making cladograms

Making cladograms is a fundamental skill in evolutionary biology that helps scientists visualize the relationships among different species or groups based on shared characteristics. Cladograms serve as a visual representation of evolutionary pathways, illustrating common ancestors and divergence points. Whether you're a student, researcher, or enthusiast, understanding how to construct accurate and meaningful cladograms is essential for interpreting evolutionary data and communicating scientific findings effectively. In this comprehensive guide, we'll explore the step-by-step process of making cladograms, including the principles behind them, data collection, analysis, and presentation.

Understanding Cladograms and Their Importance

What Is a Cladogram?

A cladogram is a type of diagram used in cladistics, a method of classifying organisms based on shared derived characteristics. Unlike traditional taxonomy, which may group organisms based on overall similarity, cladistics emphasizes evolutionary relationships, focusing on traits that are inherited from common ancestors.

A typical cladogram features:
- Branches representing evolutionary lineages
- Nodes indicating common ancestors
- Tips or leaves representing current species or taxa

Why Make Cladograms?

Creating cladograms allows scientists to:
- Visualize evolutionary relationships
- Trace the development of specific traits
- Test hypotheses about common ancestry
- Clarify the evolutionary history of groups
- Communicate complex data succinctly

Preparing to Make a Cladogram

Gathering Data

The foundation of any cladogram lies in reliable data. This involves collecting information about:
- Morphological traits (physical characteristics)

- Genetic sequences (DNA, RNA, or protein data)
- Behavioral or ecological features (less common but sometimes used)

Sources for data include:
- Scientific literature
- Fossil records
- Genetic databases like GenBank
- Field studies and observations

Choosing Taxa

Decide which species or groups you want to analyze. It's best to:
- Select closely related species for detailed analysis
- Include outgroups (species outside the main group) to root the cladogram
- Ensure data availability for all chosen taxa

Identifying Characters and Traits

Select relevant characters that vary among taxa. These can be:
- Morphological (e.g., presence of wings, limb structure)
- Molecular (e.g., gene sequences, nucleotide substitutions)
- Behavioral (e.g., mating rituals)

For each character, define:
- Ancestral (primitive) state
- Derived (advanced) state

Analyzing Data and Constructing the Cladogram

Step 1: Organize Data into a Character Matrix

Create a table with:
- Rows representing taxa
- Columns representing characters
- Cells indicating the state (e.g., 0 for ancestral, 1 for derived)

Example:

Taxon	Character 1	Character 2	Character 3
Species A	0	1	0
Species B	1	1	0
Species C	1	0	1

Step 2: Determine Shared Derived Traits

Identify which traits are shared among groups of taxa, indicating common ancestry. These traits help define the nodes in the cladogram.

Key points:
- Shared derived traits are called synapomorphies
- Traits unique to a single taxon are autapomorphies and are less useful for relationships

Step 3: Use Cladistic Analysis Methods

Apply methods to analyze the data:
- Parsimony: Choose the tree with the least number of evolutionary changes
- Distance: Calculate genetic distances and construct trees based on similarity
- Likelihood or Bayesian methods: Use statistical models for more complex analyses

Most beginners start with parsimony because it's straightforward and aligns with the principle of simplicity.

Step 4: Construct Candidate Trees

Based on data analysis, generate possible cladograms:
- Connect taxa sharing derived traits
- Identify the most parsimonious tree(s)

Step 5: Root the Cladogram

Use an outgroup—a taxon known to be outside the group of interest—to root the tree:
- Helps determine the direction of evolutionary change
- Clarifies which traits are ancestral vs. derived

Drawing and Interpreting the Cladogram

Designing the Diagram

- Use software tools (e.g., Mesquite, TreeView, or online platforms) or hand-draw for initial sketches
- Represent branches with straight lines
- Use nodes to indicate common ancestors
- Label each taxon at the tips
- Mark synapomorphies on branches

Presenting the Cladogram

- Ensure clarity in layout
- Use consistent symbols and colors if needed
- Include a legend explaining symbols or traits
- Root the tree appropriately

Interpreting the Cladogram

- Identify sister taxa (closely related species sharing a node)
- Trace the evolution of traits
- Understand the sequence of divergence events
- Recognize the most recent common ancestors

Tips for Making Accurate Cladograms

1. **Use Reliable Data:** Ensure your characters are well-defined, independent, and accurately scored.

