

Evolutionary developmental biology

GEORGE F. MICHEL

Introduction

Evolutionary developmental biology examines the developmental processes of various species to determine their ancestral relationship. It identifies how new and novel structures can be created from alteration in developmental processes including the creation of new genes (DNA sequences) from parts of old genes. Major questions addressed are:

1. How did developmental processes evolve?
2. How have modifications of developmental processes led to the production of novel features?
3. What is the role of developmental plasticity in evolution?
4. How does ecology affect development and evolutionary change?
5. What is the developmental basis of homology or similarity of form and function across species (wings in insect, bird and bat species)?
6. What is the developmental basis of homology or shared ancestry among structures across species (bat wings and primate arms)?

In 2000, the Society for Integrative and Comparative Biology formed the Evolutionary and Developmental Biology (evo-devo) division to emphasize the contribution of ontogenetic processes to evolution. This focus on developmental processes in evolution reflected dissatisfaction with the neo-Darwinian modern synthesis which explained evolution as changes in gene frequencies within populations as a consequence of mutation and the breeding effects of natural selection. Since natural selection only relates to phenotypes, the gene frequency explanation required that the development of the phenotype be controlled by the genotype (Fisher, 1930). Evo-devo advocates argued that neo-Darwinian evolution fails to explain how traits are ontogenetically created within the individual organism. In evo-devo, the individual is a complex system, composed of many sub-systems (e.g., neural, endocrine, immune, digestive), which operate as a

whole. Variations within and among the development of these sub-systems create individual differences. For many, evo-devo involves identifying the contributions of organism–environment co-action in establishing both the individual and species-typical developmental trajectories upon which natural selection operates (Michel & Moore, 1995).

This entry briefly describes current evo-devo, how it became a major interdisciplinary force in biology, how it avoids old-fashioned notions of heredity–environment and culture–biology interactions in developmental science, and how it is relevant to understanding human psychological development.

Evo-devo in brief

Recent advances in developmental biology revealed that developmental processes constrain certain possibilities and facilitate other possibilities of phenotypic variation. Thus, the variation on which natural selection operates involves development and not changes in gene frequencies (Gerhart & Kirschner, 1997; Raff, 1996; Schlichting & Pigliucci, 1998). For example, the developmental processes that result in the bird/mammalian four-chambered heart create a “new” cardiovascular organization. Although the development of a septum creates two ventricles, there are more extensive changes in the organization of the arterial and venous systems (Figure 1). Given the suite of DNA sequences that are involved in the development of the cardiovascular system, simple genetic mutations are an improbable source for this complex pattern of evolutionary changes.

Since birds and mammals evolved from separate reptilian lines (sauropsids and synapsids, respectively), their cardiovascular systems are somewhat different, as are the patterns of their development. DNA sequences are not causal mechanisms for the development of either system. Despite similarities in some sequences of DNA repurposed for the cardiovascular development

Evolutionary Developmental Biology 2nd Edition

Lei Huang



Evolutionary Developmental Biology 2nd Edition:

Evolutionary Developmental Biology Brian K. Hall, 2012-12-06 Although evolutionary developmental biology is a new field its origins lie in the last century the search for connections between embryonic development ontogeny and evolutionary change phylogeny has been a long one Evolutionary developmental biology is however more than just a fusion of the fields of developmental and evolutionary biology It forges a unification of genomic developmental organismal population and natural selection approaches to evolutionary change It is concerned with how developmental processes evolve how evolution produces novel structures functions and behaviours and how development evolution and ecology are integrated to bring about and stabilize evolutionary change The previous edition of this title published in 1992 defined the terms and laid out the field for evolutionary developmental biology This field is now one of the most active and fast growing within biology and this is reflected in this second edition which is more than twice the length of the original and brought completely up to date There are new chapters on major transitions in animal evolution expanded coverage of comparative embryonic development and the inclusion of recent advances in genetics and molecular biology The book is divided into eight parts which place evolutionary developmental biology in the historical context of the search for relationships between development and evolution detail the historical background leading to evolutionary embryology explore embryos in development and embryos in evolution discuss the relationship between embryos evolution environment and ecology discuss the dilemma for homology of the fact that development evolves deal with the importance of understanding how embryos measure time and place both through development and evolutionarily through heterochrony and heterotrophy and set out the principles and processes that underlie evolutionary developmental biology With over one hundred illustrations and photographs extensive cross referencing between chapters and boxes for ancillary material this latest edition will be of immense interest to graduate and advanced undergraduate students in cell developmental and molecular biology and in zoology evolution ecology and entomology in fact anyone with an interest in this new and increasingly important and interdisciplinary field which unifies biology

