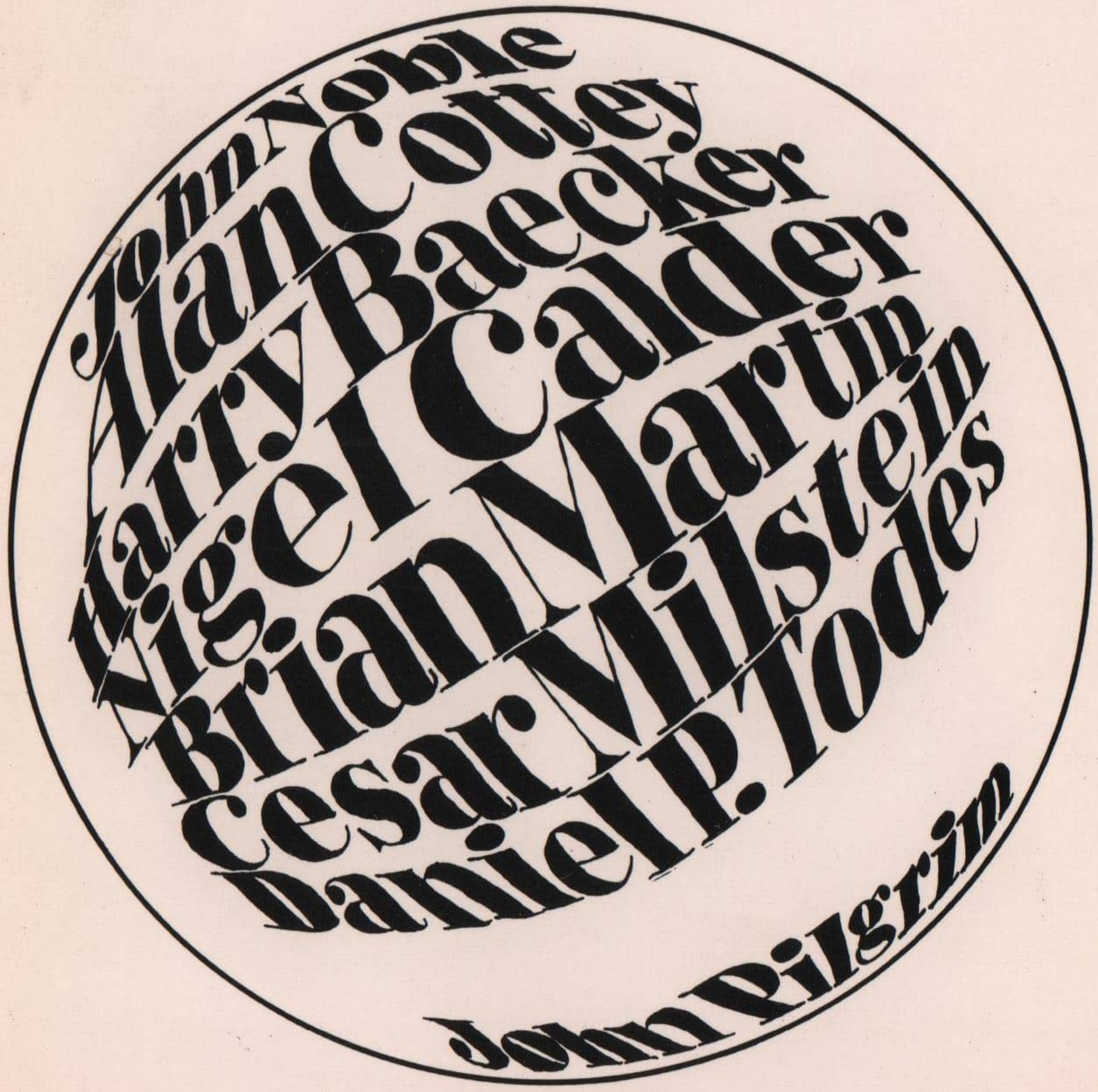
Science 1



THE RAVEN ANARCHIST QUARTERLY 24

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Contributors

Harry Baecker was a computer programmer and sociologist when he wrote this paper for *Anarchy 25* in 1963. We have been unable to trace Mr Baecker and hope that he will not object to our reprinting his still relevant argument.

Nigel Calder, formerly editor of *New Scientist*, became a freelance science writer in 1966 and since then has scripted a long succession of multinational television programmes of which the latest is *Spaceship Earth*. He dates his disillusionment with politics to the mid-1960s when he saw Harold Wilson's "white heat of technology" policies (which he had helped articulate) come to nothing, and when CND of which he had been press officer "took its eye off the ball to agitate about Vietnam". Now he described himself as a "romantic anarchist" who thinks that most good comes from individuals and most evil from depersonalised authority. The latest of his 28 books is *Giotto to the Comets* – an account of a European space mission.

Alan Cottey is a member of Scientists for Global Responsibility and of their Science and Ethics Group. He is a Fellow of the School of Physics, University of East Anglia, where he teaches a course on Science, Values and Ethics for science students.

Brian Martin is a physicist and mathematician now involved in social studies of science at the University of Wollongong, New South Wales. This brief extract is taken from *Chain Reaction no. 68*. An enthusiast for self managed science, his extended article on anarchist science policy will appear in part two of *The Raven* 'On Science' in 1994. Two of his books, *Strip the Experts* and *Social Defence: Social Change* are published by Freedom Press.

César Milstein is a biochemist who numbers the 1984 Nobel Prize for Physiology and Medicine among several scientific awards. In this interview with **Colin Ward** he talks about being converted to reading by Burrough's *Tarzan*, to anarchism by Lenin(!) and to science by de Kruif's *The Microbe Hunters*.

John Noble was a regular contributor to *Freedom*'s 'Science Notes' in the 1950s and gave Freedom a rare scoop when he broke the news

of the newly discovered contraceptive pill. A mature entrant to university, he took a PhD in Psychology and continued as a research psychologist, with a short period of school teaching, until taking early retirement. He now spends the bulk of his time reading and compiling reading lists for his friends.

John Pilgrim is a sociologist with a long term interest in the history of science. He edited *The Raven* number 18 on anthropology and *The Raven* number 19 on sociology, writes regularly for *Freedom*, and is a founder member of the John Gummer Appreciation Society.

Daniel P. Todes is at John Hopkins University's Institute of the History of Medicine in Baltimore. His paper *Darwin's Malthusian Metaphor and Russian Evolutionary Thought* first appeared in *Isis – Journal of the American History of Science Society*. We are particularly grateful to Dr Todes and *Isis* for permission to republish and to Stephen Jay Gould for steering us to it in the first place.

Announcement and Thanks

We would particularly like to thank Donald Rooum for advice on the content of this issue. Donald Rooum's discussion of 'Creation Science', squeezed out this time, will appear in *The Raven* on science part two, along with Brian Martin on self managed science, the editorial team from *The Ecologist* on the misapplication of Western technology in the third world, Sal Restivo on science and the anarchist tradition, Mike Bartholomew and Nicolas Walter on Kropotkin, Gill Baker on the morality of animal experiments, and John Pilgrim on ideology and biology.

INTRODUCTION

John Pilgrim

The Necessity of Science

Governments are ambivalent about science. They view the free discussion of ideas with dubious incomprehension. There is marked uneasiness at the spectacle of ideas that aren't always amenable to market forces or governmental authority. Yet from the time of Galileo they have been eager for the payoff, in terms of military and industrial technology, that scientific work can provide. If, that is, ideology and *realpolitik* don't get in the way. The shenanigans surrounding the funding of Professor Salter's Duck, a wave power harnessing device, provide a salutary lesson in what happens when scientific ingenuity clashes with vested interests like the nuclear and defence lobbies. In Britain the recent government White Paper *Realising Our Potential* suggests the current government will attempt to square this circle by subordinating the scientist to industrialists and commercial experts. Young scientists must be educated (the White Paper prefers to say "trained") to be the servants of industry. We are to develop our scientific potential by having fewer PhDs and more scientific skivvies in the form of MScs. Presumably it is felt that these will be less likely to challenge assumptions that the primary aim of science is the creation of wealth for capitalists. The return of the eighteenth century concept of scientist as servant.

The scientific underpinning of health and environmental research will also be endangered in the scramble for short term profits or short term political advantage. The threats to the Warren Spring Environmental Laboratory and the National Physical Laboratory are an indication of what we can expect in this area. The White Paper gives the government unprecedented control over science. It is part of the general move toward a totally centralised society exemplified by the National Curriculum, part of a concentration of power that becomes ever more menacing as intermediate associations are destroyed or rendered inoperable. We can only hope the rest of the world doesn't follow suit.

On a world scale two of the great issues in science at the moment are biogenetics and chaos theory. Genetic manipulation and the concomitant commercial rush to turn Europe and America into updated versions of the Island of Doctor Moreau offers a particularly grisly future, not just of genetically altered plants and animals but of genetically stratified human groups. Plato's Gold Silver and Bronze actualised by genetic engineering. Chaos theory, with its ideas about the spontaneous emergence of order and the ultimate unpredictability of self organising systems may offer a more hopeful field for *Raven* readers concerned, like Malatesta, with an antithesis of freedom and determinism. The importance of both fields is overwhelming and will drastically alter our perception of life, the universe, and everything. We cannot afford to ignore these fields, or anything else in science, as Bronowski cogently points out elsewhere in this issue.

The heroic age of scientific optimism exemplified by Tennyson's thrilled discovery of "the fairy-tales of science, and the long result of Time", came to an end about thirty years ago. It appeared to be the end of the idea that science could ultimately solve all our problems. With it came a gradual retreat from rationalism just as dangerous as the elevation of the scientist to a sort of God-Priest with a knowledge of mysteries beyond normal mortals. Along with it developed a general retreat from the idea of the human condition being improved by the human will. People took refuge in fatalism, a vague deism, or general disenchantment with the idea of change for the better. Alienation was a key concept while scientific explanations were regarded with the same scepticism as politicians' promises.

The operation of this post modernist world, where nothing is true and everything is the expression of an interest, created dangers which now loom ever larger. "When people learn no tools of judgement and merely follow their hopes, the seeds of political manipulation are sown" says Stephen Jay Gould. Indeed. It is therefore worth remembering that the late surge of "scientific racism" in the hands of Shockley, Jensen and Eysenck was discredited by science itself. As Nigel Calder says given a chance science will usually come up with the right answer – in time. The preferred solution to these sorts of problems is always better science, not the abandonment of science and rational thought.

In this issue of *The Raven*, one of two to be devoted to science, both **Harry Baeker** and **Nigel Calder**, writing thirty years apart, argue that technology and science are inherent in our operation as human beings. Both tread on a number of toes, including those of the Kindly

Editor, both challenge the easy cop outs of our everyday existence. Both are ultimately heartening. Indeed Calder's insistence that the nation-state and science can no longer safely co-exist, that we can't stop science, and therefore the nation-state must go, creates the sort of optimistic glow that must have been felt by an earlier generation who believed Kropotkin was right. **Nigel Calder** seems to argue that he was, but that only now, through science, has realisation of his ideas become possible.

There are no easy answers. **Alan Cottey** also recognises the survival of human culture is at stake. Taking a less optimistic view than **Nigel Calder** he nevertheless is insistent on the importance of working for the future and of not casting science as the sorcerer's apprentice. **Brian Martin** (whose full scale essay on anarchist science policy will appear in the second of these two science issues) warns us against easy extrapolation of scientific theories to human society, if only because those theories are often shaped by social values. This point recurs in **Daniel Todes** famous paper on Darwin, Kropotkin, and Malthus in a Russian context – an interesting example of cultural and geographical influences on scientific thinking.

Of course scientists, like the rest of us, are creatures of their culture. A key point of Daniel Todes' paper is that Darwin was using a Malthusian *metaphor*, and the tendency of readers to take metaphor literally creates continuing problems. **John Noble** argues here that the too easy reliance on the "God metaphor" in recent years is bot an intellectual cop-out and is providing aid and comfort to the vendors of superstition – something usually unintended by the scientists involved.

Science doesn't have the answer to every problem. Philosophers still can't prove a value judgement. Arrow's Theorem in economics states there may be no rational solution for distributing resources in the face of conflicting demands. But science can help solve the problems of distribution,and it can increase resources. It is said that fifty percent of the people in orthopaedic wards are there because of medical mistakes. No doubt. Few of us though will fail to seek medical help for cancer or suffer the agonies of an abscessed tooth without antibiotics. Whatever the disputes in science they are *in principle, and over time*, resolvable. The rejection of science and reason can only lead to a conflict of subjectivisms, to a clash of personal interests masquerading as revelation, to a domination by untested dogma.

What they say about science

"I will rejoice in the multifariousness of nature and leave the chimera of certainty to politicians and preachers."

Stephen Jay Gould, *Bully for Brontosaurus*, 1991

"One thing I have learned in a very long life – all our science, measured against reality, is primitive and childlike – yet it is the most precious thing we have."

Albert Einstein

"Teachers must encourage children to question the often exaggerated view of the infallibility of science as the only means of understanding the world and the equally exaggerated view of the inadequacy of religion and philosophy."

John Patten's National Curriculum Council, 1993

"The *substance* of science tends to mock all authoritarian ideas, whether based on religion, marxism, racism, or whatever."

Nigel Calder, 1992

"Here about the beach I wandered, nourishing a youth sublime,
With the fairy-tales of science, and the long result of Time."

Tennyson, *Locksley Hall*, 1842

"... the social responsibility of the scientist ... is not simply a matter of scientists being concerned about the 'use and abuse' of their work, but of their actions in doing their work being part of an immensely complex and largely unpredictable system of social forces."

M. Gibbons and P. Gummet (editors), ***Science, Technology and Science Today*, MUP, 1987**

"Many of the problems attributed to science and technology are in fact problems of human behaviour. Scientists and engineers must recognise the possible use and misuse of their knowledge and the limitations of their disciplines for solving social problems."

Samuel Silver, *Science Journal*, October 1969

"Women's liberation could not have succeeded if science had not provided them with contraception and household technology."

M.F. Perutz, in Lewis and Kelly (editors), *Science, Technology and Future Human Needs*, Pergamon, 1987

"It is a tendency of mankind, through the premature hurry of the understanding to leap or fly to universal or principles of things – great danger may be apprehended from philosophies of this kind."

Francis Bacon, 1560-1626

"Scientific patents are financial swindles that prevent the public having access to information."

César Milstein (discoverer of monoclonal antibodies), 1984

"The philosophy of science is a system of outdoor relief for failed physicists."

attributed to Stephen Hawkins, 1992

"The scientific mind never cherishes illusions of having found absolute Truth, it is content with partially approaching it."

Malatesta, 1924

"If science and the nation state cannot safely co-exist, one of them must go. You can stop science only by excising the lobes of curiosity from every new born child. Therefore the nation state must be abolished."

Nigel Calder, 1993

Harry Baecker

Technology, Science and Anarchism

It has always been a great temptation to give an intensive definition of man. Our ancestors were so bemused by their own philosophical capabilities, and by the, to them, evident lack of these in the rest of the fauna that they characterised themselves as *homo sapiens*. You and I have inherited that noble appellation without any effort on our part. Of late we have had other attempts at definition, *homo ludens* by Huizinga, "man the time-builder" by Korzybski. The former emphasised the importance of non-purposeful activity, play, in the development of those activities we consider more worthy and important; the latter characterised man by his ability to symbolise experience and thereby transmit it to other members of the species far distant in time and space. Korzybski's definition is, by the way, extensive, as given in his *Manhood of Humanity*.

I too have a chip on my shoulder, and as one of the mad ogres of modern times, a technologist, a blind self-abasing servant of the machine, I reject intensive definitions and choose to present my own extensive one of man, an outgrowth of that of Korzybski, and I choose the label *homo aedificans*, 'man the builder', to hang onto my definition. Intensive definitions should be left to metaphysics, so it is up to me to make it credible that my definition is extensive. The instructions for verification of the definition are as follows:

> "Observe the surface of this planet for at least one revolution round its primary in sufficient detail to resolve features one hundred millionth of its circumference in extent. You will observe several lifeforms that produce artefacts from the material in their environment. Further observation will show that in the case of all but one of these lifeforms a given lifeform produces but one type of artefact and that only within a sharply limited ecological framework. However, the residual lifeform will be observed to produce a multiplicity of artefacts and may be seen to produce the same artefact our of varying environmental material by appropriate intermediary processes. If you were to extend the period of your observations to a hundred revolutions round the primary you would observe that no change has occurred in the range of artefacts produced by the lifeforms except again in the case of the one lifeform previously noted. Some artefacts previously produced by this lifeform will no

longer be produced, some will be made out of entirely different environmental material, and a large number of artefacts not previously produced will now be noted. If you were to improve the resolution of detail of your observations by a linear factor of one hundred you will observe a class of artefact that may be deduced to be symbolisations, abstractions, of other artefacts, of events, or of actions of the lifeform. The lifeform you have particularised by your observations is called *man*."

This definition of man says nothing of heart or soul, of art or intellect. It is ignoble, you may say. Perhaps. But it is verifiable, it is devoid of private assumptions and comprises only directives for the performance of actions that will lead to the recognition of the species under discussion. It identifies man as the sole maker of gadgets and widgets on this planet, that is, by his technologies.

A few years ago such a definition might even have been challenged as totally inadequate by archaeologists and hominid palaeontologists, who had developed an evolutionary sequence largely derived from the cranial capacity of the pre-sapiens remains found. Recent years have seen the excavation of many more archaeological sites in many more parts of the planet and it has become clear cranial capacity is a secondary development. The record now shows that tool-using and tool-making goes much further back in our ancestry than had previously been supposed and, what is more important, that each stage of cranial development is *preceded* by a change in the skeletal structure of the limbs giving greater manipulative skill, and the archaeological record confirms that our ancestors immediately used the new skill to make more refined tools, before their cranial capacity had increased. The gadget is the father of wisdom.

A persistent thread in anarchist and libertarian writing, as elsewhere, is the denigration of modern technology and the expression of a thirst for the simple life, the natural life. It is presupposed that if man can slough off his concern for things he will behave more nobly towards his fellow men. The proponents of this sort of argument point to 'the simple happiness' of various primitive societies. There are several answers to this view. Firstly, the range of expectations is much narrower in such societies and therefore so are the expressions of discontent. Secondly, it is no great achievement for a society the majority of whose members are malarial or ridden by deficiency diseases to be placid, and content with the simple fact of being alive. If you expect your children to die in the first year of life and if you have no great life expectancy then there is little inducement to be ambitious or to carve out an empire. Thirdly, the technological

accomplishments of some of these societies put our own engineers to shame. Within the strict limitations of their arctic environment the Eskimo have exploited its resources and invented gadgets that have no equal. They have no word for war because they are too busy making and using gadgets to keep alive.

In conjunction with the arguments about the simplicity of life is that about the natural life. Usually this is assumed to be pastoral, horticultural or agricultural. I fail to see what is so natural about any of these. They are as artificial as the construction of nuclear reactors. The only natural habits for man would be to wander unclothed and without constructed shelter, without fire, gathering herbs and fruits to eat raw and catching small animals with his bare hands to gnaw raw, and most certainly without any language to use to communicate with his fellows. All else are constructs of a social technology of very great complexity. No natural lifer would admit conditions as primitive as these I have just described as his ideal. But none can adduce reasons why his utopia should be permitted to indulge in the degree of artificiality he feels to be desirable whilst forbidding other artificialities.

I must, of course, put up my own version of what is 'natural' for man. It is to manipulate his environment to facilitate, directly or indirectly, the survival of himself and his species, the survival value of his actions depending on his current apprehension of reality. A corollary of this view is that stasis is inconceivable for humanity. And a survey of human history will quickly confirm that change is not something facing us now, from which we can retreat into some golden era of the past, but that it is a part of all we know of ourselves, a normal condition of the race, and that it has always been with us.

The agrarian utopia can only succeed in an environment so devoid of natural resources that innovation and invention are impossible, where the struggle to survive by present means is so intense as to preclude the spare time and energy requisite to the devising of other means. Under more favourable circumstances the utopia of this type is self-destroying if stocked with healthy human stock, it will invent and innovate its way from subsistence to technological exuberance. Invention and innovation will not be confined to the arts or philosophy or the love of one's fellow man, there is no evidence that these can be independent of material activity, and indeed there is overwhelming evidence that the humanitarian must be preceded by the technician, to prepare an environment in which the race can afford the graces of life.

And if man succeeds in creating an environment in which he can exist without inventive effort then he will be dead. When curiosity and questing cease the end has come. Why should this curiosity be exercised upon the material world and not upon the finer delights of metaphysics, charity and love? Because we live in this material world, it is our world, it is the raw material out of which we can fashion our lives of our own choosing, if we have the will and the comprehension to do so. Remember the men who are regarded as the two greatest artists ever, da Vinci and Michelangelo. First and foremost they were manipulators of materials, technicians, engineers. First they had to invent the paints and other materials of their art, to devise the engineering rules for their sculpture and architecture. They commanded the material world, and comprehended it as best as they were able. Their art was based on the foremost advances of the technology of their day. Today the castrate artist hides his incomprehension of the world he inhabits behind flabby talk of art and is impotent in the face of reality, the human race has outgrown him, he is retarded in his development. In a frenzy of imagined superiority he had abdicated his right to fashion the materials of our daily lives, and then has the childish petulance to blame others for his own futility.

The relevance of this view of the world to the anarchist discussion is at least threefold. In the first place, it is a view held, usually inarticulately and even unconsciously, by very many people in positions of effective control in our culture. The task of the anarchist propagandist does not begin with attempts to persuade these people of the validity of the anarchist standpoint. The difficulty is far more fundamental, it is incumbent upon the anarchist to discover a common basis of discourse from which he can address the technologist. To the anarchist it may be a self-evident truth that 'man if born free, and everywhere he is in chains'. It is not. It is a metaphysical, not practical, statement. It requires the exhibition of examples of the states of freedom and bondage.

Man is born free. But unless he is subjected to the most rigorous social discipline in his youth not even an anarchist is likely to claim him as a comrade. For infant man must learn a language, and learn it correctly. By correctly I mean that he must learn to frame his own communication in such a way that he conveys whatever he wants to convey to others, and at the same time learns to pay attention to the communications of others so as to apprehend their meaning. By the time he has achieved fluency of expression a man's 'natural freedom'

has been severely circumscribed by society. It is a very simple, practical affair. If you wish to be a member of society you must obey the rules, if you ignore the rules you remain outside society for you are bereft of the means of communication. You can babble as much as you like about freedom, but your babbling will be couched in terms that obey the strict social rules if you wish your effusions to have any effect.

So, maybe, man is born free. But unless he loses his freedom he ceases to be a man. It is even doubtful that abstract thought is possible for us without the use of linguistic symbolism. The hermit is indebted to generations of social effort for the language in which he postulates his withdrawal. Without the cultural apparatus that your ancestors and your fellows have provided by laborious toil you, individual man, are less than nothing. You have not even the instincts that enable most animals to live, you depend for your survival upon the accumulated effort of the race.