2. **Focus on Derived Traits:** Prioritize synapomorphies over primitive traits to clarify relationships.

3. **Incorporate Multiple Data Types:** Combine morphological and molecular data for comprehensive analysis.

4. **Be Systematic:** Follow a consistent approach in data analysis and tree construction.

5. **Validate Your Tree:** Compare your cladogram with existing scientific literature or alternative analyses.

Common Challenges and How to Overcome Them

Dealing with Homoplasy

Homoplasy occurs when traits evolve independently in different lineages (convergent evolution). To address this:
- Use multiple characters
- Rely on molecular data when possible
- Be cautious in interpreting traits that may be prone to convergence

Handling Missing Data

Incomplete data can complicate analysis:
- Use methods that accommodate missing data
- Prioritize traits and taxa with complete information

Choosing the Right Method

Different analysis methods may produce varying trees:
- Cross-validate results
- Use software that allows testing of different algorithms

Conclusion

Making cladograms is a meticulous yet rewarding process that unveils the evolutionary history of organisms. By systematically gathering data, analyzing shared traits, and carefully constructing the diagram, you can create informative representations of biological relationships. Whether for academic research, classroom projects, or personal understanding, mastering the art of making cladograms enhances your appreciation of life's diversity and evolutionary complexity.

Remember, practice and critical thinking are key. As you refine your skills, you'll become more proficient at interpreting and constructing cladograms that accurately reflect the evolutionary narratives of the natural world.

Frequently Asked Questions

What is a cladogram and why is it important in evolutionary biology?

A cladogram is a diagram that shows the evolutionary relationships among different species based on shared characteristics. It helps scientists understand how species are related and trace their common ancestors.

What are the key steps involved in creating a cladogram?

The main steps include selecting species to compare, identifying shared derived characteristics (traits), creating a character matrix, determining the most parsimonious relationships, and drawing the diagram to reflect these relationships.

How do scientists choose which traits to include when

making a cladogram?

Scientists select traits that are heritable, observable, and relevant to evolutionary differences. They focus on derived traits that have evolved differentially among the species being compared.

What is the significance of outgroups in making a cladogram?

An outgroup is a species or group outside the main group being studied. It helps to root the cladogram and determine which traits are ancestral versus derived, clarifying evolutionary relationships.

How does the principle of parsimony influence cladogram construction?

The principle of parsimony suggests that the simplest explanation, or the one with the fewest evolutionary changes, is preferred. When making a cladogram, scientists choose the tree that requires the least number of trait changes.

Can molecular data, like DNA sequences, be used to make cladograms?

Yes, molecular data such as DNA or protein sequences can be used to generate cladograms, providing genetic evidence for evolutionary relationships and often increasing accuracy.

What are some common mistakes to avoid when making a cladogram?

Common mistakes include selecting inappropriate traits, ignoring the importance of outgroups, misinterpreting shared traits as evidence of common ancestry, and not considering the principle of parsimony.

How can software tools assist in creating cladograms?

Software tools can analyze large datasets of traits or genetic sequences, automatically generate possible cladograms, and help identify the most parsimonious and accurate evolutionary relationships efficiently.

Additional Resources

Making Cladograms: A Comprehensive Guide to Phylogenetic Tree Construction

In the realm of evolutionary biology, understanding the relationships among species, genes, or other taxa is fundamental. One of the most pivotal tools in this pursuit is the cladogram, a diagrammatic representation that depicts the evolutionary connections based on shared derived characteristics. Crafting an accurate and informative cladogram requires meticulous analysis, careful selection of characters, and a thorough understanding of phylogenetic principles. This article offers an in-depth review of the process involved in making cladograms, emphasizing methodologies, best practices, and common pitfalls to guide researchers, educators, and students alike.

Introduction to Cladograms

A cladogram is a branching diagram that illustrates the evolutionary relationships among various taxa. Unlike traditional phylogenetic trees, cladograms focus primarily on the pattern of shared derived characters (synapomorphies) to define groupings called clades. These diagrams are instrumental in understanding the evolutionary history and classification of organisms.

