



Brief Report

Patterning of the Vertebrate Head in Time and Space by BMP Signaling

Kongju Zhu ^{1,2,3,4,*} , Herman F. Spaink ¹  and Antony J. Durston ^{1,†}

¹ Institute of Biology, Leiden University, Sylviusweg 72, 2338BE Leiden, The Netherlands

² Department of Pathology, Brigham and Women's Hospital, 60 Fenwood Road, Boston, MA 02115, USA

³ Department of Genetics, Harvard Medical School, Boston, MA 02115, USA

⁴ Division of Genetics and Genomics, Boston Children's Hospital, Center for Life Sciences, Blackfan Circle, Boston, MA 02115, USA

* Correspondence: kczhu4@bwh.harvard.edu

† Deceased.

Abstract: How head patterning is regulated in vertebrates is yet to be understood. In this study, we show that frog embryos injected with Noggin at different blastula and gastrula stages had their head development sequentially arrested at different positions. When timed BMP inhibition was applied to BMP-overexpressing embryos, the expression of five genes: *scg-1* (a marker of the cement gland, which is the front-most structure in the frog embryo), *six3* (a forebrain marker), *otx2* (a forebrain and mid-brain marker), *gbx2* (an anterior hindbrain marker), and *hox1* (a posterior hindbrain marker) were sequentially fixed. These results suggest that the vertebrate head is patterned from anterior to posterior in a progressive fashion and may involve timed actions of the BMP signaling.

Keywords: BMP signaling; head patterning; extreme anterior domain (EAD); *Xenopus*



Citation: Zhu, K.; Spaink, H.F.; Durston, A.J. Patterning of the Vertebrate Head in Time and Space by BMP Signaling. *J. Dev. Biol.* **2023**, *11*, 31. <https://doi.org/10.3390/jdb11030031>

Academic Editors: Cynthia Bradburn and Simon J. Conway

Received: 10 January 2023

Revised: 19 June 2023

Accepted: 27 June 2023

Published: 3 July 2023



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1. Introduction

During early development, the vertebrate embryo is patterned from anterior to posterior in a temporally progressive manner [1–5]: anterior tissues are specified early, and more posterior tissues are determined progressively later. Whereas coordination between temporal and spatial control of anterior-posterior (A–P) patterning is evident, a thorough understanding of the underlying mechanisms is still lacking in vertebrates.

In frogs, a BMP/anti-BMP dependent time-space translation mechanism has been proposed for trunk-tail patterning by Hox genes [6,7]. In this mechanism, Hox genes are sequentially activated in a high BMP region of the mesoderm (non-organizer mesoderm) [8], where their expression is dynamic and unstable. As the mesoderm involutes during gastrulation, Hox expressing cells are successively exposed to signals from the Spemann organizer, resulting in the Hox sequence being fixed at different points along the forming axis. In this way, the timing information encoded by Hox genes is translated into a spatial pattern. The putative organizer signals that stabilize Hox codes are BMP antagonists, e.g., Noggin [9] and Chordin [10], because these mimic the function of the organizer in dorsalizing the embryo [11,12], inducing a secondary axis [10,13,14], and rescuing A–P axes in ventralized embryos [7,10]. Notably, timed Noggin treatments in ventralized embryos not only rescue the A–P axis, but also the spatial pattern of Hox gene expression [7]. This conclusion is further supported by a recent study in chicks, which reported the fixation of Hox codes in the explanted posterior primitive streak (containing high BMP mesoderm) by Noggin treatments [15]. Together, these findings suggest that BMP signaling is involved in patterning the trunk-tail part of the axis by (directly or indirectly) regulating Hox gene expression.

In the rescue experiments mentioned above [7,10], Noggin and Chordin treatments can also rescue the head part of the axis, suggesting that BMP signaling may also be involved in patterning the head. Using heat-shock inducible *chordin* transgenic lines (Tg

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**David Cheung, Graham J. Williams, Qing
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Patterning of Time Leonard William Doob, **Electrohydrodynamic Patterning of Functional Materials** Pola Goldberg Oppenheimer, 2013-07-23 This thesis explores a route to induce and control the structure formation process in thin films by the use of strong electric fields We investigate establish and apply the use of the electrohydrodynamic EHD lithography as a versatile patterning tool on the sub micrometre and nanometre length scales for functional materials Thin films are ubiquitous they are found in nature and used in almost every aspect of daily life While film instabilities are often undesirable in nature and technology they can be utilized to produce structures by precisely controlling the destabilization of the film EHD lithography utilizes instabilities induced by means of an electric field to fabricate periodic structures EHD patterning is set to become a competitive candidate for low cost lithographic technology for a number of applications Herein the applied potential of this lithographic process is explored by expanding its applicability to a broad range of materials and by a simultaneous patterning of multilayer systems or functional polymers yielding hierarchical architectures with novel functionalities EHD pattern formation enables for instance the fabrication of multi scale structured arrays as surface enhanced Raman scattering SERS active platforms Furthermore crystalline and conductive polymers are patterned using the EHD approach and the underlying structure formation mechanisms are discussed This extension towards functional material systems offers interesting prospects for potential applications Findings of this thesis are very promising for use in optoelectronic devices