Comrades, you see your problem!

The second problem for the anarchist in an expanding society is that of education. In an earlier issue of this journal it was asserted that an anarchist education must not compel the child to learn subjects that it does not spontaneously wish to follow. I hope that the writers were not prepared to make a few points of safety in a technical environment an elective subject. For instance, do not touch live electric mains. Now if these points are neglected we have, of course, solved the problem of overpopulation brilliantly. If we do make personal and public safety compulsory, but make the background subjects elective, we have made witchcraft the basis of our society. For without a thorough comprehension of the 'laws of nature', of science, such safety precautions are just witchcraft, or the edicts of a vengeful god. You will not get a free and open society if the basis of the elementary rules of survival is not understood by those upon whom they are enjoined. Further, unless a citizen is somehow made aware of the existence of fields of human knowledge and experience and ignorance then he has no chance to be interested in them. You cannot look for an answer before you know that there is a question. A fully elective education would be a disaster for the child.

The third problem is that of authority. This is allied to the previous one. In a technical society decisions must be made and directives must be issued of the society is to exist at all. For instance, if automobiles are desired then a rule of the road must be established *and rigorously enforced*. We cannot choose to drive on the left or the right at will,

whatever our political or philosophic persuasion the brute facts of mobile tons of machinery impose their own discipline. I said that directives must be issued. They must also be enforced. Whatever your views on the common ownership of land you cannot be permitted to wander at will on an airfield, if necessary you must be shot dead before you can endanger an airliner landing with a hundred passengers aboard.

The usual anarchist reply to the above problem is that it would not, of course, exist in a free society where all men would behave reasonably. But reason and goodwill are not enough. Knowledge and understanding must be there also, and if people are free to learn or ignore simple facts of their daily life then you must guard against the blunders occasioned by their ignorance.

Of course we can go back to the argument about the abolition of technology. By all means yearn for your little womb of pristine safety and simplicity. Do not expect the rest of us to follow you there, or to honour you for fleeing thither. And if we find that we could put your corner of paradise to more congenial use we shall probably wrest it from you without pity or remorse. Violence is the last resort of the incompetent, and oft we are incompetent. But the fact that we are incompetent does now make us scurry off to a dark corner to brood in fear, we shall try to develop competence, it will cost blood, toil, tears and sweat, both ours and yours. We know a little of whence we come, we know almost nothing of where we are going, but we shall go on, impelled by the monkey instinct, by the hands of the artificer, by the thoughts of the scientist, by the dreams of those who sought the summits of mountains and the deeps of the sea, the poles of the planet and the reaches of space. Because we are human.

We build and we also destroy. Often we destroy through ignorance. Our technology is yet poorly used, we damage ourselves with it. It has always been thus, the Roman farmers impoverished the soil of Italy with their sheep two thousand years ago, we must always be aware that every act may be a mistake. But the symbols of our common humanity are our artefacts, the tools by which we enrich and enlarge our experience and comprehension of the universe we inhabit. You may seek to change us, but to reach us you will have to undergo the discipline of language, perhaps the complex of our artefacts, and the search to convey your meaning to us will lead you first to examine our meaning and to be tainted by it.

Nigel Calder

Give Science a Chance

A dialogue is in progress between the human brain and the cosmos it inhabits. On a small planet of an undistinguished star – and nowhere else as far as we know – the Universe is fully aware of its own existence, and of its immensity and riches. You can debate how soon the physicists will write down the equation that answers Einstein's question: 'Did God have any choice in the creation of the world?' You can argue about the priority to be accorded to the human breakout into the deserts of space, and the Greening of the Galaxy. You can fret about likely minuses of the new-found powers to read and manipulate the genetic codes. But you cannot doubt that all these things and many more are on the agenda. For knowledge, for craftsmanship, and for politics, science is now the Big Time.

The geneticist J.B.S. Haldane wrote in 1925:

"The tendency of applied science is to magnify injustices until they become too intolerable to be borne, and the average man whom all the prophets and poets could not move turns at last and extinguishes the evil at its source."

I would put the same thought more mildly, and with less expectation of a sudden denouement. Science dramatises pre-existing issues of right and wrong, by amplifying the powers of the actors. A positive example is famine relief. Because agricultural science has ensured that world has plenty of food, and telecommunications brings news of hunger at the speed of light, famine is intolerable. The old option of throwing a crust to the starving family at the gate has given way to an international and charitable system for trying to rush food to wherever it is needed. In wars, the system finds itself at loggerheads with the military tactic of starving the enemy into submission.

The chief negative example is the prospect of annihilation by weapons of mass destruction. Science did not invent war, but makes it ever more terrible. We have had close shaves already, and the 'average man' and woman will have to change the political organisation of the world if they are to look towards the future with any confidence.

Let's use our brains. To counter threats to our survival, we should

try to understand the issues as deeply and rationally as possible. For instance, all propositions about society make assumptions about human nature, and anyone wishing to tinker with society had better be sure their assumptions are right.

Natural science is now the chief instrument of rationality, and I recommend that it be given a chance to reveal the way forward. In this article, I shall first sketch the strengths and weaknesses of natural science, as I see them. Then the fate of some pet ideas of would-be changers of the world will come under scrutiny. The last sections will consider science as a motor of social change.

Strengths of natural science

"I have a moral advantage over my fellow professors in this great university," a theoretical physicist boasted to me one night in his cups. "Unlike me they can't be suddenly proved completely and irretrievably wrong." As things turned out, he later shared a Nobel Prize for predicting correctly that two fundamental forces of the Universe, manifest in electricity and radioactivity, would turn out to be different aspects of a single electroweak force. But what he was on about, that boozy night, was the precision of the verdicts delivered by Nature when interrogates by skilful experimentalists, most unmercifully in particle physics.

Astrology and alchemy typified the projection of human fantasies on to the natural world, at the dawn of modern science. René Descartes was the last great medievalist attempting to spin laws of Nature off the top of his head. The intellectual breakthrough came with the 'experimental philosophy' of the seventeenth century. The discoveries of Galileo in physics and astronomy showed what wonders could appear if you stopped telling Nature what to do and instead listened to what it had to say. Experiments and open-minded observations were hearing aids for the conversation that led in less than 400 years to the Big Bang and the genetic code.

Modern science, as created by clubs like the Royal Society of London, is a social system in which anyone can come up with ideas of alleged new facts, and everyone else demands to know what Nature's verdict is. The motto is: 'Don't take anyone's word for it.' Experiments and observations have to be repeatable, and ideas that cannot be tested are, for scientific purposes, worthless.

To win credit for an idea, discovery or invention, you have to publish it or patent it first, and this gives powerful impetus to disclosure.

Openness and the free exchange of information are therefore essential to the social system of science. Preprints circulate like *samizdat* among scientists working in the same line of research, ahead of formal publication. Although commercial and military secrecy operates against the system, its effects are limited, at the level of fundamental knowledge. For example, it was obvious to many atomic scientists in 1939 that the discovery of uranium fission made the development of nuclear weapons very likely. When some details of how it was done emerged in 1945, they were unsurprising.

Science also gives generous scope to crazy ideas. Because Nature's verdicts are so stern, nonsense like cold fusion is quickly cleared away, while unverified and unfalsified hypotheses such as Gaia remain in the lumber-room. Scientists can tolerate bizarre notions from their colleagues, without fear of the befuddlement that would quickly overwhelm disciplines with less efficient antibodies against nonsense. Every so often, Nature declares that a crazy idea if correct, and knowledge makes a quantum jump.

The quantum theory itself is a once-crazy idea that is now completely verified. Others include the evolution of species, the drifting of the continents, and Einstein's discovery that time itself is malleable. Black holes have taken a secure place in the scientific Chamber of Horrors, alongside *tyrannosaurus rex* and the devilishly ingenious AIDS virus. Evidence now coming in supports the idea that one of the chief engines of the Earth's climate is a watery conveyer belt that links Scotland with New Guinea. Epidemics of icebergs in the North Atlantic can, so the story goes, switch off the conveyer and chill the world. Other current excitements include manipulations of single atoms and electrons, molecules of carbon that bounce like footballs, and movies of the human brain in action.

That non-scientists often fail to appreciate the vigour and sheer fun of current research is a cultural disappointment and a political nuisance. Why, for example, are the taxpayers of Europe contributing billions of dollars to giant accelerators at Geneva? 'Expensive toys!' the uninformed like to say. But the newest machine has just proved that all ordinary matter in the Universe is built of precisely twelve kinds of particles – no more and no less. And if the next machine, as expected, discovers the Higgs boson, that will be a vital clue to the conundrum of mass which has puzzled scientists since Galileo's time. The crazy idea of Peter Higgs is that his bosons fill 'empty' space with a kind of mud which clings to particles, slows them down, and thereby gives them mass.

Anti-authoritarian traits in science are evident in the way leaps in knowledge occur. There is a disproportionate contribution from youngsters in their twenties. Indeed, in the most Olympics-like sectors of physics and molecular biology, people are often said to be over the hill at thirty. In a potent Anglo-American tradition, tracing back to Isaac Barrow who resigned his chair so that a youngster called Isaac Newton could have it, the research student's job is to prove the professor wrong. Dan McKenzie, from the same Cambridge powerhouse 300 years later, confesses to the glee with which, in his twenties, he deflated the grand men of geology at scientific meetings when they challenged his ideas of plate tectonics.

Gatecrashers from outside the specialised departments of research sometimes initiate discoveries. A Scottish college janitor and a Yugoslav civil engineer promoted the now-accepted theory that the rhythm of the ice ages is set by wobbles in the Earth's axis and orbit. A German meteorologist was the primary twentieth century advocate of continental drift. British and Australian radar physicists turning their antennas on the sky began the revolution in astronomy which revealed the violence of the Universe, and American scientists working on satellite communications discovered direct evidence for the Big Bang. Most momentous was the intrusion, forty years ago, by British x-ray crystallographers into biology. With the aid of a very young American biologist, they revealed the structure of DNA and the secret of heredity.

Imagined weakness of natural science

Confusion reigns among non-scientists about the nature of 'uncertainty' of science. At best they are misled by a pun and at worst they use it to disparage the findings of science and open the door to obscurantist nonsense. People seize on the physicists' use of terms like 'uncertainty', 'relativity' and 'chaos' and say, 'There you are, Nature is inscrutable, and scientists must be humbler'.

But the Uncertainty Principle is a concise and very *precise* description of how the behaviour of subatomic particles differs from that of cannon balls. It heralds the concepts of quantum theory which, for example, correctly predict the inherent magnetism of an electron to an accuracy of one part in a billion. There is nothing uncertain about that. Nor about relativity theory: Einstein discovered what remains absolute and reliable in a Universe *despite* the optical illusions created by high-speed motion and gravity. Again, the theory gives precise

numbers, for example about the different rates of time in an aeroplane and on the ground, which experiments with atomic clocks confirm.

As for chaos theory, it starts off as the scientific equivalent of the nursery rhyme about the kingdom that was lost for want of a horseshoe nail. Small variations can have huge consequences. Chaos theory is in that respect commonsensical, and it disposes of a 200 year old *canard* that you might predict the future by calculating the motion of every particle in the Universe – a proposition which few scientists ever took very seriously. But chaos theory also leaps far ahead of common sense in perceiving strangely ordered patterns emerging from chaos, in a partly calculable fashion.

The authority of chaos is in any case circumscribed, leaving most of the large-scale order in the Universe unperturbed. The weather is a good example, where the demons of chaos operate mainly in the intervals of weeks and months. The weather from day to day is highly predictable, while the climate year on year is reliable enough, so that farming, for example, can prosper. Sustained changes in climate probably have a definable cause, although climatologists do not rule out the possibility that chaotic events in the weather system can make the climate flip from one orderly regime to another. Chaos is not a contradiction of cause and effect, but an addition to its repertoire.

Nothing we know about Nature itself makes the conclusions of science inherently unreliable. Ignorance and error are something else, of course, and the very fact that discovery continues at a high rate means that there are many things that scientists don't yet know. How boring if it were otherwise! And occasionally it turns out that previous ideas were not merely incomplete, but wrong.

Non-scientists should again beware of under-valuing existing science for that reason. Any rebuilding of the tower of knowledge is usually confined to the upper floors. Even when the reconstruction reaches to the foundations, as happened in geology thirty years ago, the bricks of pre-existing knowledge are recycled in a new arrangement.

Every turn of a dynamo, or any radio broadcast, confirms the laws of electromagnetism. Every pulse of a particle accelerator verifies the atomic character of matter. Each fossil falling out of a cliff adds to the evidence of evolution, however much the experts may still wrangle about the relative importance of different mechanisms in the origin of species.

Fifty years ago, hypotheses in various conditions of credence or disbelief included the gene, the localisation of brain function, and

continental drift. Doubts about them become vanishingly small now that you can read and interpret the messages of the genes, directly observe accelerated metabolism in particular regions of the brain during mental tasks, and measure continental movements from year to year using satellites.

Knowledge also interlocks. The separate, rather rickety edifices of the natural sciences in the nineteenth century – physics, astronomy, chemistry, biology, and so on – have in the twentieth century become a single tower of immense strength. More precisely, physics has engulfed the others. Astronomy proves to be a battleground of nuclear forces and gravity; in chemistry, electrons weave the atoms together; life itself decodes into the lock-and-key configurations of clusters of atoms. Now, space observations of the Earth are turning geography and ecology into branches of physics too.

And science becomes simpler. This is an assertion that surprises those who imagine that the growth of knowledge makes it less comprehensible, and that new knowledge is more difficult than old knowledge. To imagine so is to miss the point, that scientists look for general principles that account for ever-wider swathes of natural phenomena. Microbes and whales are cousins, using the same genetic code and basic molecule machinery. Six kinds of quarks assembled in threes account for all the heavy particles of matter. Three different tectonic mechanisms explain all the world's volcanoes. And so on. Call it reductionism if you like, but it works.

So far from being demoralising or discreditable, the remaining doubts and gaps in knowledge enthral the scientists. What new Einstein will resolve the contradiction between relativity and quantum theory that crops up in the extreme conditions of the Big Bang or a black hole? When shall we understand the origin of life, and be able to simulate the event in a laboratory? Are the Earth's oceans really made of melted comet-ice, as some astronomers now suggest? What are the features of the brain organisation that make possible the phenomena of self-awareness and consciousness?

Researchers shy away from questions that they do not know how to tackle. Natural science seeks no quarrel with other systems of enquiry, self-expression and belief, except when these attempt to correct its findings by unscientific means. In any such confrontations, science usually comes off best.

But you don't have to believe everything that individual scientists say. Their colleagues certainly don't. The weaknesses of science that really matter are those arising from the human fallibility of its

practitioners, in their interactions within the social system of science, and with society at large.

Real weaknesses of natural science

I suppose by now everyone knows Thomas Kuhn's distinction between 'normal science' and the 'paradigm shift'. The first conforms with the priorities and perceptions of the age, in a given field of research. Worthy but often dull, it sells like bread and butter. You have more fun and more anguish if you challenge the existing paradigm in your field. You may well starve, but you may also hit the jackpot of starting a new fashion and winning a Nobel Prize, with the cash and caviare that go with it. The juries in Stockholm require, though, that your conceptual revolution be backed up by experimental evidence.

The scientific establishment operates in conservative ways, and not only in the Germanic tradition where the research student is supposed to prove the professor right. The ideals of science are in the care of unsaintly mortals hungry for prestige and a comfortable life. Twenty years is a typical interval for a radical idea to win acceptance, against systems of peer review in formal publication and the allocation of research grants. These systems serve very well in their primary purpose of weeding out silly or sloppy work, but notoriously they disfavour new concepts that threaten the peers' own authority.

The very word authority, applied to expertise, should make us chary. Because experts concentrate on a particular line of work, they may lack both the knowledge and the objectivity to relate their interests properly to other branches of research and to the world at large. A specialist cannot be a dispassionate witness either to the importance of his/her work and ideas, or to their appropriate application.

H.G. Wells and others after him have dreamed of a world run by a panel of wise experts. The absurdity of this notion encapsulates the weaknesses and limitations of science. The assumption of a benign consensus contradicts the adversarial process that keeps science healthy. Experts representing different fields would have quite different priorities and goals. They would have no grasp of the varying needs and hopes of communities all around the world, or the special problems and opportunities of different environments. And power would corrupt the panel of experts, just as it corrupts anyone else. Either scientists are hopelessly naive about politics, or if they are not, they should be treated as manipulative politicians rather than candid

scientists.

Authority in science translates into authority in the social domain, because governments, international agencies and commercial enterprises rely on specialist advice. Scientists play a role in modern society not dissimilar from the astrologers and soothsayers of former times, and fashions can be hazardous. A case in point is the greenhouse warming, 'officially' endorsed by a large international panel of meteorologists, to the point where politicians talk earnestly about taxing carbon dioxide emissions. Yet there are equally competent scientists who aver that the warming doesn't work in the way these chaps are saying, and the increase in global temperature during the past century may have been due to a speeding-up of magnetic activity on the Sun.

We'll know who's right, within a few years. That is always the saving grace of natural science. There are enough bloody-minded people around, and ingenious ways of testing things, to get the story straight in the end. The same is true when the ideals of science are bruised by human behaviour, and scientists tell lies about their results, or steal other people's ideas. Decade on decade, with the help of the human life-cycle, verified facts and sound theories prevail in the end. But if matters of policy arise, take everything with a pinch of salt.

Medicine provides daily illustrations of the tussles between misused authority, honest error and sound knowledge. For every life saved by antibiotic or transplant surgery, somebody else probably gets inappropriate or harmful treatment. The doctors' theories and treatments vary erratically from time to time and place to place, and most irreversibly when they reach for the scalpel. In Britain low blood pressure is a matter for congratulation, while in Germany it is a disease with a choice of expensive remedies on offer – so somebody's got it wrong. The false alarm about cholesterol in food is comparatively harmless when set beside the consequences of the protein fad in the treatment of a generation of malnourished children who desperately needed carbohydrate. While I am not yet convinced that health service cuts will improve the nation's health, I know arguments that tend in that direction.

Despite all these reasons for caution, and the philosophical caveat that every theory and experimental result is open to re-examination at the technical level, you shouldn't pick and choose about science as a matter of personal fancy: favouring this bit, believing that. If I welcome the genetic proof that mankind has a single common origin, because that's nice and anti-racist, I can't at the same time reject the

evidence that ethnic groups differ markedly in their vulnerability to various diseases. The two results come from global studies of genetic similarities and differences, by the same team of Italian scientists.

Mid-century madness

Ideas cherished for philosophical or political reasons can be confounded by the march of science. Forty years ago, liberals and the Left shared the widespread liking for two prevalent theories. I remember doing so myself. One was the Steady State Theory of the Universe, which made it infinitely old and thereby swept the question of Creation under a carpet infinitely thick. Its rival, the Big Bang Theory, required a very explicit creation event, mere billions of years ago. A Belgian priest, Georges Lemaître, invented it and it was endorsed by the Vatican. There were many chuckles about that institution's record as a scientific tipster. But for once in a millennium, the Pope had backed the right horse.

In the 1960s the Steady State idea was stopped in its tracks by a fence of astronomical evidence. The Big Bang cantered home to become the central paradigm of cosmology and particle physics in the late twentieth century, and the evidence in its favour had grown irresistibly. Atheists are left biting their philosophical nails about where the stupendous explosion came from which created space and time and the stuff of billions of galaxies, in blatant violation of conservation laws.

The second cosy theory worth recalling from mid-century was purposeful evolution. Among biologists, this was more of a mind-set than a well-defined hypothesis like those of the cosmologists. But people such as Julian Huxley in England and Theodosius Dobzhansky in the USA spoke of natural selection as if it were a benign God. Another Catholic priest, Teilhard de Chardin this time, worked up a new theology about it.

In this mind-set, biologists imagined that natural selection was progressive, and guided the slow but inexorable course of evolution from bacteria to *homo sapiens*. We were self-evidently the pinnacle of the living world, so far at least. Nature was manifestly on our side, working patiently away to make sure that we should show up one day, however long it took. For people who wanted to say by analogy that society, too, would inevitably evolve in improving ways, it was all very congenial.

And it was twaddle. Nature doesn't give a damn, and we owe our

existence to dumb luck. We now know that most evolutionary changes at the molecular level escape the attention of natural selection. And species appear and die out for essentially extraneous reasons. For instance an impactor, a comet or asteroid, hit Mexico 65 million years ago and wiped out the dinosaurs. If the object had crossed the Earth's orbit safely, twenty minutes earlier or later, evolution would have unrolled in quite different directions. Certainly we would not be here. So improbable, in fact, was the emergence of high intelligence on the Earth that many scientists believe that searching for radio signals from chattering species in other parts of the Galaxy will be futile. That doesn't mean we shouldn't listen out.

Steady State universes and purposeful evolution were inconsequential pipe-dreams. The same cannot be said for the madness that seized the Marxist world, when Trofim Denisovich Lysenko persuaded Stalin that he was smarter than Gregor Mendel. The capacity to brush aside Nature's verdicts when they contradicted ideology was also evident, of course, in the ecological disasters dreamed up in Moscow: the deliberate killing of the Aral Sea, for example. But the intellectual blight and its consequences were even worse. Physicists in Moscow laughed off the ideologues' attempt to outlaw relativity, but leading Mendelian biologists lost their jobs and the most eminent geneticist died in a labour camp. While Lysenko conned the Politburo with the promise of an agricultural miracle, the deeper ideological issue concerned the improvability of people. Everyone on the Left shares the belief that people will be healthier and perform better in a better society. The Soviets wished improvements induced by the environment, whether in crop plants or in people, to be directly inheritable as 'acquired characteristics' of the Lamarckian sort, in which giraffes supposedly gained their longer necks by stretching to reach the higher foliage. Mendelian genetics, wholly explicit nowadays in the codes of DNA, simply rules that out.

The consequences could not have been greater. Soviet genetics and serious agricultural research were sterilised for a generation. Lysenko's mendacious ideas were amplified through the megaphones of the collective farms. Yields lagged far behind those in the West and the Cold War was lost before it began. How could you beat the capitalists if you would be begging wheat from them?

Original Vacuity

Errors of a similar kind overwhelmed Western psychology, archaeology and anthropology. They centred on the idea of the *tabula rasa*. Predominantly a left-wing fancy, this was a conscious rejection of Original Sin and its elaboration by the Social Darwinists, who thought the poor were born to be poor. The mind of a newborn human being was supposedly a clean slate on which society could write whatever it liked. I call it Original Vacuity.

