Introduction to Amphibian Evolution and Systematics

Todd W. Pierson
WFS 433/533
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1. Understand principles of biological systematics
2. Define 'amphibians' from an evolutionary perspective.
3. Describe some of the challenges of modern systematics.

What defines an amphibian?

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How do we categorize biological diversity?

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How do we categorize biological diversity?

Comedies

Dramas

Galifianakis

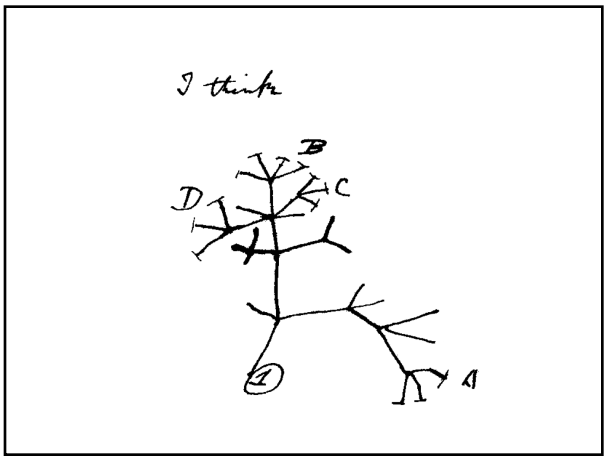
Pitt

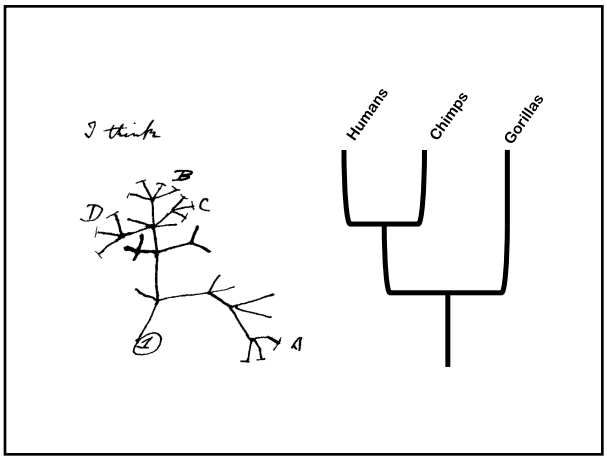
Sequels

Originals

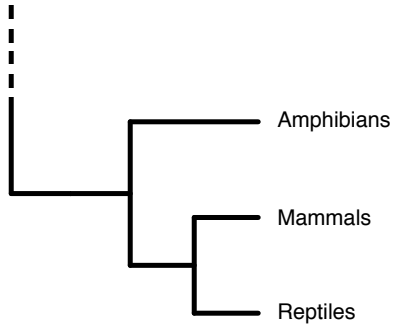
Pretty great

Sort of terrible





What is an amphibian?



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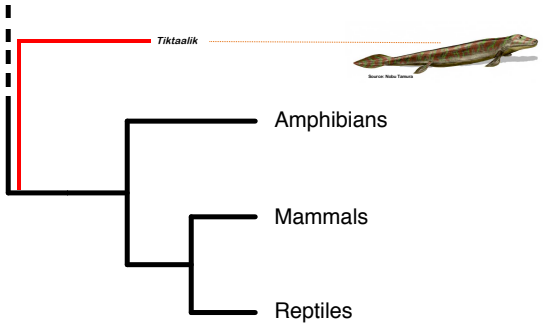

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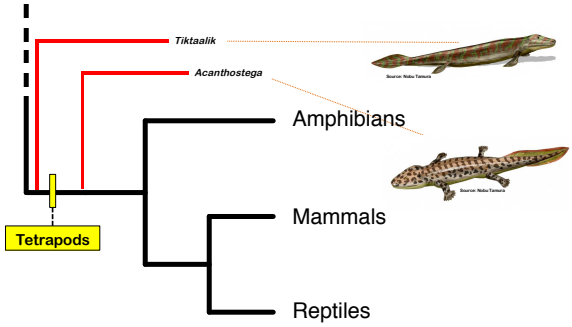

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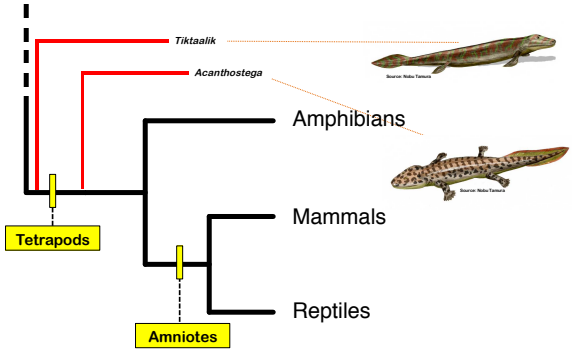