Evolutionary Developmental Biology, 2021-02-16 Evolutionary Developmental Biology Volume 141 focuses on recent research in evolutionary developmental biology the science studying how changes in development cause the variations that natural selection operate on Several new hypotheses and models are presented in this volume and these concern how homology may be properly delineated how neural crest and placode cells emerged and how they formed the skull and jaw and how plasticity and developmental symbiosis enable normal development to be regulated by environmental factors New models for homology New hypotheses for the generation of chordates New models for the roles of plasticity and symbionts in normal development

Keywords And Concepts In Evolutionary Developmental Biology Manorma Singh, 2007
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Keywords and Concepts in Evolutionary Developmental Biology Brian K. Hall, Wendy M. Olson, 2006-09 Covering more than 50 central terms and concepts in entries written by leading experts this book offers an overview of this new subdiscipline of biology providing the core insights and ideas that show how embryonic development relates to life history evolution adaptation and responses to and integration with environmental factors

The Inductive Brain in Development and Evolution Nelson R Cabej, 2021-06-22 The Inductive Brain in Development and Evolution provides readers with a substantial biological education on animal nervous systems and their role in the development adaptation homeostasis and evolution of species The book begins by delving into the embryonic development of the brain and then discusses epigenetic information and neural activity post birth It then analyzes the inductive brain's neural and brain control of such factors like myogenesis bone development sensory organs metamorphosis in vertebrates and invertebrates and wing development in insects The book closes with an examination of phenotypic evolution in neural control mechanisms and drivers of animal brains The Inductive Brain in Development and Evolution will offer evolutionary biologists specifically those researching development adaptation and evolution of animals a comprehensive text that covers a variety of valuable topics Presents the first book devoted to the inductive role of the brain in development in adaptation and in the evolution processes in animals Examines the central nervous system CNS from embryonic to adult life stages Provides detailed evidence to investigate the role of the CNS in molding animal morphology and life histories

The Handbook of Evolutionary Psychology, Volume 2 David M. Buss, 2015-09-29 A complete exploration of the real world applications and implications of evolutionary psychology The exciting and sometimes controversial science of evolutionary psychology is becoming increasingly relevant to more fields of study than ever before The Handbook of Evolutionary Psychology Volume 2 Integrations provides students and researchers with new insight into how EP draws from and is applied in fields as diverse as economics anthropology neuroscience genetics and political science among others In this thorough revision and expansion of the groundbreaking handbook luminaries in the field provide an in depth exploration of the foundations of evolutionary psychology as they relate to public policy consumer behavior organizational leadership and legal issues Evolutionary psychology seeks to explain the reasons behind friendship leadership warfare morality religion and culture in short what it means to be human This enlightening text provides a foundational knowledgebase in EP along with expert insights and the most up to date coverage of recent theories and findings Explore the vast and expanding applications of evolutionary psychology Discover the psychology of human survival mating parenting cooperation and conflict culture and more Identify how evolutionary psychology is interwoven with other academic subjects and traditional psychological disciplines Discuss future applications of the conceptual tools of evolutionary psychology As the established standard in the field The Handbook of Evolutionary Psychology Volume 2 is the definitive guide for every psychologist and student to understand the latest and most exciting applications of evolutionary psychology

