f22 Parallel and convergent evolution < homoplasy, analogies >

> One might have thought that the traditional idea that organisms are selected to be optimal for their environment would already have long ago led to some kind of predictive theory. And indeed it has for example allowed some simple numerical ratios associated with populations of organisms to be successfully derived. But about a question such as what forms of organisms are likely to occur it has much less to say.
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> There are a number of situations where fairly complicated structures appear to have arisen independently in several very different types of organisms. And it is sometimes claimed that this kind of convergent evolution occurs because these structures are in some ultimate sense optimal, making it inevitable that they will eventually be produced.
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> But I would be very surprised if this explanation were correct. And instead what I strongly suspect is that the reason certain structures appear repeatedly is just that they are somehow common among programs of certain kinds ... —Stephen Wolfram.[1]

> ... if evolution ... were repeated myriads of times, what properties of organisms would arise repeatedly, what properties would be rare, which properties were easy for evolution to happen upon, which were hard? —Stuart A. Kauffman.[2]

Homoplasy: Organisms that are not closely related can, because of independent adaptation to like environments, evolve characteristics that are similar in appearance and functionality. Example: Eyes are evolved features of all vagrant epifauna that live where light is present. Cephalopods and vertebrates (separately evolved for 1.2 billion years) have eyes convergently evolved as to cornea, iris, lens, and retina.[3] In human evolution to cope with ultraviolet (UV-B) radiation's destruction of folate (a metabolite essential for human embryonic development) and damage to sweat glands (essential for thermoregulation) is to select for variants of the gene *slc24a5* (that is highly conserved in vertebrates)[4] for the pigment melanin in skin to block ultraviolet light before it reaches cell nuclei (the same is so for other vertebrate animal's surface cells, not shaded by hair or feathers or scales, even to melanin in the eggs of some amphibians). In plants, several pigments (flavonoids and other phenolic compounds) absorb UV-B. In many microorganisms as well as in larger creatures, chemicals called *mycosporine-like amino acids* (MAAs) are evolved as natural sunscreens. Animals cannot synthesize MAAs but have found ways to obtain them from the plants, fungi, and microbes that can. J. Malcolm Shick has found that corals acquire MAAs from the algae in their flesh. Seeking shade is an obvious selected-for strategy used by plankton that move down in the water column during the day and by animals as hippopotamuses that exit water only at night to browse on land.[5]

Parallel-evolution homoplasy is exampled, classically, by the contemporaneous evolution of the extinct browsing-horses and extinct paleotheres both of which shared the same space.

Convergent-evolution homoplasy is exampled, classically, by the marsupials that can be compared to the parallel *but* separated in space, evolution of the placentals in the Cenozoic. Convergent evolution is also exampled by blood proteins that allow cold-blooded fish to live in ice water. New genes can arise when a whole gene sequence is duplicated and then gradually altered over time to perform a new function. For example, in perchlike Antarctic fish, a working antifreeze protein arose in part from a segment of the trypsinogen gene that does not code for protein. The antifreeze blood proteins bind to ice crystals and keep them from growing. Arthur L. DeVries, discovered antifreeze proteins in the 1960s.[6] All fish in polar regions produce them. He estimates (using as a clock the rate of genetic change in salmon mitochondrial DNA) an age of 5 million to 14 million years for the antifreeze protein. Coincidentally, the geophysical estimate of the time of cooling of the Antarctic Ocean began some 14 million years ago. According to John M. Logsdon Jr., gene duplication allowed a new functional segment to evolve in the trypsinogen gene without ending its function as a digestive protein.[7] This makes sense from a design standpoint. The reorganized protein works on any freezing seawater ingested with food in the intestine. Convergence is evident in the unrelated antifreeze protein in Arctic cod. In these, the antifreeze protein is made up of the same three ice-binding amino acids but *not* the same sequences of bases as the trypsinogen gene.