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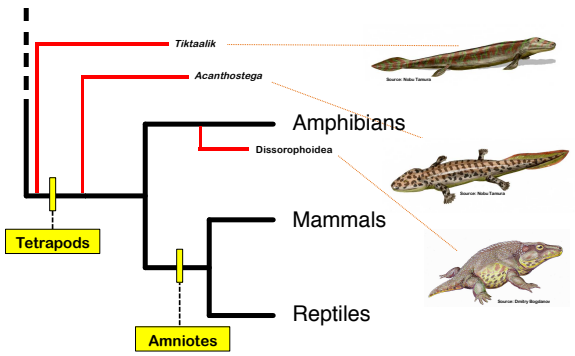

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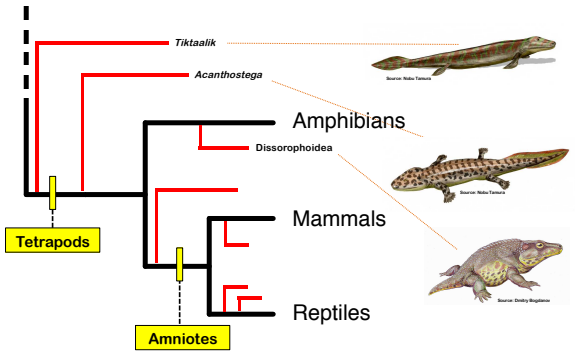
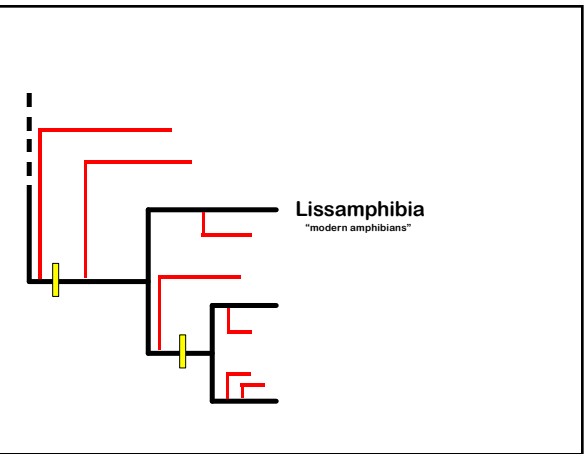
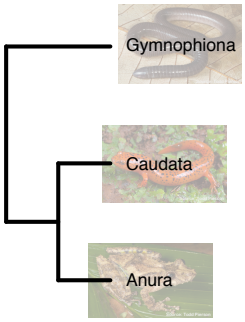




Orders of Lissamphibia



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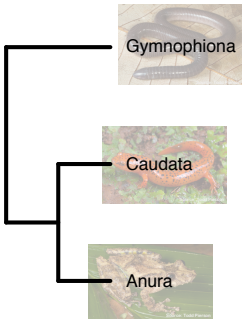
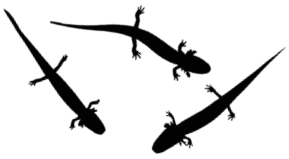


How do we infer these relationships?

We build models to infer them from…

Morphological traits



ATCCGTATTAGA
ATCTGTATTAGA
ATCCGTAGTAGA

DNA sequences

Why is it challenging?

These data can be difficult to interpret.

Evolution is sometimes complicated.

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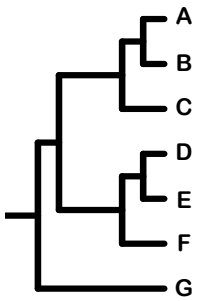
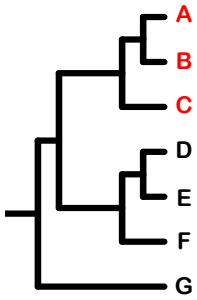


What is the relationship between shared traits and evolutionary history?

These data can be difficult to interpret.



A, B, and C are tips that define a clade (i.e., monophyletic). A clade contains all descendants of a common ancestor.