Advancing Developmental Science Anthony S. Dick, Ulrich Müller, 2017-07-06 Advancing Developmental Science

reviews the state of the science in theoretical methodological and topical research with a unique focus on the scholarship that developed within a process relational framework **The Oxford Handbook of Philosophy of Biology** Michael Ruse, 2008-07-10 This handbook covers the history of philosophy of biology then moves on to evolutionary theory It continues with discussions of molecular biology and ecology and covers biology and ethics as well as biology and religion **The Neural Crest and Neural Crest Cells in Vertebrate Development and Evolution** Brian K. Hall, 2008-12-28 A presentation of all aspects of neural crest cell origins embryological and evolutionary development and evolution neural crest cell behavior migration and anomalies neurocristopathies and birth defects that arise from defective neural crest development The treatment of development will include discussions of cellular molecular and genetic aspects of the differentiation and morphogenesis of neural crest cells and structures derived from neural crest cells The origins of the neural crest in embryology will be discussed using the recent information on the molecular basis of the specification of the neural crest Also presented are the advances in our understanding of the evolution of jaws from studies on lampreys and of the neural crest from studies on ascidians and amphioxus **The Notochord** P. Eckhard Witten, Brian K. Hall, 2022-05-09 Although it is the defining organ of the Chordata the notochord and its cells are one of the least understood vertebrate organs This may be because large parts of the notochord are often replaced with cartilaginous or bony vertebral bodies The presence of cartilage in the notochord raises questions about the evolutionary relationships between notochord cells and cartilage cells This book integrates classical analytical studies with recent palaeontological experimental and molecular studies in both developmental and evolutionary contexts For example although the early signaling function of the notochord is conserved across the vertebrates many will be surprised to find that the role of the notochord in vertebral body development in tetrapods is not the blueprint for all vertebrates Recent studies on zebrafish and medaka embryos have uncovered the molecular mechanisms of a somite independent notochord driven segmentation process that establishes vertebral centra and intervertebral spaces As this process is not restricted to teleosts the authors have written a general discussion about the role of the notochord in vertebral formation Modularity and segmentation of the vertebral column are related topics Further overarching themes are the structure function and fate of the notochord in adult vertebrates and notochord cartilage relationships Key Features The first book devoted to notochord development function and evolution Includes and integrates information on the notochord from studies going back 169 years Integrates developmental molecular functional experimental and palaeontological studies Documents the fate of the notochord across the vertebrates Extensively illustrated with classical and new images Related Titles Bard J Evolution The Origins and Mechanisms of Diversity ISBN 978 0 3673 5701 6 Leys S and Hejnal A Origin and Evolution of Metazoan Cell Types ISBN 978 1 1380 3269 9 [The Neural Crest in Development and Evolution](#) Brian K. Hall, 1999-07-30 A discussion of the neural crest and neural crest cells dealing with their discovery their embryological and evolutionary origins their cellular derivatives in both agnathan and jawed

vertebrates or gnathostomes and the broad topics of migration and differentiation in normal development. The book also considers what goes wrong when development is misdirected by mutations or by exposure of embryos to exogenous agents such as drugs, alcohol, or excess vitamin A and includes discussions of tumours and syndromes and birth defects involving neural crest cells.

Strickberger's Evolution Brian Hall, Benedikt Hallgrímsson, 2008. Thoroughly updated and reorganized, Strickberger's *Evolution* Fourth Edition presents biology students with a basic introduction to prevailing knowledge and ideas about evolution, discussing how, why, and where the world and its organisms changed throughout history. Keeping consistent with Strickberger's engaging writing style, the authors carefully unfold a broad range of philosophical and historical topics that frame the theories of today, including cosmological and geological evolution and its impact on life, the origins of life on earth, the development of molecular pathways from genetic systems to organismic morphology and function, the evolutionary history of organisms from microbes to animals, and the numerous molecular and populational concepts that explain the earth's dynamic evolution.

Evolutionary Developmental Biology of Crustacea Gerhard Scholtz, 2003-06-01. Crustaceans, due to the great diversity of their body organization, segmentation patterns, tagmatization, limb types, larval forms, cleavage, and gastrulation modes, are highly desirable for the study of questions at the interface of evolution and development. Modern interest in evolutionary developmental biology (evo devo) rests on the molecular genetic approach, and a variety of molecular techniques have proven fruitful when performed on crustaceans. *Evolutionary Developmental Biology of Crustacea* presents a comprehensive treatment of all aspects of the field, beginning with a discussion of the implications of the typological Bauplan and phylum concepts versus historical concepts such as ground pattern and monophylum for the formulation of conceptual questions in evo devo. Following this, the authors present the results of Hox gene expression in various crustacean taxa, aspects of segment formation at the cellular and genetic levels, the formation of segmental structures such as neurons, ganglia, and limbs, and the role of morphological ontogenetic characters in resolving phylogenetic relationships. By covering so many general aspects of crustacean development, morphology, and evolution, *Evolutionary Developmental Biology of Crustacea* serves as an indispensable reference for developmental and evolutionary biologists investigating the role of genetics in evolution and development.

