

Evolution of a plant growth-regulatory protein interaction specificity

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Specific protein–protein interactions (PPIs) enable biological regulation. However, the evolution of PPI specificity is little understood. Here we trace the evolution of the land-plant growth-regulatory DELLA–SLY1/GID2 PPI, revealing progressive increase in specificity of affinity of SLY1/GID2 for a particular DELLA form. While early-diverging SLY1s display relatively broad-range DELLA affinity, later-diverging SLY1s tend towards increasingly stringent affinity for a specific DELLA A' form generated by the growth-promoting phytohormone gibberellin (GA). Our novel mutational strategy reveals amino acid substitutions contributing to the evolution of *Arabidopsis thaliana* SLY1 A' specificity, also showing that routes permitting reversion to broader affinity became increasingly constrained over evolutionary time. We suggest that progressive affinity narrowing may be an important evolutionary driver of PPI specificity and that increase in SLY1/GID2–DELLA specificity enabled the enhanced flexibility of plant physiological environmental adaptation conferred by the GA–DELLA growth-regulatory mechanism.

The DELLA–SLY1/GID2 (refs. 1–6) PPI regulates plant growth, survival of environmental adversity⁷ and resource assimilation that underpins terrestrial ecosystems and agriculture^{8–10}. SLY1/GID2 is the F-box DELLA-specificity component of growth-promoting SCF^{SLY1/GID2} E3 ubiquitin ligase^{11–13}. In angiosperms, gibberellin (GA) promotes DELLA–SCF^{SLY1/GID2} binding and resultant destruction of DELLA growth repressors, as follows. First, the GA-bound GID1 (refs. 11–13) GA receptor binds the DELLA N-terminus. While the unbound N-terminus is intrinsically unstructured, GA–GID1 binding induces folding¹⁴ and presumed conversion of the native (here called A) form of the C-terminal DELLA GRAS domain into an A' alternative⁵. Although the molecular distinction between A and A' is unclear, phosphorylation¹⁵ and/or reconfiguration of the GRAS domain structure may be causal. Nevertheless, the A to A' transition is an important switch because SLY1/GID2 specifically binds the A' GRAS domain, thus promoting DELLA destruction and growth.

Angiosperms and GA-promoted growth both arose relatively recently, although at different times^{16–18} (Extended Data Fig. 1a). DELLAs probably evolved in the land-plant common ancestor^{19,20} from a GRAS protein of bacterial origin²⁰, while functional GID1 GA receptors are exclusive to vascular plants (although some bryophytes have GID1-related proteins)^{21–23}. Intriguingly, *Arabidopsis thaliana* AtSLY1 (encoding AtSLY1) orthologues (for example, *Marchantia polymorpha* MpSLY1 (ref. 19)) exist in liverworts, but not in mosses or hornworts (perhaps through gene loss during bryophyte evolution²⁴). Nevertheless, the lack of functional bryophyte GID1s suggests that both GA–GID1-mediated DELLA destruction and SCF^{SLY1/GID2} A' specificity first arose after bryophyte divergence (Extended Data Fig. 1a). Accordingly, bryophytes lack the active GA species that GID1 binds^{1,22}.

To understand the origin of SLY1/GID2 A' specificity, we first analysed variants with enhanced A affinity (reduced A' specificity). Second, our analyses of SLY1s and DELLAs²⁵ from early-diverging land plants

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Biological Specificity Growth

J. R. Heath



Biological Specificity Growth:

Biological Specificity and Growth Elmer G. Butler, 2015-12-08 The authors of the eleven chapters in this book approach the subject from a variety of viewpoints ranging from an analysis of molecular changes within differentiating cells to a consideration of the factors governing the transplantation of normal and abnormal tissues The book is based on papers presented at the Twelfth Growth Symposium of the Society for the Study of Development and Growth Originally published in 1955 The Princeton Legacy Library uses the latest print on demand technology to again make available previously out of print books from the distinguished backlist of Princeton University Press These editions preserve the original texts of these important books while presenting them in durable paperback and hardcover editions The goal of the Princeton Legacy Library is to vastly increase access to the rich scholarly heritage found in the thousands of books published by Princeton University Press since its founding in 1905

Biological Specificity and Growth Society for the Study of Development and Growth (U.S.), 1955

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Growth Factors in Biology and Medicine David Evered, Jonathan Nugent, Julie Whelan, 2009-09-14 The Novartis Foundation Series is a popular collection of the proceedings from Novartis Foundation Symposia in which groups of leading scientists from a range of topics across biology chemistry and medicine assembled to present papers and discuss results The Novartis Foundation originally known as the Ciba Foundation is well known to scientists and clinicians around the world

