

## Re: Direction of Evolution?

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ZOOLOGY 304

Concepts and Questions in Evolutionary Biology.

Is evolution progressive?

It is widely believed (or presumed) that evolution is progressive. In response to the question, "Is evolution progressive?", students in ZOOL 304 gave these answers:

Yes

Yes, complexity and optimization to niche (although perfection cannot be attained).

Yes.

Yes, better ability to survive.

Only if conditions are changing.

Yes, traits increase (physical traits and genetic traits).

Yes, better adapted (but no species is better than another, just different).

Yes.

Yes, more suitable to it's own environment.

Yes, in some areas.

Yes, it continues without stopping.

Yes, it's a continuing process.

Yes.

Yes, ability to survive increases.

However, it is also frequently declared (especially by evolutionary biologists) that evolution is NOT progressive.

"Does [the genetical theory of natural selection] necessitate a belief in progress? Many biologists have stated that it does, and many more have tacitly assumed this position. I would maintain, however, that there is nothing in the basic structure of the theory of natural selection that would suggest the idea of any kind of cumulative progress."

George Williams, *Adaptation and Natural Selection*, 1966, p. 34. (See Chapter 2 in this book for a more substantial

discussion of "progress" in evolution.)

What's going on? Could this really be an issue of some significance? The "no progress" stance is in part a response to some widespread misconceptions about evolution. Many people believe that evolution has a goal, some target that the entire process has been approaching ever since life first began.

In part, this is a hold-over from preDarwinian explanations for the history of life that interpreted the Great Chain of Being (Aristotle's "scala naturae" or "ladder of nature", with all organisms arranged in rank order from plants to plant-like animals to worms, various invertebrates, fish, reptiles, mammals, men, and angels) as reflecting a striving for perfection, with men (or angels) as the goal. In this view, living invertebrates are in some real sense "inferior" animals compared to vertebrates, living reptiles are "inferior" to mammals, and living non-human vertebrates inferior to people. This view remains "obvious" to many people, but makes no sense from a modern evolutionary perspective that recognizes that all extant species are successful descendents of lineages that have remained unbroken since life began.

More subtly, the "progressive" view holds that extinct taxa must represent inferior versions of their respective taxa. In this view, evolution is a process which replaces poorly-adapted species with better-adapted species. But this is not how evolution works.

Within a population, adaptive evolution favors a trait-variant which yields greater reproductive success than another existing variant, under the particular circumstances which prevail at the moment of selection. The result has been some impressive adaptations, but the process itself has never been working "toward" any overall, long term improvement.

And in part, the view that evolution is "progressive" is simply a matter of definition. Of course, when history is read backward, all past events represent "progress" toward the future. But this really is not the question. Past scientific attempts to identify "progress" in evolution have involved efforts to identify some characteristic of life which shows some consistent, directional increase or advance in a measureable value. But, as discussed further below, no such characteristic has been found.

This issue matters, because a presumption of progress can interfere with clear understanding of just how undirected, how local and immediate and unconcerned with future consequences, the evolutionary process actually is.

One meaning for "progress" is simple continuation of a process, without halting. In this sense (as noted by two students), evolution surely does continue without stopping, probability inevitably so. But this is a very weak definition for "progress". The qualified answer, "only

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when conditions change", is similarly weak. An iceberg floats at the surface of the sea. When the sea level changes, the iceberg rises or falls to match that change. Thus the iceberg always moves "toward" the level of the sea. But this is not "progress" in the common sense of the word.

Much more commonly, "progress" is defined and understood not just as "change which maintains some condition" but as "advancement toward a higher, better, or more advanced stage". Progress in this sense seemed to be meant by at least seven students. But if evolution is progressive in the sense of advancement or improvement, what quality is it that advances or improves?

Isn't there an obvious sense in which evolution **MUST** be progressive?

Doesn't natural selection assure that species are always becoming better adapted, so that degree of adaptedness must be increasing over time? Doesn't the fossil record document continuing advancement toward improved design and complexity? Doesn't the process of adaptative radiation (continuing speciation with adaptation) guarantee that the ecological world will be ever more precisely subdivided into niches occupied by ever-increasing numbers of species?

In short, no. No one has yet demonstrated any measureable parameter that shows a consistent, reliable increase over time as evolution proceeds. This is an important point. Belief that evolution is always necessarily "improving" something can interfere with clear appreciation of the actual mechanism of evolution, which is simply the replacement of one heritable variant by another because, in specific conditions which include the presence of both variants, one does better than the other.

