

Author's Accepted Manuscript

An ancient dental gene set governs development and continuous regeneration of teeth in sharks

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PII: S0012-1606(16)30048-3
DOI: <http://dx.doi.org/10.1016/j.ydbio.2016.01.038>
Reference: YDBIO7008

To appear in: *Developmental Biology*

Received date: 30 October 2015
Revised date: 11 January 2016
Accepted date: 29 January 2016

Cite this article as: Liam J. Rasch, Kyle J. Martin, Rory L. Cooper, Brian Metscher, Charlie Underwood and Gareth J. Fraser, An ancient dental gene set governs development and continuous regeneration of teeth in sharks *Developmental Biology*, <http://dx.doi.org/10.1016/j.ydbio.2016.01.038>

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Abstract

The evolution of oral teeth is considered a major contributor to the overall success of jawed vertebrates. This is especially apparent in cartilaginous fishes including sharks and rays, which develop elaborate arrays of highly specialized teeth, organized in rows and retain the capacity for life-long regeneration. Perpetual regeneration of oral teeth has been either lost or highly reduced in many other lineages including important developmental model species, so cartilaginous fishes are uniquely suited for deep comparative analyses of tooth development and regeneration. Additionally, sharks and rays can offer crucial insights into the characters of the dentition in the ancestor of all jawed vertebrates. Despite this, tooth development and regeneration in chondrichthyans is poorly understood and remains virtually uncharacterized from a developmental genetic standpoint. Using the emerging chondrichthyan model, the catshark (*Scyliorhinus* spp.), we characterized the expression of genes homologous to those known to be expressed during stages of early dental competence, tooth initiation, morphogenesis, and regeneration in bony vertebrates. We have found that expression patterns of several genes from Hh, Wnt/ β -catenin, Bmp and Fgf signalling pathways indicate deep conservation over ~450 million years of tooth development and regeneration. We describe how these genes participate in the initial emergence of the shark dentition and how they are re-deployed during regeneration of successive tooth generations. We suggest that at the dawn of the vertebrate lineage, teeth (i) were most likely continuously regenerative structures, and (ii) utilised a core set of genes from members of key developmental signalling pathways that were instrumental in creating a dental legacy redeployed throughout vertebrate evolution. These data lay the foundation for further experimental investigations utilizing the unique regenerative capacity of

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