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New Pollutants, or a New Photosynthesis?

THE LARGE NUMBERS OF ENGINEERED ORGANISMS which came into use for the purposes of pollution control in the period from 1995–2015 have renewed fears about the hazards associated with the transformation of micro-organisms. Although none of the organisms involved can interact with man or higher animals, and all are thus incapable of causing diseases, so many of them are being released into the environment that there must be some danger of unforeseen knock-on effects. One possibility is that organisms engineered to help cope with industrial wastes might also be able to attack and damage the artifacts produced by the same industries. If we act in order to give local ecosystems the ability to absorb and quickly recycle industrial products which we do not want to have hanging around, we are liable also to equip them with the means to recycle industrial products which we do want to keep. Forewarned of this danger, however, we should also be forearmed against it.

The point about having increased control over the properties of organisms is not just that it allows us to make them perform new and useful tricks for us. We can also incorporate checks and vulnerabilities which allow us to wipe out quickly and efficiently any organisms which become troublesome. Virtually all of the organisms which we now use in microbial mining, in pollution control, in pest control and in industrial processes of manufacture are deliberately designed so that they cannot function without the presence in their environment of particular essential metabolites that they cannot manufacture. We can therefore control where and when each organism can operate by controlling the supply of its metabolite. By this means we have kept a tight rein on the distribution and use of the new biological systems which we have created during the last thirty years.

There probably will be times and places in the future when one of these reins will break, because our manufactured organisms are as capable of mutation as natural ones. Some time, the mutants will probably emerge in one or many artificial species which will liberate them from the constraints which we have been careful to build in. There is no reason, however, to panic about this, or to see it as a reason to regress. The greater the extent and sophistication of our biotechnology, the better are our chances of responding quickly and effectively to any small-scale eco-catastrophe, whether it is one started by mutation of artificial or natural species, or by some deliberate act of biological warfare on the part of human terrorists or, conceivably, lower creatures trying to replace man in the battle for evolution, or extraterrestrial beings. To suppress or restrain biotechnology would make us more vulnerable to ecosystemic disruption, not less. Disruption is something which always might happen, whether or not we are using genetic engineering techniques routinely to modify and create species of micro-organisms. Familiarity with these techniques is our best chance of defense.

At present, the biological revolution is still in an early phase. A great deal of work is needed to consolidate the gains which have already been made. All of the innovations described so far have come into use on a relatively limited scale. Some have had more spectacular effects than others, but in every case it seems reasonable to say that the most sweeping effects are yet to come. Many applications are still in their experimental phase. The most confident expectation we can have of the future is that the revolution will spread as the Industrial Revolution did before it. The discoveries we have already made will continue to transform the world for centuries to come.

There are, however, some clearly delineated problems which still await solution by innovation. The most dramatic is the need to design an efficient system of artificial photosynthesis. All the techniques in biological engineering which we have so far developed are really mere tinkering. However clever we may be in adapting organisms to our multifarious purposes we are still essentially dependent on the bounty of nature. We have achieved so much in so little time because evolution has been so obliging in providing us with a wealth of materials to work with. We have been ingenious in transferring the abilities of one organism to another and in exaggerating particular selected properties which organisms already had. But we really have done nothing totally new. Our biotechnology is not really ours at all. It is nature's technology, shaped by evolution, which we have partly usurped.

We do have the ability now to make genes: to build up lengths of DNA from component parts. We still use this ability, however, mainly for synthesizing genes whose structure we already know. As early as the 1980s, molecular biologists were working on the synthesis of man-made enzymes; chemically synthesized heredity was already with us; and synthesis of a yeast chromosome had been achieved. We have moved a long way along such roads since then, but not yet into a new universe. No one has yet designed and built a totally new functional gene, utterly unknown within the biosphere, to produce a protein with a property and a purpose that the ceaseless trial and error of the evolutionary process has overlooked.

Our biotechnology, therefore, is still working within the context of the biology which we inherited—the biology of which we are a product. Perhaps, even probably, this is not the only biology which could exist. For every function which is served by proteins there seem to be alternatives. All mammals take up oxygen from the air by means of a pigment called hemoglobin. Some insects also use it; but some use other pigments instead. Almost all plants plunder the energy of sunlight by courtesy of the green pigment chlorophyll, but some use brown pigments and others red. Given this variety one is bound to ask: what if there are other proteins, not yet thrown up by mutational trial within our biosphere, which are more efficient at oxygen-uptake than hemoglobin and better at exploiting the energy of sunlight than chlorophyll?

Sunlight is the fuel which sustains life on Earth. The process by which plants extract energy from sunlight, using that energy to build up complex compounds from simpler ones and thereby storing the energy which animals, including humans, use to grow and move and see and think is the life-process itself. We have always exploited that life-process, but in the past we have been able to do so only by using living plants as our agents. We learned to cultivate them, develop them by selective breeding, and, since the 1980s, to meddle with their genes, but we have not yet learned to substitute something of our own making for the living plant. We have not found or made a more efficient substitute for chlorophyll itself outside the naturally-occurring factory which is the living cell.

Until we can design our own systems which can exploit and re-deploy the energy of sunlight as efficiently as the humble algae does, we humans have no real biotechnology of our own. We have many kinds of solar cells which can extract energy from the sunlight and store it as electricity or as heat, but such devices are very crude indeed when one compares them with the technical sophistication and versatility of living plants.

We are making a determined effort to capture and use a greater fraction of the solar energy which falls upon the face of the earth every day. We are trying to make plants flourish where at present they can eke out only the most precarious existence. The ideal situation, however, would be one in which we did not need to work so hard to adapt existing plants to more hostile conditions. If we had our own artificial systems of photosynthesis we might exploit the desert sun ourselves, without using other organisms as intermediaries. Our ultimate ambition must be to make artificial photosynthetic systems more efficient than those which have evolved alongside us throughout the history of life on Earth. Then and only then will we really be able to claim to be technologically self-sufficient. In 2025 it looks as if that might be one of our children's tasks.