Key Features of Cladograms:
- Depict hypothesized relationships based on morphological, molecular, or behavioral data.
- Emphasize shared derived traits to infer common ancestry.
- Present as a series of branches (clades) originating from a common ancestor.

Applications of Cladograms:
- Classifying organisms based on evolutionary relationships.
- Tracing the origin of specific traits.
- Informing conservation strategies by understanding lineage diversity.
- Supporting molecular and morphological analyses.

Given their importance, constructing a cladogram involves a systematic approach rooted in rigorous data analysis and phylogenetic principles.

Theoretical Foundations of Cladogram Construction

Before delving into the construction process, it’s essential to grasp the underlying concepts that inform cladogram development.

Phylogenetic Systematics

Phylogenetic systematics seeks to classify organisms based on their evolutionary histories. It relies on the identification of homologous characters—traits inherited from a common ancestor—and differentiates them from analogous traits, which are similar due to convergent evolution.

Shared Derived Characters (Synapomorphies)

These are traits that are present in an ancestor and all its descendants but not in distant relatives. Synapomorphies are crucial for defining clades because they indicate common ancestry.

Principles of Cladogram Construction

- Parsimony: The simplest explanation, requiring the fewest evolutionary changes, is preferred.
- Monophyly: Clades should include all descendants of a common ancestor.
- Outgroup Comparison: Using an external group helps determine which traits are ancestral versus derived.

Methodologies for Making Cladograms

Creating a cladogram involves several methodical steps, which can be broadly categorized into data collection, character coding, analysis, and interpretation.

Step 1: Data Collection

Begin with gathering comprehensive data on the taxa of interest. Data sources include:
- Morphological traits (structures, coloration, size)
- Molecular sequences (DNA, RNA, protein data)
- Behavioral characteristics
- Ecological traits

Best Practices:
- Use reliable, peer-reviewed sources.
- Ensure data completeness to avoid bias.
- Incorporate multiple data types for robustness.

Step 2: Character Selection and Coding

Identify informative characters that vary among taxa. These should be:
- Heritable
- Discrete (i.e., can be categorized)
- Independent (non-correlated)

Once selected, characters are coded numerically or categorically. For example:

Character	Taxon A	Taxon B	Taxon C

Presence of wings	1	1	0
Number of petals	5	5	4
DNA base at position 150	A	G	A

Tips for Effective Coding:
- Use binary states (0/1) for presence/absence.
- For multistate characters, assign numerical codes.
- Be consistent across all taxa.

Step 3: Constructing a Data Matrix

Organize coded characters into a matrix format, where rows represent taxa, and columns represent characters. This matrix forms the foundation for analysis.

Step 4: Phylogenetic Analysis Methods

Two primary approaches are used:

a) Parsimony Analysis

- Seeks the tree with the least number of character state changes.
- Software tools: PAUP, TNT, or Mesquite.
- Process involves heuristic searches to identify the most parsimonious trees.

b) Model-Based Methods

- Includes Maximum Likelihood (ML) and Bayesian Inference.
- Incorporate models of evolution to estimate probabilities.
- Software tools: RAxML, MrBayes, BEAST.

Step 5: Tree Construction and Visualization

After analysis, generate cladograms that best fit the data. Visualize using specialized software, which allows for annotations, rooting, and style adjustments.

Interpreting and Validating Cladograms

Once a cladogram is constructed, careful interpretation is necessary.

Rooting the Cladogram

- Use an outgroup to determine the direction of evolutionary change.

- The outgroup should be closely related but outside the ingroup taxa.

Assessing Support and Confidence

- Conduct bootstrap analysis or posterior probability calculations.
- Values >70% (bootstrap) or >0.95 (Bayesian) indicate strong support.

Testing Alternative Hypotheses

- Generate alternative trees to compare different evolutionary scenarios.
- Use statistical tests to evaluate the best-supported tree.

Common Challenges and Pitfalls in Making Cladograms

Constructing accurate cladograms is complex, with potential pitfalls:

- Homoplasy: Independent evolution of similar traits can mislead analyses.
- Character Bias: Over-reliance on morphological traits susceptible to convergent evolution.
- Incomplete Data: Missing data can obscure true relationships.
- Taxon Sampling: Limited or biased taxon sampling reduces resolution.
- Choice of Outgroup: Incorrect outgroup selection can affect rooting.