In the middle of the twentieth century you were required to choose between the family sexual melodramas of Sigmund Freud or the extreme behaviourism of Pavlov and Skinner's conditioning experiments – psychology without the psyche. Especially in the USA, and in the central domains of personal life, sex and parenthood, psychologists succeeded in screwing up three generations of people unfortunate enough to be able to read books. Manuals of childrearing veered disastrously between studied neglect and unrestrained gratification. The Greek myths resurrected by the Freudians made mothers so scared of incest that when a Czech paediatrician, Hanus Papousek, escaped to Harvard in 1968, he found himself having to teach women with PhDs how to cuddle their children.

Then Papousek and others began to find out how the all-important job of creating competent human beings out of the squalling bundles of shit ought to be done. They videoed normal, un-schooled mothers interacting graciously and skilfully with normal babies. Neither child nor minder is Originally Vacuous, dependent on society to tell them what to do. Both are genetically programmed for the playing and the conversations in baby-talk that socialise the infant and let it use brain mechanisms unique to our species to acquire his/her 'mother tongue' – an apt name indeed for the sublime gift of language.

'Hold on,' the editor says. 'The mother has still been through a social learning experience.' Yes, but any deliberate inculcation of how to do the job is as likely to be harmful as helpful. The genetic programmes supply a repertoire of intuitive signals and responses to signals (head positioning, eye and eyebrow movements, melodic vocalisations, and so on) of which the mother is so unaware that she may even deny what she has done. The split-second speed of the reactions is simply too fast for rational thought.

Further confirmation that these crucial socialising skills are quite independent of the content of what grandmother taught mother comes from fathers and non-relatives. They interact with babies by exactly the same intuitive repertoire, which is also dependent of ethnic origins, culture and age. Even a three year old child will switch to the

sing-song of baby-talk when addressing a six month old.

The real honours for intuition belong to the baby, who is born knowing how to elicit attention to his/her social and cognitive needs, and how to engage in a tennis match of non-verbal communication. The videotapes confirm that the pronouncements of greybeards about innate human nature or its absence bear little relationship to what babies actually do. Neither sinful nor vacuous, what they seem to exhibit is Original Virtue.

In archaeology, Original Vacuity meant that 'primitive' people were stupid. The idea was that 'civilisation' relied on amassing clever ideas in a centre of excellence, the Near East, and then diffusing them to the backward barbarians. This was a projection back in time of the compulsion, shared by colonialists and Marxists, to tell other people how to live. Radio-carbon dating blew up the idea of diffusion. It showed, for example, that the domestication of crops in the Near East was matched by simultaneous developments in South East Asia and the Americas. Great megalithic structures in Western Europe turned out to be older than the pyramids of Egypt.

The message now is that people everywhere were smart and inventive. Alas, the academic pendulum swung too far the other way. Anti-diffusionists tried to deny the role of superior technologies in trade migrations, and outright conquest – as if people behaved differently before they learned how to write history books, as if they burnished their weapons just to decorate homes that they never left. But the newly tamed horses of the Indo-Europeans, for instance, undoubtedly helped them to break out east and west from their homeland north of the Black Sea, and bully the indigenous peoples of India, Iran and Europe. We can expect a clearer picture of the relative importance of duplicated invention, trade and movements of populations, to come from the marriage of archaeology and the new genetic geography.

Of course 'civilisation' in the diffusionists' sense meant institutions as well as technology. The Near East can still claim primacy in the taming of human beings and the creation of the state militant. Such notable innovations as class distinctions, tax collecting, bureaucracy and chronic warfare came first in the petty priesthoods and warrior kingdoms of Sumeria and Egypt. I commend to anarchists an examination of the record emerging from scientific archaeology.

Broadly egalitarian and generally peaceful communities persisted for many millennia in the late Palaeolithic and early Neolithic. Perhaps they vacillated between male and female leadership according to

whether the main resource was animal or vegetable. The authoritarian, class-ridden state, with its concomitants of slavery and male privilege, seems to have started as a protection racket by commanders reluctant to give up the temporary privilege of battle. The would-be warrior kings of Bosnia and Somalia are examples in the 1990s.

Make sure there is always an enemy, or a possible enemy, and you never need put on your civvies and go back to weeding the crop. You can just go on bossing people about. The only fundamental change over the millennia is that we have discovered that the state was invented by men, not gods, and so can be disinvented.

The virgins of Samoa

Most farcical in its origins was the idea of the cultural anthropologists that sex could be a casual matter. Flying in the face of all individual experience, and all accounts of sexual anguish from Troilus and Cressida to Charles and Diana, the school of anthropology led by Margaret Mead alleged that free love was a viable option. Mead had discovered it on the Samoan island of Ta'u, in a five-month sojourn in 1925-26. Her bestseller, *Coming of Age in Samoa*, told of promiscuity among the adolescents of the island that made readers drool with envy. Mead became the mother-goddess of American anthropology.

Derek Freeman of Canberra wrote a reasoned refutation of Mead's 'cultural determinism' – the anthropologists' version of Original Vacuity. He showed that her findings were at odds with all independent ethnographic evidence. The nadir of anthropology in the twentieth century was the day in November 1983 when, in a tribal conclave in Chicago, the American Anthropological Association voted that Freeman was unscientific. The result was the least of it. The decision put such an issue to a vote blew away any pretensions of those social scientists to be serious imitators of natural science. Contrast this with the humble respect for facts expressed, albeit arrogantly, by the physicist quoted earlier. You don't take a vote on whether the electroweak force exists.

The anthropologists had their come-uppance a few years later when Mead's evidence turned out to be a pack of lies. They were deliberate lies, told by giggling Samoan virgins to the American lass who kept asking them dirty questions about taboo subjects in a fiercely puritanical culture. In a sworn deposition, an old Samoan lady called

Fa'apua'a Fa'amu recalled that she was affronted when, in 1926, Mead questioned her virginity. This was the more serious because she was a ceremonial virgin for her island. She and another girl, Fafao, set about hoaxing Mead, and they imparted to her the opposite of the truth about Samoan sexual mores.

They did not know that Mead would write it down in a book or that people like J.B. Watson and Bertrand Russell and the founders of a thousand hippie communes would believe it. The dusky maidens were simply following a Polynesian tradition of punishing the over-inquisitive by telling tall stories. Freeman cites the Tonga words for very large numbers, solemnly gathered by a French savant of the eighteenth century, which subsequently proved to be a string of ribald obscenities from a Tongan Rabelais.

The evolution of society

The pioneers of sociobiology, the emergent science that seeks to trace the genetic and evolutionary origins of social behaviour in animals and humans, have faced a chorus of vilification from the Left. Yet again there has been a failure to accept, or at least to await, the verdicts of Nature. No, the very idea that our conduct is strongly influenced by our genes is unacceptable, even to some left-wing evolutionists and geneticists. Somehow human social behaviour is supposed to be the one feature of life on the planet exempt from the principles of heredity and evolution.

Peter Kropotkin never imagined that. On the contrary, in *Mutual Aid*, he saw altruistic behaviour in animals the roots of the human altruism on which all his hopes depended. And the geneticist J.B.S. Haldane, who was a Marxist until Lysenkoism disillusioned him, pondered the riddle of how altruism could have evolved despite the obvious rewards of selfishness.

The very existence of society is amazing. Biologists know that, in achieving an approximate harmony in communities numbered in hundreds and even hundreds of millions, humans have pulled off a feat unrivalled among the other animals. Only the ants and the bees seem to mimic us, but they do so on the basis of close family ties, whereby service to the insect community directly promotes the survival of the workers' genes.

The human miracle is that we co-operate with people who are not our relatives. As with the British lifeboatmen so admired by Kropotkin, we will risk our own lives to save strangers whose names

we don't even know. In conventional Neo-Darwinism theory what counts is the survival of one's own genes, so selfishness ought to prevail. The evolution of human altruism made no sense at all until, in the 1970s, biologists began to reason that a creature with a long memory and a calculating mind could think in terms of trade-offs over a period of time. Today I'll help you (i.e. your genes) and maybe sometime you'll help me or my family (i.e. my genes).

What stops this reciprocal altruism being pollyanna-ish, and therefore unbelievable, is the ever-present risk of cheating and behavioural bad debts, by those ready to exploit other people's good nature for their own advantage. The biologists have turned to game theory, and experimental games run on a computer, to sort out the nuances of co-operation and defection. They find an 'evolutionarily stable strategy' which could evolve and endure despite repeated efforts by selfish individuals to wreck it. Called 'tit for tat', you offer co-operation as a matter of course, but if the other fellow tries to take advantage of you, you retaliate just once by defecting yourself. Then you offer forgiveness and resume your co-operative policy.

This must be an over-simplification of what went on in the Old Stone Age, yet it is broadly persuasive as a solution to the evolutionary riddle. It jars with many people to think that they should take no personal credit for good behaviour implanted by evolution. That is not surprising because our feelings of righteousness or guilt seem to be devices that Nature uses to encourage our altruism.

Cheating remains an everyday fact of life, aided by the amiable gullibility that characterises human trust. And because our brains need labels to maintain their ledgers of services rendered, co-operation works best in clearly identified groups or teams. The readiness with which human beings submerge themselves in a common cause makes organised warfare and football hooliganism all too easy to orchestrate.

Yet human beings remain a good deal less murderous than most other carnivorous vertebrates. Better observation of animals in the wild, and re-examination of fractured skulls of early hominids, put paid to the gross error of some palaeontologists and animal behaviourists who thought that human beings evolved peculiarly red in tooth and hand-axe. Supposed cannibals in the African fossil record turned out to be victims of leopards.

As human beings loyal to their own groups, the geneticists and sociobiologists are tempted to overstate their claims. People are not genetically programmed robots. We must keep saying that loud and

clear, especially at a time when geneticists are reading more and more of the programmes, in the Human Genome Project. Nevertheless sociobiology plus the studies of infants mentioned earlier provide the best of sustenance for Kropotkin's belief that people are born co-operators, and a better world is possible.

Three-dimensional people

The argument about nature and nurture, or genes versus environment, was always pretty silly. By reason of their specialist interests or their ideologies, people have wished to exaggerate the importance of one factor or the other. Technically, the fallacy lies in a tacit assumption that the effects of nature and nurture are additive, like two pieces of string tied end to end, and the issue is supposed to be which string is longer. In reality, the effects of genes and environment are multiplied together, like the length and breadth of a field. To ask which is more important is meaningless. If either nature or nurture is zero, you finish up with nothing.

The evidence from the infant psychologists and sociobiologists indicates that people are predisposed by their genes to be high-spirited, kindly and talented members of society. To match the promise of their genes, their early environments *must* supply nutrition for their bodies and minds, motherly love, and playful interaction with their peers.

But we are neither one-dimensional strings nor two-dimensional fields, which is why I deliberately use two words here which were out of fashion in scientific and political theory in mid-century 'mind' and 'love'. They introduce the third dimension that completes the human being. Orthogonal both to the predispositions of the genes and to the utilitarian content of nurture and learning is the emotional and imaginative axis of personal consciousness. You can raise genetically identical twins in the same home and schools, and yet have them turning out as very different people, in their careers, hobbies, habits and beliefs.

Every good teacher knows that before learning comes the motivation to learn. Politicians use evocative symbols and magical words more assiduously than reasoned argument. Religious preachers appeal directly to the spirit and even dissenters don't laugh because most people at least guess what 'spirit' means, as a matter of subjective experience.

When a scientist makes an unexpected discovery, he/she alone

knows for a few minutes or hours something that no one ever knew before. It was written neither in the genes nor in the textbooks, but leapt new-formed from a human mind contemplating Nature. To say so would seem trite, if overweening geneticists and behaviourists did not in effect deny their own human capacity for independent motivation and original thought when they proclaim either the genes or learning to be all-important.

With the dubious exception of psychoanalysis, there are no textbooks of consciousness. Instead, for information about human behaviour in its most distinctively human forms we have to turn to history, biography, journalism and literature. But consciousness is now back on the agenda of natural science, as brain researchers steel themselves to grasp the old mind-matter nettle. They have to try to say how electrochemical processes in brain tissue create the movies in our heads. They have to explain how a train of thought translates back to the material world in the form of voluntary actions, creating at least an illusion of free will.

There is no reason for expecting early success. Indeed the subject has been long neglected because it is so difficult, and reeks of subjectivity and self-reference. Prudent natural scientists shy away from problems they can't solve, but that gives them no right to sneer at the comparative lack of progress by the social scientists, who have rushed in where natural scientists have feared to tread. The effects of learning and a *fortiori* of voluntary action are much less amenable than genetics to generalisations of a clear-cut kind. Yet these are precisely the areas where enlightenment is most urgently needed, if we are not to leave a radioactive desert as the end product of all our intellectual efforts.

I hope we can call a truce to the sterile prejudices about nature and nurture, and build on the successes of the biologists, to achieve a more recognisable, three-dimensional picture of human beings as individuals and societies. Geneticists should be required to say what they believe are universal human traits, and what are the key genetic variables affecting individual behaviour. Instead of trying to deny the genetic factor, and assuming the near-infinite malleability of the *tabula rasa*, social scientists would make a much firmer case of the role of learning by addressing the question, 'Just how malleable is human behaviour, in this context and in that?'

On a positive note, let me recall a series of experiments with schoolboys by the late Henri Tajfel, a social psychologist of Bristol. He confirmed the human propensity to favour one's own group,

unfairly and irrationally, however arbitrary and meaningless the assignments to groups might be. It was a dazzling insight into the group behaviour that underpins the great achievements of human teamwork and our awful inter-group conflicts. In deference to his social-science colleagues, Tajfel was careful to call his discovery a 'generic' trait, rather than a genetic one.

This is just the sort of thing that cries out for multi-dimensional analysis. Let's pinpoint the genes that set the stage for group behaviour, and look for differences between the sexes that may explain why warfare is a male pastime. Let's study the role of experience and learning in group behaviour, and ask backhanded questions about its tone, as inculcated by the educational process itself. And in the dimension of consciousness, let's analyse the tricks that leaders and demagogues use, to create, stimulate and steer a group. Last but not least, how do we explain to the outsider, whose group behaviour is abnormal and who is liable to be called a rebel, a criminal or a mental patient?

Forbidden states

We have come to a crisis where the social order cannot safely cope with scientific knowledge and its applications. The radio astronomer Martin Ryle won a Nobel Prize for inventing a technique called aperture synthesis. When the technique was adopted in radars and sonars for nuclear warfare, he was driven to ask, "Should science be stopped? We don't *have* to know how galaxies work."

I put the question another way: 'Can people be trusted with potent knowledge?' When the ancient Greeks set out the agenda for human enquiry they said Yes. They affirmed their confidence that people on the whole are decent and sensible. Everyone who has pursued knowledge since then has tacitly shared that view. And yet we have reached an era of mortal danger, in which nuclear weapons are not the last word in methods of mass annihilation. For example, we must contemplate the possibility of genetically engineered pathogens and toxins for military purposes, including viruses tailored to kill people of a particular sex, skin colour or ethnic background. The ex-Yugoslavs may seem like amateurs when it comes to ethnic cleansing.

If we avoid a holocaust our freedom, such as it is, is threatened by novel systems of surveillance. Bugging devices, computer correlations and satellites looking down from the sky will make the apparatus of

George Orwell's Big Brother seem very primitive. The perils to life and liberty are connected. The physicist Freeman Dyson has warned that the wish to clamp down on clandestine manufacture of weapons of mass destruction may lead inexorably to the creation of a global police state. Look at what's happening in Iraq and Korea, and think about it.

I put matters as starkly as possible, before asserting that the Greeks were right. Ordinary people are okay, and I cite the evidence of Original Virtue in support of that view. The threat to life and liberty flows mainly from the recent yet already obsolescent organisation of humanity in nation-states. Inherently, nation-states are not particularly worse than they ever were. On average they may be better, in terms of human rights. But when in the name of policy they arrogate the right to threaten one another with the fires of hell and endanger everyone else, we see them as artefacts of less than human quality. Conceived in war, with defence as their principle *raison d'être* and with secretive, centralised power as the chief mode of their perpetuation, these are not entities to trust with potent knowledge.

If science and the nation-state cannot safely co-exist, one of them must go. You can stop science only by excising the lobes of curiosity from every newborn child. Therefore the nation-state must be abolished. This is the most important example of the potential of science to change the world by dramatising and amplifying pre-existing moral and political issues.

Some people cherish the idea of world government. There is a long list of practical items that can be handled sensibly only on a global basis, from famine relief and control of epidemics to weather forecasting and safety rules for shipping and aviation. The specialised agencies of the UN sketch the framework for global action, while regional collaborations in economic and social policy, as in the European Union, are preferable to regional.

Much more dubious, in my opinion, is the recent arrogation of political and military power by the UN Security Council. The very name of the United nations reminds us that it is a club of nation-states, and I would sooner be ruled by Baroness Thatcher (*absit omen*) than by unelected delegates from an arbitrary collection of nations, bland or evil. Try as I may, I can imagine no harmless form of world government which accommodates the Chinese, the Masai, the Sicilians and me. I think that Dyson is right, and a global superstate could create a tyranny lasting a thousand years.

To conclude, instead, that the nation-state should be replaced by

regional and global confederations of autonomous communes is unsurprising in an anarchist journal. But I want to suggest that science not only makes such an outcome highly desirable, for safety's sake, but also more likely.

The lead from science begins at the philosophical level. Since the sixteenth century, science has played a big part in helping to undermine the authority of religion, the aristocracy and eventually imperial power, and in promoting liberal-democratic ideas throughout the world. If human beings are born anarchists, in the sense of being able to manage their own affairs without moral supervision or instruction, then science will soon confirm it. If they're not, then forget it.

Original Virtue is far too important to be left to wishful thinking. But I confidently expect continuing studies to verify it, and as the word spreads it will alter people's self-perception. It will be the carrot encouraging them down the road from parliamentary democracy to true self-government.

The stick will be fear of the terrible things that nation-states can do to them. If the primary motivation of social change is to achieve a wiser use of scientific knowledge, and prevent its gross misuse in weaponry and tyrannical surveillance, one must work out in technical detail how to ensure the result. The essence of the answer lies in the inherently open nature of world science and its ability to predict misuses from general principles. People can be advised about what to look out for, in their own localities.

Technologies disrupt geography

There are two other ways in which the application of science will tend to encourage local autonomy. One is by continually unsettling the existing order of society, and the other is by creating the tools of devolution – on which, more later.

The impacts of technological change have reached the point where people realise that their own national governments are not in charge of events. New techniques disrupt industrial geography. When transistors replace thermionic valves and chips replace transistors, or when coal gives way to gas from the seabed, communities whither. Disruption extends to the centres of political power too. Whole nation-states can reel economically when the technological wind shifts. Jumped-up oil sheiks and computer software magnates send more tremors down the corridors of government than any old-time

anarchist bomb ever did.

Events may come to an unpleasant head in the next few years, if the industrial world comes out of recession but unemployment levels remain stubbornly high thereafter, and perhaps even continue to rise. Some foresee this as the result of cumulative mechanisation, automation and computerisation, which now outstrip the capacity of companies to invent or pay for supernumerary jobs in a highly competitive global market. With more and more goods and services coming from fewer and fewer workers, social and economic systems which have been tolerated since the industrial revolution may be insupportable.

The ultimate paradigm is the Santa Claus Machine, a hypothetical robot which eats rocks and makes anything that human beings care to name, from coffee cups to spaceships. How will society run, when wishing to work is to be a nuisance? Will people, by institutional change, manage to transform a grim era of chaotic mass unemployment unto the long-awaited age of leisure in the Land of Cockaigne? I hope they'll try, and that it won't turn out to be the Land of Cocaine.

Nor do you have to look far for other technology-engendered crises. Medicine has replaced armaments as the black hole that is quite capable of swallowing the entire economic product of the world, in a hypochondriac society. Here the extreme vision is the Disembodied Brain, in which the grey matter of an individual unwilling to die prances about in a mobile life-support machine. People will have to find a more rational and humane formula for providing running repairs to the young and for the old a gracious but not indefinitely extended twilight. The issue provokes profound questions about knowledge, human perceptions of the human life-cycle, and the use of resources.

An urgent reappraisal of the relationships of science, government, private enterprise and individuals in society will also be needed to cope with the rise of actuarial genetics. Human genetics gives increasingly clear warnings of susceptibility to various diseases. Insurance companies, and employers too, are hungry for such data on individuals, to lessen the gamble they take on how long people will stay healthy. Those whose genetic printout is deemed unfortunate may find themselves uninsurable and unemployable – second class citizens. If such use of knowledge is deemed scandalous and impermissible, as it should be, that will reaffirm the need for a social contract which takes people at face value.

Green Machines

Kropotkin, thou shoudst be living at this hour. I could quote tonnes per hectare that would make you stare. Remember Fitz Haber fixing nitrogen from the air? That's big business now, Peter. The plant breeders came up with varieties that lap the stuff up, and saved a billion people from famine. The Indians, the Chinese, they're all getting bumper yields. Africa's a hard case still – too little water and too much war. And Lenin's people screwed it up in Russia, which won't surprise you. But in Western Europe, would you believe, we're taking fields out of production because ordinary folk think they're getting too fat.

When, in *Fields, Factories and Workshops*, Kropotkin visualised self-reliant rural communities combining industrial with agricultural work, and brain work with manual work, he was stuck with the technologies of his time. His vision of industrialised Arcadia, which was endorsed by biologists like J.B.S. Haldane and C.H. Waddington, will far more easily and fruitfully be brought to pass in the decades ahead than in the century past. Two key elements are information technology and biotechnology.

Information technology is already making radical decentralisation possible, with glass-fibre or satellite communications that bring the world to the yokel's door. A village can have more megabytes of computing power than London possessed twenty years ago, and easy access to gigabytes elsewhere. Robots make manufacturing relatively easy and highly flexible. These trends are already with us, and well publicised, so that the chief thing to guard against is the blandishments of the software tycoons. That takes care of brainwork and manufacture, with the proviso that people may wish to use raw materials produced locally, largely by biological means.

Biotechnology is waiting in the wings. A long list of items is available for a bucolic package that would captivate Kropotkin. The list starts with mechanical systems like soilless crop-growing and high-tech greenhouses and fishponds. It finishes with the modification of plants and animals by recombinant DNA techniques. In between there are, for instance, smart bugs that can decompose wood, seek out metals or excrete high-value chemicals. Algae in tubes could lap up sunlight and power a diesel engine. Tissue culture could make sausages without the pigs. I could go on, but the upshot is that one can visualise Green Machines running on carbon dioxide, water and sunlight, and making pretty well everything that human beings need in the way of

food, energy, textiles, structural materials and organic chemicals.

The more closely these purposes are integrated, the more efficient the production will become. Agriculture will implode into systems requiring far less land. Ever since the dawn of the Neolithic, the clearing of land for fields has always been by far the biggest onslaught on living Nature. With the global population set to double in the next sixty years or so, the impact could become unsustainable without a radical switch to food factories, or glorified greenhouses if that sounds nicer. But the implosion will overshoot the requirements of increased demand, and will liberate huge tracts of land commandeered until now by the farmers. In principle, these areas could become parkland, or be restored to a quasi-natural wilderness.

