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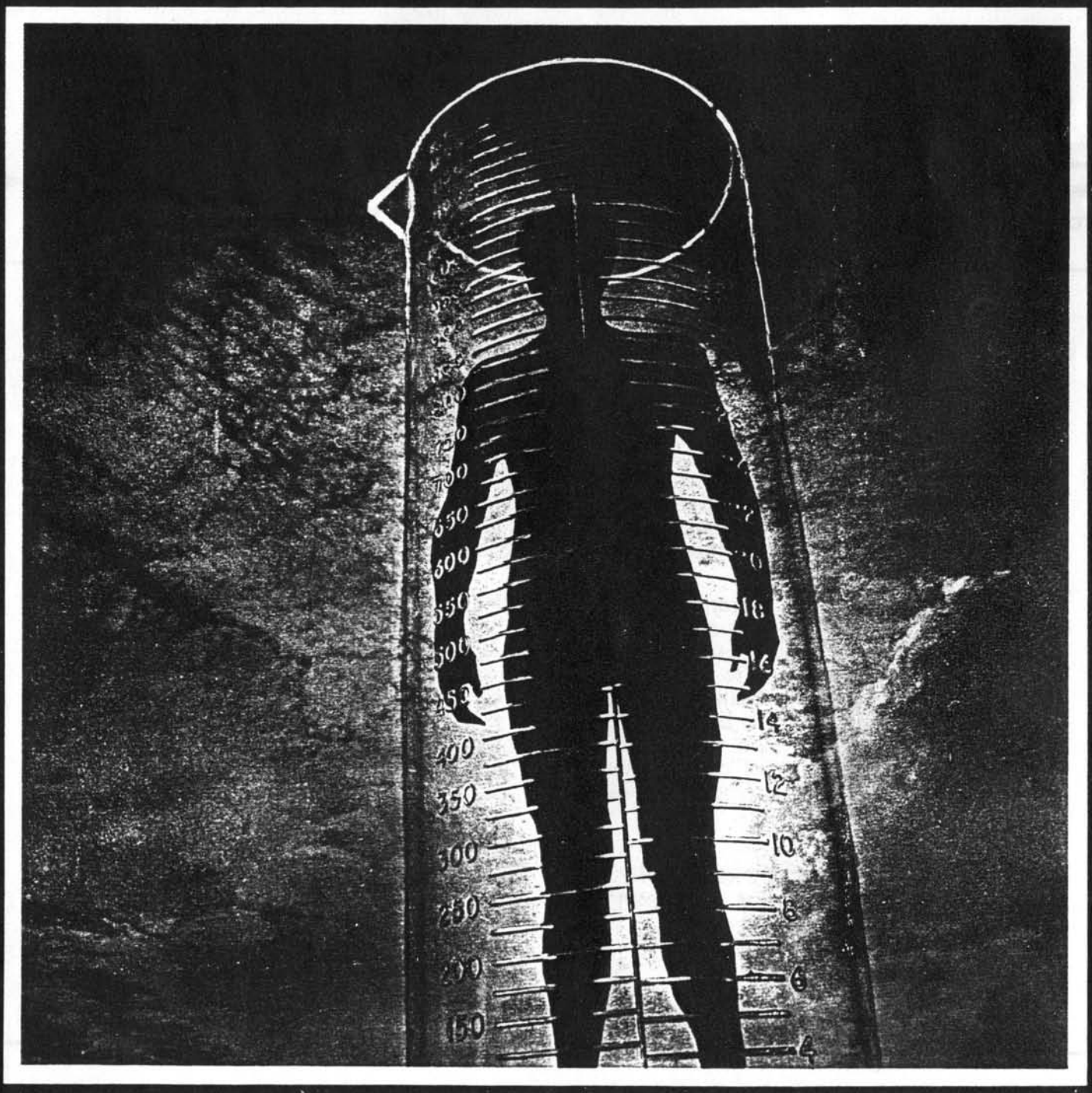
Scientific Straitjacket



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Editorial

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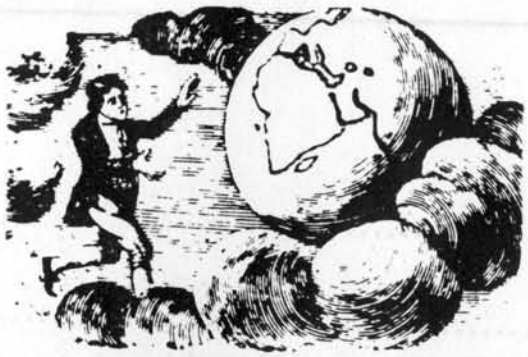
EDITORIAL



Can We Trust Scientists?

After the eruptions caused by the Cyril Burt scandal, when it was discovered that Burt had falsified data on identical twins to prove that intelligence is inherited, a new case of scientific fraud has come to light. In this instance, it appears that cells claimed by a researcher to have been from patients with Hodgkin's disease were in fact taken from a strain of owl monkey, thus invalidating four years of research. Commenting on those revelations, *Nature* (the journal which first published the story) was at pains to argue that such cases of dishonesty are extremely rare — mere snowflakes on the apocryphal iceberg rather than its ominous tip. But can the public be so sanguine? Scientists after all are human and it would be extraordinary if they were immune to the ambitions and pressures which can cloud objectivity in common mortals. Indeed, the latest revelations, coupled with accusations of bias in two recent government reports (one giving the go-ahead to badger gassing, the other giving a clean bill of health to the herbicide 2,4,5-T) raise the question: how far can we trust the objectivity of our scientists? And even if their integrity is above reproach, how far can we trust the powers-to-be to heed their advice?

By and large, scientists rely on sponsorship by industry and government to fund their research. That research is rarely undertaken for 'research's sake' alone. Generally, it is hoped that it will yield practical results and inevitably the question of vested interest raises its head. Where an industry has spent millions of pounds developing a new product, the temptation to rush it onto the market must be enormous — and the temptation for those employed testing it to bear that consideration in mind must weigh heavily. To be fair, thalidomide and other tragedies have forced companies to become more conscientious about their testing procedures (witness Fison's recent withdrawal of a new drug after trials indicated that it might have adverse long-term effects) but, nonetheless, the close ties between science and industry must cast some doubt on much research. As John Quarles, then deputy administrator of the US Environmental Protection Agency, put it to a 1976 Congressional Committee held to investigate the falsification of tests on new pesticides: "Some laboratories might be so dependent on a pesticide producer for contract work that (their) independent judgement could be impaired by the close economic relationship . . . In certain cases, a laboratory might intentionally misrepresent test results at the request of the manufacturer."

Quarles was speaking from experience. As far back as 1969, the President's Commission on Pesticides and their Relationship to the Environment, better known as the Mrak Commission after its chairman Emile Mrak, reviewed seventeen studies submitted by industry on the safety of DDT. The Commission's carcinogenicity panel found that fourteen of the studies were so badly flawed that their conclusions as to safety were deemed, at best, invalid; at worst, misleading. The same year, a committee of the House of Representatives revealed that the US Department of Agriculture had not only approved numerous pesticides for uses "it knew . . . were practically certain to result in illegal adulteration of food", but had also registered over 1,600 pesticides as 'safe' despite warnings from the Department of Health, Education and Welfare that they were dangerous to both man and the environment. Alarmed by such findings, the Environmental Protection Agency conducted a thorough review of the safety tests submitted by industry on 899 active pesticide ingredients and found that more than half of them had been so poorly tested that it was impossible to tell whether or not they were likely to be harmful to man; that a quarter were unsafe; and that eight per cent of those were judged to be carcinogenic. In spite of this, they were being used in almost a third of the pesticides on the market.

Such poor testing on the part of industry could of course be written off as plain bad science. But subsequent EPA investigation suggest that in far too many cases the explanation is more sinister. In his testimony at the congressional hearings, Quarles warned that the falsification of tests for commercial reasons — mainly to get a product onto the market as fast as possible — were widespread. Indeed the seventies saw a spate of indictments against industry-sponsored laboratories on conspiracy charges, involving the fraudulent submission of data to the EPA. In 1977, for instance, the Chicago-based Velsicol Chemical Corporation was arraigned for wilfully concealing the results of laboratory tests which had shown that two widely used insecticides chlordane and heptachlor, caused liver cancer in rats. The indictment, which alleged that Valsicol's management had been told of the pesticides dangers by its own consultants but had chosen to suppress the findings for three years, was eventually dismissed on procedural grounds. In another instance, the Federal Drugs Administration announced that it intended to prosecute Industrial Biotests Labs of Illinois for falsifying tests on Naprosyn (a widely used anti-arthritis drug) and trichlorocarbon (an anti-microbial agent contained in many brands of soap). The Agency charged that the laboratory had

deliberately withheld information and substituted false data into the test summaries it submitted in support of its application to clear the products for marketing. Shortly before the FDA announced its decision (which had been suspected for several months), the laboratory shredded its files on thousands of products it had tested previously. A.J. Frisque, the president of the company, admitted giving the order to destroy the documents but claimed it was due to a misunderstanding.

This is not to suggest that all tests are deliberately falsified or that all scientists cheat. It is merely to state the obvious: that some scientists are dishonest (and have been proven so) and that all scientists work under commercial and political pressures which may well undermine their integrity (and in numerous cases have been proved to do so). Those pressures range from the subtle to the overt and, undoubtedly, it takes considerable courage to resist them. Challenging the scientific hierarchy, let alone a powerful industry, brings little glory; frequently the reward is a ruined career, a precarious livelihood and the prospect of being labelled a trouble-maker (*see* The Scientific Straitjacket, page 33). Indeed the temptation to maintain a low profile and avoid controversy must be enormous: as a wit at *The Times* put it recently (though under slightly different circumstances), "I often find that the extent of a man's moral scruples is inversely proportional to the size of his mortgage." A case in point is that of a young researcher at the University of California who, under pressure from the tomato canning industry, destroyed a research paper which showed that canned tomatoes which had been sprayed had as many insects in them as unsprayed tomatoes which had been deliberately infested with insects. "Hell," he told Robert Van den Bosch, author of *The Pesticide Conspiracy* and an outspoken critic of the pesticide industry, "What could I do? I was just a little guy raising a family and up for promotion. You'd better believe I tore up that manuscript." And which of us could honestly say we would have done otherwise?

Pressure brought by industry and government to suppress research which is harmful to their interests inevitably brings the suspicion that their own research is either biased or, at the very least, unreliable. And with good reason. Too many cases have been uncovered of research being commissioned by powerful interests for purely political motives — of which scientists themselves may be unaware — for the public not to entertain a certain scepticism about official reports. Take for instance the guidelines laid down for the Pentagon's Tri-Service Electronmagnetic Research Programme into the effects of microwaves on human health. "The program," states a Pentagon report, "will provide the best available collective data base of electromagnetic radiation (EMR) bioeffects to make timely and appropriate decisions *in support* of specific Department of Defence systems operations. This means in effect that through this program each service can provide the best guidance available at any point in time to prepare and/or defend everything from environmental impact statements to detailed operating procedures concerning any of the EMR emitters." Comments Paul Brodeur, author of *The Zapping of America:* "Translated the Department of Defence proposals called for research not to find the truth but to 'defend' itself against other research which point an accusing finger at electromagnetic emitters."

A second illustration of such 'defensive' research projects also comes from America. In 1964, Dr. Thomas Mancuso — whose integrity as an epidemiologist is beyond reproach — was commissioned to assess the health effects of low-dose radiation on the health of workers at the Hanford reprocessing plant in Washington State. But whilst Mancuso believed that the AEC was genuinely concerned about low-dose radiation and wished to find out more about its effects, documents released under the Freedom of Information Act make it clear that the Commission had somewhat different motives for commissioning the study. Thus a memorandum to S.G. English, the AEC's assistant general manager for research, from John Trotter, director of the AEC's division of biology and medicine, argues: "The study probably will not confirm or refute any important hypotheses but should permit a statement to the effect that a careful study of workers in the industry has disclosed no harmful effects of radiation (if the results are negative as they are likely to be). That statement, supported by the appropriate documentation, would seem to justify the existence of the study. A corollary statement could presumably be made about other similarly exposed populations." Elsewhere a member of the study's peer-review group wrote: "I recognise that much of the motivation for starting this study arose from the 'political' need for assurance that AEC employees are not suffering harmful effects." In the event, the study drew very different conclusions, warning that current radiation standards might be as much as ten times too high. When Mancuso refused to bow to pressure not to publish the results, his grant was withdrawn.

Given such incidents, it is possibly unsurprising that a 1973 editorial in the *Lancet* should have advised its readers that "when some high-sounding institute states that a compound is harmless or a process free of risk, it is wise to know whence the institute or the scientists who work there obtain their financial support." The editorial, entitled 'The Medical/Industrial Complex', warned that "a sinister complex of big industrial manufacturing firms" was suppressing information on the dangers of many chemicals to which the public is exposed. "The medical men and scientists employed by these firms are chiefly concerned with their employees' and their own profits and indifferent to the health of exposed workers".

Strong stuff, but not apparently strong enough to persuade the authorities to act. And here one comes to a strange irony, best exemplified by the recent US decision to reverse a ruling banning the use of nitrates in food. That ruling was originally based on research by Paul Newberne, of the Massachusetts Institute of Technology, which showed that rats fed nitrate had twice as many lymphomas as a control group. Newberne argued that the preservative thus posed a risk of cancer to humans, and the Federal Drugs Administration — despite pressure from the meat-preservation industry — agreed with him, banning nitrates on September 11th 1978. Now the FDA alleges that Newberne's study was flawed and that in fact the rats fed nitrite had the same incidence as lymphomas as those not fed nitrite. Hence the lifting of the ban. (The most important issue, however, seems to have been ignored: namely that nitrites combine with amines after consumption to form carcinogenic nitrosamines.) And there's the rub of it: the authorities, it appears, are quick to react when a study is found to be flawed, yet all too often they turn a blind eye to gross discrepancies in studies which purportively give a product 'a clean bill of health'.

Commenting on the Hodgkin's disease fraud, *Nature* breaths a sigh of relief that public scepticism about the integrity of scientists has abated since the early seventies — an abatement it terms 'merciful'. Industry would surely agree.

Nicholas Hildyard.

The Presumptions of Science

by
Robert L. Sinsheimer

The pursuit of new knowledge has long been equated with scientific endeavour. But what are the social implications of such knowledge? Is there a case for limiting the areas of scientific inquiry?

Can there be "forbidden" — or, as I prefer, "inopportune" knowledge? Could there be knowledge, the possession of which, at a given time and stage of social development, would be inimical to human welfare — and even fatal to the further accumulation of knowledge? Could it be that just as the information latent in the genome of a developing organism must be revealed in an orderly pattern, else disaster ensue, so must our knowledge of the universe be acquired in a measured order, else disaster ensue?

Biological organisms are equipped with many sensors essential to their survival, sensors for heat, cold, pain, thirst, hunger. Social organisms similarly need sensors of peril, particularly as they evolve into new domains — and for these we must use our intelligence, limited as it may be.

Discussion of the possible restraint of inquiry touches a most sensitive nerve in the academic community. If one believes that the highest purpose available to humanity is the acquisition of knowledge (and in particular of scientific knowledge, knowledge of the natural universe), then one will regard any attempt to limit or direct the search for knowledge as deplorable — or worse.

If, however, one believes that there may be other values to be held even higher than the acquisition of knowledge — for instance, general human welfare — and that science and possible other modes of knowledge acquisition should subserve these higher values, then one is willing to (indeed, one must) consider such issues as: the possible restriction of the rate of acquisition of scientific knowledge to an "optimal" level relative to the social context into which it is brought; the selection of certain areas of scientific research as more or less appropriate for that social context; the relative priorities at a given time of the acquisition of scientific knowledge or of other knowledge such as the effectiveness of modes of social integration, or of systems of justice, or of educational patterns.

In short, if one does not regard the acquisition of scientific knowledge as an unquestioned ultimate good, one is willing to consider its disciplined direction. One may, of course, still have grave doubt as to whether mankind can know enough to be able intelligently to guide the rate or direction of the scientific endeavor, but at least one will then accept that we have a responsibility to seek answers — if there be any — to such questions.

The Impact of Science

In 1930 Robert A. Millikan, Nobel Prize winner, founder and long-time leader of Caltech,* wrote in an article entitled "The Alleged Sins of Science" that one may "sleep in peace with the consciousness that the Creator has put some foolproof elements into his handiwork, and that man is powerless to do it any titanic physical damage."[1]

To what was Millikan referring? Stimulated by the recombinant DNA controversy, I have looked back to see if there were any similar admonitions or premonitions with respect to the possible consequences of nuclear energy. And there were. Millikan, in 1930, was responding to an earlier writing of Frederick Soddy. In a book entitled *Science and Life* Soddy, who had been a collaborator of Rutherford, had written:

> Let us suppose that it became possible to extract the energy which now oozes out, so to speak, from radioactive material over a period of thousands of millions of years, in as short a time as we pleased. From a pound weight of such substance one could get about as much energy as would be obtained by burning 150 tons of coal. How splendid. Or a pound weight could be made to do the work of 150 tons of dynamite. Ah, there's the rub . . . It is a discovery that conceivably might be made tomorrow in time for its development and perfection, for the use or destruction, let us say, of the next generations, and, which it is pretty certain, will be made by science sooner or later. Surely it will not need this actual demonstration to convince the world that it is doomed if it fools with the achievements of science as it has fooled too long in the past.
>
> War, unless in the meantime man has found a better use for the gifts of science, would not be the lingering agony it is today. Any selected section of the world, or the whole of it if necessary, could be depopulated with a swiftness and dispatch that would leave nothing to be desired.[2]

Millikan commented, just prior to his statement quoted above, "Since Mr. Soddy raised the hobgoblin of dangerous quantities of available subatomic energy (science) has brought to light good evidence that this particular hobgoblin — like most of the hobgoblins that crowd in on the mind of ignorance — was a myth . . . The new evidence born of further scientific study is to the effect that it is highly improbable that there is any appreciable amount of available subatomic energy to tap."[3]

So much for scientific prophecy. But is is indeed instructive and also troubling to recognize that our scientific endeavor truly does rest upon unspoken, even unrecognized, faith — a faith in the resilience, even the

*California Institute of Technology

benevolence, of nature as we have probed it, dissected it, rearranged its components in novel configurations, bent its forms and diverted its forces to human purpose. Scientific endeavor rests upon the faith that our scientific probing and our technological ventures will not displace some key element of our protective environment and thereby collapse our ecological niche. It is faith that nature does not set booby traps for unwary species.

Our bold scientific thrusts into *new* territories uncharted by experiment and unencompassed by theory must rely wholly upon our faith in the resilience of nature. In the past that faith has been justified and rewarded, but will it always be so? The faith of one era is not always appropriate to the next, and an unexamined faith is unworthy of science. Ought we step more cautiously as we explore the deeper levels of matter and life?

How Resilient is Nature?

Most states of nature are quasiequilibria, the outcome of competing forces. Small deviations from equilibrium, the result of natural processes or human intervention, are most often countered by an opposing force and the equilibrium restored, at some rate dependent upon the kinetics of the processes, the sizes of the relevant natural pools of components, and other factors. Although we may therefore speak of the resilience of nature, this restorative capacity is finite and is limited in rate.

For example, if the ozone layer of the atmosphere is lightly and transiently depleted by a nuclear explosion or the atmospheric release of fluorocarbons, the natural processes which generate the ozone layer can restore it to the original level within a brief period. However, should the ozone layer be massively depleted — as by extended, large-scale release of fluorocarbons — many decades would be required for its renewal by natural processes, even if the release of fluorocarbons ceased.

Similarly, the populations of most living creatures can achieve an equilibrium level dependent upon birth rates and upon death rates from various causes. Most species have an excess capacity for reproduction, so that minor additions to the process of their removal (as by the harvesting of fish) cannot appreciably influence the equilibrium population. Patently however, excessive harvesting removing numbers beyond the reproductive capacity of the species will in time bring about its extinction.

In a similar manner lakes and rivers and air basins can absorb and dispose of limited amounts of pollutant but can be overwhelmed by masses beyond their capacity. Once overwhelmed the very agents responsible for disposal of pollution in small quantities may be destroyed, leaving a "dead" sea.

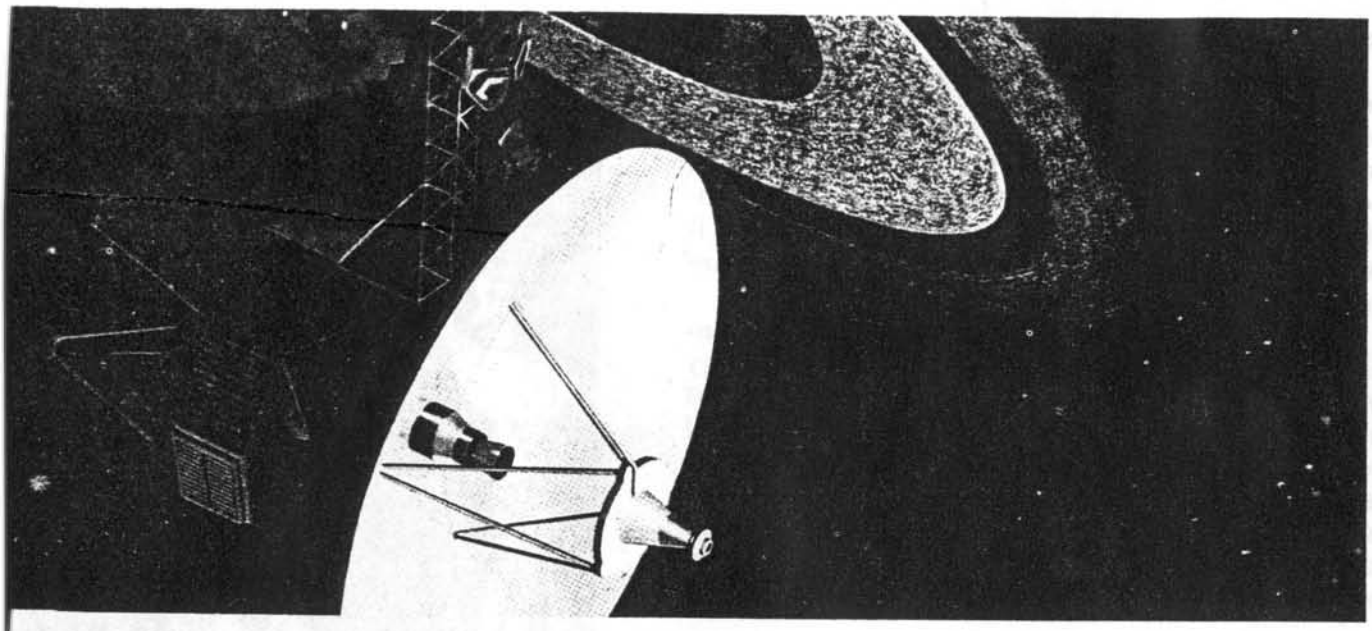
The concept of resilience extends to the planet as a whole and to the impact upon the manifold equilibria upon which the network of life forms depends as we continue to expand our intensive monoculture agriculture, as we continue to increase the total of human energy consumption (the man-made release of energy in the Los Angeles basin is now estimated at about 5 per cent of the solar input), as we continue to raise the atmospheric level of CO_2 by combustion of fossil fuel,

Scientists now claim to be closer than ever to prolonging human life way beyond the biblical 'fourscore years and ten'. Can society handle such an 'advance'?

and so forth.

Because human beings (and most creatures) are adapted by evolution to the near equilibrium states, the resilience provided by the restorative forces of nature has appeared to us to be not only benevolent, but unalterable. Less overt than our faith in the resilience of nature is the faith with which we have relied upon the resilience of our social institutions and their capacity to contain the stress of change and to adapt the knowledge gained by science — and the power inherent in that knowledge — to the benefit of society, more than to its detriment. The fragility of the equilibria underlying social institutions is even more apparent than that of the equilibria of nature. Political, economic, and cultural balances have shifted drastically in human history under the impact of new technologies, or new ideologies or religions, of invading peoples, of resource exhaustion, and other changes. Our faith in the resilience of both natural and man-made phenomena is increasingly strained by the acceleration of technical change and the magnitude of the powers deployed.

Physics and chemistry have given us the power to reshape the physical nature of the planet. We wield forces comparable to, even greater than those of, natural catastrophes. And now biology is bringing to us a comparable power over the world of life. The recombinant DNA technology, while significant and potentially a grievous hazard in itself (through the conceivable production, by design or by inadvertance, of new human, animal, or plant pathogens or of novel forms



Children are brought up on tales of extraterrestial life. But if we made contact with 'aliens' what would be the psychological consequences?

f disrupting important biological equilibria), een as a portent of things to come.

esent recombinant DNA technology, which ne addition or replacement of a few genes in s, is but the first prototype of genetic engin- lore powerful means involving cell fusion or me transfer are already close to hand; even phisticated future developments appear Since genes determine the basic structures gical potentials of all living forms, the ultimate of genetic engineering for the modification sign of plants and animals to meet human l desires seems virtually unlimited.

ıpabilities will pose major questions as to the which mankind will want to assume the res- y for the life forms of the planet. Further, o reason to believe the same technology will plicable to mankind as well; the capability of enetic engineering will raise profound ques- ılues and judgment for human societies.

s paradoxical that a living organism emergent evolutionary process after billions of years of umstance should undertake to determine its e evolution. The process is perhaps analogous the mind seeking to understand itself. In both s uncertain whether the attempt can possibly ssful. Nonetheless, at this point perhaps we step back and reconsider what it is we are

ıging Face of Science

ır centuries science has progressively expan- nowledge and reshaped our perception of the that same time technology has correspond- ıaped the pattern of our lives and the world in live.

eople would agree that the net consequence of vities has been benign. But it may be that the s which fostered such a benign outcome of advance and technological innovation are to a less favourable set. Changes in the f science or technology or in the external society — in either the scale of events or their temporal order — can affect the preconditions, the presumptions, of scientific activity, and can thus alter the future consequences of such activities.

Both quantitative and qualitative changes have surely affected the impact of science and technology upon society. Quantitatively, the exponential growth of scientific activity and the unprecedented magnitude of modern industrial ventures permit the introduction of new technologies (e.g. fluorocarbon sprays) on a massive scale within very brief periods often with unforeseen consequence. Qualitatively, science and technology have been directed increasingly to synthesis — to the formulation of new substances designed for specific human purpose. Thus we have synthetic atoms (plutonium, strontium-90), synthetic molecules (dioxin, kepone, DDT) and now synthetic microorganisms (recombinant DNA). In these activities we introduce wholly novel substances into the planetary environment, substances with which our evolution has not always prepared us to cope.

Can we continue to rely upon the past four centuries as a guide for scientific activity, given these changes? Other human activities of this same era are now increasingly seen in a different hue. The same period witnessed exponential increases in population and in the exploitation of natural resources for material wealth. Few would argue continuance of such trends will be benign.[4] The same era has witnessed the constant acceleration of the rate of change, the increasing dominance of technology in the affairs of men.

The constantly accelerating accretion of knowledge, therefore, may not always be counted as a good. Can circumstances change so as to devalue the net worth of new knowledge? Might a pause or slowdown for consolidation and reflection then be more in order? Indeed, could it be that some knowledge could, at this time, be positively malign? Hard questions, perhaps not answerable, perhaps not the right questions, but they are not answered by invoking Galileo or Darwin or Freud. I believe they demand our thought.

The Consequences of Scientific Inquiry

I would advance for consideration some propositions that frankly I'm not at all sure I entirely believe. I think that in order to find out what one does believe it is necessary to go beyond what one can readily accept — to explore honestly more extreme and more remote positions so that one's position is based upon intelligent choice, not simple ignorance.

The domain I propose to explore can be indicated by a question. The question is one I have actually raised within the administration at Caltech (and it could as well be raised elsewhere). Institutions such as Caltech and others devote much energy and effort and talent to the advancement of science. We raise funds, we provide laboratories, we train students, and so on. In so doing we apply essentially only one criterion — that it be good science as science — that the work be imaginative, skilfully done, in the forefront of the field. Is that, as we approach the end of the twentieth century, enough? As social institutions, do Caltech and others have an obligation to be concerned about the likely *consequences* of the research they foster? And if so, how might they implement such a responsibility?

For reasons which probably need no elaboration Caltech has been more than reluctant to come to grips with this question. And, indeed, it just may be — and I say this with real sorrow — that scientists are simply not the people qualified to cope with such a question. The basic tactic of natural science is analysis: fragment a phenomenon into its components, analyze each part and process in isolation, and thereby derive an understanding of the subject. In physics, chemistry, even biology, this tactic has worked splendidly.

To answer my question, however, the focus must not be inward but outward, not narrowed but broadened. The focus must be on all the ties of the sciences to society and culture and on the impact of scientific knowledge and technological advancement on all human, indeed all planetary, life.

Genetic Engineering

Consider as an instance the recombinant DNA issue. The natural tendency of the scientist, if he will admit this a problem, is to break it down, to decompose it into individually analyzable situations. If there is a danger, quantitate it: what is the numerical chance of the organisms escaping, of their colonizing the gut, of their penetrating the intestinal epithelium, of their causing disease (what disease?) If you point out that there is a nearly infinite set of possible scenarios of misfortune — that accidents do happen and in unpredictable ways, that humans do err, that bacterial or viral cultures do become contaminated, that indeed aspects of this technology involve inherently unpredictable consequence and hence are not susceptible to quantitative analysis — you are regarded as unscientific.

The consequences of the interaction of known but foreign gene products with the complex contents of a bacterial cell would be difficult enough to predict, much less the consequences of the interactions of unknown gene products, as produced in "shotgun" experiments. Some of these consequences may well modify, in unpredictable ways, the likelihood of the organism's survival

"Our bold thrusts into territories uncharted by experiment . . . must rely wholly upon our faith in the resilience of nature." Can that faith be justified?

or persistence in various environments, its potential toxicity for a host or nearby life forms. It may alter, for instance, an organism's survival in an animal intestine, contrary to our expectations, for we have presumed that we know all factors important for survival there and that no new successful adaptations could emerge.

For complex reasons, consideration of the potential hazards from organisms with recombinant DNA has focused upon immediate medical concerns. That these organisms with unpredictable properties might have impact upon any of the numerous microbiological processes which are important components of our life support systems is simply dismissed as improbable. The fact that these organisms are evolutionary innovations and have within themselves, as do all living forms, the capacity (if they survive) for their own unpredictable future evolutionary development is ignored, or dismissed as mystical.

If you point out that the recombinant DNA issue simply cannot be effectively considered in isolation but must be viewed in perspective and in a larger context as a possible precursor to future technologies available to many elements of society (including totalitarian governments, the military, and terrorist factions) your remarks are regarded as irrelevant to science.

There is an intensity of focus in the scientific perspective which is both its immediate strength and its ultimate weakness. The scientific approach focuses rigorously upon the problem at hand, ignoring as irrelevant the antecedents of motive and the prospectives of consequence.