Awareness and mitigation of these issues are vital for producing reliable cladograms.

Advances in Cladogram Construction

With technological progress, cladogram building has become more sophisticated.

Modern Developments Include:
- Integration of genomic data for high-resolution analysis.
- Use of software that automates character coding and analysis.
- Combining morphological and molecular data in total evidence approaches.
- Development of consensus trees to represent multiple plausible relationships.

Conclusion

Making cladograms is a meticulous process that combines data collection, character analysis, computational methods, and critical interpretation. When executed carefully, cladograms serve as powerful tools to unravel the evolutionary history of life, providing insights into the origins and diversification of species. As phylogenetic methods continue to evolve, so too will our ability to construct more accurate and comprehensive cladograms, deepening our understanding of biological diversity and evolution.

Summary Checklist for Making Cladograms:
- Gather comprehensive and reliable data.
- Select informative, independent characters.
- Code characters consistently.
- Use appropriate analytical methods (parsimony, ML, Bayesian).
- Interpret results critically, considering support values.
- Validate findings with alternative hypotheses.
- Remain aware of potential biases and errors.

By adhering to these principles, researchers can produce cladograms that not only reflect current understanding but also guide future investigations into the tree of life.

Making Cladograms

making cladograms: *What is a Cladogram? Examining Evolutionary Relationships in Organisms | Grade 6-8 Life Science* Baby Professor, 2024-04-15 Learn about What is a Cladogram? to unlock the secrets of evolutionary relationships for your middle school class. This enlightening book simplifies complex concepts, illustrating how scientists use cladograms like family trees to explore the connections among plants, animals, and other organisms. Filled with intriguing examples like the immortal jellyfish and living fossils, it offers a practical guide to constructing cladograms and understanding shared characteristics and convergent evolution. Ideal for inspiring young scientists. Explore this essential tool for biology education today.

making cladograms: Diagrammatic Representation and Inference Amrita Basu, Gem Stapleton, Sven Linker, Catherine Legg, Emmanuel Manalo, Petrucio Viana, 2021-09-21 This book constitutes the refereed proceedings of the 12th International Conference on the Theory and Application of Diagrams, Diagrams 2021, held virtually in September 2021. The 16 full papers and 25 short papers presented together with 16 posters were carefully reviewed and selected from 94 submissions. The papers are organized in the following topical sections: design of concrete diagrams; theory of diagrams; diagrams and mathematics; diagrams and logic; new representation systems; analysis of diagrams; diagrams and computation; cognitive analysis; diagrams as structural tools; formal diagrams; and understanding thought processes. 10 chapters are available open access under a Creative Commons Attribution 4.0 International License via link.springer.com.

making cladograms: Strategies for Quantitative Research Grant S. McCall, 2018-02-15 It is little secret that most archaeologists are uneasy with statistics. Thankfully, in the modern world, quantitative analysis has been made immensely easier by statistical software packages. Software now does virtually all our statistical calculations, removing a great burden for researchers. At the same time, since most statistical analysis now takes place through the pushing of buttons in software packages, new problems and dangers have emerged. How does one know which statistical test to use? How can one tell if certain data violate the assumptions of a particular statistical analysis? Rather than focusing on the mathematics of calculation, this concise handbook selects appropriate forms of analysis and explains the assumptions that underlie them. It deals with fundamental issues, such as what kinds of data are common in the field of archaeology and what are the goals of various forms of analysis. This accessible textbook lends a refreshing playfulness to an often-humorless subject and will be enjoyed by students and professionals alike.

making cladograms: *Species Concepts and Phylogenetic Theory* Quentin D. Wheeler, Rudolf

