Can we study history without function?

- History by itself provides no explanation of CAUSES of evolutionary change
- Note: Natural Selection is not the only agent of evolutionary change
  - Genetic drift
  - Recombination
  - Hybridization

Can we study function without history?

- Studies of function are about how natural selection has "designed" trait for particular challenges to survival
- Knowing the historical origins of traits makes clearer the starting point and subsequent path of the design process
  - May reveal why some outcomes were achieved rather than others
  - May reveal the constraints on the evolutionary process: how easily traits can arise and be lost
  - May help test ideas about function: the evolutionary pressures favoring the evolution of particular designs
How to Infer History of a Trait Without Fossils
Comparative Method I

- Study other living species that exhibit traits similar to the trait in question
- Comparisons among species can suggest evolutionary progression in trait
- Problem: this approach assumes that similarities among the comparison species are a result of their being part of same evolutionary series, which may not always be true
Homologous and Homoplastic Similarity

- Homology: similarity resulting from descent from common ancestor (within same evolutionary lineage)
- Homoplasy: similarity resulting from convergence in independent evolutionary lineages

Examples:
- Opposable thumbs in primates and pandas
- Camera eyes of vertebrates and cephalopod molluscs

Evidence for homology
- Embryology
- Genetics
- Common neuronal substrate
- Close phylogenetic relationship? (avoid circularity)

http://www.accessxcellence.org/AE/AEC/CC/vision_background.html
http://biodidac.bio.uottawa.ca/Thumbnails/CEPH005B-GIF.htm
Comparative Method II: Cladistics

The cladistic method explicitly recognizes difference between homologous and homoplastic similarity
- Makes assumption that homoplastic similarity is harder to achieve than homologous similarity (because it requires independent evolutionary events, and evolution is a conservative process)
- By parsimony, the likeliest evolutionary scenario is the one that involved the fewest evolutionary changes
- Homoplasy is inferred if it is most parsimonious interpretation

![Diagram showing homology and homoplasy in bird species with yellow and black bills.](image-url)
Cladistics cont’d

Two goals in cladistics
• Construct tree representing phylogenetic relationships
  • The most likely tree is one that requires fewest evolutionary changes
• Use tree to study evolutionary history of other traits
  • The most likely history is one that requires fewest evolutionary changes

GW Beyersbergen
http://raysweb.net/specialplaces/pages/pelican.html
Behavioral cladogram of pelicans and their relatives

Alcock
Fig. 7.4
Cladistics cont’d

Alcock
Fig. 7.4
Case Study: Swordtails

- Swords are ventral extension of the caudal fin of male swordtails
- Females (who don't have swords) prefer males with longer swords (experimental evidence)
- Functional hypothesis:
  - males with swords have higher mating success because of female choice
  - females prefer males with swords because a long sword indicates high fitness
Historical evidence: preference for swords arose before male swords did (cf. supernormal stimulus)

What does this say about the functional hypothesis?

ALCOCK FIG. 7.19
Case Study: Bee Dance Language

- Darwin’s puzzlement about “Organs of extreme perfection and complication,” such as the vertebrate eye
  - How could such marvelously designed devices arise and be perfected through the blind force of natural selection?
- Behavioral examples: brood parasitism by cuckoos, slavery in ants
- Darwin’s solution: draw upon comparative studies
  - Plausible story about intermediate stages in evolution of trait
  - Each stage has to be useful to the animal, and better than the one before
- The dance language (unknown to Darwin) as such an “organ of extreme perfection and complication
The Dance Language in Comparative Context

Asian honey bees

Apis florea: “dwarf bee”
- Nests in open
- Dances on flattened platform; view of sky
- Depends on sky for orientation
- Cannot orient dances to gravity

Apis dorsata: “rock bee”
- Nests in open
- Dances on vertical; view of sky
- Seems to orient to gravity; needs view of sky?

Apis cerana: Asian hive bee
- Nests in cavity
- Dances on vertical, in darkness
- Can orient to gravity or to sky
Initial hypothesis about history of dance language

Ancestral bee:
- Nested in open
- Oriented to sky, but not gravity
- Confused on slopes
- Confused on cloudy days
Feb 28: Phylogeny--Asian bees

New insights into the history of dance language

Ancestral bee:
- Nested in open ?
- Oriented to sky, but not gravity ?
- Confused on slopes
- Confused on cloudy days

Can orient dance to landmarks

Dances on vertical
Gravity used imperfectly

Nest in cavities
Gravity code perfected

Compensates for slope
(Unlike other species)

Orients fine without sky (landmarks)

Orients fine without sky (gravity)

Dwarf bee
Rock bee
Asian hive bee
European hive bee

Is *Apis florea* like the ancestral bee?
Is it even “primitive”?