



## Co-Evolution: Doing it Together

Michael Colebrook

One of the events I look forward to every August is the flowering of a stand of Golden Rod in the garden (the cultivated species, *Solidago canadensis*). On a calm sunny afternoon the blooms are literally buzzing with insects, and on the near-horizontal rows of flowers conveniently at eye height, they are easy to see. Nearly all of the insects look like bees and some are, but most of them are actually hover flies of various kinds. In some cases you have to look very closely to be sure which is which. The insects are deliberately collecting nectar and accidentally picking up pollen and carrying it to the next flower they visit ensuring that there is a lot of cross-fertilization.

What is happening is one of the many, many examples of co-operation between species in the natural world. Some of the most elaborate co-operative pollination systems involve orchids and moths and were first described by Charles Darwin (see box). If you think about this story and try to visualise how the process could possibly have evolved by the methods of Darwinian natural selection, you are immediately faced with the problem of deciding whether the moth became 'adapted' to the orchid, or was it the other way round, did the orchid 'adapt' to the moth? Neither

The idea of evolution as an essentially creative process was developed by Henri Bergson (1859-1941) in his book *L'Evolution Créatrice*, 1907. It had a marked influence on Teilhard de Chardin (1881-1955); it showed him 'a World which had suddenly acquired a new dimension and had thereby moved from the fragmented state of static Cosmos to the organic state and dignity of Cosmogogenesis.' (Teilhard de Chardin. *The Heart of Matter* (Collins, 1978), p. 25).

Teilhard's thinking in this area was also influenced by the work of fellow geologist Vladimir Vernadsky (1863-1945) who held that 'Life makes geology. Life is not merely a geological force, it is the geological force. Virtually all geological features at Earth's surface are bio-influenced, and are thus part of Vernadsky's biosphere'. (Lynn Margulis et al. Forward to Vladimir Vernadsky. *Biosphere* (Copernicus, 1998), p. 15).

In *The Phenomenon of Man* (Collins, 1977), p. 241, Teilhard de Chardin poses the question, 'Is evolution a theory, a system or a hypothesis? It is much more: it is a general condition to which all theories, all hypotheses, all systems must bow and which they must satisfy henceforward if they are to be thinkable and true. Evolution is a light illuminating all facts, a curve that all lines must follow.'

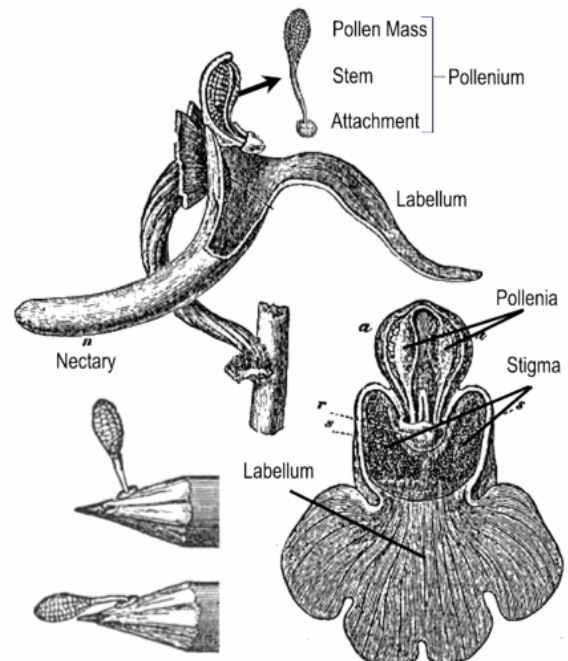
### The Moth and the Orchid

The process of cross-fertilisation of *Orchis mascula* was first described by Charles Darwin.

You have to imagine a moth landing on the labellum and pushing its head as far as it can go into the nectary. It then uncoils its long tongue and starts to suck up the sweet nectar. Meanwhile the two pollinia become attached to its head. The attachments of the pollinia consist of a minute oval of membrane with a small drop of viscid liquid. This sticks onto the moth's head and the liquid sets hard in a few minutes. Darwin used the point of a pencil to demonstrate this. When the moth leaves the flower the pollinia automatically fold down always in the direction of the proboscis of the moth (or the tip of the pencil) and are in exactly the right position to come into contact with the stigmas of the next flower the moth visits thus achieving cross-fertilisation.

