Integrative Biology 200A "PRINCIPLES OF PHYLOGENETICS" Spring 2012
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Jan. 19th **What is Systematic Biology? History and Philosophy**

Required reading: B.D. Mishler. 2009. Three centuries of paradigm changes in biological classification: is the end in sight? *Taxon* 58: 61-67.

Introduction

Why classify? Why does it matter what we call things? To look at it another way, is it possible to think or communicate *without* classifications?

Below are four generally-accepted goals in classification, arranged from the most immediate and practical, to more theoretical and esoteric.

PURPOSES FOR CLASSIFICATION:

1) PRACTICALITY
(OPERATIONALITY, EASE, STABILITY)
2) INFORMATION CONTENT
(OPTIMAL SUMMARIZATION OF WHAT IS KNOWN ABOUT ENTITIES)
3) PREDICTIVITY
(OF UNKNOWN FEATURES OF ENTITIES)
4) FUNCTION IN THEORIES
("CAPTURE" ENTITIES ACTING IN, OR RESULTING FROM, NATURAL PROCESSES)

History

--Systematics has always played a central role in the history of biology. The recognition of basic kinds of organisms, their properties and "relationships" in higher categories, was the earliest biological discipline. Developments in biology as a whole have interacted with systematics throughout. Detailed treatment of this history include Stevens, Hull, Dupuis, Donoghue & Kadereit, Mayr.

-- Important criteria to think about:
Relative balance in importance of theory vs. data -- rationalism vs empiricism
The role of technology -- a source of new characters
Metaphors that people used (trees, maps, geometric shapes, etc.)
The Great Chain of Being -- still with us after 2000 years!
Polythetic vs. monothetic classifications
"Weighting" of characters

There really have only been three revolutions, in the Kuhnian sense (Kuhn, 1970), in the history of systematics (see table on reverse). Early folk taxonomies came out of prehistory and were oriented towards practicality and human uses of organisms. Organisms were grouped by their relationship with human affairs. The first scientific revolution was that provided by the ancient Greeks; as in many fields of science, they justified a new logical framework within which to view the natural world. The effect of this on systematics was nicely discussed by Hull (1988): an essentialistic approach that gripped biology for 2,000 years. In this approach taxa were viewed as defined by the possession of necessary and sufficient defining traits.

Such a view, which reached its culmination in the work of Linnaeus, became untenable as the wealth of biological diversity became known due to the explorations of the 18th and 19th centuries. It became clear that any and all characters can vary within a named group, and thus the use of defining characters became an obvious problem when a group of plants that clearly belonged together was threatened because variation was discovered in an essential character. This set the stage for the second revolution in the history of systematics, the development of the natural system (as discussed by Stevens, 2000). In this approach taxa were recognized by overall resemblance in many characters, although these characters were often chosen for their "importance" in the biology of the group in question. It is important to note that this revolution in systematics preceded the Darwinian revolution, and in fact was prime evidence for Darwin to present in favour of evolution in the Origin. As has been noted by many, the Darwinian revolution had no fundamental impact on systematics. The language systematists used became evolutionary, but their approach remained the use of over-all resemblance. This same approach was made more efficient by the advent of computerised algorithms as the numerical phenetics school developed, but no fundamental change in underlying paradigms occurred.

The Hennigian revolution was arguably the third major revolution in the history of systematics, one that finally completed the Darwinian Revolution for systematics. The paradigm shift started by Hennig (1965, 1966) was due to a careful examination of the idea of homology, one of the most important yet controversial concepts in systematics. Hennig's central ontological advance was that homologous similarities are of two kinds, those due to recent, shared-derived homologies (synapomorphies) and those due to distant, shared-primitive homologies (symplesiomorphies). Only the former are useful for reconstructing the relative order of branching events in a system that is changing by descent with modification. The general Hennigian view is that evolution can be viewed as a series of branching events, connected by lineages: prior states transform along lineages into posterior states, that can serve as markers that a lineage existed. Under most circumstances, careful study of states possessed by the terminal twigs of the tree can allow us to reconstruct past character transformations, thus detecting the existence of lineages and inference of relative branching order (more on this next week).

