


RESEARCH ARTICLE

# Adaptive evolution and functional significance of the PPARGC1A gene across diverse animal species

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## Abstract

Codon-based analyses of the PPARGC1A gene across 38 vertebrate species were deployed to elucidate patterns of evolutionary change. Employing maximum likelihood assessments through MEGA, we scrutinized 447 codon positions addressing the entire coding region, excluding positions mined by gaps or missing data. Distinct codons manifested variance in selection pressures, particularly codons 4, 11, 66, and 123, which exhibited positive dN-dS values suggestive of positive selection. Codon 137 displayed the most pronounced dN-dS value, signifying intensified selective advantage. Meanwhile, codons 30 and 90 portrayed near-neutral scores, indicative of purifying selection. Complementary computational methods (iFEL, REL, FUBAR, and SLAC) confirmed positive selection at specific codon sites, with varying degrees of corroboration. The integration of mixed-effect modeling (MEME) identified episodic diversifying selection, pinpointing codons that underwent selection episodes in certain lineages. Refined codon model selection lent insight into substitution rates, revealing nuanced degrees of evolutionary conservation among different codons. Supporting these genetic insights, the phylogenetic analysis highlighted relationships among the PPARGC1A sequences and domain analysis confirmed conserved features across species, while protein–protein interaction networks suggested a complex web of functional interdependencies. These findings advance our understanding of the PPARGC1A gene's evolutionary trajectory and underscore the gene's potential adaptive significance within diverse vertebrate lineages.

## KEYWORDS

adaptive evolution, maximum likelihood, positive selection, PPARGC1A gene

## TAXONOMY CLASSIFICATION

Conservation ecology, Conservation genetics, Evolutionary ecology, Phylogenetics

# Functional Anatomy Adaptive Evolution

**Jeffrey G. Groth**



## **Functional Anatomy Adaptive Evolution:**

**Functional Anatomy and Adaptive Evolution of the Feeding Apparatus in the Hawaiian Honeycreeper Genus *Loxops* (Drepanididae)** Lawrence Phillips Richards, Walter Joseph Bock, 1973      **The Skull, Volume 3** James

Hanken, Brian K. Hall, 1993-07 In this authoritative three volume reference work leading researchers bring together current work to provide a comprehensive analysis of the comparative morphology development evolution and functional biology of the skull      *Ebook: Vertebrates: Comparative Anatomy, Function, Evolution* Kenneth Kardong, 2014-10-16 This one semester text is designed for an upper level majors course Vertebrates features a unique emphasis on function and evolution of vertebrates complete anatomical detail and excellent pedagogy Vertebrate groups are organized phylogenetically and their systems discussed within such a context Morphology is foremost but the author has developed and integrated an understanding of function and evolution into the discussion of anatomy of the various systems      Race and Human Evolution

Milford H. Wolpoff, Rachel Caspari, 1997 Race and Human Evolution shows how the debate over the Eve theory reflects a long history of theories about human origins and race that has been fraught with social and political implications

Fundamentals of Human Origin & Evolution EduGorilla Prep Experts, 2024-06-05 EduGorilla Publication is a trusted name in the education sector committed to empowering learners with high quality study materials and resources Specializing in competitive exams and academic support EduGorilla provides comprehensive and well structured content tailored to meet the needs of students across various streams and levels      **Encyclopedia of Human Evolution and Prehistory** Eric

Delson, Ian Tattersall, John Van Couvering, Alison S. Brooks, 2004-11-23 Praise for the first edition The most up to date and wide ranging encyclopedia work on human evolution available American Reference Books Annual For student researcher and teacher the most complete source of basic information on the subject Nature A comprehensive and authoritative source filling a unique niche essential to academic libraries important for large public libraries Booklist RBB      **In a Class of**

