

POINTS OF VIEW

Visualizing biological data

Data visualization is increasingly important, but it requires clear objectives and improved implementation.

Researchers today have access to an unprecedented amount of data. The challenge is to benefit from this abundance without being overwhelmed. Data visualization for efficient exploration and effective communication is integral to scientific progress. For visualization to continue to be an important tool for discovery, its practitioners need to be present as members of research teams.

One of the goals of data visualization is to enable people to explore and explain data through interactive software that takes advantage of human beings' ability to recognize patterns. Its success depends on the development of methods and techniques to transform information into a visual form for comprehension. It is a process that synthesizes skills from engineering, statistics and graphic design along with a number of other disciplines.

In recent years we have witnessed a growing appetite for the visual display of information. The ease of generating sophisticated computer graphics has encouraged the use of visualization. However, the value and utility of this popular form of communication remains unclear. We can easily be fooled into believing that we absorb more than we do when looking at large, colorful displays of information.

Data visualization, when applied to scientific research, has to be more than just the graphical display of information. Clear objectives are needed to drive design so we can assess the utility and practicality of visualizations. What is it that the researchers want to and need to see in the data? Which computational approaches and visual encodings will best bring out the trends? It is essential for the visualization practitioners to work side by side with the researchers to ensure that design decisions are continually refined to meet research objectives.

Unfortunately, there are few models for highly integrative teams consisting of visualization experts and biological researchers. The existence of distinct professional meetings and publication venues may be partially responsible for the barrier to working together. For example, the major professional meetings in information visualization such as Visualizing Biological Data (VIZBI) and BioVis (part of the Institute of Electrical and Electronics Engineers' VisWeek) attract few biologists. As a consequence, advances in visualization are not adequately described and shared with the biological community.

Identifying shared funding sources will certainly help to unite the professions under a common set of responsibilities and deliverables. Unfortunately, it is uncommon to hear stories in which agencies supporting scientific research have been successfully convinced to fund visualization efforts. Without the tight working relationships of an integrated team, we give up the ability to



Figure 1 | Visualization of whole-genome rearrangement. Representative Circos plots¹ of whole-genome sequence data from two different tumors showing gene duplications and chromosome rearrangements. The outer ring depicts chromosomes arranged end to end. The inner ring displays copy-number data in green and interchromosomal translocations in purple. Reprinted from ref. 2 with permission from Elsevier.

rapidly turn sketches into software prototypes at a pace relevant to the research; as data types and research questions evolve, there is a constant need to refine and adapt visualizations. One funding mechanism that has enabled an integrated focus on visualization in the context of biological research is supplemental support associated with awarded grants. The primary objective of such work is to extend the utility and accessibility of the research findings.

It is useful to recognize that not every biological question will benefit from visualization, and graphical approaches should therefore be reserved for projects for which they will produce the greatest impact. Many data challenges can be addressed perfectly with computation alone. For a subset of research questions, however, visualizations can offer specific advantages over computation. In instances when we do not yet know the regularities in the data, visualization provides a powerful approach to explore the data for patterns. Visualization can also be useful for projects in which it complements algorithmic approaches. In genomics, for example, automated processes can reliably find sites where rearrangement occurs, but visualization is then needed to provide a mental image so that the detail of structural variation can be fully appreciated and understood (Fig. 1).

Data visualization represents a powerful aid to understanding data because well-designed graphical depictions of information can replace arduous cognitive assessment with simple perceptual inferences. For this reason, visualization can have a significant impact in biology, especially in the age of big data. For the last two and a half years, I have covered visual strategies for depicting scientific data. Although Points of View will go on hiatus after this month, these columns represent part of Nature Publishing Group's commitment to meeting visual communication challenges of scientific data.

Bang Wong

1. Kryszewski, M. et al. *Genome Res.* **18**, 1639–1645 (2008).
2. Delledalle, M. et al. *Cell* **150**, 1107–1120 (2012).

Bang Wong is the creative director of the Broad Institute of the Massachusetts Institute of Technology & Harvard and an adjunct assistant professor in the Department of Art as Applied to Medicine at The Johns Hopkins University School of Medicine.