Reconstructing the Tree of Life Trevor R. Hodkinson, John A.N. Parnell, 2006-12-26. To document the world's diversity of species and reconstruct the tree of life, we need to undertake some simple but mountainous tasks. Most importantly, we need to tackle species-rich groups. We need to collect, name, and classify them and then position them on the tree of life. We need to do this systematically across all groups of organisms and b

Environment, Development, and Evolution Brian Keith Hall, Roy Douglas Pearson, Gerd B. Müller, 2004. Leading researchers in evolutionary developmental biology seek linkages between and a synthesis of development, physiology, endocrinology, ecology, and evolution. Evolutionary developmental biology, also known as evo devo or EDB, seeks to find links between development and evolution by opening the black box of development's role in evolution and in the evolution of

developmental mechanisms In particular this volume emphasizes the roles of the environment and of hormonal signaling in evo devo It brings together a group of leading researchers to analyze the dynamic interaction of environmental factors with developmental and physiological processes and to examine how environmental signals are translated into phenotypic change from the molecular and cellular level to organisms and groups of organisms Taken together these chapters demonstrate the crucial roles of those processes of genetic developmental physiological and hormonal change that underpin evolutionary change in development morphology physiology behavior and life history Part I investigates links between environmental signals and developmental processes that could be preserved over evolutionary time Several contributors evaluate the work of the late Ryuichi Matsuda especially his emphasis on the role of the external environment in genetic change and variability pan environmentalism Other contributors in part I analyze different aspects of environmental genetic evolutionary linkages including the importance of alternate ontogenies in evolution and the paradox of stability over long periods of evolutionary time Part II examines the plasticity that characterizes much of development with contributors discussing such topics as gene regulatory networks and heterochronicity Part III analyzes the role of hormones and metamorphosis in the evolution of such organisms with alternate life history stages as lampreys amphibians and insects *Cryptic Species* Alexandre K.

Monro, Simon J. Mayo, 2022-09-08 *Cryptic species* are organisms which look identical but which represent distinct evolutionary lineages They are an emerging trend in organismal biology across all groups from flatworms insects amphibians primates to vascular plants This book critically evaluates the phenomenon of cryptic species and demonstrates how they can play a valuable role in improving our understanding of evolution in particular of morphological stasis It also explores how the recognition of cryptic species is intrinsically linked to the so called species problem the lack of a unifying species concept in biology and suggests alternative approaches Bringing together a range of perspectives from practicing taxonomists the book presents case studies of cryptic species across a range of animal and plant groups It will be an invaluable text for all biologists interested in species and their delimitation definition and purpose including undergraduate and graduate students and researchers

Strickberger's Evolution Brian Keith Hall, Benedikt Hallgrímsson, Monroe W. Strickberger, 2014 The fifth Edition of Strickberger's *Evolution* is updated with the latest data and updates from the field The authors took care to carefully modify the chapter order in an effort to provide a more clear and student friendly presentation of course material The original scope and theme of this popular text remains as it continues to present an overview of prevailing evidence and theories about evolution by discussing how the world and its organisms arose and changed over time New boxed features concentrating on modern and exciting research in the field are included throughout the text New and Key Features of the Fifth Edition New Full color design and art program Maintains the student friendly engaging writing style for which it is known A reorganized chapter order provides a more clear and accessible presentation of course material Chapters on the evolution of biodiversity are now found on the text's website Access to the companion website is included with every new