**Their Own** Gary Ritchison, 2023-11-06 With more than 10 000 species that vary in size use diverse habitats that extend across latitudes and altitudes consume a wide variety of food items differ in how they fly or not communicate and reproduce and have different life histories birds exhibit remarkable variation in form anatomy and function physiology Our understanding of how natural selection has generated this variation as birds evolved and as different species adapted to their unique circumstances has grown considerably in recent years In In a Class of Their Own A Detailed Examination of Avian Forms and Functions this variation is explained in great detail beginning with an overview of avian evolution and continuing with information about the structure and function of the avian skeleton muscles and the various body systems Other chapters focus on avian locomotion including flight migration navigation communication energy balance and thermoregulation and various aspects of avian reproduction such as nests and nest building clutch sizes and parental care In a Class of Their Own A Detailed Examination of Avian Forms and Functions will be must reading for anyone professional or non professional who

needs or wants to learn more about birds      On Human Nature Michel Tibayrenc, Francisco J. Ayala, 2016-09-12 *On Human Nature* Biology Psychology Ethics Politics and Religion covers the present state of knowledge on human diversity and its adaptative significance through a broad and eclectic selection of representative chapters This transdisciplinary work brings together specialists from various fields who rarely interact including geneticists evolutionists physicians ethologists psychoanalysts anthropologists sociologists theologians historians linguists and philosophers Genomic diversity is covered in several chapters dealing with biology including the differences in men and apes and the genetic diversity of mankind Top specialists known for their open mind and broad knowledge have been carefully selected to cover each topic The book is therefore at the crossroads between biology and human sciences going beyond classical science in the Popperian sense The book is accessible not only to specialists but also to students professors and the educated public Glossaries of specialized terms and general public references help nonspecialists understand complex notions with contributions avoiding technical jargon Provides greater understanding of diversity and population structure and history with crucial foundational knowledge needed to conduct research in a variety of fields such as genetics and disease Includes three robust sections on biological psychological and ethical aspects with cross fertilization and reciprocal references between the three sections Contains contributions by leading experts in their respective fields working under the guidance of internationally recognized and highly respected editors      *Zoology for Degree Students (For B.Sc. Hons. 4rd Semester, As per CBCS)* Agarwal

V.K., 2022-01-03 This textbook has been designed to meet the needs of B Sc Hons Fourth Semester students of Zoology as per the UGC Choice Based Credit System CBCS Comprehensively written it explains the essential principles processes and methodology of Comparative Anatomy of Vertebrates Animal Physiology Life Sustaining Systems and Biochemistry of Metabolic Processes This textbook is profusely illustrated with over 550 well labelled diagrams not only to supplement the descriptions but also for sound understanding of the concepts      **Evolutionary Differentiation in Morphology,**

**Vocalizations, and Allozymes Among Nomadic Sibling Species in the North American Red Crossbill (*Loxia***

**Curvirostra)** Complex Jeffrey G. Groth, 1993-08-16 The highly variable North American red crossbill complex has presented one of the most controversial problems in avian systematics Although crossbills wander nomadically and breed all year they have not become homogenized in bill and body size This study suggests that this crossbill complex contains several distinctive sibling species that breed sympatrically and show ecological differences      *Evolutionary Neuroscience* Jon H

Kaas, 2009-07-28 *Evolutionary Neuroscience* is a collection of articles in brain evolution selected from the recent comprehensive reference *Evolution of Nervous Systems* Elsevier Academic Press 2007 The selected chapters cover a broad range of topics from historical theory to the most recent deductions from comparative studies of brains The articles are organized in sections focused on theories and brain scaling the evolution of brains from early vertebrates to present day fishes amphibians reptiles and birds the evolution of mammalian brains and the evolution of primate brains including human

brains Each chapter is written by a leader or leaders in the field and has been reviewed by other experts Specific topics include brain character reconstruction principles of brain scaling basic features of vertebrate brains the evolution of the major sensory systems and other parts of brains what we can learn from fossils the origin of neocortex and the evolution of specializations of human brains The collection of articles will be interesting to anyone who is curious about how brains evolved from the simpler nervous systems of the first vertebrates into the many different complex forms now found in present day vertebrates This book would be of use to students at the graduate or undergraduate levels as well as professional neuroscientists cognitive scientists and psychologists Together the chapters provide a comprehensive list of further reading and references for those who want to inquire further The most comprehensive authoritative and up to date single volume collection on brain evolution Full color throughout with many illustrations Written by leading scholars and experts