Viewed objectively such an approach can only make sense if either (1) the consequences are always trivial, which is patently untrue, or (2) the consequences are always benign, that is, if the acquisition of knowledge, of any knowledge at the time, is always good, a proposition one might find hard to defend, or (3) the dangers and difficulties inherent in any attempt to restrict the acquisition of knowledge are so great as to make the unhindered pursuit of science the lesser evil.

The Certainty Principle

In thinking about the impacts of science, we should, perhaps, reflect upon the inverse of the uncertainty principle. Perhaps it might be called the certainty principle. The uncertainty principle is concerned with the inevitable impact of the observer upon the observed, which therby alters the observed. Conversely, there is an effect of the observed upon the observer. The discovery of new knowledge, the addition of new certainty, which correspondingly diminishes the domain of uncertainty and mystery, inevitably alters the perspective

of the observer. We do not see the world with the same eyes as Newton or a Descartes, or even a Faraday or a Rutherford.

The acquisition of a discipline sharpens our vision in its domain, but too frequently it seems also to blind us to other concerns. Thus immersion in the world of science, with its store of accumulated and substantiated fact, can make the participant intolerant of, and impatient with the uncertainties and non-reproducibilities of the human world. Engrossed in the search for knowledge, scientists tend to adopt the position that more knowledge is the key to the solution to human problems. They may not see that the uses we make of knowledge or the ways in which we organize to use knowledge can, as well, be the limiting factors to the human condition, and they forget that even within science our knowledge and our theories are always human constructs. Moreover, we should always remember (lest we become too secure and even smug) that our knowledge and our theories are ever incomplete.

Of Dubious Merit: Isotope Fractionation

To make this discussion more specific let me consider three examples of research that I personally consider to be, on balance, of dubious merit. One is in an area of rather applied research, the second in a very speculative but surely basic area, and the third in the domain of biomedical research, which we most often conceive to be wholly benign.

The first I would cite is current research upon improved means for isotope fractionation. In one technique, one attempts to use sophisticated lasers[5] to activate selectively one isotope of a set. I do not wish to discuss the technology but rather the likely consequence of its success. To be sure, there are benign experiments that would be facilitated by the availability of less expensive, pure isotopes. For some years I wanted to do an experiment with oxygen 18 but was always deterred by the cost.

But does anyone doubt that the most immediate application of isotope fractionation techniques would be the separation of uranium isotopes? The United States recently chose to defer, at least, if not in fact to abandon, the plutonium economy and the breeder reactor because of well-founded concern that plutonium would inevitably find its way into weapons. We are thus left with uranium-fueled reactors. But uranium 235 can also be made into a bomb. Its use for power is safer only because of the difficulty in the separation of uranium 235 from the more abundant uranium 238. If we supersede the complex technology of Oak Ridge, if we devise quick and ingenious means for isotope separation, then one of the last defenses against nuclear terror will be breached. Is the advantage worth the price?

Searching for Extraterrestial Life

A second instance I would cite of research of dubious merit, and one probably even more tendentious than the first, relates to the proposal to search for and contact extraterrestial intelligence.[6] Recent proposals suggest that, using advanced electronic and computer technology, we could monitor a million "channels" in a likely region of the electromagnetic spectrum, "listening" over several years for signals with an "unnatural" regularity or complexity.

I am concerned about the psychological impact upon humanity of such contact. We have had the technical capacity to search for such postulated intelligence for less than two decades, an instant in cosmic terms. If such intelligent societies exist and if we can "hear" them, we are almost certain to be technologically less advanced and thus distinctly inferior in our development to theirs. What would be the impact of such knowledge upon human values?

Copernicus was a deep cultural shock to man. The universe did not revolve about us. But God works in mysterious ways and we could still be at the center of importance in His universe. Darwin was a deep cultural shock to man. But we were still number one. If we are closer to the animals than we thought before, and through them to the rocks and the sea, it does not really devalue man to revalue matter. To really be number two, or number 37, or in truth to be wholly outclassed, an inferior species, inferior on our own turf of intellect and creativity and imagination, would, I think, be very hard for humanity.

The impact of more advanced cultures upon less advanced has almost invariably been disastrous to the latter. We are well acquainted with such impacts as the Spanish upon the Aztecs and Incas or the British and French upon the Polynesians and Hawaiians. These instances were, however, compounded by physical interventions (warfare) and the introduction of novel diseases. I want to emphasize the purely cultural shock. Hard learned skills determinant of social usefulness and positions become quickly obsolete. Less advanced cultures quickly become derivative, seeking technological handouts. What would happen to *our* essential tradition of self-reliance? Would we be reduced to seekers of cosmic handouts?

The distance of the contacted society might, to some degree, mitigate its consequent impact. A contact with a round trip communication time of ten years would have much more effect than one with a thousand years. The likelihood of either is, however, a priori, unknown. Nor is it inconceivable that an advanced society could devise means for communication faster than light.

The proponents of such interactions have considered the consequences briefly. In a 427-page book *Communication with Extraterrestial Intelligence?*[7] sixteen pages comprise a chapter entitled "Consequences of Contact." Opinion therein ranges from "Our obligation is, I feel, to stress that in any sensible way this problem has no danger for human society. I believe we can give a full guarantee of this" to "If we come in contact with some superior civilization this would mean the end of our civilization, although that might take a while. Our period of culture would be finished."

How and by whom should such a momentous decision[8] be made — one that will clearly, if successful, have an impact upon all humanity? Somehow I cannot believe it should be left to a small group of enthusiastic radioastronomers.

My concern here does not extend so far that I would abolish the science of astronomy. If the astronomers in the course of their science come across phenomena that

can only be understood as the product of intelligent activity, so be it. But I do not believe that is the same as deliberately setting out to look for such activity with overt pretensions of social benefit.

Seeking the Elexir Of Life

The third example of research I consider of dubious merit concerns the aging process. I would suggest this subject exemplifies in supreme degree the eternal conflict between the welfare of the individual and the welfare of society and, indeed, the species. Obviously, as individuals, we would prefer youth and continued life. Equally obviously, on a finite planet, extended individual life must restrict the production of new individuals and that renewal which provides the vitality of our species.

The logic is inexorable. In a finite world the end of death means the end of birth. Who will be the last born?

If we propose such research we must take seriously the possibility of its success. The impact of a major extension of the human life span upon our entire social order, upon the life styles, mores, and adaptations associated with "three score and ten," upon the carrying capacity of a planet already facing over-population would be devastating. At this time we hardly need such enormous additional problems. Research on aging seems to me to exemplify the wrong research on the wrong problem in the wrong era. We need that talent elsewhere.

Is Restraint Feasible?

If one concedes, however reluctantly, that restraint of some directions of scientific inquiry is desirable, it is appropriate to ask if it is feasible and, if so, at what cost.

Some of my colleagues, not only in biology but in other fields of science as well, have indicated to me that they too increasingly sense that our curiosity, our exploration of nature, may unwittingly lead us into an irretrievable disaster. But they argue we have no alternative.[9] Such a position is, of course, a self-fulfilling prophecy.

I would differentiate among what might be called physical feasibility, logical feasibility, and political feasibility.

I believe that actual physical restraint is in principle feasible. There are two evident avenues of control: the power of the purse and access to instruments. Control of funding is indeed already a powerful means for control of the directions of inquiry for better or worse. To the extent that there exists a multiplicity of sources of support, such control is porous and incomplete, but it is clearly a first line of restraint.

Research today cannot be done with household tools. It is difficult to imagine, for instance, any serious research on aging that would not require the use of radioisotopes or an ultracentrifuge or an electron microscope. The use of isotopes is already regulated for other reasons. Access to electron microscopes could, in principle, be regulated, albeit at very real cost to our current concepts of intellectual freedom.

An immediately related, important aspect of any policy of restraint concerns the distinctions to be made about the nature of research. Can we logically differentiate research on aging from general basic biologic studies? I expect we cannnot in any simple, absolute sense. Yet obviously the people who established the National Institute of Aging must have believed that there is a class of studies which deserves specific support under that rubric. Indeed, distinctions of this sort are made all the time by the various institutes of National Institutes of Health in deciding which grant applications are potentially eligible for their particular support. Pragmatically, and with some considerable margin of error, such distinctions can be and are made.

Genetic engineering is introducing new materials into the environment to which we are unadapted by our evolution.

It is frequently claimed that the "unpredictability" of the outcome of research makes its restraint, for social or other purpose, illogical and indeed futile. However, the unpredictability of a research outcome is not an absolute but is both quantitatively and qualitatively variable.

In more applied research within a field with well-defined general principles, the range of possible outcomes is surely circumscribed. In more fundamental research, in wholly new fields remote from prior human experience — as in the cosmos, or the subatomic world, or the core of the planet — wholly novel phenomena may be discovered. But, for instance, even in a fundamental science such as biology, most of the overt phenomena of life have been long known.

The basic principles of heredity were discovered by Mendel a century ago and were elaborated by Morgan and others early in this century. The understanding of genetic mechanism, the reduction of genetics to chem-

istry, had to await the advent of molecular biology. This understanding of mechanism has now provided the potential for human interventions, for genetic engineering, but it has not significantly modified our comprehension of the genetic basis of biological process.[10]

The path of modern biology will surely lead to further understanding of biological mechanism, with subsequent application to medicine and agriculture (and accompanying social impact). But it would seem likely that only within the central nervous system may there be the potential for wholly novel — and correspondingly wholly unpredictable — process. Even there, the facts of human psychology and the subjective realities of human consciousness have long been familiar to us, albeit the underlying mechanisms are indeed obscure.

Political feasibility is, of course, another question. The constituency most immediately affected is, of course, the scientific. And despite our protestations and alarms this community does have real political influence. It would seem unlikely to me that a policy of scientific restraint could be adopted in any sector unless a major portion of the scientific community came to believe it desirable.

For this to happen, that community will clearly have to become far more alert to, and aware of, and responsible for the consequences of their activities. The best discipline is self-discipline. Scientists are keenly sensitive to the evaluations of their peers. The scientific community and the leaders of our scientific and technical institutions will have to develop a collective conscience; they will have to let it be known certain types of research are looked upon askance, much as biological warfare research is today; it needs to be understood that such research will not be weighed in considerations of tenure and promotion; societies need to agree not to sponsor symposia on such topics. All of these and similar measures short of law could indeed be very effective.

I am well aware of the dangers implicit in such forms of cultural restraint. But I think we really must look at the dangers we face in the absence of self-restraint. Do we accept only the restraint of catastrophe?

If we are to consider this position, we must do so in a forthright manner. We must be willing to explore the vistas exposed if we lower conventional taboos and sanctions. We may not at first enjoy what we see, but at least we will have a better perception of the available alternatives. Any attempt to limit the freedom of scientific inquiry will surely involve what will appear, at least at first, to be quite arbitrary distinctions — judgmental decisions, the establishment of boundaries in gray and amorphous terrain. These are, however, familiar processes in our society, in the courts, in the legislatures. Indeed, most of us are familiar with such problems in our educational activities. The selection of new faculty, the award of tenure, the assignment of grades are clearly judgmental decisions.

In science we try with some success to elude the necessity for such very human judgments. Indeed, one suspects that many persons go into science precisely to avoid the necessity for such complex decisions — in search of a domain of unique and unequivocal answers of enduring validity. And it is painful to see the sanctuary invaded.

Admittedly it is difficult to achieve consensus on the criteria for judgmental decisions. Such consensus is all the more difficult in the sphere of international activities such as science which involve participants from diverse cultures and traditions.

Conversely there are many persons who prefer the more common, perhaps the more human world of ambiguity and compromise and temporally valid judgments and who resist the seemingly brutal, life and death, cataclysmic types of decision increasingly imposed upon society by the works of science. And science and scientists cannot stand wholly aloof from these latter dilemmas — for science is a human activity and scientists live in the human society. We cannot expect the adaptation to be wholly one-sided.

Even if, at best, we can only slow the rate of acquisition of certain areas of knowledge, such a tactic would give us more time to prepare for social adaptation — if we mobilize ourselves to use that time.

The Case for Restraint

The view one exposes by lifting that sanction we label freedom of inquiry is frankly gloomy. It would seem that we are asked to make thorny decisions and delicate differentiations, to relinquish long-cherished rights of free inquiry, to forego clear prospects of technological process. And it would seem that all these concessions stem ultimately from recognition of human frailty and from recognition of the limitations of human rationality and foresight, of human adaptibility and even good will. Just such recognitions have already spawned many of our institutions and professions — religions, the law, government, United Nations — yet all of these are as imperfect as the world they are designed to restrain and improve.

At each level of human activity, whether individual, group, or national, we continually struggle to find acceptable compromises between the freedom to pursue varied courses and goals and the conflicts that arise when one person's actions run contrary to another's. In a crude sense the greater the power available to an entity, the more limitations must be imposed upon its freedom if conflict is to be averted. Ideally such limits are internalized through education and conscience, but we all understand the inadequacy of that process.

In short, we must pay a price for freedom, for the toleration of diversity, even eccentricity. That price may require that we forego certain technologies, even certain lines of inquiry where the likely application is incompatible with the maintenance of other freedoms. If this is so and if we can recognize and understand this, perhaps we can, as scientists, be more accepting.

Some will argue that knowledge simply provides us with more options and thus that the decision point should not be at the acquisition of knowledge but at its application.

Such a view, however ideal, overlooks the difficulty inherent in the restriction of application of new knowledge, once that knowledge has become available in a free society. Does anyone really believe, for instance, that knowledge permitting an extension of the human life span would not be applied once it were available?

One must also recognize again that the very acquisition of knowledge can change both the perceptions and the values of the acquirer. Could, for instance, deeper knowledge of the realities of human genetics affect our commitment to democracy?

It may be argued that the cost, however it may be measured, of impeding research would be greater to a society than the cost of impeding application. Perhaps so. This issue could be debated, but it must be debated in realistic terms with regard for the nature of real people and real society and with full understanding that knowledge is indeed power.

Although the nature of the measures necessary to restrict the application of knowledge has seldom been analyzed, the measures needed would surely be dependent upon the size of investment required to apply the knowledge, as well as on the form of and the need for the potential benefits of the knowledge, among other things. The compatiblity of such restrictive measures with the principles of a democratic society would need to be considered. Restriction of nuclear power may be a case in point.

Limits of the Technical Fix

Alvin Weinberg has developed the concept of the technological fix as the simple solution to cut the Gordian knot of complex social problems. However, we seem to be discovering that the application of one technological fix seems to lead us into another technological fix. For example, the development of antibiotics and other triumphs of modern medicine has led to the tyranny of over-population. In efforts to cope with overpopulation by more intensive agriculture, we develop pesticides, herbicides and other chemicals which increase the level of environmental carcinogenesis. And so on.

The moral is that we cannot ignore the social and cultural context within which the technology is deployed. In retrospect we can see that in the cultural and social context of the seventeenth, eighteenth, and nineteenth centuries the consequences of technological innovation were most often benign. Whether because of change in the society and culture or change in the nature and effectiveness of technology, at some time in the twentieth century the balance began to shift and by now our addiction to technology begins to assume an unpleasant cast.

We are indeed addicted to technology. We rely ever more upon it and thus become its servant as well as its master. It has led to human populations insupportable without its aid. Further, new technologies shape our perceptions; they spawn expectations of change or stir deep fears of disaster. They dissociate us from the past and becloud the shape of the future. Even the oldest boundary conditions of humanity fall as we leave the planet and as we plan to reshape our genes.

Conclusion

Our academic institutions and our professional societies foster and promote science. To some degree they also have concern for its consequences, but it is a minor aspect. The principle that one should separate agencies which promote and agencies which regulate may apply here.

But where then is the balance, the necessary check to the force of scientific progress? Is the accumulation of knowledge unique among human activities — an unmitigated good that needs no counterweight? Perhaps that was true when science was young and impotent, but hardly now. Yet we lack the institutional mechanisms for regulation.

Our experience with constraint upon science has hardly been encouraging. From the Inquisition to Lysenko such constraint has been the work of bigots and charlatans. Obviously, if it is to be done to a good purpose, any restraint must be informed, both as to science and as to the larger society on which science impacts.

The acquisition of knowledge is a human, a social, enterprise. If we, through the relentless, single-minded pursuit of new knowledge so destabilize society as to render it incapable — or unwilling — to continue to support the scientific enterprise, then we will have, through our obsession, defeated ourselves.

At Caltech and the many other academic institutions, we have now, *culturally*, cloned Galileo a millionfold. We have nurtured this Galilean clone well; we award prizes and honours to those most like the original. No doubt this clone has been most beneficial for humanity, but perhaps there is a time for Galileos. Perhaps we need in this time to start another clone.

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[1]R.A. Millikan, "Alleged Sins of Science," *Scribners Magazine*, 87 (2) (1930): 119-130.

[2]Frederick Soddy, *Science and Life* (London: John Murray, 1920).

[3]Precisely what evidence Dr. Millikan had in mind is uncertain. However, it is generally appreciated that the efficiency of nuclear transformation by the charged particles then in use was so low that there was no significant prospect of a net release of energy. No practical chain reaction could yet be envisaged.

[4]A.V. Hill in his presidential address to the British Association for the Advancement of Science in 1952, referring to the population problem, said, "If ethical principles deny our right to do evil in order that good may come, are we justified in doing good when the foreseeable consequence is evil?"

[5]See A.S. Krass, "Laser Enrichment of Uranium: The Proliferation Connection," *Science*, 196 (1977): 721-731; also B.M. Casper, "Laser Enrichment: A New Path to Proliferation?" *Bulletin of Atomic Scientists*, 33 (1) (1977): 28-41

[6]See T.B.H. Kuiper and M. Morris, "Searching for Extraterrestrial Civilizations," *Science*, 196 (1977): 616-621; also B. Murray, S. Gulkis, and R.E. Edelson, "Extraterrestrial Intelligence: An Observational Approach," *Science*, in press.

[7]C. Sagan (ed), *Communication with Extraterrestrial Intelligence (EETC)* (Cambridge, Mass.: MIT Press, 1973).

[8]Conceivably, we might not be given this choice if an advanced civilization were determined to contact us. At present however, it would seem to be our option.

[9]This is not a new perception. "The world is now faced with a self-evolving system which it cannot stop. There are dangers and advantages in this situation. . . . Modern science has imposed upon humanity the necessity for wandering. Its progressive thought and its progressive technology make the transition through time, from generation to generation, a true migration into uncharted seas of adventure. The very benefit of wandering is that it is dangerous and needs skill to avert evils. We must expect, therefore, that the future will disclose dangers. It is the business of the future to be dangerous; and it is the merit of science that it equips the future for its duties," wrote A.W. Whitehead in *Science and the Modern World.*

[10]Indeed the failure to discover a new class of phenomena underlying genetics has been most disappointing to some. See Gunther S. Stent, "That Was the Molecular Biology That Was," *Science*, 160 (1968): 390-395.

Early Greek and Roman Environmentalists

by
J. Donald Hughes

Pythagoras, Hippocrates, Aristotle and Plutarch had much in common with today's ecologists. What was the mainspring of their philosophy? And why were their views ignored?

When Alexander the Great was in India, Plutarch tells us, he tried to pose difficult questions to some Indian philosophers. Of one he asked, "Which animal is the most cunning?" The gymnosophist was quick with his reply: "That one which men have not yet discovered."[1]

No modern defender of endangered species could have made the point more succinctly. The classical writer was aware of an apparent enmity between men and the other animals in which mankind is dominator or destroyer and the others slaves or victims. This prevailing attitude toward animals of those who share the tradition of Greece and Rome is only one aspect of the "great divorce" between mankind and nonhuman nature that looms so large in the history of Western thought. In an earlier article, "Ecology in Ancient Greece" in *Inquiry* (1975), I have tried to trace in ancient history some roots of the dominant Western attitude toward nature. In this essay, I will attempt to investigate ideas and practices which, if not dominant, were potentially more constructive.

Four sets of attitudes are to be considered here. First, one based on certain conceptions of the gods and their relationship to man will be examined. A Greek or Roman deity embodied a complex of traditional attitudes and practices, some of them exceedingly ancient and ingrained in the lives of the people of classical times. The gods invested aspects of nature with sanctity and gave their protection to segments of the natural world.

The Role of the Gods

Everyone knows that the gods were spirits of nature. The god of the sky was Zeus who "sometimes shines brightly, sometimes rains."[2] Poseidon was god of the sea, Demeter of growing plants, and so forth. But even those gods whose primary associations were with aspects of human life had much to do with nature as well; indeed, the Greco-Roman traditional religious perspective did not distinguish sharply between human beings and the rest of the natural world. Aphrodite stirred passions not only in human beings, but also in "birds that fly in air and all the many creatures" of land and sea.[3] Among her followers were wolves, lions, bears,

and leopards. The music of Apollo's lyre-accompanied voice charmed a "tawny troop of lions" along with "dappled lynxes" and fawns in the mountain forest, causing them all to dance with delight.[4] Asclepius healed by means of snakes. None of the great Greek or Roman gods, and few of the minor ones, lacked identification with elements of the natural environment.

Some were predominantly gods of nature. Pan was a watcher of the herds who loved "soft streams," "close thickets," and also "snowy mountains and rocky peaks."[5] He could sometimes offer protection to wild creatures. But the greatest protector of natural things was Artemis, the Roman Diana, the Mistress of Wild Animals (*potnia thereon*), whose favourite places were "mountains, and forests green, and lonely glades, and sounding rivers,"[6] whose favourite activity was hunting. Let us turn our attention for a while to this goddess and to what she reveals about early attitudes toward hunting as a mode of human relationship to the natural world.

Artemis

Many of the myths made Artemis something of a game warden; in one variant story, Artemis, or possibly Ge, slew the mighty hunter, Orion, because he boasted that he would kill all animals. Artemis did away with another hunter, Actaeon, by the horribly appropriate method of having his own hounds tear him to bits, ostensibly because he spied on the goddess while she was bathing, but one suspects that there was an earlier version of the myth in which his crime was hunting the sacred deer of Artemis. That is exactly what Sophocles said Agamemnon did to earn his punishment, when "taking his pleasure in her sacred grove, he startled an antlered stag with dappled hide, shot it, and shooting made some careless boast."[7] Artemis demanded the life of Agamemnon's own daughter "in quittance for the wild creature's life." Guthrie calls this incident "perhaps the earliest example of a game preserve,"[8] but I would suggest that divine protection of wildlife is far older than Agamemnon. Artemis was guardian especially of the young of wild animals; she was "gracious to the tender whelps of fierce lions and took delight in the suckling young of every wild creature that roves the field."[9] The cults of Artemis included dances done by children called "bears" or "fawns," probably originally dressed in animal costumes. Here we should emphasize that Artemis's animals are almost exclusively the wild game species that would engage the attention of hunters, not the domestic charges of farmers and herders. The possible exception is the goat, but that creature easily becomes feral, and there were wild goats on most mountains around the Mediterranean.

How can we reconcile with Artemis's protective role the fact that she herself was represented as the huntress par excellence, the "destroyer" who loves hunting wild beasts, accepts the hunters' gifts of wild game, and even holocausts of wild creatures offered to her, as for example in Patrae? How can Artemis, mistress of wild creatures, also be patron goddess of hunters? The apparent contradiction comes from regarding hunter and prey as enemies, a view often expressed by classical writers, to be sure. But preserved in the cults of Artemis and Diana are survivals of earlier attitudes and practices from the time when ancestral societies sustained themselves by hunting, when the animals were seen as powerful beings endowed with spirits like those of human beings, and when hunting was regarded as a "holy occupation" in which both hunter and game animal participated. The hunter was expected to propitiate the animal and to treat it, either dead or alive, with respect. A certain sportsmanlike survival of this earlier functional attitude can be traced in the share of the hunter's bag or fisherman's creel that was offered to Artemis, as well as in Xenophon's remark that "hares below a certain age are left alone as sacred to the goddess."[10] Kenneth Clark sees sacrifice in somewhat the same light: "While men still felt a kinship with animals, to eat them was a crime against the group, and expiation could be achieved only by a ritual feast in which all men were involved."[11] In Greek and Roman sacrifice almost all the meat was eventually consumed by the people. The good hunter, then, who had approached the goddess in respect and observed the proper customs, could expect the kindly permission if not indeed the active aid of the goddess.

Sacred Groves

But the careful hunter would never intrude on the sacred territories set aside for the gods. Agamemnon's sin, not simply to kill a deer but to do so in a sacred precinct, was avoided by pious Greeks and Romans. Such precincts, called *temene* in Greek and *templa* in Latin, were areas set aside, usually containing groves of trees and springs or other water, though often mountaintops or other prominent features of topography were so treated. They were very numerous, and within them the environment was preserved in something like its natural state, modified usually only by the addition of an image of the god and perhaps a shrine or temple to protect it. To understand the preservation of groves, we must recall the Greco-Roman attitude toward trees. Classical writers recognized that forests, the groves themselves, were the original temples. Trees were sacred to the gods: the oak to Zeus, the laurel to Apollo, the willow to Hera, the pine tree (or perhaps an oak) to Pan. In fact, trees in general were sacred to the gods; Vergil said that every grove was sacred to Diana. As Pliny explained, "The woods were formerly temples of the deities, and even now simple country folk dedicate a tall tree to a god with the ritual of olden times; and we adore sacred groves and the very silence that reigns in them no less devoutly than images that gleam in gold and ivory."[12]

The Forest's Protectors

Stories were told of the protection of trees by the dryads, the spirits whose lives were so closely bound to their trees that to cut one down might kill the nymph who lived in it. Such acts did not go unpunished; Erysichthon, who cut an oak in Ceres' sacred forest, found himself cursed with insatiable hunger as a result of the dryads' complaint. As a punishment for upsetting the balance of nature, hunger seems singularly appropriate.

Protection of sacred groves was not merely matter for myths; Frazer's *Golden Bough* notes a number of cases where cities passed laws for-

bidding the cutting of trees, removal of wood or leaves, the pasturing of cattle, sheep, or pigs, or planting of grain in sacred groves under penalty of stiff fines, including mandatory sacrifice, and, in one case involving a slave, fifty lashes. Witnesses were required to report the transgressions or suffer similar penalties. The rules of the Arval grove of Dia went so far as to require replacing every tree that fell with a newly planted one. Illegal cultivation of Apollo's sacred land near Delphi was the announced cause of war. To the Greeks and Romans, the sanctity of holy groves was a practical matter in which local ordinances buttressed the retribution of the gods without necessarily replacing it; Cleomenes of Sparta set fire to a sacred grove and was visited by the gods with madness (the fact that five thousand Argives burned to death in that forest fire should also be mentioned).

The practical result of the careful preservation of sacred groves, forbidding even the carrying away of broken limbs in some cases, was the survival of venerable stands of trees after the surrounding areas had been deforested. These were the classical "national parks," small "wilderness areas" surrounded by vast tracts of "clearcutting". Pausanias remarked upon the gigantic size of the trees he saw in these relict forests, some so large as to overshadow hills or to allow people to picnic or sleep in their hollow trunks.

High mountains were also set aside as sacred localities. Sometimes a throne was erected on the summit for Zeus or another deity. The followers of mountain-born Dionysus possibly held that the uplands where they danced in their annual mysteries were set aside for special use. Sometimes a whole island, like Delos, was consecrated as a *temenos.*

Protection within the sacred limits was, as we have already noticed, extended to animals. Generally speaking, hunters were not allowed to go inside with their dogs and weapons. On Mount Lycaeus, if a hunter saw his quarry go into the precinct of Zeus, he had to wait outside, the belief being that if he entered he would die within the year. In places there were deer sacred to Persephone and deer and wild goats sacred to Artemis, none of which could be hunted, although a "special permit" could be issued when a sacrificial victim was desired. There were tortoises on an Arcadian peak and, as Pausanias noted, "the men of the mountain fear to catch them, and will not allow strangers to do so either, for they think they are sacred to Pan."[13] No fishing was allowed in the waters of many sanctuaries, and in some was lawful only for priests. Even eels were sacred in Arethusa.

It would be overstating the case to indicate that precincts were always kept inviolate — no laws would have been necessary if they had been — or that conservation was invariably effective in the hands of the gods. There was an annual Roman festival, the Parilia, in which shepherds were cleansed ritually for trespass in the groves, and Cata records a prayer to be used before cutting down a tree in a sacred grove. Xenophon remarked that men could hire *temene* from the city of Athens, presumably for some kind of commercial use, and Juvenal complained that foreigners rented groves in Rome.

Protection Limited

And what of nature outside the boundaries of the *temene,* where no special protection was afforded? Greek and Latin writers expressed their admiration for nature through the mouths of the Olympian deities. The subject is too vast to expand upon here, but I cannot resist quoting the Homeric *Hymn to Delian Apollo* as one illustration: "All mountain peaks and high headlands of lofty hills and rivers flowing out to the deep and beaches sloping seaward and havens of the sea are your delight."[14] This certainly implies an Olympian approbation of the entire natural world. But the gods in Olympian aspect seem more generally to have functioned so as to set the boundaries between the parts of nature that were sacred and those that were not, to lay down the distinctions between what was permitted to mankind and what was not, and to punish those who transgressed the limits. The result was to leave most of nature without divinely sanctioned protection.

Besides the Olympian gods there were gods of the earth — *chthon* — not the least among whom was Earth herself, great "mother of all, eldest of all beings, who feeds all creatures."[15] She "not only bears the crops for the husbandman, but also the flocks and herds for pastoral peoples, and even the wild creatures whose abundance is necessary for men at a still earlier stage of culture, who live by hunting and fishing."[16] In the chthonic view, all life is sacred because it comes from Mother Earth, herself the greatest deity, and human beings are simply some among her many creatures, animals more like than unlike other animals. Man goes wrong only by getting out of harmony with nature's ways: her cyclical balance, her movements through growth to fruition. Many gods had chthonic aspects, but chthonic religion was always an undercurrent in Greek and Roman thought, seldom emerging above the surface. Had it been the dominant trend, the environmental history of the classical age would have been different. In actuality, the protection afforded to the natural environment by the gods was limited, circumscribed, and often circumvented, particularly as human minds began to throw off the gods' increasingly tenuous hold.

Philosophical Attitudes

A second set of attitudes we shall consider here is that of the philosophers. A dominant tendency of Greek philosophers and of the Romans who followed in their train was to exclude the gods' actions from their account of nature and also to reify nonhuman nature, setting it apart from mankind as a series of phenomena to be categorized and explained. This approach excluded the participatory sense of identification between human beings and the rest of the natural world which, as noted above, often characterized traditional religious perspectives. But it was not the only posture philosophers could adopt in regard to nature.

I am indebted to John Rodman for an article in which he stressed the importance of another school of philosophers which he calls "a kind of counter-culture," that of Pythagoras and Empedocles, who "exhibited in both theory and practice a deep sense of the kinship of human with nonhuman (especially animal) life."[17] Were these philosophers, these

vegetarians, these almost nature-mystics, the early environmentalists we are looking for? This tradition, often called "Orphic" from its quasi-mythical founder, Orpheus, emphasized the harmony of nature and the unity of all living organisms, including human beings, and thus was fundamentally pantheistic. In the view of Empedocles, the universe was an endless recycling of elements in a kind of closed ecosystem: "There is no birth in mortal things, and no end in ruinous death. There is only mingling and interchange of parts, and it is this we call 'nature.' "[18] The idea was echoed by Lucretius: "So the sum of things is constantly renewed, all creatures live in symbiosis [*mutua vivunt*]:"[19]

Pythagoras

The Orphics and Pythagoreans taught that all living creatures are related and have a common origin and natural ties. The usual iconographic representation of Orpheus shows him surrounded by animals in whom his song has awakened a sympathetic attraction. Pythagoras was said to have charmed an eagle and a bear.

