

Molecular evidence for evolution 3: Evolutionary trees

Components

	NAME	DESCRIPTION	AUDIENCE
	<i>Evolutionary trees</i> teachers guide	This guide describes activities that may be used to explain how molecular data can be used to build evolutionary trees and explain evolutionary relationships.	teachers
	<i>Visualising evolution</i> video	This animation provides an overview of evolutionary theory, and describes evidence used to support this theory. It gives a framework for understanding relationships between species, and shows how to represent these relationships visually through an evolutionary tree.	students
	<i>Building evolutionary trees</i> learning object	This learning object guides students through the construction of a primate evolutionary tree, using molecular data.	students
	<i>What is 'molecular evidence'?</i> fact sheet	This fact sheet describes types of molecular analyses, interpretation of molecular evidence, and advantages and disadvantages of molecular techniques.	students
	<i>Primate trees</i> worksheet	This worksheet follows the learning object, <i>Building evolutionary trees</i> , and builds on concepts introduced in it.	students
	<i>Marsupial relations</i> worksheet	This worksheet guides students through the process of constructing a marsupial evolutionary tree, using molecular data, following the model presented in the learning object.	students
	<i>All about evolution</i> background sheet	This background sheet provides information on molecular evidence for evolution, common misconceptions, and Hominidae (great ape) evolution.	teachers

Purpose

To **Explain** how scientists establish evolutionary relationships between organisms by examining and comparing molecular data, genes (DNA) and proteins (amino acids).

Outcomes

Students:

- understand types of evidence used to support evolutionary theory;
- use molecular data to establish evolutionary relationships and construct evolutionary trees, for a group of primates and a group of marsupials;
- interpret evolutionary trees;
- understand importance of specific genes in evolutionary analyses; and
- consider implications of molecular evidence for our understanding of evolutionary relationships between organisms.

Activity summary

ACTIVITY	POSSIBLE STRATEGY
Students read and discuss fact sheet, <i>What is molecular evidence?</i> to provide background information for activities that follow.	in pairs or groups
Students watch animation, <i>Visualising evolution</i> , then work through learning object, <i>Building evolutionary trees</i> .	individually or in pairs
Students complete worksheet, <i>Primate trees</i> , using results from learning object and information from animation and fact sheet.	individually
Students complete worksheet, <i>Marsupial relations</i> , using processes described in learning object as a model.	individually

Teacher notes

The learning object, *Building evolutionary trees*, shows students how to build an evolutionary tree, based on data from 42-nucleotide segments of five primates' cytochrome *b* genes.

The worksheet, *Primate trees*, presents Hominoidea evolutionary trees derived from both anatomical and molecular data. It probes student understanding and ability to interpret evolutionary trees. It includes questions on: primates' shared characteristics; advantages and disadvantages of using cytochrome *b*; and candidate genes.

Using information provided in previous activities, the worksheet, *Marsupial relations*, helps students construct a marsupial evolutionary tree. We recommend students work through the learning object before attempting this worksheet. Some data in this worksheet have been modified to simplify the task for students. However the evolutionary tree shown in Figure 3 of the worksheet is derived from authentic data.

Technical requirements

The teachers guide, worksheets, fact sheet and background sheet require Adobe Reader (version 5 or later), which is a free download from www.adobe.com. The worksheets are also provided in Microsoft Word format.

 The video, *Visualising evolution*, requires Internet Explorer 9+, Google Chrome, Safari 4.0+, Opera or Firefox). It contains closed captions.

A high quality version of the video (in MP4 format) is available on CD-ROM or download from the SPICE website.

The learning object requires a modern browser (eg Internet Explorer 7 or later, Google Chrome, Safari 4.0+, Opera or Firefox). It can be placed on a web or file-server and run either locally or remotely in a web browser.

Reference

Tamura K., Peterson D., Peterson, N., Stecher G., Nei M. and Kumar S. (2011). MEGA5: Molecular Evolutionary Genetics Analysis using Maximum Likelihood, Evolutionary Distance, and Maximum Parsimony Methods. *Molecular Biology and Evolution* 28: 2731-2739.

