f20 Uncoordinated evolution < mosaic >

Anything that is produced by evolution is bound to be a bit of a mess. —Sydney Brenner.[1]

In biology, what works [and sometimes what worked] continues. —Hugh Fletcher.[2]

If the odd course of our nerves is a product of our fishy past, the hiccup itself is likely the product of our history as amphibians. Hiccups seem to be controlled by their own pattern generator [which] in the ... tadpole brain stem ensures that an inspiration is followed immediately by a closing glottis. They can breathe with their gills thanks to an extended form of hiccup. —Niel Shubin.[3]

The Frenchman exclaimed: "Mon dieu! What a country! Fifty different religions and only one sauce!"[4]

The genetic mechanism of evolution makes predictable the gradual divergence of species in which chance has its role and novelty is restricted and guided by natural selection. Developmental processes in one part of the body can be, and often are, dissociate from another. In hominins, for example, bipedalism, in its modern form, was present millions of years before the head evolved into its existing form. Called *modularity* by Rudolf A. Raff in *The Shape of Life*, 1996,[5] and called *compartmentation* by J. Gerhart and M. Kirschner in *Cells, Embryos, and Evolution*, 1997,[6] it affords animals and plants the opportunity to evolved differently the otherwise serially repeated parts of their primitive state for a variety of functions and into various forms. In complex organisms, uncoordinated evolution has the commonness of inevitability. As it perfects nothing [7] while it builds something new from whatever is close at hand, François Jacob in 1977 tellingly pictured evolution as a tinkerer, not an engineer.[8]

Genes, as they are transmissible across generations, are the ultimate determinants of organisms' development. Because of mutations, the protein each gene codes for can change. However, genes do not have a one-to-one relation to the characters they affect. As long ago as in the 1940-50s, developmental geneticists Conrad Hal Waddington (1905-1975) and Sewall Green Wright (1889-1988) were at pains to emphasize that a single gene is only one part of a complex web of interacting proteins that results in an organism's structure, functioning, and behavior. This understanding is mostly absent in those who know only of Mendel's findings and follow popular press coverage of how certain genes are now known to be key players in early embryonic development. Brian Charlesworth in his review of *The Misunderstood Gene* by Michel Morange, 2001, writes: "... surprising, complexes of changes in the organism's characteristics may arise from a single mutation; the nature or even the occurrence of changes may also depend on the nature of the environment, or on the state of other genes. When there is variation in a trait among people, as in their susceptibility to a given disease, a given gene may contribute only a minor part of the variation, and non-genetic factors frequently also contribute to the variability. This applies especially to complex traits, such as behavioural characteristics and lifespan."[9] The obesity gene, proclaims a wit, is discoverable as the one that opens the mouth.[10]

Adding dimension to the old saw that although humans are all born copies, we, because of nature and nurture, die originals, is that the extraordinary variation in lifespan between human individuals is equaled by individual worms. This is reported, by Thomas B. L. Kirkwood in 2002 for nematode strains that have exceptional genetic uniformity (arising from the fact that they are self-fertilizing hermaphrodites), are cultured in highly uniform environmental conditions, and have a developmental process of almost clockwork precision**.**[11] Unchecked random damage, at the cellular level, to the "disposable soma" is inferred to be a powerful determinant of ageing. Such stochastic damage did not catch up with Jeanne Louise Calment born in Arles, France, February 21, 1875, for 122 years and 164 days into the year of 1997.[12] With this tale, only one person in two billion will live to be 116 or older.

Often for vertebrate animals, the perception of evolutionary trends, the false phenomenon called *orthogenesis* (internal force driving evolution), is a trap in telling of the story of evolution when what is most real in it is that the fossil record is sparse. The example most commonly trotted out (pun intended) is the evolution of the horse. Trends are that the modern horse *Equus*, 150 cm tall at the shoulder with one toe per foot and high-crowned teeth fit for grazing, evolved during a period of 55 million years by steady, gradual, change, linearly from the earliest known horse, *Hyracotherium* (*Eohippus*), that was 28 cm tall at the shoulder, had four toed forefeet and hindfeet each with three complete toes and a remnant of a fourth, and teeth that were low crowned and fit only for browsing.

However, detailed analysis of the fossil data, as these became abundant, has shown that the evolutionary changes in limb proportions, number of toes, and teeth were not constant, and that there were dozens of lines of descent rather than one (***Figure f20.1***). Instead of simple progress, there were several periods of uncoordinated radiation, from which adaptive types arose and coexisted, each with a different mixture of advanced and primitive features. Mutation sometimes reactivates atavistic genes (those whose function was suppressed during evolution) such as in humans rarely for the "werewolf syndrome" of full facial furriness and commonly for more than two nipples.[13]

Evolution tends to maximize fitness to pass on genes to future generations. But optimization is not perfection: "A squid is not the best swimmer, but it may be close to the best that can be evolved from a mollusk," writes R. McNeill Alexander[14] and a cuttlefish bests all other life in its muscular ability to move its eyes from the sides of its head for panoramic gazing when cruising, to forewords to overlap its eye's visual fields for stereoscopic sight when using its tentacles to catch prey. The structure and behavior of organisms are involved. Animals may learn, for example, where to go and what to do to maximize food intake, and how to behave to maximize mating opportunity. But constrained by ancestry, as Stephen Jay Gould and Richard Lewont in 1979 emphasized, evolution makes accessible only local optima. At any time in the course of its history, an organism will be found to have an adequate a but suboptimal design. Which echoes **George Christopher Williams**': "Because there is nothing in natural selection that looks ahead and plans ahead. All it can do is make use of variation that is present. Some things work better than others, and the ones that work better are the ones that tend to be preserved. And these are always preserved in relation to immediate circumstances, never in order to facilitate anything in the future."[15] ❏

Figure f20.1 [16] **Evolutionary relationships of the known major genera of horses**
Known time ranges of the equid genera or clades are indicated by the white bars.