Note that this is a 'back-to-nature' scheme diametrically opposed to, and far more effective than, that of the would-be organic farmers. They and their sentimental 'ecologist' friends want to use systems less efficient than those of high-tech agriculture. They reach for their demo banners if anyone mentions DNA. The only possible outcome of their policy, which fortunately no one else takes seriously, would be a desperate assault on the last remaining scraps of marginal land in the world, followed by mass starvation.

The scale of the Green Machines could range from a suburban garden to a large concentrated complex serving an entire continent. They could be located anywhere, on existing farmland, in urban areas, on mountains or in deserts, or they could float on the sea. My favourite image is of a unit serving a large village or small town, say 5,000 to 50,000 people, located rurally and surrounded by restored forests. With all basic needs satisfied locally, trade would be reduced to special equipment such as microchips, luxury items, and information including entertainment.

One way or another, Green Machines will materialise within the next ten or twenty years. The chemical industry may promote them. Or they may result from local initiative, when people realise that they offer an escape from the stresses and injustices of the national and global economies, and the machinations of the money men. For the moment, in Europe, the balance is tipped in favour of local initiative in non-EC countries, because the Community has ruled that surplus agricultural products can be used as chemical feedstock only if paid for at the full food price.

Climatic anxieties may be a persuasive reason why people will turn to the Green Machines. Regardless of whether or not recent climatic changes have been due to man-made carbon dioxide, the climate

fluctuates markedly over time scales of decades and centuries, with disruptive effects on food production. The principal risk from nuclear war, to non-combatants, is the darkening of the sky by soot, known as nuclear winter, which can wipe out the current harvest. There is a growing awareness too of the hazards of volcanic winter, where a very large eruption can have similar effects.

The systems of the Green Machines, largely confined within greenhouses, will be far more resistant to climatic vagaries, natural or man-made. And scientists studying nuclear winter were appalled to discover how scanty are the food stocks of the global population. Joseph's warning to the Pharaoh has been long forgotten. More cheaply than the refrigerated stores of the European food mountains, the Green Machine will provide a means of stockpiling 'unfinished' nutrients against the season when the Sun fails or the plant pathogen strikes.

At the risk of stating the obvious, I point out that the Green Machines offer both a direct stimulus to social change, and a possible response to social change stimulated by other events.

The world is rich

Implicit in what I have said about Santa Claus Machines and Green Machines is a conviction that our planet is much richer than many people imagine. One of the best services that science can render to anarchism is to get rid of the very off-putting idea that what it offers is a dignified poverty. A scientific commentary seems hardly necessary, when Switzerland, the closest approximation we have to a confederation of anarchist communes, enjoys the highest per capita income in the world. Nevertheless some writers take a pessimistic view of the economic prospects.

I brush aside George Orwell's suggestion that anarchists could never build an aeroplane. At the level of organisation and enterprise, are we to suppose that an anarchist society will have no bridges, no ships, no fertiliser factories? At the level of motivation and manual competence, Orwell cannot have mingled with the people who build their own homes or yachts, tend vintage motor cars or restore old steam locomotives. Give those people computer-controlled machine tools and there is very little they could not fabricate.

More alarming, because more fashionable, is Colin Ward's blunt statement that an anarchistic society would necessarily be poorer. He accepts the environmentalists' anathema on economic growth. The

inference is that the industrialised countries must get poorer in order to share very limited resources more fairly with the Third World.

But the world's poor don't want a more equable poverty. They want cars, television sets and computers, and nice homes and clothes like the rest of us. Why on earth shouldn't they have them? Well, you can argue about cars and congestion, and talk of transport systems instead. Whatever they are, they will probably be made of iron, one of the commonest elements on the planet's surface. Television sets and computers are glass, silicon and a little copper. Houses are clay and wood. Clothes are cotton and wool.

It is high time to send the ghost of Thomas Malthus back to his grave in Bath, and to wonder why many people who regard themselves as being on the Left are so eager to join with the right-wingers who have always used Malthus's ideas to justify poverty. His central proposition is that population tends to increase in a geometrical progression (1, 2, 4, 8 ...) and resources in a linear progression (1, 2, 3, 4 ...). This never described any real world. For non-human species, resources do not increase at all, unless there is a benign change in the environment. For humans, the rate of increase in resources is technology-dependent. It can be anything from zero to a geometrical progression faster than the population growth. Moreover, humans can control their populations. They have done so spontaneously in the industrialised world, and in most Third World countries the rate of growth is already easing. Projections suggest that the global population will level off at twice the present numbers, some time in the 21st century.

That would be a lesser relative increase than we have experienced in the twentieth century, when the population has trebled. Resources have more than trebled in the same period. In particular, food production has kept ahead of population growth, confounding all the prophecies of mass famine. People's life expectancy has shot up too – a pretty good indicator of improved well-being.

These simple facts should have silenced the Malthusians, but instead they have changed tack. Economic growth, they say, is unsustainable because we are pushing at the limits of the planet's resources and fouling it fatally with pollution. They confuse some gross examples of harm to the environment, which are of course deplorable, with general tendencies. Projections of pollution made just twenty years ago are already falsified. And shifts in technology and policy are tending to restrain the pressures on resources and the environment.

As I tend to get into heated arguments with environmentalist friends,

let me mention my personal record in this area. In the early 1960s, before Rachel Carson's *Silent Spring*, I was publishing John Hillaby's articles on the poisoning of birds by DDT – and coping with the wrath of the chemical industry. In 1967 the publisher of the US edition of my book *The Environment Game*, which set out a programme for reafforestation of the Earth, insisted on changing the title because, he said, 'environment' meant nothing to the general public. Not until 1970 did the media and the *vin rouge* set really discover the environment. In 1973 a guide to the environmental sciences, which I edited, looked hard for the intellectual meat in the thin soup then being served up, and in the following year I put Bert Bolin on multinational television to expound the hypothesis of greenhouse warming, long before most people had heard of such a thing. In 1978 I did the same for Jim Lovelock and the Gaia hypothesis.

Since then I have watched the tender shoots of scientific ecology and Earth-system science being trampled by green wellies. And just like their imperial grandparents who bullied the world in the names of religion and commerce, the environmentalists of Europe and North America are having a lovely time telling everyone else how to live. From the comfort of their own deforested continents, where they spew carbon dioxide galore into the air and bleach their remaining trees with automobile exhaust, they reproach the Brazilians for living in Amazonia and the Chinese for burning coal. When the Indians say, very well, we shall use nuclear energy which releases no carbon dioxide, the eco-colonialists throw up their hands in Politically Correct disgust.

Just try quoting the calculations of a distinguished group of scientific ecologists in the US, indicating that a greenhouse world will be luxuriant, because the plants will love all that extra warmth, rain and carbon dioxide, and you will be shouted down by the environmentalists. Ditto if you point out that stress is good for forests, and that forest fires, hurricanes and ice-age droughts are Nature's ways of renewing the forests and diversifying the species. Environmentalism has become a pagan religion, with the unverified Gaia as its goddess, and its hatred of heresy stifles rational discussion of real and urgent problems. Thus many people still believe that the Sahara Desert is advancing southwards at several kilometres a year, and that half of Amazonia has been deforested, despite the clear evidence from satellites that falsifies both propositions. When I pointed this out in a radio discussion, a woman journalist voiced the hope of obscurantists through the ages, that it would not become

generally known.

We are indeed seeing many parts of the planet being ransacked clumsily by strangers for private profit, to the great harm of the local environments and people. This is wicked, so good luck to Greenpeace. You can make out a thoroughgoing case for anarchist self-rule on the grounds that only the local people understand an environment thoroughly enough to look after it properly. But all of this has very little to do with the general running of industries and services, or with the supposed limits of the earth's resources.

The Malthusians predicted the imminent exhaustion of tin and lead. Instead prices plummeted and mines went bust. They predicted the exhaustion of oil by the 1990s. In practice, the price of oil remains so stubbornly low that the development of all the alternative energy sources that could replace it is hampered. Regrettably they can't compete.

The one undeniable limiting resource for human well-being is well-watered land managed in a way that prevents soil erosion and other forms of degradation. This is why I have stressed the importance of pushing up yields and imploding agriculture, so that the reduction in demands for land already apparent in Europe and North America can occur also in the densely populated agrarian regions of the Third World.

Otherwise, I see no reason for wishing poverty on anyone. More and more wealth is being concentrated in silicon chips, compact discs and the like, where miniaturisation makes the demands on material resources smaller and smaller. There is of course plenty of scope for argument about the desirability of particular forms of wealth and economic habits, as mentioned in connection with cars. That is another matter entirely, closer to aesthetics than to limits of resources.

Colin Ward asserted in the aftermath of the Apollo mission that an anarchist society "would never land men on the Moon". I leave aside the question of how he knows what an anarchist society will or will not do, and read the remark as 'should never'. Why not? Space exploration gives interesting employment to many thousands of people, uses trivial quantities of materials, and is a far more adventurous channelling of surplus skill and enthusiasm than either cruise missiles or ornamental raffia work. As NASA kept reminding American taxpayers, sending the Apollo astronauts to the Moon cost them less than they spent on cosmetics over the period of the programme.

Studious passivity

I was one of the awkward squad who asked why, if the Marxist future was supposed to be an historical inevitability, anyone had to *do* anything. About anarchism I feel much the same, though much more optimistically. It must be a spontaneous process, engineered by local people. No one else, myself included, should dare to specify modalities, still less to agitate as an outsider.

If anarchism is latent in our genes, learning and imagination, and it is appropriate to our times, then there are a million villages and city wards in the world where it can evolve. Some experiments may fail, but if it worked well enough in just one place, it could replicate very rapidly. If it doesn't happen, if it doesn't work, then maybe it wasn't a good idea after all. We should be as humble about the verdicts of social experiments as about those addressed to Nature.

Within the existing political framework, one can campaign for genuine subsidiarity right down to the village level. Er ... that's it, as *Private Eye* would say. Forget the old left versus the right arguments. Who knows what opinions the inhabitants of an anarchist society will hold? Th evidence from Switzerland is that they will be awfully conservative. Maybe that's what happens when folk are genuinely in charge of their lives. So be it.

I recommend a studious passivity. But if armchair social changers give up telling other people what to do, they can channel their zeal in three less impertinent directions. One is to follow and ponder the trends in scientific knowledge and its applications. Use your head, not for capricious daydreaming about revolution, but to try to understand people and their latent powers as seriously and objectively as an astro-physicist contemplates the thermonuclear furnace at the heart of the Sun. Then by all means publicise those items of knowledge and technology that could facilitate your desired social change, and hope that someone listens.

Secondly, monitor human social behaviour worldwide, looking for publicisable breakthroughs that favour decentralisation and participative decision-making. My premise that the process can start anywhere is nicely exemplified by the pumpmakers of Sao Paolo whose astoundingly anarchistic company, Semco, is the toast of the business schools. Workers decide their own wages, and they have pushed up productivity sevenfold. Perhaps that's how the revolution will happen: simply by beating the capitalists in the market-place. But Semco also vindicates passivity. The business schools and

management press are already making a thorough job of propaganda for Semco, and if anarchist ideologues start whooping too loudly they could frighten people off.

The third suggestion is this. If you really think you have useful ideas of your own, then employ science fiction to create an attractive menu of technological and social opportunities. Why not grab your Hi-Tecpoint pen and offer *The Raven* a synopsis of your Space Age *News from Nowhere*? If, after all that, the hormones of political enthusiasm still fizz toxically in your bloodstream, then start on your home community as a laboratory for social change. At least you may claim some indispensable local knowledge. Personally I'd be happy to hear from anyone promoting a Sussex Liberation Front.

Science and Imagination

The scientific paper is a fraud ... in the sense that it does give a totally misleading narrative of the processes of thought that go into the making of scientific discoveries. The inductive format of the scientific paper should be discarded ... scientists should not be ashamed to admit, as many of them apparently *are* ashamed to admit, that hypotheses appear in their minds along uncharted by-ways of thought; that they are imaginative and inspirational in character; that they are indeed adventures of the mind. What, after all, is the good of scientists reproaching others for their neglect of, or indifference to, the scientific style of thinking that they set such great store by, if their own writings show that they themselves have no clear understanding of it?

Peter Medawar, *Is the Scientific Paper a Fraud*, BBC Talk, 1964

César Milstein talks to Colin Ward

The Background of a Scientist

César and Celia Milstein are both biochemists who have worked in Cambridge since 1963, he at the MRC Laboratory of Molecular Biology, she at the Institute of Animal Physiology. They first came to Europe in 1953 after qualifying at the University of Buenos Aires, and later to Britain in 1958.They saw the first visit as a honeymoon and a time to decide what to do with their lives. The second gave them a chance to meet the writers for *Freedom*, whose work they had translated for the famous Buenos Aires anarchist journal *La Protesta* (founded in 1897 by an Irish doctor, John Creaghe). In 1958 César has been awarded a British Council Fellowship, and they returned, permanently as it turned out, in 1963 after one of a series of military coups in Argentina. César had been the head of the division of Molecular Biology at the National Institute of Microbiology. This was an important centre for the production of vaccines, founded by a German immigrant on the lines of the French Institut Pasteur. (He recalls that while he was working there, large quantities of smallpox vaccine were sent to Britain because of an outbreak of the disease here.)

The Minister of Public Health appointed by the military junta attacked the director of the Institute. The staff protested to the Minister and four member's of César's team were dismissed, on the grounds that they were bad scientists. His response was "They are good scientists. Either they come back or I go." He is still waiting for a reply to his letter. The National Research Council offered him space and facilities elsewhere. But, as he explained to Jonathan Steinberg on Radio 4 (22nd February 1990):

"My question to them was, 'Can you guarantee that what happened to the Institute will not happen to universities, or indeed to the National Research Council?' Of course they were unable to guarantee that. So I said, 'Well, I'm afraid that, if something like that happens, I will be subject to the same kind of pressures.' And they said, 'If you have the skin of an elephant then you will be able to survive, as most of us survive here.' So I said, 'I don't want to have the skin of an elephant. Scientists should not have the skin of an elephant, but a skin of silk, so that they can listen and feel the atmosphere in which they

live, and react just as much as any other human being with sensitivity actually does'."

Steinberg asked, "So it isn't the case that the scientist practises his pure science in some ivory tower?" César replied:

"Well, some of them think they do, and certainly the public perception may be that way, but it is certainly not the case. All laboratories are subject to the winds and influences of the outside world, and if they think they can get away from that, reality often hits them very badly. It is like that in sport actually. No one can say 'I don't want to be subjected to any politics' or something like that. In a certain way, that itself is a statement of political belief."

César Milstein's work in Cambridge on the structure, evolution and genetics of immunoglobulins and phosphoenzimes has led to world fame, a reputation as 'the father of monoclonal antibodies' and to a succession of scientific awards, including that of the Nobel Prize for Physiology and Medicine in 1984. It was characteristic of the moral climate of Thatcherite Britain that reports of his particular discovery concentrated not on its medical importance but on the fact that he had failed to patent it. Thus the scientific correspondent of *The Observer* (21st October 1984), under the headline "Lost millions of the Nobel magic bullets", found it "somewhat surprising" that Dr Milstein was *glad* that monoclonal antibodies were not patented to earn Britain foreign currency, and that their discoverer actually believes that "patents are financial swindles that prevent the public from having access to information".

I went to Cambridge to ask him, not about his work, but about the background and youth that led him to a life in science. This is what he told me.

* * *

My father was an immigrant in Argentina just before the First World War. He came on his own at the age of fourteen. He was the son of the man in charge of the household in a manor house somewhere in the Ukraine, one of the younger children of a family reared in the Jewish tradition – synagogue and all that. When he arrived at Buenos Aires he didn't know a word of Spanish, of course, but went immediately to the interior where there were some Jewish colonies or settlements of poor, small farms. He was adopted, more or less, by a very nice family on the farm where he went to work, and grew up there. The people on this and the surrounding farms would get together to read and discuss social issues. They were very strongly influenced by the protagonists of anarchism. I think that this is partly

how he learned to read and write. He was completely self-taught and never went to school, but became an avid reader. He was very active in the anarcho-syndicalist movement, and worked in a number of trades, on the railways and as a carpenter. But he turned out to be allergic to the materials used in finishing and polishing wood, so he had to change trades again.

By then he had probably got to know my mother, who was a great influence in his life. She was a schoolteacher. They came to the city of Bahia Blanca where he was working as a shop assistant and then as a travelling salesman. My mother was appointed, very young, as the head of a school, and I was born in the teacher's house, right next to the school which, later on, was the one that my brothers and I attended. We used to climb up the dividing wall and look at the children on the other side. By the time I went to school she had retired, rather young, as she too had a health problem – trouble with her voice. All the teachers remembered her and had a great admiration for her.

I never knew that my father was an anarchist until a very long time later. He was always concerned that we should read about social issues. I remember him being very annoyed with me because unlike my elder brother, who was a good son, I was a complete nuisance. My brother was an intellectual from the beginning, an endless reader both of novels and sociological books. But I was very bad in that sense. The only thing I liked was playing in the street with the other children. I thought that books were boring and that there was nothing interesting in them. But in spite of that I was interested in science from very early on. It sparked something.

My mother was the one who realised that, and she too was desperately trying to get me to read something. The first book that really converted me into a book-interested-person was a translation of *Tarzan* by Edgar Rice Burroughs. That converted me. I thought it was magnificent, and very interesting. So my mother said, "Ah, there's another one, very similar", and then she introduced me to Rudyard Kipling's *The Jungle Book* and *Kim*. She was a teacher, don't forget. And then there was a girl cousin of mine who was working in one of the research institutes in Buenos Aires, on snake venom. I must have been about eleven when these two cousins came to see us. They were just-graduated university students, working on research, and talked about the preparation of vaccines. And I was absolutely fascinated by their stories. My mother realised that, and then my father, who would always bring back books from a friend with a bookshop in Buenos Aires, gave me a book called *The Microbe Hunters*

by Paul de Kruif. It had an enormous influence on a lot of children. When I read it I was thirteen or fourteen, and I remember very clearly saying "That's what I want to do". This was the sort of book I would read. It was an adventure story really, and I have always tended to read novels, even today, more than other books, even scientific books actually.

By the time my father had started on a more businesslike career, he had become rather detached from the anarcho-syndicalist movement and was much more active in issues related to the Yiddish language – he was a great defender of Yiddish. He had contact for a long time with the people from an organisation called the League of Nationalist Culture and the journal *Dos Fraye Vort*. He would always visit them on business trips to Buenos Aires and in Bahia Blanca he was involved in the non-religious Yiddish cultural movement and the founder of a Yiddish library there. These were not necessarily anarchist activities, they were the liberal, secular sides of Jewish life. Much later on, when we were at the university in Buenos Aires, he retired and came to live there too, and was even more concerned with these affairs. He was a close personal friend and admirer of Gorodisky, the editor of the *Fraye Vort*, whom he saw as a great intellectual. My father was also an intellectual in his own way, but as he was a self-taught man he was always very shy about his own 'dabblings in culture'.

One story about him is very revealing. After my university career my first job was in a laboratory doing clinical analysis. I did that half-a-day and in the other half-day I started doing a PhD. In those days to do this you didn't receive any money, and in fact the professor who was my supervisor hardly earned any money himself although he was a full-time scientist. He was extremely poor, but totally dedicated. Not only did we lack money, but even the most rudimentary things for research purposes. We used to work with yeast and we had to buy the yeast ourselves. He would pay for one pound of it each time I had to make a preparation. There was a certain amount of equipment around, so we had to make do with what was there or what he could occasionally buy, but there was no money for everyday running expenses. Now one day my father noticed that my salary was pitifully small. He didn't like that and thought I could do much better.

Now I was very independent and didn't want his help. But he said, "Look. You're fully qualified, so why don't you set up a laboratory on your own?" I said, "Well, I just want to finish this thesis. It's not a question of money." So he said, presenting it as a business deal, "Why don't I just make you a loan?" I explained that I only needed

enough to survive on while doing my thesis. But he persisted: "But what are you going to do after that? You must have some way of earning a living." I was rather embarrassed, so in the end I said, "I just want to do research". And he said, "But what exactly can you become after that?" So I replied, "Well, I could be a professor at the university." Suddenly he looked at me and said, "If that's what you want to be then go ahead. Can't I help you just a little bit?" He couldn't quite figure out what the whole thing was all about, but that kind of aim would be fine.

When I was a student, my first year at the university had been very tough. I had to work very hard and was not interested in anything else. My elder brother, on the contrary, had always been interested in sociology and politics and he knew about anarchism when very young, but he never told me anything and never tried to influence me. So I was completely oblivious. But at the university there were a lot of student movements and I gradually found that the people involved in them were the most interesting people there. They were involved in the turmoil at the end of the Second World War, and the celebrations and demonstrations at the time of the liberation of Paris. The government of Argentina, though officially at war, was in practice really pro-Nazi and didn't like these demonstrations. And I saw how the police were quite rough with the people.

I became quite active in student politics, which were not supposed to be connected with party politics, but with a sort of involved but independent point of view. It was called the Reformist Movement in Argentina, and was quite influential on a whole generation in Latin America. So I was essentially a Reformist. I discovered that there were different political movements and I tried to understand which was my particular niche.

A lot of my friends turned more and more towards communism, but somehow (perhaps it was in my genes) I knew from the start that they were wrong, and I started to read. We had a small reading group and we read the book by Lenin, *State and Revolution*, and it was that that made us anarchists. We realised that the snag about the whole idea of the 'dictatorship of the proletariat' was that it was a confidence trick. Then we read a book by the anarchist José Garcia Pradas that exposed the whole thing. We became interested in anarchism in that way. That didn't make me an anarchist in an active sense, but we were now confronting our communist colleagues with a much better ideological background, and we knew what we were talking about. We got involved with other students from other faculties and other

universities and we started what was essentially an anarchist group, and we started to make contact with real anarchists and got in touch with the people of *La Protesta* who were struggling to keep that journal alive.

They were an older generation who had survived imprisonment in the 1930s, members of the FORA (Labour Federation of Argentina) which had lost its influence and strength as a result of the military seizure of power in 1930. We were the young students coming in, full of energy and wanting to take over the paper and change it. And they were the people obliged to say, "That's all very nice, but after a few years you will disappear and *we* will have to keep the paper going." And they were essentially right. For soon after that I became more and more completely involved in science. However, there were others, like my brother Oscar, who did not become scientists and continued with *La Protesta* or similar activities to the very end.

