Essay by Richard Dawkins for Art Wolfe's *The Living Wild*

The third planet is unique. Luxuriating over its surface, thinning up into the air and etching its way down into the rocks, our sphere boasts a layer in which something rich and new is added to the physics that unremarkably pervades the rest of the solar system. That special layer is, of course, the layer of life. It is not that the laws of physics are disobeyed at the planet's rim: vanish the thought. But living matter deploys physics in unusual ways. So unusual – 'emergent' – that the error of believing the laws of physics to be defied is forgivable. Which is just as well, because everyone has been tempted by that error, most people through history have succumbed to it and many still do.

Darwin may not have been quite the first to resist the temptation, but the comprehensiveness with which he repudiated it entitles him to most of the honour. In spite of its title, his great book is less on the origin of species than on the origin of adaptation. That is to say it is on the origin of the design illusion, that powerful simulacrum which led people to suspect, wrongly, that material causes are not enough to explain biology.

The illusion of design is at its strongest in the tissues and organs, the cells and molecules, of individual creatures. The individuals of every species, without exception, show it powerfully, and it springs forth from every picture in this book. But there is another illusion of design which we notice at a higher level – also so splendidly displayed in these pages – the level of species diversity. Design seems to reappear in the disposition of species themselves, in their arrangement into communities and ecosystems, in the dovetailing of species with species in the habitats which they share. There is a pattern in the intricate jigsaw of rainforest, say, or coral reef, which leads rhetoricians to preach disaster if but one component should be untimely rip'd from the whole. In extreme cases, such rhetoric takes on mystical tones. The womb is of an earth goddess, all life her body, the species her parts. Yet, without giving in to such hyperbole, there is a strong illusion of design at the community level, less compelling within the individual organism but worth attention.

The animals and plants that live together in an area seem to fit one another with something like the glovelike intimacy with which the parts of an

animal mesh with other parts of the same organism. A Florida panther has the teeth of a carnivore, the claws of a carnivore, the eyes, ears, nose and brain of a carnivore, leg muscles that are suitable for chasing meat and guts that are primed to digest it. Its parts are choreographed in a dance of carnivorous unity. Every sinew and cell of the big cat has meateater inscribed through its very texture, and we can be sure that this extends deep into the details of biochemistry. The corresponding parts of, say, a bighorn sheep are equally unified with each other, but to different ends. Guts designed to digest plant roughage would be ill-served by claws and instincts designed to catch prey. And vice versa. A hybrid between a panther and a sheep would fall flat on its evolutionary face. Tricks of the trade cannot be cut from one and pasted into the other. Their compatibility is with other tricks of the same trade.

Something similar can be said of communities of species. The language of the ecologist reflects this. Plants are primary producers. They trap energy from the sun, and make it available to the rest of the community, via a chain of primary, secondary and even tertiary consumers, culminating in scavengers. Scavengers play a recycling 'role' in the community, and I use inverted commas advisedly. Every species, in this view of life, has a role to play. In some cases, if the performers of some role, such as scavengers, were removed, the whole community would collapse. Or its 'balance' would be upset and it might fluctuate wildly, out of 'control' until a new balance is set up, perhaps with different species playing the same roles. Desert communities are different from rainforest communities and their component parts are mutually ill-suited just as – or so it seems – herbivorous colons are ill-suited to carnivorous habits. Coral reef communities are different from sea bottom communities and their parts cannot be exchanged. Species become adapted to their community, not just to a particular physical region and climate. They become adapted to each other. The other species of the community are an important – perhaps the most important – feature of the environment to which each species becomes adapted.

The harmonious role-playing of species in a community, then, resembles the harmony of the parts of a single individual organism. The resemblance is deceptive and must be treated with caution. Yet it is not completely without foundation. There is an ecology within the individual organism, a community of genes in the gene pool of a species. The forces that produce harmony among the parts of an organism's body are not wholly

unlike the forces that produce the illusion of harmony in the species of a community. There is balance in a rainforest, structure in a reef community, an elegant meshing of parts which recalls coadaptation within an animal body. In neither case is the balanced unit favoured *as a unit* by Darwinian selection. In both cases the balance comes about through selection at a lower level. Selection doesn't favour a harmonious whole. Instead, harmonious parts flourish in the presence of each other and the illusion of a harmonious whole emerges.

At the individual level, to rehearse an earlier example in genetic language, genes that make carnivorous teeth flourish in a gene pool containing genes that make carnivorous guts and carnivorous brains, but not in a gene pool containing genes for herbivorous guts and brains. At the community level, an area that lacks carnivorous species might experience something similar to a human economy's 'gap in the market.' Carnivorous species that enter the area find themselves flourishing. If the area is a remote island which no carnivorous species has reached, or if a recent mass extinction has devastated the land and created a similar gap in the market, natural selection will favour individuals within noncarnivorous species that change their habits and become carnivores. After a long enough period of evolution, specialist carnivore species will descend from omnivorous or herbivorous ancestors.