The sense of kinship is supported by the Orphic doctrine that all living creatures, plants as well as animals, have souls like those of human beings and also a kind of intelligence. As Empedocles said, "The soul inhabits every kind of form of animals and plants."[20] There is no scale of values or hierarchy imposed; all creatures are ensouled and participate in the cyclical development of the world. The result of this view was the practice of kindness to other creatures and the refusal to do them harm. Pythagoras taught respect for life, holding that "to kill living beings is contrary to both custom and nature [*anomon kai para physin*]."[21] In the original state of nature, these philosophers held, birds, beasts, and men had been tame and gentle to one another. They urged their followers to abstain from hunting, animal sacrifice, and especially from eating meat. To those who offered animal sacrifice, Empedocles said, "You are sacrificing your own kin."[22] Hunters, butchers, and cooks were to be shunned as tainted by the shedding of blood. Pythagoras also objected to cutting or damaging trees and to eating some kinds of vegetable foods. Living strictly by Orphic principles would have meant a simple, limited diet, but it would not have been impossible. A number of foods, including some staples of the Mediterranean table, could be obtained without destroying animal or vegetable life; Ovid's "Pythagoras" mentioned apples, grapes, milk, and honey as examples.

Of course, one of the motives adduced by the Orphics against taking lives was that the souls of animals and plants are actually the reincarnated souls of human beings. The story of Pythagoras recognizing his departed friend's voice in the howls of a beaten dog has been told too often. But underlying the dogma can be detected a genuine sympathy for nature's creatures in their own right. Pythagoras' soul, it was said, "was constantly passing into whatever plants or animals it pleased."[23] And Empedocles reported, "In the past I have been a boy and a girl, a bush, a

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Hippocrates believed one must understand nature as a whole to understand the human body.

bird, and a silent water-dwelling fish.''[24] It was noted above that ancestral hunting societies regarded animals as having spirits; Orphism might be in some of its aspects a modified survival of attitudes from those distant times. Dodds, in *The Greeks and the Irrational*, suggested that the Orphic idea of soul-body dualism might have had its origins in the prehistoric hunter-shaman's experiences of ''soul-flight'', the soul leaving the body, having various experiences, and returning. Perhaps still another element of the old hunters' tribal culture also found its way into Orphism; that is, respect for nonhuman life and reluctance to kill needlessly.

The Dualist Flaw

The influence of the tradition of Orpheus, Pythagoras, and Empedocles on environmental thought was, however, not entirely or perhaps even primarily positive, since a salient element was the soul-body dualism mentioned above. The soul was captive in the body, they believed, or in a series of bodies (specifically as a result of the pollution entailed in taking life and eating meat); it was in the soul's best interest to be purified and go free. If this be true, then all bodies, human and nonhuman, are prisons. The world of nature itself must be worse than a prison, indeed, it must be a maze of prisons. Even more seriously, Orphism devalued that portion of the natural environment with which the soul is in closest association, the body itself (as some Pythagoreans put it, *soma* = *sema*, the body is a tomb). The harshness of this view of the body is mitigated elsewhere, as in Empedocles' statement that ''mortals can know and recognize'' the power of Love in the physical universe, ''for she is implanted in their bodies.''[25] But one's inescapable impression is that the dualism of soul and body promulgated by this school prepared the way for a crushing indifference to the natural world that became characteristic of much later philosophical religious thought that was touched by it. We will leave Pythagoreanism for now but will return later to see one of its more appealing influences.

In our search for early environmentalists, we might well look at a third set of attitudes to be found in those few outstanding Greek thinkers who originated inquiries we would call ecological. They might be said to have been the forerunners of the science of ecology even though, as is the case with much Greek science, interest in pursuing answers to the kind of questions they were asking did not revive until the modern period.

The philosophical basis of ecology, which conceived the world as a biological system within which cycles of change and interaction occur, was stated by Empedocles in the quotation given above, and repeated here somewhat more fully:

> There is no birth in mortal things, and no end in ruinous death. There is only mingling and interchange of parts, and it is this we call 'nature' . . . When these elements are mingled into the shape of a man living under the bright sky, or into the shape of wild beasts or plants or birds, men call it birth; and when these things are separated into their parts men speak of hapless death.[26]

One is reminded also of Anaxagoras' statement, ''Nothing exists apart; everything has a share of everything else.''[27]

Hippocrates

Hippocrates investigated the effects of varying natural environments on human health, both physical and mental. He believed that one must understand nature as a whole to understand the human body and soul. According to *Airs, Waters, Places*,[28] the climate, seasons, and

winds of a place, the drinking water found there, and the topography and exposure determine to a great extent the physique, temperament, intelligence, and therefore even the culture of the people who live there, along with the characteristic diseases to be expected among them. In addition, he maintained that the same environmental factors affect the growth of domestic and wild animals and plants in each region. Hippocrates' environmental studies were based as far as possible on careful observation of the regions discussed and are not applications a priori of the theory of humors. If ecology is in part the study of how environments affect organisms, then Hippocrates was a pioneer of ecology.

Aristotle

Aristotle, whose "philosophical emphasis is clearly the natural world" and whose "starting point . . was biology and the notion of organismic development and function,"[29] was interested not only in individual organisms but also in the relationship among living things and between them and the physical environment. In the *Metaphysics*, he said, "All things are ordered together somehow, but not all alike — both fishes and fowls and plants; and the world is not such that one thing has nothing to do with another, but they are connected."[30] This principle clearly makes the study of ecology possible, and Aristotle's own observations on ecological relationships, contained in his biological writings, were so intelligent that he has been given credit for introducing "ecologic considerations into scientific literature," and called the "Father of Animal Ecology."[31]

In the *Historia Animalium*, he notes carefully the preferences of various species in food and competition for food "between such animals as dwell in the same localities or subsist on the same food,"[32] particularly when supplies run short. The lion and civet will compete for meat, and the kite will steal food from the raven. "Thus we see in the creatures above mentioned their mutual friendship or enmity is due to the food they feed on and the life they lead."[33]

Modern ecologists have explained fluctuations of animal populations as resulting from interactions between availability of food, rapidity of reproduction, and predation. Aristotle gave a classic description of a spectacular population increase among mice and subsequent population "crash" in which he noted all the important factors (although he did not attain the complex explanation that would now be regarded as satisfactory). At the beginning of the passage, he described what might be called an experiment in population ecology. A female mouse "in a state of pregnancy was shut up by accident in a vessel containing millet-seed, and after a little while the lid of the vessel was removed and upwards of 120 mice were found inside it."[34] He went on to describe a plague of mice that appeared suddenly, devouring a whole crop. The predators, namely pigs, foxes, and ferrets, were active but ineffective in thinning the numbers, until a rapid disappearance of the mice "after heavy rains."

"To kill living things is contrary to both custom and nature."

Pythagoras.

Other ecological relationships described by Aristotle include territoriality among mammals and birds and animal behaviour such as competition and dominance within species, migration, and hibernation. Symbiosis, including parisitism and commensalism, is discussed by means of several examples including the noted one of the sea creature called the pinna and a small crab, the "pinna-guard." "If the pinna be deprived of this pinna-guard," he said, "it soon dies."[35]

Nature's Hierarchy

Aristotle's systematic view of nature, however, falls short of being ecological in the scientific sense. His scheme is hierarchical and pyramidal. Although each level of nature intergrades into the next so that sharp distinctions between classes are difficult, for example, "in most of the other animals can be discerned traces of the psychical modes which attain their clearest differentiation in man."[36] still "there is one ultimate ruler, and each lower level is subordinate to the next higher level, as in an army."[37] Anthony Preus, in a very useful discussion of Aristotle's biological writings, uses a political analogy, calling Aristotle's ecology "aristocratic." As Preus points out, Aristotle in the *Politics* "argues not only for natural slavery but also that plants exist 'for the sake of' animals, and animals exist 'for the sake of' man."[38] But scientific ecology sees nature as a reticulum, a web or net of complex inter-relationships that are neither hierarchical, pyramidal, nor aristocratic. Scientific ecology sees the existence of each species as depending upon and supporting a series of inter-actions with other species and non-living components of the environment. In such a view, questions as to whether one species is "more valuable" than another can only be answered in terms relative to a particular problem chosen for study.[39] Any system that imposes a structure of values a priori will inevitably distort the network of relationships discovered and described by scientific ecology. Aristotle's ecology is therefore unscientific unsofar as it is "aristocratic," whether its apex value is man or something beyond man.

A More Democratic View

Theophrastus, the student of Aristotle who extended his teacher's researches into botany, adopted an ecological model that was more "democratic" than Aristotle's. When Theophrastus looked for the purpost (*telos*) of a plant, he found it in the production of seeds for the perpetuation of the same species, not in producing food for animals or man. He was interested in efficient causes, not in final causes, and thus much closer to the spirit of modern science. As he expressed it in his *Metaphysics*, "We must try to find a certain limit . . . both to 'final causation' and to the 'impulse to the better.' "For this is the beginning of the inquiry about the universe, that is, of the effort to determine "the conditions on which real things depend and the relations in which they stand to one another."[40] Since he was also a careful observer of nature,

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Pythagoras. His followers split into two schools: a 'scientific' school that neglected biology and therefore ecology, a 'religious' school that emphasized purity of soul and rejected any concern with physical nature. The more 'environmentalist' of his teachings were gradually abandoned as the Pythagoreans accommodated themselves to the general attitude of Greco-Roman culture. The objections to animal sacrifice, and to most plants as food, were dropped. The divorce of body and soul in later Pythagorean thought, wherever its influence was strong, brought with it indifference not only to the body but to all the rest of the natural environment. (See: Hughes, The Environmental Ethics of the Pythagoreans, *Environmental Ethics*, Fall 1980, for further discussion of the Pythagoreans.)

he was able to provide ecological explanations of many natural phenomena.

He stressed the importance of observing plants both in undisturbed ecosystems (since where a plant grows unaided best reveals the environment to which it is best adapted) and under cultivation (which he holds to be an environmental change that operates in fundamentally natural ways). He speculated on the interplay between the "tendency of the plant's nature" (which would today be called "genotype") and the environment, giving importance to both.

We would call much of Theophrastus' writings a botanical *Airs, Waters, Places,* if by that we mean that he considers these environmental factors and do not impute to him quite as ardent a belief in environmental determinism as Hippocrates expressed. Theophrastus noted the influences of long-term climate, the growing season, and short-term changes in the weather, including temperature, wind, and rain, on the distribution and growth habits of plants. He observed the effects of changes in climate brought about by changes in the size and location of bodies of water due to natural or human agency. He distinguished among plants adapted to conditions of aridity (xerophytes), moisture (hydrophytes), and salinity (halophytes), and to various types of soil. He provided extensive discussion of the effects of slope, exposure to wind and sun, and elevation on environmental conditions in small areas (microclimates) and the plants that grow in them, and he noted correctly that mountains provide an unusual variety of these. He saw that plants of limited distribution (narrow endemics) can be associated with particular mountains or isolated marshes.

Theophrastus used certain classifying terms that are still important to ecologists; for example, he distinguished among trees, shrubs, and undershrubs. He knew that plants compete with each other for food, water, and sunlight, and he distinguished between shade-tolerant and shade-intolerant trees. He described the spread of weeds and cases of symbiosis and parisitism. He understood that legumes enrich the soil

and that decomposing leaves can provide a seedbed.

The interaction between animals and plants, through grazing and other means, received his attention. Insects, he pointed out, are often species-specific or limited to certain regions, and some plants have odours that repel them. Cultivation and other human interactions with plants form a major theme. He knew that human beings affect plants in positive and negative ways, on the one hand through manuring and other forms of tendance and on the other hand through burning, cutting, and even the trampling of armies. He recorded regulations governing the harvest of wild plants and the felling of trees and had heard that the cedars of Lebanon grew to great size where they were protected in 'paradises'' under Persian supervision.

Since, as noted above, Aristotle has been called the ''Father of Animal Ecology,'' it might be plausible to distinguish Theophrastus as ''Father of Plant Ecology.'' But while Aristotle provided us with a few outstanding descriptions and insights, Theophrastus adopted a consistent ecological viewpoint supported by observations of greater extent, variety, and importance. His philosophical stance is more congenial to ecological discoveries. Theophrastus is clearly the most important early ecologist.

Few Disciples

Unfortunately, these Greek forerunners of scientific ecology had few followers. No ancient thinkers expanded on their ecological contributions, and they cannot be shown to have had any effect on practice. In medieval times, Theophrastus was known only as the author of the satirical *Characters*, and Aristotle's biological writings were generally ignored in favour of the *Politics* and *Ethics*.

Ecological Protests

Fourth and last, let us consider the attitudes of those who might loosely be called the ancient world's environmental protest movement. There were a number of Greek and Roman writers who recognized some environmental problems caused by human beings. A few of them went so far as to speak out against the practices that caused the problems and to advocate their elimination.

Vitruvius, the Roman architect, was aware of water pollution caused by mining and the resulting danger to health. He advised methods of testing water for purity and particularly warned against lead pipes as a source of contamination harmful to the human body. He also described lead poisoning caused by industrial air pollution: ''We can take example by the workers in lead who have complexions affected by pallor. For when, in casting, the lead receives the current of air, the fumes from it occupy the members of the body, and burning them thereupon, rob the limbs of the virtue of the blood.''[41] He further suggested a method of testing air in mines for dangerous pollutants.

"All things are ordered together . . . and the world is not such that one thing has nothing to do with another, but they are connected."

Aristotle.

Strabo, the geographer, also observed industrial air pollution. In Iberia, he noted, ''They build their silver-smelting furnaces with high chimneys, so that the gas from the ore may be carried high into the air, for it is heavy and deadly.''[42]

Soil erosion due to deforestation was described by Plato in a noted passage in the *Critias*. That the soil had become increasingly exhausted since earlier, better days was a commonplace among Greek and Roman agricultural writers. Lucretius and others believed this was inevitable, as Mother Earth was growing old, but more practical farmers, such as Xenophon and Columella blamed the neglect of careless human beings: ''Land, as all men know, responds to good treatment.''[43] Horace scorned ''the owner contemptuous of the land.''[44] The major role of goats in destroying trees and other vegetation was noted by Varro.

But the urban environment received the most graphic criticism, at least during the Roman period. ''The smoke, the wealth, the noise of Rome,''[45] repelled Horace, who also objected to the city's suburban encroachment on fertile farmlands. Martial catalogued the many sources of sleep-preventing noise pollution in Rome, including traffic, hammers, and loud schoolteachers. Juvenal expanded the list of urban ills, decrying traffic congestion, fires, public works projects that destroyed natural beauty, chamber pots emptied out of upper storey windows, and ever increasing crime and vandalism. Seneca joined him in criticizing the ''towering tenements, so dangerous to the persons who dwell in them''[46] through imminent collapse.

The polarity between city and country provided a major theme in Greek and Latin literature, and the comparison was almost always favourable to the country. From Theocritus on, writers glorified pastoral and bucolic life as closer to nature and therefore to be preferred. Dio Chrysostom devoted his *Euboean Discourse* to a demonstration of the moral superiority of a hunter's clan to town dwellers. Those who shared such a view of the urban and rural environments might well be expected to ''protest with their feet'' by leaving the city and to advise others to do the same. Horace, Martial, Juvenal, and others did just that, in the firm conviction that in so doing they were not simply shunning human society (as Heraclitus and Menander's title character in the *Dyscolus* had done by retiring into the mountains) but were enabling themselves to choose their company more wisely and giving themselves enough living space to recover their essential humanity. ''There's no place in the city for a poor man to get a little peace and a chance to talk.''[47]

Survival of Pythagorean Views

Another line of protest represented the survival of some of the Pythagorean ideas discussed above. Maintaining the sanctity of all life and the possession of rational souls by animals, some writers in the Roman period objected to hunting, a meat diet, animal sacrifice, and the slaughters for public entertainment in the arenas. Pythagoras himself

was given a voice in Ovid's *Metamorphoses*, where he advised King Numa against animal food, since it is through eating the flesh of living creatures that the Golden Age came to an end, and against animal sacrifice as making the very gods the partners of men in wickedness.

Plutarch also voice Pythagorean protest. In his dialogue, *Whether Land or Sea Animals are Cleverer*, ostensibly a learned debate among cultured huntsmen, Plutarch actually argues that animals possess reason to support his contention. He admits that animals have only a degree of reason but notes that this is also true of human beings. If what we want is "true reason and wisdom, not even man may be said to exercise it."[48] But if animals are rational, then we are unjust to kill them when they have not injured us. Plutarch is not fully a Pythagorean; he denies plants souls, and elsewhere he would permit killing animals "in pity and sorrow,"[49] as well as eating meat as an unfortunate necessity.

But Plutarch's most delightful word on the subject is a brief dialogue between Odysseus, Gryllus, and Circe. Circe, the witch, had changed many men into beasts of various kinds. Odysseus won the right to have his own sailors re-transformed and then asked Circe to release the other Greeks from their animal forms. Circe agreed on one condition: that Odysseus convince a spokesman for the beasts to return willingly to human form. The one chosen to speak for the animals was Gryllus, a hog granted the power of speech by Circe. Gryllus refused the chance to return to human form, since animals, he maintained, are superior to mankind in every virtue; courage, temperance, and intelligence. Moreover, animal virtues are natural; humans must cultivate theirs. Odysseus, the famous persuasive arguer, lost the contest. Having maintained that beasts cannot be rational if they have no inborn knowledge of God, he was reminded by Gryllus that his own father was Sisyphus, a famous atheist. That Plutarch's clever dialogue was not just a set piece is evident from his serious objections voiced elsewhere to hunting, animal slaughter, and the excesses of the Roman arena. Plutarch, rejecting the argument of Hesiod and the Stoics that "human beings have no compact of justice with irrational animals,"[50] exhibited admiration and sympathy for the myriad forms of living things and was an early defender of animal rights.[51]

In society today, we can identify groups and individuals whose ideas and efforts are analogous to the sets of attitudes here studied. It is a sobering observation that none of the Greeks and Romans we have mentioned, whether the approaches they adopted were religious, philosophical, scientific, or literary, were markedly successful in preventing the environmental deterioration of the Mediterranean basin in classical times.

Footnote: Reprinted with permission from *Historical Ecology*, ed. Lester J. Bilskey, Kennikat Press, Port Washington, New York, 1980.

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2. Theocritus 4.43, quoted in W.K.C. Guthrie, *The Greeks and Their Gods* (Boston, 1954), p.38.
3. Homeric *Hymn to Aphrodite 5.3-5.*
4. Euripides, Alcestis 578 ff.
5. Homeric *Hymn to Pan* 19.5-11.
6. Catullus 34.9 ff.
7. Sophocles, *Electra* 563-72.
8. Guthrie, p.100.
9. Aeschylus, *Agamemnon* 135-43.
10. Xenophon, *Cynegeticus* 5.14. Another survival from hunting and gathering societies may be seen in the offerings of fruit and meal-cakes left by Greek rhizotomists to "pay" for certain herbs (Theophrastus, *Historia Plantarum* 9.8.7). American Indian medicine men and women had similar rituals.
11. Kenneth Clark, "Animals and Men: Love, Admiration, and Outright War," *Smithsonian*, 8 (September 1977); 55.
12. Pliny, *Natural History* 13.3.
13. Pausanias 8.54.5.
14. Homeric *Hymn to Delian Apollo* 3.22-24.
15. Homeric *Hymn to Earth the Mother of All* 30.1-4.
16. Guthrie, p.58.
17. John Rodman, "The Other Side of Ecology in Ancient Greece: Comments on Hughes," *Inquiry*, 19 (Spring 1976); 108-12.
18. Empedocles, fragment 8.
19. Lucretius, *De Rerum Natura* 2.75-79.
20. Diogenes Laertius, *Life of Empedocles* 12.
21. Iamblichus, *Life of Pythagoras* 186.
22. Empedocles, fragment 117.
23. Diogenes Laertius, *Life of Pythagoras* 8.4.
24. Empedocles, fragment 137.
25. Empedocles, fragment 17.
26. Empedocles, fragments 8-9, translated in Philip Wheelwright, *The Presocratics* (New York, 1966), p.127.
27. Anaxagoras, fragment 6.
28. Here I have ignored the question of authorship, simply postulating my "Hippocrates" as the author of this one work.
29. These quotations are from George Sessions, "Spinoza and Jeffers: An Environmental Perspective," *Inquiry*, 20 (1977), 481-528.
30. Aristotle, *Metaphysics* 12.10.2 (107a 17-20).
31. George Sarton, *A History of Science: Ancient Science Through the Golden Age of Greece* (Cambridge, Mass., 1952), p.565; Friedrich S. Bodenheimer, "Aristotle, the Father of Animal Ecology," *Homenaje a Millas-Vallicicosa* (Barcelona, 1954), pp. 165-81.
32. Aristotle, *Historia Animalium 9.* 1 (609b 19-25).
33. *Ibid.* (610a 34-35).
34. *Ibid.* 6.36 (508b 10-29).
35. *Ibid.* 5.15 (547b 15-32).
36. *Ibid.* 8.1 (588a 13-b17); see also *De Partibus Animalium* 4.5 (681a 12 ff).
37. Anthony Preus, *Science and Philosophy in Aristotle's Biological Works* (Hildesheim, 1975), p. 217.
38. *Ibid.*, Aristotle, *Politics* 1.5 (1254b 18-19), (1256b 15-26).
39. Preus attributes to "some modern scientists" belief in a "democratic" theory of ecology "which supposes that all living things have an intrinsic value which is absolute, that the value, merit, or worth of any living thing is to be regarded as intrinsically equal to that of any other; living things are not arranged in a scale of value" (p. 324, n. 48). Neither the "aristocratic" or "democratic" theory is scientific; they are philosophical models which might, perhaps, serve as guides for human technology. But the pure structure of the democratic model is more similar to the reticulum disclosed by scientific ecology and seems, therefore, better to reflect reality.
40. Theophrastus, *Metaphysics* 9.32-34. quoted in Clarence J. Glacken, *Traces on the Rhodian Shore* (Berkeley, 1967), p. 51. I am indebted to Glacken for his exegesis of Theophrastus.
41. Vitruvius, *De Architectura* 8.6.11; see also 8.3.5, 8.4.1-2, 8.6.10-13.
42. Strabo, *Geography* 3.2.8 (c. 147).
43. Xenophon, *Oeconomicus* 2.10-15. See Columella, *De Re Rustica* 1. pref. 1-3.
44. Horace, *Carmina* 3.1.36-37.
45. *Ibid.* 3.29.12.
46. Seneca, *Epistulae Morales 90.7-13.*
47. *Martial 12.57.4-6.*
48. *Plutarch, Moralia* 962-D.
49. *Ibid.* 996F.
50. *Ibid.* 999A, referring to Hesiod, *Works and Days*, 277-79.
51. But Plutarch could be conventional; see his *Life of Pericles*, 1. For a review of recent writings on animal rights, see John Rodman, "The Liberation of Nature?" *Inquiry*, 20 (Spring 1977); 83, 131.

The Gezira Scheme — A Study in Failure

by
Nigel Pollard

The Gezira Scheme — a two million hectare irrigation project in the Sudan — has variously been described as 'a model for agricultural development' and 'a classic example of developing underdeveloped areas'. In reality the project has continually been dogged by problems. Right from the start, the plans were ill-conceived.

In 1899, Sir W. Garstin published his first report on the Sudan, in which he described the Gezira as 'the richest alluvial deposit'[1]. In particular, he was impressed that during the rainy season, the entire area was covered with a type of millet known locally as 'dura'. Assuming that one grain crop was much the same as another, he recommended that the Gezira 'be turned into a large wheat producing area'[2]. In fact the growing conditions, particularly nutrient requirements, for 'dura' and wheat are different. Dura grows well on the alkaline Gezira soil which is ver low in nitrogen, whereas wheat requires a higher nitrogen level and neutral soil[3]. Although large areas have been under wheat cultivation since 1970, the economics of the venture are precarious and the soil needs heavy nitrogen applications[4]. Indeed, wheat has never been successfully grown in the Gezira.

Whilst Garstin was setting out his agricultural plans for the area, the British textile industry was looking towards the Gezira as a possible solution to the problem of supplying Britain's cotton needs. The British Cotton Growing Association was formed in 1902 to promote and coordinate supplies. The director of the largest cotton mills in Lancashire, C. Eckersly, stressed the importance of the Sudan: "Speaking as a considerable user of Egyptian cotton, and to the requirement which I know exists for this quality of cotton, I may confidently say that it would be a great boon to Lancashire if the production of Egyptian cotton could be increased. There is practically no limit to the quantity which could be taken of approved qualities at a reasonable price. I sincerely hope it may be found possible to grow suitable cotton in the Sudan."[5]

In his speech from the throne, at the opening of Parliament in 1904, King Edward VII was also worrying about the British textile industry's cotton supplies;

> The insufficiency of the supply of the raw materials upon which the great cotton industry of this country depends has inspired me with deep concern. I trust that the efforts which are being made in various parts of my Empire to increase the area under cultivation may be attended with a large measure of success.[6]

In 1904 Garstin published his second report[7]. He pointed out that the Gezira offered possibilities of a major irrigation scheme by gravity flow if a dam was built on the Blue Nile at Sennar. A development of this scale required a capital outlay then estimated at £3 million — an expenditure which could only be justified by establishing a cash crop in the area. Garstin's report inspired Mr Leigh Hunt, an American capitalist to survey the Blue Nile area, and in a letter he wrote;

> There are millions of idle acres of land along the Nile in the Sudan capable of being developed into as fertile fields as those lower down the Nile in Egypt, which are today the highest priced agricultural lands in the world . . . I see no reason why England's mills should not soon be running day and night the year through on cotton of her own growing . . . The question which interests me now is, what race of men is best adapted to assist in this pioneer work. I should like to try the American negro.[8]

Hunt immediately started an experimental farm at Zeidab, north of the Gezira, importing American negroes already experienced in cotton plantation work. Unfortunately the negroes failed to adjust to the new conditions imposed upon them, and, by 1907, all had died.[9]

There was still no sign however, that the British Government would make the loan for the dam and the canals; practical proof and not speculation was demanded and further experimental farms were set up. However in anticipation a cadastral survey in the Gezira was initiated in 1906. According to the Governor-General reports when British officials first entered the Gezira to carry out this survey the villagers were so shy and frightened that they ran and hid[10]. To win over the confidence of the villagers some of the local sheiks were appointed as intermediaries or *mamurs*.

Local Opposition

It is apparent that not all of the population wished to be settled under the British. In 1908, for example, an uprising occurred in the Messellemia district where the land settlement work had commenced. The uprising was led by Abdel Kader, a local landowner and a respected Muslim. In April of that year a band stormed the Deputy Inspectors Office of the Blue Nile Province, kil-

ling both Scott-Moncrief, and his mamur Yuzbashi Shenf. Within a few hours the Commander of the Blue Nile Province, Major Dickinson, had been notified and he set off with a small army. In the ensueing battle, fifteen government men were killed and thirty-five wounded, whilst the 'rebels' suffered thirty-five dead and 'many' wounded[11]. Abdel-Kader was taken alive and tried the following day. Not surprisingly he was sentenced to death, and the next day taken to his home village of Hillet Mustapha and hung before a crowd of 3,000 villagers as an example.[12] Twelve others were also sentenced for hanging at a later date. Wingate, Govenor General of Sudan, claimed this was essential to "prevent a recurrence of the numerous subversive attempts to which the authority of the government is exposed."[13]

The Scheme gets Under Way

In 1909, both the American and Egyptian crops which normally supplied the Lancashire spinners failed.[14] Nonetheless the government loan to develop the Sudan was still not forthcoming, no doubt due to wider Colonial interests, uncertainty of the Sudan, and the demands of other development projects. In 1910 after a speech by Sir W. Mather, the British Cotton Growing Association passed the following resolution;

> That the attention of His Majestys Government should be drawn to the extreme importance of encouraging the further cultivation of cotton in the Anglo-Egyptian Sudan, and to the necessity of immediately adopting some scheme on the lines suggested by the Rt. Hon. Sir William Mather.[15]

The issue came to a head in 1913. Lord Kitchener visited the Sudan to inspect the experimental farms and was able to report of their success with cotton.[16] There was a Parliamentary debate on the subject which gave its approval.[17] Finally a deputation of the British Cotton Growing Association went to the Prime Minister. The chairman, J.A. Hutton in his address to the premier stated;

> I firmly believe that in the Gezira plain we have the very finest cotton-growing proposition in the whole of the world . . . We therefore urge, in the interests of the cotton trade, in the interests of the whole country, and in the interests of one of our largest tropical possessions, that His Majesty's Government will . . . guarantee a loan of £3,000,000.[18]

Sir C.W. Macara, President of the Master Cotton Spinners Association, endorsed Hutton's argument:

> . . . practically all the countries of the world are customers of England for cotton goods; England's cotton industry depends for about three-quarters of its employment on export trade; cotton goods represent about one-third of the total exports of manufactures; and the cotton which can be produced in Egypt and Sudan is of the utmost importance to England, as she consumes more of this class of cotton than all the other countries of the world combined.[19]

Finally A.H. Gill, member of Parliament for Bolton presented the Prime Minister with some facts and figures;

> I to-day represent the cotton operatives who, according to the Home Office Figures, numbered 628,300 in 1911. But this does not by any means represent the people who are affected directly and indirectly by the cotton trade. This number is estimated at ten millions . . .The growth of the cotton trade has gone on in other countries as well as our own, but not at the same rate. Out of 134 million spindles in the world we have 55 millions . . .[20]

"The incidence of bilharzia and malaria are serious. In themselves, they are enough to warrant classifying the scheme as a failure."

The premier, Mr Asquith had a favourable reply for the deputation:

> It is a matter of interest, not only to Lancashire but to the whole of Great Britain and the whole of the Empire, that we should both multiply our possible sources of supply of raw cotton, and enlarge the area from which it is grown . . . I have the draft . . . which will authorise . . . a loan . . . of three million (cheers) . .
>
> In my experience it is a rare and refreshing case to find a deputation which goes away completely satisfied — (Cheers and laughter).[21]

It is interesting to note that in the same year that the Gezira Scheme was given official approval, 1913, British cotton consumption and cloth production reached its peak and thereafter declined.[22] It was the Government's intention to finance and control the entire project and accordingly they embarked on the construction of the Sennar dam and canals in 1914. However the First World War intervened and work had to be suspended. When work recommenced in 1919 a small uprising occurred in the Sennar district; this was quickly put down with forty Mahdists killed and no government casualties.[23] By 1922 the estimate for the cost of the dam had risen to over 14 million pounds, which was beyond the financial outlay the government was prepared to extend. However in the intervening years Mr Leigh Hunt had formed, along with others, the Sudan Plantation Syndicate. The Syndicate, who was administering the experimental farms, was invited to run and finance the scheme's administration.

