Ontology of Evolution: Species

"It is really laughable to see what different ideas are prominent in various naturalists' minds, when they speak of 'species'; in some, resemblance is everything and descent of little weight — in some, resemblance seems to go for nothing, and Creation the reigning idea — in some, sterility an unfailing test, with others it is not worth a farthing. It all comes, I believe, from trying to define the indefinable" (Darwin, Letter to Hooker, December 24, 1856)

Why does it Matter How Species are Characterized?

- Scientifically?
  - Understanding evolution
  - Relating organisms as model systems
- Morally?
  - Is X a human being (in the moral sense)?
  - What obligations do we have?
- Public Policy?
  - Should we protect X?
- Does (should) evolutionary biology own the species concept?

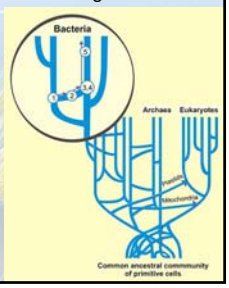
Size of the Problem

Estimated number of species in different orders

- 5–10 million bacteria
- 74,000–120,000 fungi
- 1.6 million eukaryote species
  - 297,326 plants
  - 28,849 fungi & other non-animals
  - 1,250,000 animals
    - 1,203,375 invertebrates
    - 59,811 vertebrates:
      - 29,300 fish
      - 6,199 amphibians
      - 8,240 reptiles
      - 9,956 birds
      - 5,416 mammals

The Prokaryote Challenge: Lateral Gene Transfer

- Common assumption: genes are transferred only from parent to offspring (vertical)
- Only in recent decades was the idea of lateral gene transfer introduced and supported
- Origins of mitochondrion from incorporation of one bacterium in another
- Ford Doolittle: "Uprooting the tree of life": "early cells, each having relatively few genes, differed in many ways. By swapping genes freely, they shared various of their talents with their contemporaries. Eventually this collection of eclectic and changeable cells coalesced into the three basic domains known today."



Natural Kinds

- Kind defined in terms of essential properties
  - All and only entities with the essential properties are instances of the kind
- Essential properties explain the key characteristics of the kind
- From knowing the essence, we can predict the properties associated with the kind
  - Example of chemical elements: from the atomic number of an element you know quite a bit about it

Species as Natural Kinds?

- Are any traits necessary or sufficient to belong to a particular species?
  - Necessary and sufficient traits for being a fruit fly
  - Necessary and sufficient traits for being a human
- One modern approach: human if you have human DNA
  - What is human DNA?
- Challenges
  - Would a mutant lacking the traits be excluded from the species?
  - Would a mutant of another species that acquired the trait become a member of the species?
  - Are there any sharp boundaries between members and non-members of a species?

Species as Individuals

- David Hull and Michael Ghiselin
  - Traditionally species have been construed as types or sets
  - But species are historical entities—they are born and they go extinct
  - In this, they are *individuals*—spatially, temporally extended entities
  - You and I are parts of the species *homo sapiens,* not members of it
- Are there defining traits of Charles Darwin, which if he lacked he wouldn't be Charles Darwin?
- Likewise, no expectation of defining characteristics of homo sapiens if it is an individual

Surprising Consequences of Species as Individuals

- Individual species cannot be the subject of scientific laws
- If it walks like a duck, quacks like a duck, . . . , but was not born of a duck, it is not a duck
  - And if it is born of a duck, it is a duck even if it doesn't look like a duck, quack like a duck, . . .
- There cannot be ducks, or people, anywhere else in the universe
  - Even if they look just like us, and speak English

Individualism and Human Nature

- Many people are deeply concerned to figure out what human nature consists in
  - Language
  - Tool use
  - Sociality
- But, if species are individuals, there is no human nature
  - Is that a problem?

Responses to Species as Individuals

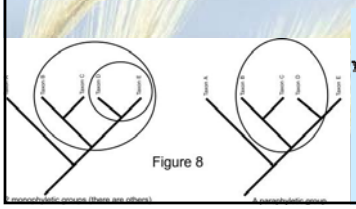
- Boyd's Homeostatic Property Clusters: There are a cluster of processes that promote stability (homeostasis) within a species
  - Gene flow
  - Stabilizing pressure
  - Developmental homeostasis
- Pluralism: different species concepts for different purposes
  - Physiology may have a very different goals in identifying species than evolutionary biology
    - Kind notion may work better there
    - But physiology increasingly done comparatively, taking phylogeny seriously

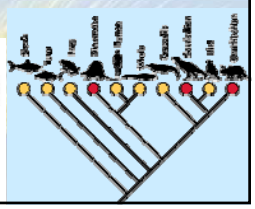
Taxonomy Wars

- Phenetics (numerical taxonomy)
  - Attempts to provide an atheoretical taxonomy (neutral between theories)
  - Start with traits and compute similarities
    - Variety of mathematical/statistical techniques recruited to create trees--phenogram
- Cladistics
  - Make phylogeny the key to taxonomy
  - Show order in which different species split from one another
  - Insist on monophyletic groups: A phyla consists of all and only the descendents of a species

Cladograms

- Represent species at terminal nodes
- Nodes represent splitting of a common ancestor
- Ancestor species ends at the split
- Higher phyla all monophyletic





Some Candidate Accounts of Species

- Phenetic species concept: species are groups defined in terms of overall similarity
- Phylogenetic species concept: species are lineages of ancestral/descendant populations between speciation events
  - Hennig: speciation always involves splitting of existing species (which then cease to exist)
- Biological species concept: species are populations that are reproductively isolated
  - Mayr: isolation via "biological properties of individuals which prevent the interbreeding [fusion] of populations"
- Others:
  - Cohesion species concept
  - Ecological species concept

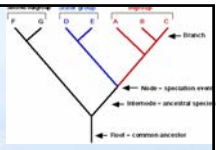
Problems with the Phenetic Species Concept

- What is *similarity*?
  - Any two objects in the universe are similar in an unlimited number of respects
  - Must specify dimensions and metrics for determining similarity
- Members of a species can vary significantly (especially in polytypic species) and members of different species may appear more similar to each other than members of the same species

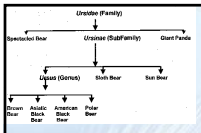
Problems with the Biological Species Concept

- Challenge temporally: depending on which organisms you start with, set the forward and backward limits of the species
- Groups that might not interbreed but easily could and groups that are different despite gene flow
  - Might try *potential* interbreeding, but no way to spell that notion out
- Problems with plants and single-celled organisms
  - Especially asexual organisms: Is each individual a different species?
  - These are most of the life forms on the planet
    - So, most organisms don't form species

Problems with the Phylogenetic Species Concept



- Need a means of identifying speciation events and so must use something like break in interbreeding or cohesiveness
- "the most plausible account of species is that they are lineages between speciation events. The biological species concept, perhaps supplemented by the ecological species concept or by something else, reemerges as an account of speciation" (Sterelny and Griffiths, p. 192).



Higher Taxa

- Linnaean Hierarchy
- Three desiderata of a classification system:
  - Position in hierarchy should convey maximal information about the traits of an item
  - Should reflect differences and evolutionary change
  - Reflect phylogeny
- Incompatible desiderata