

## On Posing Historical Scenarios for the Origin of Adaptations

1. Avoid statements of characters arising for the function of allowing groups, species, or higher taxa to survive (unless you really mean it).

✗ *Saber toothed cats evolved big teeth for the good of the species.*

ⓧ *Among the ancestors of saber toothed cats, individuals with bigger teeth were better able to hunt, were more likely to reproduce, and therefore passed their genes for big teeth on to more descendants than did individuals with smaller teeth.*

Evolution by selection happens to populations of genes through the differential performance of phenotypes as expressed in individuals. The fate of taxa is usually irrelevant, and the implication of group selection is misleading.

2. Complex adaptations usually are thought of as arising by many small steps, not by one saltation in a single individual; each small step, however, is traceable to the substitution of discrete mutations.

✗ *The first protosquid that had an eye was hugely more successful than his blind compatriots.*

ⓧ *Over many generations, numerous improvements in the visual apparatus of early cephalopods were selected for.*

Evolution happens incrementally; biologists debate how incrementally, but major features are not thought to arise like Athena from the head of Zeus. Gradualism applies both to gradual modification of structures in morphospace and gradual change through an extended period of time.

3. Selection does not anticipate long-range goals and does not compel orthogenesis.

✗ *Ever since the Eocene, horses have been selected towards ever increasing size. From Hyracotherium through Merychippus we finally arrived at the modern Equus.*

ⓧ *Many lineages of horses have evolved since the Eocene with considerable divergence in size. The earliest horse, Hyracotherium, was much smaller than the only surviving lineage, Equus. If we trace the fossil record between the two, we find that greater size evolved in several stages. The apparent "trend" that could be pointed out is an artifact of ignoring the many forms that are not in the direct line between the first (small) and the modern (large) horse.*

Never use the phrase "ladder of life." Evolution is a bush, not a ladder, and it is misleading to connect a tip to a root ignoring all other branches. Most trends in macroevolution are not likely to be the result of constant directional microevolutionary selection.

4. When discussing differential success, avoid absolutism in the form of words like "all", "only", and "every".

✗ *Only the cheetahs that were very fast at running down prey survived.*

ⓧ *The cheetahs that were very fast tended to have higher rates of survival than those that were just a little bit slower.*

The determinism of selection is typically only probabilistic.

5. Selection does not respond to needs. It is the result of variants conferring success in the context of intraspecific competition.

✗ *Once flat fishes started living on the ocean bottom, they needed to rearrange the position of their eyes to get them both on the "top" side of the fish.*

ⓧ *Once flat fishes started living on the ocean bottom, those individuals in which the "bottom" eye peeked out from under the fish a bit were better able than their more symmetric compatriots to capture prey.*

"Need", "necessary", "had to in order to survive" may apply to extinction but are unlikely to apply to selection or the causal origin of adaptive traits. True, an adaptation may be shaped primarily during hard times, but not when it is needed outright for the survival of the population. If they drop a Big one, we'll need to be tolerant of radiation, and sufficiently far from ground Zero where tolerance is not needed but provides a statistical edge there may be selection favoring more tolerant individuals over less tolerant ones, but where it is really needed, evolution is expected to be too slow to come to the rescue.

6. Evolution does not proceed by the inheritance of acquired traits ("the Lamarckian fallacy"). It is also misleading to imply that adaptations arise through the efforts and moral virtues of the organism (what Darwin distained Lamarck for).

✂ *Monkeys who used their tails to hang from grew very strong tails. This great tail strength built up over the generations.*

⚡ *Monkeys varied genetically in how strong their tails were able to grow when used to hang from. Genes that allowed the tails to grow stronger increased to fixation over the generations.*

The example was chosen because it is one in which the plasticity of growing strong tails might set the context for selection sorting out genes for stronger and stronger tails ("genetic accommodation"). This might sound like the Lamarckian fallacy but is in essence Darwinian.

7. Evolution by selection is not evolution by "randomness".

✂ *The flowers of orchids with all their functional elaborations evolved through randomness.*

⚡ *The flowers of orchids with all their functional elaborations evolved through non-directed mutation, which generated variation, and deterministic selection, which even when weak can accumulate favorable variants through many generations.*

The essence of selection is the non-random relationship between character variation and fitness. Selection is brainless, algorithmic, and automatic, but it is not random. Randomness can, however, result in nonadaptive evolution in the form of genetic drift and particular solutions to problems when more than one is possible.

8. Particular adaptations arose in particular lineages that are associated with particular phylogenetic levels; the origin of an adaptation should not be tied to narrower or broader taxa.

✂ *Once upon a time, rattlesnakes didn't have pits. Mutations arose for sensing heat, and these were selected for such that those rattlesnakes with even rudimentary pits ate more often and left more offspring than those rattlesnakes with no heat sensors. Through progressive improvements, exquisitely functional pits evolved.*

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⚡ *In the lineage that led to pit vipers, there were snakes that didn't have pits. Mutations arose for sensing heat, and these were selected for such that those snakes with even rudimentary pits ate more often and left more offspring than those snakes with no heat sensors. Through progressive improvements, exquisitely functional pits evolved.*

Rattlesnakes belong to a group called pit vipers, which unlike other snakes have pits below their eyes that they can use to sense heat differences as small as  $1/300^{\text{ths}}$  of a degree.