The Sennar Dam

The contract to build Sennar dam and the Canals was awarded to Pearson & Sons Ltd of London. At the busiest period of construction, they employed over 20,000 men, including many Egyptian convicts.[24] Considerable imported machinery was also used in constructing the dam and canals, all of it steam powered. This resulted, in conjunction with steam powered pumps in the experimental cotton farms, in the total clearance of the large forest areas in the southern Gezira and the Blue Nile valley.[25] In fact to complete the work, coal had to be imported. The areas were clear-felled, no seed bearers were left, no fences erected, and regeneration was stopped by grazing. It was not until 1929 that a programme of reforestation, where it did not impede with cotton growing, commenced.[26]

The Scheme came into operation in the 1925/6 season when 50,000 hectares of crops were put under irrigation. Since then, the area put under irrigation has increased steadily, particularly with the addition of the Managil South West Extension in 1956. The scheme now covers 840,000 hectares. In 1950 the Sudan Plantation Syndicate's contract expired, and the scheme was nationalized under the administration of the Sudan Gezira Board.

Schistosomiasis

Before 1925, schistosomiasis was practically unknown in the Blue Nile Province.[27] The Blue Nile is unfavourable to snail breeding as it is swift running with steep banks. Following the construction of the Sennar dam, the river behind the dam was raised so that it topped its historical banks. The water spread out into lagoons forming many favourable breeding grounds for snails and mosquitoes.

It is well known that schistosomiasis is one of the great dangers of any perennial irrigation scheme. This was recognised in respect of the Gezira scheme from its start. The year before the canal construction work was started, an examination of children in twenty Gezira villages was made. No child was found to be infected with *S. haematobium*[28], which lies in the veins of the bladder. In 1926, although schistosomiasis host snails had not yet been discovered in the canals, a survey was made to check for sources of infection once the snails appeared. Nine hundred and twenty-one persons (out of twenty-seven thousand) were found to be infected, ninety-two per cent of these were immigrants, West Africans on the pilgrimage to Mecca.[29]

In 1925 repeated searches were made of the canals for the secondary snail host, but none were found. Eighteen months after the canals had been filled the first snails were discovered in six canals. One year later they had spread to all the canals in the region. No snails infested with cercariae (larvae) were found in the 1927 collections. In 1928 four batches of snails were found to be shedding *S. haematobium* cercariae, and the same number again in 1929.[30]

Having created an ideal habitat for the snails, and observed them move in, the British decided it was time to try and break the life cycle of the disease. The following measures were introduced:

(1) Immigrants from West Africa and Egypt were quarantined at the major towns. Those infected, around 20 per cent, were held until cleared by long and dangerous treatment with antimony tartrate injections. This proved unpopular, especially as some died of the treatment. So many immigrants evaded the quarantine that the stations were all closed by 1933.

(2) Orders were issued to all British officials and local village Sheiks to prevent anyone from urinating, defaecating, bathing, or washing in the canals. This measure was never effective as no latrines or separate water supplies were made available in most villages.

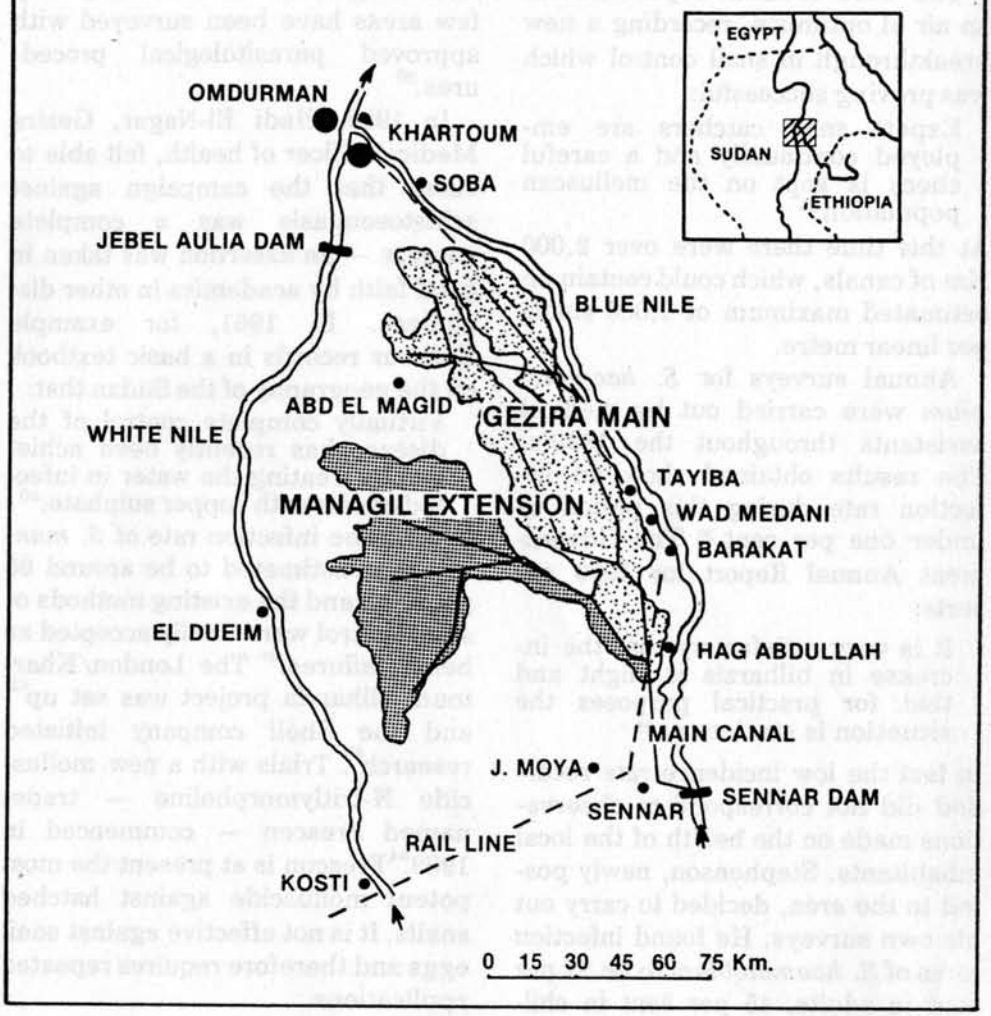
(3) Two pamphlets, in arabic, warning of the dangers were also printed and circulated to the local population, over 80 per cent of which was illiterate.

(4) Each year about one-third of the canals were dried out to destroy the snails. It was later discovered that the snails can survive 3 to 4 months in a dried out river bed.

(5) The remaining canals were treated with copper sulphate. This has remained a standard procedure until recently. Its effectiveness is largely diminished as it rapidly becomes inert in the canal bed.

(6) Attempts were made to trap the snails on slatted hurdles across the canals. This proved ineffective.

FIG. 1 — THE GEZIRA PLAIN, SHOWING THE MAJOR FEATURES OF THE IRRIGATION SCHEME



(7) British officials were encouraged to keep ducks which would eat the snails. This experiment failed as all the ducks were stolen within a few days of their introduction.[31]

Nonetheless, it was apparently considered that the situation was under control, Humphreys concluded that these measures:

> Thwarted a threatened danger to the health of a population already liable to epidemics of malaria, and on whose working powers in the cultivation of the cotton area the ultimate financial success of the Gezira irrigation scheme depends.[32]

In 1930 the authorities decided it was time to provide a number of augerbore latrines close to the canals at points near the villages. However the 1932 medical report records:

> The programme of work has been delayed owing to the stress of economic conditions . . . to do this it will be necessary to reorganise and lay out every village in an orderly manner, ensuring each house has its own yard and own latrine.[33]

In fact, although the report mentions houses, the village people have al-

ways lived in an assortment of thatched mud huts.

The 1933 medical report carries an air of optimism, recording a new breakthrough in snail control which was proving successful:

> Expert snail catchers are employed continually and a careful check is kept on the molluscan population.[34]

At this time there were over 2,000 Km of canals, which could contain an estimated maximum of 1,000 snails per linear metre.

Annual surveys for *S. haematobium* were carried out by medical assistants throughout the 1930's. The results obtained show an infection rate during this period of under one per cent.[35] The Government Annual Report for 1939 asserts:

> It is very satisfactory that the increase in bilharzia is slight and that for practical purposes the situation is stationary.[36]

In fact the low incidence rate recorded did not correspond to observations made on the health of the local inhabitants. Stephenson, newly posted to the area, decided to carry out his own surveys. He found infection rates of *S. haematobium* to be 21 per cent in adults, 45 per cent in children, with an overall average of 30 per cent. He also surveyed for another more serious schistome, *S. mansoni*, which lies in the veins of the bowel. He found an infection rate for this of between 40 to 53 per cent.[37] This represented the first statistical evidence that the existing control and preventative measures had failed.

In the late 1940's medical assistants under Greany carried out a survey of 80,000 people to check the infection rates. They recorded the average infection rates for both *S. haematobium* and *S. mansoni* to be 'only' around 8 per cent.[38] Although accepted by a learned journal and although the results were acted upon by the government, the methodology they used in sampling does not conform to any scientific method. Local villagers were very reluctant to give samples of stool and urine and Greanys data relates only to villagers who voluntarily came forward to take part. Surveying for the disease involves the microscopic examination of human excreta for schistoma ova. The method of sampling is crucial as the eggs are not evenly distributed in the excreta. According to Weller even today very few areas have been surveyed with approved parasitological procedures.[39]

In 1958, Hadi El-Nagar, Gezira Medical officer of health, felt able to claim that the campaign against schistosomiasis was a complete success — an assertion was taken in good faith by academics in other disciplines. In 1961, for example Barbour records in a basic textbook on the geography of the Sudan that:

> Virtually complete control of the disease has recently been achieved by treating the water in infected canals with copper sulphate.[40]

In 1972 the infection rate of *S. mansoni* was estimated to be around 60 per cent, and the existing methods of snail control were finally accepted as being failures.[41] The London/Khartoum bilharzia project was set up[42], and the Shell company initiated research[43]. Trials with a new molluscide N-tritlymorpholine — tradenamed Frescon — commenced in 1969.[44] Frescon is at present the most potent molluscide against hatched snails. It is not effective against snail eggs and therefore requires repeated applications.

Using Frescon in drip-feed techniques, aerial applications, and hand spraying the smaller canals, Amin concluded that control of the snails was possible[45,46]. It should be noted that many villages are entirely dependant on filtered canal water for their water supply. The effect of Frescon intake on a regular basis, in conjunction with DDT and other pesticides used on cotton, in a population already weakened by disease is not discussed. However, in 1976 the trial method had not been extended to the whole area because, in the words of Amin:

> The effectiveness of the regimen in achieving reduction of transmission and the cost effectiveness of other methods must be considered before large-scale control is implemented.[47]

In 1976 surveys indicated an infection rate of *S. mansoni* of over 70 per cent in some villages; *S. haematobium* on the other hand had declined to an incidence rate of 'only' one to thirteen per cent.[48] The main reason for the reduction of *S. haematobium*, which is transmitted via human urine, is cultural. The local population was persuaded to urinate away from the canals, which are still used for defaecating in order to have privacy and water for cleaning purposes.[49] Within the Gezira villages around 45 per cent of the inhabitants still have no direct access to pit latrine facilities.[50]

In 1977 Amin estimated that the economic loss as a result of absenteesism due to ill health was 30 million Sudanese pounds per year, (approximately 1.8 million pounds Sterling). The cost of applying molluscides to control the disease is estimated at 1 million pounds a year, and to that figure one must add nearly half a million pounds to treat those infected.[51] The latest surveys indicate that the general infection rate is 60 to 70 per cent, and can reach over 90 per cent in school children aged 8 to 15 years.[52] No accurate population figures are available for the Gezira. It was estimated to be 250,000 in 1920, and is now about 1,500,000, with an additional 400,000 seasonal workers.[53]

One might have thought that certain lessons on schistosomiasis prevention and control have been learnt from the Gezira. Yet Sudan's latest irrigation scheme at Rahad, 50 kilometres from the Gezira, is beset by the same laissez-faire attitude towards schistosomiasis. The opinion most commonly voiced is that, "education and rising standards of living are the only long-term answer".[54] Meanwhile the first reports of snails arriving in the irrigation system are beginning to filter through.[55]

In 1980 the World Health Authority embarked on a 155 million dollar programme in the Blue Nile area to tackle diseases linked to irrigation. An array of experts have been flown in to evaluate the cost and effectiveness of Control strategies. The WHO states, however, that "only from 1984 will new and proven strategies be gradually applied to cover all three zones." Meanwhile, the problem has never been greater with over 12,000 Km of weed infested canals serving as the ideal environment for the snails. The rising cost of imported pesticides, fertilizers, and agricultural requisites has meant that the local agriculture is facing economic collapse.[56,57] The central question

The Pesticide Treadmill

Prior to the Second World War crop varieties, rotations, and specific cultivation practices were the main methods used to reduce pests and diseases of the cotton crop. After a few early disastrous years these measures enabled the cotton yield to maintain a steady average of around 235 Kg/hectare. A number of agricultural research farms were set up and virtually all the research was geared to the cash-crop cotton, the local staple foods, *dura* and *lubia*, receiving little attention. During this period Sudan underwent the transition from a country self-sufficient in food to that of a net importer of food, a position still held in 1975.

Since the Second World War the amount of inorganic fertilizer application has increased steadily to ensure that lack of nitrogen is no longer the limiting factor for the cotton crop. The local food crops such as *dura* usually receive no fertilizer. The area of cotton applied with nitrogen, mainly Ammonium nitrate, since the war may be seen in table 1.

The application rates have also increased from 6.5 Kg/hectare in 1954, to 15 Kg/hectare in 1974. The Sudan is dependent on other countries for all its supply of fertilizers. Plans to construct their own fertilizer plant have been underway since 1968. It is hoped that construction may commence in 1982, but in view of Sudan's economic position this seems unlikely. Until Sudans independence in 1956 it imported all fertilizer from the U.K., now Kuwait, which has the required cheap energy for nitrogen fixation, is the main supplier. Since fertilizers (inorganic) represent one-quarter to one-third the energy input to general crop production, energy related price rises are likely to affect the price of fertilizer, and hence crop production quite significantly. Therefore the agricultural technology, as in the industrialized world, is linked to an unstable commodity.

Scarcely any cultivated plant is attacked by so many pests as cotton. Cotton varieties that respond to heavy doses of fertilizer are particularly susceptible to attacks by pests and diseases, especially when grown in large mono-culture stands as in the Gezira. It is not surprising therefore that pesticide usage has increased substantially since 1946. This is best illustrated by the data in table 2.

Readers of *The Ecologist* will be fully aware of the environmental and pest resistance problems associated with pesticides. However a few points relevant to the Gezira are worth making. In 1976 it was estimated that at the current rate of spraying not less than 2,500 tonnes of active insecticides are being deposited annually in the Gezira, nearly two-thirds of which represents DDT. Residues of organochlorine pesticides are present in most fish species 1500 kilometres downstream the Nile in lake Nubia; these are thought to have originated from the Gezira. The spraying strategies used have merely allowed whitefly *Bemisia tabaci* to replace American bollworm *Heliothis armigera* as the major cotton pest in the Gezira.

Like fertilizer, Sudan imports all its pesticides, originally all from the U.K. after independence from Europe in general, particularly France. The rise in insecticide expenditure between 1966-67 and 1980-81 will be over 1,400 per cent, of which nearly half will have occurred in just two years.

Although long-staple cotton can not be mechanically harvested without damage, other machinery has been incorporated into the agricultural cycle. In the 1950's Scott found that 98 per cent of private tractor owners in the Gezira possessed a tool-bar, but no other item of equipment. Between 1955 and 1964, over 2,800 tractors were imported into the Sudan, but in 1966 many were found to be lying idle for want of spare parts and competent mechanics. In recent years the supply of spare parts, competent mechanics, and localized fuel shortages have continued to cause major problems.

In spite of these problems, further industrialization of agriculture is planned for the Gezira. The new Managing Director of the Gezira board, El-Hag whilst admitting that, "The whole system is beginning to crumble" goes on to state in an interview:

> In 20 years time, my hope would be to see the scheme pointed to not just as the worlds biggest farm, but as the most outstanding agro-business complex in the Third World.

Table 1. Area of cotton applied with N - fertilizer, and percentage of cotton applied with N fertilizer. 1947-1955.

Year	Area Cotton Applied With Fertilizer, Hectares	Cotton Area Fertilized percentage
1947	1,680	1.8
1949	13,860	15.9
1951	63,000	72.0
1953	77,700	78.0
1955	98,500	100.0

Source: Richardson, Agricultural Research in the Sudan, ICI;

Table 2. Area of Cotton sprayed, percentage of cotton area sprayed, and number of applications/year. 1946-1979.

Year	(1) Cotton Sprayed Hectares	(2) Cotton Sprayed Percentage of Area	(3) Average Number Sprays/Year.
1946	600	0.7	1.0
1947	3,500	4.0	1.0
1948	14,500	17.0	1.0
1949	32,700	37.0	1.0
1950	53,000	60.0	1.0
1951	70,000	80.0	1.0
1954	98,000	100.0	1.0
1959	158,000	100.0	1.0
1964	213,000	100.0	2.5
1969	246,000	100.0	4.9
1974	247,000	100.0	6.0
1979	209,000	100.0	7.0

Source: Bartsch, Economic Problems of Pest Control, examined for the case of the Gezira, Sudan, London, 1978.

remains, will the true social cost of the scheme be met?

Malaria

In the Gezira both *Plasmodium falciparum* and *Plasmodium vivax* are endemic. Malaria was present before the irrigation scheme commenced and in some areas reached epidemic proportions during the rainy season. During the eight month dry season malaria died away and the infected population recovered.

With the implementation of the Gezira scheme malaria transmission became a perennial problem. The water in the canals and fields provided ideal conditions for both vectors to survive throughout the year. By 1930 malaria had become widespread, and the consequent disablement among the local population marked.[58] In the Blue Nile Province, of which the Gezira contains half the population, about 100,000 cases and 35 deaths were reported each year between 1959-1967.[59]

Weeds in the 12,000 Km of canals favour snail and mosquito breeding. They obstruct the water courses causing stagnation, and reduce the efficiency of chemical sprays.[60] It is well known that one cubic metre of stagnant water is sufficient for a mosquito to breed in; this being one of the main reasons why malaria is so difficult to control.

Anopheles gambiae, the principal vector, has shown resistance to DDT and the pesticide's use to combat cotton pests is considered to have contributed significantly in the early formation of such resistance. The use of the more expensive malathion in the control of mosquitoes and the additional cost involved has led to incomplete application and control has not yet been accomplished.[61]

Yellow Fever

Yellow fever immunity exists among the population of the southern Gezira where the disease can occur. Before 1934 there was no suspicion of the existence of the clinical disease.[62] Outbreaks occurred for the first time in the southern Gezira in 1939, and again in 1959. These outbreaks have been ascribed to the changes in the environment. Formerly in the prolonged dry season the mosquito vector would be restricted to the forest areas in the south. The Sennar dam and irrigation canals have been implicated in allowing the vector to extend its range and transmission period.[63]

In addition to these man-induced diseases in the natural environment, the industrial disease of *byssinosis* is a serious problem among cotton-gin workers.[64] A positive correlation between cotton dust concentration in the ginneries, and the number of workers affected with byssinosis has been demonstrated. Byssinosis causes coughing and phlegm, eventually leading to bronchitis.

The incidence rates of the diseases discussed are serious. In themselves they are enough to warrant classifying the Gezira scheme a failure for the local people who live and work there. It would be expected that they would figure prominently in any discussion. This is not the case. In over twenty major research reports on the Gezira scheme, these diseases are omitted from the discussion, or given at most a passing mention.[65]

For example, Gaitskell in a major study, *Gezira: A story of development in the Sudan*, comments that in the period 1925-46;

> Gezira villages were dirty and hygiene primitive. Dysentary, malaria, and bilharzia were endemic

Whereas by 1950

> They began to have new standards of health. They needed new medicines and took a taxi to get to the doctor. Private practice flourished as they sought to avoid the queues at the hospital.

The colonialists had indeed introduced them to civilization!

Cultural Impact

The Gezira is thought to be an alluvial plain laid down by the Blue Nile, approximately 30,000 years ago.[66] Human occupation in the period 10,000 B.C. to 5,000 B.C. is indicated by the remains of simple pottery. Excavations within the Gezira have identified at least six distinct pre-arab cultures on the basis of burial grounds, pottery and ornament remains, and hut sites. Archaeological evidence indicates that around 4,000 B.C., grain was being ground in saddle querns precisely like those used in villages in 1950.[67]

By around 500 A.D. the Gezira had become part of the Christian kingdom of Soba, but a strong affinity to the earlier system of sun, fire, tree and animal worship remained.[68] From the seventh century A.D. successive Arab invasions followed the Nile route from Egypt. They tended to travel up the east and west banks of the Blue and White Niles respectively, thus the Gezira was only partially penetrated by Islam. A 13th century traveller, Abu-Salih, records that Soba was a large kingdom with upwards of 400 churches. The city of Soba within the Gezira was renowned for its market.[69] Archaeological evidence confirms that large red-brick churches were built in this period.[70] The people at this time were described as a tall, well set up, dark race, who possessed a knowledge of iron smelting.[71]

The Arabs who had previously invaded southern Sudan and Ethiopia, after bypassing the Gezira, intermarried with the local population. This was the probable origin of the Fung tribe.[72] In 1504 A.D. the Fung led by Omaras Dunkas invaded the Gezira. After defeating the Arab Abdullah tribe at Sennar, and establishing a historical ascendancy, they joined forces and conquered the rest of the Gezira. Under Islamic rule each existing tribe or clan was allowed to occupy its own area or 'dar'. The land was divided up for cultivation purposes between the various sections and families by the chief, who was the trustee for the tribe.[73]

The Gezira population adopted Islam. The construction of Mosques now took place, but as with the earlier Christians, agricultural practice continued as before. The Fung collected taxes on grain and locally manufactured cloth; Sennar became an important centre of commerce.

Cultivation of cotton and *dura* was helped by irrigation using the 'sāqiya' or Persian water-wheel worked by bullocks, and the 'shadūf' a lift mechanism worked by man. The 'sāqiya' can raise water from 3 to 8 metres, and, when the Nile is high 2 to 3 hectares can be kept under crop.[74] The 'shadūf' can lift water up to 3 metres giving an output suitable for the irrigation of 1 hectare of vegetables.[75] Irrigation of this type antidates recorded history, and has been known in the Nile valley since 3,000 B.C.[76]

In the southern central regions rain cultivation of crops took place.

The Ecologist Digest

Nuclear Energy: Accidents, Economics and Opposition

In Hot Water: Uranium Mining and Water Pollution, Carol Polsgrove, *Sierra Club Bulletin*, Nov/Dec 1980.

Uranium mining not only depletes water supplies but also causes serious pollution of underground aquifers. In New Mexico, where approximately half of America's uranium is mined, enough water to supply a town of 50,000 people is discharged from uranium mines each year. The 'drawdown' from a single mine is estimated to cover several counties — with serious consequences for the water table in arid areas. The Environmental Protection Agency (EPA) warns that waste water from the mines is creating 'a long-lived source of groundwater contamination', and has already led to several serious pollution incidents. Several wells on a Navajo Reservation in the San Juan Basin have been shut down because the levels of selenium and arsenic — both heavy metals brought up in the course of mining — exceeded federal limits. A number of wells in the area have levels of radioactivity that approach federal limits.

The article is accompanied by a boxed account of the 1979 accident at Church Rock, New Mexico, when a uranium tailings dam collapsed, spilling 100 million gallons of radioactive liquids and 1100 tons of solid waste into the Rio Puerco, (*Disaster at Church Rock: The Untold Story* by Allan Richards). Only 0.3 per cent of the spilled material was ever cleaned up and the Nuclear Regulatory Commission (NRC) described the accident as 'the worst ever incident of radiation contamination in the history of the US'. Tests showed that levels of radium in the Rio Puerco were 120 times above background; thorium levels were 6000 times higher; and the high acid content of the tailings gave the river an acidity equivalent to that of a car battery. Investigators found that aquifers (30-40 feet below ground) fifteen miles downstream had been contaminated with high levels of radioactivity and heavy metals.

Nucleaire: l'inquietante demission de M. Securite, *Le Matin*, Dec. 15th 1980.

Nuclear Chief Resigns over Safety Policy, Ian Murray, *The Times*, Dec. 16th 1980.

M. Jean Servant, head of the security service responsible for health and safety at France's nuclear power plants, has resigned because he believes he has not been given sufficient support to do his job properly. His letter of resignation, leaked to *Le Point*, gave six reasons for leaving the job. "The principal difficulty is the inability to carry out my functions fully," he wrote. The letter accuses the Ministry of the Interior of 'thinly veiled hostility' towards his work and of openly refusing to help him carry out his duties. Only the Ministry of the Interior had shown any willingness to co-operate with him, he said, whilst the Ministry of Health "from the outset refused all co-operation on the grounds of opposing any interference by engineers from the Ministry of Industry on matters of nuclear safety." As Secretary-General of the Inter-ministerial committee for nuclear safety, Savant was attached to the Prime Minister's office and had no budget of his own. He thus had to rely for staff and finance on other ministries — a situation, he said, which produced "a dependence which is difficult to reconcile with a mission of general inspection". An inter-ministerial committee on nuclear safety had only met once in the two years of its existence and, Savant alleges, co-ordination between different government departments on nuclear matters had become 'purely formal and illusiory'. In the letter, he writes: "I did not ask for the job of inspector-general, but having received it, I can see no point in continuing to carry out my duties in the face of opposition from the Ministry of Industry and, more to the point, of the minister himself . . . It is painful for me to work in an atmosphere of mutual distrust . . . which is scarcely compatible with a real concern for nuclear safety." Savant has been replaced by M. Bernard Augustin, who has no specific training in the field of nuclear safety.

Fire at French Nuclear Plant leaks Radiation, Andrew Lloyd, *New Scientist*, Jan. 15th 1981.

Radiation Affects Twenty, Paul Webster, *The Guardian*, Jan. 10th 1981.

Twenty people were contaminated by radioactive fumes at the La Hague reprocessing plant near Cherbourg. One worker received what unions described as 'a serious dose' and the rest were only slightly affected. Three of the twenty are receiving further checks but trade unions at the plant accuse the management of trying to play down the incident. Trade union officials said they were 'sick and tired' of the management's attitude to safety. The fumes emitted a radioactive cloud that workers said would have contamination over a wide area if it had not been blown out to sea. Filters in a silo containing graphite-magnesium were blocked. The union said that proper decontamination procedures were not carried out on staff after the leak and that the radioactivity was spread to their homes and to their cars. The accident happened after a fire in a waste silo and unions fear the radioactive cloud may have contained strontium-90, in addition to caesium. No general alert was given and Cogema announced

that radioactivity did not exceed one-fifth of the maximum permissible dose. However, the next day, the La Hague Hygiene and Security Committee revealed that in parts of the site radiation had reached maximum levels. The unions also claimed that radiation at the plant's medical centre, some 200 metres from the main road, reached a level 10 times that allowed outside the confines of the plant, a figure which is not disputed by Cogema.

Fast Reactors: Low Moral, Judy Redfearn, *Nature,* vol 288, 18/25 December 1980.
Staff Moral may be as much of a threat to the British fast reactor programme as the prospect of a public inquiry on the project. The latest sign is the resignation of Mr. Jack Moore, co-ordinator of the fast reactor programme at the UK Atomic Energy Authority (UKAEA). Moore said that at the UKAEA he was unlikely to see his work of the past seven years come to fruition before his retirement. (He is 57 years old). Moore's resignation highlights two potential problems for the staffing policy of the fast reactor team. Although no other senior staff are reported to be leaving, further delay in a commitment to build a fast reactor may prompt others to go. The second problem is that of the age structure of the design team. Although the UKAEA have expanded the team by bringing in young people, previous recruitment policies have left a noticeable dearth of people in their forties. When the senior staff retire or leave, their posts will have to be filled by much younger people.

The French Nuclear Harvest: Abundant Energy or Bitter Fruit? Irvin C. Bupp, *Technology Review,* November/December 1980.
A review of the progress of the French nuclear energy programme and the opposition to it. The article concludes that the speed at which the programme proceeds depends on "whether the distribution of political power in the French society, and the values that currently control French life, can be maintained." Technical issues will not be important. Bupp also argues that developments outside France, over which French politicians have little control, could significantly affect the French nuclear programme. "The revolution in Iran was an especially pertinent example", he writes. "The loss of reactor sales to Iran has been a heavy blow to the French nuclear industry. Framatome — France's partially nationalised, and only, reactor manufacturer — has but one foreign customer (South Africa) and prospects elsewhere are not bright for the immediate future. Electricité de France can keep the company busy for a while longer, but government officials admit that France's domestic market cannot indefinitely sustain the six-reactor-per-year demand to which Framatome's manufacturing capacity is geared. Ultimately, the problem is more general. A major pillar of the entire French nuclear development effort is the expectation of significant long-term export markets on all fronts: for nuclear power plants, uranium enrichment, and fuel reprocessing. If much of the non-Communist world turns away from nuclear power, both the pace and the scope of the French programme will almost certainly require profound revisions."

Nuclear Fuel Account Books in Bad Shape, Eliot Marshall, *Science,* vol. 211, Jan. 9th 1981.
The US Nuclear Regulatory Commission's statistical checks on nuclear fuel shipments have become so muddled in recent years that they are now meaningless, claim a group of NRC statisticians. A report by the group lists thirteen specific deficiencies in the NRC's accounting techniques, some of which are easily remedied, others of which would require an enormous campaign to rectify. The significance of the report is clear. One can have little confidence at the moment that the NRC's system of accounting would catch a skillful fuel thief.

How Radioactive are our Atomic Workers? Guess! Richard P. Pollock, *Critical Mass*, Oct/Nov. 1980.
A report by the US Nuclear Regulatory Commission, undertaken by the University of Michigan's School of Public Health, reveals that eighty per cent of radiation devices used in the US to monitor exposure to different categories of radiation fail to come within fifty per cent accuracy. The report follows an admission by the owners of California's San Onofre nuclear plant that up to 73 workers may have received more than twice the federally allowed dose of radiation in a quarter year even though none of the radiation detection devices worn by the workers reported high dosages. The NRC study involved a survey of the performance levels of companies that take radiation dosimetres from workers, process them and send back the results to the workplace. The companies were tested for their ability to detect eight categories of radiation — from gamma radiation to low energy x-rays. The Michigan team describes the dosimetry industry's performance as 'poor' and blames the companies for calibrating their equipment with radiation sources other than those specified by the Health Physics Society; for using defective radiation devices; for not detecting clerical errors; and for displaying a 'poor attitude' about achieving high standards of quality control. Fifty-nine processing companies were surveyed and the NRC estimates the sampling covered 90 per cent of the radiation dosimetry field. Part of the study involved the companies in 'blind' tests in which dosimetres with pre-set dosages were submitted along with other regular batches from nuclear power plants. The processing firms did not know they were being secretly evaluated and, apart from the researchers, no-one knew the pre-set dosages. In the first round of tests, only 9 per cent of the companies correctly assessed the pre-set dosages. In a second round, only 6 per cent passed the NRC test. "To the extent that these tests are representative of routine field conditions the results indicate that the dose received by occupationally exposed personnel may often be considerably different from the dose reported by the dosi-

metry processor'', the NRC concluded. Just as controversial as the findings themselves, however, is the NRC's solution to the problem. It recommends lowering the Health Physic's Society's standards for assessing radiation exposure from dosimetres in order to allow more companies to pass the NRC tests.