HISTORICAL PERIODS IN BIOLOGICAL SYSTEMATICS:

1) PRE-HISTORY -- FOLK CLASSIFICATIONS
* 2) ANCIENT GREEKS THROUGH LINNAEUS-- ESSENTIALISM
* 3) NATURAL SYSTEM -- OVERALL RESEMBLANCE; "IMPORTANCE"
4) DARWIN -- EVOLUTIONARY LANGUAGE [only a superficial effect]
5) NUMERICAL PHENETICS -- COMPUTERS [only a superficial effect]
* 6) PHYLOGENETIC SYSTEMATICS (CLADISTICS) -- SYNAPOMORPHIES, MONOPHLYLY

* Argued to be the only true revolutions in the conceptual bases of systematics

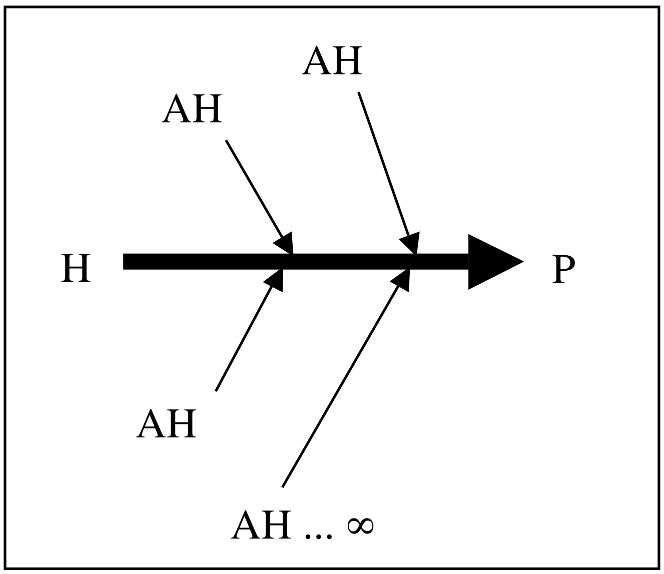
Philosophy

-- Some might think philosophy has nothing to do with biology (the traditionalists view), but that couldn't be more wrong. There are many important philosophical issues in systematics, the most important of which, for our purposes, being:

1. *Ontology* -- Background theories stating what kinds of entities exists, what are their fundamental meanings and relationships. [e.g., homologies, phylogenies, species, etc.]

2. *Epistemology* -- Background theories stating what kinds of empirical operations and methods can be used to discover the underlying ontological entities and relationships. [e.g., characters, statistics, cladistic analysis, etc.]

The reigning epistemology of science, its connection with ontology, and some variants:



Concepts to discuss:
- Hypothesis & Prediction
  - Main hypothesis
  - Auxiliary hypotheses
  - Null hypothesis
- Falsification (the boundary between science and non-science?)
- Experiment
  - Control
  - Replication
- Observation versus experiment
- Historical versus experimental science
- Cause
- Model
- Confidence

3. Sociology of science -- Motivations; patterns of teaching, cooperating, fighting; "progress" in science (Kuhn, 1970 is the classic; see Hull 1988, *Science as a Process*, for major treatment of subject in systematics).

Natural selection explained:

replicator -- any entity that passes its structure on with high fidelity
lineage -- a sequence of ancestor/descendent replicators
interactor -- an entity that interacts with other entities such that replication is differential
evolution by natural selection:

1. heritable variation in a trait causing...
2. differential reproductive success of one replicator lineage over others...
3. due to competition among interactors within a common environment.

To what extent does the process of science follow the model of natural selection? What are the analogies and non-analogies? What does it matter? *Plenty* -- the better you understand the process of science, the better you'll do at it!

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