Carnivores flourish in the presence of herbivores, and herbivores flourish in the presence of plants. But what about the other way around. Do plants flourish in the presence of herbivores? Do herbivores flourish in the presence of carnivores? Do animals and plants need enemies to eat them in order to flourish? Not in the straightforward way that is suggested by the rhetoric of some ecological activists. No creature normally benefits from being eaten. But grasses that can withstand being cropped better than rival plants can, really do flourish in the presence of grazers – on the principle of 'my enemy's enemy.' And something like the same story might be told of some animal victims of parasites – and predators, although here the story is more complicated. It is still misleading to say that a community 'needs' its parasites and predators like a polar bear needs its liver or its teeth. But the enemy's enemy principle does lead to something like the same result. It can be right to see a community of species as a kind of balanced entity which is potentially threatened by removal of any its parts.

This idea of community, as made up of lower level units that flourish in the presence of each other, pervades life. Even within the single cell, the principle applies. Most animal cells are communities of hundreds or thousands of bacteria which have become so comprehensively integrated into the smooth working of the cell that their bacterial origins have only recently become understood. Mitochondria, once free-living bacteria, are as essential to the workings of our cells as our cells are to them. Their genes have flourished in the presence of ours as ours have flourished in the presence of theirs. Plant cells by themselves are incapable of photosynthesis. That chemical wizardry is performed by guest workers within the cells, originally bacteria and now relabelled chloroplasts. Plant eaters such as ruminants and termites are themselves largely incapable of digesting cellulose. But they are good at finding and chewing plants. The gap in the market offered by their plant-filled guts is exploited by symbiotic micro-organisms who possess the biochemical expertise necessary to digest plant material efficiently. Creatures with complementary skills flourish in each other's presence.

And the process is mirrored at the level of every species' 'own' genes. The entire genome of a polar bear or a penguin, of a caiman or a guanaco, is a set of genes that flourish in each other's presence. The immediate arena of this flourishing is the interior of an individual's cells. But the long term arena is the gene pool of the species. Given sexual reproduction, the gene pool is the habitat of every gene as it is recopied and recombined down the generations.

This gives the species its singular status in the taxonomic hierarchy. Nobody knows how many separate species there are in the world, but we at least know what it would mean to count them. Arguments about whether there are 30 million separate species, as some have estimated, or only 5 million, are real arguments. The answer matters. Arguments about how many genera there are, or how many orders, families, classes or phyla have no more status than arguments about how many tall men there are. It's up to you how you define tall and how you define a genus or a family. But – as long as reproduction is sexual – the species has a definition which goes beyond individual taste and does so in a way that is really important. Fellow members of a species participate in the same shared gene pool. The species is defined as the community whose genes share that most intimate of cohabiting arenas, the cell nucleus – a succession of cell nuclei through generations.

When a species splits off a daughter species, usually after a period of accidental geographical isolation, the new gene pool constitutes a new arena for inter-gene cooperation to evolve. All the diversity on earth has come about through such splittings. Every species is a unique entity, a unique set of coadapted genes, cooperating with each other in the enterprise of building individual organisms. The gene pool of a species is an edifice of harmonious cooperators, built up through a unique history. Any gene pool, as I have argued elsewhere is a unique written record of ancestral history. Slightly fanciful perhaps, but it follows indirectly from Darwinian natural selection. A well adapted animal reflects, in minute detail even down to the biochemical, the environments in which its ancestors survived. A gene pool is carved and whittled through generations of ancestral natural selection, to fit that environment. In theory a knowledgeable zoologist, presented with the complete transcript of a genome, should be able to reconstruct the environmental circumstances that did the carving. In this sense the DNA is a coded description of ancestral environments, a 'genetic book of the dead.'

The extinction of a species therefore diminishes us in a sense that the death of an individual perhaps does not. To be sure, every individual is unique, and to that extent irreplaceable. But the set of genes in a species' gene pool represents a unique solution to the problem of survival. An individual organism, by contrast, is only a permutation of the units of that solution: unique, but not unique in an interesting way. If an individual dies, there are lots more where it came from. It is just another deal from the same pack of cards. When the last individual of a species dies, the whole pack has been destroyed. No doubt other species will arise to take its place, but they will take time to build up an equivalently intricate collection of mutually compatible genes, and their new solution to the problem of DNA preservation will always be different from the old. When the last (probably) Tasmanian wolf, *Thylacinus*, died in Hobart zoo in 1936, we lost tens of millions of years worth of carnivorous R and D.