37 Billion Federal Dollars Subsidize the Nuclear Industry, Jim Harding, *Not Man Apart,* February 1981.

Taxpayers have subsidized the development of commercial nuclear energy to the tune of more than 37 billion dollars (at 1979 rates), according to a draft report of the Energy Information Administration of the US Department of Energy. Without these subsidies the EIA estimates the cost of nuclear electricity would be 66 to 100 per cent higher. The report suggests that the annual rate for subsidies is growing, exceeding 3 billion dollars in 1979. Amortized over the entire production period, the nuclear research and development (R and D) subsidy calculated by the equal to $28 to $42/ barrel of oil equivalent in delivered energy. Although the EIA estimate takes into account several sources of subsidies, the analysis is incomplete since it does not consider such important subsidies as tax reliefs for nuclear plants or the limitation of accident liability as provided by the Price-Anderson Act. The principal direct federal subsidy for commercial nuclear power has been the research and development effort, totalling 23.7 billion dollars between 1950 and 1979, according to EIA estimates. Other subsidiaries include: $0.2 billion on boosting foreign reactor sales (under the 'Atoms for Peace' programme, research reactors and equipment were sent to 27 countries at a cost of $29.1 million); $2.5 billion on uranium production (for ten years, the AEC offered a guaranteed price for uranium yellowcake; $7.1 billion on uranium enrichment (mainly through an intensive federal exploration programme); and $6.5 billion on waste management. The EIA report makes no attempt to calculate the cost of tax benefits that utilities enjoy when they purchase nuclear reactors, yet some believe this to be one of the largest taxpayer contributions to the nuclear industry. Economist Duane Chapman of Cornell University, in a 1979 report to the California Energy Commission, found that state and federal tax subsidies for a new nuclear plant amount to over $200 million a year (in 1980 dollars).

Nuclear Business asks Government to pay for TMI, Christopher Joyce, *New Scientist,* January 1st 1981.

Facing financial doom from the snowballing cost of the incident two years ago at the Three Mile Island nuclear power plant, General Public Utilities, the corporation that owns TMI, now claims that the federal government should pay the cost of the accident — 4 billion dollars. GPU argues that the Nuclear Regulatory Commission 'induced' the company and Metropolitan Edison, the utility operating TMI, to rely on the government to review the equipment, operating procedures and training programmes at TMI — but that it had failed to warn of a major fault in the reactor, designed by Babcock and Wilcock. The key to GPU's complaint is an accident in September 1977 at the Davis-Besse nuclear power plant in Ohio. The Davis-Besse and TMI-2 reactors were sister reactors, and the accidents at the two plants were strikingly similar. Over a year after the Davis-Besse accident (but before the TMI incident), the NRC revised the operating procedures for the David-Besse plant. Even though the NRC realised there were flaws in the reactor design, the agency failed to warn other utilities, according to GPU, nor did it properly train operators to handle such an accident. This negligence 'was one of the causes of the TMI accident', GPU concludes. Critics of the company point out that details of the Davis-Besse accident were well known within the industry, and say that Met.Ed. had experienced similar problems before the debacle at TMI.

Debate over Waste Imperils Three-Mile Clean-Up, Luther L. Carter, *Science*, Vol. 210, Oct. 1980.

The clean-up of Three Mile Island represents a challenge unlike anything yet faced by the nuclear industry. Decontaminating the reactor, the containment building and other facilities will continue over five years and will require more than 2000 workers, and a minimum expenditure of a half billion dollars. During the accident, more than 300,000 gallons of water contaminated with fission products overflowed into the auxilliary and fuel handling building from the primary coolant system, and nearly 700,000 gallons of coolant water with a half million curies of radioactivity poured into the containment building sump. Also some 43,000 curies of krypton-85 escaped from the reactor vessel and dispersed within the containment building. The problem now is what to do with the contaminated wastes that must be removed from the reactor if the site is to be cleaned up. Much of the waste will be material that has been contaminated in the decontamination process itself. Low and intermediate level wastes will fill thousands of drums. There will also be the damaged fuel assemblies from the reactor core: a third or more of the 177 assemblies in the core may have suffered damage. Those fuel assemblies will probably be stored on site in an existing storage pool to await the opening of a permanent disposal site or of a commercial reprocessing plant. No-one knows, however, what will become of the low level wastes. At the moment they are being trucked across the States to a 'burial' ground at Hanford, Washington. But this may soon become politically unfeasible, leaving the equivalent of hundreds of truckloads of waste filled boxes and drums with no place to go. GPU's suggestion that all the wastes could be kept on the TMI site have met a frosty reception: ''Who wants all that radioactive material to be sitting, for a considerable time, on an island in the middle of the Susquehanna?'' asks Thomas M. Gerusky, Pennsylvania's top radiation protection official. The thorniest problem, however, may be the wastes generated in cleaning up the containment building's sump water. In

the first stage of the ion exchange process, when most of the fission products will be removed, the radioactivity of the zeolites (or resins) used in the filters will run as high as 1500 curies per cubic metre, as opposed to a maximum of 10 curies in ordinary low-level wastes. Disposal of these first-stage zeolites will be well nigh impossible unless the Department of Energy lends a strong helping hand. If the efforts to clean up TMI arrive at an impasse because politically and technically acceptable means of disposing of the wastes are not found, the implications for the nuclear industry could be profound. "If the DOE can't solve this little problem (of the zeolites) should NRC be licensing more nuclear plants?" asks Bernard Snyder, the NRC official overseeing the clean-up. Meanwhile delay over waste disposal could make the clean-up ruinously expensive for GPU.

Nuclear Accident Bungled, Christopher Reed, *The Guardian*, Jan. 7th 1981.
A member of the commission which investigated the Three Mile Island accident has written a book highly critical of the authorities handling of the near disaster. Dr. Mark Stephens, a teaching fellow at Stamford University, alleges that the control room staff were 'poorly trained and under-educated' about the mechanics of the accident, and had 'they not touched anything the reactor probably would have been back generating electricity within three or four days'. Stephens claims that the nuclear industry was so convinced it knew what it was doing that it did not believe what was happening was possible. No emergency procedures or computer programmes had been written to guide the station operators. Stephens also alleges that officials knew there was at least a partial melt-down of the fuel within the first few days of the accident, even while Metropolitan Edison were denying it. "A spokesman at TMI was correct in stating that events there were not dissimilar to those shown in Jane Fonda's film *China Syndrome*," says Stephens." In fact, they were much worse." He also accuses the NRC of 'bumbling and stumbling' in its efforts to control the situation. Both the NRC and Metropolitan Edison tried to minimise the importance of the accident through 'deliberate falsehoods', Stephens alleges.

Handle with Care, Shoja Etemad, *The Guardian*, January 22nd 1981.
The French Confederation of Trade Unions (CFDT) has issued a technical statement which confirms that the highly radioactive oxide fuels from pressurised water reactors cannot yet be routinely handled. It is misleading for France to claim to have a commercial process and the capability of accepting fuels from other countries for reprocessing, the statement implies. The fact that reprocessing from the early French and British nuclear power stations continues successfully is not relevant to the oxide fuel in question. The only honest solution to the problem, says the CFDT, is that adopted in the US where oxide fuels are to be stored in pools until a process becomes feasible. By increasing the short-term demand for uranium, however, such a programme might substantially increase the costs of the nuclear fuel cycle. The union also points out that reprocessing fuel from breeder reactors may prove even more difficult than oxide fuel. One problem is to make the most of its plutonium content it should be reprocessed as soon as possible after leaving the reactor — perhaps within three months. At that time it is much too radioactive to put through a routine process, argues the CFDT. A further problem is that the effective reprocessing capacity for oxide fuels in France has fallen well below projected capacity. On the basis of experience since 1976, and assuming no serious accidents, France will be able to reprocess about 2,200 tonnes of fuel during the eighties although the requirement, with foreign contracts, will be 13,160 tonnes. That means 84 per cent of spent oxide fuels will have to be put into long-term storage. Countries which believe that they can export their reprocessing problems will thus find that they are left with an oxide fuel storage problem, the union claims.

Pollution: Chemicals, Waste Dumps, Pesticides

Muddying the Water at Niagara, Irwin D.J Bross, *New Scientist*, Dec. 11th 1980.
A panel convened by Governor Carey of New York State has concluded that the evidence that Love Canal — the notorious toxic waste dump that led to the wholesale contamination of an area of Niagara City — caused miscarriages and other health effects is 'inconclusive'. The panel's report has been called 'the last word' on the subject. But were all the facts taken into account? Independent analysis reveals a statistically significant difference in the rates of miscarriages and birth defects in those areas most severely affected by the contamination and in those areas least affected. The risk of miscarriage was found to be more than twice as high amongst women in the areas of high contamination, as was the risk of birth defects. In the two most contaminated areas, there were 158 pregnancies and 37 miscarriages. In the least contaminated area, there were 318 pregnancies and 35 miscarriages. Fourteen birth defects were documented out of 122 live births in the most contaminated areas, compared to 28 live births and 15 birth defects in the control area.

New Cancer Risk Rears its Head, *New Scientist*, January 1st 1981.
The doses of a carcinogenic chemical that people receive from some commonplace substances could be large enough to cause cancer. Cutting oils, used in

working metals with machines such as lathes and drills, and some cosmetics called nitrosodiethanolamine, which researchers found some time ago to cause cancer in rats and hamsters. But they argued that the danger to people exposed to the chemical was not high, because only very big doses induced cancer in animals; humans receive much smaller doses. Now, William Lijinsky of the National Cancer Institute has discovered that quite small doses of the chemical cause liver cancers in rats. In a group of twenty rats given drinking water that contained 3900 million parts per million of the chemical over a period of 34 weeks, all developed liver cancer.

Overuse of chemicals poses 'main threat' to control of farm pests, Richard Norton-Taylor, *The Guardian,* January 12th 1981.
The build-up of resistance as a result of chemicals is now the most serious threat in the fight to control pests, warned Dr. George Cooke, the chief research scientist at the Agricultural Research Council. The quantity of pesticides used by farmers could be reduced 1000 times and still be more effective with better spraying techniques. Overspraying, he said, increased the risk of pollution, and could be avoided if an insecticide was used so that only the insect was hit with a lethal dose.

Food Chemical Hazard Unresolved. Hugh Clayton, *The Times,* January 27th 1981.
Government scientists at the Ministry of Agriculture Fisheries and Food do not know if a chemical found to cause nervous disorders in rats is still being used for flavouring in British food. The substance is versalide and has been shown to have neurotoxic properties in experimental rats, leading to weakness and lack of coordination in the limbs. The Ministry said that government scientists had been told of the chemical's dangers in 1976 but that a subcommittee had reviewed the medical literature and decided 'further research' was necessary before any action was taken. The substance is used in some processed desserts, sugary confectionary and baked foods. The Ministry has no plans for an investigation of versalide. It will be included in a series of safety tests on all artificial food flavourings, which will be completed in two years.

Acid River Blamed on Steel Works, James Tucker, *The Sunday Times,* February 1st 1981.
A spillage of 2000 gallons of concentrated nitric acid into a tributory of the River Usk, killing hundreds of trout and salmon and thousands of eels, has been traced to a British Steel Corporation works at Panteg, Wales. The acid had leaked into the river after eating its way through the metal of a storage tank where the rubber lining was defective. The Welsh water authority warned people to stay away from the river and keep their animals out of it. "A six mile stretch of the river is affected," said Mike Henderson, environmental officer for the Welsh water authority. "Although our monitors tells us that the acid has not passed through Newport and cleared into the Severn estuary, we have lost the fish life and the flora and fauna on which fish feed. Full recovery will take anything up to two years."

Row over Toxic Waste Plan, John Carvel, *The Guardian,* January 24th 1981. **Health Dangers Feared in Toxic Waste Regulations,** David Nicholson-Lord, *The Times,* January 22nd 1981.
Loopholes in the new regulations on the disposal of toxic wastes could seriously increase the risks of accidents and contamination of water supplies, local authority leaders warn. The regulations, brought in under the 1974 Control of Pollution Act, will replace the Disposal of Poisonous Waste Act, an emergency measure introduced in response to controvery about the dumping of cyanide in the Midlands. Although local authorities agree that the DPW needs ammendments, they say that the new regulations will cut down the number of substances that have to be notified and introduce a definition of toxicity which few people understand and which will therefore prove unenforceable. They cite the death of a lorry driver at the Pitsea site in Essex five years ago, caused by an interaction of acid and sulphide to produce highly toxic hydrogen sulphide gas. Neither substance would be considered toxic under the new system. "The new regulations are based on the threat to the life of a hypothetical 20 kg. child aged about four and a half, and not on the threat to water supplies and the environment," say the authorities.

Groundwater Purity Seriously Threatened, Jeff Kole, *Not Man Apart,* January 1981.
A report, written under the auspices of the US Environmental Protection Agency, has warned that "groundwater destruction will be one of the most serious environmental problems of the 1980s". The report identifies a high number of industrial sites where contaminants could conceivably seep 'unimpeded' into the groundwaters below. According to the report, 70 per cent of some 26,000 unspecified industrial liquid waste treatment or disposal areas are located above such porous ground that contamination can seep into the groundwater. "Contamination may (result) in irreversible damage to groundwater resources or (render) them unusable for decades or perhaps for geological time." Half of these unlined sites, or about 9,100 distinct locations, "may contain potentially hazardous components" while 7,800 (or about 30 per cent) sit directly above groundwater sources with no barrier. Fully ten per cent of the sites are within one mile of a potential water supply well. The hazard resulting from potentially dangerous sites that are not presently monitored is stressed in the report. "Over 90 per cent of the industrial pits, ponds and lagoons," it states, "are virtually unmonitored." At present, groundwater supplies about one quarter of America's total water supply, while more than 95 per cent of all rural Americans get their water direct from that source.

Toxic Waste: Dutch Dumps. Casper Schuuring, *Nature,* Vol 289, January 29th 1981.
The cost to the Netherlands of dealing with chemical waste from years of heavy industrialisation is mounting. So far about 3000 dumps containing chemical waste have been found, 500 of them a recognised danger to public health. The Minister for Public Health and Environmental Protection has estimated that it would cost about £200 million to clear the 500 dangerous dumps. Since that announcement, the estimated cost has been reassessed and put at £400 million. In the village of Lekkerkerk, not far from Rotterdam, many buildings were found to have been built on a chemical waste dump. About 1700 drums were recovered from the site, containing materials such as tuolene and xylene from the dye industry and metals such as cadmium, zinc and lead. Some 300 houses were evacuated and 150,000 tons of polluted soil have had to be removed, while medical examinations may yet be carried out on the population. Several more chemical waste dumps have since been found in the area. In another case, an investigation of cattle infertility and the discovery of dead birds led to the authorities uncovering 10000 drums of chemical waste from a 2,4,5-T factory owned by Philips-Duphar. The drums had been dumped in a marshy area five miles from the centre of Amsterdam.

Superflies foil the Scientists, *The Guardian,* January 9th 1981.
Superflies which cannot be killed by known insecticides are threatening to take over some parts of Britain, Government scientists have warned. The indestructability of the flies, which have been studied at the Ministry of Agriculture's research station at Slough, is believed to be caused by 'unintentional immunisation'. New chemical insecticides, unlike older ones, do not decay as fast and persist in the environment. The flies which are exposed to them have developed resistence. "We are very much aware of the problem," said a ministry spokesman. At present, the problem is largely confined to flies on farms, where their exposure to chemicals is greatest, but resistence has also been noted in household flies. The fear is that the superflies will spread disease, carrying dysentry, gastroenteritis, and every cholera and typhoid.

Scientists Battle over Valium and Cancer, *New Scientist,* January 8th 1981.
Roche Products, the manufacturer of valium, has reacted fast and furious against the findings of Dr. David Horrobin, a British scientist now resident in Canada, that valium promotes and accelerates the growth of cancer in laboratory rats. The Swiss pharmaceutical company called in Dr. Francis Roe — a consultant toxicologist to the drug and cosmetics industry — for an opinion on Horrobin's work. His verdict is that Horrobin's results "do not lead one rationally or reasonably to the view that valium either causes or promotes cancer." Roe argues that Horrobin has done some "very odd and unusual experiments, some of which are quite ingenious." But he dismissed them by saying that the experiments were on a very small scale and the results "inconclusive and trivial and in no way justify the fuss." Horrobin staunchly defends his research against the onslaught. "Not one of the things Dr. Roe says in any way invalidates what we are claiming. Our research was on groups of animals of perfectly conventional sizes in cancer research. If you get unequivocal results in a group of ten animals, there is no need to do studies on much larger groups. Our results were absolutely unequivocal and very highly statistically significant. The laboratories in the US which confirmed our results are in fact two of the leading laboratories in the US which confirmed our results are in fact two of the leading laboratories in the world on tumour promotion. These are completely independent laboratories, and quite honestly I would back their opinion against that of work done by Hoffman La Roche."

Dioxin Turns Up in Great Lakes, *New Scientist,* December 18/25, 1980 *and* January 15th 1981.
Levels of TCDD — one of the most potent chemicals known to man — in fish in Lake Ontario averaged between three and eight parts per trillion (ppt). The only other area of the world with higher concentrations of the chemical is Vietnam where the defolieant Agent Orange — a mixture of 2,4,5-T and 2,4,D — was sprayed in an effort to combat guerrilla attacks. Canadian wildlife service also found TCDD in the eggs of Herring gulls at levels of about 10ppt. 'Hot' spots at Saginaw Bay in Lake Huron produced eggs with up to 90 ppt and in Lake Ontario with levels up to 64 ppt. A scientist with Environment Canada reveals that levels in eggs frozen in 1971 but only just analysed were 800 ppt. Dow Chemicals is the only manufacturer of dioxin compounds in the Great Lake Basin but, until the mid-1970s, Hooker Chemicals manufactured the chemical at a plant near Niagara Falls. Dump sites near Niagara have revealed the presence of TCDD and 2,4,5-T. Douglas Hallet of the Canadian Wildlife Service concludes that waste dumping or 'catastrophic accidents' during 2,4,5-T manufacture by Hooker Chemicals is the most likely source of dioxins in Lake Ontario. He also notes that TCDD levels in gulls eggs have dropped dramatically since the Hooker plant shut down.

DDT in Malaya, *New Internationalist,* January 1981.
High levels of DDT and other organochlorine pesticides — many of which are banned in the West — have been found in the blood serum of Malayan rice paddy farmers and rubber workers. The mean concentration of organochlorine pesticides in the blood serum of North Americans is estimated to be 26.9 ppm. The comparitive figure for Malay paddy farmers is 110.38 ppm; for rubber estate workers, 90.04 ppm; and for the general population, 66.15 ppm. Research undertaken by Wong Kien Keong of Malaysia's University of Agriculture, also reveals that the increasing inneffectiveness of pesticides in controlling brown hopper epidemics in rice areas is

leading to more and more pesticides being used; that fish-kills are prevalent in sprayed areas; and that pesticide resistant strains of insects are on the increase.

More Evidence of the Dangers of Lead Pollution, *New Scientist,* January 5th 1981.
At the recent meeting of the American Association for the Advancement of Science, Herbert Needleman of the Harvard Medical School revealed the latest results of his study of the effects of lead on intelligence. Previous research had shown that the higher the level of lead in children's shed milk teeth — a good measure of their cumulative dose of lead — the lower their IQ, the less they are able to concentrate at school, and the lower their scores on tests of their verbal abilities. Now Needleman and his colleagues have discovered that electrencephalograms (brain waves) of children with high levels of lead in their teeth differ from those of children with less lead in their bodies. Ellen Silbergeld, of the US National Institutes of Health, added another piece of evidence to the jigsaw. Over the past four years, she has been studying the effect of lead on the chemicals that transmit and receive nerve impulses in the brain. Clearly it is impossible to do this directly, so her research team measured the breakdown products of these chemicals in the urine of children exposed to lead. She found that children exposed to lead excrete abnormal amounts of the chemicals — "the first dose-related, chemical indicators of lead's neurotoxicity in humans."

Land-Use, Agriculture, Forestry

Is US Paving Over Too Much Farmland? Kenneth R. Sheets, *US News and World Report,* February 2nd 1981.
Prime agricultural land in the US is being lost to urban and industrial sprawl at an alarming rate. Studies indicate that approximately 12 square miles of US farmland are being lost to concrete each day. Three million acres are estimated to go out of production each year, one million acres of which is considered prime agricultural land. Another four million acres is lost each year through erosion. All told, the area of prime agricultural land lost 'to other uses' from 1967-77 amounted to an area the size of the State of New Jersey. New England has seen the disappearance of half its available farmland. The mid-Atlantic states have lost 22 per cent of their farmland; and the major agricultural states of the mid-West have suffered the loss of 9 per cent of their cropland. Florida is predicted to lose all its prime land by the year 2000 and California could have lost 15 per cent of hers by that time. Such losses should be seen against official estimates that the US will need to plant between 84 and 143 additional acres by 2000 AD if it is to meet anticipated domestic and foreign demand for US agricultural products. Despite expenditure of 15 billion dollars on soil conservation since the mid-1930s, topsoil losses are 25 per cent worse today than in the dustbowl years of the 1930s.

Small Woods cut down at 'quite alarming rate'. *The Times,* January 30th 1981.
Small woods are being cut down 'at a quite alarming rate', warns Derek Barner of the Countryside Commission. "Modern farmers have undoubtedly destroyed a great deal of the pattern of the past," he told the annual meeting of the Timber Growers Association. "There are many farmers, particularly the bigger ones, who could make a much better contribution than they do. Unless farmers and landowners do something, then in 15 or 20 years time someone is going to make (them) do it." He gave a warning that farmers and foresters would probably face stricter planning controls in the uplands but not in the lowlands. "I think that would be absolutely barmy."

Wood: An Ancient Fuel with a New Future, Nigel Smith, *Worldwatch Paper No. 42,* January 1981.
Wood has a bright future as a fuel, according to Worldwatch. By the end of the century wood fuel use around the world is likely to increase by at least fifty per cent. Wood's potential contribution to the US energy budget is even more promising, says the report. Wood has already surpassed nuclear power as a source of energy in the US and could provide up to one-fifth of the country's energy by the year 2000. The economic case for switching to wood gains strength with every increase in the price of oil and natural gas, argues the report. In the United States, homeowners using heating oil, which is expected to exceed $1.25 a gallon by Spring 1981, would be advised to switch to a wood stove if they live in an area where a cord of wood costs less than $150. Large wood-fired boilers are also economical. A utility in Burlington, Vermont, expects to generate electricity from wood at a cost of 20 per cent below that of a comparable coal-fired plant. Not that wood burning is without its ecological problems. Wood exploitation is exceeding the regenerating capacity of forests in many Third World nations, and woodlands are shrinking steadily. Indiscriminate harvesting of fuelwood is having a devastating effect on thousands of plant and animal species in tropical forests. And atmospheric pollution from wood burning is also a potential problem. However, the study suggests that none of these environmental problems are insurmountable; technology can reduce harmful fumes from wood smoke; and the establishment of tree plantations could help reverse the process of deforestation. "A five-fold increase in tree planting is needed around the world just to ease firewood shortages, which are particularly severe in some parts of the Third World. If the world can gear up to this level of planting, wood fuel use could grow even faster than projected."

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Before the area was developed, the Gezira had ample tree cover. Now it is scrub.

Small earth banks 0.5 metres high were constructed to hold water. These divided up the land into a complicated irregular patch-work; villages were dotted here and there usually on the higher land, where drinking water was obtained from deep wells. The banks were termed 'teras' and represent a similar practice to basin irrigation in Egypt.[77] In the dryer northern regions seminomadic farming with some rain cultivation was the practice. The animals, mainly sheep and camels, provided the security in years of low rainfall when harvests were hit.

During the middle period of the Fung rule the Gezira was visited by the first European travellers, Poncet and Brevedent.[78] Passing through the Gezira they describe, "pleasant forests of flowering acacias full of little green parrots", with "fruitful and well-cultivated plains"; they called it "Gods country (Belad-Allah) by reasons of the great plenty". On reaching Sennar in 1699 they were met by a governor who examined all the caravans entering the city to check for small-pox. Poncet records that the king then received them with, "great vessels filled with butter, honey, and other refreshments, and two oxen and two sheep".

The next traveller to visit the Gezira was Bruce in 1770. He recorded at Halfaya that the manufacturing of cotton homespun 'damours' was the chief source of livelihood and that cloth was extensively used as currency.[79] At this time the Gezira was intersected by several caravan trade routes. It was also the route for West Africans on the 'Hajj' or pilgrimage to Mecca, also participated in by the Gezira population.[80] This ensured the local informal economy did not stagnate, and increased the spread and flowering of technological innovations found compatible with Islamic culture and tradition. Bruce also met the King and noted that he was, "seated on a mattress, clothed only in a blue cotton shirt of *Indian* make with white silk trimmings."

Bruce in his extensive travels throughout the Gezira described the use of 'matamores' in the following way:

> There were large pits plastered with clay into which a quantity of grain was put when it was cheapest. They are then covered up, and plastered again at the top which they call sealing . . . these matamores are in great numbers all over the plain, and on any prospect of corn growing dearer they are opened, and corn sold at low price both in town and country.[81]

In 1814 the Gezira was exporting cloth to Dongola, Kordofan, Darfur, Ethiopia and all of eastern Nubia to the Red sea.[82] Every woman or girl spun for her own use or sale, and in every village there were a number of weavers who worked the spun yarn into a variety of materials. Sennar was well known for its homespun 'damours' worn all over the Sudan. The Gezira was also renowned for its common cotton materials. These were brought to the market in large quantities and purchased mainly by the poorer people.[83] At this time most of the cotton was obtained from the indigenous perennial 'old Sennar cotton tree' *Gossypium arboreum Var soudanese*, which grew to six metres in height but is now rarely found.[84]

By 1820 the Fung rule had declined and Sudan was conquered and became part of the Ottaman Empire. During this rule at least two industries other than textiles were found in the Gezira, the extraction of dye from the indigo plant, and soap making.[84]

Before the British came the local Gezira people had their own institutions, and ideas of government. The evidence indicates that the population had stabilized at or below the carrying capacity of the environ-

ment. This is in contrast to the often made British claim that the Gezira scheme was established in a flat, unvegetated, unpopulated, desert region. As they also settled the seminomadic population, the grazing of goats in the limited rangeland prevented vegetation regeneration. Experiments were tried of treating the foliage with repellants, but the goats were undeterred by this.[85] In later years the destructive agency of goats was demonstrated by fencing off half an hectare of unvegetated land near Sennar; it quickly became covered with grass and shrubs and developed into a 'copse in the wilderness'.[86]

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Washing in the canals brings contact with waterborn parasites.

Tenets of Stability

Goldsmith has argued that the criteria for a stable society is that it must be based on the family as the social unit, with religion as the ultimate cultural determinate.[87] The Muslim system theoretically fits these criteria. In the Gezira the extended family was always the basic social unit. Sardar has described the general cultural determinant for Islam as follows:

> Traditionally, the goal of the Muslim system is to seek the pleasure of Allah, that is, to create and maintain an environment in which Islam can be operationalised in all its manifestations for the pleasure of Allah. . . . Thus in contemporary terms the goal is the maintenance and stability of the system itself.[88]

In the Gezira villages the Mosque is the largest and best building and serves as the central focus for the community.[89] The British gave full respect to Muslim tradition in the north, and even forbade Christian missionaries. However missionaries were encouraged to pursue their work in the 'pagan' south. This has contributed in recent years to the problem of achieving the unification of what is an artificially created 'Sudan'.[90] Under the impact of modernism, Sudan, like other Islamic countries is undergoing cultural strain.[91 92]

The main impact of the Gezira scheme has been in disrupting the family social unit, and the traditional occupations of the people. Spinning and weaving of cotton, wool, and flax were formerly an important part of the cottage industry of the Gezira people. The spinning of the long fibres of flax and wool is thought to be more ancient than cotton spinning. This is because the shorter staple length of cotton requires a high degree of technical skill. The craft of spinning dates back to the pre-Christian era, and fine linen found in Sudan has been dated at around 2,000 B.C.[93 94]

Traditional Agriculture

Cotton which demands more water than *dura* was grown mainly in the south or under irrigation. After the Anglo-Egyptian Condominium commenced in 1899 traditional agricultural practices were allowed to continue much as before. However by 1912 the local cotton industry was already in decline because grain production was more profitable.[95] This was because the caravan trade routes had declined during the previous years of war, and were being superseded by the new railways. The increasing urban population looked to the Gezira for the supply of staple food. The new experimental cotton farms, such as that started at Zeidab (1906) by Leigh Hunt took over the markets for the supply of raw cotton. Cheap European and Indian cotton goods were also being imported into the Sudan, and these, began to take over the textile market.[96]

By 1924, the whole local industry, now mainly cotton, was seriously threatened. In the words of Crowfoot:

> Last year, 1924, it became very difficult for the women to obtain enough cotton for their spinning at any price. Their main difficulty lies in the fact that they must have cotton on the seed. It is quite impossible to spin fine thread on a handspindle from machine ginned cotton.[97]

By 1924 the pump stations which now included experimental stations in the Gezira dominated the cotton market; the cotton being sent straight to the gins, the inhabitants of the Gezira were discouraged from growing any cotton. The storing of cotton was prohibited as the government feared this might act as a source of infection to the experimental stations. The seed was known to harbour both the bacterium *Xanthomonas malvacearum*, and eggs of the bollworm *Heliothis armigera*.[98]

The government then classified the Gezira as an area where only government purchased cotton seed could be sown.[99] Effectively, these measures of the formal economy decimated the local industry. In the past both men and women would participate in spinning and weaving[100] and a central occupation of the family was lost. A recent sociological study of a Gezira village mentioned one old lady still spinning, but that craft production as such hardly existed.[101]

The Tenancy System

With the Sennar dam and canals under construction the government and the Sudan Plantation Syndicate arranged to rent the land from the registered owners for a small fee. Local people were then allowed to

take up tenancies of 12 or 16 hectares. Evidently, this was not popular with the local population who complained;

> The Sheiks will be nobodies, the Syndicate inspectors will be kings of the country. We hate these straight lines, we would rather be hungry once every few years, with freedom to range with our cattle unconfined, than have full bellies and be fined if we stray outside these horrid little squares.