Meier, 2000 No question in theoretical biology has been more perennially controversial or perplexing than What is a species? Recent advances in phylogenetic theory have called into question traditional views of species and spawned many concepts that are currently competing for general acceptance. Once the subject of esoteric intellectual exercises, the species problem has emerged as a critically important aspect of global environmental concerns. Completion of an inventory of biodiversity, success in conservation, predictive knowledge about life on earth, management of material resources, formulation of scientifically credible public policy and law, and more depend upon our adoption of the right species concept. Quentin D. Wheeler and Rudolf Meier present a debate among top systematic biology theorists to consider the strengths and weaknesses of five competing concepts. Debaters include (1) Ernst Mayr (Biological Species Concept), (2) Rudolf Meier and Rainer Willmann (Hennigian species concept), (3) Brent Mishler and Edward Theriot (one version of the Phylogenetic Species Concept), (4) Quentin Wheeler and Norman Platnick (a competing version of the Phylogenetic Species Concept), and (5) E. O. Wiley and Richard Mayden (the Evolutionary Species Concept). Each author or pair of authors contributes three essays to the debate: first, a position paper with an opening argument for their respective concept of species; second, a counterpoint view of the weakness of competing concepts; and, finally, a rebuttal of the attacks made by other authors. This unique and lively debate format makes the comparative advantages and disadvantages of competing species concepts clear and accessible in a single book for the first time, bringing to light numerous controversies in phylogenetic theory, taxonomy, and philosophy of science that are important to a wide audience. Species Concepts and Phylogenetic Theory will meet a need among scientists, conservationists, policy-makers, and students of biology for an explicit, critical evaluation of a large and complex literature on species. An important reference for professionals, the book will prove especially useful in classrooms and discussion groups where students may find a concise, lucid entrée to one of the most complex questions facing science and society.

making cladograms: Biology Julian Sutton, 1998-11-11 Dr Sutton's exciting text provides a comprehensive introduction to the core concepts of biology. Starting with an overview of the diversity of life, the author covers a range of subjects from the naming and grouping of organisms through natural selection, molecular and cell biology, genetics, reproduction, physiology, ecology and biotechnology. Written in a student-friendly style and with an emphasis on explaining concepts rather than cataloguing facts, the book is fully illustrated with copious diagrams and photographs. Exercises with answers are also included. Beginning students in biology or first-year undergraduates with biology as a subsidiary will find this book invaluable.

making cladograms: The Evolution of Phylogenetic Systematics Andrew Hamilton, 2013-11-09 The Evolution of Phylogenetic Systematics aims to make sense of the rise of phylogenetic systematics—its methods, its objects of study, and its theoretical foundations—with contributions from historians, philosophers, and biologists. This volume articulates an intellectual agenda for the study of systematics and taxonomy in a way that connects classification with larger historical themes in the biological sciences, including morphology, experimental and observational approaches, evolution, biogeography, debates over form and function, character transformation, development, and biodiversity. It aims to provide frameworks for answering the question: how did systematics become phylogenetic?

making cladograms: Cladistic Biogeography Christopher John Humphries, Lynne R. Parenti, 1986 This clearly written, nontechnical introduction to cladistic biogeography treats earth history and biohistory as interdependent and attempts to explain patterns of plant and animal distribution through a systematic reconstruction of different groups of organisms found in similar areas. Emphasizing an historical approach, the authors cover the methodology, the applications, and the potential value of cladistic biogeography in developing a new view of the organic world.

making cladograms: Tiger Beetles David L. Pearson, Alfried P. Vogler, 2001 Tiger beetles are one of the most obvious and ubiquitous families of any insect taxon--some 2300 species are found on nearly all the land surfaces of the earth. Their frequently showy colors, brazen behavior, and ability to live in habitats ranging from dry, alkaline lakebeds to tropical rain forests have captured the interest of amateur and professional entomologists alike. Although tiger beetles have been widely studied, the wealth of knowledge has been synthesized only briefly in a few sources.In Tiger Beetles, David L. Pearson and Alfried P. Vogler provide for the first time a detailed integration and summary of all that is known about the family Cicindelidae. The book's early chapters cover anatomy, distribution, and natural history. Pearson and Vogler build from these basics to show the usefulness of tiger beetles for exploring questions in genetics, biogeography, ecology, behavior, and conservation. As bioindicators, the tiger beetles present in an area may allow biologists to pinpoint places with the richest diversity of animal and plant life. The use of tiger beetles as model organisms has made possible or greatly enhanced many areas of research, including molecular phylogeny, the function of acute hearing, spatial modeling, and physiology of vision.