**Sensory Evolution on the Threshold** J. G. M. Thewissen, Sirpa Nummela, 2008-02-04 Ranging from crocodiles and penguins to seals and whales this synthesis explores the function and evolution of sensory systems in animals whose ancestors lived on land It explores the dramatic transformation of smell taste sight hearing and balance that occurred as lineages of reptiles birds and mammals returned to aquatic environments *Comparative Vertebrate Reproduction* Julian Lombardi, 2012-12-06 Comparative Vertebrate Reproduction is the only comprehensive textbook covering major topics in the reproductive biology of vertebrates from sexuality and gametogenesis to reproductive ecology and life history tactics The work draws heavily on recent reviews and papers while placing topics in a historical context and conceptual framework In addition the author provides detailed comparative surveys of each of the major topics discussed Comparative Vertebrate Reproduction has been written as a textbook for upper level undergraduate and graduate level students in biology zoology physiology animal science and veterinary medicine The work also serves as an excellent reference for researchers in medical and veterinary schools working in reproductive medicine **Adaptive Radiations of Neotropical Primates** Marilyn A. Norconk, Alfred L. Rosenberger, Paul A. Garber, 2011-06-28 This collection of 29 papers grew out of a symposium entitled Setting the Future Agenda for Neotropical Primates The symposium was held at the Department of Zoological Research National Zoological Park Washington D C on February 26 27 1994 and was sponsored by the Wenner Gren Foundation for Anthropological Research Smithsonian Institution and Friends of the National Zoo We put the symposium together with two objectives to honor Warren G Kinzey for his contributions to the growing field of platyrrhine studies and to provide researchers who work in the Neotropics with the opportunity to discuss recent developments to identify areas of research that require additional study and especially to help guide the next generation of researchers The symposium provided the opportunity to recognize Warren as a mentor and collaborator to the contribution of the study of platyrrhines Contributions to the book were expanded in order to provide a more comprehensive view of platyrrhine evolution and ecology to emphasize the interdisciplinary nature of many of these studies and to highlight the central role that New World monkeys play in

advancing primatology If this volume were to require major revisions after just one more decade of research that would be a fitting testament to Warren's enthusiasm and his drive to continually update the field with new ideas and methods Tributes to Warren and a list of his publications have been published elsewhere Norconk 1994 1996 Rosenberger 1994 1995

Mammalian Evolutionary Morphology Eric J. Sargis, Marian Dagosto, 2008-05-21 This book celebrates the contributions of Dr Frederick S Szalay to the field of Mammalian Evolutionary Morphology Professor Szalay is a strong advocate for biologically and evolutionarily meaningful character analysis He has published about 200 articles six monographs and six books on this subject This book features subjects such as the evolution and adaptation of mammals and provides up to date articles on the evolutionary morphology of a wide range of mammalian groups *Carnivore Behavior, Ecology, and Evolution* John L. Gittleman, 2019-05-15 The mammalian order Carnivora is characterized by an incredible range of morphological ecological and behavioral variation Carnivores can be as small as the 100 gram least weasel or as large as the 800 kilogram polar bear Their reproductive rate can vary from one offspring every five years as with some black bears to three litters a year as with the dwarf mongoose Group sizes can be traced along a wide continuum from the solitary ermine to the monogamous golden jackal to the large extended packs of as many as 80 spotted hyenas Until recently the general habits of most wild carnivore species were inadequately understood In the last decade however improved technologies including the use of radiotelemetry and night vision scopes have led to many important discoveries This book is at once a critical summary and an evaluation of current research on carnivores A worthy successor to R F Ewer's monumental volume *The Carnivores* Cornell University Press it is the work of 30 leading carnivore biologists who here assemble comparative data on the basic anatomical behavioral ecological physiological reproductive and evolutionary characteristics of this group After a general introduction to the Carnivora the volume is divided in three parts each of which begins with a brief introduction outlining its main themes Part I Behavior covers acoustic and olfactory communication behavioral development behavioral ecology of canids and hyaenids modes of solitary living and group living In Part II Ecology topics include feeding ecology of the giant panda and Asiatic black bear adaptations for aquatic living ecological constraints on predation in felids consequences of small size in mustelids rate of basal metabolism and food habits and reproductive output Part III Evolution deals with the morphological approaches to phylogeny and the fossil record An appendix presents a complete classification of the Carnivora including topics of continuing controversy Highlighting recent developments in the study of the Carnivora and areas for further research this broad synthesis will be of great value of students and researchers in animal behavior behavioral ecology wildlife ecology mammalogy paleontology systematics and evolution theory It will also encourage realistic conservation programs to manage rapidly diminishing populations and will elucidate particular features of the carnivores for nonspecialist readers **A Guide to Morphosyntax-phonology Interface Theories** Tobias Scheer, 2011 This book reviews the history of the interface between morpho syntax and phonology roughly since World War II Structuralist and generative interface