Clarke, an adminstrator for the allocation of tenancies, stressed the arguments on the 'other side':

> These arguments consisted in appeals to the grosser more materialistic side; the probability of wealth beyond their dreams; water laid on without the trouble of drawing it; security against famine were — one was compelled to argue, of far more value to them than their freedom and administration powers and responsibility.[102]

Briefly, apart from a few years in the 1950's (when fertilizers and pesticides were *first* used) the proceeds from the cotton crop has remained under one hundred pounds sterling per tenant, per year.[103] [104] The tenants have always been allowed to grow *dura* and *lubia* for their own needs. In recent years they have also received an undisclosed income from wheat and groundnut sales. The official procedure laid down for watering the tenancy was more demanding and tedious than anything they had encountered previously.[105] In fact the tenants have now abandoned it and unofficially adopted their own system — flooding the entire tenancy in one go, which consumes much more water.[106] So even the promised materialistic benefits have not actually materialised.

Considering the cultural background of the Gezira people it is not surprising that they found adjustment to the new system imposed upon them difficult. Beer, the first Social Development Officer, described the position as follows:

> In a highly-geared agricultural scheme, dependant on a strictly regulated system of irrigation, it is inevitable that there should be a high degree of regimentation and control. For the tenant it meant a strict adherence to a defined and closely supervised system of cultivation in which there was virtually no place for the exercise of initiative. Every tenant had to conform to an agricultural time-table which moved relentlessly forward under the vigorous control of supervisory agricultural staff . . . He found this irksome because his natural qualities did not fit him for this way of life, and strong persuasive methods had to be used to turn him into a competent cultivator.[107]

The British Colonialists always had a vague notion of the inhabitants working their alloted tenancies as a family unit. In practise this could never materialise for three main reasons:

(1) Field work of the type required by the scheme was never popular with the tenants. It must be remembered that summer temperatures exceed 100F (38C) every day, with winter temperatures ranging from 75F (24C) to 95F (35C). A member of the Sudan Plantation Syndicate, accustomed to driving his Morris around the tenancies, described the position thus:

> To an Englishman it does not seem that the tenant has much to complain about on the side of hard work, but to a habitual sunbasker it seems to be rather trying. They are a most exasperating race of people from whom to extract work.[108]

(2) The families are Muslim and the preference is for the women not to work directly in the tenancy, thus reducing the available labour of the family unit. In the past women contributed their share to the family labour force, they worked in the fields alongside their male relatives. As the *dura* ripened the children would also participate by scaring the birds away from the family harvest.[109] Under the scheme if the women worked in one of the scattered tenancy plots they came into contact with both outside hired labour, and administrative officials. It was considered improper for women to work in the field.[110]

(3) Labour demand reaches a peak which far exceeds the available resources of the family unit, during the cotton picking season. Long-staple cotton, the mainstay of the Gezira scheme can not be mechanically harvested without damage. The number of seasonal labourers has risen from 58,000 in 1929, to over 400,000 in the mid-seventies, reflecting the expansion of the scheme.[111] [112] Many tenants spend their share of the cotton proceeds to employ labourers the year through in order to lighten the work load, and avoid further infection with bilharzia. The International Labour Office estimated that seasonal workers earn roughly two-thirds of the minimum urban wage, and their wages for cotton picking have increased by only about 3 per cent over the last twenty years.[113]

Conclusion

The Gezira scheme has been in operation for over 50 years. In this time the promised material prosperity for the tenants has not taken place. The technological system used for the production of cotton has resulted in considerable cultural strain. The family as the social unit has been disrupted, many of the children have emigrated to Khartoum and Ommdurman in search of office and factory jobs.[114] These jobs are not readily available, Sudan has experienced great difficulty in industrializing.[115] In fact Sudan is still an importer of cotton textiles, its most obvious industry to develop[116].[117] Women now live a much more restricted life within the confines of the village, and part of their former occupation of spinning and weaving has diminished if not finished. Men who still work in the tenancies show little enthusiasm for their daily work, and if financially possible cheap labour is hired as a preference. Little information is available on the seasonal workers, but they are almost certainly worse off than the tenants.

There is a case to be made for the technology determining a certain lifestyle which is fundamentally incompatible with the culture of the people it has been imposed on. It may be argued that the breakdown of the self-regulating mechanism of a traditional society, which constitutes that society itself, is a requisite and a small price to pay for 'development'. In the case of the Gezira, which in the late 1950's was receiving 77 per cent of all government spending,[118] development by any definition has yet to be realised for the Gezira people. In fact their quality of life has declined; their true position is that of an appendage to industrial society. The Colonialists have left, but their technology and its mode of operation remains, and blunders on in a cultural environment where it is ill-suited.

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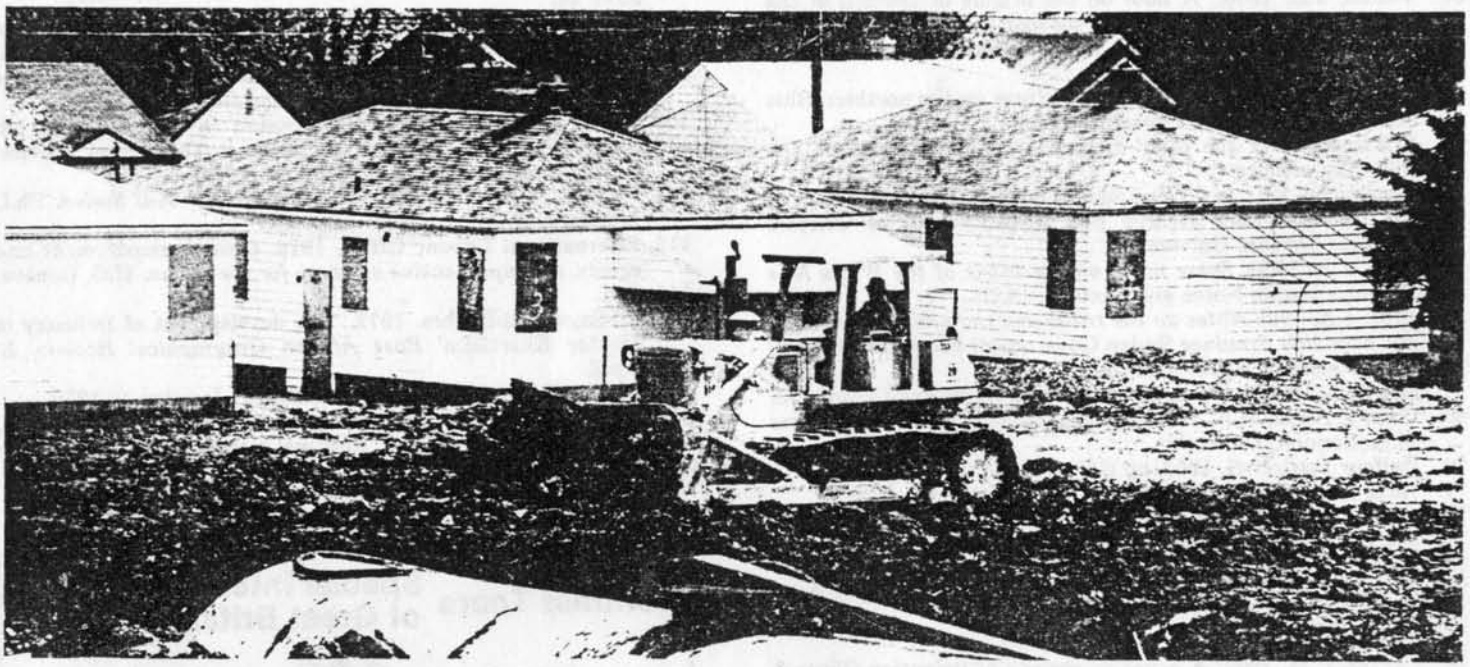

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After residents' complaints, researchers began studies of those residents' high incidence of cancer, birth defects, and respiratory and neurological problems. The Federal Government has paid to evacuate about half of the 710 families declared eligible to be moved. The estimated dollar cost to clean up Love Canal? $124,000,000.

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The Scientific Straightjacket

The Power Structure of Science and the Suppression of Environmental Scholarship

by
Brian Martin

Dissident scientists in communist countries receive wide publicity for their causes. But what of cases of suppression in the West? How do those who challenge the scientific establishment fare? And why have environmentalists become the chief target of those who seek to preserve the status quo?

Inscribed across the facade of the Sydney University School of Physics are the names of twenty or so famous scientists: Archimedes, Roger Bacon, Copernicus, Kepler, Galileo, Newton and others. As a result of their scientific achievements, such illustrious forebears commanded respect; through their authority and prestige in scientific matters, they influenced the direction of scientific research. Or so the standard image of scientific 'greats', as portrayed in textbooks and the media, would suggest.

But what is the relation of the image of the eminent scientists of past eras to the present generation of scientific elites who hold positions of power in large research organisations around the world? Setting aside the question of the actual status of past elites, there is no doubt that a vast change in the organisation of scientific research has come about in the past few decades. This transformation may be called bureaucratisation, industrialisation, or the shift from 'little' science to 'big' science. Even if it were ever the case in the past, it is doubtful that the leaders of the scientific community today exert power primarily through their authority on scientific matters alone.

Suppression of Scientists

Table 1 lists a number of instances of suppression from Australia and New Zealand involving individuals who have been engaged in research or teaching relating to environmental issues. There is little documentation of the scale of suppression in the scientific and academic communities, and most of the cases came to my attention through personal contacts. For example, within the Australian National University, where four of the ten cases originated, there is no straightforward or easy way to determine the existence of academic suppression. However, there are several reasons to believe that cases such as those in Table 1 are only the tip of an iceberg.

In a survey of evidence about suppression of dissident scientists, Manwell and Baker conclude that such suppression is much more widespread in the west than generally acknowledged.[15] But, they note, cases in the west receive very little publicity compared to the great attention focussed on dissidents in communist countries. For example, it was only as a result of his personal case and the publicity it received that Manwell was informed of over one hundred cases of suppression in the English-speaking world.[16]

It is well known that there were wide-scale sackings and harassment of scientists and academics in the 1940s and 1950s, especially in the US.[17] The large scale of this activity is often forgotten, as are the long term effects of this attack on nonconformist scholarship. Just as important is the low level of awareness of the political suppression which has continued since then.[18]

As well as political beliefs, suppression is often closely connected with struggles with organisational vested interests, and with disputes over the validity of different types of knowledge and ways of acquiring it — that is, paradigm disputes.[19] A mixture of political, organisational and paradigm aspects in suppression cases is quite common.[20]

Most scientists prefer to avoid public controversy concerning their own research and teaching. This means that it is difficult to find individuals willing to have their cases presented as in Table 1. I know of several other suppression cases in which those involved do not wish publicity for personal or career reasons. There are also many cases in which suppression is a likely possibility but in which there is insufficient evidence to make a firm public case.

For these reasons it seems reasonable to infer that publicised cases are a small fraction of total cases.[21] Furthermore, since some types of suppression receive more publicity than others, it is highly likely that outright attempts to sack dissidents (as in the cases of Coulter, Evans and Manwell) are greatly outnumbered by non-tenured positions not being renewed; by failures to hire and promote; and by particular types of environmental research and teaching simply not being initiated in the first place.

At a more fundamental level, suppression merges with inhibition. As clearly expressed by C. Wright Mills years ago in relation to university teachers, "the deepest problem of freedom for teachers is not the occasional ousting of a professor, but a vague general fear — sometimes politely known as 'discretion', 'good taste', or 'balanced judgment'. It is a fear which leads to self-intimidation and finally becomes so habitual that the scholar is unaware of it. The real restraints are not

Table 1: Cases

Table 1. Instances of suppression from Australia and New Zealand involving individuals engaged in environmental research or teaching.

CASE 1: *Name* Dr John Coulter
Position Surgical Research Officer, Institute of Medical and Veterinary Science, Adelaide (1959-).
Background (a) Outspoken on numerous and diverse environmental issues, such as the impacts of environmental chemicals (1956-).
(b) As a researcher in IMVS, started on his own initiative (1977-) a routine service for testing substances for mutagenic properties.
(c) Prepared a report on the hazards of ethylene oxide (ETO) as a sterilant, and gave this to ETO workers as well as to the appropriate IMVS Committee (16 April 1980).
(d) Posted on IMVS noticeboards copies of the ETO report and related correspondence with the Director of IMVS (8 May 1980).
Action (a) Letters of complaint to IMVS from chemical companies. .
(b) Environmental mutagens testing unit closed by IMVS on 30 June 1980.
(c) Letter of rebuke from Director of IMVS for releasing ETO report to workers (23 April 1980).
(d) Instruction from Director of IMVS to not make available material dealing with the affairs of IMVS to any staff member without express approval from the Director (9 May 1980).
(e) Coulter dismissed from IMVS (30 June 1980).
Status Unresolved (September 1980).
Reference (1)

CASE 2: *Name* Dr Jeremy Evans
Position Senior Lecturer, Human Sciences Program, Australian National University (1973-).
Background Taught in environmentally oriented Human Sciences Program (1973-).
Action Reappointment and review committees recommended that tenure be denied (1979).
Status Tenure decision postponed until 1982.
References (2), (3)

CASE 3: *Name* Dr John Hookey
Position Senior Lecturer, Faculty of Law, Australian National University (1971-1974).
Background Introduced (1972) and taught first Australian undergraduate course in Environmental and Natural Resources Law, at Australian National University.
Action Indication that tenure would be denied (1973).
Status Resigned (1974) pending completion of internal appeal to take up appointment as Public Hearings Commissioner in Federal Department of Environment and Conservation; subsequently Commissioner, Redcliff Environmental Inquiry, and Presiding Commissioner, Fraser Island Environmental Inquiry.
Reference (4)

CASE 4: *Name* Dr Philip Keane
Position Lecturer in Botany, La Trobe University (1975-).
Background Published an article (5) in a national weekly newspaper (January 1977) about the spread of cinnamon fungus in Victorian forests.
Action Chairman of the Forests Commission of Victoria applied great pressure on the University's Chancellor, Acting Vice-Chancellor and the Deans of Science to take action — nine letters written and hand-delivered between 3rd and 24th February 1977 (6).
Status Unchanged by events. The University Council was informed of the attacks and the appropriate officers (Chairman of Department, Dean of School of Biological Sciences) resisted all pressures and strongly rejected the allegations made. The Chairman of the Forests Commission was further informed that all Australian University Statutes are framed to allow staff to speak publicly on controversial issues thereby preserving academic freedom.
Reference (7)

CASE 5: *Name* Dr Robert Mann
Position Senior Lecturer, Department of Biochemistry, on secondment to Centre for Continuing Education (1976-), University of Auckland.
Background A founding teacher (1974-) of the Environmental Studies programme; publicly active on issues of nuclear power, nuclear weapons, 2,4,5-T, etc.
Action Dismissal proceedings initiated (1977) by University of Auckland after letter to Vice-Chancellor

so much external prohibitions as control of the insurgent by the agreements of academic gentlemen''.[22]

The incidence of suppression in the environmental area is almost certainly greater in government and industry than in academia, especially when cases of inhibition are included. Academics generally have much greater freedom — in that their jobs are less immediately threatened — to carry out research on and speak out on controversial topics. Because of this, academics are also more likely to speak up when attempts at suppression are made, though this is seldom enough. Dissidents in government or industry generally keep quiet, learn a new set of standards, or quietly exit. Especially in industry where few voice criticisms and stay around to tell about it.

Incompetence Rarely a Factor

Is there an underlying reason for suppression in the environmental and other areas? One answer is that the grounds given for dismissal, non-renewal and the like are themselves valid. A detailed assessment of this would require full documentation of each case, hardly possible here. Suffice it to say that purely academic or scientific judgements are almost always insufficient as an explanation. In almost every case in Table 1, the research output or teaching performance of the individual under threat was well above average, and in several cases the research or teaching records were outstanding.

For example, the outstanding teaching performance of Evans has been widely acknowledged[3]; Manwell's publication record placed him in the top one per cent of comparable scientists[10]; Smith, in the few years since submitting his Ph.D. thesis, has an enviable publication record. A similar pattern has been noted in cases of political suppression, in which shortcomings of ability, competence or performance have been sufficient to justify suppression in only a tiny proportion of cases[23] Indeed a study of all contested dismissals in the period 1916-1970 reported in the *American Association of University Professors* found that ''in only 13 of the 217 dismissal cases was there even a suggestion of incompetence in either their teaching or research''.[24,25]

The cases as listed in Table 1 are only outlines. In almost every case, further details and information show even more clearly that the suppression is illegitimate by normal scientific and academic criteria, and that efforts at suppression are more systematic and sustained than first meets the eye. For example, at the time of the Routley case, several scientists in different organisations were threatened with dismissal or other reprisals for merely giving the Routleys publicly available information and references to public documents.

of Suppression

from Head of Department of Biochemistry (no grounds given).
Status Dismissal efforts renewed 1979; University Council proposed further probation and implied cancellation of accumulated leave entitlement.
Reference (8)

CASE 6: *Name* Professor Clyde Manwell
Position Professor of Zoology, University of Adelaide (1970-).
Background Sent letter (co-author, C.M.A. Baker) to newspaper criticising aspects of the South Australian government fruit-fly spraying programme (1971).
Action (a) Dismissal proceedings initiated by senior Professor of Zoology (1971).
(b) Australian Research Grants Committee grant cut off (1972).
Status (a) Proceedings dropped (1975).
(b) Grants not resumed (1980).
References (a) (9); (b) (10)

CASE 7: *Name* Mr Peter Rawlinson
Position Senior Lecturer, Zoology Department, La Trobe University (1967-).
Background Involved in a series of radio and television interviews critical of the activity of the Forests Commission of Victoria, especially with regard to the spread of cinnamon fungus (January and February 1977), at the time being an elected member of the Conservation Council of Victoria Executive and their spokesperson on forestry issues.
Action Chairman of the Forests Commission of Victoria applied great pressure to the University's Chancellor, Acting Vice-Chancellor and the Deans of Science to take action: nine letters written and hand-delivered between 3rd and 24th February 1977.
Status Unchanged by events. The University Council was informed of the attacks and the appropriate officers resisted all pressures and strongly rejected the allegations made. The Chairman of the Forests Commission was further informed that all Australian University Statutes are framed to allow staff to speak publicly on controversial issues thereby preserving academic freedom.
Reference (7)

CASE 8: *Name* Mr Richard Routley
Position Senior Fellow, Philosophy Department, Research School of Social Sciences, Australian National University (1971-).
Background Wrote a book (co-author, Val Routley), *Fight for the Forests* (11), which was critical of Australian forestry planning and practice. Publication by Research School of Social Sciences arranged (1972).
Action (a) ANU Vice-Chancellor suggested that printing should not proceed unless book was given to the Head of the Forestry Department at ANU, to be revised in accordance with his comments (1973).
(b) R. Routley barred from using Forestry Department library (1974).
Status (a) Three editions (1973, 1974, 1975) of book published and sold out; strong interest in book continues (1980), but funding for further editions or reprints unavailable.
(b) Bar dropped (1974).
Reference (12)

CASE 9: *Name* Mr David Smith
Position Ph.D candidate, Forestry Department, Australian National University (1974-).
Background Ph.D thesis showed inadequacies in current procedures for evaluating effectiveness of pesticides (1977).
Action Two of three examiners rejected Ph.D thesis (1978).
Status Unresolved (1980); working elsewhere (1978-).
Reference (13)

CASE 10: *Name* Dr Peter Springell
Position Principal Research Scientist, Commonwealth Scientific and Industrial Research Organisation (1953-1976).
Background Scientific research undertaken and published on environmental topics; criticism of CSIRO for lack of environmental research (1974-1976).
Action Refusal to allow papers to be published through CSIRO; attempts at dismissal and transfer (1974-1976).
Status Resigned from post (1976); working elsewhere.
Reference (14)

Environmentalists Singled Out?

In cases in which no clear reasons for the suppression action were given, there was a lack of scientific or academic justification for the action. But there are suggestive alternative explanations. It is reasonable in Mann's case to imagine that his public activities as an environmentalist played some role in the initiation of dismissal efforts. And those familiar with Hookey's career would be disinclined to accept that the action taken against him was a result of poor teaching or research, given his initiative in introducing the first Australian undergraduate course in environmental and natural resources law, his publication of papers on Aboriginal land rights and his participation in Papua New Guinea land rights cases [26,27].

It might be claimed that suppression in the area of environmental research and teaching is not unusual, since suppression is common in all areas of research and teaching. No doubt this is true in a general sense. But as noted before, available evidence suggests that suppression is closely connected with political beliefs, organisational vested interests, paradigm disputes and combinations of these. Each of these factors helps make the environmental area a prime one for suppression. Environmental scholarship is often seen as linked to the 'politics' of the environmental movement; environmental scholarship often presents a challenge to established practices and policies of powerful organisations; and environmental scholarship often challenges the dogmas of various scientific disciplines.

The data presented here suggest an explanation for suppression of scientists based on an understanding of the power structure of science. Suppression *does* occur in a wide range of areas of scientific research and application, from anthropology to engineering to zoology. Tellingly, it occurs most frequently in areas such as environmental studies where opportunities arise for teaching and research which provides a threat to vested interests either inside or outside the scientific community.

The Scientific Elite

There is a considerable literature documenting the existence of an elite group within the scientific community which is characterised by high productivity in scientific research, a high degree of professional recognition of its intellectual achievements, a high degree of internal interaction and clustering at a few select institutions, and a high degree of influence over the professional activities of non-elite scientists [28,29]. This group may be called the *cognitive* scientific elite, because as usually studied it is concerned mainly with academic

scientists and with activities relating to the production of scientific knowledge.

It is also possible to focus on a group which may be called the *political* scientific elite, that group of scientists with the greatest political power (both within and without the scientific community) to influence government and corporate policies and to influence developments in the scientific community. The power of this elite is manifest in the promotion of research in certain areas and its restraint in others; in the creation or closing of research institutions; in the hiring or dismissing of staff; in the allocation of funds from specific research projects and in the setting of policies for scientific journals and texts[28 30]. It is clear that there is a considerable degree of overlap between the membership of the cognitive and political scientific elites, as well as a degree of overlap between the activities and characteristics of the two[31]. The cognitive and the political scientific elites are linked in another important way. Leaders of the scientific research community often attempt to use their political power to control what counts as scientific knowledge and how it may validly be obtained and verified, and vice versa .[32 33]

Most studies which treat aspects of the political scientific elite either do not address the question of the advantages and disadvantages of the existence of an elite, or tend to emphasise the functional uses of the elite, as presently constituted, to the scientific community and society as a whole[34]. Few studies challenge the view, common among scientists who support the present organisation of the scientific community, that leading scientists are in positions of power due to their superior scientific abilities and achievements, and therefore are the best people to make decisions about the functioning and development of scientific research and the scientific community.

In one of the few studies of the political scientific elite, Mulkay[28] argues that scientific elites mediate between working research scientists and powerful groups, notably in government and industry, which have an interest in influencing the direction and content of scientific research. In Mulkay's view, then, the scientific elites serve to protect the working scientists from these outside, non-scientific influences.

The object here is not to provide a detailed critique of these views, but rather to present an alternative, partly supplementary perspective. But it may be useful to mention some inadequacies of the views referred to above. First, it has not been demonstrated that there is a correlation between rising within the scientific hierarchy and the making of productive and equitable decisions about scientific priorities. Second, the positions of political power accessible via a scientific career often attract individuals interested in personal aggrandisement[35]. Third, the strong vested interests which most scientific elites have in their reputations and in the perpetuation of particular types and styles of scientific research often lead to scientific or public interest[36]. These second and third points are seldom taken into account in studies of the scientific elite. Finally, attention mostly has been focussed on justifying, explaining or at most reforming the structure of the current scientific elite. Little attention has been focussed on the possibilities for alternative structures.

According to Mulkay's view, the main source of direct suppression of scientists would be from government and industry. Although this is indeed a primary source of suppression, I argue below that leading scientists and academics have taken an active role in many suppression efforts. More generally, it may be argued that the politics of the scientific community is characterised by what Haberer calls 'prudential acquiescence'[37]. For example, German scientific leaders under Nazism adopted a course of accommodation rather than opposition to outside political direction.

Rather than speak of the scientific elite structure, it is a useful generalisation to speak of the scientific power structure, recognising that a power structure has many levels rather than a single elite versus all the rest. Springell in Table 1 was fairly senior in the scientific hierarchy and hence suppression came from scientists and administrators who might reasonably be called elites. But in the case of Ph.D. candidate Smith, suppression was initiated by lower level scientists, though higher in the hierarchy than Smith.

Three main aspects of the scientific power structure will be briefly discussed here: its relation to powerful groups outside the scientific community, its relation to the scientific community and its relation to scientific knowledge .[38]

The influence of political and economic interests on the giving of scientific advice, which frequently ends up serving to justify particular policies and practices that promote the interests of powerful groups, is well documented .[36]

The patronage of leading scientists and scientific organisations by powerful non-scientific individuals and organisations is threatened when issues are taken into the domain of public debate, since the legitimacy conferred by the stamp of unanimous scientific approval is undermined. For this reason there is a strong preference among politically powerful scientists for patterns of closed decision-making[37 39]. Secrecy in scientific decision-making is the norm in the processes of allocating research grants, filling posts and making organisational policies — all areas where the influence of, and service to, powerful political and economic interests is crucial. When issues are taken to the public by concerned scientists, this often is seen as inappropriate and even contrary to proper scientific behaviour. Examples can be found in many areas, such as debates relating to nuclear power and nuclear weapons.[40 41]

The Forest Industry

The link between powerful interest groups inside and outside the scientific community helps to explain several of the cases in Table 1. In the forestry area in Australia, there appear to be strong links between university forestry departments, government forest services and research organisations, and the forest industries (timber, pulp, wood chip and other industries based on forest products). These links include informal networks of communication, professional and commercial organisations, clubs, joint conferences, consultation concerning appointments, planning and the like. These social and organisational links lead to the sharing of values and goals, which in turn influence patterns of interaction.

Routley

Logged eucalyptus forest. The Australian forestry industry exercises a powerful grip on forestry research.

One example of the link between forestry researchers and personnel in the forest industries is the international organisation called the Concatenated Order of the Hoo-Hoo[42]. In Australia, the members of this social and 'service' organisation are "limited to male persons of the full age of 21 years, of good moral character and engaged in forestry, sawmilling, the manufacture of timber products, wood pulp and insulation materials derived from forest products, officials of the forestry service, forest commissions and boards, officers of timber organisations and makers of the allied industries."[43]. Despite its name and associated rituals, the Hoo-Hoo plays an important role not only in generally promoting the forest industries but in helping attune forest regulatory agencies and certain forest researchers to the interests of the forest industries.

The movement of key persons between posts in forest industries and government forest services also plays a key role in strengthening the links between the forestry industry and those who conduct forestry research. In particular there are quite a few leading figures in the government forest services who on retirement have taken positions with forest industries [44]This interaction by personnel interchange is common in many fields beside forestry, such as nuclear power, armaments and agriculture.

In many Australian states, the link between government forest services and the forest industries operates through the structure of the state and federal government bureaucracies. The state cabinets appoint senior officials in the bureaucracy, including the departmental head responsible for forestry. Due to the political influence of industry in lobbying, creating jobs locally and supplying election funds, most departmental heads are chosen to be acceptable to industry. The powers of the departmental heads are considerable. For example, in Victoria, public service regulations make it punishable with dismissal for a state government scientist to criticise the departmental head or departmental policies to three or more people or to make critical comment regarding matters outside one's field. Even if such regulations are seldom applied in practice, their presence is a strong deterrent to the voicing of dissent.

The Dangers of Speaking Out

Although in principle one can speak out in one's 'private capacity', in practice it is easy to get into trouble doing this. For example, John French in September 1976 spoke out as a member of the Native Forests Action Council about the spread of cinnamon fungus in Victorian forests, but was reported in a newspaper article as speaking in his capacity as a government scientist in the CSIRO. A correction was later published, but French also received a letter of concern from the Chairman of CSIRO about the newspaper article .[45]

The basic orientation of the government forest services and many forestry academics is to promote the exploitation of forest resources for the purposes of production and profit .[46] This orientation carries over into the research of government and university foresters, where the criteria for valid and useful knowledge, and how it may be obtained, are influenced by the interests of the forest industries. In other words, the paradigm for many forest researchers is, to put it bluntly, based around ensuring that forests exist primarily for the forest industries.

Anyone who challenges this view — who criticises the way foresters manage the forests, or who promotes an alternative use of forests — is apt to be attacked by the powerful forestry interest group. Indeed, I have been informed of a considerable number of cases of suppression in the forestry area. Access to most jobs in forestry work is directly influenced by the powerful forestry interest group; hence most of those suppressed are hesitant to have their cases publicised. Indeed, the only cases which could be presented in Table 1 — Keane's, Rawlinson's and Routley's — involve individuals not working directly in the forestry area.

Patterns of Suppression

Cases of suppression seem to follow a typical pattern. A person makes a public criticism, a critical analysis in a research document, or some other 'threat' to the forestry establishment. Leading foresters, for example in the government forest services, then apply pressure on the individual's boss to have the criticism stopped, for example by making complaints in person or by telephone, or by sending letters of complaint. Steps taken to prevent recurrence of criticism include informal comments about the individual's competence and motivations, hindering of research, blocking of appointment or promotion, and threats of dismissal. Such efforts (even when immediately unsuccessful as in the cases of Keane and Rawlinson) can by setting an example serve to reduce the future likelihood of research in sensitive areas or of public comment by others.

Besides the forest industries, some other prime sources of suppression — either directly, or indirectly via subservient government and academic bodies — are chemical industries, pharmaceutical industries, electrical industries, mining industries and automotive industries.

The Smear Campaign

One method of suppression deserves special mention: the smear campaign or the threat of it. The following excerpt from a letter by a 'distinguished organic chemist' speaks for itself:

> "I appreciate your views that it would be desirable to have independent tests on water and plants in the area to see if residues of 2,4,5-T are present.
>
> "Regretfully, however, I feel that I should not at any price undertake such tests, or indeed direct anyone in the department . . . to conduct such tests.
>
> "My reasons for this stem from my complete lack of faith in certain government people who, in conjunction with their confraternity in the commercial sphere, tried very hard in a thoroughly despicable way last year to bring discredit upon me, following my criticisms of spraying activities in SA with 2,4,5-T and with amitrole.
>
> "If any tests conducted by me or anyone in my department yielded positive results of an embarrassing nature to the same people, I fear that another smear campaign would be implemented and that rumours would be concomitantly circulated to the effect that we had 'cooked' our findings.
>
> ". . . I trust that you will understand my point of view."[47]

The links between powerful interest groups inside and outside the scientific community can also help explain the cases of Coulter, Manwell and Smith in Table 1. On a number of occasions pressure was brought to bear on Coulter because of activities undertaken in his 'private capacity'.

In 1978 the Bayer company brought an action against the Australian Broadcasting Commission, partly over remarks Coulter had made on a television programme regarding one of its products containing the mutagenic pesticide dichlorvos. The action was subsequently dropped about two years later but in the interim pressure was brought to bear on Coulter through the Agricultural Chemical Trade Association and the Director of the Institute of Medical and Veterinary Science, where Coulter worked.