Scientific Knowledge

As a product of a socially organised activity, scientific knowledge is very different from soap and those who plan for science neglect that difference at their peril ... The illusion that there is a natural science standing pure and separate from all involvement with society is disappearing rapidly; but it tends to be replaced by the vulgar reduction of science to a branch of commercial or military industry. Unless science itself is to be debased and corrupted, and its results used in a headlong rush to social and ecological catastrophe, there must be renewed understanding of the very special sort of work ... of scientific inquiry.

from J.R. Ravetz, *Scientific Knowledge and its Social Problems*, Oxford University Press, 1971

Alan Cottey

Science, Scientists and Responsibility

Is Responsibility Possible?

In the classical myths, we often read how some god knows the outcome in advance – it is predetermined. If we take this notion seriously, and hold on to it all the time, the rest of the story is tedious. But the focus of attention shifts. We get involved in the struggles and emotions of the humans. Their problems are real and they do not seem to be automatons. We identify with them.

This ambiguity in the myths has, I think, a direct connection with our modern world-view. The sequencing of the genomes of lower organisms and of humans proceeds apace. So does discovery about how the genes are expressed, and how the ensuing production of appropriate proteins produces a complex organism of differentiated cells. More and more aspects of the life of simple organisms and of people are being treated mechanistically.

Will we go so far as to say that social responsibility is meaningless, because even moral actions are determined? Commonsense says 'no'. Can Leo Szilard, who prodded the US into a sense of urgency, be held responsible in some degree for the fact that atomic bombs were completed before the end of the war between the Allies and Japan? Commonsense says 'yes'.

I accept this commonsense view. I see no prospect of the new genetics predicting the most complex social processes and thereby undermining the notion of social responsibility. (The philosophical conundrum of reconciling determinism with responsibility is an old one. It is made even more problematic by the recent progress in genetics. For those interested, I supply in the Appendix a brief 'where I stand' statement about this and related foundations.)

What's Special About Science?

Science is one of those umbrella words, like democracy, which are used in a subtle way by each speaker, setting up many resonances with the hearer's earlier experiences, but sometimes also obscuring

connections. I shall use a broad meaning, embracing such phrases as 'pure science', 'systematic and formulated knowledge', 'applied science and technology' and also the associated human activities.

Social responsibility relates, of course, to all kinds of human activity. Modern science, however, provides special problems in relation to social responsibility. *Science is special in three ways.*

First, we now have the ability to make a complete pig's ear of the planet, and in several different ways. For those still reluctant to accept this, Clive Ponting's *A Green History of the World* (1991) gives examples of local ecological destruction by humankind in history, using technological means modest with those we now 'command'.

Perhaps the glowering stone gods of Easter Island are giving us an awful warning. A thriving community deforested the island, and when Admiral Roggeveen arrived in the early 18th century he found a depressed and struggling society. (It must be noted, however, that religious matters are best interpreted cautiously. The Islanders' downfall seems to have been due to unsustainable tree-felling to provide rollers on which to transport the huge stones.)

Second, science gives us the ability to recognise causalities and links which formerly we would not have been aware of. The contrast between this foresight and our inability to do what is needed makes our age even more tragic, in the sense of Greek drama, than earlier periods.

These two points imply that social responsibility must have a broader, though still limited, scope than hitherto. The third way in which science differs from other cultural activities is that scientific knowledge is widely claimed to be a special kind of knowledge. Put crudely, it is *objectively true*. I believe there is something in this, but exaggerated claims for the degree of objectivity and neutrality are dangerous, an obstacle to our very survival.

What's not at all Special About Science?

In a word – *interest*. In 1942 Robert K. Merton proposed that four *norms* "comprise the ethos of science" (reprinted in Merton 1968):

- *universalism* (truth claims should be valid for all places, times and cultures. For example, no 'Jewish science')
- *communalism* (scientific knowledge is published; 'belongs' to world culture)
- *organised scepticism* (truth claims are subjected to critical review, including comparison with other 'scientific knowledge')

- *disinterestedness* (scientists judge truth claims without regard to such parochial considerations as personal advancement).

Half a century later, the last of these four norms seems the least convincing as a sociologist's description of science as it is. The limits of disinterestedness are most obvious in relation to applications of science. A recent article by Jeremy Rifkin and Ted Howard (1993) has drawn a remarkably heated response. The authors are leading advocates of the Pure Food Campaign in the US, which is attempting to forestall hasty and irresponsible applications of genetic modification in the production of food. In my view, what Rifkin and Howard say about the risks is reasonable, although they do use some emotive language. For example "While genetic engineers madly race to be first in the marketplace, they suddenly find themselves beset by a public backlash against their 'frankenfood' products." Even so, the reactions (same journal, page 102, page 134) are extraordinary. The following phrases appear: "His [Rifkin's] ill-advised and fanatical views..."; "He, however, would like to play the dictator..."; "alarmist and unsubstantiated ramblings of a pair of food politicians"; "... 50 years ago, would you [the editor] have thought to invite Hermann Goering to contribute an article on industrial fire hazards." I think Rifkin and Howard's crime, in the subconscious of the critics, is not that they are "fanatical", "rambling", etc., but that they represent a real threat to the competitiveness of biotechnology companies (no patents rights to those who come second). Biotechnology is an extremely important matter. It is not surprising that people on all sides get heated.

Getting heated can be dangerous, but so also can false claims of objectivity and rationality. This is the case if different standards are applied to the arguments for 'full steam ahead' as against those for proceeding cautiously. Sir Alan Cottrell (1984) reviewing the 3-volume work *Nuclear Power Technology* claimed it was "uncoloured by rhetoric, unstrained by advocacy, unheated by passion, unbiased by prejudice." But "The great world which fashions public opinion – the world of hyperbole and shock-horror, of the self-inflated politician, bombastic trades union leader, committed journalist, trendy teleperson – resonates to a different sound. The anti-nuclear lobby knows this full well." Jerome Ravetz, same journal page 446, exposes Cottrell's double standard by pointing out that the connection between nuclear power and nuclear weapons has no visibility in the review. (In the 1,300 pages of *Nuclear Power Technology*

the power-weapons link is not completely absent, but it is in general marginalised and sanitised.)

In my opinion, the intense and polarised debate about nuclear power is not really about nuclear power safety *as such*. If nuclear energy could be released gradually but nuclear explosions were impossible, one can readily imagine the development of nuclear energy being similar to that of such 'normal' technologies as oil energy, coal energy, gas energy, telecommunications. The dangers of nuclear power are not of a different order from those of other technologies, but the dangers of nuclear weapons are. This had two effects on the development of nuclear power. One was that the horrific nature of nuclear weapons and the associated secrecy interacted to produce a spiral of dread, which affected everyone and inhibited sensible discussion not only of weapons but also of power. The other effect was that in the early postwar years those who got their living from nuclear expertise had a strong desire to produce something unequivocally good, untainted by the weapons connection.

Later, as the public dread was attached to nuclear power, rather than the real target, weapons, the nuclear power industry was unable to defend itself with a frank analysis. Mentioning weapons was hardly going to help. The industry focused instead on a safer and easier target, the low level of technical knowledge of the average anti-nuclear citizen. Unfortunately, despite having an easy target, the industry shot many of its rounds into its own foot; this happened as special pleading combined with a lack of self-awareness. To this day, the output of the pro-nuclear-energy lobby combines strong claims for objectivity and rationality with rigorous selection of information.

Those making use of 'strong objectivity and rationality' claims sometimes deflect the above criticism by defining science as 'systematic and formulated knowledge' or in a similar way, separating off applications as something else. Thus Sir Ernst Chain (1970) "...science, as long as it limits itself to the descriptive study of Nature, has no moral or ethical quality..." The essential question here concerns 'limited science': what kind of a subset is this of the word 'science' in all its usages? It is true that 'science as [systematic and formulated] description...' is the key feature which makes science different from other intellectual and social activities (such as advocacy, literature, art, struggles for power and resources). It is the *source* of science's potency. The weakness of the traditionalist's claim is that, in general, they fail to remark the elision of the limited meaning of science with other meanings more useful in the struggle for status,

influence and resources. The elision has validity, in the sense that scientists do operate this way. Chain's article and indeed his career show the close connection between 'description' and the personal, institutional and nation-state uses of the knowledge gained. The 'science' that has "no moral or ethical quality" is an artificially and unrealistically separated part of human activity.

Daniel Koshland (1983), then editor of *Science*, provides an example of separatist thinking in relation to science education: "Developing 'good guys' and 'civic minded women' is all very well, but the greatest contribution that can be made by undergraduate training is to expose students to deep intellectual experiences and to show them how to do a job, almost any job, extremely well." The problem of inconsistency in the separatists' case is well expressed by Michael Gibbons and Philip Gummett (1984) "if scientists were to be distanced from the 'evil' effects of the applications of scientific ideas, so too should they receive no credit for the 'good'..."

Many non-scientists react to science with reserve and even hostility. Scientists respond in moods ranging from sadness to anger. A common response is to reconstruct the public – more and better science education. The limitations of this approach, with its assumption that the deficiencies are all on the public's side, have been exposed in an article entitled *A Slow Revolution to Reclaim the Anti-science Generation* by my *Scientists for Global Responsibility* colleague Tom Wakeford (1993).

Most non-scientists do not know enough about science to articulate their reservations clearly. I think these reservations are based on an intuition that scientists apply double standards in their advocacy. Scientists' technical 'information' presented to the public and to elites is assumed to have a significant special-pleading element. I suggest that this intuition is well-founded. If scientists want better relations with non-scientists, they need to look more critically at their own methods of advocacy, and beyond that at their aims.

It is contrary to the nature of human social existence to demand, or claim, that scientists refrain entirely from 'mixing it' in the general struggle (with rules) for individual and group advantage. Nevertheless, the value of science as 'systematic and formulated knowledge' might be more widely accepted if traditionalists were more careful to avoid exaggerated claims and double-standard advocacy.

Phaethon and the Academia Europaea

One may distinguish collective and individual responsibility. The former is an idea less developed, both philosophically and in law, than the latter. (This does not save the unfortunate people of Iraq from being being squeezed from two sides, although they are not accused of collective responsibility.)

Responsibility in relation to scientists normally assumes, more-or-less tacitly, individual responsibility. It was therefore useful that the Academia Europaea held a symposium focusing explicitly on the individual: "*The Responsibility of the Individual Scientist to Society*", the proceedings published in Arnold Burgen *et al* 1990. P.J.D. Drenth, pages 75-7, identifies "the scientist's dual responsibility: commitment to social norms and social responsibilities on the one hand, and to scientific norms on the other." Drenth urges the same advice as Helios, the sun-god, gave to his son Phaethon, who insisted on driving his father's chariot across the sky for one day – "keep to the track in between". Drenth ends with "Let us hope we will do better than the ill-fated Phaethon, who in the end loses control over the sun-god's chariot and who, after having caused great damage, is struck by one of Zeus' thunderbolts and plunged into unfathomable depths."

As one reads the whole of the symposium proceedings one notices an elitist approach: example, page 67, "This Europe boasts some 250 Nobel Laureates (many are members of the Academia)." This has some bearing on the question of individual responsibility. Was Phaethon irresponsible? In Ovid's *Metamorphoses* Phaethon is an arrogant youth; perhaps he overcompensates for insecurity about not being certain who is his true father. Still, it is clear that he is a likeable lad, because even after he has nearly destroyed the heavens and the earth, his demise is bitterly mourned by his friends and family.

Helios' vehicle is high-powered:

> My horses too, when fire within their breasts
> Rages, from mouth and nostrils breathing flames,
> Are hard to hold; even I can scarce restrain
> Their ardent hearts, their necks that fight the rein.
> (A.D. Melville's translation, 1986)

How did young Phaethon come to be in charge of it? The answer is that Helios, out of sheer carelessness and indulgence, invited his son to

... ask what you will
That I may satisfy your heart's desire;

He is horrified when Phaethon asks to drive his chariot, but the option which would appear obvious to us, namely to simply break his word, is apparently not on. Surely someone whose word is absolutely irrevocable should not sign a blank cheque.

My general impression from the Academia's proceedings is that the participants did not think carefully about who are the 'we' who should attend to 'our' individual responsibilities. Non-elite scientists cannot be absolved from responsibility, but it has to be remembered that that their situation is very different from that of an elite. If a non-elite person blows the whistle, the consequences will usually be severe – for that person. For several decades the British nuclear and political establishment maintained that none of the plutonium produced by UK civil nuclear power stations was used for military purposes. When Ross Hesketh, a scientist employed by the Central Electricity Generating Board published, without permission, evidence demolishing this claim, he was dismissed (Nick Kollerstrom 1983).

Likewise, if something goes badly wrong in a large institution and cannot be covered up, scapegoats may be sought. Elie Wollman's letter (1993) "Scapegoats in the French contaminated-blood trial" deprecates the witchhunt against "four competent and dedicated medical doctors" singled out in the high-profile case of accidental transfusion of HIV-infected clotting products into haemophiliacs. Ovid's version of the Phaethon story also ends with a scapegoating. In the circumstances blaming the horses was unreasonable, yet

So the Sun took in hand his maddened team,
Still terrified, and whipped them savagely,
Whipped them and cursed them for their guilt that they
Destroyed his son, their master, that dire day.

The Restraint of Science

Before we proceed to to consider a positive future, it is necessary, I believe, to face directly an important obstacle – the attitude of scientists to the restraint of science. Whereas generalities about the cultural and practical value of science, the need for openness and democracy, etc., are uncontroversial, the slightest suggestion that scientific research should be restrained brings an intemperate

response from scientists. The flak received by Rifkin and Howard is an example.

The traditionalists' view on the restraint of science is usually based on a simplistic model: enquiry limited in Dark Ages; Renaissance and all is light; occasional regression under totalitarianism. This model is inaccurate, because science has always been subject to restraints other than the 'pathological' ones on which the model focuses. Science is, and always has been, subject to constraints which can be considered 'normal'. Currently there are constraints on investigations which involve

- cruelty, suffering or danger to animal or human subjects
- assault on the dignity of humans
- invasion of privacy of humans
- compromising commercial secrecy
- compromising 'national security'
- taboo subjects
- danger to investigators, including assistants
- danger to the public.

In none of these cases is restraint absolute; nor is freedom of enquiry. This representation will, I hope, be taken as obvious. Both the statement of the situation, and the situation itself, are commonsensical. It is depressing how many scientists are unable even to consider suggestions that the speed of discovery should be slowed down. In a speech which the reporter says "chilled the bones of some of those who listened" Philip Handler (1969), then President of the US National Academy of Sciences, said "In the United States we are, I regret, decelerating the pace of science."

I believe the source of the traditionalists' attitude to the restraint of science is the competition to be first to make a major discovery. This requires single-mindedness and ruthlessness; worries about consequences can come later. It is true that other cultural activities, notably commerce and sport, are even more competitive. The special problem in responsibility and science arises from basic science's potential for radical, culture-transforming applications.

The Mertonian norms, which are internalised by scientists, are quite effective in restraining 'scientific antisocial' behaviour. They say nothing, however, about the likely consequences of discovery. As Priscilla Alderson and Naomi Pfeffer point out (1992) in relation to the new biology "Scientists like to present their research as a largely unpredictable activity rather than as part of a well-planned programme driven by commercial imperatives. They can then portray

ethical dilemmas as surprising, inconvenient, almost accidental side effects...". This 'use' of the notion of unpredictability did not matter so much in earlier times when one could hold to the optimistic belief that knowledge necessarily led to 'progress'. Now we (should) know better, but those with the traditional view about restraint of science have compartmentalised their thinking: 'distance from evil effects' in one box, 'credit for good' in another.

If basic science were simply a process of making intellectual discoveries of remarkable beauty, the 'glittering prize syndrome' – scientists racing for gold, the winners heroic – might be harmless fun. It is not at all like that. Many of the principal discoveries of basic science contribute significantly to the transformation of human culture and the global ecology. This might yet be acceptable – progress – if humanity had the wisdom to choose and control the transformation. Unfortunately, we are far from having sufficient wisdom.

It is, however, not necessary or appropriate to restrain basic research unselectively. The unqualified assertion that the consequences of basic research are unknowable does not bear close examination. Becquerel's accidental discovery of radioactivity in 1896 is often cited as an example whose consequences (the nuclear age) were not and could not have been foreseen. That is true in a limited and simplistic sense, but the argument is an example of the kind of selection I discussed earlier. What is not said is (i) many steps besides Becquerel's led to the nuclear age; (ii) already by the very early years of our century it was known that radioactivity implied a large amount of energy 'locked up in matter'. Numerous speculations were made about its release; Brian Easlea (1983) demolishes the perception that nuclear energy was not anticipated to a significant extent before 1939. Rutherford's *dicta* are interesting. He made such remarks as 'moonshine' to the public, but warned the Secretary of the Imperial War Committee "...nuclear energy might one day have a decisive effect on war ... keep an eye on it". Hankey did.

The question of applicability is more straightforward in biology, and especially since the 1970 discovery of how to 'snip' DNA in specific places, and hence to determine the sequence of bases along any particular type of DNA molecule. Since then it has been known, with sufficient reliability, that basic work in molecular genetics would contribute to applications very difficult for society to cope with, by virtue of their scope and speed. Drenth's response, it will be recalled, is "let us hope...". Sir Samuel Curran came to a similar conclusion

(1989) about the dangers of the nuclear arms race: "Armaments can become obsolete suddenly and arrangements among powers entirely invalidated. Let us trust no great changes for the worse occur in the near future."

Scientists are supposed to be attracted to problems and challenges. It is sobering to find that so many of them, including leaders, can do little more than hope for the best concerning humanity's survival and the planet's ecology. I suggest that a major obstacle inhibiting scientists from a constructive response is a package of poorly thought-through ideas about freedom of enquiry in science.

No Technical Fix

Traditionalists (in the sense used in the last section) and political conservatives often respond to warnings about uncontrolled scientific 'progress' with references to Luddism, Dark Ages, hair shirts, doom and gloom, totalitarianism. These responses amount to a head-in-the-sand attitude. Positive visions are, however, also available. One has been given by John Platt (1969), whose title *What We Must Do* is accurately summarised by the abstract: "A large-scale mobilisation of scientists may be the only way to solve our crisis problems." I think Platt's programme emphasises the technical-fix type of approach too much. In considering whether this would likely deliver the goods, let us briefly remind ourselves of humanity's history of exploitation, aggressiveness and cruelty. We note a few egregious but by no means rare examples:

- "In the year AD80 the Colosseum opened with what must stand as quite the longest, most disgusting organised mass binge in history. According to Suetonius, various sorts of large scale slaughter, both of animals and of men, were appreciatively watched by the Emperor Titus and a packed audience for the next hundred days." (John Pearson 1973)
- a sufficient reminder from the history of enslavement may be the well-known diagrams showing the conditions under which Africans were shipped to the Americas (see for example James Walvin 1992)
- the first World War showed humanity's incapacity to adapt culturally to new technology, even when the disastrous consequences of outmoded thinking were an actuality, plainly visible. For an educative survey of one aspect of this, see John Ellis *The Social History of the Machine Gun* 1975
- the nuclear arms race led to the possibility (still present) of a

catastrophe, perhaps omnicide. The situation did not arise by itself, but was built up with enormous effort and ingenuity by 'normal' people
- atrocities described as 'ethnic cleansing' occur in the former Yugoslavia, an area not particularly isolated, by world standards, from science and its fruits.
In the light of all this Platt's "mobilisation of scientists" seems insufficient (and Koshland's "almost any job" is chilling). Humanity's *basic* problem is exploitativeness and cruelty; science is a problem insofar as it allows these traits to be expressed on an enlarged scale. Of the obstacles to the building of a beautiful world (a phrase used to telling effect in Brian Easlea's *Liberation and the Aims of Science* 1973), those of a scientific nature are slight compared with those of a spiritual nature.

In their grief for Phaethon, his sisters turned into poplar trees, and their tears to amber. Surely this kind of love will be as important for our future as 'systematic and formulated knowledge'.

No Quick Solution

Science, in that sense, has now been the engine of cultural change for several centuries. Observing the tortuous, sometimes retrograde, path of our 'progress' in this era, I think of a century as a realistic time-scale for the needed transformation: from a culture in which exploitation and cruelty are normalised in many social contexts, to one in which they, though probably not overcome entirely, at least are deviant.

There has been intense debate in the US for a decade about the Superconducting Super Collider, a particle accelerator project whose estimated cost rose to $11 billion. Members of Congress usually focused on whether the US, with its large federal budget deficit could afford the project. Scientists from subjects other than particle physics feared that the funding would be at the expense of their subjects. Particle physicists pointed out that the collider had a high probability of finding Higgs bosons, a set of particles anticipated by theorists and of special significance but not yet observed. In October 1993 the project was cancelled, despite $2 billion having been already spent. In my view, none of the above representations addressed the real point, which is that human culture now faces a crisis of survival. Higgs bosons, if they exist, will still exist in a hundred years time. The 22nd century will not be Utopia, but there might be sufficient genuine security that an $11 billion accelerator project would not be a heartless

choice of priorities.

I would like to think that the money saved would be directed to the consideration of long-term global sustainability. The idea that $9 billion cannot be directed this way, but has to 'disappear' because of the federal budget deficit, is self-destructive. Really, a radical adjustment of world priorities is needed, in which the equivalent of trillions of dollars per annum are switched from competitive, military and consumerist activities towards long-term survival. So far from being dour or depressing, such a switch would add to the quality of life, even of those now 'prosperous', because people could have a sense of a 70-year lifespan connected with a past and a future.

Considered as a whole, the suggested programme – transformation of human culture on the timescale of a century – is enormous. The individual feels overwhelmed, impotent. I think the correct response to this feeling is that no one person out of five billion has even the *right* to save the world. An individual's contribution must be minute, but transformations of culture do occur. Those based on new technology, for example telecommunications, occur perhaps *too* readily. We are concerned here with spiritual transformations, which are more difficult. Still, slavery was abolished from the earth (almost completely). "The campaign which culminated in black freedom in the 1830s began in 1787 when a small group of Quakers launched a public campaign against the British slave trade. Few of the men who gathered in that small abolitionist circle could have imagined that the whole slave system would be brought down within a lifetime."(page 304 of Walvin 1992)

Another progressive movement whose 'time came' in the nineteenth century was the antivivisection movement. "A physiologist is not a man of fashion, he is a man of science, absorbed by the scientific idea which he pursues: he no longer hears the cry of animals, he no longer sees the blood that flows, he see only his idea ..." page 103 of Claude Bernard 1957 (the original French edition was published in 1865). The translation also contains the obituary of Bernard by his former pupil Paul Bert, who uses the phrases (page xix) "... such kindliness, such simplicity of soul, such naive generosity ... great and noble character ... pure and harmonious life ... noble passions ..." The attitude of these scientists is now beyond the pale. Although the antivivisectionists did not achieve their full aims, they and less radical groups concerned about all forms of cruelty to animals did bring about a major change in our attitude to animals.

In each of these two examples, significant progress was achieved.