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The Biology of Sea Turtles, Volume I Peter L. Lutz, John A. Musick, 2017-12-06 Sea turtles have existed for millions of years making them fascinating subjects of study In the last 20 years the science of sea turtle biology has expanded at an exponential rate leading to major advances in many areas This book synthesizes the results of these advances and focuses on how these endangered marine reptiles operate in adapt to and are dependent upon particular features of their

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Biology Of Wastewater Treatment (2nd Edition)

Nicholas F Gray, 2004-04-06 This comprehensive text provides the reader with both a detailed reference and a unified course on wastewater treatment Aimed at scientists and engineers it deals with the environmental and biological aspects of wastewater treatment and sludge disposal The book starts by examining the nature of wastewaters and how they are oxidized in the natural environment An introductory chapter deals with wastewater treatment systems and examines how natural principles have been harnessed by man to treat his own waste in specialist reactors The role of organisms is considered by looking at kinetics metabolism and the different types of micro organisms involved All the major biological process groups are examined in detail in highly referenced chapters they include fixed film reactors activated sludge stabilization ponds anaerobic systems and vegetative processes Sludge treatment and disposal is examined with particular reference to the environmental problems associated with the various disposal routes A comprehensive chapter on public health looks at the important waterborne organisms associated with disease as well as removal processes within treatment

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Biomedical Index to PHS-supported Research ,1993 Advances in Marine Biology ,2003-05-28 Volume 44 is an eclectic volume with timely reviews on invertebrate zooplankton growth rates and movements on marine fish and decapod crustaceans Advances in Marine Biology was first published in 1963 Now edited by A J Southward Marine Biological Association UK P A Tyler Southampton Oceanography Association UK C M Young Harbor Branch Oceanographic Institution USA and L A Fuiman University of Texas USA the serial publishes in depth and up to date reviews on a wide range of topics which will appeal to postgraduates and researchers in marine biology fisheries science ecology zoology oceanography Eclectic volumes in the series are supplemented by thematic volumes on such topics as The Biology of Calanoid Copepods Series features over 35 years of coverage of the research Biology of the Prokaryotes Joseph W. Lengeler, Gerhart Drews, Hans G. Schlegel, 1999-02-03 Designed as an upper level textbook and a reference for researchers this important book concentrates on central concepts of the bacterial lifestyle Taking a refreshingly new approach it present an integrated view of the prokaryotic cell as an organism and as a member of an interacting population Beginning with a description of cellular structures the text proceeds through metabolic pathways and metabolic reactions to the genes and regulatory mechanisms At a higher level of complexity a discussion of cell differentiation processes is followed by a description of the diversity of prokaryotes and their role in the biosphere A closing section deals with man and microbes ie applied microbiology The first text to adopt an integrated view of the prokaryotic cell as an organism and as a member of a population Vividly illustrates the diversity of the prokaryotic world nearly all the metabolic diversity in living organisms is found in microbes New developments in applied microbiology highlighted Extensive linking between related topics allows easy navigation through the book Essential definitions and conclusions highlighted Supplementary information in boxes **Mathematical Models in Cell Biology and Cancer Chemotherapy** M. Eisen, 2013-03-13 The purpose of this book is to show how mathematics can be applied to improve cancer chemotherapy Unfortunately most drugs used in treating cancer kill both normal and abnormal cells However more cancer cells than normal cells can be destroyed by the drug because tumor cells usually exhibit different growth kinetics than normal cells To capitalize on this last fact cell kinetics must be studied by formulating mathematical models of normal and abnormal cell growth These models allow the therapeutic and harmful effects of cancer drugs to be simulated quantitatively The combined cell and drug models can be used to study the effects of different methods of administering drugs The least harmful method of drug administration according to a given criterion can be found by applying optimal control theory The prerequisites for reading this book are an elementary knowledge of ordinary differential equations probability statistics and linear algebra In order to make this book self contained a chapter on cell biology and a chapter on

control theory have been included Those readers who have had some exposure to biology may prefer to omit Chapter I Cell Biology and only use it as a reference when required However few biologists have been exposed to control theory Chapter 7 provides a short coherent and comprehensible presentation of this subject The concepts of control theory are necessary for a full understanding of Chapters 8 and 9

