SYLLABUS – Molecular approaches to the diversity of life. Spring 2003, Catalina Island.

OVERVIEW

The patterns of evolutionary change, both within and among populations and species, may be investigated by examining DNA, the molecular basis of heredity in organisms. DNA molecules may be manipulated, tagged, read and compared with various biological, chemical, and analytical techniques, and this information can be used to describe diversity among organisms at the molecular level as well as reveal the historical origin of this diversity. This course will provide an introduction to the uses of molecular information in evolution and biodiversity research, including project design, DNA extraction, amplification and sequencing, and data manipulation and analysis for both inter- and intra-specific studies. Students will be introduced to the history, principles and applications of molecular systematics, and then be guided through a project examining the genetic variation among goby populations inhabiting the Channel Islands and the reconstruction of their phylogenetic history.

INSTRUCTORS:

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SCHEDULE:

Lectures will be from 9:30 to 11:30 am, Tuesday through Friday.
Labs will be from 1:00 to 5:00 pm, Monday through Thursday.
Students will be expected to continue laboratory exercises on their own time.

COURSE MATERIALS:

Reader of selections from various books and research papers; additional books for reference and additional reading will be available in the library.

COMPUTER LABS:

Students will use the most commonly employed software programs for molecular data manipulation and analysis, including Sequencher, MacClade, and PAUP. Instruction will also be given on the use of public molecular databases such as GenBank.

LABORATORY AND FIELD EXERCISES:

Generation of DNA data in the laboratory will be a significant portion of this course. Students will receive hands-on training in molecular techniques, and collection of marine organisms for student research projects may be coordinated with the research diving program.

ASSIGNMENTS AND EXAMS:

At the end of the course, each student will submit a report in standard academic format (Abstract, Introduction, Materials and Methods, Results, Discussion, Literature Cited and Figures) detailing the research project. This report should be typed, double-spaced, and approximately 5-7 pages long. Students will also take a midterm, final exam, and two shorter quizzes; all of which will test the student's knowledge and understanding of the material provided in lecture, laboratory and through assigned readings.

Missed exams will receive a grade of zero unless the student has an excused absence due to a documented medical or family emergency. At the discretion of the instructor, a missed exam may be retaken as a written or oral exam, or the student may be given a prorated score based on performance in the rest of the course. Late assignments will be downgraded 10% per day until turned in. Regrades will be considered on exams or assignments only if the student submits a written explanation of why the grading is being disputed. The entire exam or assignment will be regraded, and the score may be increased, decreased or unchanged at the instructor's discretion. Regrade requests must be submitted within one week of when the exam or assignment is returned.

GRADING:
Midterm: 25%
Final: 25%
Project report: 25%
Interim short quizzes, 2 @ 10% each
Lab skills: 5%

SCHEDULE: MARCH 24-APRIL 18, 2003

	LECTURE	LABORATORY
M 24th		Basic principles / Tissue Extraction I
Tu 25th	DNA basics / PCR	Tissue Extraction II / PCR
W 26th	Sequencing / phylogeny	PCR / electrophoresis / gel extraction
Th 27th	Phylogeny, characters, homology	Sequencing : cycle sequencing
F 28th	QUIZ; Catalina goby project	
M 31st		Data analysis: sequence reconciling
Tu 1st	Phylogenetic theory & species	Data analysis: editing & alignment
W 2nd	Phylogenetic practice	Data analysis: phylogeny estimation
Th 3rd	Support / consensus / rates	Data analysis: support / rates
F 4th	MIDTERM	
M 7th		PCR / Sequencing / Discussion
Tu 8th	Biogeography, Heterochrony	PCR / Sequencing / Discussion
W 9th	Phylogeny & Conservation	PCR / Sequencing / Discussion
Th 10th	Speciation & Coevolution	PCR / Sequencing / Discussion
F 11th	QUIZ; Population methods	
M 14th		Data analysis: phylogenetics
Tu 15th	Genomics and Proteomics	Data analysis: phylogenetics
W 16th	Future of phylogenetics & museums	Overview / comparison of results
Th 17th	Kizirian lecture: Galapagos lizards	Discussion / report critique
F 18th	FINAL; PROJECT REPORTS DUE	

Lectures for Molecular Approaches to the Diversity of Life, Spring 2003

Week I (Thacker): MOLECULAR TECHNIQUES AND COMPARATIVE BIOLOGY

DNA basics/PCR
- Structure of DNA, transcription / translation / replication
- PCR amplification, cycles, primers
- DNA as character evidence, comparison to morphology
- Molecular biodiversity, why is DNA useful

