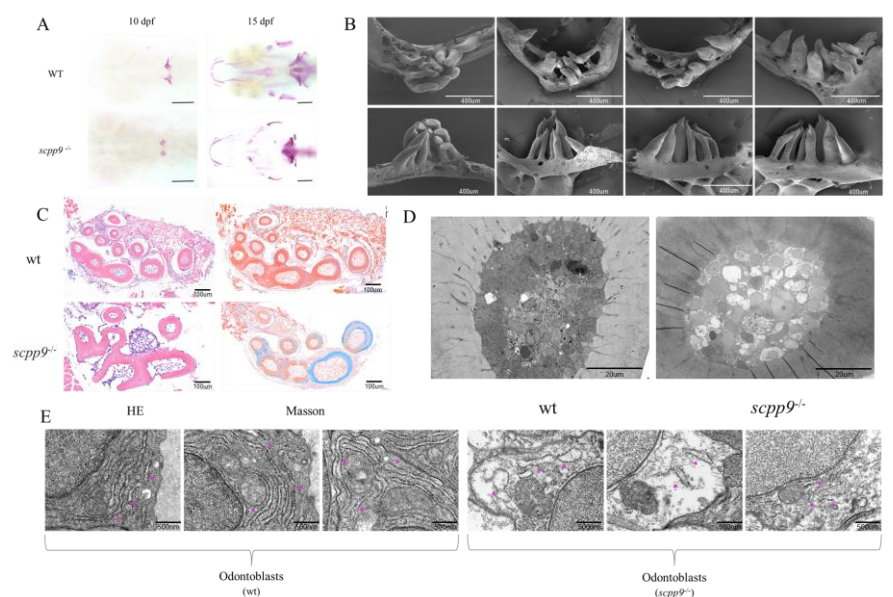


Fig4. Phenotypic Analysis of *scpp9*^{+/+} and *scpp9*^{-/-} Zebrafish.

scpp9^{-/-} zebrafish mutants exhibited developmental defects including a reduced tooth number, impaired odontoblast function, and inhibited mineralization of the remaining teeth, revealing the central regulatory role of *scpp9* in pharyngeal tooth development.

Conclusion

This study identifies *scpp9* as a key regulator of fish pharyngeal tooth development, providing new evidence for the interplay between adaptive evolution and conserved developmental mechanisms. Our findings strongly suggest *scpp9* is a critical driver of dental diversity (such as tooth number) during evolution and offers a new perspective on the molecular basis of human dental pathologies like anodontia.