making cladograms: Time of Nature and the Nature of Time Christophe Bouton, Philippe Huneman, 2017-05-30 This volume addresses the question of time from the perspective of the time of nature. Its aim is to provide some insights about the nature of time on the basis of the different uses of the concept of time in natural sciences. Presenting a dialogue between philosophy and science, it features a collection of papers that investigate the representation, modeling and understanding of time as they appear in physics, biology, geology and paleontology. It asks questions such as: whether or not the notions of time in the various sciences are reducible to the same physical time, what status should be given to timescale differences, or what are the specific epistemic issues raised by past facts in natural sciences. The book first explores the experience of time and its relation to time in nature in a set of chapters that bring together what human experience and physics enable metaphysicians, logicians and scientists to say about time. Next, it studies time in physics, including some puzzling paradoxes about time raised by the theory of relativity and quantum mechanics. The volume then goes on to examine the distinctive problems and conceptions of time in the life sciences. It explores the concept of deep time in paleontology and geology, time in the epistemology of evolutionary biology, and time in developmental biology. Each scientific discipline features a specific approach to time and uses distinctive methodologies for implementing time in its models. This volume seeks to define a common language to conceive of the distinct ways different scientific disciplines view time. In the process, it offers a new approach to the issue of time that will appeal to a wide range of readers: philosophers and historians of science, metaphysicians and natural scientists - be they scholars, advanced students or readers from an educated general audience.

making cladograms: Encyclopedia of Biodiversity , 2013-02-05 The 7-volume Encyclopedia of Biodiversity, Second Edition maintains the reputation of the highly regarded original, presenting the most current information available in this globally crucial area of research and study. It brings together the dimensions of biodiversity and examines both the services it provides and the measures to protect it. Major themes of the work include the evolution of biodiversity, systems for classifying and defining biodiversity, ecological patterns and theories of biodiversity, and an assessment of contemporary patterns and trends in biodiversity. The science of biodiversity has become the science of our future. It is an interdisciplinary field spanning areas of both physical and life sciences. Our awareness of the loss of biodiversity has brought a long overdue appreciation of the magnitude of this loss and a determination to develop the tools to protect our future. Second edition includes over 100 new articles and 226 updated articles covering this multidisciplinary field— from evolution to habits to economics, in 7 volumes The editors of this edition are all well respected, instantly recognizable academics operating at the top of their respective fields in biodiversity research; readers can be assured that they are reading material that has been meticulously checked and reviewed by experts Approximately 1,800 figures and 350 tables complement the text, and more than 3,000 glossary entries explain key terms

making cladograms: Milestones in Systematics David M. Williams, Peter L. Forey, 2004-05-12 Presenting a historical analysis of the evolution of systematics during the last one hundred years, Milestones in Systematics reviews many of the major issues in systematic theory and practice that have driven the working methods of systematics during the 20th century and looks at the issues most likely to preoccupy systematists in the immediate fu

making cladograms: Governing the Wild Stephanie Rutherford, Shows how iconic representations of nature—from museum to theme park—define our ideas about saving the natural world

making cladograms: Cladistic Theory and Methodology Thomas Duncan, Tod F. Stuessy, 1985

making cladograms: The Basics of Biology Anne Wanjie, 2013-07-15 Life is the most basic and fundamental fact of our existence and yet remains one of the greatest and most impenetrable mysteries. This enthralling survey of biology contains the riches of awe-inspiring discoveries and a rare glimpse into biologists' working methods. All of this is further complemented by stunning full-color photos, illustrations, diagrams, and primary source images, as well as intriguing sidebars that detail do-it-yourself experiments; test reading comprehension; relate failed theories of the past; spotlight current debates, disagreements, and discussions; and reveal the practical applications of the scientific research. This is a stellar survey of biology, of life on earth and how it works. As a superb example of science writing, it perfectly meets the Common Core curriculum standards for the reading of science texts relating to key ideas and details, craft and structure, integration of knowledge and ideas, range of reading, and level of text complexity.