Sequencing/Phylogeny
- Fluorescent cycle sequencing methods
- Phylogenetic basics, characters, methods
- Molecular techniques: allozymes, RFLPS, RAPDS

Phylogeny, characters, homology
- Definition of homology, identification of homology
- Character identification, coding

Catalina goby project
- Introduction to *Rhinogobiops* ecology & biology
- Sister taxon, *Coryphopterus*, *Fusigobius*
- Phylogeny of species, phylogeography of *Rhinogobiops*

Week II (Hardman): PHYLOGENETIC ANALYSIS

Phylogenetic theory & species concepts
- Hypothesis testing in the historical sciences
- The relationship between classification, phylogenetics and evolutionary biology
- Individuals, species and taxa
- Tokogeny and phylogeny
- Research programs in phylogenetic biology

Phylogenetic reconstruction
- Phenetics versus cladistics
- Distance methods
- Parsimony
- Likelihood
- Bayesian

Evaluating phylogenies 1: Support for the optimal topology
- Tree length distributions
- Resampling methods (Bootstrap and jackknife), Bremer support
- Testing alternative hypotheses in a statistical framework
- Consensus methods

Evaluating phylogenies 2: Sources of error, and protection from them
- Phylogeny and genealogy
- The relationship between gene trees and a species tree
- Lateral gene transfer
- Combining data, and combining trees (Supertrees)
- Rates of evolution and speciation
- Molecular clocks

Week III (Thacker): PHYLOGENETIC APPLICATIONS

Biogeography, Heterochrony
- Ontogeny, heterochrony, VonBaer / Haeckel
- Ontogeny criterion of character polarization
- Polarizing / understanding ontogenetic change with phylogeny
- Biogeography, methods and goals

Phylogeny & Conservation
- Species, taxonomy, understanding biodiversity
- Genome projects

Speciation and Coevolution
- Types of speciation
- Comparing host / parasite phylogenies

Phylogeography & population methods
- Phylogeography with mitochondrial loci
- Distance-based population methods vs. phylogeny
- Tokogenetic vs. Phylogenetic array

Week IV (Hardman): FUTURE OF PHYLOGENETICS

Bioinformatics, Genomics and Proteomics
- Molecular evolution - reciprocal illumination
- Models, simulation studies
- Mitochondrial studies
- Human genome and others
- Comparative genomics
- Proteomics

Future of phylogenetics, & museums
- All taxon inventories
- All taxon phylogenies
- The contents of biological collections and their importance in 21st century
- Biodiversity crisis
- The pattern of extinction

READINGS FOR MOLECULAR APPROACHES TO THE DIVERSITY OF LIFE, SPRING 2003

Week I (Thacker): MOLECULAR TECHNIQUES AND COMPARATIVE BIOLOGY

DNA basics, PCR, sequencing, phylogeny

Li, W-H. and D. Graur. 1991. Fundamentals of Molecular Evolution. Sinauer Associates, Inc.
Chapter 1, Gene structure and Mutation. Pgs. 1-19.

Hillis, D. M., C. Moritz and B. K. Mable. 1996. Molecular Systematics, Second edition. Sinauer Associates, Inc.
Chapter 7, PCR. Pgs. 205-232
Chapter 9, Sequencing. Pgs. 326-339

Hillis, D. M. and J. J. Wiens. 2000. Molecules versus morphology in systematics: conflicts, artifacts, and misconceptions. Pgs. 1-19. In: Phylogenetic analysis of morphological data, J. J. Wiens (ed.) Smithsonian Institution Press.

Patterson, C. 1988. Homology in classical and molecular biology. Mol. Biol. Evol. 5:603-625.

Randall, J. E. 1995. *Fusigobius* Whitley, a junior synonym of the gobiid fish genus *Coryphopterus* Gill. Bull. Mar. Sci. 56(3):795-798.

Smith, C. L. and J. C. Tyler. 1977. Redescription of the gobiid fish *Coryphopterus lipernes* Böhlke and Robins, with notes on its habits and relationships. Amer. Mus. Novit. 2616:1-10.

Miller, D. J. and R. M. Lea. 1972. Guide to the coastal marine fishes of California. Fish Bulletin 157, California department of Fish and Game.
Gobies, family Gobiidae. Pgs. 186-189.