Image credits

fact sheet, *What is 'molecular evidence'*?

- 'TEM image of mammalian lung tissue' by Louisa Howard. PD, remf.dartmouth.edu/images/mammalianLungTEM/source/1.html
- image of cytochrome bc1 complex from the RCSB PDB (www.pdb.org) of PDB ID IBCC (Zhang Z., Huang L., Shulmeister V., Chi Y., Kim K., Hung L., Crofts A., Berry E. and Kim S. (1998). Electron transfer by domain movement in cytochrome bc1. *Nature* 392, 677-684)
- 'group specific Conserved signature INDEL' by Radhey S Gupta. CC-BY-SA-2.5, commons.wikimedia.org/wiki/File:Group_indel_picture.png

worksheet, *Marsupial relatives*

- 'red kangaroo' by Paul Ricketts. All rights reserved.
- 'Macropus eugenii (tammar wallaby)' by Arthur Chapman. CC-BY-NC-SA-2.0, www.flickr.com/photos/arthur_chapman/8198085187/
- 'Macropus agilis' by Nino Barbieri. CC-BY-SA-3.0, commons.wikimedia.org/wiki/File:Macropus_agilis_-_01.jpg
- 'wombat' by Julian Berry. CC-BY-SA-2.0, www.flickr.com/photos/julianjb/463699422/
- 'wallaroo ready' by Shannon Kringen. CC-BY-SA-2.0, www.flickr.com/photos/shannonkringen/4781221686/in/photostream/

Acknowledgements

Grateful thanks are extended to Winthrop Professor Linc Schmitt (School of Anatomy, Physiology and Human Biology, The University of Western Australia) for his help, feedback and support in developing this activity.

Thanks to Celeste Wale (School of Anatomy, Physiology and Human Biology, The University of Western Australia) for assistance with marsupial evolutionary trees. Data analysis conducted using MEGA5 (see Reference below).

Designed and developed by the Centre for Learning Technology, The University of Western Australia. Production team: Anton Ball, Pauline Charman, Jan Dook, Alwyn Evans, Dan Hutton, Bec McKinney, Emma Pointon, Paul Ricketts, Jodie Ween and Michael Wheatley with thanks to Bob Fitzpatrick, Jenny Gull and Wendy Sanderson.

SPICE resources and copyright

All SPICE resources are available from the Centre for Learning Technology at The University of Western Australia ("UWA"). Selected SPICE resources are available through the websites of Australian State and Territory Education Authorities.

Copyright of SPICE resources belongs to The University of Western Australia unless otherwise indicated.

Teachers and students at Australian and New Zealand schools are granted permission to reproduce, edit, recompile and include in derivative works the resources subject to conditions detailed at spice.wa.edu.au/usage.

All questions involving copyright and use should be directed to SPICE at UWA.

Web: spice.wa.edu.au

Email: spice@uwa.edu.au

Phone: (08) 6488 3917

Centre for Learning Technology (M016)

The University of Western Australia

35 Stirling Highway

Crawley WA 6009

Associated SPICE resources

Molecular evidence for evolution 3: Evolutionary trees may be used in conjunction with related SPICE resources to teach the topic of molecular evidence for evolution.

DESCRIPTION	LEARNING PURPOSE
<i>Molecular evidence for evolution (overview)</i>	
<i>Molecular evidence for evolution 1: Mammal evolution</i> A card game engages student interest in evidence used to determine evolutionary relationships between eutherians (placental mammals).	Engage
<i>Molecular evidence for evolution 2: Primates</i> Students use interactive learning objects to explore how anatomical evidence may be used to determine relatedness.	Explore
<i>Molecular evidence for evolution 3: Evolutionary trees</i> The use of molecular evidence to determine relatedness between species is explained. Students draw evolutionary trees to represent relatedness.	Explain
<i>Molecular evidence for evolution 4: Viral evolution</i> Students use the Influenza Research Database to investigate virus evolution. This bioinformatics database is an authentic research tool used to compare genetic sequences of virus strains, and to construct cladograms to draw conclusions about their relatedness.	Elaborate