In 1979 Velsicol Australia complained to the Director of the IMVS about a lecture Coulter had given, in a private capacity, to a Melbourne seminar on pesticides. Coulter had mentioned the way the parent company in the US had handled the information on the carcinogenicity of two of their products, chlordane and heptachlor[48]. By dismissing Coulter, the managers of the IMVS, whatever their reasons, certainly served the interests of corporate and government bodies which produce and regulate the use of chemicals such as dichlorvos, chlordane and heptachlor.

Concerning Manwell's case, speaking out against aspects of a government fruit fly spraying programme would hardly seem grounds for great concern. Indeed, a number of individuals had done this in Adelaide prior to the publication of Manwell's letter — but none were scientists. Manwell was a scientist working in a relevant field. His letter threatened the rationale for an existing government programme benefiting various political and administrative figures, a programme which previously had had the scientific stamp of approval. It is noteworthy that Manwell's writing of a letter to the newspaper was fiercely criticised by certain conservative South Australian parliamentarians prior to the attempt of academic suppression [9]. (In the forestry area also, criticisms by scientists, and criticisms presented in rigorous technical fashion, have induced much stronger responses than less technical criticism by non-scientists.)

In the case of Smith, the suppression took place at a much lower level in the scientific hierarchy. Here a vital factor seems to be the prevalence of a perspective underlying much research on pests, which is based on the extension of engineering concepts and linear analysis. In crude terms, this particular pest control paradigm is essentially 'biocidal': the only solution perceived to the problem of pests is applying pesticides. In this view everything else is treated as an externality of secondary importance. The generation and maintenance of this paradigm is strongly influenced by industries profiting from chemical methods of pest control and by government policies legitimising these methods [49]. Scientists steeped in this pest control paradigm may not have any direct contacts with the chemical and other industries which support and benefit from research done within the paradigm. But such scientists might well be unsympathetic to research, such as presented in Smith's thesis, which questions commonly held beliefs about effectiveness of the biocidal approach.

Seen from the point of view of the interests of powerful non-scientific groups, the scientific power structure serves a valuable function of social control. The patronage of politically powerful scientists provides a ready means for outside interests to influence the direction of scientific research, and to obtain scientific legitimisation for preferred policies. If patterns of control over scientists were less hierarchical, such outside influence would be less easily exercised and less effective.

Areas of Suppression

Karl Z. Morgan. Although not opposed to nuclear energy, Morgan has been consistently outspoken in his criticisms of the nuclear industry's safety record. Highly regarded in the scientific community as the 'Father of Health Physics', he was part of the team which developed the atomic bomb. Later he became a director of the prestigious Oak Ridge National Laboratory. His first brush with the authorities came after he wrote a speech critical of the liquid metal fast reactor. Advance copies were siezed and replaced by an edited version. In 1980, he was relieved of his post as professor at the Georgia Institute of Technology. According to the World Information Service on Energy, "Sources close to Morgan claim that his dismissal is most probably linked to his continuing criticisms of the nuclear industry."

John Goffman and Arthur Tamplin. Presented a paper in 1969 challenging current radiation exposure standards. Attempts were made to censor a subsequent report to the American Association for the Advancement of Science. Goffman's research grant was terminated. Tamplin stayed on at the Lawrence Livermore Laboratory, "essentially a non-person." Later he resigned and moved to the Natural Resources Defence Council.

Thomas Mancuso. Regarded as one of America's most outstanding epidemiologists, Mancuso was awarded a contract by the Atomic Energy Commission in 1964 to study the effects of low-level radiation on the health of workers at the Hanford reprocessing plant in Washington State. In 1974, pressure was put on Mancuso to refute the findings of an independent study which revealed that cancer rates at the plant were five times higher than expected. Mancuso refused and his grant was terminated. His own report estimated that workers at Hanford had 26 per cent higher risk of dying from cancer and that the risks of dying from cancer of the bone marrow was increased by 107 per cent.

Irwin Bross. Funds cut off after publishing the results of a survey showing that children x-rayed in the womb had a three to four times higher chance of developing leukemia than those who had not been x-rayed.

Milton Zaret. First experienced attempts to suppress his research when he reported that microwaves, well within the current exposure limits, could adversely effect the behaviour of rats. Later he established a link between microwave exposure and the development of cataracts. His research grant from the Department of Defence was terminated and he was brusquely told that there is 'no such thing as a microwave cateract'. Zaret now alleges that he is blacklisted from receiving funds from the Department of Defence, the Food and Drug Administration and the Environmental Protection Agency. In an interview with the environmental magazine *Commonweal,* he described most government-sponsored research on the effects of microwaves as 'intelligent looks in the wrong direction'. (See *The Ecologist,* Jan-Feb 1979).

Robert Van Den Bosch. Outspoken critic of the pesticide industry. As a result he suffered frequent attempts to discredit him and to oust him from his post at the University of California — none of which were successful. In his book, *The Pesticide Conspiracy,* he described the pesticide industry as a 'mafia' with "its own lobbyists, front organisations, PR apparaatus, and 'hit men'". He also accused the industry of owning "politicians, bureaucrats, researchers, administrators, and elements of the media" and of being quite capable of breaking those who do not conform to its rules. Tragically he died in 1969.

Specialisation and Suppression

Those who rise within the scientific power structure often do so via a successful research career following orthodox research channels in a fairly narrow specialisation. The bases on which power and prestige rest within the hierarchy depend therefore on the status of specialised research within a recognised discipline. In other words, empire-building in scientific organisations tends to follow disciplinary lines[50]. It is no coincidence that the elite body the Australian Academy of Science is a group of specialists.

Disciplines and specialism themselves should not be seen as 'natural' divisions of knowledge, but as socially constructed divisions which are established, maintained or altered on the basis of social conventions and institutional arrangements[51]. Power struggles within scientific organisations thus have several facets. They involve positions within the hierarchy: struggles for appointment, promotion and research grants. They involve the nature of the hierarchy: struggles over specialism and discipline boundaries, as in the setting up of departments and courses. And they involve the standards and frameworks for knowledge: struggles over paradigms and struggles using paradigms as resources.[52]

The status of specialised research within a recognised discipline depends in part on the discipline in question being off limits or opaque to non-specialists and to the public. Only to the extent that the essence of the work in a discipline and its specialities is either a special preserve or else not readily grasped by outsiders is it possible for members of the discipline to claim exclusive rights to judge the importance of work in the discipline.

I have suggested that specialisation and disciplinary exclusiveness serve the interests of many who work in traditional disciplines, especially those who rise to positions of power within these disciplines. With this perspective, it is understandable that many scientists in traditional disciplines would be antagonistic to potentially substantial programmes relating to science which are either truly interdisciplinary or popular with students or the public. Interdisciplinary research and teaching is, by its nature, subversive to that portion of

the scientific power structure which is founded on narrow disciplinary research and teaching. Likewise, scientific programmes or ideas that involve the public in active understanding or participation are also a threat to the power structure of science, since the exclusive judgement rights over the development of the discipline are potentially challenged.

The Human Sciences Program

In recent years the environmental area has been a source of scientific research and teaching which is potentially threatening to many parts of the traditional power structure of science. By its nature much environmental research is interdisciplinary. The results of this research often offer a challenge to existing policies and practices of government and industry, and the area is one of high public concern. Such research can thus provide a threat to the hierarchical power structure of science.[53] The same strictures apply to the achievement of successful environmental education.

These points help to explain the cases of Evans, Mann and Springell (Table 1). On the basis of information available to me, the case of Evans provides the best illustration. The Human Sciences Program in which he works has been under attack by various people, especially people in positions of power within traditional departments, from the time it was first proposed in 1970, although the Program has been vindicated in several reviews. The Program is the only one of its kind in Australia to espouse clearly the ideal of holistic education in which a number of different possible approaches to knowledge and understanding (of which science is only one) are studied, with special application to environmental issues. Predictably, some scientists have criticised the lack of a disciplinary base for the Program. Their commitment to specialist, discipline-based perspectives helps to explain their negative evaluation of Evans' research, which is actually above the average for his faculty in terms of quantity.

Antagonism to the Program was strong from some sections of the University even in the days when there was plenty of government money for nearly everyone in the universities; therefore departmental competition for resources cannot be the sole explanatory factor. The recent years of increasingly tight university budgets seem to have provided the extra pressure which led to the attempt to deny tenure to Evans, the only potentially tenurable member of the Program.

A study of environmental programmes in U.S. universities concluded that two features were necessary, though not alone sufficient, for their success:

> "1. Substantial or complete control of the faculty reward structure and
> 2. Freedom to be innovative in introducing course material, educational programs, work study programs, and curriculum requirements for degrees."[54]

Such requirements obviously conflict with the maintenance of the current scientific power structure. Therefore, it is not surprising that decision-making groups within the Australian National University have maintained a tight rein over the academic staff of the Human Science Program with regard to each of these two features.

Institutionalised Suppression

Links between powerful groups inside and outside the scientific community, and vested interests in disciplinary exclusiveness within scientific organisations, are two major features of the power structure of science which lead to suppression of dissident viewpoints. These two features should not be seen simply as bases for overt attempts at suppression such as blocking publications or appointments. The basis for suppression is institutionalised in science through the very nature of scientific research and scientific organisations.

Corporate and government bodies have an important direct influence on the nature of scientific research. This influence operates through funding of research, through availability of jobs in particular areas and industries, and through the general benefits to scientific elites for setting up research bodies that are designed not to challenge the status quo. Many funds are available for studying fossil fuels and nuclear fission, few for studying the conserver society. Lots of investment is made in microprocessors and other labour-saving technology, little is put into industrial democracy. There is plenty of research into how to make war, almost none into how to make peace. In short, existing patterns of funding for science, existing orientations of scientific organisations and current scientific paradigms all tend to discourage or suppress views contrary to the interests of powerful groups in society.

I have argued that the scientific community is based on hierarchies of power as well as status, on specialised disciplinary research and teaching and on the separation of scientific work from the public. Most leading scientists have vested interests in these aspects of science, and this can lead to suppression as in the case of Evans. But it is important to note that hierarchy, specialisation and exclusiveness in science are also valuable to powerful groups *outside* the scientific community. Specialised research is selectively useful to powerful groups who have the resources to hire experts to study and apply it; hierarchically organised scientific organisations mesh well with hierarchical organisations in government and industry; and the chopping up of the learning experience into specialist bits tends to produce scientists who do not question the premises underlying their work. Hierarchy, specialisation and the separation of scientific work from public scrutiny thus help retain the patronage of powerful non-scientific groups.

Specialised research and teaching is much less likely to lead to or serve public campaigns which might damage the interests of groups in government and industry. For example, a great deal of Japanese research of the orthodox, large-scale, discipline-based type — mostly funded by government and industry — was unable to determine the cause of Minamata disease. On the other hand, the local groups of concerned scientists, school teachers and citizens who carried out simple but insightful and wide-ranging experiments were able to trace the disease to mercury poisoning caused by industrial effluents.[55] Ui argues on the basis of cases such as this that scholars working in specialisms in traditional organisations *necessarily* stand on the side of the institutions which produce environmental problems.[56]

In the case of the Centre for Resource and Environ-

mental Studies (CRES) at the Australian National University, the traditional disciplinary approaches used and the traditional hierarchical structure of the organisation make it a very inadequate base for getting to the roots of environmental problems, as I have argued previously[57]. CRES, which was set up by elites in the academic and wider community, was from the beginning strongly oriented towards government and industry rather than to community groups or the general public. That it was also set up by these elites to carry out discipline-based research in a traditional hierarchical structure seems no coincidence.

The Human Sciences Program in which Evans teaches is an example of the holistic approach to knowledge, which involves integrating knowledge, perspectives and methods from different disciplines and world views into a unified framework. By contrast, much multidisciplinary research and teaching such as in CRES involves merely the collection together of narrow specialists from different fields. Multidisciplinary interaction of this latter type poses relatively little threat to traditional patterns of power and professional control.[57,58] This is especially the case when, as in many problem-oriented projects, the work is carried out under the aegis of one particular discipline or approach.[59]

In the above examples a strong connection can be seen between the scientific power structure's links with powerful groups outside the scientific community and the pressures within the scientific community for specialisation and discipline-based research and teaching. Indeed, it may be argued that many characteristics of the scientific community have evolved out of the community's history of interaction with government, industry and other groups. For example, the tendency of academics to avoid the limelight[60], which is part of the scientific ethos, can be interpreted as an adaptive response to avoid alienating potential sources of patronage. More generally, the process of professionalisation of science can be seen as a process of transforming the special knowledge and skills of scientists into social and economic rewards[61]. The scientific power structure would seem to be an important component in this process.

Challenges to the Scientific Power Structure

I have described how the power structure of science is sustained by links with powerful non-scientific groups, by the self-interest of those high in the scientific hierarchy and by the vested interests of the scientific community in specialised, discipline-based research and teaching. However, by no means all scientists acquiesce in these arrangements. Especially in the past decade or so, there have been increasing challenges to the scientific power structure.

One potent challenge to the links between powerful scientists and powerful non-scientific groups is simply public exposure of these links. Such exposure has occurred especially in controversies over issues such as the supersonic transport aircraft, nuclear power, food additives and pesticides[36]. When the public is made aware of conflicts of interests in the roles of scientists[62,63] and becomes aware of the existence of value assumptions underlying statements and advice by scientists, the ability of scientific experts to legitimise policies and practices of government and industry is greatly reduced.

Another development in this area is the creation of scientific research groups which are committed to 'public interest science' and hence less susceptible to pressures or cooption by powerful special interest groups. Examples are the Union of Concerned Scientists in the U.S., the Science Shop at the University of Amsterdam[64] and the citizen-based environmental research groups in Japan[55]. Such initiatives also tend to emphasise interdisciplinary approaches and to modify or replace the traditional hierarchies in science. One model for such efforts is the high level of community involvement in scientific research, reduction in scientific training and orientation of research to practical problems in China in the early 1970s, as described by *Science for the People*[65].

Also important in challenging the power structure of science is challenging traditional paradigms, especially when established ideas and ways of doing research and teaching are clearly linked to vested interests. Challenging paradigms is especially significant when the dispute is taken outside disciplinary boundaries and involves non-scientists.

Another set of challenges to the scientific power structure arises from attempts to change scientific organisations from within, for example, by introducing innovative interdisciplinary research and teaching programmes in areas such as alternative technology, women's studies or participatory democracy. This approach may be one of the most difficult to bring off.

The existing emphases in universities — not to mention government and industry — are predominantly in traditional subject areas, using traditional methods in traditional organisational structures. As a consequence, there is an in-built resistance to changes in such institutions from the usually narrow purposes for which they were designed.

In the area of energy and environment in the US, no holistic study programmes were established at universities before 1971. Thus the programmes followed rather than preceded the development of widespread public interest and definition of the main problems[58]. This suggests that the generation of public interest in issues and the creation of independent, citizen-oriented research groups may have a larger impact on existing scientific institutions than isolated attempts for change from within.

In the meantime, struggles do continue within scientific organisations, of which the cases in Table 1 are a sample. As noted before, many such encounters are hushed up by all concerned. However, the general interests of environmental scholarship are more likely to be served by publicity in at least some cases. Publicity is usually avoided by the individuals and groups carrying out the suppression, especially when their side of the case cannot be openly or readily justified in scientific or academic terms. Also, publicity threatens to expose the existence and methods of operation of the vested interests involved in the suppression effort. In the case of Hookey, no information about the case reached the general university community or the wider community; the individuals and organisational interests which led to the suppression were relatively undisturbed. However, the later case of Evans has generated a number of newspaper articles and letters, petitions, and support groups of staff and students. Even unpublicised cases, such as those of Hookey and Smith, can cause embarrassing divisions and conflicts within the university hierarchy. Publicity and staff or student action as in the cases of Coulter, Evans, Mann, Manwell and Springell can be a real threat to business as usual.

Incidentally, it would seem unwise for those involved in suppression cases to put heavy reliance on staff or professional organisations for support. In many suppression cases such organisations have been conspicuous by their absence. For example, when an engineer who worked for the Electricity Trust of South Australia provided public information to a newspaper, he was "severely criticised by the Institution of Engineers for saying things critical of other engineers"[66]. It seems better to look for support from individuals and groups which are in no way beholden to the groups attempting the suppression.

It would be unrealistic to expect all suppressed scientists to speak out about their cases. Those in the middle stages of a scientific career often have heavy financial or family commitments and can ill afford risking job security or promotion prospects. Those just beginning a career or with a well-established reputation often are in a better position to take risks — both in making scientific innovations[67] and in speaking out and so inviting or challenging suppression — though sacrifices may be entailed in these cases also, for example by jeopardising job prospects or losing pension benefits. But then, power structures of any kind have seldom been reformed without risk or sacrifice.

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    Dr F.R. Moulds, Chairman of the Forests Commission of Victoria, after retirement became a forestry consultant and also Chairman of Victoria's Timber Promotion Council.
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The Battle of Terania Creek

by
Alan Grainger

The struggle to save one of Australia's last remaining tracts of tropical forest.

Tree lovers in the Australian state of New South Wales have been climbing trees, singing to bulldozers, and massaging policemen in their attempts to prevent the local Forestry Commission from logging one of the last areas of sub-tropical rain forest in the state. The Battle of Terania Creek started on August 14th 1979 and lasted for almost a month. Foresters, conservationists and cabinet ministers were all drawn into the confrontation before it was finally resolved by the promise of an official inquiry. The whole of Australia has been forced to choose between the rapacious mentality which made the country what it is, and a new spirit of caring for nature which gushed out like an uncontrollable fountain at Terania Creek. All of this because of a fragment of rain forest tucked away at the head of a moist and often cloudy valley.

The Last of the Few

Most of Australia's rain forest has been cleared for agriculture or logged. The total of 1.8 million hectares (less than 0.24 per cent of the whole country) includes small areas of tropical rain forest on Queensland's Cape York Peninsula north of Cairns; sub-tropical rain forest from Townsville to northern New South Wales; and warm temperate rain forest further south, changing to cool temperate rain forest in Tasmania and parts of Victoria.

Of the 300,300 hectares of rain forest officially remaining in New South Wales, much consists mainly of weeds and scrub, and only 42,800 hectares is sub-tropical. About 90 per cent of the original rain forest has been destroyed since the start of European settlement, and all that remains is that which is situated in the less accessible mountainous region behind the coastal plain. That's where we find Terania Creek.

The Terania forest is thought to be the largest remaining area of the Big Scrub, which was the most extensive tall sub-tropical rain forest in Australia. Both the National Parks and Wildlife Service and the Australian Conservation Foundation have called for an end to logging in *all* publicly owned rain forests and for them to be declared permanent reserves. There have been very active campaigns to save the sub-tropical rain forests in the Border Ranges to the north-west of Terania, and in the Colo river wilderness some eighty miles north of Sydney in the centre of the state. The New South Wales Forestry Commission is acutely aware of the depth of concern felt all over the country about the fate of the remaining rain forests, and it has steadfastly maintained throughout the Terania controversy that it does not plan to log rain forest as such, a semantic difference made possible by the complexity of the vegetation at Terania Creek (see box).

The idea of a National Park in the area of the Nightcap Range (of which the Terania Basin is a part) dates back to 1937. In that year the then Minister for Mines and Forests, Mr Roy S. Vincent, in the declaration of the Nightcap National Forest (incorporating the Whian Whian and Goonimbar State Forests) said that: "The local authorities shall be drawn into consultation in the management of this bushland so that there shall be, within the National Forest, what is, to all intents and purposes, a National Park serving all time."

The earlier proposals did not mention Terania Creek specifically, but most of the intended area was either clear felled or heavily logged during the second World War. According to the Terania Native Forest Action Group (TNFAG) "It seems that the (Forestry) Commission remained unaware of the earlier National Forest Declaration until 20th April 1979 when (we) informed the Commission of it by letter. By the end of the war the Commission had managed to lose some records, including the records dealing with the National Park. Thus when management plans for Whian Whian State Forest were finally drawn up they failed to provide for the National Park. Work proceeded in the clear-felling and heavy logging of those sections of the National Park area remaining after the War Effort."

"It is clear here that bureaucratic bungling by an inefficient Forestry Commission was directly responsible for yet another example of the State's heritage being sadly abused . . . This must surely have been an extremely severe lapse in management because, for the proposed National Park to be completely forgotten in management plans, all relevant records must have been lost and forgotten in *both* the district offices and at the Head Office in Sydney, as staff in Murwillumbah, Casino and Sydney have a say in drafting the plans . . . After the Commission's past logging efforts in the area, Terania remains the most attractive area for inclusion in a National Park left on the Nightcap."

The Fight Begins

Nothing was known about either the 1937 declaration or even the real value of the Terania forest when, in March 1975, some recent settlers in the area discovered by accident that the Forestry Commission planned to log the Terania Creek Basin. Enquiries were made, but the Forestry Commission was unable to come up with a final management plan for the area. In May a public meeting was held for local residents (including saw millers) and passed a resolution against the logging of the Basin and the use of the very poor Terania Creek road by logging trucks.

By 1976 a five point submission had been sent to the Forestry Commission, recommending that; (1) The area of 600 hectares which form the Terania Creek Basin be zoned a Forest Preserve; (2) That the wet sclerophyll forest above the Basin but still within the catchment be selectively logged and not clear-felled; (3) That Terania Creek Road not be used as a hauliers' road; (4) That the Forestry Commission seek greater public participation at the planning stage; (5) That a reaf-forestation programme be established.

The Commission was clearly not very impressed by this submission, but did send its Research Scientist, Mr Alex Floyd, to have a look at the Basin forest. Unfortunately he only saw the part which had been al-

ready logged, and this did not seem to be as rich as a remnant of the Big Scrub should have been.

In July 1976, the Terania Native Forests Action Group was formed, and in February of the next year a letter was sent to the State Premier asking him to intervene to halt the logging scheme. The letter was referred to the Minister for Planning and Environment, Mr Landa, who in turn referred it to the State Pollution Control Commission (S.P.C.C.). In June 1977 the Group received a letter from Mr Landa saying that the S.P.C.C. had concluded that there was "insufficient evidence to justify its intervention in the proposed logging operations." Unaware of any inspection by the S.P.C.C. the Group protested to the Ombudsman, who reported in June 1979 that he could find no documents relating to a review by the S.P.C.C., and "it appears that the review consisted of informal discussion of officers of the S.P.C.C. between themselves and also with officers of the Forestry Commission."

Another submission was made in August 1977, supplementing the first by recommending that a moratorium be declared on the proposed logging of State Forests in the Terania Creek Basin and on all other significant tracts of rain forest in the state, until a full scientific assessment was made, and that Terania Creek Basin be declared a Nature Reserve.

This brought Alex Floyd back to the area again and this time he was able to inspect the unlogged part of the Basin forest. His report was not made public until June 1979, when the Australian Broadcasting Commission requested a copy. Although again playing down the overall importance of the Terania forests, Mr Floyd did say that: "The extensive apparently natural palm forests at the head of the creek could be of ecological interest as they must surely be the greatest area of this type in N.S.W.", and further study was necessary.

In December 1977 the Minister for Conservation, Mr Gordon, made three concessions in response to the Group's submission. There was to be no logging of the rain forest *at this time*. The Terania Creek Road would not be used for logging trucks. The brush box forest would be selectively logged rather than clearfelled. The Group replied that the assurance not to log the rain forest 'at this time' was practically meaningless, the logging of brush box forest was deplorable, and no mention had been made of the reforestation programme called for in both submissions.

Grainger

Over two hundred police were drafted in to control protestors.

Finally, in February 1979 the Minister for Conservation announced that logging of the brush box would now go ahead, and the Terania Creek Road would have to be used because the only alternative route (McKay's Road), had been found to be unsuitable. The Group, aware that logging and extraction of the brush box would probably cause a lot of disturbance to the rain forest, called for an environmental impact study, and tried all legal means to stop the logging. Politicians were lobbied, and an intensive press and public relations campaign was launched. After a visit to Terania in May, Mr Gordon dismissed any hope of a reprieve. The tree lovers of Terania Creek knew that they had a fight on their hands, but were determined to win in a peaceful way.

The Battle of Terania Creek

August 13th, 1979. More than 300 people responded to the call for help and gathered at a camp set up on private property on the edge of the forest. Look-out posts equipped with walkie-talkies were set up in the mountains to monitor all movement of traffic up the valley. TV and press people arrived. Cars were used to blockade Terania Creek Road and McKay's Road.

The loggers first appeared three days later, accompanied by police. They didn't pass the blockade. The next day, August 17th, they came back, with 108 policemen. Tow trucks were used to remove the cars and the Forestry Commission bulldozer went down McKay's Road and started to clear the old logging road. Seventeen people were arrested.

Four days passed without any sign of either loggers or police. Then on the morning of Wednesday August 22nd, 130 police arrived with one bus, three tow trucks, twenty police cars, five paddy wagons, and one rescue vehicle. They had the audacity to park on the private property of one of the leaders of the Terania Native Forest Action Group and refused to move. Finally the owner marked the boundary lines of his property with paraffin. The police moved. Meanwhile, the bulldozer continued to clear the old road into the forest, but was halted for 15 minutes so the tree people could sing to it. Twelve arrests were made.

Next day about 200 policemen arrived. None of them wore numbers on their shirts for identification. The loggers started to fell the brush box, while the tree people sat in the trees that might be in the path of the falling trees. Three arrests were made. Felling continued on Friday. As the brush boxes crashed to the ground, the protestors held up their arms like their giant friends swaying in the breeze, and sang 'Give Trees A Chance'.

Over the weekend 70 Australian conservation groups came out in support of the people of Terania. Unfortunately someone cut up some of the brush boxes lying on the ground, making them worthless. Other standing trees were spiked so that it would be dangerous to use a chain saw on them. The Action Group had no knowledge of who had done this, and informed the police and saw-

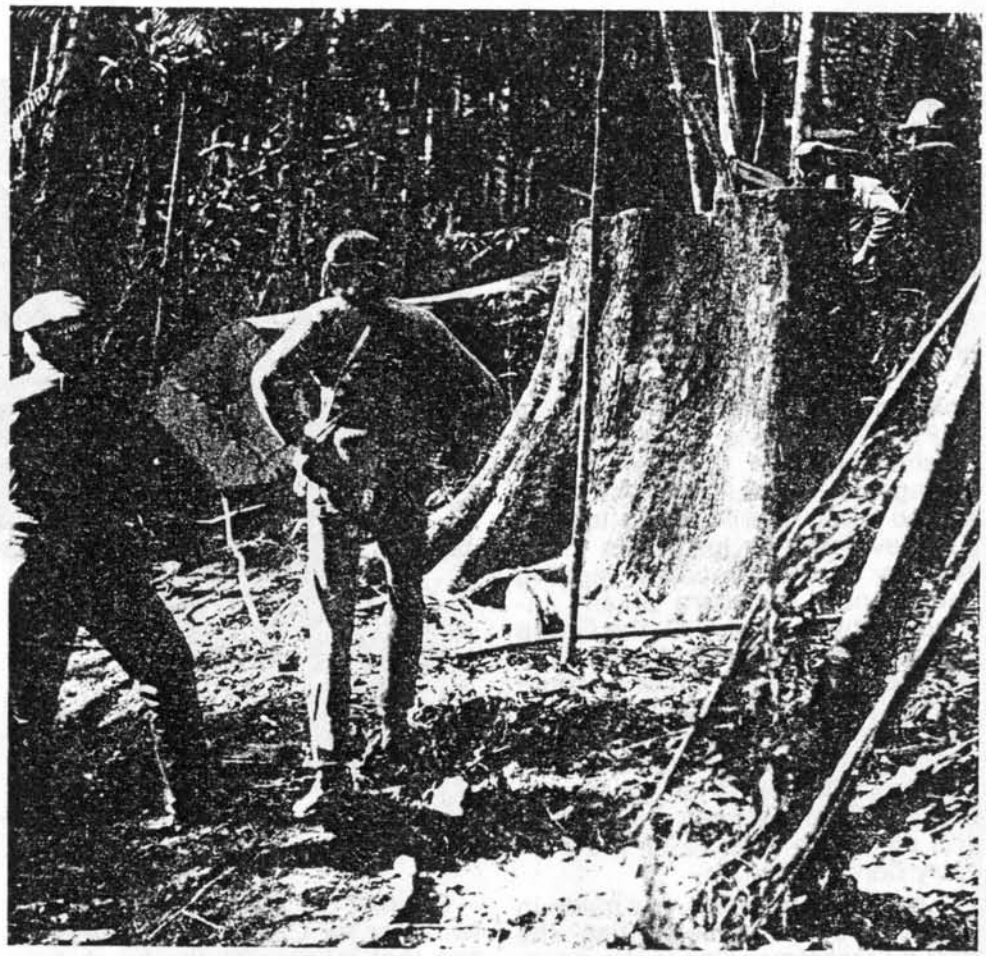
millers. There are fears that this may harm the non-violent image of the protest.

More felling on Tuesday. A reporter described how he went into a clearing and found "at one end a big log with twenty policemen in pale blue uniforms sitting on it. Touching side by side . . . they certainly looked pretty foolish. Reminded me of a row of blue budgerigars on a perch." The days were long and hard work for both police and protestors. A feeling of mutual respect developed and exhausted policemen went to the protest camp for a massage. On Wednesday the first trees were taken out by truck.

On Thursday August 30th there was a demonstration outside the Ministry of Conservation in Sydney and members of the T.N.F.A.G. saw the State Premier Mr Neville Wran. At the weekend up to 2,000 people came to Terania for a big rally. Aborigine Burnam Burnam told them that Terania Forest was a sacred aboriginal place. "Not one fern should be touched. These (tree) people are behaving like Aboriginal people did."

Dr Len Webb, Australia's top forest expert, explained the importance of the Terania forests, and went on: "I think that Terania Creek is the kind of issue that I feel I must identify with as a professional ecologist. Part of my doctorate of philosophy work back in 1952 began here in Whian Whian State Forest. Isn't it ironic that I'm back here 27 years later, for God's sake, and I'm trying to preserve the remaining fragments of that forest. . Some of us are starting to understand that forests are part of our cultural heritage. It's part of our self identity emerging. It's not just values of watershed protection or even biological control. Forests are part of us. It is a feeling of communion and intimacy with the bush."

On September 4th the Cabinet decided to halt logging for a week. This was a considerable victory for the tree people, bearing in mind the ideas of some members of the Cabinet, like Mr Don Day, the Minister of Agriculture. On a visit to coastal areas in the far north of the state, he had previously pressed Mr Ron Mulock, the Minister for Mineral Resources who was accompanying him, to allow further beach-mining operations in National Parks (against the ruling Labour Party's policy). Dr Webb recalls how "Day stood at the edge of the mining operation at Jerusalem Creek and waved his arm across the surrounding untouched wildflower swamps: "It's all bloody rubbish," he said. "Ninety per cent of it and not worth a single job."""



Grainger

Conservationists tried to prevent felling by hugging the trees.