What would it mean to become progressively better at surviving or reproducing, to become progressively better adapted? Well, if adaptation implies an increase in fitness, and if fitness is measured as reproductive success, then an ongoing progressive process of adaptative evolution should yield increasing reproductive success over time. And this would imply that descendent species should reproduce more successfully than their ancestors. Thus a presumption of progress leads to an unreasonable conclusion of ever-increasing reproductive rates over time. But evolution is just a process whereby one variant is replaced by another. Perhaps surprisingly, there really is no expectation that any quality will be better after the replacement than before, only different. Natural selection works on relative fitness, not on some "absolute" measure of adaptedness which might show ever-increasing improvement. The net result is typically not improvement, just change. There is no reason to believe that progressive increase in reproductive success has occurred in ANY lineage, certainly not in most lineages.

What matters in evolution is variation, the relative differences in reproductive success that occur among members of a population. By

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definition, selection favors those variants which out-reproduce their fellows. But in what sense can that yield a consistently progressive increase in some measurable quality?

For example, imagine an environment which supports one hundred individuals. Mutations appear which make the individuals which carry the mutant alleles stronger and more aggressive. At first, the mutant individuals drive others away from resources, so within a few generations all individuals are similarly strong and aggressive. The environment still only supports one hundred individuals (maybe fewer, because they are all expending more energy on growing strong and fighting). No one is better off than before. In fact, fewer resources may now be available for reproduction because of the costs of conflict.

Adaptation has changed the basis for reproductive success. But where is the progress? Overall, what has increased, or "improved"?

In one famous example (cited by over 200 websites, with a couple links in this paragraph), adaptive evolution drives each of three lizard genotypes in an endless cycle of predominance, with each one replacing the preceding one in turn, mimicking the game of "rock, paper, scissors" (more, more). This and the preceding imagined example are not peculiar or unusual. They represent the basic mechanism by which evolution proceeds. One heritable variant replaces another because under it was more successful under certain particular conditions which included the presence of the other variants. This does not imply any long-term advancement in a progressive sense.

What about improved function? An impression of increasing complexity, associated with advanced engineering design, is easily obtained by picking an exceptionally complex organism (human beings are an obvious choice) and following its lineage backwards in time toward ancestral simplicity. But the impression of "progress" is determined by the choice of organism.

Hummingbirds and ospreys are certainly better at flying than are herrings or sharks. But fish, even ancient placoderms and ancestral agnathans, are far better at being fish than are most birds (penguins excepted?). In an evolutionary sense, the only measure of quality engineering design which has any significance is, "good enough; adequate to continue reproduction in competition with other variant designs".

As one student noted, "no species is better than another, just different". This applies to species in ancestor-descendent relationships just as much as to coeval species.

In many lineages (most famously parasite species, which may be more numerous than host species), evolution has proceeded with reduction toward simplicity from an ancestral state. (One might even argue that the predominant trend in evolution has been toward greater parasitism.)

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And of course, in many other lineages (especially bacteria, which outnumber eukaryotes by several orders of magnitude), there appears to have been no significant increase in complexity whatsoever.

Regarding overall species diversity, it is true that there have been times when diversity has increased. But these seem to have been momentary (geologically speaking) fluctuations associated with arbitrary incidents of mass extinction. On average, speciation seems to be largely balanced by extinction. There is no evidence, and no theoretical expectation, that diversity in the Paleozoic and Mesozoic eras was any less than that in the Cenozoic.

Ever since Aristotle, people have had an inclination to rank living things in a single dimension of "lower to higher" or "primitive to advanced". Such rankings have a name, "the Great Chain of Being" or "the Ladder of Life". But such rankings have no basis in evolutionary biology. All living organisms occupy equivalent positions on the tips of the latest twigs in phylogeny. The "lowliest" worm or microbe is just as "advanced", just as successful at adaptation and reproduction throughout its lineage, as is the "highest" primate or social insect.

"Progress" was an essential feature of some pre-Darwinian evolutionary theories, notably Lamarck's believe in evolution driven by inward striving toward improvement. But modern evolutionary theory supports no clear expectation of progress, at least not in any dimension that has yet been explored.

Not convinced? That's okay. What matters is clear thinking about the evolutionary process. The question of progress in evolution remains open. Prevailing opinion among professional biologists is that no progressive trend will be found. But an intuitive suspicion persists, that something might be increasing over time in many or even most lineages. Possibly something like efficiency of genomic information utilization, or genomically-based facility at sustaining the evolutionary process itself.

So, if you hold a position that evolution is indeed progress, you must be aware that this is a challenging position to maintain.

Intellectual integrity obliges you to justify any opinion by considering its implications. In this case, that means identifying just what measurement would use to demonstrate a progressive advancement over time.

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"It's uncertain whether intelligence has any long term survival value.  
Bacteria do quite well without it."  
Stephen Hawking