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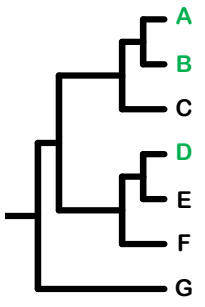
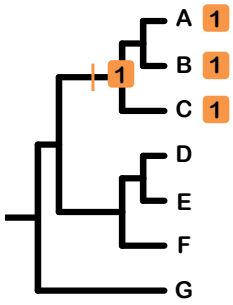


A, B, and D are tips representing a paraphyletic (or polyphyletic) group, because not all descendants of their common ancestor are included.

We classify organisms based on monophyletic groups (i.e., clades).

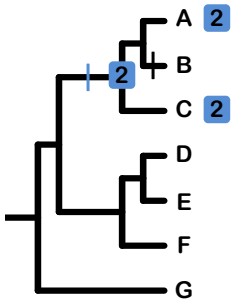
These data can be difficult to interpret.



Trait 1 is a synapomorphy of the clade consisting of A, B, and C, with respect to other tips.

A synapomorphy is a shared, derived character.

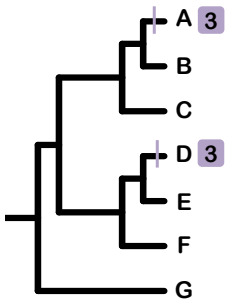
These data can be difficult to interpret.



Trait 2 is a symplesiomorphy in the clade consisting of A, B, and C.

A symplesiomorphy is a shared ancestral trait not found in all descendants of that ancestor.

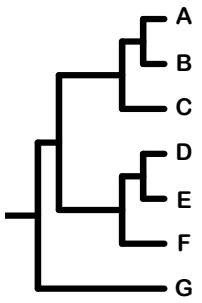
These data can be difficult to interpret.



Trait 3 is a homoplasy for tips A and D.

A homoplasy is a shared trait not found in a common ancestor.

These data can be difficult to interpret.



What is the relationship between shared traits and evolutionary history?

It's variable. But using appropriate models and suitable data can help us infer the latter from the former.

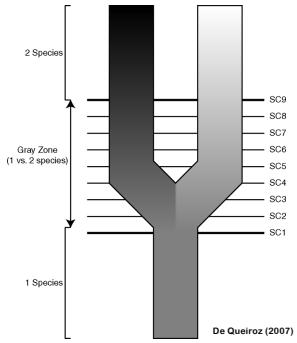
Species Concepts

Evolution is sometimes complicated.