Visualizing Biological Information

Clifford A. Pickover



Visualizing Biological Information:

Visualizing Biological Information Clifford A Pickover, 1995-12-15 Biological data of all kinds is proliferating at an incredible rate. If humans attempt to read such data in the form of numbers and letters they will take in the information at a snail's pace. If the information is rendered graphically however human analysts can assimilate it and gain insight at a much faster rate. The emphasis of this book is on the graphic representation of information containing sequences such as DNA and amino acid sequences in order to help the human analyst find interesting and biologically relevant patterns. The editor's goal is to make this voyage through molecular biology, genetics and computer graphics as accessible to a broad audience as possible with the inclusion of glossaries at the end of most chapters and program outlines where applicable. The book will be of most interest to biologists and computer scientists and the various large reference lists should be of interest to beginners and advanced students of biology, graphic art and computer science. Contributors have sought to find pattern and meaning in the cacophony of genetic and protein sequence data using unusual computer graphics and musical techniques.

Handbook of Particle Detection and Imaging Claus Grupen, Irène Buvat, 2012-01-08 The handbook centers on detection techniques in the field of particle physics, medical imaging and related subjects. It is structured into three parts. The first one is dealing with basic ideas of particle detectors followed by applications of these devices in high energy physics and other fields. In the last part the large field of medical imaging using similar detection techniques is described. The different chapters of the book are written by world experts in their field. Clear instructions on the detection techniques and principles in terms of relevant operation parameters for scientists and graduate students are given. Detailed tables and diagrams will make this a very useful handbook for the application of these techniques in many different fields like physics, medicine, biology and other areas of natural science.

[Interactive Visualization and Plotting with Julia](#) Diego Javier Zea, 2022-08-29 Represent and analyze data using Plots to find actionable insights using Julia programming. Key Features: Learn to use static and interactive plots to explore data with Julia. Become well versed with the various plotting attributes needed to customize your plots. Create insightful and appealing plots using data interactions, animations, layouts and themes. Book Description: The Julia programming language offers a fresh perspective into the data visualization field. Interactive Visualization and Plotting with Julia begins by introducing the Julia language and the Plots package. The book then gives a quick overview of the Julia plotting ecosystem to help you choose the best library for your task. In particular you will discover the many ways to create interactive visualizations with its packages. You'll also leverage Pluto notebooks to gain interactivity and use them intensively through this book. You'll find out how to create animations, a handy skill for communication and teaching. Then the book shows how to solve data analysis problems using DataFrames and various plotting packages based on the grammar of graphics. Furthermore you'll discover how to create the most common statistical plots for data exploration. Also you'll learn to visualize geographically distributed data, graphs and networks and biological data. Lastly this book will go deeper into plot

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Bioinformatics, second edition Pierre Baldi, Søren Brunak, 2001-07-20 A guide to machine learning approaches and their application to the analysis of biological data An unprecedented wealth of data is being generated by genome sequencing projects and other experimental efforts to determine the structure and function of biological molecules The demands and opportunities for interpreting these data are expanding rapidly Bioinformatics is the development and application of computer methods for management analysis interpretation and prediction as well as for the design of experiments Machine learning approaches e g neural networks hidden Markov models and belief networks are ideally suited for areas where there is a lot of data but little theory which is the situation in molecular biology The goal in machine learning is to extract useful information from a body of data by building good probabilistic models and to automate the process as much as possible In this book Pierre Baldi and S ren Brunak present the key machine learning approaches and apply them to the computational problems encountered in the analysis of biological data The book is aimed both at biologists and biochemists who need to understand new data driven algorithms and at those with a primary background in physics mathematics statistics or computer science who need to know more about applications in molecular biology This new second edition contains expanded coverage of probabilistic graphical models and of the applications of neural networks as well as a new chapter on microarrays and gene expression The entire text has been extensively revised