Using Time Series to Analyze Long-Range Fractal Patterns Matthijs Koopmans, 2020-09-23 Using Time Series to Analyze Long Range Fractal Patterns presents methods for describing and analyzing dependency and irregularity in long time series Irregularity refers to cycles that are similar in appearance but unlike seasonal patterns more familiar to social scientists repeated over a time scale that is not fixed Until now the application of these methods has mainly involved analysis of dynamical systems outside of the social sciences but this volume makes it possible for social scientists to explore and document fractal patterns in dynamical social systems Author Matthijs Koopmans concentrates on two general approaches to irregularity in long time series autoregressive fractionally integrated moving average models and power spectral density analysis He demonstrates the methods through two kinds of examples simulations that illustrate the patterns that might be encountered and serve as a benchmark for interpreting patterns in real data and secondly social science examples such a long range data on monthly unemployment figures daily school attendance rates daily numbers of births to teens and weekly survey data on political orientation Data and R scripts to replicate the analyses are available on an accompanying website

Unsupervised Pattern Discovery in Automotive Time Series Fabian Kai Dietrich Noering, 2022-03-23 In the last decade unsupervised pattern discovery in time series i e the problem of finding recurrent similar subsequences in long multivariate time series without the need of querying subsequences has earned more and more attention in research and industry Pattern discovery was already successfully applied to various areas like seismology

medicine robotics or music Until now an application to automotive time series has not been investigated This dissertation fills this desideratum by studying the special characteristics of vehicle sensor logs and proposing an appropriate approach for pattern discovery To prove the benefit of pattern discovery methods in automotive applications the algorithm is applied to construct representative driving cycles

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Advances in Knowledge Discovery and Data Mining David Cheung, Graham J. Williams, Qing Li, 2001-04-04 This book constitutes the refereed proceedings of the 5th Pacific Asia Conference on Knowledge Discovery and Data Mining PAKDD 2001 held in Hong Kong China in April 2001 The 38 revised full papers and 22 short papers presented were carefully reviewed and selected from a total of 152 submissions The book offers topical sections on Web mining text mining applications and tools concept hierarchies feature selection interestingness sequence mining spatial and temporal mining association mining classification and rule induction clustering and advanced topics and new methods

Head First Design Patterns Eric Freeman, Elisabeth Robson, 2020-11-24 What will you learn from this book You know you don't want to reinvent the wheel so you look to Design Patterns the lessons learned by those who've faced the same software design problems With Design Patterns you get to take advantage of the best practices and experience of others so you can spend your time on something more challenging Something more fun This book shows you the patterns that matter when to use them and why how to apply them to your own designs and the object oriented design principles on which they're based Join hundreds of thousands of developers who've improved their object oriented design skills through Head First Design Patterns What's so special about this book If you've read a Head First book you know what to expect a visually rich format designed for the way your brain works With Head First Design Patterns 2E you'll learn design principles and patterns in a way that won't put you to sleep so you can get out there to solve software design problems and speak the language of patterns with others on your team

Design Patterns for Embedded Systems in C Bruce Powel Douglass, 2010-11-03 A recent survey stated that 52% of embedded projects are late by 4-5 months This book can help get those projects in on time with design patterns The author carefully takes into account the special concerns found in designing and developing embedded applications specifically concurrency communication speed and memory usage Patterns are given in UML Unified Modeling Language with examples including ANSI C for direct and practical application to C code A basic C knowledge is a prerequisite for the book while UML notation and terminology is included General C programming books do not include discussion of the constraints found within embedded system design The practical examples give the reader an understanding

of the use of UML and OO Object Oriented designs in a resource limited environment Also included are two chapters on state machines The beauty of this book is that it can help you today Design Patterns within these pages are immediately applicable to your project Addresses embedded system design concerns such as concurrency communication and memory usage Examples contain ANSI C for ease of use with C programming code *Real-time Design Patterns* Bruce Powel Douglass,2003 This revised and enlarged edition of a classic in Old Testament scholarship reflects the most up to date research on the prophetic books and offers substantially expanded discussions of important new insight on Isaiah and the other prophets

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