Agamospecies	Cain 1954, Eigen 1993	Asexual lineages...that cluster together in terms of their genome.
Autapomorphic species	Nelson and Platnick 1981	A geographically constrained group of individuals with some unique apomorphous characters.
Biospecies / Biological species	Key et al. 1955, Mayr 1942	Inclusive Mendelian population of sexually reproducing organisms. ...interbreeding natural population isolated from other such groups.
Cladospecies	Hennig 1966, Kornet 1993	Set of organisms between speciation events or between speciation event and extinction.
Cohesion species	Templeton 1989	Evolutionary lineages bounded by cohesion mechanisms that cause reproductive communities, particularly genetic exchange, and ecological interchangeability.
Compilospecies	Harlan 1942, Aguilar 1999	A species pair where one species "plunders" the genetic resources of another via introgressive interbreeding.
Composite species	Kornet 1993	All organisms belonging to an interaction and its descendents until any subsequent interaction.
Ecospecies / Ecological species	Simpson 1961, Stebbins 1998, Turesson 1922, Van Valen 1976	A lineage (or closely related set of lineages) which occupies an adaptive zone minimally different from that of any other lineage in its range and which evolves separately from all lineages outside its range.
Evolutionary species	Simpson 1961, Wiley 1978, 1981	A lineage (an ancestral-descendent sequence of populations) evolving separately from others and with its own unitary evolutionary role and tendencies.
Evolutionary significant unit	Waples 1991	A population (or group of populations) that (1) is substantially reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species.
Genealogical concordance species	Avise and Ball 1990	Population subdivisions concordantly identified by multiple independent genetic traits constitute the population units worthy of recognition as phylogenetic taxa
Genic species	Wu 2001	A species formed by the fixation of all isolating genetic traits in the common genome of the entire population
Genetic species	Dobzhansky 1950, Mayr 1969, Simpson 1963	Group of organisms that may inherit characters from each other, common gene pool, reproductive community that forms a genetic unit.
Genotypic cluster	Mallet 1995	Clusters of monotypic or polytypic biological entities, identified using morphology or genetics, forming groups that have few or no intermediates where in contact.
Hennigian species	Hennig 1966, Hennig 1950	A tokogenetic community that arises when a stem species is dissolved into two new species and ends when it goes extinct or speciates.
Intermodal species	1993	Organisms are conspecific in virtue of their common membership of a part of a genealogical network between two permanent splitting events or a splitting event and extinction
Least inclusive taxonomic unit	Paquin 1999, Paquin and Rouse 2000	A taxonomic group that is diagnosable in terms of its autapomorphies, but has no fixed rank or binomial.
Morphospecies	Cronquist 1978	Species are the smallest groups that are consistently and persistently distinct, and distinguishable by ordinary means.
Non-dimensional species	Mayr 1963	Species delimitation in a non-dimensional system
Nothospecies	Wagner 1983	Species formed from the hybridization of two distinct parental species, often by polyploidy.
Phylospecies	Cracraft 1983, Eldredge and Cracraft 1980, Nelson and Platnick 1981, Rosen 1979	The smallest unit appropriate for phylogenetic analysis, the smallest biological entities that are diagnosable and monophyletic, until product of natural selection and descent.
Phylogenetic taxon species	Cracraft 1983, Eldredge and Cracraft 1980, Nixon and Wheeler 1990	A species is the smallest diagnosable cluster of individual organisms within which there is a parental pattern of ancestry and descent
Phenospecies	Beckner 1959, Sokal and Sneath 1963	A cluster of characters that statistically covary, a family resemblance concept in which possession of most characters is required for inclusion in a species, but not all.
Recognition species	Patterson 1985	A species is that most inclusive population of individual, biparental organisms which share a common fertilization system
Reproductive competition species	Ghiselin 1974	The most extension units in the natural economy such that reproductive competition occurs among their parts.
Successional species	George 1956, Simpson 1961	Arbitrary anagenetic stages in morphological forms, mainly in the paleontological record.
Taxonomic species	Blackwelder 1967	Specimens considered by a taxonomist to be members of a kind on the evidence or on the assumption they are as alike as their offspring of hereditary relatives within a few generations.

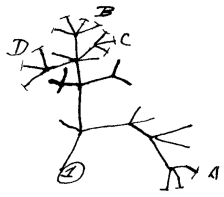
From John Wilkins (http://scienceblogs.com/evolvingthoughts/2006/10/01/a-list-of-26-species-concepts/)

Evolution is sometimes complicated.



Evolution is sometimes complicated.

I think



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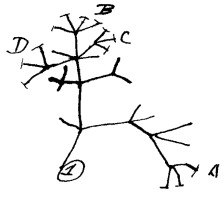
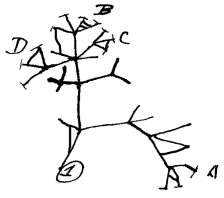


…but now, we sometimes think



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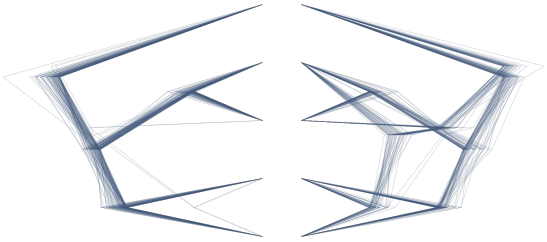

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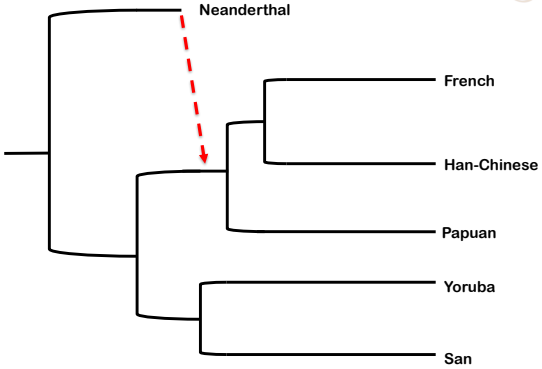
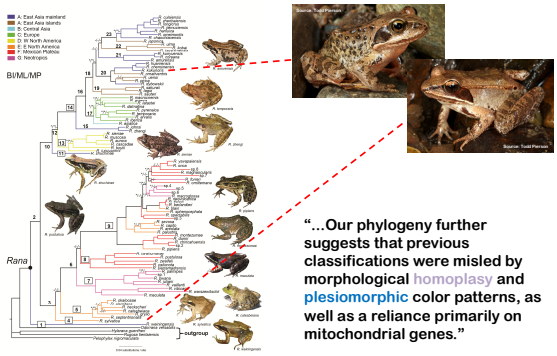