Very roughly, one might think of a consciousness-raising period of the order of a century followed by a topical campaign lasting a few decades. After the atomic bombings of Hiroshima and Nagasaki, there was a widespread view that many decades were not available. Humanity had to change its ways or perish. Almost fifty years later, we are still here, having changed our political ways rather little. Perhaps we have been lucky – we may never know. This sense of urgency was not unique. Many thought in the 1950s that automation would bring a speedy and radical change to employment as it was known. Four decades later, it seems that those thinkers underestimated capitalism's ability to accommodate the new technology – by growth, transfer to service employment and a gradually increasing structural unemployment. This adjustment has 'worked' in the medium term, but facing the problem properly cannot be postponed indefinitely.

There is current concern about environmental problems, including some potential global catastrophes. Nevertheless, I suggest that society is still in the early, consciousness-raising phase. The willingness to do what is needed, in particular to give up a growth-oriented economism, is still absent. We are at an even earlier phase in relation to biotechnology. The profit-motive is bringing applications rather rapidly, but appropriate political and moral adjustments seem far off.

My conclusion from this section is that we should not be spellbound by thoughts of imminent catastrophe. We do not know what the future holds. The historical examples show that progressive movements have a long timescale. It is necessary to work steadily and patiently. Perhaps the worst betrayal, in some poetic sense, would be failure to work against a catastrophe that we still had time to prevent.

Responsible Science

In this essay, I have emphasised the problematic in science and technology, as a corrective to what I see as a prevalent and dangerous gung-ho. People who are *simply* anti-science, however, miss the real problem and throw out the good with the bad. Apart from the cultural value of science, which is not appreciated by all, the practical benefit of making possible a secure and comfortable life (potentially for all) is too obvious to need stressing. Something like a 'Platt programme' might be a major element of our transition to a viable future. But it

will not be enough. Such a programme will not automatically lead to improvement for all. Almost a quarter-century after Platt wrote, the condition of the world's poor is getting worse. This is not a run of bad luck, but a systematic trend. Natural science and technology, controlled ruthlessly by the powerful, are as much part of the problem as of the solution. Moving towards Easlea's 'beautiful world' will involve transformation of our culture, going beyond the 'simple' application of natural science. It will involve moral and political progress. This is not, of course, the preserve of scientists alone, but they do have a special role.

To understand this role it necessary to think of 'science' in a broad sense, as in the German *Wissenschaft*. Besides natural science, *social science* and *scholarship* are included. To be more exact, those parts of these endeavours which contribute to 'systematic and formulated knowledge' are included. The relevance for moral development of this broad conception of science is this: it guards one against the temptation to put aside or deny unpleasant facts about the past and unpleasant but realistic projections about the future. Parochialism, temporal or spatial or cultural, is not compatible with the scientific/scholarly outlook. This point is exemplified by Einstein's scientific, philosophical, political and moral thinking.

This kind of science, allied with a sense of history might help us transcend the present dangerous phase of human culture. A degree of optimism, despite all obstacles and a love of life are also needed. These may be fortified by Ovid's very short prologue to *Metamorphoses*:

> Of bodies changed to other forms I tell;
> You Gods, who have yourselves wrought every change,
> Inspire my enterprise and lead my lay
> In one continuous song from nature's first
> Remote beginnings to our modern times.

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Appendix: Philosophical background

Everyone has some philosophical underpinnings of more practical conclusions, whether they know it or not. Here, as far as I can elucidate them, are the foundations of this essay:

- a mechanistic view of nature, including living organisms, has a great deal of explanatory power, which is likely to go on increasing

- advances in this view of the human organism are disagreeable, in that they nibble away at our sense of free-will

- the extrapolation from determinism of particular, relatively simple processes to a blanket assertion of determinism is unwarranted

- quantum mechanics and theories concerning chaos give some grounds for resisting a naive global determinism, but

- there is a more relevant and powerful barrier to the application of deterministic models to problems with a social dimension. This is the presence of human 'frailties', associated with subjectivity, in the processes (science, scholarship, thought, discourse) whereby we acquire knowledge

- concerning the difficult philosophical problems associated with the subjective/objective dichotomy, it is helpful to consider that knowledge is neither fully objective, nor fully subjective, but intersubjective, that is, existing between conscious minds. (Intersubjectivity has surprisingly little salience in the literature. John Ziman (1978) gives a straightforward discussion in relation to scientific knowledge)

- all knowledge has a social dimension

- the nature of ethics is to have 'social reality' (John Barnsley 1972). Religious, fundamentalist and absolutist assertions are to be interpreted in this light

- social power structures, especially those relating to the nation-state, need to be kept in the foreground in the interpretation of ideologies (concerning, for example, politics, culture, education, science).

This 'standpoint' leads to the view that, despite all reductionist and mechanistic inroads to date, the notions of individual and collective responsibility do have meaning. These meanings are not amenable to formal definition. They are socially negotiated. All humans, as individuals and as groups take part in an immensely proliferated struggle for the general acceptance of ideas, as well as for resources and power.

Those, fundamentalists, who claim their ideas to be absolute are to have their ideas reinterpreted in terms of social negotiation. This treatment is to be served out, not only to overt fundamentalists (usually religious), but also to the less overt kind: "We hold these truths to be self-evident: that all men are created equal ..." Thomas Jefferson; "... the supreme good, the standard of value, is objective knowledge itself and for its own sake." (Jacques Monod, in Fuller 1971).

From this standpoint, with its emphasis on social interaction, responsibility is a quality that individuals and groups naturally possess. I take responsibility to mean a tendency in an individual or group to be answerable for its actions to a wider group (in space, in time or in 'cultural space'). The breadth of the wider group is however limited. From a socially oriented point of view I admit a considerable amount of relativity; different individuals and groups set in different places the dividing line between legitimate self-interest and irresponsibility.

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Brian Martin

Is the 'new paradigm' of physics inherently ecological?

"A new age is coming, right? The old days were the days of mechanistic Newtonian physics, rigid social frameworks and brutal attacks on an alien environment. But that's been superseded by quantum theory with its interminacy, where everything interacts with everything else in the universe. The coming perspective is a holistic world view: interaction, wholes, none of that old, hateful possessive individualism. The new world view is inherently ecological. After all, ecologists tell us, nature is interdependent. Humans should fit in with nature, not dominate it. Nature really is holistic, and that means society should develop in that direction too."

Over the years, I've heard quite a few people say things like this. I usually listen politely. I agree with many of their ideas about society. But I can't agree that these ideas are justified by some new 'holistic' paradigm of subatomic particles and ecology.

Ideas about links between physics, nature and society have been popularised by some talented writers. Fritjof Capra captured the imagination with his book *The Tao of Physics*, which argued that there is a strong link between conceptions of nature found in quantum theory and strands of eastern mysticism, specifically Hinduism, Buddhism and Taoism. Capra suggested that scientists are finding out that nature really works the way that mystics have long realised: it is interactive, indeterminate and doesn't distinguish between subject and object. A similar picture of the 'new physics' and mysticism is painted by Gary Zukav in *The Dancing Wu Li Masters*.

Sociologist Sal Restivo decided to examine these claims. He found that the alleged link between physics and mysticism can't be sustained. Capra picked out certain features of physics and certain features of eastern traditions and found similarities. But, Restivo argues, if you picked out different features of quantum theory or different features of mysticism, or both, quite the opposite conclusions could be reached.

In fact, by picking examples appropriately, you could find

similarities between mysticism and old-style billiard-ball Newtonian physics.

Whose arguments should you believe, Capra's or Restivo's? Ideally, people should make up their own minds after carefully studying both sets of arguments. But very few do this. Capra's work is widely known but Restivo's is virtually unknown. Why? One reason is that Restivo only published his ideas in a densely written academic tome entitled *The Social Relations of Physics, Mysticism and Mathematics*.

But there is another reason. Many people want to believe what Capra has to say. They want to believe that nature is on *their* side. Many environmentalists want to believe that nature – nuclear processes as well as forests and oceans – really is interactive, holistic, non-hierarchical and mysterious. If nature is this way, then society should be too.

But how do we know what nature is 'really' like? There's a problem here. Scientists have no guaranteed method to determine the reality of nature or, for that matter, the nature of reality. They can only develop pictures and models to describe it. And the models they use are drawn partly from current ideas about society.

In developing his theory of evolution, Charles Darwin was influenced by ideas about society presented earlier by Thomas Malthus, who described society as competitive. Although Darwin recognised a role for co-operation, he made competition – a struggle in which the fittest survive – a central metaphor in his picture of nature.

After Darwin came the social Darwinists. They emphasised only the competitive aspects of the theory of evolution. They said that because nature *is* competitive, therefore society should be and those who can't compete successfully deserve no support. Social Darwinism was quite a convenient justification for ruthless capitalist exploitation.

Peter Kropotkin, the famous anarchist from the last century, believed in co-operation rather than competition. He looked at nature and found lots of co-operation. He then used what he found to justify his belief in co-operation between humans. Murray Bookchin, one of today's leading anarchists, has used the same sort of approach in *The Ecology of Freedom*.

Different people can draw different conclusions from nature. The trouble is that 'nature' doesn't speak with its own voice. It must be interpreted, and there is plenty of scope for different interpretations. And not all interpretations are ones you might like. The Nazis, remember, made a big thing of links with nature.

So here's the process. At any given time, there are ideas about how society is and should be organised: competitive, co-operative or whatever. When scientists describe nature, they draw on some of these ideas. Then some people say that because nature is competitive, co-operative or whatever, society should be too. It's all rather circular!

My view is that if we want an egalitarian society, we should argue for it and try to create it and not worry about whether nature is competitive, co-operative or something in between. ideas about new paradigms in physics really have little connection with the organisation of society.

Capra's later book, *The Turning Point*, tells of the transformation of society towards a new ecological paradigm. It sounds attractive but, on closer inspection, Capra's analysis of society turns out to be confused and unhelpful. He has no coherent strategy for challenging and replacing the old systems of power. (Interested readers should consult Stephan Elkins, 'The Politics of Mystical Ecology' in *Telos*, winter 1989-90.)

If you want to read Capra, do so by all means. My point here is simple. The idea of a 'new ecological paradigm' of physics or society is only one way of looking at things and, furthermore, it may not be a very helpful perspective when it comes to the rough slog of creating a better society. Claims about a new paradigm should be taken with a dose of scepticism.

And remember, a new paradigm isn't always a good thing.

Postscript

Back in the 1970s I was impressed by Carlos Casteneda's fascinating book *The Teachings of Don Juan*, which describes the author's encounters with a Yaqui sorcerer and a completely different way of understanding and interacting with the world. Casteneda expanded on his experiences in later books, describing a different paradigm for comprehending nature.

Years later, I came across the critiques by Richard de Mille. According to de Mille, Casteneda almost certainly never had the experiences he tells about in his books. In other words, the stories are fraudulent or, if you prefer, fictional. The 'separate reality' described by Casteneda was a hoax.

Now, you may choose to believe Casteneda or to believe de Mille. That's your choice. The point is that most readers of Casteneda have never heard of de Mille's criticisms. My guess is that lots of people

want to believe in Casteneda's stories. Scepticism seldom makes for a best-seller.

Looking for inspiration from modern physics or from mystical traditions can be a deceptive process. What is found in these quests may simply be an exotic version, a distorted reflection of our familiar, banal, everyday experiences. Rather than looking for an alternative somewhere else, eventually we will just have to deal with our own lives and society.

Biology and Culture

We must (Rose, Lewontin and Kamin argue) go beyond reductionism to a holistic recognition that biology and culture interpenetrate in an inextricable manner. One is not given, and the other built upon it. Although stomping dinosaurs cannot make continents drift, organisms do create and shape their environment; they are not billiard balls passively buffeted about by the pool cues of natural selection. Individuals are not real and primary, with collectivities (including societies and cultures) merely constructed from their accumulated properties. Cultures make individuals too; neither comes first, neither is more basic. You can't add up the attributes of individuals and derive a culture from them.

Stephen Jay Gould reviewing Rose et al, *Not in Our Genes*, Penguin

Daniel P. Todes

The Scientific Background of Kropotkin's Mutual Aid

[Editor's note: Kropotkin's Mutual Aid was a reply to T.H. Huxley's version of Darwinism, which appeared to posit a Hobbesian war of each against all in the animal kingdom, and a natural tendency that way in human society. As Freud, and later still Margaret Thatcher, were to do, Huxley opposed society and the individual. He saw humans and animals as engaged in a constant war of each against all and this natural condition as something that social organisation attempted to mitigate.

Kropotkin's answer insisted on the importance of co-operation in the struggle for existence and in evolutionary success. Because, in his view, co-operation was basic, he felt that human society should be built on the expression of our natural inclinations rather than their repression. *Mutual Aid* was at root a polemical expression of that view. For all its insights it was a little short of scientific detachment. Like many of us, Kropotkin looked for evidence that would support his ideas and, perhaps feeling that Huxley had made the case for the prosecution, did not give proper attention to evidence casting doubt on his hypothesis. This led to marginalisation. His work was dismissed as unscientific. One of the most astute commentators of the scientific world, Stephen Jay Gould, admitted in *Bully for Brontosaurus* (Penguin 1992) that he had always viewed Kropotkin as "daftly idiosyncratic ... one of those soft and woolly thinkers who let hope and sentimentality get in the way of analytic toughness ..." He was to alter this view rather drastically.

Stephen Jay Gould's change of mind is detailed in his splendid essay 'Kropotkin Was No Crackpot' in the Penguin noted above. He had discovered that Kropotkin's views were those of Russian Darwinians in general. Studying in the northern wastes they saw the struggle for survival somewhat differently from those who studied in tropical forests. Kropotkin seemed oddball because Western naturalists did not read Russian and Kropotkin was the only Russian Darwinian writing in English. The source of his enlightenment was a paper in *Isis* (no 78, pages 537-551), the official journal of the (American) History of Science Society, titled 'Darwin's Malthusian Metaphor and Russian Evolutionary Thought'. Daniel P. Todes' paper changed Gould's mind and did much to create the new serious interest in Kropotkin's work.

By permission of the author and the publishers, here is that paper. The only alteration we have made, apart from the title, is to shorten Dr Todes' notes somewhat, for reasons of space.]

★ ★ ★

"Nothing is easier than to admit in words the truth of the universal struggle for life," wrote Charles Darwin in *The Origin of Species*, "or more difficult than constantly to bear this conclusion in mind".[1]

Darwin frequently employed the imagery of direct combat in his work, which is permeated by phrases such as "the great battle for life" and "the war of nature". Yet he considered indirect competition within a single species to be the central factor in the divergence of characters and the evolution of new forms. Introducing his concept of a "struggle for existence" Darwin explained:

> "I use this term in a large and metaphorical sense including dependence of one being on another, and including (which is more important) not only the life of the individual but success in leaving progeny. Two canine animals, in a time of dearth, may be truly said to struggle with each other which shall get food and live. But a plant on the edge of a desert is said to struggle for life against the drought, though more properly it should be said to be dependent on the moisture. A plant which annually produces a thousand seeds, of which only one of an average comes to maturity, may be more truly said to struggle with the plants of the same and other kinds which already clothe the ground. The mistletoe is dependent on the apple and a few other trees, but can only in a far-reached sense be said to struggle with these trees, for if too many of these parasites grow on the same tree, it will languish and die. But several seedling mistletoes, growing close together on the same branch, may more truly be said to struggle with each other. As the mistletoe is disseminated by birds, its existence depends on birds; and it may metaphorically be said to struggle with other fruit-bearing plants, in order to tempt birds to devour and thus disseminate its seeds rather than those of other plants. In these several sense, which pass into each other, I use for convenience sake the general term of struggle for existence."[2]

The "struggle for existence", then, was a metaphor for what Darwin realised were complex relations among organisms and between the organism and abiotic conditions.

This struggle for existence followed necessarily from the rate at which organisms reproduced: "As more individuals are produced than can possibly survive," Darwin wrote, "there must in every case be a struggle for existence, either one individual with another of the same species, or with the individuals of distinct species, or with the physical conditions of life. It is the doctrine of Malthus applied with manifold force to the whole animal and vegetable kingdoms".[3]

Several years later Darwin defended his use of metaphor, explaining: "Everyone knows what is meant and what is implied by such metaphorical expressions, and they are almost necessary for brevity".[4]

However necessary they may be, metaphorical expressions are culturally specific. They draw upon shared perceptions of one subject in order to illuminate another. For Darwin and other leading British evolutionists the term 'struggle for existence' appealed to common sense, and its Malthusian associations posed no problem.

For Russian intellectuals, however, this metaphor was at best imprecise and confusing. At worst, and this was much more common, it was fallacious and offensive. They reacted negatively to what they perceived as a transparent introduction of Malthusianism – or, for some, simply the British enthusiasm for competition – into evolutionary theory.

These thinkers genuinely admired Darwin, and very few thought that this flaw justified total rejection of his theory. The common reaction was to break down the so-called struggle for existence into its component parts, to explore their relationship and relative importance in nature, and to conclude that Darwin had greatly exaggerated the role of the two parts most closely identified with Thomas Malthus: that is, of overpopulation as the generator of conflict and of intra-specific competition as its result. This common reaction – the intensive exploration of Darwin's metaphor and its criticism from an anti-Malthusian or non-Malthusian perspective – constituted a 'national style' in the Russian reaction to Darwin.

I distinguish 'anti-Malthusian' from 'non-Malthusian' to underline two sources of this Russian response. 'Anti-Malthusianism', the aversion to Russians across the political spectrum to Malthus's doctrine, had its roots in the class structure and political traditions of tsarist Russia. 'Non-Malthusianism', the failure of Malthusian perceptions to resonate with Russians' experience with nature, reflected the physio-goegraphical realities of the Russian setting.

In this article I first sketch the reaction of Russian intellectuals to Malthus, then illustrate their criticism of Darwin's concept of the struggle for existence, and, finally, comment on the origins of Petr Kropotkin's theory of mutual aid.

The Russian reaction to Malthus

The argument in Malthus's *Essay on Population* (1798) was foreign to Russians' experience and inimical to their values.

It was foreign to their experience because, quite simply, Russia's huge land mass dwarfed its sparse population. For a Russian to see

an inexorably increasing population inevitably straining potential supplies of food and space required quite a leap of imagination.

Malthus himself was incapable of it. When visiting Russia in 1799 he remarked upon its "deficiency of population", marvelled at its great agricultural potential, and applauded the state's attempts to spur population growth. The main obstacle to such efforts, he concluded, was Russia's feudal system, which demonstrated that poor governance could lead to suffering and want even amidst great natural bounty.[5] These observations hardly recall the Malthus that British intellectuals debated so vigorously, and that Darwin and Alfred Russel Wallace read to such great advantage.

Malthus's argument was distant from Russian reality, and his *Essay* was not even reviewed in a Russian journal until 1818, twenty years after its publication, and was not translated for another half century, by which time Darwin had drawn attention to it.[6] Malthus did have one disciple among Russian economists, A.I. Butovskii, who lauded him in the 1840s as "the Galileo of political economy". But even Butovskii conceded that the Malthusian law was of course inapplicable to "our broad and expansive Russia".[7]

As a description of Russian reality, then, Malthus's *Essay* offered little of interest. As a political document, however, beginning in the 1840s, it was sharply criticised. Western Europe was a yardstick by which Russian intellectuals measured their own aspirations, and they discussed Malthus while evaluating British life and thought. Radicals agreed with conservatives that Malthus's law was but an arithmetical illusion reflective of an inhumane and soulless individualism.[8] Radicals, who hoped to build a socialist society, saw Malthusianism as a reactionary current in bourgeois political economy. Conservatives, who hoped to preserve the communal virtues of tsarist Russia, saw it as an expression of the 'British national type'.

In the mid 1840s, for example, the socialist V.A. Miliutin criticised Malthus as "an economist of the privileged classes" while the monarchist Prince V.F. Odoevskii linked him to "the coarse materialism of Adam Smith". In his popular fictional work *Russian Nights* Odoevskii portrayed a Malthusian economist driven to suicide by his pessimistic mathematical fantasies and explained to readers that "the country that wallowed in the moral bookkeeping of the past century was destined to create a man who focused in himself all the crimes, all the fallacies of his epoch, and squeezed strict and mathematically formulated laws of society out of them".[9]

This critical reaction intensified in the late 1850s and 1860s, a period of great social reform and vigorous debate about Russia's future. In his *Essay on the History of Labour* (1862) the radical theorist D.I. Pisarev derided the "Malthusian attitude towards nature" with its comparison of the earth and its productive forces to a "chest full of money". The radical columnist N.V. Sokolov added that "for both the Jesuits and the Malthusian school of economists the end justifies the means; the Jesuits lie and deceive in the name of the Catholic Church, and the capitalists do so in the name of capital". Some conservative intellectuals argued that Malthus's law was applicable to capitalist societies and that Russia's feudal institutions should be maintained as an obstacle to them; and some liberals feared that overpopulation might eventually become a problem in the absence of industrial growth. Even these few thinkers, however, denied the inexorability of Malthus's law and forcefully disassociated themselves from Malthusian fatalism and social prescriptions.[10]

A.I. Herzen summarised a broad consensus when he contrasted Malthus's values with those of the cherished peasant commune. The commune, he wrote, embodied an economic principle that was "the perfect antithesis of Malthus's celebrated proposition: it allows everyone without exception to take his place at the table".[11]

By tying his concept of the struggle for existence to Malthus, then, Darwin almost assured the skepticism of his Russian audience.

Darwin as Malthusian

Darwin's theory was first communicated to the Russians in 1860, and the first Russian translation of the *Origin* appeared in 1864. It sold out quickly, and other editions soon followed. Darwin's other works were rapidly translated and widely reviewed. For the great majority of Russian intellectuals he became a highly prestigious figure – the embodiment of modern natural science, the author of a powerful argument for evolutionism, and the discoverer of an important factor in evolution, natural selection. No less universal, however, was the perception that Darwin's Malthusianism constituted an important weakness in his theory.[12] Consider a few illustrations.