It is possible to take a robust view of extinction, even mass extinction. We can tough-mindedly point out that extinction is the norm for species throughout geological history. Even our own swathe of chainsaw and concrete devastation is only the latest in a long series of clean-outs from which life has always bounced back. What are we and our domination of the world but another natural process, no worse than many before? The

catastrophe which ended the dinosaurs had a consequence which might lead us to take a positively cheerful attitude towards it: us. From a more dispassionate point of view, every mass extinction opens up yawning gaps in the market, and the headlong rush to fill them is what, time after time, has enriched the diversity of our planet.

Even the most devastating of mass extinctions can be defended as the necessary purging that makes rebirth possible. No doubt it is fascinating to wonder whether rats or starlings might provide the ancestral stock for a new radiation of giant predators, in the event that the whole order Carnivora were wiped out. But none of us would ever know, for we do not live on the evolutionary time scale. It is an aesthetic argument, an argument of feeling, not reason, and I confess that my own feelings recoil. I find my aesthetics incapable of quite such a long view.

The dinosaurs are gone. I mourn them and I mourn the giant ammonites, and before them the mammal-like reptiles and the clubmoss and treefern forests of the coal measures, and before them the trilobites and eurypterids, but they are beyond recall. What we have now is a new set of communities, our own contemporary build-up of mutually compatible mammals and birds, flowering plants and pollinating insects. They are not better than the communities the preceded them. But they are here, we have the privilege of studying them, they took agonizing ages to build up, and if we destroy them we shall not see them replaced. Not in our lifetime, not in five million years. If we destroy the ecosystems of which we are a part, we condemn not just our own generation but all the generations of descendants that we could realistically hope to succeed us, to a world of devastation and impoverishment.

The case for conserving wild nature is sometimes made in terms of the crudest self-interest. We need the diversity of the rainforests because who knows where our next set of medicines and crop plants will come from? Well, if that is what it takes to mobilise support, so be it, though it rings hollow to me, hollow and even ignoble. The justification for conservation to which I return is an aesthetic one, and what is wrong with that? Who, having looked through the pages of this book, could contemplate with anything but sorrow the extinction of any one of the species here pictured?

But the best is the enemy of the good. We live in an economic world (interestingly, the Darwinian world of wild nature is an economic one too) where everything has its price. It seems all too easy to take the aesthetic high ground and look down on selfish, utilitarian motives for saving rainforests and rare species. But what proportion of our own wealth, or our own time, are we prepared to sacrifice to such an end? Not much. Even before we get selfish, there are other calls on our charitable generosity. What about the victims of the latest earthquake, famine, tornado or other human catastrophe? Many of the habitats of endangered species are also the homelands of human poor, who can be forgiven for seeing wild animals as competitors rather than as enhancers of life's richness. 'Life's richness' can ring hollow, as hollow perhaps as your own child's stomach. The aesthetic view of wild nature is, from such a low vantage point, a luxury that the hungry cannot afford.

Let us not be too ready, then, to condemn those attempts by southern African states to make game parks 'pay their way', perhaps by turning the need to 'cull' into an excuse to sell big game shooting licences. Of course it seems obscene to gratify the bloodlust of fat, lazy, ignorant, hideous, gum-chewing stalwarts of the National Rifle Association, very probably in baseball hats. Especially in those cases where the animals themselves are tame and trusting, and the 'hunters' safely ensconced in vehicles, with experienced rangers on hand to protect them if they miss. But this too is an aesthetic judgement, and the practice can be defended on grounds of economic practicality, a defence which is not available to, for example, the mincing, strutting, primping bullfighter. Disagreeable as it sounds, I sometimes find it hard to maintain my confidence that the southern African solution to the problem of saving the elephant and the black rhinoceros is not the most practical one. Nevertheless, on balance I still prefer the solution of a total ban on all trading in ivory and rhinoceros horn.

Such inconclusive meditation is a sure sign that I have no easy solution to offer. I return to aesthetics, but this book persuades me that here are more than ordinary aesthetics. It is not just the streamlined beauty of a swimming whale, the muscular tautness of a stalking big cat, the iridescent extravaganza of peacock, or scarlet macaw. It is not just the pleasure of gazing at a spectacle, and of reflecting on the privilege of being able to do what future generations may be denied. Evolutionary thinking can give our aesthetic a new depth. We are not just looking at an animal as if it were an ordinary

work of art. If it is a work of art, it is one that has been perhaps ten million years in the crafting. It seems to me to make a difference.