making cladograms: *Corals in Space and Time* John Edward Norwood Veron, 1995 As concerns about the change in global climate and the loss of biodiversity have mounted, attention has focused on the depletion of the ozone layer and the destruction of tropical rainforests. But recently scientists have identified another seriously endangered ecosystem: coral reefs. In Corals in Space and Time, J.E.N. Veron provides a richly detailed study of corals that will inform investigations of these fragile ecosystems. Drawing on twenty-five years of research, Veron brings together extensive field observations about the taxonomy, biogeography, paleontology, and biology of corals. After introducing coral taxonomy and biogeography, as well as relevant aspects of coral biology for the non-specialist, he provides an interpretation of the fossil record and paleoclimates, an analysis of modern coral distribution, and a discussion of the evolutionary nature and origins of coral species. Revealing a sharp conflict between empirical observations about the geographical variation within species, Veron introduces a non-Darwinian theory of coral evolution. He proposes that the evolution of coral species is driven not primarily by natural selection, but by constantly shifting patterns of ocean circulation, which produce changing variations of genetic connectivity. This mechanism of speciation and hybridization has far-reaching consequences for the study of all types of corals and potentially many other groups of organisms as well.

making cladograms: *Problems of Phylogenetic Reconstruction* Systematics Association, 1982

making cladograms: Cladistic Biogeography Christopher J. Humphries, Lynne R. Parenti, 1999-04-15 The distribution and classification of life on earth has long been of interest to biological theorists, as well as to travellers and explorers. Cladistic biogeography is the study of the historical and evolutionary relationships between species, based on their particular distribution patterns across the earth. Analysis of the distributions of species in different areas of the world can tell us how those species and areas are related, what regions or larger groups of areas exist, and what their origins might be. The first edition of Cladistic Biogeography was published in 1986. It was a concise exposition of the history, methods, applications of, and prospects for cladistic biogeography. Well reviewed, and widely used in teaching, Cladistic Biogeography is still in demand, despite having been out of print for some time. This new edition draws on a wide range of examples, both plant and animal, from marine, terrestrial, and freshwater habitats. It has been updated throughout, with the chapters being rewritten and expanded to incorporate the latest research findings and theoretical and methodological advances in this dynamic field.

making cladograms: Mammalian Evolution, Diversity and Systematics Frank Zachos, Robert Asher, 2018-10-22 There are nearly 6,000 mammalian species, among them our own. Research on our evolutionary cousins has a long history, but the last 20 years have seen particularly rapid progress in disentangling the interrelationships and evolutionary history of mammals. The present volume combines up-to-date reviews on mammalian phylogenetics with paleontological, taxonomic and evolutionary chapters and also summarizes the historical development of our insights in mammalian relationships, and thus our own place in the Tree of Life. Our book places the present biodiversity crisis in context, with one in four mammal species threatened by extinction, and reviews the distribution and conservation of mammalian diversity across the globe. This volume is the introductory tome to the new Mammalia series of the Handbook of Zoology and will be essential reading for mammalogists, zoologists and conservationists alike.

making cladograms: Cladistics Peter Skelton, Andrew Smith, Neale Monks, 2002-09-19 A complete course on cladistic techniques for students of palaeontology and biological systematics.

making cladograms: Botany James D. Mauseth, 2009 The fourth edition of Botany: an introduction to plant biology provides a thorough and current overview of the fundamentals of botany while retaining the important focus of natural selection, analysis of botanical phenomena, and diversity. Students are first introduced to topics that should be most familiar (plant structure), proceed to those less familiar (plant physiology and development), and conclude with topics that are likely least familiar to the introductory student (genetics, evolution, and ecology). Sections are written to be self-contained, allowing topics to be covered in various orders.

Related to making cladograms

MAKING Definition & Meaning - Merriam-Webster The meaning of MAKING is the act or process of forming, causing, doing, or coming into being. How to use making in a sentence

MAKING | English meaning - Cambridge Dictionary MAKING definition: 1. the activity or process of producing something: 2. the things used to make or build something. Learn more

MAKING Definition & Meaning | Making definition: the act of a person or thing that makes.. See examples of MAKING used in a sentence

MAKING definition and meaning | Collins English Dictionary the material or qualities needed for the making or development of something to have the makings of a good doctor

