

f17 Divergent evolution and speciation <fertile species, hybrids>

All species are unique, but humans are unique. —Theodosius Dobzhansky.¹

Darwin wrote a whole book entitled: “*The Origin of the Species*,” 1859,² without anywhere in it defining the word species. We have a simple definition: *a species is an interbreeding population of organisms that have fertile offspring*. This definition, attributable to John Ray, is however of limited value (see Topic f33), but has been aired so often that it has become iconic. Indeed, in an essay on the *Darwinian Hypothesis*, Huxley in 1859 wrote: “Great authorities affirm that ... the unions of members of the same species are always fertile [mostly true], while those of distinct species are either sterile, or their offspring, called *hybrids*, are so [occasionally false].”³

How species arise had no easy resolution for Darwin.⁴ Ernst Mayr reminds:

It must be remembered that at first Darwin believed in Lyell’s sudden, saltational ‘introduction’ of new species. It was John Gould’s pronouncement in March 1837 that ... started Darwin ... thinking about the origin of diversity [although Darwin might have disagreed here as nine months after his return he wrote that he started thinking seriously about the subject in March 1836 when the Beagle departed Australia to return home and, as Keith Thomson has pointed out, gave him a long contemplative time]. Obviously, the different mockingbirds [and finches] on the three islands in the Galápagos had all descended from colonists of the South American mainland species; but the three populations [of mockingbirds, and too the finches] had evolved in a slightly different manner on each of the three islands. This led Darwin to adopt the theory of speciation by the gradual modification of populations that were geographically isolated from their parent species. ... It was not a new theory, because a similar one had previously been proposed by [Leopold Freiherr] von Buch (1825). Later, [Moritz] Wagner [1813-1887] (1841) and [Alfred Russel] Wallace (1855) also independently arrived at the same conclusion.⁵

In *Origin*, 1859, Darwin provides proof for three theories not necessarily dependent on each other. These Mayr discerns are:

- 1) his theory of evolution which makes explicit the nonconstancy of species,
- 2) his theory of common descent, and
- 3) his theory that species multiply.

“Within fifteen years of the publication of the *Origin*” writes Mayr in *One Long Argument*, 1991, “hardly a qualified biologist was left who had not become an evolutionist” and this was true of Dobzhansky: *ladybirds*, Mayr: *New Guinea birds*, Simpson: *mammals*, and Stebbins: *plants*.



Charles Darwin was the first to grasp firmly the importance of descent with modification. We can now complete for him how by “the clumsy, wasteful, blundering low & horribly cruel” (1856)⁶ workings of nature, “endless forms most beautiful and wonderful have been, and are being, evolved” (1859).² Heritable errors (mutations) can occur in the production of the germ cell contributed by either parent, or both parents, to the zygote beginning of an offspring. Mutations per se are neutral. Momentary realities for an organism makes a mutation harmful or helpful, or leaves it neutral.

The synthetic theory of evolution in place since 1950 has to do, not with the individual, but with the group and their gene pool, and how it evolves. Accepted is that mutations can spread through a population by “random genetic drift” (term introduced by animal breeder **Sewall Green Wright** (1889-1988) for its mathematically predictable effect, observed, he maintained, in small populations)⁷ and by the action of Darwinian natural selection. How much each

of these two processes contributes to evolution at the DNA level makes for lively research.⁸ Of genetic differences accumulated, for example, since human and chimpanzee species diverged from a common ancestor, in addition to some five million insertion/deletion events, and various chromosomal rearrangements, random genetic drift arguably mostly accounts for thirty-five million single-nucleotide changes found.⁹

In time, a species can become more diverse (divergent evolution). Individuals do not carry all the genes of their species. Isolation of interbreeding individuals of a species can give rise to new species. This occurs because linking parts of a subdividing gene pool can by chance become eliminated. For example, if all breeds of dogs except Great Danes and Chihuahua were eliminated we would have from then on (for mechanical reasons) two species. In natural populations mechanical isolation of species that could otherwise cross-fertilize is most common in plants that depend on insect pollinators. Isolations are various: habitat, seasonal, behavioral, gametic, developmental, and fashion. Fashion being sexual selection of advertised features that, in population segments, evolve to reach different equilibria of fitness-costs of ornamentation to benefits of attractiveness. New characteristics that accrue in isolated populations can make unions infertile would they mingle again.

Between species, in the strict sense of Ray's definition, there is no gene flow. Nevertheless, we know hybridization does sometimes occur in spite of genetic distance and the offspring can be fertile. An extreme example is insertion of genes in a higher organism by a retrovirus. In 2001, bioengineers Anthony W. S. Chan and Gerald Schatten reported on a 3-month-old rhesus monkey (named ANDI, a backward homage to "inserted DNA") that had received into its genome a gene (for the green fluorescent protein) that gives a jellyfish its glow. The procedure used a retrovirus carrier (crippled for safety). This was injected into 224 monkey eggs that were then fertilized by normal sperm. These, implanted into surrogate mothers, resulted in six pregnancies and one successful birth: ANDI.¹⁰

In the human genome, 113 genes are identified as having been acquired directly from bacteria.

Speciation can be accounted for *not* by the struggle of survival of the individual but by extrinsic (environmental) mechanisms that reinforce inhomogeneities in the distribution of a species' characteristics. Evolution is a shift in gene frequencies and speciation involves adaptation to one environment and loss of adaptation to another—*ecological specialization*.

Genetic explanations:

- polymorphisms acted on by natural selection allow for disruptive evolution.
- mutations become fixed by genetic drift in genes not maintained by natural selection—*mutation accumulation*.¹¹
- mutations, beneficial in one environment, are detrimental in another—*antagonistic pleiotropy*.

The reality of these processes can be tested for. One such demonstration is a ten year study by Vaughn S. Cooper and Richard E. Lenski reported in 2000 of the decay of unused catabolic functions (metabolic pathways for energy) in 12 lines of (the bacterium) *Escherichia coli* propagated on glucose for 20,000 generations. Antagonistic pleiotropy, more than mutation accumulation, was evidently operative during that time in several lines that had fortuitously evolved high mutation rates. For in them, if mutation accumulation had been more important, their unused functions would have decayed more than in the other lines, but no significant difference was observed. However, predictable as a consequence of antagonistic pleiotropy, was that catabolic losses occurred early in the experiment when the trade off was for beneficial mutations, and these were rapidly fixed.¹²

Having come into being from a common source, two species, as judged from their phenotype, can have evolved along paths describable as divergent, parallel, or convergent (even on other species).

Between what are otherwise very different organisms (say we and houseflies) are deep genetic similarities. Simon Conway Morris emphasizes that a "substantial part of innovation now appears to be by the simple mechanism of duplicating genes, one to proceed with an established function, the other perhaps to explore a new area of protein space" and genes "seemingly randomly co-opted for a new function."¹³ □