A few days later, around midnight on Thursday September 6th, part of Hurford's sawmill in Lismore burned down. *The Northern Star* had a field day, quoting Mr Colin Withey of Standard Sawmills as saying that: "Law and order is now the issue." The tree people were blamed but no evidence was found to link them with the fire. Indeed, with a week long moratorium on logging just announced, they had nothing at all to gain from the incident. Could it have been a last desperate effort by the loggers? A week before, local sawmillers had asked to see Mr Wran, the State Premier, to discuss 'the serious new turn in the demonstration at Terania Creek'. They saw him on the Friday morning after the fire. Petitions that had been collected in favour of logging at Terania were taken from the Hurford's office just before the blaze — by Mr Hurford.

Fortunately, this did not result in the Cabinet over-reacting in favour of logging. Instead, on Tuesday September 11th, it decided to send a sub-committee to Terania to make an on-the-spot report. The tree people held a victory party and next day the camp broke up.

When the sub-committee flew in on the 16th of September, it was greeted at the airport by a group of singing tree people, and saw delegations from all sides in the dispute. On their return the Cabinet was still undecided, so a week later a group of back-bench Labour M.P.s, who stepped off the plane to a hostile demonstration by loggers and sawmillers waving placards bearing messages like: 'Give us jobs, not hippy slobs'. The subcommittee report, and those of groups of members of both opposition parties who later visited the area, convinced the Cabinet to hold a public inquiry into the whole issue, under Mr Justice Isaacs. The Battle of Terania Creek was over, and a new phase in the campaign had begun.

Planting Seeds for the Future

The inquiry received a 73 page submission from the Forestry Commission and a counter-submission from the T.N.F.A.G. that was over twice as long. The tree people were able to state much more clearly, in the light of recent studies, their case for preserving the Terania Creek Basin forest for its floral wealth. They were also able to present evidence as to the effects which the logging had had on the forest before being halted.

There is of course a dispute about what is and what is not rain forest. The Commission has stated that it does *not* intend to log the rain forest on this occasion and that only damaged commercial rain forest species will be harvested. They have defined coachwood areas as

'hardwood stands' despite the floristic advice of A.G. Floyd, their own research scientist, so that, *by their definition only*, the Commission plans for Terania Creek don't involve logging rain forest.

Mr Floyd predicted that: "If logging is mainly aimed at the brush box type, which would appear more likely, then the intensity of logging will determine the degree of damage to the coachwood rain forest beneath and its ability to recover. Because the trees to be removed are mainly veterans with large spreading crowns and are on steep to moderately steep slopes, damage downslope could be greater than if the trees were small and on gentler topography. Logging under these conditions must also cause some damage to the gully rain forest near the type boundary." The T.N.F.A.G. states that: "A visit to the logged area confirms that the rain forest has not been 'logged' but rather crushed and flattened by larger falling trees followed by the removal of large sections to allow snigging."

The T.N.F.A.G. goes on to say that the Commission's claim also "ignores the inevitable damage caused by roading in the pure rain forest and in the rain forest with brush box emergents . . . Putting roads through the middle of the best parts of the virgin forest . . . is destroying the rain forest's integrity. The road into the rain forest has already resulted in weed invasion. It will also cause die-back from damaged trees, as even small injuries result in fungal invasion . . The logging operation itself will encourage regrowth of hardwood species and . . . the road through the rain forest will be replanted with eucalypts, of all things, not rain forest trees." The T.N.F.A.G. also claims that the Forestry Commission was incorrect in stating that "there is now no visible evidence of serious erosion resulting from . . . former (logging) operations" and that erosion is likely after the present operations.

The T.N.F.A.G. calls into question the ability of the Forestry Commission to properly care for existing forests and supply wood needs in the state. "The Forestry Commission has claimed on 14th December 1979 that the area for proposed logging is 70 hectares and that the total log volume to be obtained is about 6,400 m^3. Only three months earlier on 5th September 1979 the Commission estimated that 160 hectares would be logged to give 6,000 m^3 gross."

The Group is also disappointed that the Commission has not taken up its proposals for large scale reforestation. "If reforestation in northern N.S.W. had been tackled many years ago, the Commission would not be forced into the position of using conservation battles like Terania Creek to disguise the real cause of the shortfall in wood and employment in the timber industry . . . The Country Sawmillers Association admitted on A.B.C. 'Nationwide' television that the timber industries are presently harvesting N.S.W. rain forest beyond sustained yield and felt justified in doing so because "the demand and economic conditions are there." The Commission has also stated that "the principal problem lies in the expected sawlog deficit for the next 20-30 years. Management should aim to minimise this deficit by maintaining the indigenous forest sawlog yield for the next 30 years at the highest level compatible with maintaining desirable forest conditions in the long term."

At the moment the Commission is responsible for both utilisation *and* conservation of State Forests, and more often than not the former is regarded as being the more important function. In the absence of institutional checks, there is also very little scope (or desire on the part of the Commission) for public participation. "At present", says the Group, "appeal can only be made to the Commission itself and hence it stands as judge and defendent in its own cause. The confrontation at Terania Creek occurred because the thousands of concerned people who found themselves very strongly against the Forestry Commission policy, were given no right of appeal under the present act."

For four and a half years members of the T.F.N.A.G. tried unsuccessfully to inspect a copy of the management plan for the State Forests of which Terania Creek is a part. For two years members of the T.N.F.A.G. were consistently told that Mr Floyd's second report was unavailable for complete public scrutiny and only part of it could be read at National Parks and Wildlife Services offices. It was not made public until May 15th 1979, when Mr Patrick O'Neal of A.B.C. Television's 'Nationwide' asked for it.

The tree people did not have high hopes regarding the outcome of the official inquiry. They felt that the whole procedure was loaded against them, and even Dr Len Webb was forced to give only 'yes' or 'no' answers to questions. A superb documentary film about the battle of Terania Creek was made by Jeni Kendell, one of the country's top television film-makers who worked for A.B.C. for many years before branching out as an independent. Political pressure is likely to keep the film off Australian television screens, just as happened to E.F. Schumacher's 'On the Edge of the Forest' which exposed what was happening to the jarrah and karri forests in Western Australia. Jeni Kendell's 'Give Trees A Chance' was shown by accident at the 1980 Sydney Film Festival, because an America film was delayed in Customs, and received a standing ovation from the audience of journalists and critics. Substantial extracts from the sound track were subsequently broadcast on A.B.C. Radio's very popular 'Science Programme'.

The tree people of Terania Creek are pressing ahead with their plans for large scale reforestation in the area and last September held a three day workshop in conjunction with local foresters, sawmillers, local councils and chambers of commerce, and all interested people and groups. The workshop, opened by Dr Richard St. Barbe Baker, founder of The Men of the Trees, was the first step in developing a genuinely publicly backed forestry programme for New South Wales. Members of the T.N.F.A.G. are preparing to move into other threatened areas, such as the warm temperate (coachwood) rain forests in the 26,000 hectare Washpool wilderness.

Trees need our respect, not our sentiment. They worked for millions of years to make it possible for mankind to live on this planet. Today they are still willing to serve, but not to be subservient. When all is said and done, the battle of Terania Creek happened because we, for all our technical prowess, are still not capable of working with the greatest living things on this planet.

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Books

Feature Review: The Tropical Rainforest Dilemma

by
Alan Grainger

Present and Future Forest and Plantation Areas in the Tropics, by J.P. Lanly and J.Clement, F.A.O. Document FO:MISC/79/1, January 1979 (Rome). pp 46. (U.K. availability: January 1980).

Conversion of Tropical Moist Forests, a report prepared by Norman Myers for the Committee on Research Priorities in Tropical Biology of the National Research Council, U.S. National Academy of Sciences, July 1980 (Washington) pp 176 + 31. £8.10 in U.K.*

United Nations Environment Programme Overview Document for Experts Meeting on Tropical Forests, Libreville/Nairobi, 25th February-1st March 1980, (Nairobi-Limited Distribution). pp 70.

UNEP Rain Forests Document: Comments from a Botanist, M.Jacobs, Rijksherbarium, Box 9514, Leiden, Netherlands, February 1980. Cyclostyled mss. pp 5.

Save the Rainforests, IUCN Bulletin New Series *11* No.5, May 1980, (1196 Gland, Switzerland) pp 32. 70p. (Includes IUCN Rainforest Statement).

These five major reports, published since my overview on "The State of the World's Tropical Forests" (*Ecologist* Jan/Feb 1980), express most vividly the great tropical rain forests dilemma: we do not know with any accuracy their present area or how fast they are disappearing, and even if we did we would not know how to utilise and/or conserve them.

Lanly and Clement present the latest F.A.O. estimates of closed tropical hardwood forests, and their findings are markedly different from Sommer's previous F.A.O. study (Unasylva No.28 (1976). Regional forest areas are much higher, with the exception of South East Asia (about the same) and West Africa (lower). Instead of a rate of deforestation of the order of 15 million hectares a year (the previous F.A.O. figure), Lanley and Clement estimate the annual loss in the major regions as 6.24 million hectares (Table 1).

Their report is a desk study, based on "the organisation, compilation and interpretation on a country basis of the information available, i.e.: country progess reports at World Forestry Congresses, FAO Regional Forestry Commissions, Commonwealth Forestry Conferences etc; proceedings of technical forestry meetings at national, regional or world levels organised by FAO or other institutions; annual reports by national forestry institutions; forestry studies by national and bilateral/multilateral agencies; questionnaires to countries, correspondence and interviews with national and international experts knowledgeable about the forest resources situation in given countries; and articles in technical publications."

Norman Myers' report is also a review of available published material, although the commission by the National Academy of Sciences did allow for travel during the ten months in which it was researched (July 1978-April 1979). Written enquiries to officials in tropical countries did not manage to elicit much hard information, and 32 letters to Zaire failed to produce any response at all. As a result he covers very much the same ground as in his book 'The Sinking Ark', though amplified and structured into an encyclopaedic country by country listing (47 in all) grouped in three regional chapters which occupy 105 of the 176 pages.

Both reports recognise the unreliability of their primary source material, although Dr Myers' criticisms are perhaps more biting: "Much information, presented as ostensibly up-to-date and authoritative, does not withstand critical scrutiny . . . Indonesia, with roughly one-tenth of the biome, still publishes a figure for its forest cover that is more than 20 years old, and that takes no account of the widespread logging, shifting cultivation, and transmigration programmes that during the last two decades have affected large areas of undisturbed forest, possibly as much as one third of its entire extent; and Zaire, also with one-tenth of the biome, had virtually no statistical information whatever."

"According to a National Forest Inventory taken in 1965 the Philippines then contained 170,300 km^2 of forestlands, constituting 56.76% of the country. A further estimate in 1971 indicated that 132,721 km^2 or 44.24% could still be classified as forestlands (logging and shifting cultivation greatly increased in the late 1960s — A.G.) though an official Country Report to the 8th World Forestry Congress in late 1978 stated that the Philippines forestlands continued to accord with the 1965 figure." This despite the fact that results from satellite imagery (published in 1978) showed "that only 38.2% of the nation was still forested in 1976."

The message is very clear: the only way we are going to get reliable

* available in the U.K. from Castle House Publications Ltd., 27 London Rd, Tunbridge Wells, Kent.

data is by remote sensing. Cloud cover is a great barrier to monitoring the humid tropics by satellite and so information from LANDSAT satellites often has to be supplemented by that obtained from airborne radar scanning. So far only the Philippines and Thailand have been surveyed by LANDSAT and the results published, but we can expect LANDSAT estimates from Liberia, Nigeria, Brazil, Indonesia, Venezuela, Peru and Colombia in the next few years. The surveys are supported by grants from the U.S. Agency for International Development, its Canadian equivalent, and F.A.O., and one of the main (implicit) recommendations of this report is that such programmes should be continued, if not expanded in scope. A recent UNEP report* has recommended that "the F.A.O./U.N.E.P. forest resources monitoring programme for the tropical zone (should be developed) to a stage of operational continuous global resource inventory."

TABLE 1: Estimates of Closed Hardwood Forest Resources in the Humid Tropics (in millions of hectares)

REGION	LANLEY & CLEMENT	SOMMER	CLIMAX FOREST (SOMMER)	ANNUAL REGRESSION L & C*	F.A.O. (Previous)
Central America	57.4	34.0	53.0	0.3	
South America	526.4	472.0	750.0	2.8	
Caribbean and other islands	43.6	—	—	0.02	
TOTAL LATIN AMERICA	627.3	506.0	803.0	3.1	5-10
Central Africa	170.6	149.0	269.0	0.13	
West Africa	14.1	19.0	68.0	0.46	
East Africa & Islands	16.9	7.0	25.0	0.14	
TOTAL AFRICA	201.6	175.0	362.0	0.73	2
Pacific Region	41.1	36.0	48.0	0.03	
South East Asia	188.6	187.0	302.0	1.54	
South Asia	61.4	31.0	85.0	0.82	
TOTAL ASIA	291.1	254.0	435.0	2.4	5
TOTAL	**1120.0**		**1600.0**	**6.24**	**12-17**

* between 1975 and 1980.

Because of the limitations in the primary source material of the F.A.O. report (and no national forest areas are given to enable us to judge the accuracy of the regional figures) its numerical conclusions should be treated with reserve, and projections of deforestation losses between 1975 and 2000 will probably be made redundant by the publication of LANDSAT figures in the next few years. Norman Myers is cautious about committing himself to definite figures, and with good reason, but does provide a broad comparison between the rates of deforestation taking place in different countries. There are some anomalies however, e.g. he expects deforestation in Sabah to accelerate even though the state government has severely cut back on logging.

If we are going to be more sophisticated in our analysis we shall certainly need to use more terms, and have general agreement as to what each of them mean. In my report I used 'degradation' to refer to total forest removal from an area, and 'depletion' to describe forest that had been logged over. However, Lanly and Clement use both words to refer to the first process (removal) and UNEP uses disruption and degradation to refer to the second (partial forest utilisation). While I am not partisan in this matter it would seem desirable to achieve some kind of uniformity in usage.

Myers uses 'agroforestry' (the collective name for all mixed farming and forestry practices) to refer to just one-mixed planting of food and tree crops by peasants which will eventually lead to reforestation — which is known by the name of agrisilviculture (see my review of agroforestry in the first issue of *The International Tree Crops Journal* for more details). The term forest farming turns up in both Myers' and UNEP's reports (Myers was associated with the organisation of the UNEP Experts Meeting) as a collective name for shifting and encroaching cultivation in forests, but since it and 'tree farming' are already much over-used to refer to a number of different practices it would seem prudent to consider using another term.

While IUCN takes a middle of the road view with respect to rain forests: "far from wishing to lock up all tropical forests, it promotes conservation as part of an overall regime aimed at sustainable use", there does seem to be some confusion at UNEP as to the exact relationship between 'development' and conservation. Paragraph 54 of the Overview Document states: "This does not mean that tropical forests should not be developed, utilised and exploited in whatever manner best serves human needs. This is a central issue which must be stressed. This overview document certainly does not view tropical forests as a unique biological phenomenon that must be safeguarded as an absolute end in itself; far from it, when tropical forests are wisely utilised and conserved, they generate many renewable benefits."

One of the serious deficiencies which he and UNEP find in the F.A.O Report is that: "it proposes that logged-over forest can be considered to still constitute forest in the usual sense, i.e. the study does not differentiate between primary and secondary forest, nor does it take account of the pronounced tendency for logging tracks to be used by forest farmers who thereby penetrate deep into the heart of the forest territories that have hitherto been closed to them, effectively eliminating large areas of forest." So UNEP recommends that "a review of the decline of forests therefore needs to consider not only outright removal of forests. It must also consider disruption and degradation of *primary* forests that have hitherto remained

* Tropical Woodlands and Forest Ecosystems, UNEP Report No.1 (1980), Nairobi. 81 + 4 pp.

more or less undisturbed." UNEP quotes a Myers' figure of at least 20 million hectares of primary forest being disrupted each year, although it is possible that there has been some confusion with his estimate for forest removal by shifting and encroaching cultivators, cattle ranchers etc. With greater use of remote-sensing (and Dr Myers includes an excellent review chapter) it should be possible to obtain far more detailed information about the different degrees of deforestation.

Those are very ill-chosen words to come from an environmental agency, even though the word conservation is inserted near the end, and less understandable when elsewhere it is said that "the fragility of tropical forests has led some scientists to label these forests as a non-renewable resource" (paragraph 135) and one which is "exceptionally susceptible to irreversible degradation." There is a world of difference between not condemning a country for not stopping all of the deforestation but at the same time encouraging it to adopt a positive attitude to conservation (the IUCN approach), and saying that cutting down forests could be a laudable development aim.

As Dr Marius Jacobs has commented: "Apparently a deep uncertainty about the possibility at all to exploit rain forests rationally has pervaded the considerations. I have no doubt that many of the calls for more research are uttered to mask just this uncertainty. If we go for mapping, planning and monitoring alone (useful and necessary as they are) years might elapse before decisions could be made, and conservation potential would continue to erode. Hence let me suggest . . . that top priority be given to *effectively protecting existing rain* forest reserves, and to granting proposals to create new reserves where these already have been submitted. This is the least we can do for the safety of a first minimum of rain forest area . . . We should never be trapped by a dogma that tropical forests must be developed (see paragraphs 12-18). It may eventually restrict our options, especially as long as we do not precisely know how to tap their resources on a permanent basis. As for the limited exploitation to which paragraph 243 alludes, the risk is simply too great that it becomes unlimited."

The way in which we monitor the changes in our forests says a great deal about our attitudes to them. Dr Jacobs criticises the "disregard for biological reality" which led to logged and unlogged forest to be pooled together in Lanly and Clement's report. "No discussion on tropical rain forest utilization and conservation will bring clarity unless these distinctions are observed . . . because modified forest will not regenerate within 'plannable' spans of time." Which brings us back to where we started, for while the sudden upsurge of interest must surely have made 1980 'the year of the rain forest,' we are certainly no nearer to solving the dilemma which they present to a human race only gradually beginning to appreciate just how important they are.

Fast Reactions

THE FAST BREEDER REACTOR, Need? Cost? Risk? Edited by Colin Sweet. Macmillans, London, £20.00.

As many critics of nuclear power are well aware, there is an inevitability about the development of nuclear power in Britain. The PWR debate and public inquiry may indeed happen, as the government has promised, but few believe that such processes will have much bearing on the final outcome: thus by 1990 a PWR will have taken shape in the Suffolk landscape at Sizewell. Cynics aside, the nuclear industry and the generating boards are likely to declare that if the result of any such inquiries are in their favour, that is because of the unassailable case for nuclear power, and specifically for the PWR on the grounds of economics, safety and ultimate acceptability.

But there is a level of debate on nuclear matters which does not necessarily come to the attention of the public, and which indicates that the issues are far more controversial and uncertain than the decision-makers would ever admit. In November 1978, the Polytechnic of the South Bank held a conference on the fast reactor, and Macmillans have now published the proceedings at a price that will surely limit the sales to specialised libraries and institutions. Nevertheless, for those prepared to unearth it, that book contains the nub of arguments why nuclear power in general is in reality a bad buy for a country such as Britain blessed with ample resources of conventional fuels and with good scope for conservation and for utilising renewable energy resources. More important several of the contributors indicate why the fast reactor would be a disastrous commercial investment with real costs significantly above those of thermal reactor systems, even in an expanded nuclear programme.

The case for the fast reactor is put by Walter Marshall and Peter Jones of the Atomic Energy Authority, Marshall reiterating the point that the fast reactor is not simply a means of amplifying the available energy of uranium by some sixty times, but as an incinerator of plutonium will help solve the potential problems of nuclear weapons proliferation, and will provide a logical alternative to the once-through non-reprocessing system at present practised by the Americans and Canadians. To overcome the threat of terrorists making off with plutonium he returns to the theme first announced at the Windscale Inquiry of 'spiking' reprocessed fissile material with radioactive contaminants. Marshall is not disturbed by the prospect of thousands of tons of plutonium passing through the nuclear fuel cycle should fast reactors become the dominant reactor type. Peter Jones, meanwhile, is out to show that nuclear power is the cheap option for electricity generation in Britain, and by extrapolating expected trends for fuel costs and capital costs of coal-fired and nuclear stations into the mid-1980s, he demonstrates that down to load-factors of as low as 40 per cent, nuclear power thermal systems such as AGRs have a considerable cost advantage. Below 30 per cent availability of plant the costs of both coal and nuclear plants increase exponentially together. Jones quotes Hunt and

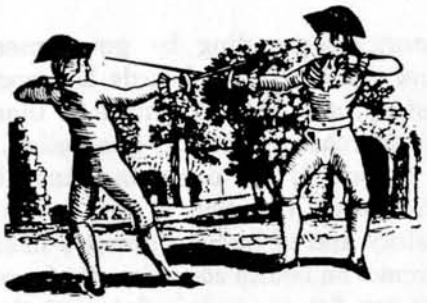
Betteridge of the UK Atomic Energy Authority who claim that the proportion of nuclear capacity in the generating mix for Britain could be increased by a factor of four for all base-load electricity to be nuclear generated and by a factor of seven before the cost advantage of nuclear power would be whittled away by falling load factors because of fluctuating demand. The CEGB assessment of the economic advantages of nuclear power tallies with that of the UKAEA, and the rationale is that the Board would actually save itself and the consumer money by putting conventional plant into early retirement and replacing it with new nuclear stations.

How different the conclusions of Michael Prior who was with the Economic Assessment Service of the International Energy Agency Coal Research. Indeed according to his data nuclear power plants would have to operate with load factors above 60 per cent to have any cost advantage over coal, while below 60 per cent and down coal would have an increasing lead. Prior points out that capital costs have risen well above inflation for nuclear power, and that fuel cycle costs are becoming an increasingly heavy proportion of total costs. The data for making an economic assessment of the fast reactor are just not available, but on the basis of straightforward reasoning of the likely capital costs, of the rate of feasible introduction of a fast reactor programme and of the closed fuel cycle costs, including the reprocessing of high burn-up spent fast reactor fuel, Prior cannot begin to see how the fast reactor is justifiable on economic grounds. His contentions are strongly supported by Colin Sweet's own paper in the proceedings.

A large component of the advocacy for nuclear power and hence of the fast reactor is that coal which would otherwise have to be consumed in power plants will be available for other important purposes such as conversion into gas or liquid hydrocarbons. At stake is the very nature of energy utilisation in Britain, and Gerald Leach and Peter Odell in particular point out that far more energy efficient and cheaper systems are already technically feasible or available than nuclear generated electricity. Peter Odell, for example, is not the first to point out that more natural gas is available than had hitherto been expected, and that in reality nuclear power can in no way compete with the direct use of natural gas by the consumer, even with its artificially jacked-up price. Leach meanwhile shows how far energy forecasting by government and the electricity boards has gone astray, and how little need is there for increased electricity generation.

Others in the conference turn to the vexed question of fast reactor safety and of nuclear power's likely impact on health statistics. Professor Lindop for example points out that reprocessing technology will have markedly to improve its containment of actinides such as plutonium and americium. From the proceedings, it is clear that the conference on the fast reactor was an extremely useful exercise in the presentation of fundamental issues. As a number of the speakers pointed out, the answers to many of the issues will depend on the industry releasing far more information than is presently available. On the other hand, the industry itself does not seem to know the answers, Hunt admitting at one time that the UKAEA would need several years before it oculd put a second case in favour of the fast reactor at a public inquiry. Despite that paucity of information, the critics of the fast reactor appear to have done an excellent job in eroding the apparent need for such costly and dubious reactor systems.

Peter Bunyard



Letters

Uranium Appeal

Dear Sir,

In our nation's push to become less dependent on foreign energy sources, occasional dangerous sacrifices are being made. A case in point is the hellbound drive to develop uranium ore in Crownpoint, New Mexico.

Crownpoint is a town of 1,000 located 7,000 feet up in the Grants Uranium Belt. As the Eastern Navajo Agency Headquarters, its primary employers are involved in Indian Services, notably a Public Health Service hospital which attracts numbers of reservation residents each day. Ironically, in a few years a trip to the Crownpoint hospital may put a patient in greater danger than staying home and weathering the illness.

About 2,000 feet below Crownpoint and much of the surrounding area lies a uranium lode. Unfortunately, this is the same depth as the aquifer from which Crownpoint wells draw their water. A Conoco mine is now being drilled one-half mile from the center of town. When the drill reaches the uranium deposit, the dewatering process will begin. This will involve pumping the aquifer water from the mine in order to be able to extract the ore. According to Conoco's own plan for discharge treatment, at full capacity the mine will be pumping over ten million gallons a day from the aquifer. This enormous drawdown will greatly intensify the problem of Crownpoint's [and much of the Southwest's] plummeting water table. A government official in charge of community wells has publicly stated that the water level may drop below the level of area wells in five years due to the mining. Conoco has thus far offered no concrete provision for restocking community water supplies.

Even if the mine does not use up all the water so fast, it could contaminate the town's water supply for eons. Minerals such as oil and substances such as arsenic and silenium, as well as radioactivity leached from ores, could use mine shafts as access routes to water below. It is an irreversible process.

Perhaps as great a danger as pollution and depletion of water supplies posed by this backyard mine is the venting of radioactive radon 222 from the mine. While there are OSHA regulations relating to miners' exposure to this gas, no agency has established safe limits for the concentrations of radon 222 [and its daughters] in the air outside the mine. With a half-life of three days, radon could easily be carried as particulate matter to each Crownpoint resident before it converts its toxic effects.

Many people are concerned about the extent of uranium development in the Crownpoint area and the potential effects on our air and water quality and water quantity. Within the next few years development calls for ten to fifteen uranium mines within a twenty-five mile radius of Crownpoint. Other of the town's residents who are worried by the Conoco mine are not opposed to uranium mining in general. Rather, it is the placement of this particular mine, literally across the street from three churches, so close to residences, that has upset so many people. There is a prevailing feeling of hopelessness, that nothing short of another Indian War could stop Conoco from digging for profit.

Sincerely,
Donald Levering,
P.O. Box 1449,
Crownpoint, NM 87313.
505-786-7343.

Action Not Words

Dear Sir,

Old timers in the ecology movement have evolved through the years, as so aptly described by Lawrence Hills [10th Birthday Issue], but I disagree with him on one point. The doom sayers would not have saved the Titanic because, when the guy on his lonely watch in the bow saw what loomed ahead and hollered, "Iceberg, reverse engines", the captain would not have believed him. We all hold our pre-conceptions very dear.

Please, don't get me wrong. Your journal, books, FOE and all other groups [I belonged to three of of them] did a tremendous job in awakening our consciousness to the dangers of our course. But now we know. It is boring to be told about the air, the water, the forests and the nukes. We know, and the ones who don't, do not read the Ecologist.

What old timers want to know is what to do and how to do it. A blueprint for survival for the family and individual. I worked for six years on my own solution and I'm always amazed at the fascination I generate even with the most conservative people. Besides, our personal changes are the only ones we control. All others can be wiped out with a stroke of a pen by a new president or legislator.

People's spirits are not kindled by warnings, they are kindled by challenges. Nobody stays enthusiastic fighting a windmill institution, but all enjoy beating the taxman at his own game. Let's bring ecology down to the level of personal action and reaction.

Robert Allen writes: "The way to save the world is to invent and apply patterns of development that also conserve the living resources essential for human survival and well being." True, but what rubbish to say in a popular or should be popular magazine. Who, I pray, can and will react to that? However, if Robert Allen had told me that he boycotts beef, lives in a communal house and walks five miles to work in second-hand army boots, I would have been very interested and perhaps stimulated to do the same.

I decided to write this letter after reading Vince Taylor's to his student, whom he obviously liked or he would not have bothered. You too have blind spots. You see the catastrophic consequences of the destruction of our forests and you write about that, fine. But what are your readers supposed to do? Worry and write a letter to the wood cutter? Please shift your emphasis from the it to the us. It is us who use the paper and lumber and eat the steer and drink the coffee. We are the culprits, because nobody would bother cutting a single twig if he can't sell it and make money. Oversimplification? Yes, but take it as food for thought.

If the doom sayers on the Titanic had succeeded in getting people to forget their Tuxedos and invest in wetsuits, the boat would have gone down but, . . . and who is ecologically more valuable?

Nevertheless, many thanks for your tireless work for the future of this planet and mine.

Yours sincerely,
Victor Prochaska,
Box 416,
Pemberton, B.C.,
Canada.

CLASSIFIED

MISCELLANEOUS

SCULPTOR has living accommodation and workshop space for Craftsman Woodworker in Rural Area of Norfolk. Couple preferred. Enquiries to Box No. 139.

FAMILY AIMING FOR S/S LIVING in Manchester area would like to meet similar with view to joint purchase of land in Lancs area (probably Rossendale). Write to Box No. 140.

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PERSONAL

AUSTRALIAN BACHELOR, 42, tall, presentable, vegetarian, conservation-minded, would like to contact lady 29/36 with sense of adventure wishing to live low consumption, self-sufficient in tropical area Australia. Permanent relationship. Write outlining likes, interests, pastimes, etc. Photo appreciated. Murray, Box 38, Bondi, 2026, Australia.

COURSES & EVENTS

WHERE DO WE GO FROM HERE?

A series of lectures to be held at the Museum Lecture Room, Public Library Building, Tunbridge Wells, Kent, in March and April at 8 p.m.

Fri. March 13th: Has science reached the threshold of the spirit? Lecturer John Davy.

Fri. March 20th: The art of healing. Lecturer Dr. Ralph Twentyman.

Fri. March 27th: Who is bringing up your children — you or T.V.? Lecturer Alan Hall.

Fri. April 3rd: Re-incarnation within Christianity. Lecturer Rev. Evelyn Capel.

Fri. April 10th: Where do we go from here? Lecturer Russell Evans.

For further information please apply to the Secretary of the Forest Row Group of the Anthroposophical Society in Great Britain. (Pamela Jackson, Springmead, Dale Road, Forest Row, E. Sussex, Tel: 034-282-3346).

One day seminar on NATURAL APPROACH TO HEART DISEASE will be held on Saturday February 21st 10 am - 5 pm, sponsored by the Community Health Foundation, at the cost of £8. There will be a panel of distinguished speakers who examine the ways heart disease can be prevented. Further information from: Bretta Carthey, Community Health Foundation, 188 Old Street, London EC1 (01-251 4076).

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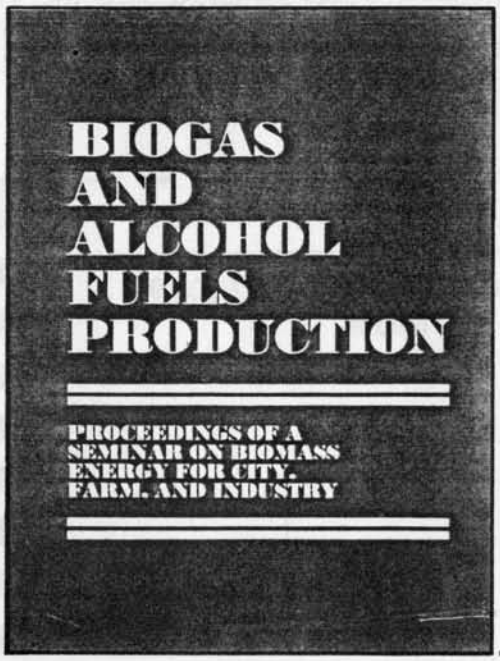

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