Trichromatic color vision which allows discrimination of red–green colors has evolved convergently in certain catarrhines ("Old World monkeys" of Africa and Asia which are anthropoid primates, including us) and in one genus of platyrrhines ("New World monkeys" of Central and South American). Other mammals do not have this color vision. Young leaves which frequently flush red in the tropics against a background of mature foliage have high protein levels and low toughness. Nathaniel J. Dominy and Peter W. Lucas in 2001 find that primates who can, will visually pick out this food source when preferred, other, foods are scarce. The occasional and minimal foraging has not prompted plants to evolve to change the coloration of their young leaves.[8]

When convergence is not contemporaneous, then it is called *evolutionary relay*. Separated in time Cenozoic marine mammals (whales) have come to occupy the ecological niches that Mesozoic marine reptiles (ichthyosaurs) once occupied. Also, the thunniform ("h" is silent as in Thames or thyme) body of the tuna with its crescent-moon shape tail (like the swept-back wings of a fighter jet) separately evolved in unrelated groups of large, cruising, swimming animals (dolphin, lamnid sharks —as the great white and the mako),[9] repeats that of the ichthyosaurs.[10]

Neither separated in space or time, white ants (mostly defenseless) and ants (often predatory) evolved to social colonial animals (with no truce struck between them) in the Late Paleozoic from solitary cockroaches and wasps respectively.

To distinguish analogies that can be explained by evolutionary convergence (wings of birds and flies, dorsal fins of sharks and extinct ichthyosaurs) from homologies derived by descent from a common ancestor (pectoral fins of fishes), is not always easy. A classic example is E. Geoffroy Saint-Hilaire's comparison of a lobster on its back and a mammal on its belly.[11]

Oft told by Gould: in *Wonderful Life*, in a *"This View of Life"* essay, in the pages of *Natural History*, and reprinted in the *Eight Little Piggies* collection (*vol.6* of these),[12] is the story of the upside-down reconstruction by **Simon Conway Morris** in 1977 of the Burgess shale species *Hallucigenia sparsa*—the genus name is for "the bizarre and dream-like appearance of the animal."[13] But, as Gould summarized, "the inverted beast immediately says 'onychophoran' to any expert." Now the late Gould is subject to some knocks against his favorite imagining by Conway Morris's *Inevitable Humans in a Lonely Universe*, 2003,[14] which may give the lie to Gould's claim that "Re-run the tape of life, and the outcome must be entirely different: an alien world, without humans and maybe not even intelligence." Yearning to find truth in the philosophical position posited by Kenneth Raymond Miller in 1999 that evolution is stacked to give God "a creature like us who could know Him and love Him," Conway Morris's hymn celebrating convergence, yet with a note of sadness,[15] is paraphrased by R. E. Lenski: "Life [has an] almost eerie ability to navigate to a single solution, repeatedly. Eyes, brains, tools, even culture: all are very much on the cards. So if these are all evolutionary inevitabilities, where are our counterparts across the galaxy? The tape of life can only run on a suitable planet, and it seems that such Earthlike planets may be much rarer than hoped. Inevitable humans, yes, but in a lonely Universe."[16]

Unforgettably though, the late Gould in *Time's Arrow / Time's Cycle* (1987) has written: "The arrow of homology and the cycle of analogy are not warring concepts." When pressed as to which of these "categories of our invention" he favors, his reply is "both and neither." ... "To judge the interaction of time's arrow and time's cycle within each object ... we must not seek one in order to exclude the other (as Hutton did in denying history, before Lyell expanded his vision to become a historian of time's cycle); but neither should we espouse a form of wishy-washy pluralism that melds ... the uniqueness of history, and the immanence of law. ... The immanent and predictable features of good design are crafted from materials that preserve the stamp of time's arrow. 'Fishness' is a timeless principle of good design; *Ichthyosaurus* is a particular reptile in a particular time and place" and an example of "a cycle within the arrow" of time.[17] ❑