Week II (Hardman): PHYLOGENETIC ANALYSIS

Phylogenetic theory & species concepts

Cleland, C. E. 2001. Historical science, experimental science, and the scientific method. *Geology* 29: 987-990.

Patterson, C. 1980. Cladistics. *Biologist* 27: 234-240.

Vrana, P., and W. Wheeler. 1992. Individual organisms as terminal entities: laying the species problem to rest. Cladistics 8:67-72.

Cracraft, J. 2000. Species concepts in theoretical and applied biology: a systematic debate with consequences. Pgs. 3-14. In: Wheeler, Q. D. and R. Meier (eds.) Species concepts and phylogenetic theory: a debate. Columbia University Press, New York.

Phylogenetic reconstruction

Page, R. D. M. and E. C. Holmes. 1998. Molecular Evolution: A Phylogenetic Approach. Blackwell Science, Ltd.
Chapter 6, Inferring Molecular Phylogeny. Pgs. 172-201.

Evaluating phylogenies 1: Support for the optimal topology

Kitching, I. J., P. L. Forey, C. J. Humphries, and D. M. Williams. 1998. Cladistics: The theory and practice of phylogenetic systematics. 2nd edition. The Systematics Association Publication No. 11, Oxford University Press.
Chapter 6, Support and confidence statistics for cladograms and groups. Pgs. 118-138.
Chapter 7, Consensus trees. Pgs. 139-150.

Evaluating phylogenies 2: Sources of error, and protection from them

Avise, J. C. 1994. Molecular markers, natural history and evolution. Chapman & Hall.
Molecular clocks. Pp. 100-109.
Gene trees versus species trees. Pgs. 126-138.

Page, R. D. M. and E. C. Holmes. 1998. Molecular Evolution: A Phylogenetic Approach. Blackwell Science, Ltd.
Chapter 8, Applications of molecular phylogenetics. Pgs. 280-293.

Doolittle, W. F. 1999. Phylogenetic classification and the universal tree. *Science* 284: 2124-2128.

Pisani, D. A. M. Yates, M. C. Langer, and M. J. Benton. 2002. A genus level supertree of the Dinosauria. *Proceedings of the Royal Society of London* 269: 915-921

Week III (Thacker): PHYLOGENETIC APPLICATIONS

Biogeography/Heterochrony

Fink, W. L. 1982. The conceptual relationship between ontogeny and phylogeny. Paleobiology 8:254-264.

Mabee, P. M. 1989. An empirical rejection of the ontogenetic polarity criterion. Cladistics 5:409-416.

Bernardi, G. 2000. Barriers to gene flow in *Embiotoca jacksoni*, a marine fish lacking a pelagic larval stage. Evolution 54(1):226-237.

Phylogeny/Conservation

Barraclough, T. G. and S. Nee. 2001. Phylogenetics and speciation. Trends in Ecology and Evolution 16(7):391-399.

Daugherty, C., A. Cree, J.M. Hay and M.B. Thompson. 1990. Neglected taxonomy and continued extinctions in Tuatura. Nature 347: 177-178.

Speciation/Coevolution

Page, R. D. M. and E. C. Holmes. 1998. Molecular Evolution: A Phylogenetic Approach. Blackwell Science, Ltd.
Chapter 8, Applications of molecular phylogenetics. Pgs. 293-313.

Phylogeography/Population methods

Avise, J. C. 2000. Phylogeography: the history and formation of species. Harvard University Press, Cambridge.
Chapter 1, The history and purview of phylogeography. Pgs. 3-36.

Week IV (Hardman): FUTURE OF PHYLOGENETICS

Bioinformatics, genomics and proteomics

Thomas, J. W. and J. W. Touchman. 2002. Vertebrate genome sequencing: building a backbone for comparative genomics. *Trends in Genetics* 18: 104-108.

Fitzgerald, J. R. and J. M. Musser. 2001. Evolutionary genomics of pathogenic bacteria. *Trends in Microbiology* 9: 547-553.

Future of phylogenetics and museums

Morin, N. R. and J. Gomon. 1993. Data banking and the role of natural history collections. *Annals of the Missouri Botanic Garden* 83: 536-545.

Shaffer, H. B., R. N. Fisher, C. Davidson. 1998. The role of natural history collections in documenting species declines. *Trends in Ecology and Evolution* 13: 27-30.

Galapagos Lizards

Dave will pick papers for this.