Molecular Biology and Biotechnology John M Walker, E B Gingold, 2007-10-31 The 3rd Edition of this immensely popular textbook brings readers up to date with the latest advances in this rapidly developing field It has been thoroughly revised and expanded combining entirely new chapters on current hot topics with existing chapters that have been rewritten and extended Molecular Biology and Biotechnology 3rd Edition provides real breadth of coverage taking account of both molecular biology and industrial applications It also gives in depth coverage of key areas resulting in a uniquely comprehensive publication Highlights of this 3rd Edition include increased coverage of the cloning of yeast and animal cells and plant genetic engineering and new coverage of polymerase chain reactions DNA fingerprinting transgenesis and vaccine development reflecting the rapid growth of interest in these areas The book presents the information in an easily assimilated form and makes an ideal undergraduate text It will be of particular interest to students of biology and chemistry as well as to scientific workers from outside the field who need a rapid introduction to the subject Molecular Biology and Biotechnology primarily has a teaching function and as such should prove invaluable

Biology Bulletin of the Academy of Sciences of the USSR Akademii nauk SSSR, 1977

Biology of Copepods Geoffrey Boxshall, H.K. Schminke, 2012-12-06 This volume contains the Proceedings of the Third International Conference on Copepoda held at the British Museum Natural History in London during August 1987 The central theme of the conference was the biology of marine planktonic copepods although the scientific programme was extremely varied reflecting the wide range of life styles adopted by copepods The three invited symposia held during the conference focussed attention on particular topical areas of research within the field of marine plankton and also provided reviews of chosen aspects of copepod biology These symposia were highly successful The papers they contained were both informative and stimulating and they bring to this volume a lasting significance Each symposium was organised by its chairman Bruce Frost University of Washington decided on the balance of topics selected the speakers and introduced the session on The biology and taxonomy of Calanus Roger Harris Marine Biological Association performed the same vital role for Experimental studies rate processes in field populations of planktonic copepods and Howard Roe Institute of Oceanographic Sciences for Oceanic and deep sea copepods The impact of these papers will be much enhanced by the large number of high quality contributed and poster papers on marine plankton and by the invited review of Copepod luminescence by Peter Herring Institute of Oceanographic Sciences The fascinating review of Copepod eyes by Mike Land FRS University of Sussex is not published here

Engineering Corynebacterium Glutamicum Chassis for Synthetic Biology, Biomanufacturing, and Bioremediation Akihiko Kondo, Yu Wang, Volker F. Wendisch, Christoph Wittmann, Zheng-Hong Xu, Ping Zheng, 2022-07-01

Methods in Systems Biology Daniel Jameson, Malkhey Verma, Hans Westerhoff, 2011-09-26 Systems biology is a term used to describe a number of trends in bioscience research and a movement that draws on those trends This volume in the Methods in Enzymology series comprehensively covers the methods in systems biology With an international board of authors this volume is split into sections that cover subjects such as machines for systems biology protein production and quantification for systems biology and enzymatic assays in systems biology research This volume in the Methods in Enzymology series comprehensively covers the methods in systems biology With an international board of authors this volume is split into sections that cover subjects such as machines for systems biology protein production and quantification for systems biology and enzymatic assays in systems biology research

The Mathematical Biology of Diatoms Janice L. Pappas, 2023-04-18 THE MATHEMATICAL BIOLOGY OF DIATOMS This book contains unique advanced applications using mathematics algorithmic techniques geometric analysis and other computational methods in diatom research Historically diatom research has centered on taxonomy and systematics While these topics are of the utmost importance other aspects of this important group of unicells have been increasingly explored in the biological sciences While mathematical applications are still rare they are starting take hold and provide an extensive avenue of new diatom research including applications in multidisciplinary fields The work contained in this volume is an eclectic mix of analytical studies on diatoms Mathematical treatment of the various biological disciplines covered in this book range from implicit but succinct studies to more elaborate detailed computational studies Topics include growth models nanostructure nanoengineering cell growth araphid diatoms valve ontogeny diatom metabolism diatom motility synchronization diatom kinematics photonics biogenic sensors photochemistry diatom light response colony growth siliceous unicells algal kinetics diatom structure diatom imaging functional morphology geometric structure biomineralization high resolution imaging non destructive imaging and 3D structure This wide ranging volume provides an introductory as well as an advanced treatment of recent interests in diatom research The mathematical research in this volume may be applicable to studies of other unicells biomechanics biological processes physio chemical analyses or nanoscience

Biological Specificity Growth Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has been apparent than ever. Its ability to stir emotions, provoke thought, and instigate transformation is truly remarkable. This extraordinary book, aptly titled "**Biological Specificity Growth**," written by a highly acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound impact on our existence. Throughout this critique, we shall delve into the book's central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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