Making - definition of making by The Free Dictionary making noun 1. creation, production, manufacture, construction, assembly, forging, composition, fabrication a book about the making of the movie plural noun

making noun - Definition, pictures, pronunciation and usage Definition of making noun in Oxford Advanced Learner's Dictionary. Meaning, pronunciation, picture, example sentences, grammar, usage notes, synonyms and more

Making Or Makeing: Which Is Correct? - VocabClarified In summary, “making” is the correct spelling and should be used in all contexts where you describe the act of creating or producing something. The term “makeing” is simply a

making - Dictionary of English the act of a person or thing that makes, produces, etc.:[uncountable] the making of dresses. Usually, makings. [plural] the qualities necessary to develop into or become something: has

Makeing or Making – Which is Correct? - IELTS Lounge To summarize, “making” is the correct form of the verb to use when talking about an ongoing action in present or past continuous tense. The word “makeing” is not a recognized

making - Wiktionary, the free dictionary making (countable and uncountable, plural makings) The act of forming, causing, or constituting; workmanship; construction. Process of growth or development

MAKING Definition & Meaning - Merriam-Webster The meaning of MAKING is the act or process of forming, causing, doing, or coming into being. How to use making in a sentence

MAKING | English meaning - Cambridge Dictionary MAKING definition: 1. the activity or process of producing something: 2. the things used to make or build something. Learn more

MAKING Definition & Meaning | Making definition: the act of a person or thing that makes.. See examples of MAKING used in a sentence

MAKING definition and meaning | Collins English Dictionary the material or qualities needed

for the making or development of something to have the makings of a good doctor
Making - definition of making by The Free Dictionary making noun 1. creation, production, manufacture, construction, assembly, forging, composition, fabrication a book about the making of the movie plural noun
making noun - Definition, pictures, pronunciation and usage Definition of making noun in Oxford Advanced Learner's Dictionary. Meaning, pronunciation, picture, example sentences, grammar, usage notes, synonyms and more
Making Or Makeing: Which Is Correct? - VocabClarified In summary, “making” is the correct spelling and should be used in all contexts where you describe the act of creating or producing something. The term “makeing” is simply a
making - Dictionary of English the act of a person or thing that makes, produces, etc.:[uncountable] the making of dresses. Usually, makings. [plural] the qualities necessary to develop into or become something: has
Makeing or Making – Which is Correct? - IELTS Lounge To summarize, “making” is the correct form of the verb to use when talking about an ongoing action in present or past continuous tense. The word “makeing” is not a recognized
making - Wiktionary, the free dictionary making (countable and uncountable, plural makings) The act of forming, causing, or constituting; workmanship; construction. Process of growth or development
MAKING Definition & Meaning - Merriam-Webster The meaning of MAKING is the act or process of forming, causing, doing, or coming into being. How to use making in a sentence
MAKING | English meaning - Cambridge Dictionary MAKING definition: 1. the activity or process of producing something: 2. the things used to make or build something. Learn more
MAKING Definition & Meaning | Making definition: the act of a person or thing that makes.. See examples of MAKING used in a sentence
MAKING definition and meaning | Collins English Dictionary the material or qualities needed for the making or development of something to have the makings of a good doctor
Making - definition of making by The Free Dictionary making noun 1. creation, production, manufacture, construction, assembly, forging, composition, fabrication a book about the making of the movie plural noun
making noun - Definition, pictures, pronunciation and usage Definition of making noun in Oxford Advanced Learner's Dictionary. Meaning, pronunciation, picture, example sentences, grammar, usage notes, synonyms and more
Making Or Makeing: Which Is Correct? - VocabClarified In summary, “making” is the correct spelling and should be used in all contexts where you describe the act of creating or producing something. The term “makeing” is simply a
making - Dictionary of English the act of a person or thing that makes, produces, etc.:[uncountable] the making of dresses. Usually, makings. [plural] the qualities necessary to develop into or become something: has
Makeing or Making – Which is Correct? - IELTS Lounge To summarize, “making” is the correct form of the verb to use when talking about an ongoing action in present or past continuous tense. The word “makeing” is not a recognized
making - Wiktionary, the free dictionary making (countable and uncountable, plural makings) The act of forming, causing, or constituting; workmanship; construction. Process of growth or development

Related Articles

- baxter oven manual

- lalitha sahasranamam in sanskrit pdf
- karen to english dictionary