Evolution and Emergence William R. Stoeger, 2007-04-05 A collection of essays by experts in the field exploring how nature works at every level to produce more complex and highly organized objects systems and organisms from much simpler components and how our increasing understanding of this universal phenomenon of emergence can lead us to a deeper and richer appreciation of who we are as human beings and of our relationship to God Several chapters introduce the key philosophical ideas about reductionism and

emergence while others explore the fascinating world of emergent phenomena in physics biology and the neurosciences Finally there are contributions probing the meaning and significance of these findings for our general description of the world and ourselves in relation to God from philosophy and theology The collection as a whole will extend the mutual creative interaction among the sciences philosophy and theology *Graph Drawing* Ioannis G. Tollis, Maurizio Patrignani, 2009-02-13 This book constitutes the proceedings of the 16th International Symposium on Graph Drawing GD 2008 held in Heraklion Crete Greece during September 21-24 2008 The 31 long papers and 8 short papers presented together with 10 posters and two invited papers were carefully reviewed and selected from 83 submissions The volume also includes a report on the Graph Drawing Contest which was held during the conference An important aspect of the conference is bridging the gap between theoretical advances and implemented solutions of geometric representation of graphs and networks It is motivated by those applications where it is crucial to visualize structural information as graphs *Visual Culture and Bioscience* Suzanne Anker, J. D. Talasek, 2008 Edited by Suzanne Anker JD Talasek Preface by David Yager Foreword by JD Talasek Introduction by Suzanne Anker *Cadernos de Computação*, 2000 **Scientific Perspectives on Divine Action** Robert J. Russell, 2008 *Scientific Perspectives on Divine Action* is a collection of essays assessing the series of the same name which advances the engagement of constructive theology with the natural sciences **Information Imagineering** Milton T. Wolf, Pat Ensor, Mary Augusta Thomas, 1998 Editors from LITA and LAMA have assembled some of the best and brightest opinions from libraries and various related fields to determine how to keep pace with the rapid rate of technological change *Genome Research*, 2004 Contemporary Authors New Revision Pamela Dear, 2000-06 This volume of Contemporary Authors R New Revision Series brings you up to date information on approximately 250 writers Editors have scoured dozens of leading journals magazines newspapers and online sources in search of the latest news and criticism Writers appearing in this volume include Gail Anderson Dargatz Valerie Martin Isidore Okpewho Philip Roth **ISMB-97**, 1997 Conference Proceedings, 2001 **Biological and Medical Data Analysis**, 2004 **The Science Of Aliens** Clifford A. Pickover, 1998-11-05 If we were to meet actual aliens from outer space what would they look like Noted author Clifford Pickover speculates on their appearance biology language even their sex lives Lipidomics Donald Armstrong, 2009 **The Alien Iq Test** Clifford A. Pickover, 1997-05-01 Here is an irresistibly addictive book for anyone whose juices flow when presented with a baffling puzzle This fiendishly clever book pits readers wits and deductive powers against a dizzying array of word problems questions riddles and graphic brainteasers all devised if you dare to believe by aliens who have arrived to assess our intelligence in such far flung areas of the human mind as abstract reasoning mathematics religion morality and humanity s concepts of beauty *Library & Information Science Abstracts*, 2005 Quantum Mechanics Robert J. Russell, *Specola vaticana*, Center for Theology and the Natural Sciences, 2001 *Quantum Mechanics* a collection of fifteen essays explores the creative interaction among quantum physics philosophy and theology This fine collection presents

the results of the fifth international research conference co sponsored by the Vatican Observatory Rome and the Center for Theology and the Natural Sciences Berkeley The overarching goal of these conferences is to support the engagement of constructive theology with the natural sciences and to investigate the philosophical and theological elements in ongoing theoretical research in the natural sciences In the first section of this collection contributors examine scientific and historical context Section two features essays covering a wide range of philosophical interpretations of quantum mechanics The final set of essays explores the theological implications of quantum theory Abner Shimony Raymond Y Chiao Michael Berry Ernan McMullin William R Stoeger S J James T Cushing Jeremy Butterfield Michael Redhead Chris Clarke John Polkinghorne Michael Heller Philip Clayton Thomas F Tracy George F R Ellis and Robert John Russell all contributed essays to this volume

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