copy of the text New boxed features highlight new and exciting research in the field *Biological Individuality* Scott Lidgard, Lynn K Nyhart, 2017-05-24 Individuals are things that everybody knows or thinks they do Yet even scholars who practice or analyze the biological sciences often cannot agree on what an individual is and why One reason for this disagreement is that the many important biological individuality concepts serve very different purposes defining classifying or explaining living structure function interaction persistence or evolution Indeed as the contributors to *Biological Individuality* reveal nature is too messy for simple definitions of this concept organisms too quirky in the diverse ways they reproduce function and interact and human ideas about individuality too fraught with philosophical and historical meaning Bringing together biologists historians and philosophers this book provides a multifaceted exploration of biological individuality that identifies leading and less familiar perceptions of individuality both past and present what they are good for and in what contexts Biological practice and theory recognize individuals at myriad levels of organization from genes to organisms to symbiotic systems We depend on these notions of individuality to address theoretical questions about multilevel natural selection and Darwinian fitness to illuminate empirical questions about development function and ecology to ground philosophical questions about the nature of organisms and causation and to probe historical and cultural circumstances that resonate with parallel questions about the nature of society Charting an interdisciplinary research agenda that broadens the frameworks in which biological individuality is discussed this book makes clear that in the realm of the individual there is not and should not be a direct path from biological paradigms based on model organisms through to philosophical generalization and historical reification *Evolutionary Developmental Biology of Invertebrates 1* Andreas Wanninger, 2015-08-10 This multi author six volume work summarizes our current knowledge on the developmental biology of all major invertebrate animal phyla The main aspects of cleavage embryogenesis organogenesis and gene expression are discussed in an evolutionary framework Each chapter presents an in depth yet concise overview of both classical and recent literature supplemented by numerous color illustrations and micrographs of a given animal group The largely taxon based chapters are supplemented by essays on topical aspects relevant to modern day EvoDevo research such as regeneration embryos in the fossil record homology in the age of genomics and the role of EvoDevo in the context of reconstructing evolutionary and phylogenetic scenarios A list of open questions at the end of each chapter may serve as a source of inspiration for the next generation of EvoDevo scientists *Evolutionary Developmental Biology of Invertebrates* is a must have for any scientist teacher or student interested in developmental and evolutionary biology as well as in general invertebrate zoology This volume starts off with three chapters that set the stage for the entire work by covering general aspects of EvoDevo research including its relevance for animal phylogeny homology issues in the age of developmental genomics and embryological data in the fossil record These are followed by taxon based chapters on the animals that are commonly considered to have branched off the Animal Tree of Life before the evolution of the Bilateria the Porifera Placozoa Cnidaria with the Myxozoa

being treated separately and Ctenophora. In addition the Acoelomorpha, Xenoturbellida and Chaetognatha are examined including their currently hotly debated phylogenetic affinities. Evolutionary Developmental Biology of Invertebrates 4 Andreas Wanninger, 2015-08-10. This multi-author six-volume work summarizes our current knowledge on the developmental biology of all major invertebrate animal phyla. The main aspects of cleavage, embryogenesis, organogenesis and gene expression are discussed in an evolutionary framework. Each chapter presents an in-depth yet concise overview of both classical and recent literature, supplemented by numerous color illustrations and micrographs of a given animal group. The largely taxon-based chapters are supplemented by essays on topical aspects relevant to modern-day EvoDevo research, such as regeneration, embryos in the fossil record, homology in the age of genomics and the role of EvoDevo in the context of reconstructing evolutionary and phylogenetic scenarios. A list of open questions at the end of each chapter may serve as a source of inspiration for the next generation of EvoDevo scientists. Evolutionary Developmental Biology of Invertebrates is a must-have for any scientist, teacher or student interested in developmental and evolutionary biology as well as in general invertebrate zoology. This second volume on ecdysozoans covers all animals commonly known as crustaceans. While Crustacea is currently not considered a monophylum, it still appears reasonable to combine its representatives in one joint volume due to their numerous shared morphological and developmental characteristics. Because of the huge variation in the amount of available developmental data between the various taxa, only the Dendrobranchiata, Astacida and Cirripedia are treated in individual chapters. The remaining data on crustacean development, usually incomplete and often patchy, is presented in two chapters summarizing early development and larval diversity, thereby also taking into account the data on fossil larval forms.

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