Darwin goes into much more detail and his description is worth reading. The reference is:

Charles Darwin. *On the various contrivances by which British and foreign orchids are fertilized by insects* (John Murray, 1862), pp. 9-19. It is available at: [http://pages.britishlibrary.net/charles.darwin3/orchids/orchids\\_fm.htm](http://pages.britishlibrary.net/charles.darwin3/orchids/orchids_fm.htm) and can be found in chapter 1.



Flower of *Orchis mascula* showing only the labellum and nectary

From figures drawn by Charles Darwin

option stands out as being the obvious one. There is a third possibility; that they did it *together*: a process that biologists call co-evolution.

It is necessary to be aware that biological evolution proceeds by a process that the French biologist François Jacob called *bricolage*: a process of tinkering, of taking something that is there already, making a small change and seeing what happens. What is there already are living organisms that already have unimaginably long evolutionary histories. The small changes are essentially random, they are the result of events (mutation and recombination) the causes of which are not connected in any way with the outcomes. The process of seeing what happens is mediated by Darwin's stroke of genius, natural selection. This is far from random, and is derived from the considerable problems of surviving as a living organism in a constantly changing environment inhabited by lots of other evolving organisms. These problems impose substantial constraints and provide substantial opportunities for the evolutionary trajectories of organisms.

As the environments of organisms include other evolving organisms then, strictly speaking, all biological evolution is co-evolution. But the term has historically been confined to obvious cases such as the moth and the orchid, because, in the context of the traditional reductionist and competitive view, co-evolution was regarded as very much the exception rather than the rule. The traditional story has dominated evolutionary biology for so long that it is quite a struggle to realise that it is not the case of individuals *contra mundum*, nor Richard Dawkins' 'selfish genes' *contra mundum*. The American evolutionary biologist Richard Lewontin emphasises in his book *The Triple Helix* that the trinity of gene, organism and environment are inextricably and mutually involved in the processes of evolution. It is also becoming generally accepted that competitive pressure is only one of an enormously complex nexus of factors involved, and, in the vivid insight of Mary Midgley, one that ignores 'the fact that competition can't get going without an enormous amount of cooperation to make it possible.'

A major problem with strict competition as the main driving force behind biological evolution is that it is necessarily a mechanism involving negative feedback. In business, if several companies compete for a limited market, the usual result is that the strongest companies capture an ever-increasing share of the market until the weaker ones go to the wall. The end result is fewer companies. In biological terms, the winners survive the losers become extinct. Biological evolution, on the other hand, has to be a positive feedback system. It is a matter of historical record that on the whole, the rate of emergence of new species is

greater than the rate of extinction. From relatively simple beginnings life has evolved into the magnificent complex of between ten and maybe as many as thirty million different species of living organisms. Even after the various catastrophes that have occurred, life has bounced back with ever greater diversity. This could not have happened unless there are ways in which life creates opportunities for more life; unless positive feedback mechanisms are involved.

A N Whitehead realised, in a remarkable insight, that 'successful organisms modify their environment. Those organisms are successful which modify their environments so as to assist each other. This law is exemplified in nature on a vast scale.' This is the law of co-evolution, of doing it together. This is the main source of the positive feed-back that has produced the amazing variety of living things.

The trees of a forest provide food and shelter for lots of other species that have evolved to take advantage of these resources and the trees have co-evolved to take advantage of some of these species to pollinate their flowers and distribute their seeds. Some the trees have developed toxins to prevent or at least discourage organisms from eating them, and some organisms have co-evolved with the trees and have learned how to use these toxins to avoid being eaten by other organisms, and so it goes on and on.

When birds learnt to avoid eating bees this provided opportunities for other insects to mimic bees and to join them in pollinating the flowers of Golden Rod.