thinking is presented chronologically but also theory by theory from the point of view of a historically interested observer who however in the last third of the book distills lessons in order to assess present day interface theories and to establish a catalogue of properties that a correct interface theory should or must not have The book also introduces modularity the rationalist theory of the human cognitive system that underlies the generative approach to language from a Cognitive Science perspective Modularity is used as a referee for interface theories in the book Finally the book locates the interface debate in the landscape of current minimalist syntax and phase theory and fosters intermodular argumentation how can we use properties of morpho syntactic theory in order to argue for or against competing theories of phonology and vice versa

Understanding C4 Evolution and Function Sarah Covshoff,Martha Ludwig,Florian A. Busch,Roxana

Khoshravesh,2021-12-28

Great Transformations in Vertebrate Evolution Kenneth P. Dial,Neil Shubin,Elizabeth L.

Brainerd,2015-07-20 How did flying birds evolve from running dinosaurs terrestrial trotting tetrapods evolve from swimming fish and whales return to swim in the sea These are some of the great transformations in the 500 million year history of vertebrate life And with the aid of new techniques and approaches across a range of fields work spanning multiple levels of biological organization from DNA sequences to organs and the physiology and ecology of whole organisms we are now beginning to unravel the confounding evolutionary mysteries contained in the structure genes and fossil record of every living species This book gathers a diverse team of renowned scientists to capture the excitement of these new discoveries in a collection that is both accessible to students and an important contribution to the future of its field Marshaling a range of disciplines from paleobiology to phylogenetics developmental biology ecology and evolutionary biology the contributors attack particular transformations in the head and neck trunk appendages such as fins and limbs and the whole body as well as offer synthetic perspectives Illustrated throughout Great Transformations in Vertebrate Evolution not only reveals the true origins of whales with legs fish with elbows wrists and necks and feathered dinosaurs but also the relevance to our lives today of these extraordinary narratives of change

Evolution of the Primate Brain ,2012-01-25 This volume of Progress in Brain Research provides a synthetic source of information about state of the art research that has important implications for the evolution of the brain and cognition in primates including humans This topic requires input from a variety of fields that are developing at an unprecedented pace genetics developmental neurobiology comparative and functional neuroanatomy at gross and microanatomical levels quantitative neurobiology related to scaling factors that constrain brain organization and evolution primate palaeontology including paleoneurology paleo anthropology comparative psychology and behavioural evolutionary biology Written by internationally renowned scientists this timely volume will be of wide interest to students scholars science journalists and a variety of experts who are interested in keeping track of the discoveries that are rapidly emerging about the evolution of the brain and cognition Written by internationally renowned scientists this timely volume will be of wide interest to students scholars science journalists and a variety of experts who are interested in keeping track of

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