The famous radical essayist N.G. Chernyshevskii was both an evolutionist and an influential critic of Malthus before 1859. He observed in 1873 that:

"... the vileness of Malthusianism has passed into Darwin's doctrine ... Poor Darwin reads Malthus, or some Malthusian pamphlet, and, struck with the brilliant idea of the 'beneficial consequences' of hunger and illness, discovers his America: organisms are improved by the struggle for life ... In what does the essence of Darwin's error and that of his followers consist? A specialised science, political economy, has acquired such great stature (through Ricardo and others, but not through Malthus) that it seems capable of providing mathematical truths. Darwin noticed this. And made use of what he understood ... And the result was the same as if Adam Smith had taken it upon himself to write a course in zoology."[13]

Many other radical theorists, including P.L. Lavrov, N.K. Mikhailovskii, N.D. Nozhin and P.N. Tkachev, also recognised the relationship of British political economy in general, and Malthus in particular, to Darwin's theory.[14]

Conservative intellectuals also identified and rejected Darwin's Malthusianism. N. Ia. Danilevskii was an expert on fisheries and population dynamics, a fierce defender of Russia's distinctively Slavic destiny, and the author of a massive two-volume critique of Darwinism. For him, Darwin's debt to Malthus illustrated the inseparability of science from subjective cultural values. The English "national type", he explained, "accepts [struggle] with all its consequences, demands it as his right, tolerates no limits upon it". He struggles from his days as a schoolchild: running, swimming, boating – all were competitive sports for him. "He boxes one on one, not in a group as we Russians like to spar", founds debating societies for the "struggle of opinions", and even establishes mountain-climbing clubs, not for scholarly purposes, "but solely to allow oneself the satisfaction of overcoming difficulties and dangers ... in competition with others".[15] Darwinism was clearly "a purely English doctrine" expressing the English preoccupation with practicality and competition: "On usefulness and utilitarianism is founded Benthamite ethics, and essentially Spencer's also; on the war of all against all, now termed the struggle for existence – Hobbes's theory of politics; on competition – the economic theory of Adam Smith ... Malthus applied the very same principle to the problem of population ... Darwin extended both Malthus's partial theory and the general theory of the political economists to the organic world".[16]

This was also obvious to th great novelist Lev Tolstoi. Excoriating Malthus as a "malicious mediocrity", he praised Chernyshevskii and Danilevskii for exposing Darwin's debt to him. Tolstoi developed this theme in *Anna Karenina* and returned to it repeatedly, perhaps most

dramatically in a final letter to his children, dictated from his deathbed in 1910, that warned of dire consequences should they accept Darwin's struggle for existence as a moral guide.[17]

Such examples could be multiplied almost without end, but one more will suffice. In 1868 P.A. Bibikov, an unsuccessful liberal journalist, published the first Russian edition of Malthus's *Essay*. In his introductory essay he observed that although Malthus was a discredited reactionary, his law of population contained a kernel of truth. This could be discerned if one closely examined the work of "its most powerful defender and sharpest investigator" – Charles Darwin.[18] Departing from Darwin's description of the struggle for existence, Bibikov discussed its metaphorical character and examined the fluid relationship and relative importance of its different aspects.

More important than Bibikov's conclusions is the fact that this widely reviewed volume stimulated discussions of Malthus while Russians were also evaluating Darwin, and that it both reflected and reinforced the perception that to think through Darwin's theory one must analyse carefully its disturbing and fallacious Malthusian aspects.

Russian scientists often did just that.

Examining Darwin's metaphor

The critical reaction to Darwin's metaphor among Russian biologists from the 1860s until World War One transcended disciplinary, institutional and ideological boundaries. Field zoologists such as K.F. Kessler and M.N. Bogdanov, botanical geographers such as I.I. Mechnikov and N.F. Levakovskii all addressed this troublesome expression. In this respect there was unity among radicals such as N.D. Nozhin, liberals such as Beketov, and conservatives such as Korzhinskii.

A first common perception was that the metaphor 'struggle for existence' was confusing and in need of clarification. One result was a profusion of schematic classifications, beginning with those proposed by the plant physiologist K.A. Timiriazev in 1865, the zoologist G. Seidlitz in 1871, Beketov in 1873, and Mechnikov in 1876.[19] These scientists 'unpacked' Darwin's metaphor in order better to understand and explain it and to analyse the relationship and relative weight of its different components. They were especially careful to make three sets of distinctions: between indirect competition and direct struggle (after all, it was often noted, humans

do not 'compete' with tapeworms, they 'struggle' against them); between intraspecific and interspecific relations; and between an organism's relations with other life forms and those with the physical environment.

Naturalists were enjoined to keep such distinctions constantly in mind when investigating the struggle for existence in nature. Only in this manner, as one botanist put it, could science go beyond "mere words" and understand the physical process at work in the distribution and evolution of organisms.[20]

Experimentalists took up this same task. In 1869, for example, the Kazan Society of Naturalists approved N.F. Levakovskii's proposal to analyse the struggle for existence by experimenting with various wild plants. "It is easy to see the extraordinary complexity of the question of the so-called struggle for existence", Levakovskii observed, "and an attempt to discover the several causes facilitating the supplanting of some plants by others is possible and not at all lacking in interest".[21] By varying the physical conditions to which plants were subject and determining the proportion of plants that perished in the different moments of the struggle for existence, Levakovskii hoped better to understand temporal changes in regional flora.

A second common perception was that Darwin's emphasis upon overpopulation and intraspecific competition reflected a false, Malthusian, and socially insidious image of nature.

Reviewing in *Origin* in 1863, eighteen-year-old Ilya Mechnikov commented that its chief weakness was the author's "generalisation of the Malthusian law".[22] In the 1870s Mechnikov analysed several sections of Darwin's work to demonstrate the paradoxes and self-contradictions that had resulted. For instance, Darwin had explained the relative lack of new species among freshwater forms and lower organisms, such as *Amphioxus*, by their geographical isolation from potential competitors. Mechnikov commented that "here Malthus's law, which constitutes such an important foundation of Darwinism, is forgotten ... From a truly Darwinist point of view the competitors are largely individuals of one and the same species, *Amphioxus* itself. If it lives in isolation it should multiply without hindrance in a geometrical progression, and this circumstance should in itself lead to variations".[23] Russian naturalists often observed that Darwin had simply assumed the truth of Malthus's propositions and had failed to provide the same rich evidence for them as he had for other arguments in his book.

A.N. Beketov, Russia's most influential botanist and chair of the Department of Botany at St Petersburg University for twenty years, wrote the following in his notebooks on 'Morality and Natural Science': "Malthus's stupidity has yielded dangerous fruits. Malthus concludes that widespread hunger, deadly epidemics and destructive wars will save humanity from perishing, putting this off until distant times. The poor, according to Malthus's counsel, should not even reproduce, or should do so with extreme caution. All these sordid principles, unhappily, gain further support by [Darwin's] incorrect framing of the question of the struggle for existence".[24] For Beketov, Darwin's Malthusian error lay in two unsupported assertions: that conflict was generated by population pressures and that it was frequently resolved by intraspecific competition. Neither Malthusian factor, Beketov insisted, was more than an "occasional phenomenon" in nature. It was obvious that more plants and animals were born than remained alive, "but the essence of the question lies elsewhere. It is necessary [for Darwinists] to prove that these deaths are caused specifically by [intraspecific] competition".[25]

Beketov developed this argument in popular essays, textbooks and botanical studies. It defined his position, and that of his students, in the stormy debates among plant geographers concerning the reasons for the treelessness of the Russian steppes. In his autobiography he proudly summarised the chief result of his theoretical efforts as follows: "Malthusianism loses its significance".[26]

The ideological element in Russian arguments was often explicit. In 1896, for example, the conservative morphologist A.F. Brandt urged zoologists "to demonstrate that the significance of the struggle for existence [amongst organisms] ... is exaggerated" and so to combat pseudoscienific rationales for "this struggle for existence, this war of all against all, the philosophical system of Friedrich Nietszche and the right of the fist in human society".[27]

A third common, though less universal, proposition was that the central aspect of the struggle for existence was the organism's struggle with abiotic conditions. As the leading physiologist and psychiatrist V.M. Bekhterev put it: "It should be obvious to anyone that what is universal is not the struggle for existence among individuals of the same species, or of different species, but rather struggle for the right of life generally, for the acquisition of the necessary conditions of existence from surrounding nature".[28] As we shall see shortly, this perception provided the pivot point for mutual aid theorists.

These reactions defined a common direction of inquiry. Yet individual scientists – influenced by their own biological material, disciplinary training, institutional setting and ideological orientation – took different paths. Mechnikov developed a non-Malthusian reformulation of the struggle for existence that proved critical to his phagocytic theory of inflammation. Beketov devalued natural selection and reaffirmed his original view that evolution resulted chiefly from the direct action of the environment upon organisms. Korzhinskii conceived his theory of heterogenesis, published in 1899. Comparing his mutation theory with Darwin's hypothesis, Korzhinskii emphasised one advantage of the former: its denial of any creative evolutionary role to the struggle for existence and natural selection.[29]

The theory of mutual aid

One common path led many Russians to th so-called theory of mutual aid.

Like Darwin, these naturalists called attention to cooperation in nature. Yet they went far beyond Darwin in their acceptance of four basic tenets: the central aspect of the struggle for existence is the organism's struggle with abiotic conditions; organisms join forces to wage this struggle more effectively, and such mutual aid is favoured by natural selection; since cooperation, not competition, dominates intraspecific relations, Darwin's Malthusian characterisation of those relations is false; and cooperation so vitiates intraspecific competition that the latter cannot be the chief cause of the divergence of characters and the origin of new species.

This view was often voiced in the 1860s and 1870s by both scientists and lay intellectuals as an obvious objection to Darwin's theory.[30] It was first systemised by K.F. Kessler, the politically moderate ichthyologist who was rector of St Petersburg University and chair of its Department of Zoology.

Speaking before the St Petersburg Society of Naturalists in 1879, Kessler observed that "the cruel, so-called law of the struggle for existence" was often invoked by Darwinists to resolve social and moral issues. Yet Darwin himself had described several different aspects of this struggle, and it remained for naturalists to explore their relative significance and interaction. Kessler agreed that overpopulation sometimes generated intraspecific competition, and that conflict within a species "is often the cruelest, most merciless of

all". But Darwin, and especially "Darwinists", had exaggerated its place in nature.[31]

The need to find food, Kessler explained, stimulated struggle among organisms. But the need to defend themselves and reproduce led to cooperation. While studying the geographical distribution of fish Kessler had observed that spawning fish that traversed long and arduous migratory paths formed larger schools than those with less difficult journeys. Within such groups "separate individuals cease to be concerned only with feeding and preserving themselves, and begin to aid other individuals".[32]

He illustrated this same point with examples of mutual aid among bees, ants, beetles, spiders, reptiles, birds and mammals. Different organisms lived together under different conditions, and so their degree of mutualism varied. The importance of "family and social life" among birds, for instance, was "stunning". While travelling in the Crimea, Kessler recalled, he had often seen colonies of different species playing happily together, enjoying the material and spiritual advantages afforded by mutual aid. "Some like to entertain one another with song, others enjoy various flying competitions, still others find satisfaction in dance and in bloodless duels before a crowd of their fellows".[33]

Mutual aid contributed to evolution in two ways. First, it increased the resources and life span of species, and so the likelihood that the direct action of the environment would create new forms; and second, it increased the chances that these forms would prosper.

The political significance of this view was clear to Kessler and much appreciated by the zoologists in attendance: "I do not reject the struggle for existence," he explained, "but only affirm that the progressive development both of the entire animal kingdom and, especially, of mankind is not facilitated by mutual struggle so much as mutual aid."[34]

Kessler's "law of mutual aid" was greeted enthusiastically and widely cited. His position was endorsed by numerous political thinkers, theologians and philosophers, and by many naturalists including Bogdanov, Beketov, Brandt, Bekhterev and the soil scientist V.V. Dokuchaev.[35]

Another of Kessler's admirers, Petr Kropotkin, commented in 1909 upon a striking difference between the zoologists of his native Russia and his adopted England: "Kessler, Seversov, Menzbir, Brandt – four great Russian zoologists, and a fifth lesser one, Poliakov, and finally myself, a simple traveller, stand against the Darwinist exaggeration of

struggle within a species. We see a great deal of mutual aid where Darwin and Wallace see only struggle." Kropotkin attributed this, in part, to the Malthusian ethos in England but emphasised another factor: "Russian zoologists investigated enormous continental regions in the temperate zone, where the struggle of the species against natural conditions ... is more obvious; while Wallace and Darwin primarily studied the coastal zones of tropical lands, where overcrowding is more noticeable. In the continental regions that we visited there is a paucity of animal population; overcrowding is possible there, but only temporarily."[36]

Here Kropotkin was recalling the origins of his own belief in mutual aid, which, despite its seemingly direct relationship to his anarchist philosophy, actually had a more complex and interesting history. At age nineteen, as a young liberal nobleman unsure of his future plans, Kropotkin had attached himself to a series of military and commercial expeditions through Siberia. He traversed over fifty thousand miles in the years 1862-1867, playing the same role of 'gentleman-observer' as had Darwin on the *Beagle* years earlier. Already an evolutionist, Kropotkin read the *Origin* en route, measured Darwin's theory against the wilderness around him, and corresponded about it with his brother. These letters support his later recollection that he and the young zoologist I.S. Poliakov "daily looked for the keen competition between animals of the same species which the reading of Darwin's work had prepared us to expect" but were struck instead by the many "adaptations for struggling, very often in common, against the adverse circumstances of climate or against various enemies".[37] Only years afterward, by which time he was an accomplished and celebrated member of St Petersburg's scientific community, did Kropotkin become a revolutionary anarchist.

Kropotkin was in exile when Kessler spoke on mutual aid, but in 1882 he read his compatriot's remarks with enthusiasm. Six years later T.H. Huxley published what Kropotkin termed an "audacious article" entitled 'The Struggle for Existence in Human Society'. Huxley did not espouse triumphalist 'Social Darwinism', but his rendering of the struggle for existence was Malthusian and pessimistic. His comparison of relations in the animal world with "a gladiator's show" could not have differed more dramatically from the view shared by Kropotkin and his colleagues in St Petersburg. Kropotkin responded to Huxley in 'Mutual Aid: A Factor of Evolution' which appeared as articles in *Nineteenth Century* from 1890-1896 and as a book in 1902.[38]

This treatise followed the basic logic of the Russian national style: Kropotkin broke down the struggle for existence into its component parts, placed the organism's struggle with abiotic conditions at its centre, and criticised as Malthusian Darwin's conception of population dynamics and intraspecific relations. He concluded that relations within a species were shaped by the physical conditions of life and that these conditions often led to mutual aid:

> "In the animal world we have seen that the vast majority of species live in societies, and that they find in association the best arms for the struggle for life: understood, of course, in its wide Darwinian sense – not as a struggle for the sheer means of existence, but as a struggle against all natural conditions unfavourable to the species. The animal species, in which individual struggle has been reduced to its narrowest limits, and the practice of mutual aid has attained the greatest development, are invariably the most numerous, the most prosperous, and the most open to further progress."

Because mutual aid resulted from demanding physical circumstances, it was rare among domesticated animals. For example, marmots were forced to cooperate in their natural habitat, "where they lived in peace and harmony"; captivity, on the other hand, brought out their fighting instincts. Weasels had been highly sociable until human settlements destroyed their food supplies, forcing them to scatter in order to avoid intraspecific competition.[39]

Kropotkin recognised that mutual aid alone could not substitute for intraspecific competition as an explanation for the evolution of physical traits. In the first two decades of the twentieth century he wrote many articles on the evolutionary role of the direct action of the environment and the inheritance of acquired characteristics. He hoped thereby to develop a non-Malthusian evolutionism, or, as he put it in one letter, "to demonstrate that Mutual Aid does not contradict Darwinism, if natural selection of properly understood".[40]

An admirer of Darwin, Kropotkin considered himself a follower of the Darwin of the sixth edition of the *Origin*. Citing Darwin's published correspondence, he contended that this mature Darwin had been approaching a theory much like his own. Darwin's successors, however, had been blinded by their relative neglect of field investigations, their Malthusianism, and the philosophical idealism that had infected both the neo-Darwinist and neo-Lamarckian camps.[41]

What, then, are we to make of the fact that the most elaborate expression of Russia's mutual aid tradition was written by an émigré

anarchist in England? Mutual aid was not a controversial idea in Russia. Classical Darwinists there declined to attack it, nor did they associate Darwin's theory with even a relatively mild Social Darwinism like Huxley's.[42] Only when Kropotkin brought this Russian tradition into contact with a quite different British one did he feel compelled to defend at length what for many Russians was commonsensical.

Conclusion

I have argued that the intensive exploration of the struggle for existence and criticism of its Malthusian components constituted a Russian national style in the response to Darwin.

Was this response unique? In one sense it was not. At the turn of the century the German biologist Ludwig Plate developed an extensive classification of the struggle for existence, and similar individual cases can be found in other countries.[42] Furthermore, the Russian response followed not from a mysterious 'Russian soul' but from the confluence of two specific conditions, one physico-geographical, the other socio-economic. Variants of these conditions must have influenced discourse in other countries as well.

Yet they seem to have combined with particular intensity and effect in Russia. Their influence framed the terms in which Russian naturalists, as a population, discussed and developed Darwin's theory. The extent to which this was true elsewhere can only be determined by comparative studies of reactions to the hypothesised struggle for existence by other populations. In the absence of such studies, let me suggest some tentative comparisons with England.

It has often been observed that the two Englishmen who simultaneously developed the selection theory shared two experiences: a voyage to the tropical forests of the equator and a sympathetic reading of Malthus's *Essay*. Most Russian evolutionists shared two experiences that were roughly opposite to these: travels upon a vast continental plain (with sharply contrasting and swiftly changing environmental conditions) and an aversion to Malthus.

The naturalists of each country had knowledge of a variety of natural settings. Russians, however, tended to perceive the great continental expanse upon which they lived, and which they were encouraged to study as the tsarist empire expanded inland, as paradigmatic of essential relations in nature. The explorer-zoologist A. Middendorf, for example, contended that the enormous distances, sharp climatic

contrasts and simplicity of life conditions in Siberia provided an ideal context for the study of nature: "The very scarcity of a variety of animal forms facilitates a better understanding of the general laws of life". He felt that in the tropics naturalists were swamped by an abundance of organic forms, which obfuscated fundamental relationships and prevented them from "penetrating deeper into the subject". To what extent did British naturalists, investigating the tropical possessions of a sea power, tend to perceive tropical nature as similarly paradigmatic?[43]

As for Malthus, very few Russian naturalists agreed with Joseph Hooker, T.H. Huxley and other leading British evolutionists that his argument was "incontrovertible".[44] Nor would a single one have identified with Malthus when under attack, as Darwin did in 1866. "It consoles me that [he] sneers at Malthus," Darwin wrote to Charles Lyell about one critic, "for that clearly shows, mathematician though he may be, he cannot understand common reasoning". One month later, he confided to Alfred Russel Wallace that misunderstandings about the selection theory were perhaps inevitable, "for we do not see even to the present day Malthus on Population absurdly misunderstood? This reflection about Malthus had often comforted me when I have been vexed at the mis-statement of my views".[45]

No doubt some British naturalists had a problem with the struggle for existence, just as some Russians did not share the difficulties of their countrymen.[46] But such variations found highly propitious conditions in Russia, shifting evolutionary thought in a discernible direction. In England the ground for them was relatively barren – or, more appropriately, they were lost amid more adaptive responses.

The 'selection pressures' in Russia are evident even in the work of the most outstanding exception to the rule there. The plant physiologist K.A. Timiriazev, a proponent of Darwinian orthodoxy and a prolific populariser, laboured mightily to convince his compatriots that Darwin's approach to the struggle for existence was separable from Malthus's reactionary views. He reminded Russians that the law of population underlying Darwin's concept had first been discovered by the popular Benjamin Franklin, not the despised Malthus. He insisted that, although invoked by reactionaries to justify "soulless inertia" in social life, this law remained a "mechanistic cause of progress" in the natural world.[47] He emphasised that neither Darwin "nor any consistent Darwinist" had ever extended the concept of the "struggle for existence" to "the cultured human of today".[48] Such arguments, he finally concluded, were futile.

Beginning in the early 1890s he dropped Darwin's metaphor from his explanations of the selection theory. He later explained that "I have systematically avoided the unhappy expression 'struggle for existence', which the enemies of Darwinism exploit so unceremoniously".[49]

One can imagine Timiriazev's delight upon encountering Wallace's article 'Mr Darwin's Metaphors Liable to Misconception' (1868), and his disappointment upon reading it. For Wallace addressed the metaphor most troubling for British naturalists. He mentioned the 'struggle for existence' only as a self-evident truth, apprehension of which enabled one to grasp the meaning of the problematic 'natural selection'. Wallace and Hooker had earlier advised Darwin to drop the latter expression altogether, eliciting the response that "every one knows what is meant and is implied by such metaphorical expressions". But, as Darwin himself surely knew, this was wishful thinking. The fate of his theory in Russia illustrates the effect that culturally specific metaphors can have on the reception and elaboration of scientific ideas.[50]

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Notes

1. Charles Darwin, *On the Origin of Species* (facsimile of the first edition, Cambridge, Massachusetts: Harvard University Press, 1964), page 62.

2. *Ibid*, pages 62-63.

3. *Ibid*, page 63.

4. Charles Darwin, *On the Origin of Species* (sixth edition, New York: D. Appleton, 1876), page 63. The phrase first appeared in the third edition, published in 1861.

5. These conclusions first appeared in the second, much-revised edition of the *Essay*. See T.R. Malthus, *An Essay on the Principle of Population* (fifth edition, London: John Murray, 1817), pages 235-242.

6. Malthus's *Essay* was translated into German in 1807 and into French in 1809. Extensive excerpts appeared in a Spanish journal in 1808, and the complete text was translated in 1845.

7. For Butovskii's favourable estimation of Malthus's theory see A.I. Butovskii, *Opyt o narodnom bogatsve, ili o nachalakh politicheskoi ekonomii* (St Petersburg, 1847), pages 350-351, 367, 370 and 376. For his admission that this theory was inapplicable to Russia see Butovskii, 'Obshchinnoe vladenie i sobstvennost' in *Russkii Vestnik*, 1858, *16*:5-59, on page 34. All translations unless otherwise indicated are my own.

8. The point here is not to explore the nuances of individuals' political views but to display the great political diversity of those who rejected Malthusian principles. I use 'conservative' to encompass monarchists, Pan-Slavists and others who sought to preserve the tsarist socio-economic system essentially intact; and 'radical' to include nihilists, anarchists, left populists, Marxists and others who sought its overthrow and replacement with a socialist system. 'Liberals' held a wide range of centrist views, ranging from constitutional monarchism to evolutionary socialism. They did not advocate laissez-faire economic politics, for which there was no significant constituency in Russia.

9. V.A, Miliutin 'Mal'tus i ego prtivniki' in *Sovremennik*, 1847, *4*(8):151; and V.F. Odoevsky, *Russian Nights* (1844), translated by Olga Koshansky-Olienikov and Ralph Mitlow (New York: Dutton, 1965), page 50.

10. Dmitry Pisarev, *Selected Philosophical, Social and Political Works* (Moscow, Foreign Language Publishing House, 1958), pages 202-203; and N.V. Sokolov, cited in G.N. Korostelev, *Kritika mal'tuzianskikh i neomal'tuzianskikh vzgliadov: Rossiia xix-nachala xxv* (Moscow: Statistika, 1978), page 86.