Doing it together does not always mean cooperation, it can be competitive and may result in what evolutionary biologists call the Red Queen Syndrome. In Lewis Carroll's *Through the Looking Glass* the Red Queen takes Alice on a frantic run that gets them nowhere "Here, you see, it takes all the running you can do, to keep in the same place," declared the Red Queen.' In evolutionary terms this refers to the

possibility of an endless race between a predator, to improve its ability to catch its prey, and its prey to avoid being captured. By definition it is a race that gets them nowhere, but it locks both of them into an evolutionary treadmill. Evolution can lead to dead-ends.

Some of the ways in which organisms do it together are not always immediately obvious and may be counter-intuitive as Aldo Leopold found out with the predator/prey relationship between wolf and deer being vital to the well-being of the mountain (see box). Here, the predator/prey relationship can be seen as advantageous to the environment and hence, in the long term, to both predator and prey. But it may look very different from the point of view of an individual deer. One has to match the criteria to the context and they can, and often do, conflict. One of the heroines of Barbara Kingsolver's novel *Prodigal Summer* argues for the vital role of predators (in this instance coyotes) in maintaining a healthy and balanced ecosystem, contrasted with her feelings when a snake eats a nest-full of fledgling birds. There is the supreme paradox that the best thing any organism can do to further the process of evolution is to die.

Once you start to look carefully it is obvious that the environments of just about every living organism have been either created by, or at least modified by, other living organisms. The whole show has been, and still is, a process of doing it together, and, as Whitehead realised, 'This law is exemplified in nature on a vast scale'.

As Annie Dillard has brilliantly put it, 'We walk around; we see a shred of the infinite possible combinations of an infinite variety of forms. Anything can happen; any pattern of speckles may appear in a world ceaselessly bawling with newness... The wonder is - given the errant nature of freedom and the burgeoning of texture in time - the wonder is that all the forms are not monsters, that there is beauty at all, grace gratuitous... Beauty itself is the fruit of the creator's exuberance that grew such a tangle, and the grotesques and horrors bloom from that same free growth, that intricate scramble and twine up and down the conditions of time.

'This, then, is the extravagant landscape of the world, given, given with pizzazz, given in good measure, pressed down, shaken together, and running over.'

## Thinking Like a Mountain

We were eating lunch on a high rimrock, at the foot of which a turbulent river elbowed its way. We saw what we thought was a doe fording the torrent... When she climbed the bank toward us and shook out her tail, we realized our error: it was a wolf. A half-dozen others, evidently grown pups, sprang from the willows and all joined in a welcoming melee of wagging tails and playful maulings. In a second we were pumping lead into the pack. When our rifles were empty, the old wolf was down, and a pup was dragging a leg into impassable slide-rocks.



We reached the old wolf in time to watch a fierce green fire dying in her eyes. I realized then, and have known ever since, that there was something new to me in those eyes - something known only to her and to the mountain. I was young then, and full of trigger-itch; I thought that because fewer wolves meant more deer, that no wolves would mean hunters' paradise. But after seeing the green fire die, I sensed that neither the wolf nor the mountain agreed with such a view.

Since then I have lived to see state after state extirpate its wolves. I have watched the face of many a newly wolfless mountain, and seen the south-facing slopes wrinkle with a maze of new deer trails. I have seen every edible bush and seedling browsed, first to anaemic desuetude, and then to death. I have seen every edible tree defoliated to the height of a saddlehorn. In the end the starved bones of the hoped-for deer herd, dead of its own too-much, bleach with the bones of the dead sage, or molder under the high-lined junipers.

Aldo Leopold. *A Sand County Almanac* (OUP, 1989), pp. 129-131.

### References

- Annie Dillard. *Pilgrim at Tinker Creek* (HarperPerennial, 1988), pp.146.
- François Jacob. *The Possible and the Actual* (Penguin Books, 1989).
- Barbara Kingsolver. *Prodigal Summer* (Faber & Faber, 2001).
- Richard Lewontin. *The Triple Helix* (Harvard University Press, 2000).
- Mary Midgley. *The Myths We Live By* (Routledge, 2004), p. 9.
- Alfred North Whitehead. *Science and the Modern World* (Free Association Books, 1985), p. 256.

*Michael is a retired Marine Ecologist and currently a member of the editorial team of GreenSpirit Journal.*