Green *et al.* 2010

Amphibian case studies

Spatiotemporal Diversification of the True Frogs (Genus *Rana*): A Historical Framework for a Widely Studied Group of Model Organisms

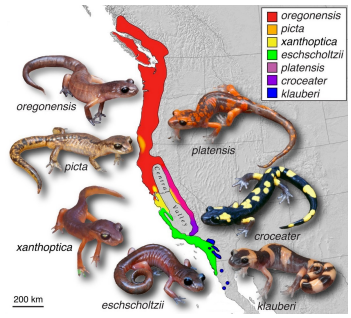
Zhi-Yong Yuan[1,2], Wei-Wei Zhou[1], Xin Chen[3], Nikolay A. Poyarkov, Jr[4], Hong-Man Chen[1], Nian-Hong Jang-Liaw[5], Wen-Hao Chou[6], Nicholas J. Matzke[7], Koji Iizuka[8], Mi-Sook Min[9], Sergius L. Kuzmin[10], Ya-Ping Zhang[1,*], David C. Cannatella[11,*], David M. Hillis[11,*], and Jing Che[1,*]



"…Our phylogeny further suggests that previous classifications were misled by morphological homoplasy and plesiomorphic color patterns, as well as a reliance primarily on mitochondrial genes."

Asymmetric reproductive isolation between terminal forms of the salamander ring species *Ensatina eschscholtzii* revealed by fine-scale genetic analysis of a hybrid zone

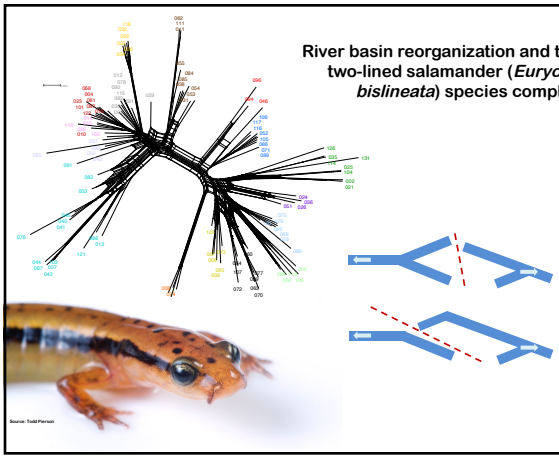
Thomas J Devitt[1,2*], Stuart JE Baird[2] and Craig Moritz[1]



"[Previous work suggests} the biogeographic history of *Ensatina* is much more complex, having featured periods of geographic isolation and multiple instances of secondary contact."

"Geographic variation in hybridization frequency among the four contact zones at the end of the ring suggests that reproductive isolation may not be uniform across contact zones…"

River basin reorganization and the two-lined salamander (*Eurycea bislineata*) species complex



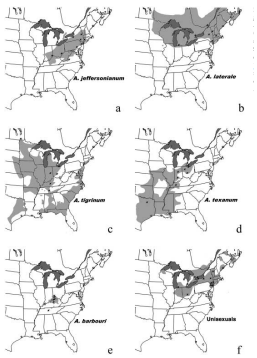
Unisexual salamanders (genus *Ambystoma*) present a new reproductive mode for eukaryotes

James P. Bogart, Ke Bi, Jinzong Fu, Daniel W.A. Noble, and John Niedzwiecki

" We believe that the unisexual *Ambystoma* exemplify a new unisexual reproductive mode, kleptogenesis. Kleptogens would be females that maintain a common cytoplasm but have a flexible nuclear genomic constitution. They acquire genomes from males of species that are compatible with their cytoplasm. The sperm nucleus may or may not be incorporated to increase ploidy level or to replace a genome."

An unexpected recent ancestor of unisexual *Ambystoma*

ALEXANDER V. ROBERTSON,[a] CADHLA RAMSDEN,[a] JOHN NIEDZWIECKI,[b] JINZHONG FU[b] and JAMES P. BOGART[a]
[a]Department of Integrative Biology, University of Guelph, Guelph, ON, Canada N1G 2W1; [b]Center for Ecology, Evolution and Behaviour, T.H. Morgan School of Biological Sciences, University of Kentucky, Lexington KY 40506-0225, USA



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