11. A.I. Gertsen, *Sobranie sochinenie v tridtsati tomakh*, Vol. VI (Moscow: Akademia Nauk, 1955), page 163.

12. On the reception of Darwin's theory in Russia see K.M. Zavadskii, *Razvitie evoliutsionnoi teorii posle Darvina* (Leningrad: Nauka, 1973); Ia. M. Gall, *Bor'ba zu Sushchestvovanie kak faktor evoliutsii* (Leningrad: Nauka, 1976); and Francesco M. Scudo and Michele Acanfora, 'Darwin and Russian Evolutionary Biology' in *The Darwinian Heritage* edited by David Kohn (Princeton, New Jersey: Princeton University Press, 1985), pages 731-754.

13. N.G. Chernyshevskii, *Chernyshevskii v sibiri: Perepiska s rodnymi*, Vol. 1 (St Petersburg, 1913), page 71.

14. Some thought this relationship profound, others superficial; all addressed it by analysing the dynamics of the struggle for existence.

15. N. Ia. Danilevskii, *Rossiia i Evropa* (1869, New York / London: Johnson reprint, 1966), pages 146-147.

16. N. Ia. Danilevskii, *Darvinizm: Kriticheskoe izsledovanie*, Vol. I (St Petersburg, 1885), page 478.

17. *Tolstoy's Letters*, edited and translated by R.F. Christian, Vol. II (New York: Scribner's, 1978), page 717.

18. T.R. Malthus, *Opyt o zakone narodonaseliniia*, translated, with an introductory essay, by Pa'a Bibikov (St Petersburg, 1868), page 23.

19. K.A. Timiriazev, 'Kratkii ocherk teroii darvina' (1865) in *Sochineniia* (Moscow: Sel'khozgiz, 1939-1940), Vol. VII; G. Seidliz, *Die darwinische Theorie* (Dorpat, 1871); A.N. Beketov 'O bor'be za sushchestvovanie v organicheskom mire', *Vest. Evr.*, 1873, *10*:558-593; and I.I. Mechnikov, 'Ocherk voprosa o proiskhozhdenii vidov' (1876) in *Akademisheskoe sobranie sochinenie*, Vol. IV (Moscow: Akademiia Nauk, 1950).

20. A.N. Beketov, 'O bor'be za sushchestvovanie v organicheskom more', *Vest. Evr.*, 1873, *10*:558-593, on page 575.

21. N.F. Levakovskii, 'K voprosu o vytesnenii odnikh rastenii drugimi, I: Otnoshenie semian' rastenii k vlage', *Trudy Obshchestva Estestvoispytatelei pri Imperatorskom Kazanskom Universitete*, 1873, *1*:35-52, on page 37.

22. I.I. Mechnikov, 'Nskol'ko slov o sovremennoi teorii proiskhozhdeniia vidov' (1863) in *Akademicheskoe sobranie sochinenie* (cit. n. 19), Vol. IV, page 20. The authorities suppressed the journal for which this review was intended; it was first published in 1950.

23. Mechnikov, 'Ocherk voprosa proiskhozdeniia vidov' (cit. n. 19), page 254.

24. A.N. Beketov, notebooks, cited from archival material in A.A. Scherbakova, *Andrei Nikolaevich Beketov* (Moscow: Akademiia Nauk, 1958), page 207.

25. A.N. Beketov, *Geografii rastenii* (St Petersburg, 1896), page 16.

26. [A.N. Beketov] 'Beketov, Andrei Nikolaevich, botanik' in *Kritiko-biograficheskii slovar' russkikh pisatelei i uchenykh*, edited by S.A. Vengerov, Vol. II, Pt. 22-30 (St Petersburg, 1891), page 361.

27. A.F. Brandt, 'Sozhitel'stvo i vzaimnaia pomoshch', *Mir Bozhii*, 1896, *5*(5):1-22, 93-116, on page 1.

28. V.M. Bekhterev, 'Sotsial'nyi otbor i go biologicheskoe znachemie', *Vestnik Znaniia*, 1912, *12*:947-954, on page 949.

29. These different paths are examined in my forthcoming book, Daniel P. Todes, *Darwin Without Malthus: The 'Struggle for Existence' and Russian Evolutionary Thought, 1859-1917.*

30. For example, the radical embryologist N.D. Nozhin observed that Darwin's theory "is true only in the sense that Malthus's theory is also true". Bourgeois ideology had blinded both to the fact that intraspecific competition was not a normal, healthy, physiological process resulting in progress, but merely an abnormal "source of pathological phenomena", N.D. Nozhin, 'Nasha nauk i uchenye: stat'ia V' *Obechestvennye Zapiski* 1869 *7*-40-46..

31. K.F. Kessler, 'O zakone vzaimnoi pomoshchi', *Trudy Sankt-Peterburgskogo Obshchestiva Estestvoipytatelei*, 1880, *11*(1):124- 127.

32. K.F. Kessler, *Ryby, vodiashchiiasia i vstrechaiusshchiesia v Aralo-Kaspiisko-Pontiiskoi ikhtiologicheskoi oblasti* (St Petersburg, 1877).

33. Kessler, 'O zakone', pages 132-133.

34. *Ibid*, page 135.

35. As this list of names indicates, the mutual aid tradition was strongest in St Petersburg; see A.N. Beketov, *Uchebnik botaniki* (St Petersburg, 1880-1883), page 508;

Beketov, *Geografi Rastenii* (cited in note 24), page 19; M.N. Bogdanov, *Iz zhizni russkoi prirody* (St Petersburg, 1889), pages 215-218; V.M. Bekhterev, 'Sotsial'nyi otbor' (cited in note 27), page 948; and V.V. Dokuchaev, Publichnye lektsii po pochvovedeniiu i sel'skomu khoziadtvu' in *Sochinenie*, Vol. VII (Moscow/Leningrad: Akademiia Nauk, 1953), page 277.

36. P.A. Kropotkin to Marie Goldsmith, 15th August 1909, Boris Nicolaevsky Collection, Hoover Institution on War, Revolution and Peace, Stanford University, Stanford, California, File 6, pages 351-352.

37. P.A. Kropotkin, *Mutual Aid: A Factor of Evolution* (London: Freedom Press, 1987), page 26. For Kropotkin's impressions of Siberian nature see *Perepiska Petra i Aleksandra Kropotkinykh*, edited by N.I. Lebedev, 2 vols. (Moscow/ Leningrad: Academia, 1932); and P.A. Kropotkin, *Pis'ma iz Vostochnoi Sibiria*, edited by V.A. Markin and E.V. Starostin (Irkutsk: Vostochno-Siberirskoe Knizhnoe izdatel'stu, 1983).

38. T.H. Huxley's 'The Struggle for Existence in Human Society' is reprinted in Kropotkin's *Mutual Aid* (Boston: Extending Horizons Books, 1955), pages 329-341.

39. Kropotkin, *Mutual Aid* (Freedom Press), page 230 (quotation) 48,51.

40. Kropotkin to Goldsmith, 3rd November 1909.

41. See Kropotkin to Goldsmith, 2nd February and 8th March 1910, File 6, pages 378, 382. See also Kropotkin, 'Direct Action of Environment on Plants', page 62.

42. Ludwig Plate, *Über die Bedeutung der Darwinischen Selektionsprinzipe* (Leipzig/Berlin, 1903).

43. A. Middendorf, *Puteshestvie na sever' i vostok sibiri*, Part II: *Sever' i vostok sibiri v estestvennoistoriecheskom otnoshenii* (St Petersburg, 1869), page 2.

44. *Life and Letters of Sir Joseph Hooker*, edited by Leonard Huxley (London: Murray, 1918), Vol. II, page 43. For Huxley's similar sentiments see T.H. Huxley, *On the Origin of Species; or, The causes of the Phenomena of Organic Nature* (New York: Appleton, 1873), page 120.

45. Charles Darwin to Charles Lyell, 6th June 1860, in *Life and Letters of Charles Darwin*, edited by Francis Darwin, Vol. I (New York: Appleton, 1891), page 111; and Darwin to Alfred Russel Wallace, 5th July 1866, in *More Letters of Charles Darwin*, edited by Francis Darwin, Vol. I (New York: Johnson Reprint, 1972), page 230.

46. The palaeontologist V.O. Kovalevskii, the zoologists N.A. Severtsov and M.A. Menzbir, and the plant physiologist K.A. Timiriazev would be included here. See Daniel P. Todes, 'V.O. Kovalevskii: The Genesis Content, and Reception of his Paleontological Work' in *Studies in History of Biology*, 1978, *2*:99-165; and Timiriazev, *Sochinenie* (cit. n. 19).

47. K.A. Timiarizev, 'Istoricheskii metod v biologii' (1892-1895) in *Sochinenie* (cited in note 19), Vol. VI, paged 118-119.

48. K.A. Timiarizev, 'Stoletnye itogi fiziologii rastenii' (1901) in *Sochinenie*, Vol. V, page 425.

49. Ibid.

50. See Robert Young, 'Darwin's Metaphor: Does Nature Select?' reprinted in Young, *Darwin's Metaphor: Nature's Place in Victorian Culture* (Cambridge: CUP, 1985), pages 79-125. 'Mr Darwin's Metaphors Liable to Misconception' was first published in the *Quarterly Journal of Science* in October 1868 and was republished as 'Creation by Law' in Wallace's *Natural Selection and Tropical Nature* (London: Macmillan, 1891), pages 141-166.

Why Science Matters

When Shelley pictured science as a modern Prometheus who would wake the world to a wonderful dream of Godwin, he was alas too simple. But it is as pointless to read what has happened since as a nightmare. Dream or nightmare, we have to live our experience as it is, and we have to live it awake. We live in a world which is penetrated through and through by science, and which is both whole and real. We cannot turn it into a game simply by taking sides.

And this make-believe game might cost us what we value most: the human content of our lives. The scholar who disdains science may speak in fun, but his fun is not quite a laughing matter. To think of science as a set of special tricks, to see the scientist as the manipulator of outstanding skills – this is the root of the poison mandrake which flourishes rank in the comic strips. There is no more threatening and no more degrading doctrine than the fancy that somehow we may shelve the responsibility for making the decisions of our society by passing it to a few scientists armed with a special magic. This is another dream, the dream of H.G. Wells, in which the tall elegant engineers rule, with perfect benevolence, a humanity which has no business except to be happy. To H.G. Wells this was a dream of heaven – a modern version of the idle, harp-resounding heaven of other childhood pieties. But it is in fact the picture of a slave society, and should make us shiver whenever we hear a man of sensibility dismiss science as someone else's concern. The world today is made by science. It is powered by science. For any man to abdicate an interest in science is to walk with open eyes towards slavery.

from J. Bronowski, *Science and Human Values*

John Noble

Cosmology and the God Metaphor

If you can scan the science section of any bookshop you may be left with the impression that the shelf-stackers have a categorisation problem and are in need of a refresher course; it is easy to believe that you have strayed into the religious section. Running your eye quickly over the book-covers reveals such titles as *The Mind of God*,[1] *God and the New Physics*,[2] *Does God Play Dice*,[3] which vie with the more traditional titles for your attention. The first two books are from the pen of a theoretical physicist, the other from that of a mathematician. Beware, these books are infected with the GOD virus. But even titles free of the virus, such as *Infinite in all Directions*,[4] *A Brief History of Time*,[5] *Science and Creation*,[6] seductive to the uninitiated, hide texts sprinkled with, or in the case of the last mentioned book (the work of an ex-theoretical physicist who is now an anglican priest), heavily infected with, the three-letter virus.

Like another three-letter virus, HIV, it is extremely dangerous. In common with HIV, GOD is spreading rapidly and only a change in lifestyle will contain it; there is at present no vaccine or effective treatment. It has been around for a very long time, but over the last two centuries it has been in decline in the West and hopes that it would be, like smallpox, completely eradicated were high. The present strain is more virulent, and resistance to it is low.

It is primarily books about cosmology and astronomy that are attacked. Other branches of physics and biology (which was affected in the past) only present sporadic cases. The infection is rarely evident in popular books on brain science or artificial intelligence where it might be expected to be rampant. It must be stressed that not all books on cosmology are infected; many show a strong resistance to the virus. Significantly, GOD is rarely detected in papers read at scientific conferences or printed in scientific journals.

In likening God to a virus I am, of course, employing an allegory in order to highlight the spread of the God metaphor over the last decade or so. I am not suggesting that the authors of the aforesaid books necessarily have a belief in God or belong to a religious organisation.

That it should be these subjects infected by the GOD virus is because workers in these fields have strayed into areas traditionally the domain of metaphysics or religion. Some cosmologists have suggested that they are near to a complete understanding of the origin of the Universe (the Big Bang Theory is the current favourite). There are even rumours that the end of physics is in sight. It is an exciting time for theory: there are theories which aim to explain everything (TOEs), Grand Unifying theories (GUTs) aiming to unify three of the four fundamental forces (gravity is resisting inclusion at present). There are black holes, wormholes, string, superstrings, supergravity and many more exotic ideas to confuse or entrance the novice. Something called the Anthropic Principle has surfaced, which is concerned with the realisation that the presence of *homo sapiens* in the scheme of things is only possible because the Universe and its laws are as they are (if the laws were slightly different to what they are life could not have evolved). Since it is conceivable that the laws could have been different, some explanation of why they are as they are is required. The possibility of other universes, of which we do not and could not have cognisance, is being discussed; if ours is the only universe one is forced to accept that consciousness and man's ability to explain the way things are would seem to have been specified in the Big Bang – not an appetising idea since it smacks of teleology and it lets in God.

The use of metaphor is common amongst scientists and non-scientist alike. Our discourse and language is riddled with metaphors. Stebbing[7] writes: "metaphor, simile, parable and allegory, all involve implicit or explicit comparison. A metaphor is an implicit comparison in which the notion compared replaces the notion that could be illustrated by the comparison. Thus we speak of 'weighing the evidence' although there is no explicit comparison between the process of weighing bodies and evaluating evidence" and adds "Our language abounds with metaphors which are – metaphorically – 'dead' ..." It is impossible to avoid the use of metaphors but we need to be aware that we are using them and to recognise their limitations.

When Einstein said "God does not play dice" when Hawking argued that if we are able to formulate a Theory of Everything we will be able to "read the mind of God", they were not making a declaration of belief in a personal god; they were using the term metaphorically. Einstein didn't like the idea that at the quantum level of physics there was an indeterminacy: Hawking was expressing a belief that when we

have a Theory of Everything we will know all there is to know, or all we can know. Einstein often referred to "The dear Lord" though he had no traditional religious belief.[8] Bohr was more circumspect; he changed "God" to "the providential authority".[9]

There have been many occasions when new scientific discoveries necessitated a revision of existing ideas; developing new models to fit new facts and finding useful metaphors is often a painful process. The initial strangeness of Faraday's postulated 'field' in which electrical and magnetic forces act, is one we have become accustomed to but accepting the dual nature of light (as both wave and particle) has proved to be less easy – here we have two metaphors for light which are difficult to reconcile, for scientist and layperson alike.

The physical sciences are heavily dependent on mathematics: mathematics is effective (according to some unreasonably so) in describing the physical world. But mathematical theories are as much metaphorical as are non-mathematical theories. It is when the mathematical formulae have to be translated into everyday language that difficulties arise; it is not just non-scientists who have problems of understanding. Maxwell, who developed the mathematical theory of electromagnetism, himself imagined a system of particles and gears in the propagation of magnetic and electric fields[10] and Einstein pictured himself running alongside lightbeams and employed 'clocks' and 'lifts' when explaining General Relativity. In facing up to new ideas – ideas which may be strange and counter to common sense – we are forced to adapt ideas and processes from a different area of experience. All the concepts of science – space, matter, light, field – employ words in common usage but which are redefined by the scientific community; the space I occupy is not the space of the cosmologist.

A recent illustration of the limitations of metaphors is found in issues of *The New Scientist* published earlier this year (1993). In one issue experts were invited to answer readers' questions about the Big Bang and the expansion of the Universe. The experts contradicted one another, creating more fog than light. The next issue contained irate and sarcastic letters in response to the experts' answers and the editorial attempted to pacify its readers by emphasising the limitations of metaphor and analogy in explaining physical theories which are mathematical or which use everyday concepts in restricted and specialised ways.[11]

The confidence of those who claim that final answers are near, or that the end of physics is in sight, is easily tempered with examples from history. There have been many occasions when it was thought that a final stage of understanding had been reached. Protons, neutrons and electrons were once thought to be the most fundamental particles of matter but the subsequent discovery of antiparticles and a plethora of other particles demolished that complacency. Newton's Law of Gravity, stood for three hundred years, until Einstein formulated the Theory of Relativity.

Not all physicists are so bold (or foolhardy) in their prognostications. Feynman, among others, emphasises major areas of physics where problems still remain. He adopts a rugged, pragmatic approach which forsakes any forecasting as to what will happen in the future. We must wait and see. Likewise he is not enamoured of some theories which don't appear to be testable and therefore not strictly within the realm of science. He argues that it is not possible to say that the Universe is or is not completely understandable and there is no point in speculation about it.[12, 13]

There are anyway, I suggest, reasons for doubting man's ability to explain everything or to discover the cause of the Universe – assuming that there was a cause. Our notion of causality (except in the sense of something preceding something else) is probably an example of anthromorphism; 'causing' is a human attribute – we can cause things to happen. Attributing a cause to nature or the Universe implies an agent, but it is questionable whether the implication is legitimate. The laws of science are not causes in the usual sense of the word. Gravity does not cause objects to fall to the centre of the Earth; it is a summary of a set of equations which describe the relationship between the objects in question. The reason 'why' this particular relationship exists is apart from the equations. The laws governing the Universe (if they exist – it is only a scientist's faith that the Universe is lawful) cannot be its cause. The cause must be outside of them. This reasoning leads to an infinite regress, as does the God hypothesis. To argue that the Universe had no beginning gets us nowhere either. The problem is that our ideas of beginnings and ends are derived from out finite world which, like ourselves, had a start and will come to an end. The terms we use to describe the Universe are necessarily anthropomorphic.

People are always going to ask these metaphysical questions, but it is likely there are no answers. It can be argued anyway (if one accepts Popper's principle of falsifiability) that such questions are not scientific since they are not testable – they must remain matters of opinion. I personally don't have a problem accepting that there may be questions without answers; that there are limits to scientific knowledge. Seeking a purpose to the Universe or a meaning to life is probably futile[14] – the likely result, a headache. In any event we have not run out of interesting scientific problems; we can leave the 'deep' questions to the future. If the future does provide scientific explanations for them, so be it.

But this essay is not primarily about viruses or cosmological theory. No, my concern is that the over-use of the God metaphor in popular scientific books is unhelpful and gives comfort to propagators of the various religions that have survived the Enlightenment and the success of the scientific method.

There would be no objection to the use of 'God' as a metaphor – demarcating an area of our ignorance – if it was not that the term carried less benign connotations. Much of the dissonance and strife in the world is in the name of God. This was true of the past and is no less true of today. It is often difficult to disentangle ethnic, national and religious descriptions, but there is little doubt that religious beliefs play a large part in bloody disputations throughout the world. One has only to think of Ireland, India, the Middle East and what was once basically secular Yugoslavia, to appreciate this.

Religious organisations primarily exist to maintain power and control over their adherents and, whenever possible, to extend it to non-members; most of them aim to convert the world to their own particular variety of belief. Even though the men in these streets may have only nominal religious affiliations, the religious organisations speak in their names whether or not they wish to be included. The role of the Roman Catholic Church as well as Muslim leaders in preventing the spread of birth control is well documented.[15, 16]

Traditionally church and state were closely linked and still today there are few areas of life in which the churches do not force an opinion or have a presence. In moments of crisis their representatives are prominent. Even in our secular society they sit on commissions, university boards, school boards and public bodies of all descriptions, along with MPs, business representatives and chief constables.

In Eastern Europe the breakdown of communism has heralded the appearance of all the old religious denominations, and the recent spate of new religions in America, which employ the latest communication techniques, emphasises the fact that religion is far from a spent force. In the Middle East revolutions are made in the name of ancient prophets for peoples manipulated by clerics (it is inconceivable that the thousands of chanting demonstrators in Iran and other countries against Rushdie's *The Satanic Verses* will have read the book or, even if they had, whether it would have caused them much concern).

Neither can there be objection to scientists and non-scientists holding a religious belief in private. Yes, there are scientists who hold to religious beliefs of the traditional kind; others are of the 'born-again' variety. Some, perhaps out of laziness or not wishing to 'rock the boat', define religious belief or religious experience in such broad terms that it includes almost anything. But many are atheists or agnostics and reject the idea of God and an after-life. The Christian personal God (or any other God) is a strange one for scientists; nonetheless I do not complain that they believe, but that by default they inflict the consequences of their belief on others.

The conflict between religions, each claiming to be the one true one (if there is a God then only one of the competitors can be true) is truly disruptive of this planet and, as Bondi and others[17,18] have suggested, religious believers should keep their mouths shut. If this were to happen, if religious beliefs were confined to the private domain, much misery in the world would be avoided – there would be fewer excuses for warmongering. We hear a great deal about child abuse but little about the corruption of children's minds, caused by the filling of their heads with religious nonsense. The guilt and unhappiness produced in children by religious bigots, so painfully described in earlier times,[19,20] has not disappeared. Is it any wonder that so many people are unable to think rationally following the childhood brainwashing called religious instruction?

Scientists have a particular need and responsibility to counteract dogma – their discipline depends on open-mindedness and scepticism. Religious bodies are adept at gleaning the smallest crumb of support from science – witness the Vatican Observatory conferences at which scientists are invited to discuss their theories,[21] thus allowing the church to claim freedom of speech whilst denying freedom of action to many of its victims. The Pope even has opinions

as to the correctness of scientific theory; he apparently prefers the Big Bang theory of the origin of the Universe to the Steady State theory,[22] presumably because it ensures a beginning to the Universe – a cosmic crack for God to squeeze through!

By keeping quiet, by excusing the need to speak out because religion is no longer important and is dying out anyway, by giving credence to God by using the God metaphor, scientists are doing themselves and mankind great damage.

None of the books which employ the God metaphor would suffer is another metaphor was employed in its place. 'Nature' or 'The Universe' or Bohr's 'Providential Authority' could easily replace it without there being any loss of clarity. These alternatives would not make the origin of the Universe any easier to comprehend but that is in the nature of what is probably, from our standpoint, finally incomprehensible.

In their own interests, and for the benefit of mankind, popularisers of science should avoid the God metaphor and play their part in helping to free the world from the tyranny of superstition. Their reward won't be in an after-life but in their lifetime on earth.

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A Sociologist on Science

Consider Durkheim's great study of suicide. Basically it is the view of the artist as much as that of the scientist ... How did Durkheim get his controlling idea? We may be sure of one thing; he did not get it, as the stork story of science might have it, from a preliminary examination of the vital registers of Europe, any more than Darwin got the idea of natural selection from his observations during the voyage of the 'Beagle'.

Robert Nisbet, *The Sociological Tradition*, Heinnemann, 1966

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